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Identifying priority agricultural value chains in Senegal

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IDENTIFYING PRIORITY AGRICULTURAL VALUE CHAINS IN SENEGAL*

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Abstract

In developing countries, where agriculture is a major economic sector, value-chain development is expected to contribute to high-level outcomes. In this paper, we aim at quantitatively assessing the value-chains which will be the most effective at fostering national and regional economic development along four dimensions: generating economic growth in the agricultural-food sector; reducing national and rural poverty; creating employment; and improving nutrition by diversifying diets. We propose an economywide systems-approach using a spatially-disaggregated dynamic computable general equilibrium model that we apply to Senegal.

Simulation results indicate that fishery is the most effective value chain at generating growth in the regions with potential for fishery expansion (Thies-Diourbel, the Northern, and the Southern regions). Rice is the first value chain to reduce poverty in the Northern and Southern regions where irrigated and rainfed rice cultivation respectively dominate. Growth led by the fruits sector is the most effective at improving nutrition in all four regions where fruits are grown (Thies-Diourbel, the Northern, Central, and Southern regions).

Keywords: Senegal; regions; agricultural-food system; value chains

1. Introduction

The research reported in this paper identifies for Senegal the agricultural activities and value-chains which will be the most effective at generating economic growth; reducing national and rural poverty; creating jobs; and improving nutrition by diversifying diets. The Rural Investment and Policy Analysis (RIAPA) model is used to estimate how increasing production in different agricultural sectors leads to changes in national and household outcomes. RIAPA captures linkages between sectors and rural-urban economies, as well as changes throughout the agriculture-food system (AFS). The section 2 situates agriculture within the national and regional economy; section 3 introduces the underlying data, the model, and describes the model simulations; section 4 evaluates the impacts of promoting alternative value-chains; and section 5 provides a final assessment of priority value chains.

2. Agriculture in Senegal

2.1. Agriculture in the national economy

Senegal experienced sustained growth over 6 percent since 2014. Growth accelerated to over 7 percent in 2017 and is expected to remain over 6 percent in the coming years with the recent discovery of large offshore reserves of oil and gas (World Bank, 2019). While the economic growth has since improved, Senegal remains one of the world's poor countries, with average per capita GDP of only $ 1,448 per year in 2017 (World Bank, 2019). The national poverty rate is 46.7 percent; poverty is significantly higher in the rural areas with 57.1 percent compared to 41.2 percent in other urban area and 26.1 percent in Dakar (ANSD, 2013).

Agriculture plays a key role in Senegalese economy. Agriculture generates 16.6 percent of national GDP, 32.0 percent of total employment in 2018 (World Bank, 2019). Compared to 2015, agriculture contribution to the national GDP is stable (15.5 percent of national GDP in 2015), while its contribution to the national employment declines (14.3 percent of national GDP in 2015). Crops dominate the agricultural sector: major crops include millet, sorghum, rice, and maize, which annual production fluctuates according to rainfall levels. Fisheries and livestock are also important sources of income and employment.

Major agricultural exports include fishery products, phosphates, fertilizers, cotton, peanut; other major exports are cement and gold. The country has seen an increase in exports of new products contributing to 40 percent of the growth of exports, while the traditional exports contribute to only 19 percent. Fish is the largest agricultural commodity exported from Senegal, which has shifted from being a net importer to a net exporter of fish and animal products.[1] Since 2010, exports of horticulture products has also seen sharp rise (IPAr 2015a). In contrast, the country is experiencing a decline of its traditional exports: the groundnuts oil exports declined from 22 percent of Senegal's exports in 1995 to 2 percent in 2014; cotton exports declined from 3 percent to 1 percent.

Imports are mainly composed of petroleum products, manufacture, and rice. Senegal is second to Côte d'Ivoire in Africa in rice imports, with the annual average of 165 billion FCFA, or 7 percent of total value and 31 percent of food imports (ANSD 2015, IPAr 2015b). Senegal imports most nonagricultural manufactured goods, such as machinery, equipment, and vehicles. About three-

[1] https://tradingeconomics.com/senegal/exports.

fifths of national GDP is generated by services, which are dominated by finance and business service as well as trade.

Table 1: Structure of the national economy of Senegal, 2015

	Share of total (%)					
	GDP	Employ-ment	Exports	Imports	Exports / output (%)	Imports / demand (%)
All sectors	**100.0**	**100.0**	**100.0**	**100.0**	**10.6**	**18.3**
Agriculture	**15.5**	**14.3**	**6.4**	**8.3**	**5.5**	**12.8**
Crops	9.3	8.8	5.3	8.3	7.5	19.5
Livestock	4.3	4.3	0.3	0.0	0.9	0.2
Forestry	0.5	0.4	0.0	0.0	0.6	2.8
Fishing	1.4	0.8	0.8	0.0	7.2	0.0
Industry	**26.6**	**20.6**	**66.3**	**72.4**	**16.1**	**28.2**
Mining	3.2	1.7	5.9	7.1	23.8	38.4
Manufacturing	19.1	14.0	60.4	65.2	20.3	33.0
Agro-processing	9.1	5.3	22.7	8.6	16.7	14.1
Other manufacturing	10.1	8.7	37.7	56.7	23.2	43.2
Other industry	4.3	4.9	0.0	0.0	0.0	0.0
Services	**57.9**	**65.1**	**27.4**	**19.3**	**6.9**	**7.8**
Trade and hotels	16.2	12.9	18.8	0.0	15.4	0.0
Transport services	9.7	7.6	8.5	19.3	10.1	29.2
Finance & business	18.1	16.0	0.0	0.0	0.0	0.0
Government services	11.9	26.7	0.0	0.0	0.0	0.0
Other services	2.0	1.9	0.0	0.0	0.0	0.0

Source: RIAPA CGE Model and SAM for Senegal.
Notes: GDP is gross domestic product; employment is workers in primary jobs. The final two columns report the share of exports in total sectoral output and the share of imports in total commodity demand. Agro-processing includes beverages and tobacco, but not wood products; catering services includes food services (meals prepared away from the home); and transport includes communications.

Agriculture's role in the economy extends beyond the sector itself, with many industrial and service sectors forming parts of the AFS. Agriculture and agro-processing together account for 25 percent and 20 percent of GDP and employment, respectively. Downstream processing generates 9 percent of GDP, 6 percent of employment, and 23 percent of exports. Major processed exports include processed food mainly fish, and sunflower seeds.

Apart from imported machinery, these sectors use domestically-produced inputs, such as seeds and animal feed, whose production creates additional value-added and jobs within the AFS. An even larger AFS component is transport services moving agriculture-related products between farmers, processors and markets. Households also consume food services or meals prepared outside the home, such as at restaurants or from street vendors. In total, the AFS accounts for 33 percent and 27 percent of national GDP and employment, respectively. One-third of the economy therefore depends on agriculture, either directly or indirectly.

Table 2. Senegal's agriculture-food system GDP and employment, 2015

	Share of national total (%)	
	GDP	**Employment**
National economy	**100.0**	**100.0**
Agriculture-food system	**32.9**	**26.6**
Direct production	**24.8**	**19.9**
Agriculture	15.5	14.3
Agro-processing	9.4	5.6
Input production	**2.5**	**2.1**
Agriculture	0.7	0.7
Agro-processing	1.8	1.4
Trade and transport	**5.6**	**4.6**
Agriculture	2.0	1.7
Agro-processing	3.6	3.0
Food services	**0.6**	**0.3**

Source: RIAPA CGE Model and SAM for Senegal.
Notes: GDP is gross domestic product; employment is workers in primary jobs. Agro-processing includes foods, beverages, tobacco, paper products, cotton yarn, and basic word products; and food services includes meals prepared away from the home.

Table 3 provides national level summary production statistics for the 10 primary product categories for the agricultural value-chains to evaluate in this paper. Appendix Table A1 lists the detailed agricultural products included in each category. Millet is the dominant staple crop and is grown mostly by smallholder farmers (12 percent of national agricultural GDP). Other major food crops include rice, groundnuts, oil seeds (sesame seeds), vegetables and fruits (about 50 percent together). Livestock and fisheries are also large subsectors – mainly cattle and milk, and capture fisheries, respectively.

Table 3. National agricultural production statistics for Senegal, 2015

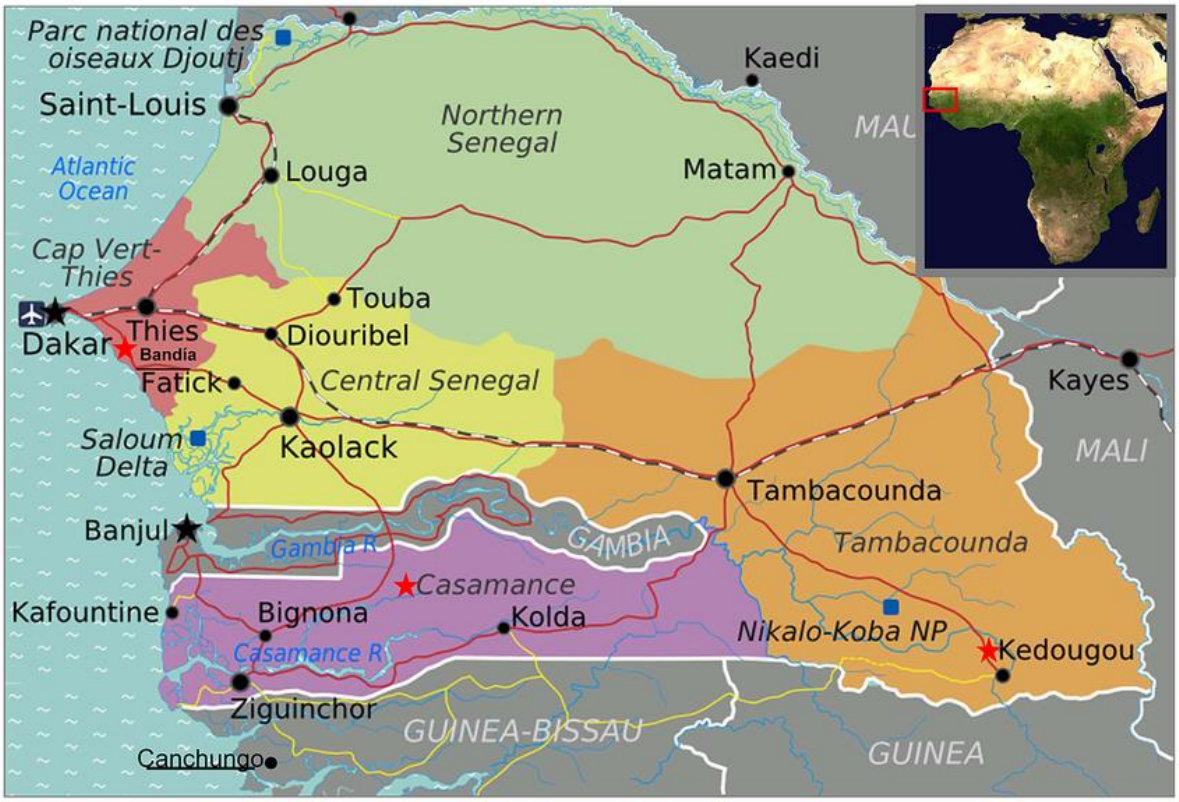
	Agriculture GDP share (%)	Cultivated hectares ('000)	Crop yield (mt per hectare)
Agriculture	100.0	2,378	-
Sorghum, millet	12.1	841	0.6
Rice	9.5	135	4.1
Groundnuts	8.4	879	0.8
Oilseeds	12.3	41	4.3
Vegetables	7.3	18	17.6
Fruits	11.6	58	7.9
Cattle	10.0		
Raw Milk	10.0		
Poultry	7.0		
Fishing	11.8		

Source: RIAPA CGE Model and SAM for Senegal.
Notes: Table A1 in appendix lists the crops or products included in each value-chain category. mt = metric ton

2.2. Agriculture in the regional economy

Sub-national regional differences also matter as sectors differ across regions. At the regional level, Senegal has 14 administrative regions (at which level representative data are available) and is divided into 7 agroecological zones based on biophysical and socioeconomic criteria: (i) the Senegal valley; (ii) the Niayes; (iii) Northern Groundnut Basin; (iv) Southern Groundnut Basin; (v) the Sylvopastoral Zone; (vi) Eastern Senegal and Upper Casamance; and (vii) Lower and Middle Casamance.

In this report, we combine the administrative and agroecological zones to form 5 new regions (see map below): Dakar (Dakar), Thies-Diourbel (Thies, Diourbel), Northern region (Saint-Louis, Matam), Central region (Fatick, Kaffrine, Kaolack, Louga), and Southern region (Kedougou, Kolda, Sedhiou, Tambacounda, Ziguinchor). We separated Thies and Dourbel from Central because of the role the two regions play in the industrial sector. Table 4 reports the regional contribution to the national economy.



Source: Randriamamonjy and Thurlow 2019.

Table 4. Regional agricultural production statistics for Senegal, 2015

	National	Dakar	Thies-Diourbel	Northern	Central	Southern
Population	**100.0**	23.2	24.2	10.9	23.1	18.5
Poverty headcount	**46.7**	26.1	44.3	41.7	53.8	69.3
GDP	**100.0**	55.3	17.2	9.1	10.1	8.3
Employment	**100.0**	57.1	15.6	9.5	10.1	7.8
	GDP- share of national agriculture total (percent)					
AGRICULTURE	**100.0**	**4.2**	**11.8**	**25.9**	**34.5**	**23.6**
Crops	**59.9**	**2.6**	**6.1**	**13.8**	**22.5**	**14.9**
Food crops	58.4	2.6	6.1	13.2	22.5	14.0
Sorghum and millet	9.5	0.0	1.7	0.3	4.4	3.0
Rice	7.4	0.0	0.0	6.0	0.1	1.3
Groundnuts	6.6	0.0	0.7	0.1	3.7	2.1
Other oilseeds	9.6	0.0	0.0	0.0	7.1	2.5
Other vegetables	5.7	2.4	0.0	2.3	0.0	1.0
Other fruits	9.1	0.1	1.3	1.7	5.5	0.5
Non-food crops	1.5	0.1	0.0	0.6	0.0	0.9
Livestock	**27.7**	**0.7**	**1.6**	**8.9**	**10.5**	**6.0**
Cattle	7.8	0.0	0.4	2.9	2.0	2.5
Raw milk	7.8	0.0	0.0	2.7	5.0	0.1
Poultry	5.5	0.5	0.8	1.0	1.3	1.9
Other agriculture	**12.4**	**0.9**	**4.1**	**3.2**	**1.6**	**2.7**
Capture fisheries	9.2	0.7	3.9	2.5	0.5	1.6
	Employment - share of national agricultural employment total (%)					
AGRICULTURE	**100.0**	**4.2**	**10.7**	**24.9**	**37.3**	**23.0**
Crops	**61.3**	**2.9**	**6.6**	**12.9**	**23.4**	**15.5**
Food crops	58.8	2.9	6.5	12.1	23.4	13.9
Sorghum and millet	6.6	0.0	1.2	0.2	3.1	2.1
Rice	5.1	0.0	0.0	4.1	0.1	0.9
Groundnuts	7.7	0.0	0.8	0.1	4.3	2.5
Other oilseeds	11.2	0.0	0.0	0.0	8.3	2.9
Other vegetables	6.4	2.7	0.0	2.6	0.0	1.1
Other fruits	9.9	0.1	1.4	1.8	5.9	0.6
Non-food crops	2.5	0.0	0.0	0.8	0.0	1.6
Livestock	**29.8**	**0.6**	**1.5**	**9.7**	**12.6**	**5.5**
Cattle	5.7	0.0	0.3	2.2	1.5	1.8
Raw milk	11.6	0.0	0.0	4.0	7.4	0.1
Poultry	4.8	0.5	0.7	0.8	1.2	1.7
Other agriculture	**8.8**	**0.6**	**2.6**	**2.3**	**1.3**	**2.0**
Capture fisheries	5.9	0.5	2.5	1.6	0.3	1.0

Source: RIAPA CGE Model and SAM for Senegal.
Notes: Table A1 in appendix lists the crops or products included in each value-chain category. mt = metric ton

Dakar is the capital city, very urbanized with high population density – less than 1percent of Senegal territory but home to more than 20 percent of the country's population. Dakar is covered by the zone of Niayes (about 10 km strip of land along the shoreline) which is the major horticultural crop cultivation and commercial area in Senegal. Dakar has the lowest poverty rate. The region contributes to 55 percent and 57 percent of Senegal's GDP and employment, respectively.

Thies-Diourbel region belongs to the Groundnut Basin zone. The coastal communities depend on fishing, accounting for 42 percent of the Senegal's fishery's GDP. Millet is the main crop grown in the interior of the region and fisheries is the main agricultural activity in the coastal region. Population growth in the area is accelerating resource use; weather conditions have worsened ecosystem degradation and marine invasion, which disrupt fish stocks and reduce arable land in the region. The region contributes to 17 percent and 16 percent of Senegal's GDP and employment, respectively.

The Northern region including the Saint-Louis and Matam regions belongs to the Senegal River Valley zone, characterized by alluvial plains and sandy uplands. Most crop production relies on irrigation due to poor and irregular rainfall. The region contributes to more than 80 percent of Senegal's rice GDP, which meets only about 20 percent of the country's needs; 30 percent of this production is used for subsistence. Fisheries, cattle farming, and dairy agro-industrial are developing in the region. Poverty and food insecurity are particularly prevalent in rural areas.

The Central region including Kaolack, Fatick, and Kaffrine regions on the south is covered by the Groundnut Basin zone. The crop production is dominated by millet, groundnuts, sesame seeds, and fruits (watermelon, mangoes, etc.). Groundnuts continue to play an important role in the overall economy as the main cash crop for many rural Senegalese farmers although the sector's contribution to export has dropped below that of fishing. Sesame seeds and fruits production contributes to 75percent and 60 percent of the Senegal's oilseeds and fruit GDP, respectively. The north of the Central region (Louga) belongs to the Sylvopastoral zone characterized by sandy soils, a long dry season with winds from the very dry Sahara Desert. Senegal's major cattle farming is located there. Dairy processing is also developing in the area.

The Southern region is covered by the Casamance zone on the west and Senegal Oriental zone on the east. Casamance has average rainfall greater than the rest of Senegal, with most areas receiving over 1200 mm annually. Millet, rice, groundnuts, sesame seeds, and vegetable are grown in the regions; rainfed rice is carried out within the Casamance River watershed. Senegal Oriental is the country's cotton-producing zone covering the region of Tamba, Kedougou and few districts of Kolda. Yet, due in part to heavy population pressure on natural resources, the lower and upper Casamance zones are subject to the highest food insecurity rates in Senegal. The Southern region, particularly Kolda and Kedougou are the most vulnerable with a poverty rate greater than 70 percent (ANSD, 2013).

In addition to regional differences in production, differences in consumption patterns matter for value chain prioritization. Table 5 describes aggregate income and consumption patterns. Senegal's population of 15 million people consume, on average, US$ 1549 of goods and services per person each year (at market exchange rates unadjusted for purchasing power parity). Consumption levels are much lower in rural areas and amongst the poor. Poor households spend more of their earnings on food and processed products. Starches from cereals and roots dominate the consumption patterns of the rural poor, whereas nonpoor and urban households consume more dairy, meat, fish and eggs, as well as more meals prepared outside of the household. Finally, poor rural households, on average, rely more on incomes from farming and less-educated labor, suggesting that agriculture and the rural nonfarm economy play key roles in the livelihoods of the poorest households.

Table 5. Household incomes and consumption for the population of Senegal, 2015

	National	Rural	Rural poor	Urban
Population (millions)	**15.0**	**8.4**	**5.1**	**6.6**
Consumption per capita (USD)	**1,549**	**713**	**452**	**2,621**
Food consumption as share of total consumption (%)	47.9	62.8	64.9	42.7
Food consumption share (%)	**100.0**	**100.0**	**100.0**	**100.0**
Cereals and roots	20.9	40.2	47.8	11.0
Vegetables	6.9	5.9	5.5	7.4
Fruits	5.1	2.1	0.8	6.6
Meat, fish and eggs	19.0	11.8	8.3	22.6
Milk and dairy	10.0	7.0	5.3	11.6
Pulses and oilseeds	15.2	17.7	17.9	14.0
Prepared meals	4.6	1.0	0.9	6.4
Other foods	18.4	14.3	13.4	20.5
Processed food share (%)	68.5	78.4	80.8	63.4
Total household income (%)	**100.0**	**100.0**	**100.0**	**100.0**
Crop land returns	4.6	17.3	21.4	0.4
Labor remuneration	33.2	25.2	25.2	35.8
Less-educated workers	15.8	20.2	22.3	14.3
More-educated workers	17.4	5.0	3.0	21.5
Capital profits	49.8	40.3	35.2	52.9
Other sources	12.4	17.2	18.2	10.9

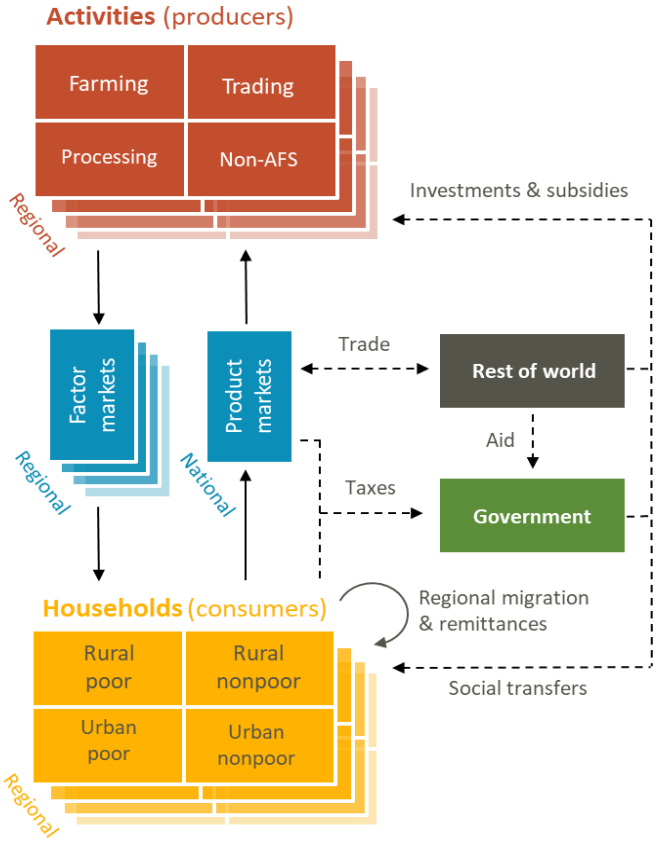
Source: RIAPA CGE Model and SAM for Senegal.
Notes: Food consumption excludes meals prepared outside the household. Processed foods exclude products processed and consumed within the household. Better-educated workers are those who have at least completed primary schooling. Capital income includes gross operating surplus. Other income sources include social and foreign transfers. Table A1 in appendix lists the crops or products included in each value-chain category.

3. Methodology

3.1. Model and data

The effectiveness of agricultural value chains in generating additional growth and employment opportunities and in reducing poverty and improving nutrition is analyzed using an economy-wide regionalized dynamic computable general equilibrium model, the Rural Investment and Policy Analysis (RIAPA) that has been developed by IFPRI in collaboration and with support from IFAD and CGIAR-PIM. This class of economy-wide models simulates the workings of a market-based open economy in which supply and demand of commodities and factors are determined by market-clearing flexible prices, subject to resource constraints and macroeconomic consistency (see Diao and Thurlow 2012 for a description and mathematical specification of the model together with data requirements and calibration procedure). The flow diagram in Figure 1 provides a stylized picture of the circular flow of goods and factors as well as financial transactions between economic agents – producers and consumers in different regions, government, and rest of the world – acting in national and international product markets and regional factor markets.

Figure 1. Stylized Rural Investment and Policy Analysis (RIAPA) model



Source: Authors' compilation

The RIAPA model separates Senegal's economy into 75 standard sectors in each of the five sub-national regions. The 75 sectors are made up of 27 agriculture (labeled farming in Figure 1), 14 in agro-processing, 2 in trading and transport (trading in Figure 1), and 32 in mining, industrial and services sectors. The latter are related, at least in part, to the agriculture or agro-processing system. Representative producers in each sector and region combine factors of production, i.e. land, labor, and capital, using a constant elasticity of substitution production function under constant returns to scale. Cropland and labor are defined regionally. Labor within each region is divided into four categories based on education level, i.e., uneducated, primary, secondary, and tertiary. Capital is divided into four capital types depending on the sectors using the capital, i.e., crop, livestock, mining, and other capital.

The model runs over the period 2018 to 2022. Land and labor are fully employed and mobile across sectors, but not regions, and their total supply generally grows over time based on historical trends[2]. The exception is uneducated and primary educated labor, which are treated as underemployed and for which we assume wage elastic labor supply curves in all five regions. Past investment determines new capital stocks, which are allocated to sectors according to their relative profitability. Once invested, capital becomes immobile and earns sector-specific returns, i.e., the putty-clay assumption.

[2] Assuming interregional immobility for all labor categories implies that the short-run adjustment flexibility to regional shocks is limited since labor reallocation is restricted. Moreover, it implies that wages for the same labor categories may differ across regions.

There is imperfect substitution between domestic and foreign goods, i.e., the Armington assumption. Producers' decision to supply to export markets or domestic markets and consumers' decision to buy imported or domestically produced goods are based on changes in domestic prices relative to fixed world market prices. All domestic, import, and export prices include relevant indirect taxes. The current account balance is maintained though changes in the real exchange rate.

The model separates Senegal's households into 15 groups within each region. These groups include farm and non-farm households within rural areas and households within urban areas, separated into per-capita-consumption quintiles. RIAPA tracks changes in incomes and expenditures for different household groups, including changes in food and nonfood consumption patterns. Poverty impacts are measured using survey-based microsimulation analysis. Individual survey households map to the model's household groups. Estimated consumption changes in the model are applied proportionally to survey households, and post-simulation consumption values are recalculated and compared to a poverty line to determine households' poverty status. Representative households receive incomes based on their factor endowments and then use that income to pay taxes, to save, and to consume goods. The latter is determined by a linear expenditure system with income elasticities estimated according to King and Byerlee (1978).

The government receives direct and indirect taxes and foreign aid and uses these revenues to pay for recurrent spending and investment. Private, public, and foreign savings, i.e., capital inflows, are pooled and used to finance domestic investment. We assume that public spending grows in line with recent trends and that the fiscal deficit adjusts to equate revenues and expenditures. Household savings rates are fixed, and investment demand adjusts so that it equals total savings in equilibrium.

Because the focus is on agriculture and agricultural value chains, the CGE model gives emphasis to agricultural activities and their linkages to other production sectors, especially agricultural processing sectors and trade sectors, but also to manufacturing and services sectors producing intermediate inputs that are used by the agricultural food system. Moreover, the model takes into account regional differences in production and consumption. A regional SAM for 2015 constructed by IFPRI (Randriamamonjy and Thurlow, mimeo)[3] is the core database of this study. It integrates national income, input-output, flow-of-funds, balance-of-payments current accounts, and household income and expenditure data into a comprehensive and consistent data set. It is assumed to represent the initial equilibrium position of the Senegalese economy and provides numerical values to several parameters of the analytical model.

3.2. Simulations

We design several scenarios to determine which agricultural value-chains, if scaled-up, are most effective at[4]:

- accelerating economy-wide and agri-food-sector growth;
- creating jobs inside and outside the agri-food sector;
- raising farmers' and other households' incomes and reducing poverty;
- improving nutrition by diversifying diets.

[3] See Appendix Table A3 for the classification of SAM accounts and activities, commodities, factors, and institutions included in the RIAPA CGE model.

[4] The environmental sustainability dimension is not explicitly considered in this paper. Several aspects of environmental sustainability such as water, however, are included in the model as a production input.

We use the RIAPA model to simulate the effects of expanding farm production within existing agricultural value-chains. Total factor productivity (TFP) growth in each group of agricultural products and regions is accelerated beyond baseline growth rates, such that, in each value-chain scenario, total agricultural GDP or regional agricultural GDP is one percent higher in 2022 than it is in the baseline scenario.[5] National and regional agricultural subsectors differ in size. So, to achieve the same absolute increase in total and regional agricultural value-added, it is generally necessary for smaller value-chains to expand more rapidly than the larger ones. Table 6 lists the national and regional value-chains analyzed in this report, including their initial regional agricultural GDP shares and required TFP changes.

Table 6. Expansion of production for value chain scenarios at national and regional level

	National		**Dakar**		**Thies-Diourbel**		**Northern**		**Central**		**Southern**	
	Share of AGGDP	TFP change	Share of AGGDP	TFP change	Share of AGGDP	TFP change	Share of AGGDP	TFP change	Share of AGGDP	TFP change	Share of AGGDP	TFP change
Sorgh. & millet	12.1	2.9	0.0	1.0	19.7	1.7	1.7	1.0	15.0	1.5	18.0	1.5
Rice	9.5	1.9	0.0	1.0	0.0	1.0	30.8	0.7	0.3	1.0	8.0	2.1
Groundnuts	8.4	4.6	0.1	1.0	8.1	1.5	0.3	1.0	12.4	1.6	12.9	1.5
Other oilseeds	12.3	2.4	0.0	1.0	0.0	1.0	0.0	1.0	24.1	0.8	14.9	1.1
Vegetables	7.3	4.8	63.7	0.2	0.0	1.0	11.9	1.7	0.0	1.0	6.2	2.5
Other fruits	11.6	1.9	2.3	1.0	14.9	0.9	8.6	1.6	18.4	0.9	3.2	3.8
Cattle	10.0	3.3	1.0	1.0	4.6	1.0	15.0	1.6	6.7	3.1	15.0	1.8
Raw milk	10.0	2.2	0.0	1.0	0.0	1.0	13.9	1.5	16.9	1.2	0.4	1.0
Poultry	7.0	4.7	13.7	1.0	8.8	1.0	4.8	1.0	4.5	1.0	11.6	2.4
Fishery	11.8	3.5	19.2	1.0	44.0	0.5	12.8	1.4	1.7	1.0	9.8	1.8

Source: Authors' compilation
Note: Total Factor Productivity (TFP) change is 1.0 for all agricultural sectors and all years in the baseline scenario.

Relatively modest productivity gains in large agricultural subsectors are enough to match the effects of yield gains from small subsectors. Vegetables, fishery, rice, oilseeds, and millet are the largest sectors in Dakar, Thies-Diourbel, Northern, Central, and Southern, respectively. These sectors require relatively low TFP growth rates to reach the one-percent growth target for agriculture in these regions in 2022. While such rapid growth may be difficult to achieve in small sectors, targeting the same absolute increase in agricultural GDP permits comparisons across scenarios at the national level and within regions..

4. Results: Evaluating Alternative Value Chains

There are several key transmission channels that determine the impact of promoting agricultural value chains in an economy-wide context. Because we are primarily interested in the impact on the agro-food system, we focus on how and why prices, income generation, and employment differ across agricultural value chains and how these differences affect economy-wide income generation, employment, poverty, and nutrition.

[5] The choice to target one percent increase in agricultural GDP is somewhat arbitrary, since results are largely unaffected by the magnitude of the target growth acceleration.

Table 7. Agricultural supply and demand characteristics of Senegal

	EXP-OUTshr (percent)	IMP-DEMshr (percent)	Trade substi-tution elasticity	INT-OUTshr (percent)	HHD-OUTshr (percent)	Income elasticity demand η	QINTshr (percent)
	1	2	3	4	5	6	7
Sorghum - millet			1.3	75.3	1.0	0.9	16.9
Rice	17.4	64.2	5.1	81.4	9.6	1.5	26.9
Groundnuts	5.6		2.5	24.6	70.2	0.2	47.4
Other oilseeds	3.9	1.4	2.5	21.8	-		32.2
Vegetables	2.9	8.5	1.9	21.8	75.2	0.3	46.0
Other fruits	7.3	4.0	1.9	23.8	66.9	4.0	37.7
Cattle		0.3	2.0	67.2	15.5	1.3	21.7
Raw milk			3.7	28.8	71.2	2.6	5.8
Poultry	0.1	0.3	1.3	23.0	77.0	1.4	49.8
Fishery	7.2		1.3	77.1	16.1	0.9	34.6

Source: RIAPA CGE Model and SAM for Senegal.
Note: EXP-OUTshr = sectoral export-output share; IMP-DEMshr = sectoral import penetration rate; INT-OUTshr = share of sectoral output that is processed; HHD-OUTshr = share of sectoral output directly consumed by households; QINTshr = secondary inputs as a share of total sectoral input demand; TRCshr = share of total sectoral value of demand made up by trading services; η = weighted average of household income elasticities.

The first important transmission channel is the initial domestic output price response in agricultural sub-sectors. Rising TFP increases output and supply, resulting in lower domestic prices. The extent of the fall in domestic prices depends on the tradability of the agricultural goods, as reflected by export orientation, i.e., the share of export supply in total supply and the export transformation elasticity.[6] The lower the export share and the lower the export transformation elasticity, the larger the domestic price reductions in reaction to TFP growth. From the sectoral export-output shares and the trade substitution elasticities[7] shown in columns (1) and (3) in Table 7, one would expect relatively large price reductions for all sectors except rice and raw milkin response to higher sectoral TFP's. Most of the sectors are inward-oriented producing largely for the domestic market and exhibit low export shares and low export transformation elasticities. Thus, their prices are largely determined by domestic supply and demand. Rice is one exception as high export transformation possibilities and high export orientation lead to a sizeable restructuring of supply, which lowers domestic supply of rice, thereby reducing downward pressure on prices. The other exception is the raw milk sector for which a relatively high export transformation lowers downward pressure on domestic prices despite low export orientation.

Together these characteristics imply large price reductions with increases in output and supply for most of the domestically produced agricultural goods. This will induce domestic users, both consumers and agricultural processing sectors, to change their composition of demand — less imports and more domestically produced substitutes — thereby causing upward pressure on domestic prices. The resulting change in domestic prices depends on the cross-price elasticity of demand for the composite good, which itself depends on the price elasticity of demand for the composite good and the elasticity of substitution in use between the domestically produced and

[6] The export transformation elasticity measures the percentage change in the export supply to domestic supply in response to a 1 percent change in the export price to the domestic price. The higher the export transformation elasticity the easier it is for the good to penetrate world markets.

[7] We assume identical substitution elasticities between exports and imports on the one hand, and domestically produced goods on the other hand.

foreign goods. Lower domestic prices for agricultural goods will, ceteris paribus, lead to a large increase in demand for the domestically produced goods if the following conditions are met:

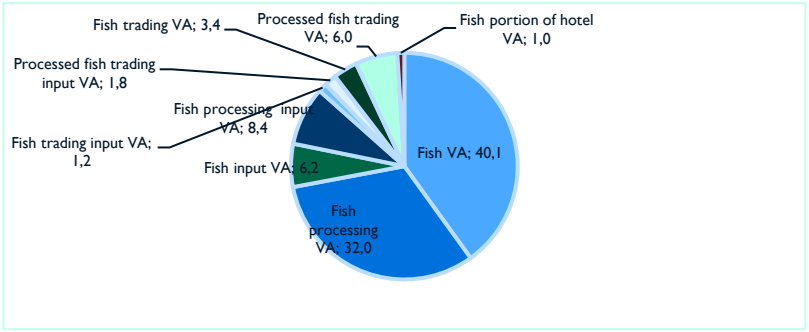
- If it is easy to substitute them for imports, as indicated by high trade substitution elasticities;
- If the sectoral import share is large, implying relatively large demand increases for the domestically produced product in order to compensate for relatively small reductions in imports; and
- If the demand for the composite good is relatively inelastic with respect to the composite price, reflecting the importance of these goods as intermediates in domestic production.

Returning to Table 7, from the demand characteristics of agricultural markets one would expect no secondary repercussions on domestic prices for all goods, except for rice. The other sectors face no or only weak import competition, as reflected by their low import penetration rates (column 2) and low import substitution elasticities (column 3). The rice sector shows the highest import share and import substitution elasticity, implying strong repercussions on domestic prices.

Beside these transmission channels, which determine the initial domestic output price response in agricultural markets, there are other transmission channels that determine the final growth and employment effects of sectoral agricultural TFP growth: First, other things being equal, the stronger are the forward and backward economic linkages of a value chain, the stronger are the economy-wide growth effects.

An example is the fish value chain where the fish sector accounts for 33 percent of total value-added and the downstream fish processing generates another 26 percent. The rest of the value added is indirect, generated either in backward linked intermediate input production (30 percent) or forward linked transport sectors. Thus, it is also important to consider the indirect growth impacts outside the fish production and processing.

Figure 2 Fish value chain, percentage share of total GDP generated by the component parts of the fish supply chain, 2015



Second, the economy-wide, net employment effects matter for household incomes, poverty, and dietary diversity. Promoting agricultural production through increasing productivity means that more output is produced with the same or fewer inputs by increasing the efficiency of factors, such as labor. As observed in all successfully transforming countries, the share and number of people employed in agriculture is expected to decline over time. However, given the forward and backward linkages of agriculture, people that move out of agriculture may move to higher-valued jobs in the agro-food system, for example in processing or services.

Third, as already discussed for agricultural goods, the impact of promoting selected agricultural value chains on (relative) prices can be significant. The price effects crucially depend on the income elasticity of demand of households and the trade elasticities. The price effect (decline in price) of increasing supply is usually stronger the more inferior the good is. For example, staple goods, such as bread, have a lower price elasticity and, even if the price falls, people are less likely to buy more bread. Fruits, on the other hand, often have a high elasticity of demand and so a reduction in price would lead to an increase in purchases of fruits. Regarding trade, usually the less internationally traded a good is, the more an increase in domestic production will lead to a decline in domestic prices. Obviously, lower prices lead to higher real incomes and greater dietary diversity for net consuming households, whereas net producing households of the commodity may experience negative real income and nutrition effects.

Against this theoretical discussion of key transmission channels, we now move to the discussion of the empirical results for Senegal. We first discuss the expected impacts on economic growth and employment and then on poverty and nutrition.

4.1. Growth and employment effects

Table 8 reports the growth and employment effects of expanding agricultural production in different value chains together with rankings of value chains on the basis of these effects. In each region, value chains are expanded over the period 2018 to 2022 such that total regional agricultural GDP is one percent higher in year 2022 than without the value chain expansion. The table reports growth and employment elasticities for the total economy and for the agricultural food system (AFS) only. Although the scenarios are labeled by the names of the value-chains in which productivity growth originates, it does not imply that all growth and employment occur only within these value-chains. Increasing rice productivity, for example, may allow farmers to diversify production by reallocating resources to other crops and activities, including nonfarm enterprises. Increasing value-chain workers' incomes also allows their households to purchase products from other sectors or value-chains, thereby generating economy-wide spillovers. The higher the total GDP growth that results from a one percent expansion of agriculture, the higher is non-agricultural growth. The higher the AFS GDP growth, the higher is growth in agro-processing. Thus, the former is an indicator of agriculture-led development, whereas the latter is an indicator of agricultural transformation.

Fishery's AFS growth elasticity of 0.96 implies that a one percent increase in agricultural GDP (which makes up 15.5 percent of total GDP in 2015) driven by fishery's productivity increases AFS GDP (which makes up 32.9 percent of total GDP in 2015) by 0.96 percent. Fishery comes out on top nationally for the total economy and for the agricultural food system. The sector is export-oriented but with relatively weak export transformation possibilities and has strong forward and backward linkages. Together, this implies a strong reduction of the domestic price for fish and strong incentives for fish processing and intermediate production for the fishery sector. For the same reason cattle and millet take the second and the third place respectively for the total economy, and second and fourth place for the AFS. These sectors supply downstream meat sector and grain milling, 67 percent and 76 percent of sectoral outputs are processed. Oilseeds value chain is effective in creating growth in AFS while being significantly less effective at generating economy-wide growth, only 22 percent of its production goes to oil processing.

Table 8. National growth and employment linkages

Targeted sector within agriculture	GDP growth elasticity (rank in parentheses)		Employment elasticity (rank in parentheses)	
	Total	AFS only	Total	AFS only
		National		
Sorghum, millet	0.22 (3)	0.68 (4)	-0.01 (5)	-0.13 (7)
Rice	0.12 (10)	0.43 (10)	0.04 (2)	0.26 (1)
Groundnuts	0.19 (4)	0.56 (7)	-0.02 (8)	-0.22 (9)
Oilseeds	0.18 (6)	0.75 (3)	-0.01 (6)	0.03 (5)
Vegetables	0.18 (5)	0.56 (6)	-0.02 (7)	-0.18 (8)
Fruits	0.13 (9)	0.48 (9)	0.03 (3)	0.22 (3)
Cattle	0.28 (2)	0.84 (2)	-0.06 (10)	-0.53 (10)
Milk	0.13 (8)	0.48 (8)	0.04 (1)	0.25 (2)
Poultry, eggs	0.17 (7)	0.66 (5)	-0.04 (9)	-0.03 (6)
Fishing	0.31 (1)	0.96 (1)	0.02 (4)	0.11 (4)

Source: RIAPA CGE Model and SAM for Senegal.
Notes: AFS is agriculture-food system; total is the whole economy. GDP (employment) elasticity is the percentage increase in total or agriculture-food system GDP (employment) given a one percent increase in agricultural GDP.

The rice sector is the least effective in generating growth despite high forward linkages; more than 80 percent of total output is used as intermediate input in processing industries. With rice being highly tradable[8], domestic producer and consumer prices are largely determined on the world market. Any change in domestic output and supply that results from productivity change leaves domestic prices and intermediate input costs of processing industries largely unaffected and therefore are not providing significant incentives to expand grain milling activities

By contrast, rice is the most effective value chain in creating jobs followed by milk, fruits, and fishery. Rice's AFS employment elasticity of 0.26 implies that a one percent increase in agricultural GDP driven by rice farming productivity causes AFS employment to increase by 0.26 percent. The detrimental ranking of growth and employment effects in rice sector indicates a trade-off between the absolute number of jobs created and the "quality" or labor productivity of these jobs. Expanding rice production may create many jobs, but AFS GDP per worker generated in these jobs is the lowest among the 10 value-chain sectors (mainly because most jobs are created on the farm).

At the regional level, the potential of a sector within regions is a necessary but not a sufficient condition for its effectiveness in creating economy-wide growth and employment opportunities. As a result, rankings of agricultural value chains may differ not only across sectors but also across regions. Most importantly, rankings may differ between individual regions and the national economy. This is shown in Table 9, which compares national and regional impacts of expanding regional value-chains. Regional impacts are measured by the percentage change in regional growth or employment that result from a regional change in total regional agricultural output, while national impacts are measured by the percentage change in national growth or employment that result from a change in national agricultural output.

[8] More than 17 percent of total rice production is exported, and more than 64 percent of domestic rice demand are covered by imports. In addition, trade substitution elasticities between domestically produced rice and rice produced abroad are high. A trade substitution elasticity of 5.1 implies that a relative price change of one percent leads to a relative change in exported/imported and domestically produced quantities by 5.1 percent. Thus, trade substitution does induce large quantity adjustments to low price changes; as a result, the price for domestically produced rice will not differ very much from world market prices.

Millet comes out on top in the three regions where fishing is considered as a potential sector for expansion (Thies-Diourbel, Central, and Southern regions). In regions, where cattle is the dominant livestock sector, it comes out as the sector with the strongest growth effects (first in the Sylvopastoral zone of the Northern and second in Central region and Southern region. Groundnut is a growth enhancing sector in the Central region; in Thies-Diourbel and the Northern region, fishing takes the second place after millet and cattle, respectively. The vegetable sector (horticulture) is the only crop sub-sector to intervene in Dakar.

The impacts on employment are more mixed. Among all potential regional value chains, millet is the only value chain that is not effective in creating jobs, neither in individual regions nor at the national level. Groundnuts, cattle, and poultry&eggs, which lead to less employment at the national level is creating additional jobs in the Northern, Central, and Southern regions. In the Northern region, while being the most effective value chains in creating jobs, fruits and milk are the least effective at generating growth. In the fruits sector, this is largely due to limited spillovers as a result of limited domestic price reductions for highly tradable fruits. Thus, TFP growth in the rice sector leads to higher employment and income in the rice sector itself but not elsewhere. Milk is not traded and largely directly consumed by households with little processing. For that reason, employment and growth generation is confined to the sector itself with limited growth effects elsewhere.

Table 9. National versus regional growth and employment linkages

	National								Regional							
	Total-GDP		AFS-GDP		Total-EMP		AFS-EMP		Total-GDP		AFS-GDP		Total-EMP		AFS-EMP	
Dakar																
Vegetables	0.14	(1)	0.53	(1)	0.04	(1)	0.44	(1)	0.01	(1)	0.06	(1)	0.01	(1)	0.10	(1)
Thies-Diourbel																
Sorghum, millet	0.23	(2)	0.73	(2)	-0.01	(4)	-0.19	(4)	0.13	(1)	0.45	(1)	-0.02	(4)	-0.44	(4)
Groundnuts	0.15	(3)	0.55	(3)	0.03	(3)	0.34	(2)	0.07	(3)	0.39	(3)	0.06	(2)	0.60	(2)
Fruits	0.10	(4)	0.48	(4)	0.06	(1)	0.57	(1)	0.06	(4)	0.38	(4)	0.07	(1)	0.70	(1)
Fishing	0.30	(1)	0.96	(1)	0.03	(2)	0.23	(3)	0.10	(2)	0.41	(2)	0.01	(3)	0.16	(3)
Northern																
Rice	0.12	(6)	0.43	(6)	0.04	(2)	0.27	(2)	0.35	(4)	0.63	(4)	0.04	(5)	0.19	(5)
Vegetables	0.26	(3)	0.66	(3)	-0.11	(6)	-1.16	(6)	0.35	(3)	0.63	(3)	0.09	(3)	0.27	(3)
Fruits	0.14	(4)	0.56	(4)	0.03	(3)	0.24	(3)	0.32	(6)	0.63	(5)	0.18	(1)	0.56	(1)
Cattle	0.28	(2)	0.84	(2)	-0.06	(5)	-0.57	(5)	0.41	(1)	0.70	(1)	0.01	(6)	0.02	(6)
Milk	0.12	(5)	0.47	(5)	0.05	(1)	0.31	(1)	0.32	(5)	0.62	(6)	0.17	(2)	0.50	(2)
Fishing	0.34	(1)	1.05	(1)	0.01	(4)	-0.06	(4)	0.36	(2)	0.65	(2)	0.05	(4)	0.20	(4)
Central																
Sorghum, millet	0.21	(3)	0.62	(3)	0.00	(3)	-0.10	(4)	0.62	(1)	0.88	(1)	-0.05	(6)	-0.20	(6)
Groundnuts	0.22	(2)	0.57	(4)	-0.04	(5)	-0.42	(5)	0.55	(4)	0.85	(4)	0.08	(3)	0.16	(3)
Oilseeds	0.18	(4)	0.76	(2)	-0.01	(4)	0.00	(3)	0.56	(3)	0.88	(2)	0.06	(4)	0.13	(4)
Fruits	0.13	(6)	0.45	(6)	0.03	(2)	0.13	(2)	0.50	(6)	0.83	(6)	0.17	(2)	0.41	(1)
Cattle	0.30	(1)	0.87	(1)	-0.07	(6)	-0.68	(6)	0.58	(2)	0.87	(3)	0.05	(5)	0.06	(5)
Milk	0.14	(5)	0.48	(5)	0.05	(1)	0.24	(1)	0.52	(5)	0.84	(5)	0.17	(1)	0.39	(2)
Southern																
Sorghum, millet	0.21	(3)	0.66	(5)	0.00	(4)	-0.06	(4)	0.46	(1)	0.81	(1)	-0.03	(9)	-0.19	(9)
Rice	0.11	(9)	0.41	(9)	0.04	(2)	0.27	(1)	0.37	(6)	0.77	(7)	0.06	(5)	0.30	(5)
Groundnuts	0.19	(5)	0.56	(6)	-0.03	(6)	-0.29	(7)	0.38	(5)	0.77	(6)	0.13	(4)	0.37	(4)
Oilseeds	0.16	(7)	0.73	(3)	0.00	(5)	0.10	(3)	0.37	(6)	0.78	(4)	0.16	(3)	0.48	(3)
Vegetables	0.20	(4)	0.47	(7)	-0.07	(9)	-0.87	(9)	0.36	(8)	0.76	(8)	0.18	(2)	0.55	(2)
Fruits	0.12	(8)	0.46	(8)	0.04	(1)	0.27	(2)	0.34	(9)	0.75	(9)	0.22	(1)	0.70	(1)
Cattle	0.29	(2)	0.86	(2)	-0.07	(8)	-0.59	(8)	0.43	(2)	0.80	(2)	0.03	(8)	0.04	(8)
Poultry, eggs	0.17	(6)	0.67	(4)	-0.05	(7)	-0.14	(6)	0.41	(3)	0.78	(3)	0.05	(7)	0.13	(7)
Fishing	0.35	(1)	1.07	(1)	0.00	(3)	-0.07	(5)	0.39	(4)	0.78	(5)	0.05	(6)	0.24	(6)

Source: RIAPA CGE Model and SAM for Senegal.

4.2. Poverty effects

An agricultural value chain's impact on poverty, measured by the semi-PGEs, depends on various factors, including whether poorer households engage in the value chain as a primary activity and earn higher farm revenues; whether poorer workers are employed in downstream processing and upstream input production and trading and earn higher wages; or whether poorer households consume the final product at lower prices: The more that an increase in production comes as a result of productivity-driven growth in a sub-sector, the greater the reduction in the price for the respective agricultural good, and the more a certain household consumes that commodity or a related processed item that benefits from the lower input prices, the higher the positive impact on the household's welfare.

Poverty headcount rates focus on people living close to the poverty line, whereas poverty gaps measure how far poor households are from the poverty line. Poverty gaps better reflect the conditions of the poorest of the poor. These households may have different consumption patterns and factor endowments than the less poor, such as more limited access to land, and so the value-chains can be more effective at reducing poverty gaps than poverty headcounts.

Table 10 reports the national and regional poverty effects of expanding agricultural production in different value chains together with rankings of value chains.

Expanding rice production reduces the national poverty headcount rate by 2.4 percentage points for every one percent increase in GDP per capita, making rice a "pro-poor" value-chain. Rice has the largest elasticity of all value-chains considered here, implying that growth in the rice and downstream milling sectors are most effective at reducing national poverty (see ranking in parentheses). In fact, 90 percent of the labor employed in rice activity is unskilled labor on which poor households rely on. Rice has even stronger linkages to rural poverty reduction -3.9 percentage points), particularly of rural farmer households (-4.8 percentage points).

Likewise, expanding milk production reduces the national and rural poverty headcount rate by 0.5 and 0.65 percentage points, respectively, for every one percent increase in per-capita GDP.

Note that value-chain PGEs are often larger than the baseline's overall PGE, indicating that agricultural growth is generally more pro-poor than nonagricultural growth. Rural PGEs also tend to be larger than national PGEs, indicating that, as expected, agricultural growth favors the rural poor. They are largest in the regions, where the agricultural productivity gains emerge.

Table 10. Poverty-Growth Elasticity (PGE) results

Baseline or targeted sector within agriculture	Estimated Semi-PGE (sectoral rank in parentheses)											
	National headcount		Rural headcount		National gap		Rural farmer headcount		Female household headcount		Region headcount	
Baseline	**-0.78**		**-0.87**		**-0.27**		**-1.01**		**-0.75**		**Baseline**	
					National						**-0.78**	
Sorghum, millet	2.06	(9)	3.98	(9)	0.12	(8)	5.18	(9)	0.29	(6)	2.06	(9)
Rice	-2.42	(1)	-3.90	(1)	-1.44	(1)	-4.76	(1)	-0.09	(2)	-2.42	(1)
Groundnuts	0.17	(4)	0.38	(4)	-0.10	(4)	0.78	(4)	0.72	(7)	0.17	(4)
Oilseeds	0.28	(5)	0.76	(5)	-0.05	(5)	1.29	(6)	0.79	(9)	0.28	(5)
Vegetables	0.40	(6)	1.03	(6)	0.01	(7)	1.26	(5)	0.77	(8)	0.40	(6)
Fruits	0.01	(3)	0.00	(3)	-0.12	(3)	0.00	(3)	0.04	(4)	0.01	(3)
Cattle	1.57	(8)	3.04	(8)	0.81	(9)	4.16	(8)	0.29	(5)	1.57	(8)
Milk	-0.50	(2)	-0.65	(2)	-0.26	(2)	-0.80	(2)	0.04	(3)	-0.50	(2)
Poultry, eggs	3.38	(10)	6.12	(10)	0.85	(10)	7.40	(10)	0.87	(10)	3.38	(10)
Fishing	1.30	(7)	2.77	(7)	-0.04	(6)	3.73	(7)	-0.37	(1)	1.30	(7)
					Dakar						**-0.79**	
Vegetables	0.00	(1)	0.00	(1)	0.75	(1)	0.00	(1)	0.00	(1)	0.00	(1)
					Thies-Diourbel						**-0.66**	
Sorghum, millet	1.83	(4)	3.80	(4)	-0.57	(3)	4.64	(4)	4.78	(4)	-5.31	(4)
Groundnuts	-0.82	(3)	-1.47	(3)	-0.74	(2)	-1.79	(3)	2.49	(3)	-16.82	(1)
Fruits	-4.12	(1)	-7.33	(1)	-0.95	(1)	-8.95	(1)	0.00	(1)	-16.72	(2)
Fishing	-2.74	(2)	-3.95	(2)	-0.20	(4)	-4.82	(2)	0.00	(1)	-9.01	(3)
					Northern						**-1.79**	
Rice	-3.89	(1)	-5.99	(1)	-1.54	(1)	-7.31	(1)	-0.20	(2)	-10.06	(4)
Vegetables	0.14	(3)	0.92	(3)	-0.50	(4)	1.12	(3)	0.61	(4)	-4.47	(5)
Fruits	6.24	(5)	10.10	(5)	-0.60	(2)	12.33	(5)	0.70	(5)	-12.55	(2)
Cattle	3.21	(4)	6.00	(4)	0.93	(6)	7.15	(4)	2.33	(6)	-0.85	(6)
Milk	-2.76	(2)	-4.27	(2)	-0.53	(3)	-5.21	(2)	-0.21	(1)	-12.93	(1)
Fishing	8.49	(6)	16.15	(6)	-0.16	(5)	19.71	(6)	-0.19	(3)	-10.62	(3)
					Central						**-2.59**	
Sorghum, millet	7.25	(6)	13.59	(6)	0.52	(5)	16.59	(6)	2.09	(4)	-1.24	(5)
Groundnuts	5.16	(5)	9.96	(5)	0.43	(4)	12.15	(5)	3.45	(6)	-1.96	(2)
Oilseeds	1.92	(2)	4.17	(2)	0.27	(2)	4.87	(2)	2.97	(5)	-1.77	(4)
Fruits	3.33	(4)	6.29	(3)	0.30	(3)	7.68	(4)	0.13	(2)	-2.23	(1)
Cattle	3.29	(3)	6.30	(4)	1.22	(6)	7.56	(3)	1.80	(3)	-1.03	(6)
Milk	-0.17	(1)	0.00	(1)	-0.14	(1)	0.00	(1)	0.11	(1)	-1.86	(3)
					Southern						**-1.75**	
Sorghum, millet	6.18	(8)	11.42	(8)	-0.11	(6)	13.94	(8)	-0.14	(1)	-5.64	(5)
Rice	-4.54	(2)	-7.44	(2)	-1.36	(1)	-9.09	(2)	0.00	(2)	-13.23	(2)
Groundnuts	5.44	(6)	8.49	(6)	-0.80	(5)	10.48	(6)	0.00	(2)	-4.35	(7)
Oilseeds	-0.59	(3)	-1.55	(3)	-1.05	(2)	-1.78	(3)	0.00	(2)	-4.46	(6)
Vegetables	-4.68	(1)	-7.59	(1)	-0.84	(4)	-9.14	(1)	0.00	(2)	-12.37	(3)
Fruits	0.79	(5)	1.42	(5)	-0.94	(3)	3.09	(5)	0.14	(9)	-15.62	(1)
Cattle	0.53	(4)	1.12	(4)	0.52	(8)	1.37	(4)	0.00	(2)	0.00	(8)
Poultry, eggs	5.74	(7)	10.21	(7)	0.54	(9)	12.46	(7)	0.00	(2)	0.00	(8)
Fishing	9.58	(9)	18.17	(9)	0.05	(7)	22.18	(9)	0.00	(2)	-8.97	(4)

Source: RIAPA CGE Model and SAM for Senegal.
Notes: Semi-PGE is the percentage point change in the poverty rate per one percent increase in GDP per capita driven by GDP growth originating from within the targeted sector. Poverty headcount rate is the share of the national or rural population with consumption levels below the official poverty line. Poverty gap rate is the cumulative distance between poor people's consumption levels and the poverty line.

At the regional level**,** while increasing production of groundnuts, fruits, and fishery are effective at reducing poverty headcount in Thies-Diourbel, expanding sorghum and millet in addition to the three value-chains improve the national poverty gap as well.

Table 11. Dietary-Diversity-Growth Elasticity (DDGE) results

	Estimated DDGE (sectoral rank in parentheses)		
	All households	**Rural households**	**Poor rural households**
	National		
Sorghum, millet	0.52 (3)	0.26 (3)	0.22 (3)
Rice	-0.44 (9)	-0.05 (7)	0.00 (7)
Groundnuts	0.22 (4)	0.14 (4)	0.14 (5)
Oilseeds	0.05 (7)	0.06 (6)	0.06 (6)
Vegetables	0.72 (2)	0.27 (2)	0.24 (2)
Fruits	2.28 (1)	1.25 (1)	1.51 (1)
Cattle	0.07 (6)	-0.09 (8)	-0.19 (9)
Milk	0.11 (5)	0.14 (5)	0.19 (4)
Poultry, eggs	-0.60 (10)	-0.20 (9)	-0.13 (8)
Fishing	-0.29 (8)	-0.23 (10)	-0.31 (10)
	Dakar		
Vegetables	0.02 (1)	0.00 (1)	0.00 (1)
	Thies-Diourbel		
Sorghum, millet	0.07 (2)	0.07 (2)	0.10 (2)
Groundnuts	0.03 (3)	0.04 (3)	0.05 (3)
Fruits	0.21 (1)	0.14 (1)	0.17 (1)
Fishing	-0.01 (4)	0.01 (4)	0.01 (4)
	Northern		
Rice	-0.12 (6)	-0.01 (5)	0.02 (4)
Vegetables	0.11 (2)	0.07 (2)	0.08 (3)
Fruits	0.58 (1)	0.33 (1)	0.43 (1)
Cattle	0.03 (4)	0.01 (4)	0.00 (5)
Milk	0.05 (3)	0.07 (3)	0.08 (2)
Fishing	-0.04 (5)	-0.03 (6)	-0.02 (6)
Central			
Sorghum, millet	0.06 (2)	0.02 (3)	-0.03 (5)
Groundnuts	0.03 (4)	0.01 (4)	-0.01 (4)
Oilseeds	-0.01 (6)	0.01 (5)	0.00 (3)
Fruits	0.69 (1)	0.35 (1)	0.41 (1)
Cattle	0.02 (5)	-0.06 (6)	-0.09 (6)
Milk	0.03 (3)	0.03 (2)	0.04 (2)
	Southern		
Sorghum, millet	0.24 (2)	0.10 (2)	0.09 (2)
Rice	-0.10 (8)	-0.03 (6)	-0.06 (7)
Groundnuts	0.06 (4)	0.03 (5)	0.02 (4)
Oilseeds	0.05 (5)	0.03 (4)	0.03 (3)
Vegetables	0.09 (3)	0.03 (3)	0.00 (5)
Fruits	0.82 (1)	0.42 (1)	0.49 (1)
Cattle	0.02 (6)	-0.05 (7)	-0.08 (8)
Poultry, eggs	-0.12 (9)	-0.06 (8)	-0.05 (6)
Fishing	-0.04 (7)	-0.07 (9)	-0.10 (9)

Source: RIAPA CGE Model and SAM for Senegal.
Notes: Dietary diversity score (DDS) measures the unevenness of the real value of consumption across major food groups (i.e., negative entropy distance from equality). DDGE is the percentage change in the DDS per one percent increase in GDP per capita driven by GDP growth originating within the targeted agricultural sector.

4.3. Nutrition effects

Table 11 reports dietary-diversity-growth elasticities (DDGE), which show how effective value-chains are at improving nutrition outcomes of household groups. We define nutrition outcomes by dietary diversity, which is estimated using a generalized entropy measure across seven food categories – cereals and root crops; vegetables; fruits; meat, fish and eggs; milk and dairy; pulses and oilseeds; and meals prepared outside the household. Diversity is measured by expenditures across seven food groups. Two food groups – cereals and root crops, and meat, eggs, and fish – are already the dominant food groups, and so expanding these agricultural goods' production reduces dietary diversity (by increasing availability and reducing prices).

Overall, the value-chains that are most effective at promoting dietary diversity amongst poor rural households are fruits, vegetables, groundnuts, milk, and sorghum and millet.

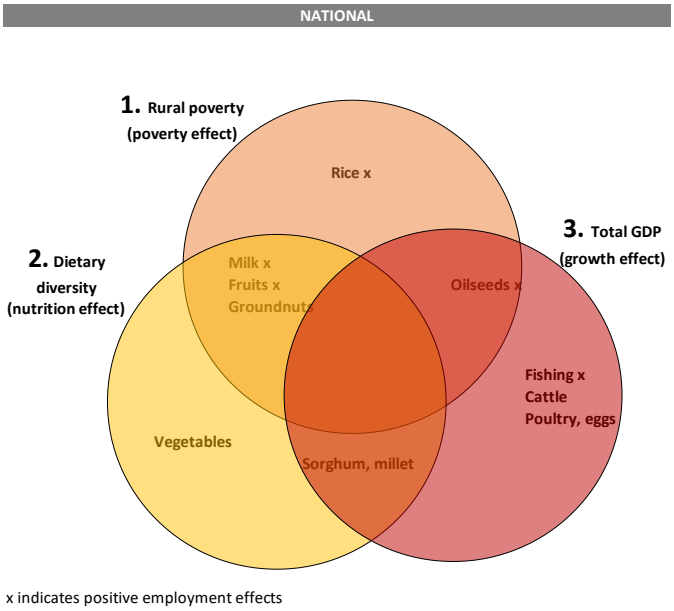
Fruits is the most effective value chain at promoting nutrition in all four regions where fruits are grown. Growth led by vegetables shows positive impact on households' nutrition in Dakar, the Northern and the Southern regions. Likewise, growth in the milk sector improves nutrition in the Northern and Central regions, while growth in the rice sector can worsen nutrition in the Northern and Southern regions.

5. Final Assessment

Figure 3 and Figures 4-7 show respectively the national and regional five highest ranked value-chains across three targeted outcomes: (1) reducing rural poverty headcount rate; (2) diversifying poor rural households' diets; and (3) promoting national AFS GDP growth. The value-chains with stronger employment effects are marked with an "x".

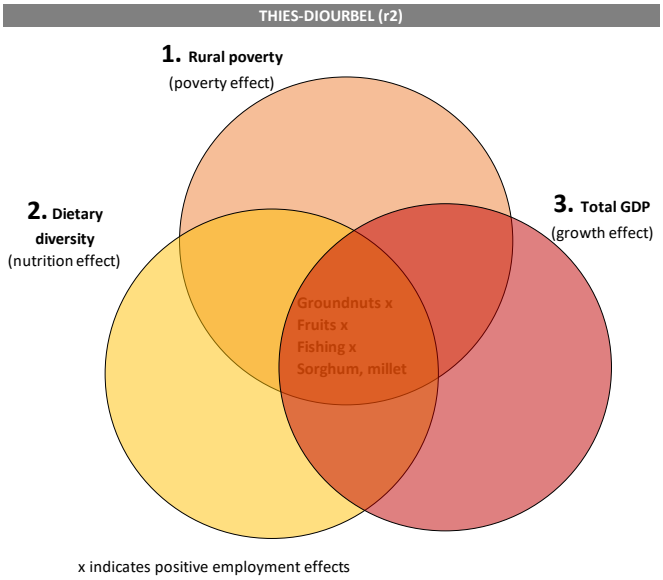
At the national level, there is no value-chain that is effective at reaching the four objectives at the same time. We can derive from the combination of the rankings in Table 8-11 and Figure 3 that rice is the most effective value chain at reducing poverty and creating jobs. Fishery is the most effective at generating economy-wide growth. It has also a positive employment effect, but it does not help reduce poverty nor diversify diets. The fruits sector is the most effective at diversifying diets; it has also a positive employment effect. Along with milk and groundnuts, the three sectors are very effective at improving nutrition. They also reduce poverty, but do not have impacts on national growth.

Figure 3. Agricultural value-chains in Senegal with strong poverty, nutrition, economic growth, and employment effects: NATIONAL



Dakar is the first region. Being a very urbanized region, Dakar depends less on agriculture. Vegetables is the only sector for potential expansion. Vegetables is effective at achieving the three targeted outcomes at the same time.

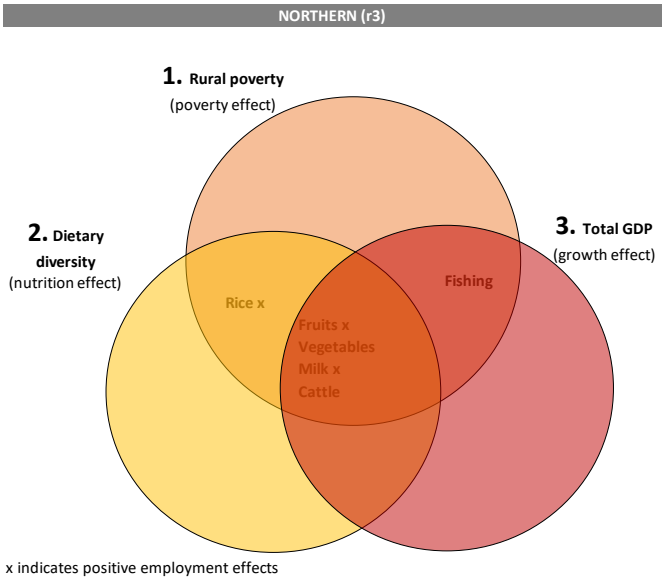
Figure 4. Agricultural value-chains in Senegal with strong poverty, nutrition, economic growth, and employment effects: THIES-DIOURBEL



Groundnuts, fruits, fishery, and sorghum and millet - the four potential value chains for expansion in Thies-Diourbel - are effective at reaching the three targeted outcomes at the same time. Figure 4 and the ranking results in Tables 8-11 implies that the fruits sector is the most effective at reducing poverty in the region. The sector is also in the first rank to improve diet diversity and create jobs.

Fishery is the most effective at promoting growth. Groundnuts value chain is the third to have impacts on each of the four targeted outcomes. Sorghum and millet sector is second in promoting growth.

Figure 5. Agricultural value-chains in Senegal with strong poverty, nutrition, economic growth, and employment effects: NORTHERN REGION



Fruits, vegetables, milk, and cattle are the value-chains in the Northern region which are effective at reaching the three targeted outcomes at the same time. Combined with the ranking results in Tables 8-11, Figure 3 shows that irrigated rice is the most effective at reducing rural poverty in the Northern region. Fruits is the most effective at diversifying diets. Fishery is the most effective at generating growth while having some positive impact on the rural poverty rate. Milk is the first value chain to create jobs.

Figure 6. Agricultural value-chains in Senegal with strong poverty, nutrition, economic growth, and employment effects: CENTRAL REGION

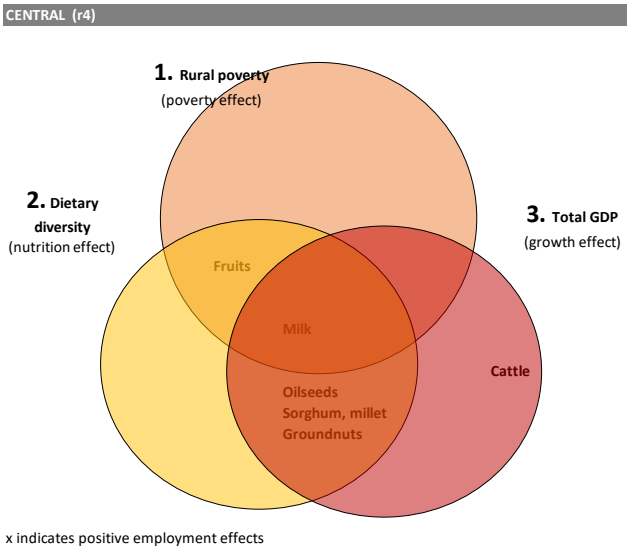
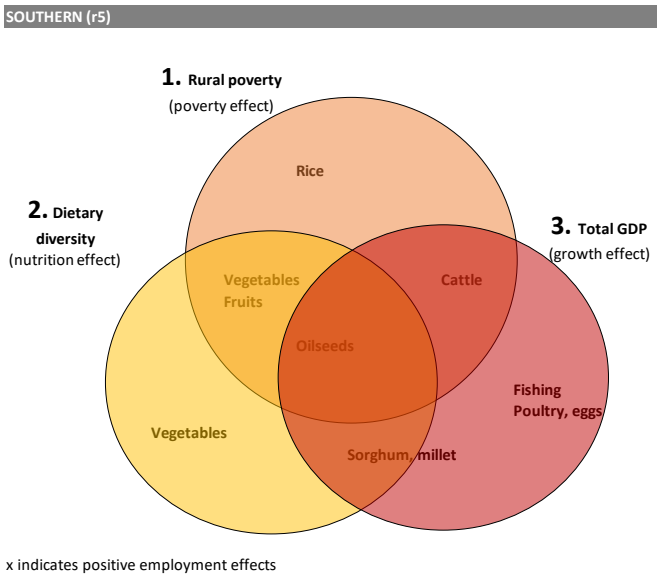


Figure 6 combined with the ranking results in Tables 8-11 shows that milk is the most effective at reducing rural poverty in the Central region; milk is also a strong job-creating value-chain and effective in generating growth and improving nutrition. Fruits is the most effective at diversifying diets. Cattle is the most effective at generating growth

Figure 7. Agricultural value-chains in Senegal with strong poverty, nutrition, economic growth, and employment effects: SOUTHERN REGION



The Southern region has the most diverse potential value-chains for expansion among the five regions. Combined with the ranking results in Tables 8-11, Figure 7 shows that the vegetables sector is the most effective at reducing poverty in the region, followed by the rainfed rice sector. The latter is the first at creating jobs. Fishery is the most effective at generating growth followed by cattle, while the latter is also effective at reducing poverty in the region. Like other region, the fruits sector is the most effective at diversifying diets.

CONCLUSION

National and regional priorities may diverge because of socio-economic and agro-ecological potential variation within countries, or due to differences in the weighing of targeted outcomes. This paper aims at determining which national and regional agricultural value-chains, if scaled-up, are most effective at accelerating economic growth, creating jobs on and off the farm, reducing rural poverty, and improving nutrition by diversifying diets.

The economic growth priorities are identified through key economy-wide transmission channels that determine the impacts of expanding agricultural value chains, namely the forward and backward linkages of agricultural activities, the extent of tradability of agricultural commodities and the income elasticities of demand for these commodities. Poor households' factor endowments, their sources of income, and their consumption patterns are the main determinant of the effects of promoting a value chain on poverty and nutrition.

Using the framework of the dynamic economic modeling RIAPA approach, simulation results indicate that there is no value-chain that is effective at reaching the four objectives at the same time.

Fishery is the most effective at generating economy-wide growth. Rice is the most effective value chain at reducing poverty and creating jobs. It also has a positive employment impact. Fruits, milk, and groundnuts sectors are very effective at improving nutrition, as well as reducing poverty nationally.

At the regional level, the results show that expanding fishery in Thies-Diourbel, the Northern, and the Southern regions is also the most effective at generating national growth. However, millet expansion is superior to fishery in promoting regional growth in Thies-Diourbel and the Southern region, while cattle outperforms fishery in the Northern region. Promoting rice in the Northern, and Southern regions are also the most effective at reducing national poverty. Growth led by the fruits sector is the most effective at improving nutrition in all four regions where fruits are grown (Thies-Diourbel, the Northern, Central, and Southern regions). In addition to the shared national and regional priority value chains, regions may have their own priorities. For instance, cattle are the first sector to generate growth in the Northern region; or milk is the most effective at creating jobs in the Central regions.

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Appendix

Table A1. Composition of value-chain product categories for Senegal

Category	Detailed agricultural products in the product category or value-chain
Sorghum, millet	Sorghum; millet
Rice	Rice
Groundnuts	Groundnuts
Oilseeds	Palm fruits, sesame seeds, cotton seeds
Vegetables	Green beans, onions, okra, eggplants, cabbages, other vegetables
Fruits	Watermelons, mangoes, other fruits
Cattle	Cattle
Milk	Milk, dairy
Poultry, eggs	Poultry, eggs
Fishing	Capture fisheries

Source: RIAPA CGE Model and SAM for Senegal.

Table A2. Regional contribution to national economy of Senegal, 2015

Region	Province	GDP (%)	Employment (%)
Dakar	**Dakar**	55.3	57.1
Thies-Diourbel	Thies-Diourbel	17.2	15.6
Central	Fatick, Kaffrine, Kaolack, Louga	10.1	10.1
Northern	Saint-Louis, Matam	9.1	9.5
Southern	Kedougou, Kolda, Sedhiou, Tambacounda, Ziguinchor	8.3	7.8

Source: RIAPA CGE Model and SAM for Senegal.

Table A3. Classification of the Senegal SAM and RIAPA CGE model

Quintiles (q=5)	Activities and commodities			Households (h=15)
	Agriculture	**Agro-processing**	**Other non-agriculture**	
Quintile 1	Maize	Meat processing	Crude oil	Urban
Quintile 2	Sorghum and millet	Fish and seafood processing	Other mining	Rural - farm
Quintile 3	Rice	Dairy	Petroleum products	Rural - nonfarm
Quintile 4	Wheat and barley	Fruit and vegetable processing	Fertilizers and herbicides	
Quintile 5	Other cereals	Fats and oils	Other chemicals	
	Pulses	Maize milling	Non-metal minerals	**Other accounts**
Regions (r=5)	Groundnuts	Sorghum and millet milling	Metals and metal products	
	Other oilseeds	Rice milling	Machinery and other equipment	Enterprises*r
Dakar	Cassava	Other grain milling	Electrical equipment	Government
Thies & Diourbel	Irish potatoes	Sugar refining	Vehicles and transport equipment	Taxes - direct
Saint-Louis & Matam	Sweet potatoes	Other foods	Other manufacturing	Taxes - factor
Louga, Kaolack,	Leafy vegetables	Animal feed	Electricity, gas and steam	Taxes - import
Fatick & Kaffrine	Other vegetables	Beverages	Water supply and sewage	Taxes - sales
Ziguinchor, Sedhiou,	Sugarcane	Tobacco processing	Construction	Savings-investment
Kolda, Kedougou	Tobacco	Cotton yarn	Wholesale and retail trade	Change in stocks
& Tambacounda	Cotton and fibres	Textiles	Transportation and storage	Rest of world
	Nuts	Clothing	Accommodation	Transaction costs
	Bananas and plantains	Leather and footwear	Restaurants and food services	Total
Factors of production (f=9)	Other fruits	Wood products	Information and communication	
	Leaf tea	Paper products and publishing	Finance and insurance	
Labor - uneducated	Other crops		Real estate activities	
Labor - primary	Cattle		Business services	
Labor - secondary	Raw milk		Public administration	
Labor - tertiary	Poultry		Education	
Land	Small ruminants		Health and social work	
Capital - crops	Other livestock		Other services	
Capital - livestock	Forestry			
Capital - mining	Aquaculture			
Capital - non-primary	Capture fisheries			

Source: Randraimanonjy and Thurlow (mimeo.).