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Synopsis: Economywide Assessment of CSA Interventions in Building Resilient Agri-Food Systems in Rwanda

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This research extends IFPRI's RIAPA modeling to include both the full implementation of PSTA 5's climate smart agriculture and a once-in-five-year weather shock, and the interactions of both on agricultural sectors, agricultural GDP, and on national GDP. Main findings include:

- Rwanda's agri-food system is highly vulnerable to climate variability due to its structural characteristics.
- Results indicate that CSA practices during the PSTA-5 period (2024/25–2028/29) increase agricultural GDP growth by 0.9 percentage points annually, with the largest impacts on horticulture and roots and tubers. However, several CSA interventions relate to infrastructural improvements and therefore the benefits extend over a longer time horizon, ultimately having even greater impact beyond PSTA 5.
- The weather shock causes dramatic declines in agricultural GDP (-1.6 percent), with horticulture affected most negatively, suffering a 2.4 percent decline.
- The joint Climate + CSA scenario depicts how CSA helps mitigate, but not fully eliminate, the negative impacts of weather shocks during the PSTA 5 period.

Rwanda's agri-food system involves a complex network of actors linked to each other through their roles in producing, distributing, processing, and consuming primary agricultural and agro-processed products. The country's agri-food system contributes over 36 percent of gross domestic product (GDP) and employs about 68 percent of the workforce (Diao et al. 2023). With appropriate policy reforms and targeted investments, the sector has tremendous potential to further accelerate and contribute its critical share to Rwanda's economic transition. However, the agriculture sector is highly vulnerable to climate change induced risks. Rainfall variability has been the most significant climatic risk affecting the performance of the agrifood system in Rwanda (Twahirwa et al. 2023). Changes in temperature and precipitation are the key drivers of climate and weather-related disasters that negatively affect Rwandans and the overall economy (MoE 2020). With the changing climate, it is likely that these phenomena will increase both in intensity and duration.

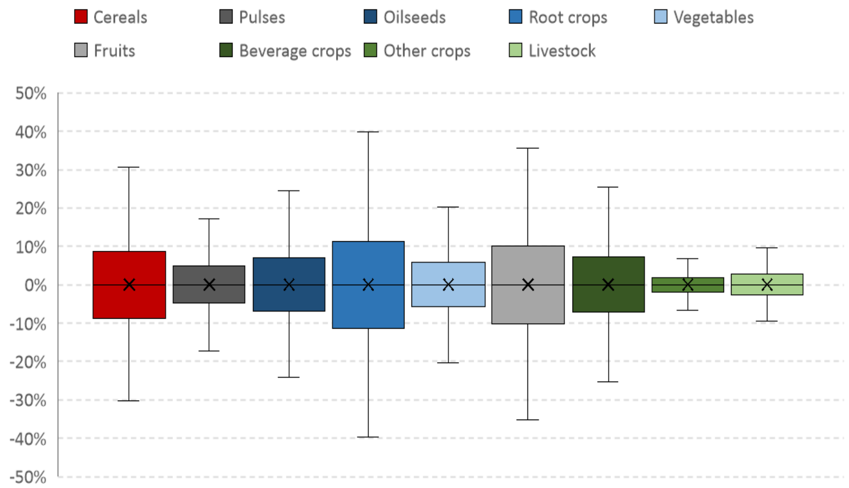
Rwanda's Fifth Strategic Plan for Agricultural Transformation (PSTA 5) is recognized as the first comprehensive food systems and climate resilient focused strategy for the country. In accordance with this recognition, MINAGRI plans to expand agricultural infrastructure by investing in climate-resilient agricultural infrastructure, including various types of irrigation schemes (marshland, hillside, and small scale) and terracing (progressive and radical), and detailed targets of achievement have been established. However, there are no detailed quantitative assessments of the benefits of a successful achievement of these targets on the Rwandan agri-food system both with and without climatic risks. Given this situation, and to better support evidence-based policy making, this policy note aims at assessing the impacts of identified climate-smart agricultural (CSA) interventions identified in the PSTA 5 on the Rwandan economy, focusing on macroeconomic, sectoral, and household level outcomes. This is accomplished by integrating IFPRI's Rural Investment and Policy Analysis (RIAPA) modeling system (IFPRI 2023) with detailed climate information to better understand how shocks to the agricultural sector impact agricultural GDP, various sub-sectors of agriculture and effects on households. Ultimately the model demonstrates that fully implemented CSA interventions can mitigate well over half the climate-related impacts. Identifying the consequences of climate change and possible mitigation strategies are critical for reducing the effects of climate change as well as other critical issues like food security, resilience, and agriculture household welfare, particularly at the lowest economic strata.

Due to its structural features, the Rwanda's agri-food system is extremely vulnerable to the risks of climate variability. Historically recurring climatic shocks with 1-in-5-year magnitude in Rwanda is estimated to likely cause substantial reductions in agricultural (-7.6 percent) and overall (-2.7 percent) GDP during the year of the shock. To accelerate and sustain growth in the food system, increase its resilience to shocks, and improve food security, the Rwandan government incorporated several ambitious CSA interventions into its PSTA 5 program. This policy note reviews the impacts of these CSA interventions on Rwanda's agri-food system, both with and without our stylized effects of climate change.[1] Results show that modeled CSA practices, during the PSTA 5 period, significantly improve both agricultural and overall GDP growth. In addition, the CSA interventions are impactful in minimizing the negative effects of climate change on the Rwandan economy.

Figure 1 outlines what a typical shock, experienced approximately once every five years, does to various sectors of the agricultural economy and demonstrates that, historically, cereals, fruits, and root crops experience the highest yield shocks in the range of 10.8 - 14.1 percent, whereas cash crops, other than beverages and livestock, experience the least, suggesting interventions that focus on the most vulnerable sectors may face volatility under weather shocks. This further suggests that policymakers must carefully incorporate the likely volatility of specific sector growth into their planning frameworks to effectively mitigate future weather impacts.

[1] For a comprehensive analysis, see IFPRI Discussion Paper 02373, Economywide Assessment of CSA Interventions in Building Resilient Agri-food Systems in Rwanda.

Figure 1: Historical production shocks for crops and livestock in Rwanda (% variation)



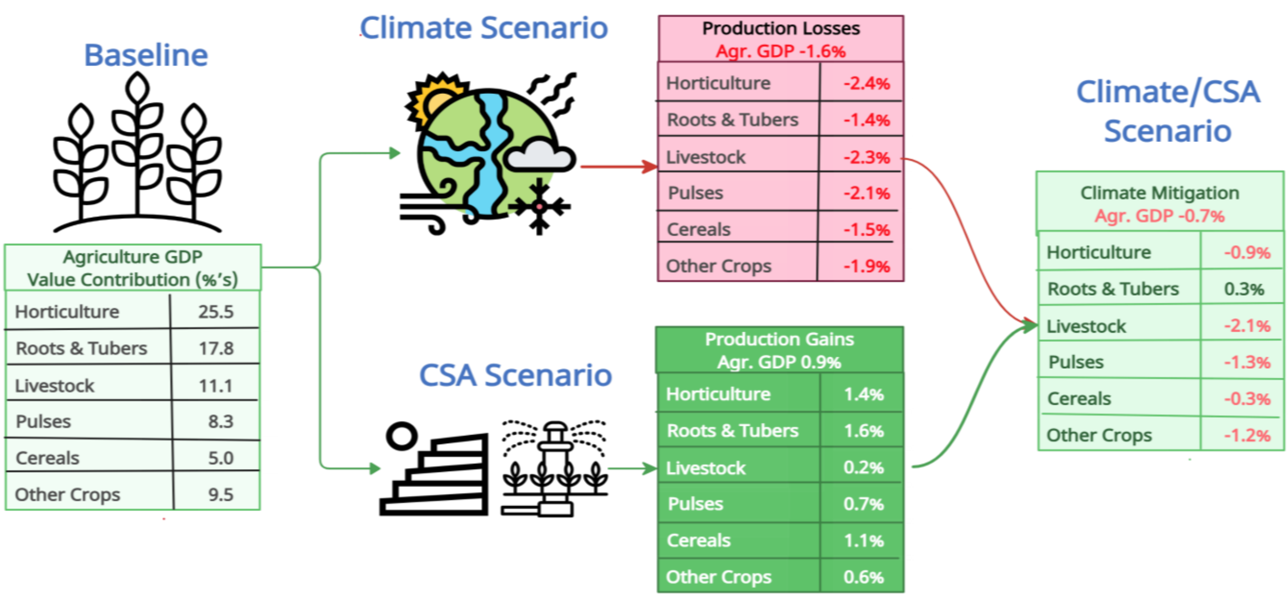
Annual production losses during climate event

Cereals	-10.8%
Pulses	-6.1%
Oilseeds	-8.7%
Root crops	-14.1%
Vegetables	-7.2%
Fruits	-12.6%
Beverage crops	-9.1%
Other crops	-2.4%
Livestock	-3.4%

Source: IFPRI (2024)

Beyond the annual estimated weather-related shocks are longer term average impacts and CSA mitigation strategies. Presented here are results from three modeled scenarios broken down by sectoral changes: (i) the CSA scenario, (ii) the Climate scenario, and (iii) the CSA + Climate scenario. In the CSA scenario, we assume that the various CSA practices identified in PSTA 5 are fully implemented, and these practices are not affected by climatic shocks. In addition, in the Climate scenario, based on climate impact projections and historical evidence of yield fluctuations, we assume that agricultural subsectors experience recurrent yield shocks or climatic risks every five years. Finally, we assess the contribution of CSA in mitigating some of the impacts of climate change as proxied by the decline in yield defined in the Climate scenario (ie. CSA + Climate scenario). All three scenarios are presented in annual agricultural GDP growth rates for ease of comparison.

Figure 2: Annual growth impacts of Climate and CSA scenarios on selected agricultural sectors



Source: Aragie et al. (2025)

Figure 2 depicts a general overview of the importance of six important agricultural sectors and how they are impacted by modeled CSA interventions (detailed in PSTA 5), climate effects, and the net effects of both scenarios at once and is meant to provide a “snapshot” of the model effects by providing annual average effects for clarity of comparison during the PSTA 5 period. The purpose of the Climate and CSA scenario sectoral analysis is to detail how different crop groups are impacted using annual growth rates. The joint Climate + CSA scenario combines both scenarios and depicts how CSA helps mitigate the negative impacts of weather shocks.

On the far-left panel, i.e. “Baseline,” six selected categories and their relative value contributions to agricultural GDP are provided. Overall, these six comprise over 75 percent of all value in agricultural GDP with horticulture contributing the highest percentage in 2023 value terms at 25.5 percent. As mentioned, the once-in-five-year shock, presented in the middle top “Climate” panel, is depicted as an average annual impact for clarity of exposition and relative comparison. In other words, Figure 1 highlights the dramatic losses experienced in the year of the shock while Figure 2 depicts an average annual expected value over the PSTA 5 period, that, while far less than the shock year, has negative impacts across all sectors, with greater than one percent losses experienced by all sectors. Importantly, horticulture is most negatively affected, suffering a 2.4 percent decline in production value. Taken by itself, the CSA scenario depicts a positive annual impact on agricultural GDP of just less than one percent, with the largest impacts on horticulture and roots and tubers, 1.4 and 1.6 percent, respectively.

Relative to the baseline (no-CSA) scenario, agricultural GDP is projected to be 4.2 percent higher by 2028/29 when CSA interventions are implemented. Even though the model only simulates the period 2024/25-2028/29, many CSA investments continue to generate benefits that extend well beyond that period. Consequently, positive impacts persist for several years due to lagged effects. The analysis indicates that the agricultural sector remains approximately 2.2 percent larger during 2033/34-2038/39, reflecting the persistence of productivity improvements associated with these longer-term investments.

Under the Climate + CSA scenario, we overlay climate risk onto the CSA to see the net effects of the identified interventions. While the magnitude of the historically observed yield shock in agriculture is significant enough that the CSA interventions do not fully compensate for the effects of climate on the economy, these CSA interventions moderate the effects to a significant degree when compared to the outcome under just the climate scenario. Overall, the CSA interventions identified in the PSTA 5 help the economy mitigate the impacts of climate shocks.

Beyond the overall, and sectoral impacts, are how households are affected both positively and negatively by CSA interventions and climate shocks. Under the CSA scenario, gains mainly flow to poorer households - both in rural and urban areas - as these households heavily rely on the domestic agricultural sector as a source of income and consumption. Arguably, the gain in consumption spending is stronger in rural areas due to the strong income effect on residents in these parts of the country as agriculture growth accelerates. As expected, the Climate scenario presents an opposite consumption effect when compared with the CSA scenario and the poor in both rural and urban areas suffer the brunt of the climatic shocks.

In contrast to the positive impacts of CSA interventions on the rate of poverty, climatic risks that cause yield declines equivalent to the historically observed 1-in-5-year shock can add to poverty as a development challenge by increasing the poverty rate by over 3.4 percentage points during the specific years that such shocks occur. As the benefits of CSA interventions are pronounced in rural areas, the cost of climatic shocks in the form of poverty is also stronger in rural areas due to the direct impact on the agricultural sector. The poverty impact in urban areas is also not negligible as urban households in developing countries such as Rwanda rely on agri-food systems for their livelihoods and spend most of their incomes on agri-food products.

Conclusion and recommendations

This study assesses the impacts of climate-smart agricultural (CSA) interventions outlined in PSTA 5 on the Rwandan economy, focusing on macroeconomic, sectoral, and household-level outcomes. It also evaluates the moderating role of these interventions when the economy is exposed to historically observed 1-in-5-year climatic shocks affecting agricultural performance. To achieve these results this analysis employs IFPRI's Rural Investment and Policy Analysis (RIAPA) modeling system, which integrates (i) an investment module that translates intervention targets into subsector-level productivity changes and (ii) a household survey–based microsimulation module that estimates effects on poverty and undernourishment.

The somewhat modest impacts of PSTA 5 CSA investments during the planned period can be attributed to at least three factors. First, the targeted expansion of some high-impact interventions, such as progressive terracing, is limited in percentage growth terms. Second, several CSA interventions are infrastructural in nature and therefore require time to generate measurable benefits; however, they produce persistent, lagged impacts that extend well beyond the PSTA 5 period. For example, over the five years following the PSTA-5 investments, cumulative agricultural GDP gains attributable to CSA investments reach 15.6 percent (approximately USD 0.6 billion) of the 2023/24 agricultural sector GDP. Third, the analysis models the impacts of only a subset of PSTA 5 interventions—specifically those that can be directly linked to CSA expenditures, thereby understating the full potential effects of the plan.

Results indicate that CSA interventions can accelerate overall GDP growth with roots and tubers and horticulture sectors experiencing the fastest growth. As agriculture expands, agro-processing also accelerates, reaching improved growth due to cheaper intermediate inputs. By contrast, recurrent climate shocks—modeled as 1-in-5-year yield losses—significantly disrupt economic performance, reducing overall GDP by 2.7 percent and agricultural GDP by 7.4 percent in the simulated shock year. The magnitude of the historically observed 1-in-5-years yield shock in the economy is strong enough to negate the positive CSA interventions of climate on the macroeconomy. However, longer term performance indicates positive net effects from these interventions. Infrastructure-focused interventions, particularly irrigation and terracing, emerge as the most impactful, with their relative contribution increasing over time.

At the household level, CSA practices boost consumption and reduce poverty and undernourishment. Poor and rural households benefit the most, given their heavy reliance on domestic agriculture. In contrast, under the climate shock scenario, consumption falls sharply, with rural households and the poor in both rural and urban areas most adversely affected. CSA interventions mitigate these risks, reducing poverty and undernourishment across rural and urban areas, while climatic shocks threaten to reverse development gains achieved through agricultural growth.

Overall, the study demonstrates significant economic and welfare gains from fully implementing CSA interventions under PSTA 5. Realizing these benefits, however, will depend on Rwanda's ability to mobilize sufficient financing, strengthen implementation capacity, and effectively target interventions. Given the persistent risks posed by climate variability, increased investment in early warning systems and resilience-building infrastructure will be essential to safeguard and sustain development gains.

Rwanda should scale up climate-resilient infrastructure, especially irrigation and terracing, in the most climate-vulnerable sub-sectors to reduce recurrent GDP losses due to recurring climatic shocks. Strengthening CSA adoption among smallholders and poor rural households will deepen productivity gains and protect poverty-reduction progress. Finally, integrating climate-risk diagnostics and early warning systems into national planning cycles will enable the government to anticipate sectoral volatility, guide investment targeting, and safeguard long-term agrifood system resilience.

To strengthen Rwanda's resilience to the recurrent climate shocks, coordinated public effort should **accelerate investment in climate-resilient infrastructure**, particularly, hillside and small-scale irrigation and both radical and progressive terracing. These interventions should be oriented to districts where cereals, fruits and roots and tubers historically suffer the largest yield volatility so that public resources address the highest-risk areas. Directing PSTA 5 investment toward these subprojects will help stabilize annual agricultural GDP growth, mitigate more than half of the climate-induced losses observed in the model, and support NST2's objectives of raising productivity and building climate resilience across the agrifood system.

Deepen CSA adoption through targeted extension and input support: To maximize the CSA scenario productivity gains, MINAGRI, RAB, SPIUs, and district extension services should scale up farmer training and advisory services on practices that deliver the strongest modeled benefits, i.e. improved seed use, enhanced soil fertility management, water-efficient practices, and diversification into resilient crop varieties. These efforts should be complemented by input subsidies and credit for poor and vulnerable households, who bear the brunt of climate shocks and stand to benefit the most in terms of welfare and consumption gains when CSA is adopted widely. Prioritizing CSA investments in horticulture, roots and tubers, and livestock systems will allow Rwanda to leverage the sectors that respond most strongly to interventions, thereby advancing PSTA 5's productivity goals and reducing the estimated 3.4-percentage-point increase in poverty observed during climatic shock years.

Institutionalize Climate-Risk Analysis and Early Warning for Planning: To prevent climate variability from eroding development gains, government institutions should collaborate and integrate climate-risk diagnostics into annual sector planning, budgeting processes, and PSTA 5 performance reviews. This includes applying RIAPA-based climate scenarios to guide public investment prioritization and establishing a climate-risk monitoring dashboard that highlights the most climate-volatile subsectors and activates contingency financing when shocks approach historically observed magnitudes. Strengthening early warning systems by linking forecasts with district-level advisories disseminated through digital channels, cooperatives, and local extension agents will enable farmers and policymakers to act proactively. Such climate informed planning is essential for safeguarding NST2 development targets, maintaining agricultural growth momentum, and protecting household welfare during shock years.

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