Cereal Systems and Food Security in Senegal: A Recursive Dynamic Economy-Wide and Distributional Analysis

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Abstract

Senegal's food system is increasingly challenged by rising cereal demand, import dependence, and exposure to international food price shocks. While rice has become the dominant staple food, traditional cereals such as millet remain essential for rural livelihoods, subsistence consumption, and climate resilience. This paper analyses Senegal's cereal system using a recursive dynamic computable general equilibrium (CGE) model combined with a microsimulation approach to assess the impacts of cereal productivity growth and external rice import price shocks on growth, trade, food security, and poverty. Four scenarios are simulated over 2025–2030: rice productivity improvement, millet productivity improvement, an increase in world rice import prices, and a combined diversification scenario.

The results show that productivity improvements in domestic cereals strengthen economic growth, reduce import dependence, and improve household welfare, particularly in rural areas. Millet productivity generates the strongest poverty-reduction effects, while higher rice import prices negatively affect household consumption and increase vulnerability in urban and deficit-producing regions. The diversification scenario partially offsets these adverse effects by improving domestic cereal supply and strengthening food-system resilience.

The findings suggest that food security strategies in Senegal should move beyond a narrow focus on rice self-sufficiency toward a broader cereal-system approach that combines productivity growth, diversification, and resilience-oriented agricultural policies.

Keywords: Food security, Cereal Systems, CGE Model, Microsimulation, Poverty, Senegal

1. Introduction

Recent global crises—including the 2008 food price crisis, the COVID-19 pandemic, and the war in Ukraine—have exposed the vulnerability of global food systems and intensified concerns over food security, particularly in import-dependent economies (Headey and Fan, 2008; Timmer, 2010; Glauben et al., 2022). Rising cereal and energy prices associated with these shocks have aggravated existing tensions in agricultural commodity markets, disproportionately affecting low-income food-importing countries (Glauben et al., 2022). According to the Food and Agriculture Organization (FAO), more than 280 million people in Africa were undernourished by 2020 (FAO, 2021). Food security and poverty reduction therefore remain central development priorities in SSA and are directly linked to Sustainable Development Goals (SDGs) 1 and 2 (United Nations, 2015) Food security encompasses not only food availability, but also access, utilization, and stability over time (Barrett, 2010).

The 2008 food crisis demonstrated the extent to which African economies dependent on food imports are vulnerable to international market volatility and supply disruptions. Increases in global food prices can generate substantial impacts on household welfare, poverty, and political stability (Demont, 2013; Seck et al., 2010). These concerns are particularly important for rice, whose consumption has increased rapidly across West Africa due to urbanization, population growth, and changing dietary preferences (Arouna et al., 2017). However, domestic rice production has generally failed to keep pace with demand growth, leading to increasing dependence on imports throughout the region.

Senegal represents a particularly relevant case of a structurally food-deficit economy undergoing rapid dietary transformation. Rice has become the dominant staple food and constitutes a central component of both urban and rural diets. Annual per capita rice consumption exceeds 80 kg, placing Senegal among the largest rice consumers in West Africa. Despite substantial increases in domestic production over the last decade, the country remains highly dependent on imported rice to satisfy domestic demand. Senegal is therefore highly exposed to external market shocks, including international price volatility, export restrictions, and disruptions in global supply chains (Clapp, 2017).

In response, the Government of Senegal has made food security and agricultural transformation central pillars of national development policy. Since the adoption of the Plan Sénégal Émergent (PSE), several programs have promoted irrigation expansion, mechanization, improved seed varieties, fertilizer use, and investments in rice value chains. Previous studies emphasize that improving competitiveness in domestic rice markets also requires investments in value-chain upgrading, processing quality, and market integration (Demont and Rizzotto, 2012; Arouna et al., 2021). The National Strategy for Rice Development

(NSDR) has contributed to a significant increase in domestic rice production, yet national output still covers less than half of total domestic demand.

At the same time, traditional cereals—particularly millet—remain essential components of Senegal's rural food systems and livelihoods. Unlike rice, millet is primarily produced under rainfed conditions and is closely associated with subsistence-oriented farming systems. Millet production relies heavily on labour and rainfed land and plays an important role in supporting food access, resilience, and income generation in semi-arid rural areas vulnerable to climate variability.

The coexistence of a market-oriented and import-dependent rice system with a subsistence-oriented millet system creates a dual cereal economy with important implications for food security and resilience. Rice contributes primarily to urban food supply and market integration, while millet supports rural food security and climate resilience through own-consumption and lower dependence on imported inputs. These cereals therefore play complementary rather than substitutable roles within Senegal's food system.

Despite the importance of these interactions, most existing studies focus mainly on rice self-sufficiency and do not explicitly analyze the broader cereal system, the coexistence of irrigated and rainfed production systems, or the role of subsistence-oriented agriculture in food security and poverty reduction. This limits the ability to assess the economy-wide and distributional impacts of alternative agricultural and trade strategies. Rather than focusing exclusively on rice self-sufficiency, this paper adopts a broader cereal-system perspective that considers complementarities between imported staples and traditional domestic cereals

This paper addresses this gap by analyzing Senegal's cereal system within a recursive dynamic computable general equilibrium (CGE) framework combined with a microsimulation approach. The analysis explicitly distinguishes between rice and millet production systems, between irrigated and rainfed agriculture, and between subsistence and market-oriented activities. The model is calibrated using a highly disaggregated Social Accounting Matrix (SAM) for Senegal and incorporates regional heterogeneity across the country's 14 administrative regions.

The paper contributes to the literature in three main ways. First, it develops an integrated economy-wide framework that captures the coexistence of irrigated commercial cereal systems and rainfed subsistence-oriented systems. Second, it evaluates the impacts of productivity improvements, external import price shocks, and diversification strategies across cereals. Third, it assesses the implications of these scenarios for growth, food security, poverty, and regional inequality using a recursive dynamic CGE-microsimulation approach.

The remainder of the paper is organized as follows. Section 2 presents the data and describes the structure of Senegal's cereal economy and the Social Accounting Matrix used for model calibration. Section 3 describes the model and methodology. Section 4 presents the baseline and policy simulation scenarios. Section 5 discusses the simulation results and their implications for food security and poverty reduction. Section 6 concludes and provides policy recommendations.

2. Data and Structure of the Senegalese Cereal Economy

2.1 Social Accounting Matrix

The model is calibrated based on highly disaggregated Social Accounting Matrix (SAM) for 2014 (Mainar Causapé et al. 2018) which was updated using the model recursive dynamics to the year 2021. A SAM is a comprehensive, economy-wide database to represent all the economic transactions carried out among the agents of a specific economy over a period, generally one year. The SAM represents 61 production activities and 70 commodities, with a detailed regional disaggregation across 14 administrative regions and a distinction between rural and urban households.

A key feature of the SAM is the explicit disaggregation of cereal systems, particularly rice and millet. Rice production is represented both as household-based regional activities and as commercial market-oriented production, while millet is primarily modeled as a household-based activity with significant subsistence consumption. The SAM distinguishes three production channels:

1. Subsistence household production consumed directly by households;
2. Household market-oriented production supplying domestic markets; and
3. Commercial agricultural production.

This structure allows for a detailed representation of production systems, market participation, and regional heterogeneity.

The SAM also distinguishes between multiple factors of production, including skilled, semi-skilled, and unskilled labour, agricultural capital, and land differentiated by irrigation status (irrigated and rainfed). This structure enables the model to capture technological differences across crops and production systems.

2.2 Structure of Rice and Millet Production Systems

The benchmark SAM reveals a strongly differentiated cereal production structure in Senegal.

Rice production combines irrigated and rainfed systems and exhibits relatively high levels of commercialization and capital intensity. Irrigated regions account for nearly half of total rice production and more than three-quarters of irrigated land use and agricultural capital employed in rice production. Commercial rice production also represents a significant component of total output, indicating strong integration with domestic markets.

Rice production in irrigated zones is concentrated in the Senegal River Valley, particularly in Saint-Louis and Matam, where irrigation infrastructure and public investment programs have supported the expansion of production. In contrast, rainfed rice production remains important in Casamance.

Millet production exhibits a very different structure. Production is entirely rainfed and overwhelmingly concentrated in subsistence-oriented farming systems located in the groundnut basin and other central and eastern regions. Millet production relies heavily on labour and rainfed land, with only a limited commercial component.

The benchmark results therefore suggest the existence of two complementary cereal systems:

- a market-oriented and irrigated rice system linked to urban consumption and imports; and
- a rainfed and subsistence-oriented millet system contributing to rural resilience and food security.

Table 1: Production Systems of Rice and Millet

		Labour			Land		
	Production	Skilled	Semi	Unskilled	Irrigated	Rainfed	Capital
Rice Activities							
Subsistence farming							
Irrigated zones	49.1	22.7	44.0	53.1	77.4	0.8	56.8
Casamance	23.6	38.4	33.1	18.7	0.7	33.3	16.0
Groundnut basin	1.6	1.2	0.7	0.9	0.1	9.2	1.6
Other regions	4.9	4.2	2.6	3.3	0.8	6.8	5.8
Commercial farming	20.8	33.5	19.6	23.9	21.1	49.9	19.8
Total	100	100	100	100	100	100	100
Millet Activities							
Subsistence farming							
Irrigated zones	2.0	0.4	0.8	0.6	0.0	3.3	6.3
Casamance	8.3	7.2	12.4	6.7	0.0	9.5	7.8
Groundnut basin	39.0	51.5	41.5	43.1	0.0	38.6	25.9
Other regions	43.7	30.0	36.9	41.1	0.0	44.8	49.8
Commercial farming	7.0	10.9	8.4	8.5	0.0	3.7	10.1
Total	100	100	100	100	0	100	100

Source: Authors' own computation based on the SAM

2.3 Consumption Structure and Food Systems

The SAM also reveals important differences in the structure of cereal consumption across household groups and regions.

Subsistence consumption is overwhelmingly concentrated among rural households for both cereals, particularly in Casamance and the groundnut basin. In contrast, marketed consumption is dominated by urban households, especially in the case of rice, where urban consumers account for more than three-quarters of marketed demand nationally.

Millet exhibits a relatively stronger rural-market component than rice, reflecting its continued importance within local and regional food systems. These findings suggest that rice functions primarily as an urban market staple, while millet plays a broader role in supporting rural food security and resilience.

Taken together, the production and consumption structures indicate that Senegal's food security depends on the interaction between a market-oriented irrigated rice system and a rural subsistence-oriented millet system.

Table 2: Rice and Millet consumption by sources and region (% distributions)

	Subsistence		Marketed	
	Urbaan	Rural	Urbaan	Rural
Rice				
Irrigated zones	23.5	76.5	49.4	50.6
Casamance	6.6	93.4	61.1	38.9
Groundnut basin	9.2	90.8	58.5	41.5
Other regions	40.3	59.7	82.7	17.3
Total	**24.7**	**75.3**	**75.2**	**24.8**
Millet				
Irrigated zones	24.1	75.9	49.3	50.7
Casamance	4.4	95.6	48.2	51.8
Groundnut basin	17.2	82.8	35.3	64.7
Other regions	10.9	89.1	60.3	39.7
Total	**11.5**	**88.5**	**55.0**	**45.0**

Source: Authors' own computation based on the SAM

3. Model and Methodology

This study uses a recursive dynamic computable general equilibrium (CGE) model, namely DEMETRA (Dynamic Equilibrium Model for Economic development Resources and Agriculture) (McDonald et al., 2016; Boulanger et al. (2019)), and microsimulation approach to assess the impacts of reducing trade costs and improving rice productivity on growth, food security, and poverty. The DEMETRA recursive dynamic framework has been widely applied to analyse structural transformation, trade integration, and food-security shocks in African economies (Boulanger et al., 2019; Nechifor et al., 2020, 2021, 2022). The model captures production, consumption, trade, and factor market interactions across sectors, regions, and institutions, and is calibrated to reproduce the benchmark SAM equilibrium.

Production is modeled using a nested structure combining Leontief and constant elasticity of substitution (CES) functions. At the top level, output is produced using intermediate inputs and value added. Intermediate inputs are combined in fixed proportions, while value added is represented as a CES aggregation of primary factors.

The model distinguishes skilled, semi-skilled, and unskilled labour, agricultural capital, and land differentiated by irrigation status. Rice production uses both irrigated and rainfed land

and is relatively capital-intensive, while millet production relies almost exclusively on rainfed land and is more labour-intensive.

The explicit representation of subsistence and market-oriented production systems constitutes one of the key innovations of the analysis. Household behavior is modeled using a two-level demand system combining a Stone-Geary (LES) utility function with CES aggregation across commodity groups. This allows the model to represent both minimum consumption requirements and substitution across commodities. The model explicitly captures subsistence production and consumption, particularly for millet, enabling the analysis of food security and resilience effects associated with own-consumption systems.

The model adopts the Armington assumption, distinguishing between domestic and imported goods. Imports and domestic products are treated as imperfect substitutes, while producers allocate output between domestic and export markets through a constant elasticity of transformation (CET) function.

Senegal is modeled as a small open economy taking world prices as exogenous. The exchange rate adjusts to maintain external balance. Particular attention is given to rice imports because Senegal remains structurally dependent on imported rice to satisfy domestic demand. The Armington elasticity between imported and domestic rice is therefore set at a relatively low level (1.5), reflecting limited substitutability between imported and locally produced rice due to differences in quality, processing, and consumer preferences. Existing empirical evidence suggests that imported and domestic rice are treated as differentiated products, especially among urban consumers.

The model is solved recursively from 2014 to 2030. Capital accumulates over time through investment and depreciation, labour supply evolves with population growth, and productivity changes are introduced exogenously. Land is assumed to be fixed by type (irrigated and rainfed), reflecting structural constraints in agricultural production.

A baseline scenario is first generated to represent a business-as-usual growth path over the period 2014–2030. Policy scenarios are subsequently introduced progressively from 2025 onwards and evaluated relative to the baseline.

A top-down microsimulation approach is used to assess poverty and distributional impacts. Changes in representative household consumption generated by the CGE model are transmitted to micro-level household survey data, allowing the computation of poverty indicators based on Foster-Greer-Thorbecke (FGT) measures.

The household disaggregation, consumption and poverty line information are based on the Harmonized Survey on Households Living Standards 2018-2019 (EHCVM 2018/19) (ANSD, 2021). The EHCVM is a nationally representative survey of 7,100 households, which are also representative of the geopolitical zones (at both the urban and rural level), and took place between September 2018 and July 2019.

4. Baseline and Simulation Scenarios

To evaluate the implications of cereal productivity improvements and external market vulnerabilities in Senegal, four simulation scenarios were designed within the recursive dynamic CGE framework. The scenarios are implemented progressively over the period 2025–2030 relative to the business-as-usual baseline trajectory.

Scenario 1 (S1): Rice Productivity Improvement by 10%

This scenario simulates a 10% improvement in domestic rice productivity. The shock captures technological progress and production-enhancing interventions such as irrigation expansion, improved seed varieties, mechanization, extension services, and more efficient input use. Within the model, the shock is implemented as a productivity increase in rice-producing activities.

The scenario evaluates the extent to which strengthening domestic rice production can reduce Senegal's dependence on imported rice, improve household welfare, and enhance food security outcomes.

Scenario 2 (S2): Millet Productivity Improvement by 10%

This scenario introduces a 10% increase in millet productivity. The objective is to assess the economic and nutritional role of traditional cereals in strengthening agricultural resilience and reducing reliance on imported staples.

The productivity gains represent improvements in climate-resilient agricultural practices, better seed systems, enhanced extension support, and improved access to agricultural inputs for millet producers. As with S1, the intervention is modelled through a productivity enhancement in millet-producing activities.

Scenario 3 (S3): External Rice Import Price Shock by 15%

Scenario 3 examines Senegal's vulnerability to international rice market disturbances by imposing a 15% increase in the world import price of rice (PWM). The shock reflects adverse global market conditions such as international food price crises, export restrictions by major exporters, rising transportation costs, or exchange-rate-induced import price increases.

The increase is implemented directly through the world import price variable for rice imports, allowing the model to capture transmission effects on domestic prices, household consumption, trade balances, and macroeconomic stability.

Scenario 4 (S4): Diversification and Resilience Package

The final scenario combines the previous interventions by simultaneously introducing:

- a 10% increase in rice productivity,
- a 10% increase in millet productivity, and
- a 15% increase in the world import price of rice.

This integrated scenario evaluates whether domestic cereal productivity improvements can mitigate the adverse effects of external import price shocks. It represents a resilience-oriented diversification strategy aimed at strengthening domestic food systems while reducing exposure to international market volatility.

The scenario is particularly relevant for assessing the potential of combined productivity policies to improve food security, stabilize household welfare, and enhance the resilience of Senegal's cereal economy under external shocks.

The magnitude of the simulated shocks is chosen to reflect realistic and empirically grounded changes in Senegal's cereal system. Empirical evidence from West Africa suggests that productivity gains under farmer conditions generally range between 5% and 20%, despite larger gains observed in experimental trials. A conservative productivity increase of 10% is therefore adopted for both rice and millet.

For millet, empirical studies in Senegal and the Sahel indicate that improved seed adoption and climate-smart agricultural practices can substantially increase yields under rainfed conditions (Abdulai and Huffman, 2014; Sultan and Gaetani, 2016).

In the case of rice, productivity improvements are associated with irrigation development, mechanization, improved varieties, and value-chain modernization. However, structural constraints linked to processing quality, market access, and consumer preferences continue to limit the substitutability between imported and domestic rice (Seck et al., 2013; Demont and Ndour, 2015).

The 15% import price shock reflects the magnitude of fluctuations observed during recent global food crises, including the 2008 food crisis and subsequent international market disruptions (FAO, 2011; Headey and Fan, 2008; World Bank, 2022).

5. Results

5.1. Impacts on macro indicators

Figure 1 summarizes the macroeconomic impacts of the four simulation scenarios relative to the baseline in 2030. The results show clear differences between productivity-enhancing policies and external import-price shocks.

Under **Scenario 1 (S1)**, a 10% increase in rice productivity generates moderate positive effects on the economy. Household consumption rises by 0.26%, household income by 0.17%, and GDP by 0.16%. Production and exports also increase slightly, reflecting improved domestic rice supply and competitiveness.

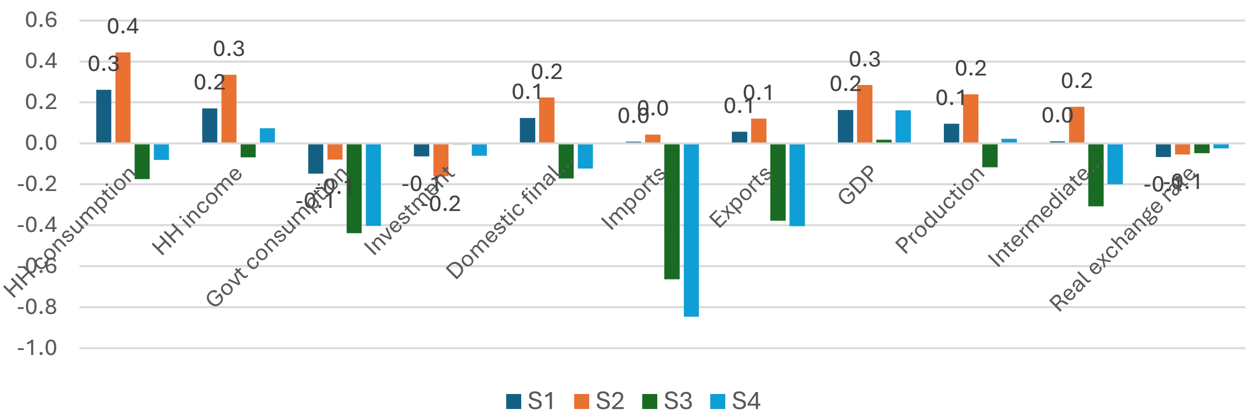
The strongest positive effects are observed under **Scenario 2 (S2)**, which increases millet productivity by 10%. Household consumption and income rise by 0.44% and 0.33%, respectively, while GDP increases by 0.28%. Production and intermediate input demand also expand significantly. These results highlight the important role of millet in supporting rural livelihoods, domestic demand, and food security.

In contrast, **Scenario 3 (S3)**, which simulates a 15% increase in world rice import prices, produces contractionary effects. Household consumption declines by 0.17%, imports fall by 0.66%, and production decreases by 0.12%. The results illustrate Senegal's vulnerability to external rice market shocks due to its high dependence on imported rice.

Finally, **Scenario 4 (S4)** combines rice and millet productivity improvements with the external rice price shock. Although household consumption remains slightly negative (-0.08%), GDP still grows by 0.16%, suggesting that domestic productivity gains partially offset the adverse effects of higher import prices. The diversification strategy therefore improves economic resilience relative to the import shock scenario alone.

Overall, the findings suggest that productivity growth in domestic cereals—particularly millet—can strengthen economic performance and reduce vulnerability to external food-price shocks.

Figure 1: Impacts on macro indicators (% change from the base in 2030)



Source: Authors' own computation based on simulations

5.2. Impacts on productive sectors, prices, demand and trade

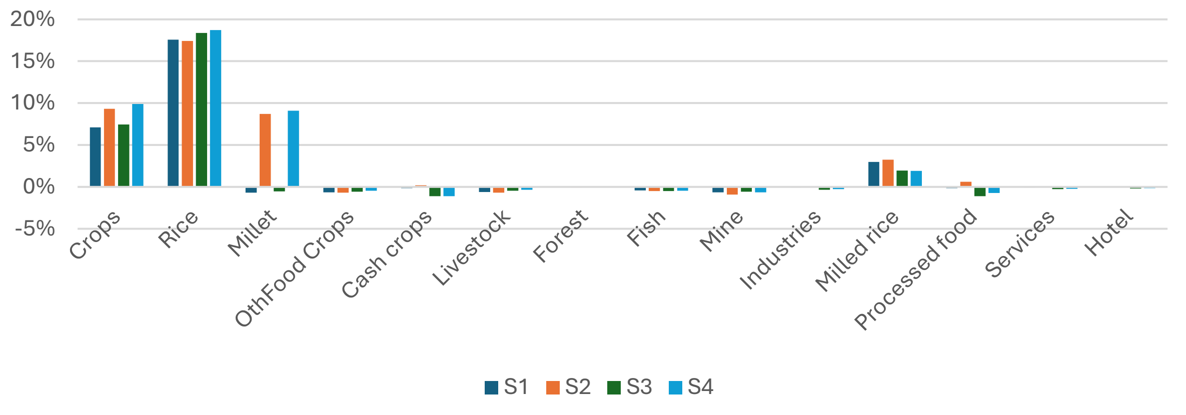
Figure 2 shows that cereal productivity improvements generate strong expansion effects within agriculture, particularly for rice and millet production. Under **S1**, rice production increases by 17.6%, contributing to overall crop growth of 7.1% and stimulating the milled rice sector (+3.0%). However, some non-targeted agricultural activities decline slightly, reflecting resource reallocation toward rice.

Under **S2**, millet productivity growth produces broader agricultural gains. Millet production rises by 8.7%, while total crop production increases by 9.3%. Rice production also expands significantly (+17.4%), suggesting complementarities within the cereal economy.

In **S3**, higher rice import prices stimulate domestic rice production (+18.4%) through import substitution. However, most non-rice sectors contract, including cash crops, processed food, industries, and services, reflecting weaker domestic demand and higher production costs.

The combined diversification strategy in **S4** generates the strongest overall crop expansion (+9.9%), with large increases in both rice (+18.7%) and millet (+9.1%) production. Overall, the results highlight the importance of cereal productivity growth for strengthening agricultural production and food-system resilience

Figure 2: Impacts on sectoral production (% change from the base in 2025)



Source: Authors' own computation based on simulations

Table 3 indicates that productivity improvements in rice and millet increase domestic food demand while generally reducing food prices. Under **S1**, rice demand rises by 13.3%, while rice prices decline by 4.6%, reflecting improved domestic supply conditions. Millet demand declines slightly, suggesting substitution toward rice consumption.

Under **S2**, millet demand increases strongly (+8.6%) and millet prices fall sharply (-8.0%), improving food affordability, particularly for rural households. Rice prices also decline, indicating improved overall cereal supply conditions.

In contrast, **S3** generates inflationary pressures. Although domestic rice demand increases (+14.4%), prices for milled rice and processed food rise due to higher import costs. The import shock therefore weakens consumer welfare despite higher domestic production.

Under **S4**, productivity gains partly offset the adverse effects of higher rice import prices. Demand for both rice and millet increases, while millet prices continue to decline substantially. However, rice and milled rice prices remain above baseline levels due to continued external price pressures.

Overall, the results suggest that cereal productivity growth improves food affordability and domestic demand, while import-price shocks increase food inflation and reduce welfare.

Table3: Impacts on domestic demand and prices (% change from the base 2030)

	Domestic demand (% change from base 2030)				Domestic Prices (% change from base 2030			
	S1	S2	S3	S4	S1	S2	S3	S4
Crops	5.4%	8.1%	5.9%	8.9%	-2.0%	-4.3%	0.2%	-1.0%
Rice	13.3%	13.1%	14.4%	14.9%	-4.6%	-4.6%	-0.1%	2.0%
Millet	-0.7%	8.6%	-0.5%	9.0%	0.2%	-8.0%	0.2%	-7.9%
Oth food crops	9.7%	9.6%	10.6%	11.1%	-0.3%	0.1%	0.4%	0.9%
Cash crops	-0.1%	0.3%	-1.1%	-1.1%	0.0%	0.1%	-0.2%	-0.1%
Livestock	-0.6%	-0.7%	-0.5%	-0.3%	-0.3%	-0.4%	0.3%	0.4%
Forest	0.1%	0.1%	0.0%	0.0%	0.2%	0.4%	0.0%	0.1%
Fish	-0.3%	-0.3%	-0.4%	-0.3%	0.2%	0.3%	0.2%	0.2%
Mine	-0.3%	-0.5%	-0.3%	-0.4%	-0.1%	0.0%	0.0%	0.0%
Industries	0.1%	0.5%	-0.2%	0.1%	-0.1%	-0.2%	0.4%	0.4%
Milled rice	2.8%	3.0%	2.0%	2.0%	-1.8%	-1.7%	2.8%	5.1%
Processed food	0.1%	1.0%	-0.5%	0.2%	-0.3%	-0.8%	0.7%	0.7%
Services	-0.1%	0.0%	-0.2%	-0.2%	0.2%	0.4%	0.1%	0.2%
Hotel	0.1%	0.3%	-0.3%	-0.2%	0.0%	-0.1%	0.2%	0.3%

Source: Authors' own computation based on simulations

Table 4 shows that cereal productivity improvements strengthen Senegal's agricultural trade balance through increased exports and lower rice imports.

Under both **S1** and **S2**, rice exports increase by about 35%, while rice imports decline modestly. Crop exports rise strongly, reflecting improved competitiveness of domestic cereal production.

The import-price shock in **S3** produces the largest reduction in rice imports (-12.6%) as higher international prices encourage domestic substitution. However, processed food and industrial exports decline, indicating negative spillover effects on non-agricultural sectors.

The diversification strategy in **S4** generates the strongest reduction in rice imports (-17.6%) while maintaining high rice export growth. These results suggest that combining rice and millet productivity improvements can reduce external dependence and strengthen resilience to international food-price shocks.

Table 4: Impacts on exports, imports and production (% change from the base 2030)

	Exports				Imports			
	S1	S2	S3	S4	S1	S2	S3	S4

Crops	11.3%	11.3%	11.0%	11.0%	-0.8%	-0.8%	-5.0%	-6.7%
Rice	35.5%	35.5%	35.2%	35.1%	-1.1%	-1.3%	-12.6%	-17.6%
Oth food crop	-0.4%	-0.4%	-0.4%	-0.3%	-1.8%	-2.1%	0.1%	0.8%
Cash crop	-0.2%	0.0%	-1.1%	-1.1%	0.0%	0.4%	-0.9%	-0.9%
Livestock	-0.2%	0.0%	-1.3%	-1.4%	-1.0%	-1.4%	0.4%	0.8%
Forest	-0.5%	-0.9%	-0.2%	-0.2%	0.6%	0.9%	0.1%	0.2%
Fish	-1.0%	-1.2%	-0.9%	-0.9%	0.4%	0.4%	0.2%	0.3%
Mine	-0.7%	-0.9%	-0.6%	-0.7%	0.0%	-0.1%	-0.1%	-0.1%
Industries	-0.4%	-0.2%	-1.0%	-1.0%	0.1%	0.1%	-0.4%	-0.4%
Processed meat	-0.3%	-0.5%	-0.5%	-0.5%	0.2%	0.3%	0.0%	0.2%
Oth proc. food	-0.4%	0.8%	-2.8%	-2.7%	0.0%	-0.3%	-1.4%	-2.2%
Petroleum	-0.5%	-0.7%	-0.4%	-0.5%	0.1%	0.3%	-0.2%	-0.1%
Chemicals	-0.1%	-0.2%	-0.1%	-0.1%	0.1%	0.2%	-0.1%	0.0%
Oth. Manufacturing	-0.5%	-0.9%	-0.3%	-0.4%	0.1%	0.1%	-0.2%	-0.1%
Services	-0.3%	-0.2%	-0.7%	-0.7%	0.3%	0.5%	-0.1%	0.1%

Source: Authors' own computation based on simulations

5.3. Impacts on households

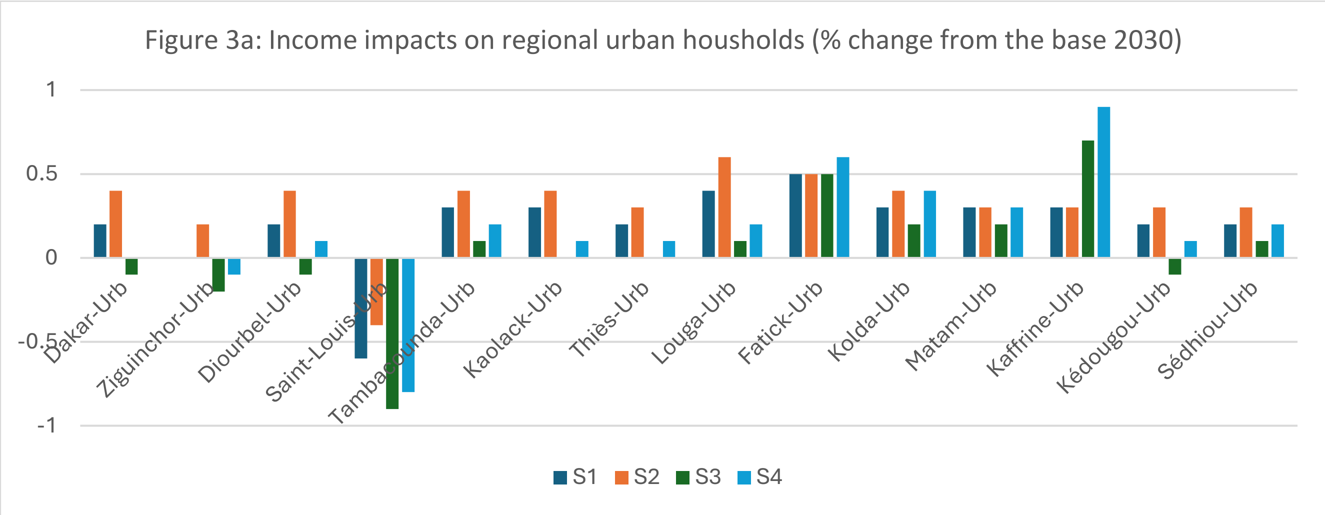
Figures 3a, 3b, and 4 present the impacts of the simulation scenarios on regional household incomes and factor returns in 2030 relative to the baseline. Overall, the productivity scenarios generate positive income effects, with stronger gains for rural households and agricultural factors.

Urban household income effects remain relatively modest. The rice and millet productivity scenarios (S1 and S2) slightly increase incomes across most urban regions, while the rice import price shock (S3) negatively affects urban households in Dakar, Ziguinchor, and particularly Saint-Louis because of higher food prices and reduced purchasing power. The diversification scenario (S4) partly offsets these adverse effects.

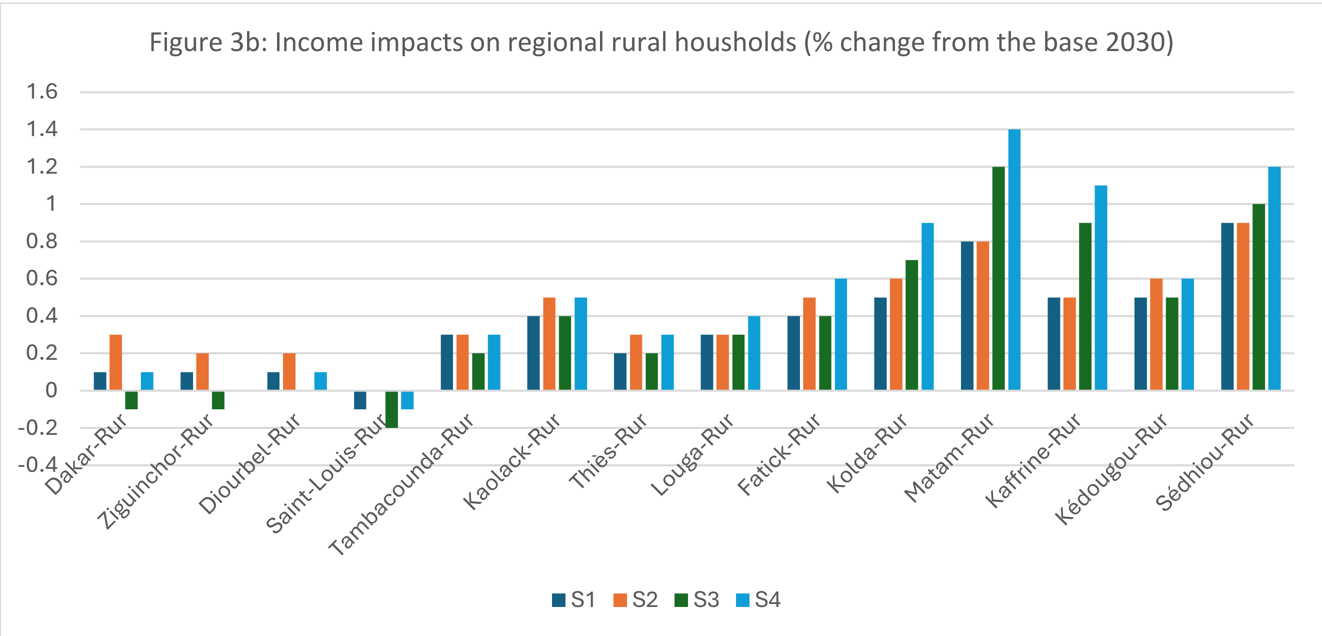
Rural households benefit more strongly from all productivity scenarios because of their greater dependence on agricultural activities. The largest gains are observed in Matam, Sédhiou, Kaffrine, and Kolda. Several rural regions also benefit from the rice import price shock, as higher domestic cereal prices improve producer incentives and agricultural incomes. The combined diversification scenario generates the strongest positive outcomes overall, particularly for rural households in Matam (+1.4%), Sédhiou (+1.2%), and Kaffrine (+1.1%).

The factor market results are consistent with these distributional effects. Productivity improvements substantially increase returns to agricultural capital and unskilled labour, especially under the millet productivity scenario. The import price shock also raises returns to land and agricultural capital by stimulating domestic cereal production, although it slightly reduces returns to skilled and semi-skilled labour. Under the diversification scenario, agricultural capital records the largest increase (+2.5%), while rural household incomes continue to improve.

Overall, the results highlight the complementary roles of rice and millet within Senegal's cereal economy. Productivity growth in both cereals strengthens rural livelihoods, agricultural incomes, and resilience to external food price shocks.

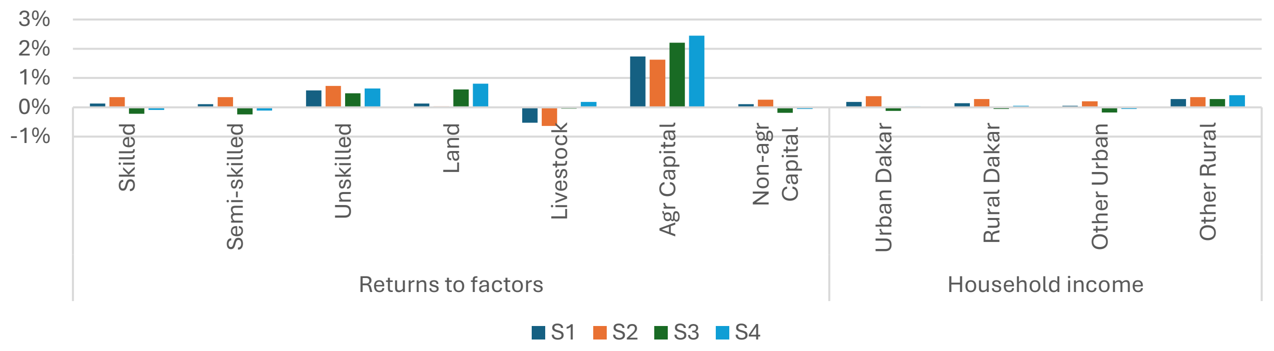


Source: Authors' own computation based on simulations



Source: Authors' own computation based on simulations

Figure 4: Impacts onreturns to factors and household income (% change from the base 2030)



Source: Authors' own computation based on simulations

5.4. Poverty impacts

Overall, the productivity scenarios reduce poverty, particularly in rural areas, while the external rice import price shock worsens poverty outcomes in several regions (Table 5-7) .

At the national level, rice productivity growth (S1) reduces poverty incidence by 3.1%, while millet productivity growth (S2) reduces poverty by 1.8%. The combined diversification scenario (S4) also generates substantial poverty reduction (-2.1%). In contrast, the rice import price shock (S3) slightly increases national poverty incidence (+0.5%), reflecting the adverse effects of higher food prices on household purchasing power.

The poverty impacts are strongly differentiated across regions and between rural and urban areas. Rural households experience the largest poverty reductions because they benefit directly from higher agricultural incomes and increased demand for labour. The strongest improvements are observed in Louga, Kolda, Matam, and Kaffrine under the productivity scenarios. For example, S1 reduces poverty incidence by 9.2% in Kolda and 7.1% in Louga, while S4 generates the largest reduction in Kaffrine (-9.9%).

The poverty gap and poverty severity indicators show similar patterns. Productivity improvements reduce not only the number of poor households but also the depth and intensity of poverty, especially in rural regions with strong agricultural dependence. The diversification scenario (S4) produces the broadest reductions in poverty severity, particularly in Kaffrine (-9.6%), Fatick (-7.7%), and Sédhiou (-4.7%).

By contrast, the rice import price shock (S3) increases poverty gap and severity in several urban and deficit-producing regions, including Dakar, Saint-Louis, and Ziguinchor, where households are more exposed to higher food prices and depend more heavily on purchased rice consumption.

The microsimulation results also indicate that the productivity scenarios lift a substantial number of households out of poverty. Nationally, approximately 38,000–58,000 individuals could be lifted out of poverty relative to the baseline, with the majority located in rural areas, except for the import price shock (S3). The largest reductions in the number of poor are observed in Diourbel and Louga.

Table 5: Impacts on poverty incidene (% change from the base 2030)							
	Observed poverty 2019	Observed population share	Baseline poverty 2030	S1	S2	S3	S4
National	37.8	100	11.8	-3.05	-1.84	0.52	-2.12
Rural all	53.6	44.9	18.9	-3.28	-2.17	0.60	-2.50
Urban all	19.8	55.1	3.8	-1.75	0.00	0.08	0.05
Dakar	9.0	14.3	0.5	0.00	0.00	0.00	0.00
Ziguincho	51.1	6.7	10.2	0.00	0.00	0.00	0.00
Diourbel	43.9	7.7	20.8	-3.62	-1.74	0.99	-1.74
Saint-Louis	40.1	7.0	12.8	-3.30	0.00	0.00	0.00
Tambacounda-	61.9	6.0	14.8	-4.85	0.00	3.82	0.00
Kaolack	41.5	7.4	13.8	0.00	-1.99	0.00	-1.99
Thiès	34.1	8.0	9.1	0.00	-1.51	0.00	-1.51
Louga	43.4	6.7	15.7	-7.07	-7.07	0.00	-7.07
Fatick	49.2	6.4	17.7	0.00	-1.69	0.00	-1.69
Kolda	56.6	6.0	11.4	-9.17	0.00	0.00	0.00
Matam	47.7	5.7	10.7	-6.89	0.00	0.00	0.00
Kaffrine	53.0	6.0	17.7	-2.84	-5.42	0.00	-9.85
Kédougou	61.9	6.4	24.6	-2.14	-2.14	0.54	-1.82
Sédhiou	65.6	5.7	35.6	-2.50	-0.48	0.68	-0.48

Source: Authors' own computation based on simulations

Table 6: Impacts on poverty gap (% change from the base 2030)						
	Observed poverty 2019	Baseline poverty 2030	S1	S2	S3	S4
National	10.3	2.3	-3.25	-2.11	1.61	-2.44
Rural all	15.3	3.6	-3.41	-2.38	1.39	-3.08
Urban all	4.6	0.7	-2.38	-0.64	2.87	1.08
Dakar	1.4	0.0	-3.21	-1.14	4.88	2.05
Ziguincho	15.5	2.3	-1.98	-1.16	2.41	-0.46
Diourbel	10.6	3.9	-1.88	-2.36	1.69	-1.43
Saint-Louis	11.1	2.4	-1.69	0.11	4.10	3.61
Tambacounda-	19.6	3.0	-2.88	-2.12	2.05	-2.23
Kaolack	11.9	2.9	-3.07	-2.48	1.09	-2.92
Thiès	7.7	1.4	-3.65	-3.65	1.87	-3.39
Louga	11.3	2.4	-3.77	-1.88	1.45	-2.12
Fatick	13.0	3.1	-3.83	-5.51	0.93	-6.70
Kolda	16.3	2.7	-4.26	0.37	2.53	-0.66
Matam	14.6	2.4	-3.34	-1.34	0.42	-2.65
Kaffrine	16.8	3.1	-4.03	-4.61	-1.36	-8.09
Kédougou	22.1	7.1	-2.24	0.24	0.98	-0.59
Sédhiou	21.6	7.5	-5.75	-1.06	1.75	-3.80

Source: Authors' own computation based on simulations

Table 7: Impacts on poverty severity (% change from the base 2030)						
	Observed poverty 2019	Baseline poverty 2030	S1	S2	S3	S4
National	3.9	0.7	-3.74	-2.40	1.93	-2.74
Rural all	5.9	1.1	-3.87	-2.70	1.69	-3.42
Urban all	1.7	0.2	-3.11	-0.84	3.20	0.75
Dakar	0.4	0.0	-5.65	-2.01	9.14	4.00
Ziguincho	6.5	0.9	-2.13	-0.95	2.54	-0.14
Diourbel	3.6	1.0	-2.58	-3.37	2.30	-2.15
Saint-Louis	4.2	0.8	-2.34	0.22	4.15	3.31
Tambacounda-	8.1	1.0	-3.13	-2.04	2.38	-2.09
Kaolack	4.9	1.0	-3.07	-2.47	1.18	-2.82
Thiès	2.5	0.4	-3.78	-5.77	1.82	-5.48
Louga	4.0	0.6	-3.73	-2.54	1.23	-2.91
Fatick	4.5	0.8	-4.82	-6.33	1.29	-7.70
Kolda	6.3	0.9	-5.30	0.51	3.22	-0.57
Matam	6.1	0.9	-3.06	-1.18	0.98	-1.51
Kaffrine	7.3	0.8	-4.75	-5.49	-1.48	-9.61
Kédougou	10.6	2.9	-2.64	0.29	1.13	-0.67
Sédhiou	9.1	2.3	-6.94	-1.55	2.26	-4.66

Source: Authors' own computation based on simulations

6. Conclusion and Policy Implications

Senegal's cereal economy is characterized by the coexistence of a market-oriented and import-dependent rice system alongside a rainfed and subsistence-oriented millet system. The results show that productivity improvements in domestic cereals strengthen economic growth, increase agricultural production, and reduce poverty, particularly in rural areas. Millet productivity generates especially strong gains for rural incomes and food-system resilience, while external rice price shocks negatively affect household welfare and macroeconomic stability.

Using a recursive dynamic CGE model combined with microsimulation analysis, this paper assessed the impacts of cereal productivity improvements and external rice import price shocks on growth, trade, household welfare, and poverty. The findings suggest that food security strategies in Senegal should move beyond a narrow focus on rice self-sufficiency toward a broader cereal-system approach. Investments in irrigation, improved seed systems, mechanization, and value-chain upgrading remain important for rice competitiveness. However, supporting traditional cereals such as millet can strengthen resilience to external shocks, improve rural livelihoods, and reduce poverty in vulnerable regions. Diversification strategies combining productivity improvements across cereals appear particularly effective in reducing import dependence while stabilizing food access and household welfare.

The simulations also demonstrate Senegal's vulnerability to external rice market shocks. Higher international rice prices reduce household consumption and increase poverty pressures, particularly in urban and deficit-producing regions. However, the diversification scenario combining rice and millet productivity improvements partially offsets these adverse effects and improves food-system resilience. These findings are consistent with broader evidence that diversified domestic food systems improve resilience to international food-market volatility (Timmer, 2010)

Overall, the paper highlights the importance of integrated and diversified cereal policies for achieving food security and agricultural transformation in Senegal. The recursive dynamic CGE-microsimulation framework also provides useful insights for analyzing resilience-oriented food policies in other import-dependent economies in West Africa

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