SUDAN
IFPRI

STRATEGY SUPPORT PROGRAM | WORKING PAPER 9 JULY 2023

Sudan's Agrifood System

Structure and Drivers of Transformation

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ABSTRACT

Based on a set of economywide databases for Sudan that have detailed content on agricultural production and processing, this study diagnoses the transformation of Sudan's agrifood system against a background of broad economic growth and transformation. Sudan's agrifood system registered only modest GDP growth between 2011 and 2019. Moreover, little change was seen in the structure of the system over this period. The share of total employment in agriculture fell significantly, contributing to some structural change in the broad economy. However, agriculture continues to absorb almost half of Sudan's total employment, while having the lowest labor productivity across the main economic sectors. The growth in Sudan's agrifood system between 2011 and 2019 was mainly driven by expansion in domestic market-oriented value chains. Agrifood value chains that are focused on exportable or imported commodities remain small with below-average growth. Comparing sources of future growth in Sudan's agrifood system across ten different agrifood value chains shows that fruits, root crops, and cereals rank highest in their potential to contribute to a range of development outcomes, including reductions in poverty, improvement in diet quality, job creation, and growth in national GDP. Although the livestock ranks lower per unit of growth, it is distinct from the higher-ranked value chains in that it has a sizable impact on all four development outcomes, while as a large and established sector in Sudan even small gains in productivity can have significant impacts in absolute terms.

Keywords: Agrifood, agriculture, growth, poverty, diet quality, employment, Sudan.

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1 INTRODUCTION

The Sudanese economy has performed poorly over the past decade. This could be associated with several external factors, including the loss of around 75 percent of oil revenue with the secession of South Sudan in 2011 and, more recently, the global economic impacts of the COVID-19 pandemic and Russia's war against Ukraine (Abay et al. 2023). However, of equal, if not greater, importance has been repeated episodes of civil strife and political instability (Alhelo et al. 2023). Political tensions between civilians and military forces in the transitional government after the fall of the al-Bashir regime in 2019, the military takeover in 2021, and the ongoing conflict that erupted in April 2023 between the Sudanese army and the paramilitary Rapid Support Forces have all caused continuing deterioration in the economy (Abushama et al. 2023). As a result, the annual inflation rate increased from 63 percent in 2018 to 360 percent in 2021 before declining to 218 percent in 2022 (CBS 2022). Exchange rates in the parallel market reached an average of SDG 550 per USD in 2022 compared to SDG 42 in 2018. The trade deficit expanded from USD 3.6 billion in 2018 to USD 4.0 billion in 2021. The Sudanese economy shrank by 1.9 percent in 2021 compared to an increase of 2.8 percent in 2018 (CBoS 2022). More than 11 million of the 49 million people in the country faced acute food insecurity between May and September 2022 (UNOCHA 2023).

After the 2019 overthrow of the al-Bashir regime, the transitional government (2019-2021) adopted several macroeconomic measures to stabilize the Sudanese economy. These included unifying foreign exchange rates, removing fuel subsidies, and downscaling food subsidies. The transitional government also established social protection programs to mitigate the adverse impacts of removing fuel and bread subsidies on the most vulnerable households, particularly the Sudan Family Support Program (Abdalla 2021). However, the overthrow of the transitional government by the military in October 2021 led to the immediate suspension of donor support to the government of Sudan, as such support was conditional on the country realizing a transition to democracy. In consequence, the country was deprived of expected external resources in the form of debt forgiveness, development assistance, and concessional loans.

Despite these significant economic and political challenges, Sudan has significant economic potential in agriculture. The agricultural sector accounts for about one-fifth of Sudan's total Gross Domestic Product (GDP), employs almost half of the country's labor force, and provides a livelihood to around two-thirds of the population (MHRDL 2011). Almost 40 percent of Sudan's land is arable. The agro-climatic zones of the country range from tropical in the south to arid desert in the north (UNEP and HCENR 2020). Significant water resources are found in the southern states. The Blue Nile and White Nile rivers provide considerable irrigation potential for drier areas in the north and northeast of the country. Sudan's agricultural sector grew significantly in the 1990s. That growth potential remains, but has not been exploited since.

To achieve inclusive and sustainable growth in agriculture, the internal and external shocks Sudan faces must be addressed, and strategic investments must be made in the sector. Growth in the Sudanese agriculture sector has been slow in recent decades due to a lack of political commitment toward expanding agricultural production and processing. This is manifest in the small share of the government budget that is allocated annually to agriculture and the lack of commitment to implementing the agricultural development strategies formulated by the government (Alhelo et al. 2023). Moreover, the limited government funding to the sector is not fairly distributed among subsectors. Notably, the traditional farming subsector in which most smallholder farmers operate typically has received the smallest share of total government expenditures on agriculture, while the irrigated subsector dominated by large commercial farms has received a substantially larger share (WB-MFEP 2016).

Despite its recent lackluster performance, it is important to place the agriculture sector in Sudan within the broader context of the national economy to better understand the contributions it might make to broad economic growth and structural change. However, this study looks beyond agricultural production alone to examine the role of the entire agrifood system (AFS) of Sudan. While agricultural production is the dominant economic activity within Sudan's AFS, the system is made up of a complex network of economic actors connected by their differing roles that include providing supportive services and inputs to producers and processors and in managing the supply, processing, marketing, and consumption of agrifood products.

Just as economies develop and transform, AFSs are expected to evolve in parallel (Diao et al. 2010; Timmer 1988). Subsistence farming typically dominates agriculture during the earliest stages of development, but as agricultural productivity rises, farmers start to supply surplus production to markets, thus creating job opportunities for workers in the off-farm economy (Haggblade et al. 2007), both within and outside of AFS. Rising rural incomes generates demand for more diverse products, leading to more agricultural production feeding into increased processing, packaging, transporting, trading, and other off-farm activities. In the early stages of transformation, the agricultural sector serves as an engine of rural, and even national, economic growth. Eventually, urbanization, the nonfarm economy, and nonagricultural incomes play more dominant roles in propelling AFS development, with urban and rural nonfarm consumers creating most of the demand for agricultural outputs via value chains connecting rural areas to towns and cities (Dorosh and Thurlow 2013). However, the exact nature of this transformation process varies across countries because of the diverse structure of their economies and the unique growth trajectories of their various agrifood and nonfood subsectors.

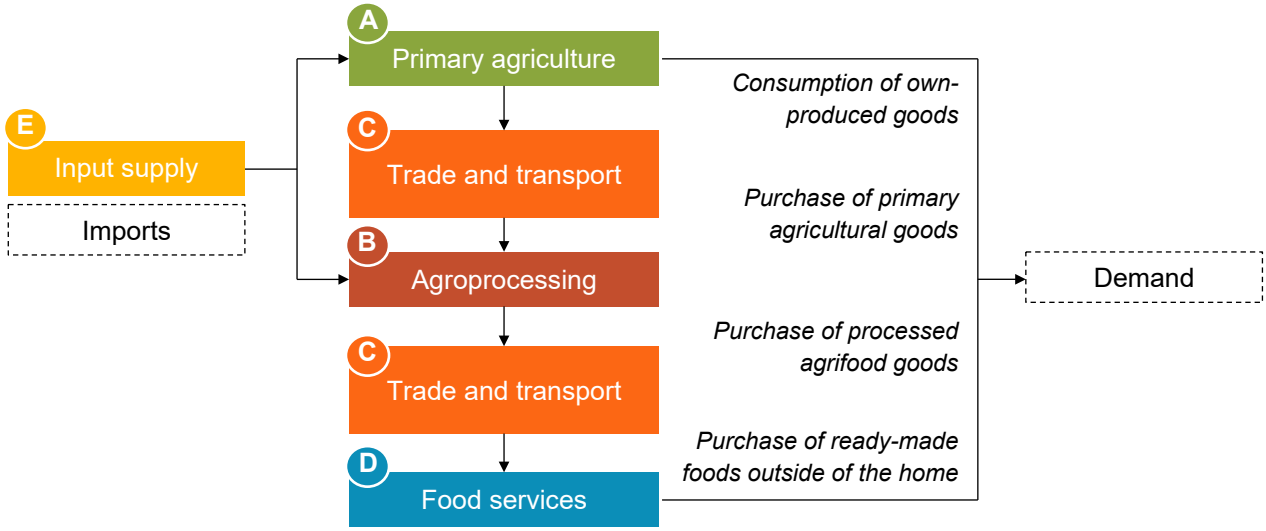
This study describes the current and changing structure of Sudan's AFS and evaluates the potential contribution of different value chains within it to accelerate agricultural transformation and to make it more inclusive. We focus on the period between 2011 and 2019, i.e., the period after the secession of South Sudan and before the global COVID-19 pandemic. In the next section, we describe a conceptual framework of the AFS and apply that framework to Sudan's AFS. In doing so, we disaggregate Sudan's AFS across agricultural value chains, taking into consideration their different market structures and historical contribution to economic growth and transformation. Section 3 examines changes in Sudan's AFS and to what extent it has contributed to broad economic transformation. Section 4 then uses a forward-looking economywide model for Sudan to identify future drivers of economic transformation and which value chains in Sudan's AFS could be more effective in driving inclusive economic transformation. Section 5 summarizes the main findings and concludes.

2 SUDAN'S AGRIFOOD SYSTEM

2.1 A conceptual framework of a country's agrifood system

A country's AFS is a complex network of actors, connected by their differing roles in supplying and using agrifood products and in the governance of those activities. A detailed conceptual description of AFS is offered by Fanzo et al. (2020). Rather than examining all components of Sudan's AFS, we have a narrower focus in this study—the conceptual framework we use allows us to measure the size, structure, and historical contribution of the AFS to economic growth and transformation through what is primarily a data-driven exercise. This conceptual framework measures the AFS from a supply-side perspective, i.e., we use national accounts and employment statistics to measure, track, or simulate growth and employment changes over time.

Figure 1. Conceptual framework of the agrifood system



Source: Thurlow et al. (forthcoming).

Figure 1 presents a conceptual framework of the AFS made up of five components (A to E) (Thurlow et al. forthcoming), as follows:

- *Primary agriculture* (A) is the production component of the AFS and includes the value-added generated by all agricultural subsectors—crops, livestock, forestry, and fishing.[1]
- *Agroprocessing* (B) is part of the broader manufacturing sector in national accounts and includes the value-added from processing foods and other agriculture-related products, such as tobacco, yarn, and timber.
- *Input supply* (E) is the value-added generated during the production of intermediate inputs used directly by farmers and agroprocessors, such as fertilizers or financial services. Inputs that are produced by farmers and processors themselves are excluded to avoid double-counting, since these are captured in components A and B. However, only a portion of the GDP generated by local input producers is included in the AFS. This portion is the share of input demand from agriculture and agroprocessing in the total economywide demand for that input.[2]
- *Trade and transport services* (C) includes all GDP generated by the transporting, wholesaling, and retailing of agrifood products between farms, firms, and final points of sale, either in domestic markets or for exported goods, to the country's border. National accounts data do not separate the trade sector's GDP into its food and nonfood components, but these can be estimated using product-level data on transaction cost margins. Transaction costs are the main source of demand for trade services, so a portion of trade sector GDP can be attributed to the AFS based on the total share of trade margins on agrifood products relative to the total margins on all marketed products.
- *Food services* (D) is the value-added generated by the food services sector, plus a portion of the value-added generated by the hotels and accommodation sector. Producers of food services run standalone operations (e.g., restaurants or stalls), whereas hotels often operate

[1] Note that GDP or value-added is equal to the value of gross output minus the cost of intermediate inputs, such as the cost of seed and fertilizer used by farmers.

[2] For example, if farmers and processors use a third of all petroleum in the economy, then a third of the petroleum sector's GDP is considered part of the agrifood system. However, if all petroleum is imported, then this input does not contribute to the agrifood system, because the value-added occurs outside the country.

restaurants in addition to providing accommodation. The portion of GDP in the hotels and accommodation sector that is assigned to the AFS is based on the share of agrifood inputs in the sector's overall intermediate inputs.

The total GDP generated by a country's AFS, AgGDP+, is the sum of value-added in the five components of the AFS and is estimated for Sudan using a Social Accounting Matrix (SAM) constructed using the latest national accounts data.[3]

The total employment in a country's AFS, AgEMP+, is estimated following a similar procedure but requires some additional data. For Sudan, GDP from 14 disaggregated sectors in the SAM is combined with labor productivity estimates, i.e., GDP per worker, to estimate the number of workers in each. The employment database triangulates information from a variety of sources, including the 2008 population census (CBS 2009), household income and expenditure surveys (CBS 2009; 2015), and the labor force survey (MHRDL 2011), as well as international databases containing sectoral employment time series (De Vries et al. 2021; ILO 2020). Our definition of employment includes all workers aged 15 years or older, with workers assigned to sectors based on their primary sector of employment.

2.2 Structure of Sudan's agrifood system

The structure of the Sudanese economy in 2019 is shown in Table 1, based on official national accounts data and sectoral employment statistics as described above. Primary agriculture generates about 20 percent of total GDP but employs close to 50 percent of the total labor force. Services are the largest sector in the economy, accounting for 58 percent of Sudan's total GDP. However, in terms of employment, the service sector ranks after agriculture with only 36 percent of the total labor force. Within services, trade, transport, and food services are the largest sub-sectors. Some of these services are accounted for as part of AFS.

Table 1. Sudan's agrifood system, 2019

Sectors	GDP		Employment		Average GDP per worker (USD)
	Value (USD billions)	Share of total (%)	Workers (millions)	Share of total (%)	
Total economy	**32.3**	**100.0**	**12.4**	**100.0**	**2,609**
Agrifood system	**11.1**	**34.4**	**7.2**	**57.8**	**1,554**
Primary agriculture (A)	6.5	20.2	6.2	49.9	1,057
Off-farm agrifood system	4.6	14.2	1.0	7.9	4,684
Agro-processing (B)	1.4	4.2	0.2	1.8	6,301
Trade and transport (C)	1.9	5.9	0.6	5.0	3,088
Hotels and food services (D)	1.0	3.2	0.1	0.9	9,780
Input supply (E)	0.3	0.9	0.04	0.3	6,844
Rest of the economy	**21.1**	**65.6**	**5.2**	**42.2**	**4,057**
Total manufacturing	3.2	9.9	0.8	6.5	4,000
Total services	18.7	58.0	4.5	36.4	4,156
Trade, transport & food services	8.4	26.4	2.6	21.0	3,231

Source: Author's analysis using IFPRI's 2019 Sudan SAM.
Notes: A to E correspond with the five agrifood system components from Figure 1.

The size and components of Sudan's AFS are measured by AFS GDP (AgGDP+) and AFS employment (AgEMP+). AgGDP+ was USD 11.1 billion in 2019—well above the USD 6.5 billion of

[3] A Social Accounting Matrix is an economywide database that captures resource flows associated with all economic transactions between all agents—households, producers, or government—in an economy during a calendar year, thus providing a snapshot of the structure of an economy at a point in time (Round 2003).

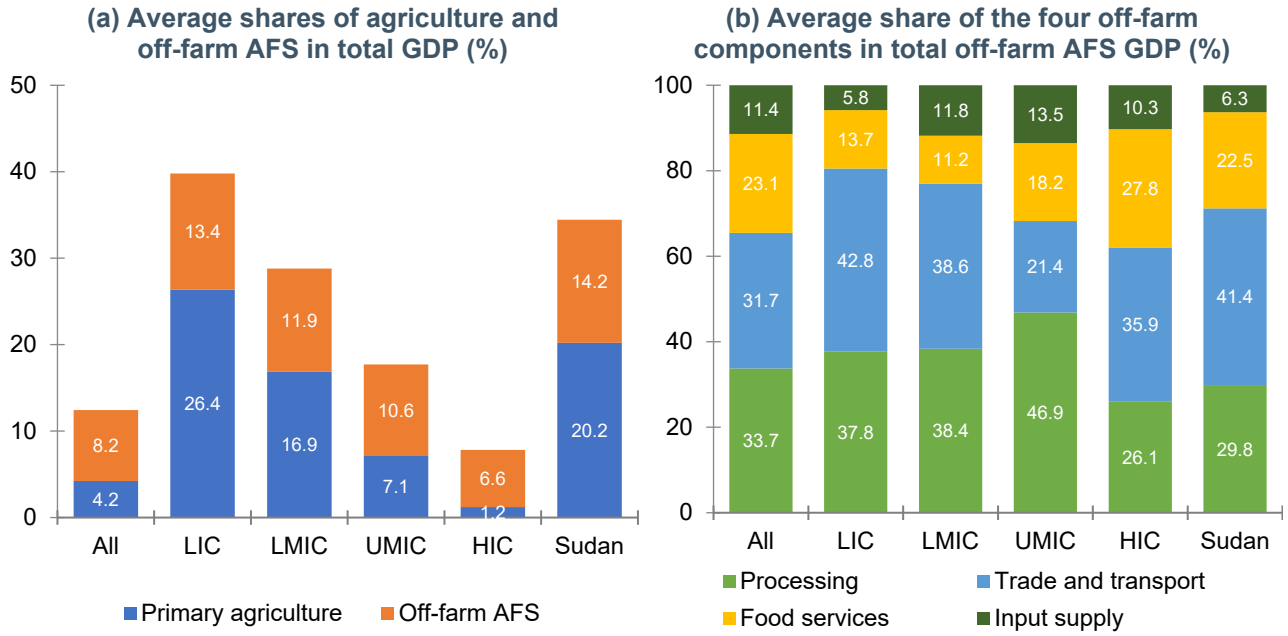
primary agricultural GDP (Table 1). Thus, within the AFS, for every dollar of GDP generated on the farm, an additional 70 cents of GDP is generated off the farm. A large portion of this off-farm GDP is from agroprocessing, where labor productivity measured in GDP per worker is much higher than for the whole AFS—USD 6,301 per worker versus USD 1,554 per worker, respectively (last column of Table 1). In general, labor productivity in the off-farm components of the AFS is much higher than in primary agriculture. Specifically, labor productivity in the off-farm AFS is USD 4,684 per worker, four times the labor productivity in primary agriculture (USD 1,057 per worker). Off-farm labor productivity within AFS is comparable to the average labor productivity for the rest of the economy outside of the AFS (USD 4,057 per worker).

2.3 Comparing Sudan's agrifood system to other countries

The importance and structure of the AFS varies at different stages of development. Following World Bank definitions, low-income countries (LIC) are those with per capita gross national income (GNI) below USD 1,025 in 2019, while lower-middle-income countries (LMIC) have a GNI per capita between USD 1,026 and USD 3,995. Sudan was in the LMIC group over most years of the 2010 decade, but was part of the LIC group in 2019 when its GNI per capita fell to USD 940.

Comparing Sudan to the country groups, Sudan's share of AFS in total GDP lies between those of the LICs as a group and those of the LMICs (Figure 2 (a)). Within the off-farm components of the AFS, Sudan's agroprocessing is smaller than expected, while its food services make up a larger share than is typical for LIC and LMIC countries (Figure 2 (b)).

Figure 2. Comparing Sudan's agrifood system to other countries, 2019



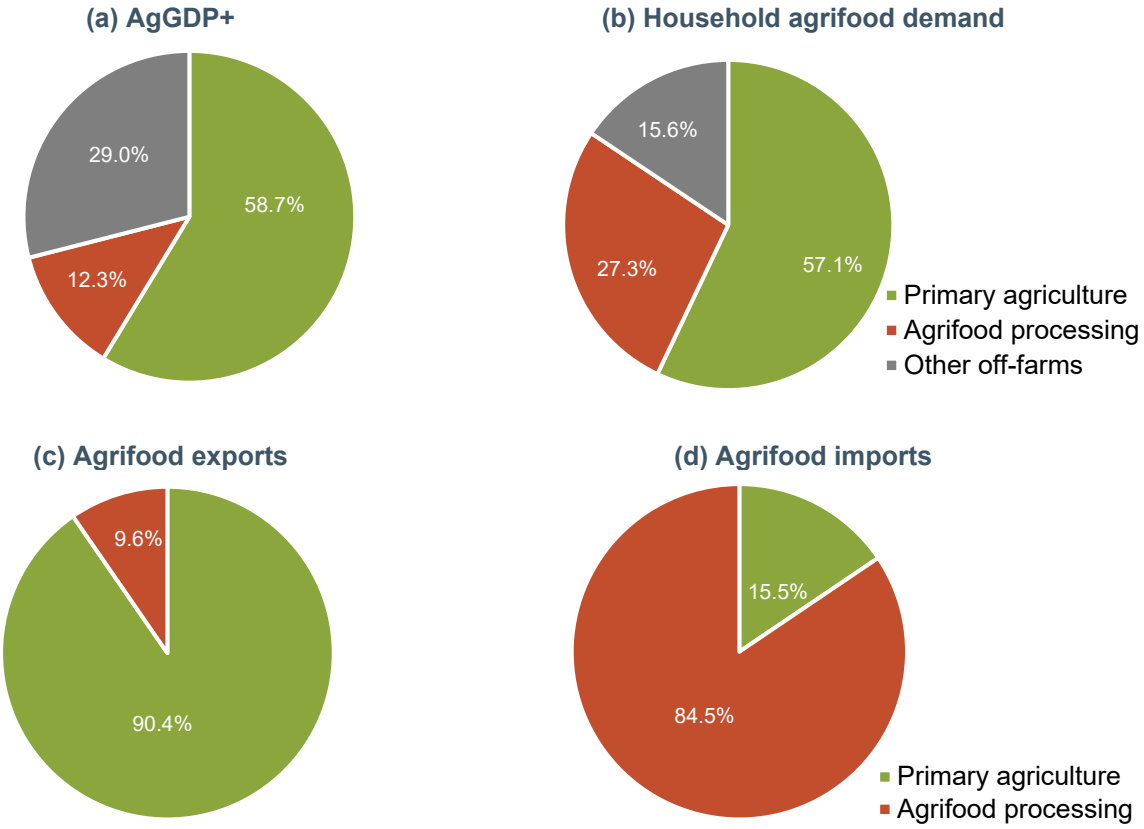
Source: IFPRI's Agrifood System Database (Thurlow et al. forthcoming) and IFPRI's 2019 Sudan SAM.
Notes: LIC = low-income countries; LMIC = lower-middle-income; UMIC = upper-middle-income (GNI per capita between USD 3,996 and USD 12,375; HIC = high-income (GNI per capita above USD 12,375 (World Bank Group, 2023).

2.4 Unpacking the demand side of Sudan's agrifood system

The five components of AgGDP+ measure the structure of the AFS on its supply side. On the demand side, we use household agrifood demand and agrifood trade to measure the structure of Sudan's AFS. Figure 3 compares the structure of Sudan's AFS from the supply side, as measured

by AgGDP+ (panel (a)), against the structure of the AFS from the demand side, as measured by household consumption of agrifood products (panel (b)). Primary agriculture makes up similar shares of Sudan's AFS under the two measures. In contrast, household demand for processed agrifood products accounts for 27 percent of total agrifood demand, while from the demand side processed agrifood products account for only 12 percent of AgGDP+. The bias toward processed agrifood products in demand is mirrored in the high share of agrifood imports accounted for by processed products. Specifically, while only 10 percent of agrifood commodity exports are processed agrifood products (panel (c)), 85 percent of agrifood imports are processed (panel (d)). This competition between domestic agrifood processors and processed imports is an important challenge to address in the transformation of Sudan's AFS.

Figure 3. Composition of Sudan's agrifood system GDP, household demand, and trade, 2019



Source: Authors' calculation using IFPRI's 2019 Sudan SAM

2.5 Disaggregating Sudan's agrifood system across value chains

For a more detailed assessment of the structure and historical growth patterns within Sudan's AFS, we subdivide it into value chain groups. IFPRI's 2019 Sudan SAM covers 19 primary agricultural sectors or commodities and 18 agroprocessing sectors or commodities. We grouped the 19 primary agricultural sectors into 12 value chain groups (see Annex Table 1) and mapped the 18 agroprocessing sectors into these 12 groups according to their relationship with each of the 19. Two agroprocessing sectors—processed food and beverages—have quite complex linkages to primary agriculture. Consequently, we place these two agroprocessing sectors in a separate "unattributable" group that is part of off-farm AFS. Nevertheless, more than 95 percent of Sudan's off-farm AFS by value-added can be attributed to 12 distinct product groups. The value chains comprise both primary production and off-farm processing, trade, and transport activities, but are

named according to their primary agricultural products. Table 2 presents for these 12 value chains their share of total AgGDP+, as well as their share of total primary agriculture GDP and total aggregate off-farm GDP.

Table 2. Decomposing Sudan's agrifood system across value chains, 2019

Value chains	Share of GDP (percent)			Exports/ output	Imports/ consumption
	Agrifood system	Primary agriculture	Off-farm AFS		
Total	**100.0**	**100.0**	**100.0**	**1.8**	**6.3**
Exportable	**8.9**	**10.2**	**7.1**	**13.8**	**6.8**
Oilseeds	8.7	9.9	7.1	12.2	6.8
Cotton	0.2	0.3	0.1	64.3	0.0
Importable	**10.4**	**7.7**	**14.2**	**1.6**	**32.4**
Other cereals	2.4	0.9	4.5	2.6	24.2
Other crops	5.7	4.4	7.5	0.0	42.5
Forestry	2.3	2.3	2.2	3.7	11.3
Less traded	**78.0**	**82.2**	**72.2**	**0.5**	**1.3**
Sorghum	13.8	13.7	14.0	0.0	0.0
Pulses	4.1	5.4	2.4	1.0	5.7
Roots	0.9	1.3	0.3	0.0	0.0
Vegetables	6.5	9.2	2.6	0.4	0.8
Fruits	7.4	6.5	8.6	0.1	2.4
Livestock	44.1	44.9	42.9	0.7	1.1
Fish	1.3	1.2	1.4	0.5	1.3
Unattributable	**2.7**	**0.0**	**6.5**	**0.0**	**14.5**

Source: Author's analysis using IFPRI's 2019 Sudan SAM.
Note: Sorghum also includes millet. Other cereals are dominated by rice and wheat, but include maize, barley, and other cereals. Other crops include sugarcane, tobacco, tea, coffee, and other crops. Fish includes aquaculture and capture fisheries. Livestock includes cattle, raw milk, poultry, eggs, small ruminants, and other livestock.

The trade status of the 12 value chains is used to further categorize them into three types—exportable, importable, and less traded value chains. The last two columns of Table 2 present the ratio of exports to output and the ratio of imports to total consumption of primary and processed agriculture commodities combined, excluding other off-farm components in the calculation. We use these ratios to assign a trade status to individual value chains. A value chain is identified as exportable if it has an above-average portion of agricultural and processed products produced for foreign markets, while an importable value chain has an above-average portion of primary agricultural and processed products imported for meeting domestic demand. The other value chains that are shown to be less dependent on international trade belong to the less traded group.

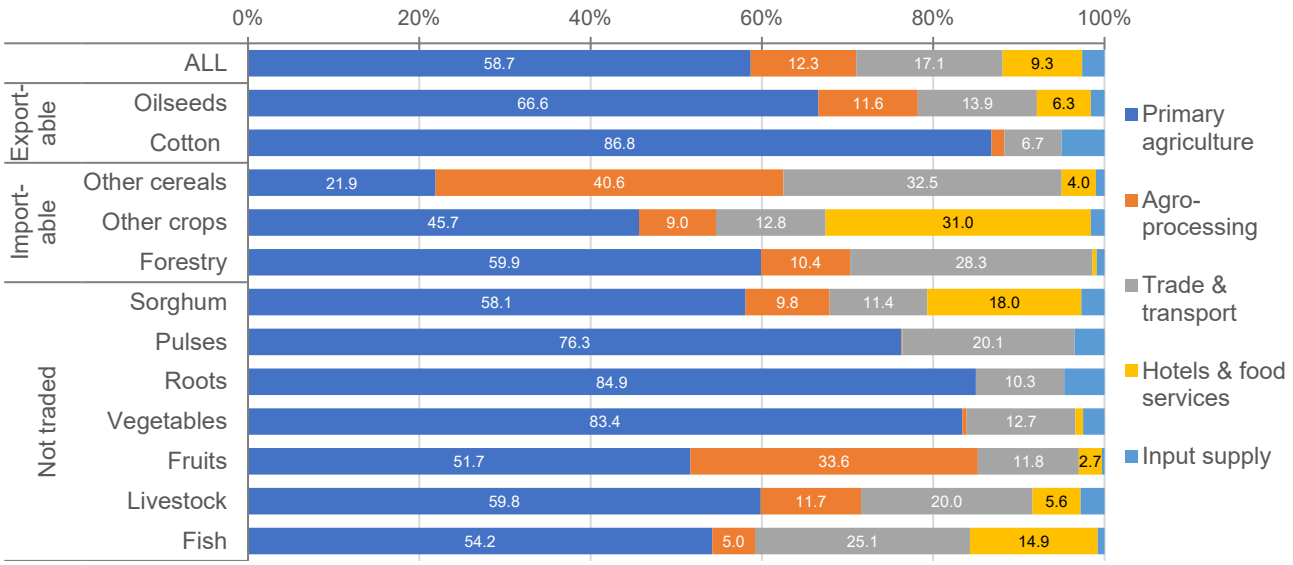
Sudan's AFS is dominated by domestic market-oriented value chains—the less traded value chains. The two exportable value chains account for only 8.9 percent of total AgGDP+, 10.2 percent of primary agriculture GDP, and 7.1 percent of off-farm AFS GDP. The three importable value chains account for only 10.4 percent of total AgGDP+. However, two of the three importable value chains—other cereals and other crops—have disproportionate shares of off-farm AFS GDP. For example, while other cereals account for only 0.9 percent of total primary agriculture GDP, they account for 4.5 percent of total AFS GDP off-farm—this principally reflects off-farm value-addition resulting from domestic milling of the predominantly imported grain.

The domestic market dominates Sudan's AFS. The seven less traded value chains account for 78 percent of total AgGDP+. Less traded value chains have a relatively smaller share (72 percent) of total off-farm AFS GDP and a relatively larger share (82 percent) of total on-farm AFS GDP. However, the sorghum and fruits value chains are exceptions to this pattern. Livestock, a less-traded value chain, is Sudan's largest value chain, accounting for 44 percent of total AgGDP+.

Sorghum and fruits, as well as vegetables, also are sizable less-traded value chains. The sorghum and fruit value chains have relatively large shares of total off-farm AFS GDP. Because of their large size, promoting growth in the livestock, sorghum, and fruit value chains is expected to contribute both to improved national food security and to effectively driving agricultural transformation by boosting value addition and employment in AFS off-farm.

Figure 4 disaggregates each value chain group across the five components of the AFS. At least one-third of the value-added in the other cereals and fruits value chains is generated from processed agriculture. Trade and transport margins make up at least 20 percent of GDP in other cereals, forestry, pulses, livestock, and fish value chains. Hotel and food services generate more than 30 percent of value-added in the other crops value chain and 18 percent for the sorghum value chain, suggesting that both sets of commodities are highly tradable in Sudan's domestic markets. In contrast, more than three-quarters of value-addition for the cotton, pulses, root crops, and vegetables value chains is generated on farm. Thus, despite the growing importance of purchased and processed foods in Sudan, many value chains still generate most of their value-addition on farm. Overall, 59 percent of total AgGDP+ in Sudan is generated on-farm.

Figure 4. Decomposing Sudan's agrifood GDP within value chains, 2019



Source: Author's analysis using IFPRI's 2019 Sudan SAM.

In summary, Sudan's AFS is predominantly domestic market oriented. Primary agriculture makes up the largest part of total AgGDP+, even though several off-farm components are important. For every dollar generated on farm, an additional 70 cents is generated off-farm in Sudan's AFS. The structural relationship between the on-farm and off-farm components of the AFS described in this section helps us understand how the AFS links to the rest of the Sudanese economy and how it might potentially contribute to economic growth and broad structural change in the economy. Measured by GDP per worker, the off-farm segments of Sudan's AFS are more productive than on-farm, which means that with growth in those off-farm components, more income could be generated within the rural economy than through agriculture alone. On the other hand, because the off-farm components are more productive than farming, absorbing workers exiting from farming will require more rapid growth in off-farm economic activities both within and outside the AFS. Finally, decomposing AgGDP+ across the 12 value chains helps us anticipate how different value chains and their growth might differentially affect the transformation of Sudan's AFS. We turn to this question by first examining past growth trends in section 3 and then assessing drivers of future growth in section 4.

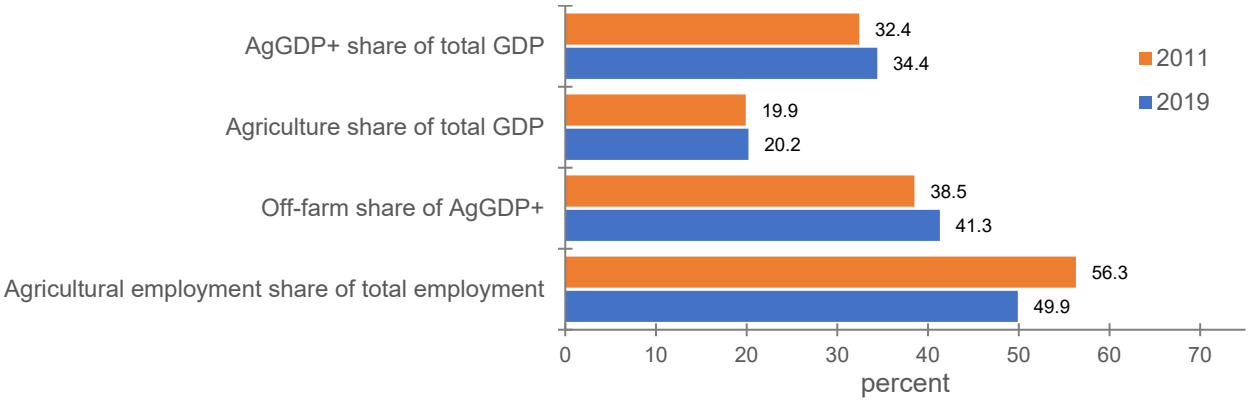
3 AGRIFOOD SECTOR PERFORMANCE BETWEEN 2011 AND 2019

Our analysis focuses on the period from 2011 to 2019—from after the secession of South Sudan to just before the start of the global COVID-19 pandemic. The analysis relies on IFPRI's 2011 and 2019 Sudan SAMs. These were constructed using official national accounts data to estimate GDP and using various national and international sources to estimate employment. Although SAMs are measured in current prices, these are converted to constant prices in the analysis here to facilitate a comparison of the structure of Sudan's economy between the two years.

In our assessment of the performance of Sudan's AFS, we focus on structural change. Agriculture generally has the lowest labor productivity in an economy—productivity is higher off-farm both within and outside the AFS. Economic growth and continuing urbanization in Sudan are expected to lead to growth in nonagricultural sectors, including in the off-farm components of the AFS. This will create jobs with higher wages for rural households, thereby increasing the incomes of rural households. If some of their members can obtain off-farm employment, even smallholder farming households may realize higher incomes.

Figure 5 compares the shares of AgGDP+ and agricultural GDP as shares of total GDP and agricultural employment as a share of total employment in 2011 and 2019. The figure also compares the share of off-farm components in AgGDP+ in these two years. The largest change is seen in agricultural employment as a share of total employment with a drop of over 6 percentage points, suggesting a modest improvement in agricultural productivity. There was a slight increase in the share of total GDP made up by AgGDP+. However, very little change is seen overall in the role that agriculture and the AFS more broadly played in the Sudanese economy between 2011 and 2019.

Figure 5. Agrifood system in Sudan—GDP and employment, 2011 and 2019



Source: Author's analysis using IFPRI's 2011 and 2019 Sudan SAMs.

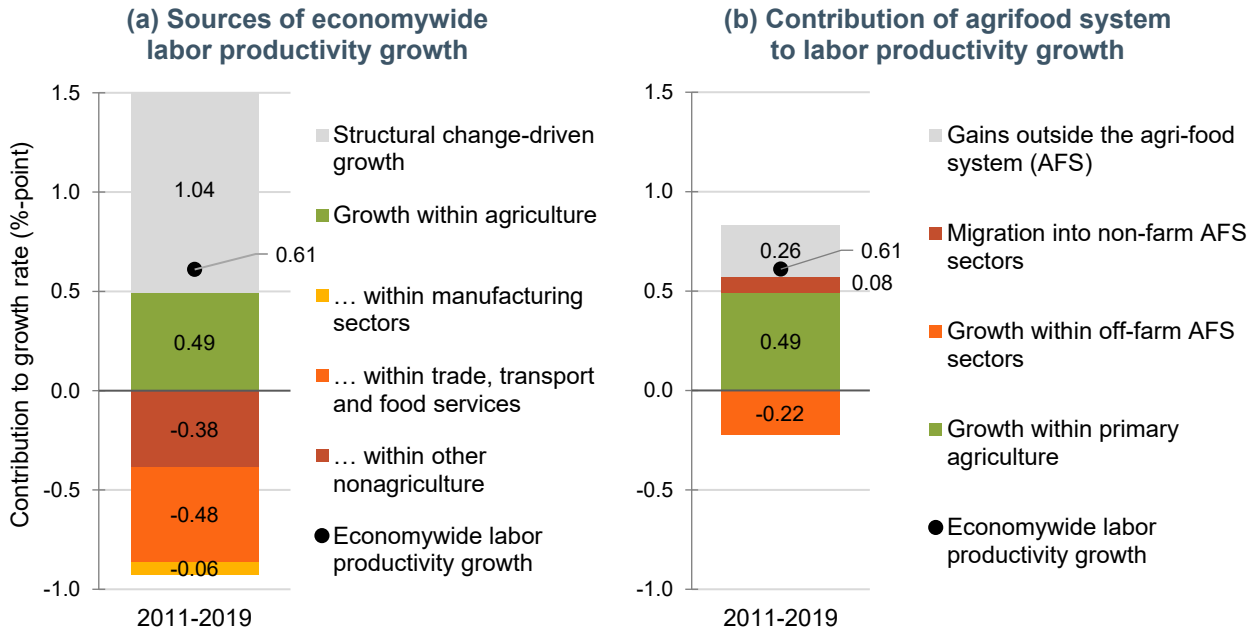
This stagnation in Sudan's AFS is consistent with the poor performance of the overall economy over this period. Sudan's overall economy grew at 3 percent per year between 2011 and 2019. Growth in the primary agriculture sector over this period was almost identical to overall economic growth. This level of growth can principally be attributed to the increasing population of Sudan directly increasing economic demand. Economywide labor productivity barely changed over this period (Figure 6).

Broad economic structural change is an indication of economic development. Productivity growth is the fundamental driver of economic development. Productivity growth comes from either of two

channels. First, productivity can increase among workers within their sectors of employment. Alternatively, economywide productivity increases when workers migrate from less to more productive sectors. These two channels are usually referred to as the "within sector" and "between sector" (or "structural change") drivers of labor productivity growth. As mentioned earlier, GDP per worker in agriculture in Sudan is much lower than in other parts of the AFS and in the rest of the economy. As such, a shift in employment away from agriculture and into other sectors—both within and outside of the AFS—should generally increase labor productivity economywide. The individual contributions of these structural drivers of growth can be estimated using a decomposition approach described in McMillan et al. (2014).

Figure 6, panel (a) presents the findings from such a growth decomposition analysis for the Sudanese economy over the period 2011 to 2019. Economywide labor productivity grew at an average annual rate of 0.61 percent over this period. Within-sector productivity growth was negative for all nonagricultural sectors—it was positive only for agriculture. This makes labor productivity growth within agriculture the second largest contributor to economywide labor productivity growth, at 0.49 percent—structural change-led growth registered 1.04 percent per year over this period.

Figure 6. Decomposition of average annual labor productivity growth rate in Sudan, 2011-2019



Source: Author's analysis using IFPRI's 2011 and 2019 Sudan SAMs and employment database.

Figure 6, panel (b) estimates the contribution of the AFS to total labor productivity growth in the Sudanese economy. This includes the contribution from primary agriculture and the rest of AFS. The within-sector contribution from primary agriculture is the same in both panels, at 0.49 percent per year. The migration of workers into the off-farm components of the AFS accounts for a small share of the structural change-led growth that took place in Sudan between 2011 and 2019, i.e., 0.08 percent out of a total 1.04 percent. However, like the nonagricultural sectors in the broad economy, labor productivity growth within off-farm AFS components was negative at -0.22 percent. This causes the total contribution of AFS to the economywide labor productivity growth to be smaller than the contribution of primary agriculture, at 0.35 percent.

We further evaluate growth performance across the 12 agrifood value chains (Table 3). As previously, value chains are grouped according to their trade status, i.e., exportable, importable, and less traded. At the aggregate, Sudan's AFS observed modest growth between 2011 and 2019 with an annual growth rate of 4.0 percent for AgGDP+ and 3.4 percent for primary agriculture GDP. Agroprocessing grew more rapidly at 7.9 percent per year.

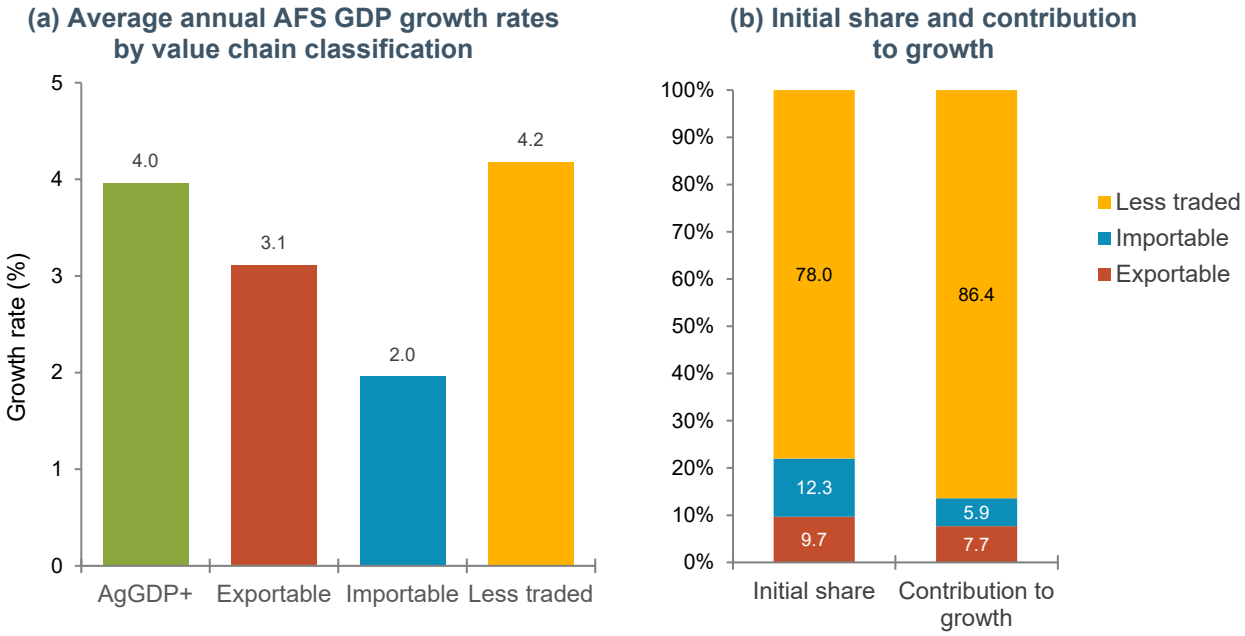
Table 3. Agrifood system value chain growth in Sudan, 2011 to 2019

Value chains	Average annual GDP growth rate (percent)			
	Agrifood system	Primary agriculture	Off-farm AFS	Processing
Total	**4.0**	**3.4**	**4.9**	**7.9**
Exportable	**3.1**	**2.3**	**4.9**	**8.4**
Oilseeds	3.0	2.2	5.0	8.5
Cotton*	6.8	7.6	2.6	-7.0
Importable	**2.0**	**-1.7**	**5.8**	**10.0**
Other cereals*	6.7	6.5	6.7	9.2
Other crops	1.0	-4.5	9.2	11.7
Forestry	0.6	3.1	-2.3	9.8
Less tradable	**4.2**	**4.1**	**4.3**	**7.4**
Sorghum	0.6	-2.3	6.2	8.0
Pulses	-0.8	-0.1	-4.1	
Roots	2.4	3.0	0.6	9.7
Vegetables	-0.3	0.4	-3.4	10.1
Fruits	0.6	-2.4	4.9	8.5
Livestock*	7.8	10.6	4.6	6.8
Fish*	6.5	7.4	5.6	8.4

Source: Author's analysis using IFPRI's 2011 and 2019 Sudan SAMs.
Note: The value chains marked with * have an agrifood GDP growth rate above the 4.0 percent average for total AgGDP+.

Four value chains achieved an annual growth rate above the average (4 percent) between 2011 and 2019. These are marked with an asterisk in Table 3. Two of these faster-growing value chains are exportable (cotton) or importable (other cereals). However, for these four value chains, off-farm growth was slower than on-farm growth—growth in these value chains primarily was led primarily by growth in on-farm agricultural production.

Figure 7. AgGDP+ growth rates, shares, and contribution to growth, by value chain grouping, 2011-2019



Source: Author's analysis using IFPRI's 2011 and 2019 Sudan SAMs.

Figure 7 summarizes some of the findings of Table 3. The domestic market has been the driving force for agrifood growth in Sudan in recent years. Less traded value chains dominated the AFS with their large size and above-average growth (4.2 percent), contributing 86 percent of agrifood growth between 2011 and 2019. Growth in the tradable value chains was slow, and with their small sizes in AFS, the contribution of both the exportable and the importable value chains to total agrifood growth was modest and below-average, with growth at 3 and 2 percent, respectively.

4 DRIVERS OF INCLUSIVE AGRICULTURAL TRANSFORMATION IN SUDAN

In this section, we use IFPRI's Rural Investment and Policy Analysis (RIAPA) model to compare the potential contributions of growth from different agricultural value chains to inclusive agricultural transformation. The four development outcomes associated with inclusive agricultural transformation used here are reductions in poverty, improvement in diet quality, job creation economywide, and growth in national GDP.

4.1 The Rural Investment and Policy Analysis (RIAPA) model

RIAPA is used to assess and to prioritize AFS value chain investments at the country level. It is constructed from a set of interlinked datasets and sub-models. At its core is an economywide computable general equilibrium (CGE) model that simulates the functioning of a market economy, including markets for products and factors, i.e., land, labor, and capital. A detailed description of the CGE model and its behavioral assumptions is provided by Diao and Thurlow (2012).

The SAM for Sudan contains ten representative household groups that separate households by consumption quintiles and rural or urban location. RIAPA simulates changes in the incomes and expenditures for these household groups, including changes in food and nonfood consumption

patterns. From these results, poverty and dietary impacts are estimated using survey-based microsimulation models.

We use RIAPA to simulate the economywide effects of raising productivity in ten agrifood value chains or value chain groupings for Sudan. Ten of the 12 value chain groups discussed in the previous section are considered in the simulation analysis—fishery and forestry, two relatively small value chains, are excluded. In each simulation scenario, farm-level total factor productivity growth in a targeted value chain group is accelerated beyond its baseline growth rate to achieve total agriculture GDP which is one percentage point higher by 2025 than in the baseline scenario. As the ten value chains differ in size, to achieve the same absolute increase in total agriculture GDP in each scenario, productivity in smaller value chains, such as for cotton and for other cereals, must grow faster than in larger ones, such as livestock and sorghum. Agricultural value chains also differ in terms of their structure and downstream linkages. Therefore, while the targeted increase in agriculture GDP is one percentage point in all value chain scenarios, induced growth in upstream input supply activities, in downstream processing activities, and in demand for trade and transport services along agrifood value chains may differ across scenarios. The value chain scenarios may therefore have different development implications both for the AFS and the entire Sudanese economy.

Four outcome indicators are used to assess the impacts of agricultural productivity growth originating from various targeted value chains. They measure changes in poverty, diet quality, economic growth, and employment, and together serve as an indication of a value chain's contribution to inclusive agricultural transformation.

- The poverty-growth elasticity (semi-PGE) measures the percentage-point change in the poverty headcount rate associated with a one percentage point growth in agriculture GDP led by productivity growth in a targeted value chain. The poverty headcount rate used is the share of the population with consumption below the international USD 1.90 poverty line. For comparison purposes, a semi-PGE is also estimated for the poverty gap, which measures the average gap between poor people's consumption levels and the poverty line.
- Diet quality changes are measured by changes in the Reference Diet Deprivation (ReDD) index (Pauw et al. 2023). ReDD estimates the incidence, breadth, and depth of food consumption gaps across six food groups by comparing observed consumption against consumption levels recommended by the EAT-Lancet healthy reference diet (Willett et al. 2019). Increases in ReDD indicate a narrowing of the multidimensional food consumption gap, signifying an improvement in diet quality. Our measure is diet quality growth elasticity (DGE), which measures the percentage change in the ReDD index with agricultural growth of one percentage point in a targeted value chain.
- GDP and employment impacts are measured by the changes in GDP (in USD million) or employment (in 1,000 persons) in the total economy associated with a USD 1.0 million increase in agriculture GDP in a targeted value chain.

4.2 Development outcomes associated with increased agrifood value chain productivity in Sudan

Table 4 reports changes in poverty, diet quality, economic growth, and employment for each of the ten value chain growth scenarios. The results show that increasing sorghum productivity reduces the national poverty headcount rate by 0.44 percentage points for every one percentage point of agriculture GDP growth led by increases in sorghum productivity. Among the value chains

considered, productivity growth in sorghum is the most pro-poor, followed by other cereals (dominated by rice and wheat) and root crops. Productivity growth in livestock has a much smaller impact on poverty reduction. However, all values are negative in the first column of Table 4, indicating that all value chains, including livestock, are pro-poor—productivity growth in any of these will lead to some poverty reduction.

Whereas the poverty headcount rate measures the share of people with consumption levels below the poverty line, the poverty gap measures how far the consumption of poor people is, on average, below that poverty line. As with the poverty rate, the poverty gap falls in all value chain scenarios. In general, the effectiveness of productivity growth in reducing the poverty rate versus the poverty gap is similar for all value chains. While there are a few exceptions, the rankings over the value chains across the two poverty measures only change modestly. This suggests that the distributional impact of growth in a value chain is relatively consistent with its pro-poor effect—that is, a value chain in Sudan that benefits very poor households and helps reduce the depth of poverty also often raises incomes enough to help poor people rise above the poverty line.

Table 4. Estimated poverty, diet quality, economic growth, and employment elasticities for agrifood system value chains in Sudan

Targeted value chains	Change in indicator given a one percentage point change in agriculture GDP driven by productivity gains in targeted value chain (value chain rank in parentheses)				
	Poverty headcount rate semi-PGE (%-point)	Poverty gap semi-PGE (%-point)	Diet quality (DGE)	Total GDP (USD million)	Total employment (1,000 persons)
Sorghum	-0.44 (1)	-0.10 (1)	0.04 (10)	1.09 (6)	-0.02 (5)
Other cereals	-0.36 (2)	-0.08 (2)	0.09 (5)	1.65 (2)	-0.19 (9)
Pulses	-0.07 (8)	-0.01 (8)	0.07 (8)	1.14 (5)	-0.06 (6)
Oilseeds	-0.10 (6)	-0.03 (6)	0.15 (4)	1.27 (4)	-0.07 (7)
Root crops	-0.29 (3)	-0.06 (3)	0.05 (9)	2.10 (1)	-0.30 (10)
Vegetables	-0.07 (7)	-0.01 (9)	0.19 (2)	1.34 (3)	-0.08 (8)
Fruits	-0.26 (4)	-0.06 (4)	1.32 (1)	0.90 (9)	0.00 (4)
Cotton	-0.15 (5)	-0.04 (5)	0.08 (7)	0.23 (10)	0.40 (1)
Other crops	-0.04 (10)	-0.00 (10)	0.08 (6)	1.01 (8)	0.01 (3)
Livestock	-0.07 (9)	-0.01 (7)	0.16 (3)	1.03 (7)	0.12 (2)

Source: Results from IFPRI's Sudan RIAPA model.
Notes: Other cereals include maize, rice, wheat, barley, and other cereals. Other crops include sugarcane, tobacco, leaf tea, coffee, and other crops.
Changes in all outcome indicators are expressed in per unit of agriculture GDP growth driven by agricultural productivity growth in a targeted value chain.
The two poverty growth elasticities (semi-PGE) measure percentage-point changes in the poverty headcount rate and poverty gap with a one percentage point growth in agriculture GDP. Poverty is measured at the international USD 1.90 poverty line.
The diet quality growth elasticity (DGE) measures the percentage change in the Reference Diet Deprivation (ReDD) index with one percentage point growth in agriculture GDP.
Changes in GDP (million USD US) and employment (1,000 persons) are measured based on the impact of a USD 1.0 million increase in value-added for the targeted value chain.

With respect to diet quality, the largest improvement in diet quality is seen in growth led by the fruits value chain, followed by vegetables, livestock, and oilseeds. Diet quality improves by 1.32 percent with a one percentage point increase in agriculture GDP in the fruits value chain scenario (third column, Table 4). Despite being the most effective value chain in reducing poverty headcount and depth, sorghum is the worst-performing value chain for diet quality improvement. Sorghum is already a dominant food item among poor households in Sudan. Consequently, expanding its production will further lower the price of sorghum. This will result in a shift of consumption away from other food groups that are important in the healthy reference diet towards sorghum.

The final two indicators measure the impacts of productivity growth in different value chains on GDP and employment. It is worth reiterating that although agricultural productivity growth originates in specific value chains, not all gains in GDP or increases in employment occur within the targeted value chains. Raising root crop productivity, for example, allows farmers to diversify into other crops and activities, including working off the farm. Increasing household incomes also allows them to purchase products from other sectors or value chains, thus generating spillover effects within the broader economy. These effects are captured by the model and influence the value chain rankings.

A closer examination of the results reveals that other cereals, which is the value chain with the largest off-farm components, has a large growth multiplier effect and ranks second in terms of growth impact on total GDP. The growth multiplier value of 1.65 in the fourth column of Table 4 for other cereals means that a USD 1.0 million increase in value-added of other cereals results in a USD 1.65 million increase in total GDP. Excluding the USD 1.0 million from other cereals' on-farm value-added itself, the USD 0.65 million GDP is additional gains coming from linkage effects within the other cereal value chain (e.g., rice and wheat milling, transporting, and trading) or spillover effects to other value chains.

In contrast, cotton, which is an export-oriented value chain, does not generate additional gain in the total economy. Growth in the cotton value chain has a limited impact on its price since it is mainly determined by the international market. Consequently, higher productivity in cotton production results in the cotton value chain attracting labor and land away from other value chains, causing a decline in production in some. In total, the losses in value-added from other sectors that are hurt by growth in the cotton value chain are more than the value-added gain in the cotton sector. The value 0.23 in column four of Table 4 for cotton means that increases in total GDP are only USD 0.23 million, much less than the gain in the cotton value chain itself, which is USD 1.0 million, i.e., total losses in the GDP for other value chains are about USD 0.77 million.

Both GDP and employment outcomes are measured for the total economy. However, a value chain that is effective at generating additional total GDP will not necessarily create more jobs in the total economy. In fact, additional jobs are created economywide only for growth led by the cotton, livestock, fruits, and other crops value chains in Sudan, while total employment declines in the other six value chain growth scenarios, as indicated by the negative signs in the last column of Table 4 for these value chains. Although cotton growth hurts growth in many other value chains, its growth requires hiring more workers than what it attracts away from other value chains. Thus, cotton growth has a net positive impact on employment—a USD 1.0 million increase in value-addition in the cotton value chain creates 400 new jobs in the economy. The main reason for this is that productivity growth in cotton does not cause cotton prices to fall, as cotton is grown mainly for exports with prices determined by the international market. In contrast, most of the other value chains are domestic market oriented. Productivity growth in these value chains generally results in lower commodity prices, especially for agricultural products with inelastic household income demand, such as root crops and sorghum. Growth in such value chains will benefit households as consumers, but it may lower wage rates within the value chains and, hence, reduces opportunities for creating jobs.

4.3 Prioritizing value chains

These results show significant trade-offs across the different development outcomes in the growth impacts of these value chains. Thus, policy choices concerning which AFS value chains to prioritize for increased investment may be sensitive to the relative importance that policymakers attach to different development outcomes.

Figure 8 compares the relative effectiveness of growth in each value chain in achieving each of the four development outcomes. For the poverty dimension, we use the poverty headcount rate as the outcome indicator rather than the poverty gap. Since the outcome indicators have different underlying units, it is necessary to normalize individual outcome scores so that they are directly comparable. The values of each indicator are therefore scaled so that the most effective value chain for an indicator is given a score of one and the least effective is given a score of zero. Normalization does not alter the relative effectiveness of value chains within each outcome category but converts the indicators to the same scale to facilitate their comparison. For example, sorghum and other crops were, respectively, the most and least effective value chains in reducing national poverty (Table 4), and they remain so after their poverty elasticities are normalized. Additionally, for a value chain that has an adverse effect on an outcome, the normalized score is assigned to zero for this outcome. For example, cotton-led growth causes a change in total GDP less than the USD 1.0 million increase in its own value-added (i.e., value less than 1.0 in the fourth column of Table 4), and root crops, sorghum, and four other value chains cause total employment to fall (i.e., negative values in the fifth column of Table 4). In these cases, the normalized score for GDP assigned to cotton is zero, as are the employment scores for root crops, sorghum, and the other four value chains.

Figure 8. Normalized value chain scores for different inclusive development outcomes

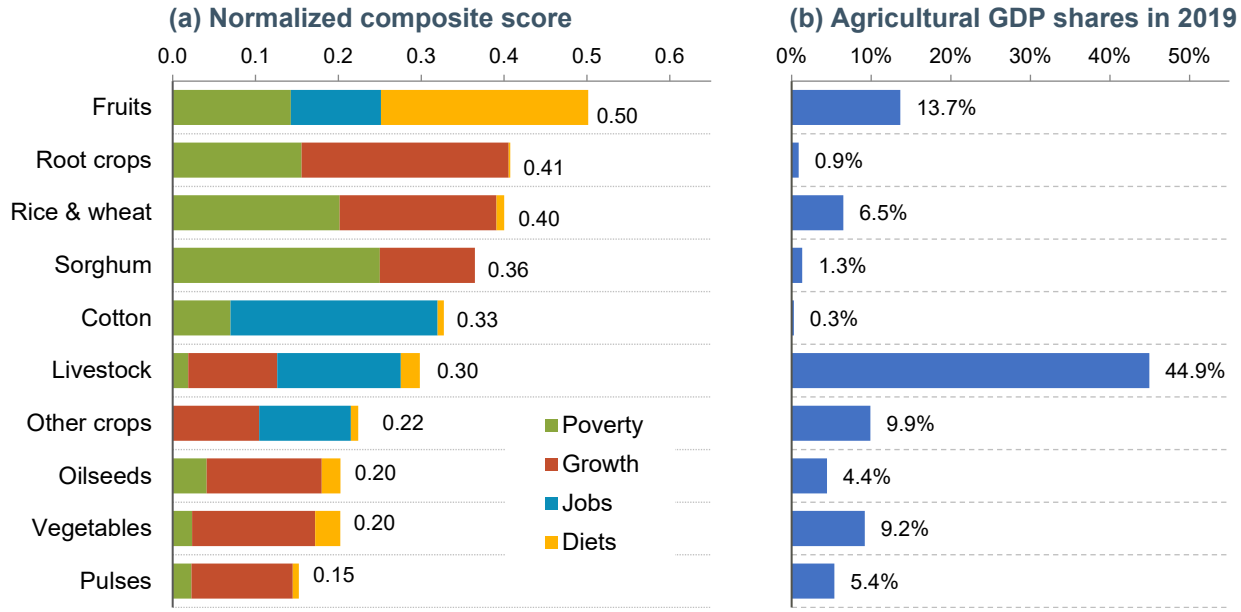
Source: Results from IFPRI's Sudan RIAPA model.
Notes: Scores for each outcome category are normalized so that the value chain whose growth is most effective at improving that outcome has a score of one, while the least effective value chain has a score of zero. For a value chain that has an adverse effect on an outcome, the normalized score is assigned to zero. The value chains are ordered here by the poverty outcome indicator.

The value chains in Figure 8 are ordered based on the poverty outcome. While sorghum is the most effective value chain at achieving poverty outcomes, it is the least effective with respect to diet quality improvement and it also lacks capacity for creating jobs. The root crops value chain is the third most effective at achieving poverty reduction and is most effective for GDP growth, but it does not provide a positive impact on employment. Similarly, cotton is most effective at creating jobs, while it is least effective in GDP growth and the third least effective at improving diet quality. This variation between value chains across outcomes further reflects the trade-offs in most value chains on their impacts on different inclusive development outcomes.

To identify those value chains for which growth in them is most effective across multiple development outcomes, a composite score across different outcome indicators is created. In the

composite score, which value chains have the highest score depends on the importance (or weights) attached to each of the four outcome areas. Figure 9 shows composite scores estimated by assuming that each of the four outcomes is equally important. In other words, the composite score in the left-hand-side panel of Figure 9 is a simple average of the four normalized scores in Figure 8. The value chains are reranked based on the composite score, and different color sections of each bar in the figure indicate the contribution of each outcome to the value chain's final score. The fruits value chain emerges as the top-ranked value chain as it has the highest score for diet quality, the fourth-best score for poverty reduction, and the fourth-best score for job creation outcomes. The second-ranked value chain is root crops, mainly driven by its strong contribution to GDP growth, for which it was the most effective value chain, and poverty reduction, for which it ranked third. The pulses value chain is at the bottom of the composite score ranking despite never scoring at the bottom of any of the individual development outcomes. This is because growth in pulses makes no strong contribution to any individual outcome—its best contribution is to GDP growth, for which it ranks fifth.

Figure 9. Composite score ranking based on equally weighted inclusive development outcomes



Source: Results from IFPRI's Sudan RIAPA model.
Notes: The composite score is a simple average of the normalized scores for the four focus outcome indicators in Figure 8.

The analysis of Figure 9 suggests that if these development outcomes are considered equally important, then fruits, root crops, rice, wheat, and sorghum should be prioritized to achieve maximum impact for inclusive agricultural transformation. However, among the top-ranking value chains, there is no single value chain for which each of the four outcome indicators makes an important contribution to its combined score. The fruit value chain has a large impact on diet quality, poverty, and growth, but it does not contribute to job creation. For the other three top-ranked value chains, their composite scores are determined by their large impacts on poverty and growth, but have no or small impacts on diet quality and job creation. On the other hand, while livestock ranks sixth by composite score, it is one of few value chains with visible growth impacts on all four development outcome indicators. This indicates that, while the composite scores allow us to rank value chains considering multiple outcomes, trade-offs still exist as to which outcomes are most significantly affected by productivity-led growth in each value chain.

5 CONCLUSION

This study examines the degree to which Sudan's AFS transformed between 2011 and 2019 against a background of stagnant performance in Sudan's economy. Sudan's AgGDP+ realized modest growth over this period, but there was little change in the structure of the system. Agriculture's share of total employment fell more significantly, contributing to some structural change in the broad economy. However, agricultural production continues to employ almost half of Sudan's workers, but at the lowest labor productivity levels of all Sudan's workers. Agricultural production remains the largest component of the AFS.

Sudan's agrifood growth between 2011 and 2019 was driven by domestic market oriented value chains. Less traded value chains dominate agrifood growth with their large size and above-average growth. Both exportable and importable value chains are small, and with below-average growth, their contribution to agrifood growth was modest.

Comparing sources of future growth using IFPRI's RIAPA model shows that there is no single AFS value chain that will be the most effective in achieving all desired inclusive development outcomes—reduced poverty, improved diet quality, GDP growth, and more jobs. The fruits, root crops, and cereals rank highly in their composite outcome scores, while livestock is one of the few value chains with impacts across all four development outcomes examined. These value chains supply mainly the domestic market, and some experienced above-average growth between 2011 and 2019. Promoting multiple AFS value chains will be necessary to effectively achieve broad-based development outcomes.

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ACKNOWLEDGMENTS

This paper was prepared with the gracious financial support of the United States Agency for International Development (USAID).

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ANNEX

Annex Table 1. Value chain groups and agricultural sub-sectors in individual value chain groups

Value chain group, with share of AFS GDP	Individual products, with share of GDP of the value chain group
Sorghum (13.8%)	Sorghum and millet 100%
Other cereals (2.7%)	Maize 2.4%; Rice 11.9%; Wheat & barley 6.5%; Other cereals 79.2%
Oilseeds (8.7%)	Groundnuts 60.6%; Other oilseeds 39.4%
Pulses (4.1%)	Pulses 100%
Roots (0.9%)	Sweet potatoes 40.1%; Other roots 59.9%
Vegetables (6.5%)	Vegetables 100%
Fruits and nuts (7.4%)	Nuts 1.8%| Bananas 23.2%; Other fruits 75.0%
Cotton (0.2%)	Cotton 100%
Other crops (5.7%)	Sugarcane 37.2%; Tea 1.6%; Other crops 61.2%
Livestock (44.1%)	Cattle meat 28.8%; Raw milk 35.2%; Poultry meat 2.5%; Eggs 1.5%; Small ruminants 20.8%; Other livestock 11.2%
Fish (1.3%)	Aquaculture 10.7%; Capture fisheries 89.3%
Forestry (2.3%)	Forestry 100%

Source: Author's analysis using IFPRI's 2019 Sudan SAM.

The Sudan Strategy Support Program (SSSP) is managed by the International Food Policy Research Institute (IFPRI) and is financially supported by the United States Agency for International Development (USAID). This publication has been prepared as an output of the SSSP and has not been independently peer-reviewed. Any opinions expressed here belong to the author(s) and are not necessarily representative of or endorsed by IFPRI.

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