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Cost effective options for inclusive and sustainable development

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This brief is part of IFPRI's series of country studies that utilize the RIAPA modeling system to systematically evaluate and rank agrifood system investment options based on their cost-effectiveness in achieving multiple development objectives. These country studies examine whether the rankings evolve over time and production shocks such as droughts influence their relative cost-effectiveness.

Abstract

In this policy brief, we present findings of a systematic evaluation and ranking of investment options for Ghana's agrifood system based on their cost-effectiveness in achieving multiple development outcomes, including agrifood gross domestic product (GDP) growth, agrifood job creation, poverty reduction, declining undernourishment, and lowering diet deprivation. Additionally, the study assesses their environmental footprints, focusing on water consumption, land use, and emissions. In Ghana, extension in agronomy and post-harvest food loss reduction are the most cost-effective ways to improve social outcomes, including notably reducing poverty and undernourishment levels. Meanwhile, advisory services in livestock and support to small and medium enterprise (SME) processors are highly ranked in accelerating agrifood GDP and employment. Moreover, extension services for agronomy and climate, and investments in mechanization are also highly ranked. However, many of these cost-effective investments come with relatively high environmental footprints, which highlights potential tradeoffs. The study further reveals shifts in the cost-effectiveness ranking of investment options over time and moderately so in the presence of extreme production shocks.

Keywords: Investment priorities, agrifood system, economic, social, environmental, Ghana

Introduction

The agrifood system in Ghana serves as the main driver of economic growth, a major source of employment, and the foundation of livelihoods for millions of people. Nonetheless, low-productivity agriculture continues to dominate it, finding it difficult to provide affordable, high-quality food for a rapidly growing population. This imbalance highlights the urgent need for a sustainable transformation of the agrifood system. Providing technical and financial support to the sector is crucial to achieving this transformation. However, policy and investment choices, and the growth patterns they drive, play a decisive role in shaping the magnitude and sustainability of development gains (Christiaensen and Martin, 2018; Pham and Riedel, 2019). As such, policies and investments should be evaluated in terms of their impact on key economic outcomes, such as economic growth or job creation, as well as social outcomes, including poverty, undernourishment, or diet deprivation. Identifying potential tradeoffs across these outcomes can support more informed decisions about resource allocations. Increasingly, policymakers and development partners are also incorporating environmental sustainability considerations into their evaluation frameworks. This is based on an enhanced awareness that unsustainable production practices contribute to environmental degradation and climate change, the burden of which will fall disproportionately on future generations of poor people (GLOPAN, 2020).

The effectiveness of policies and investments may be undermined by unforeseen shocks, such as global commodity market disruptions, conflict and war, and climate-related events. We focus on the latter, given that climatic shocks have been the most significant exogenous factors affecting the performance of agrifood systems in Ghana (Michalscheck et al., 2023; Danso, 2025). Extreme events like drought and flooding have become increasingly common and are expected to intensify in frequency and severity (Alhassan et al., 2025). While there is little doubt these climatic shocks adversely affect the performance of the agrifood system, and, therefore, the effectiveness of agrifood system policies and investments in general, it remains unclear whether such shocks would also influence how these policies and investments are prioritized.

In this country brief, we provide data- and model-driven insights to inform policy discussions on the design and prioritization of agrifood system interventions, considering both the current state of the system in Ghana and the emerging risks that threaten its performance, sustainability, and resilience. We systematically evaluate a range of investment options and rank them based on their cost-effectiveness in delivering multiple development outcomes, including agrifood gross domestic product (GDP) growth, agrifood job creation, poverty reduction, undernourishment reduction, and improvements in diet deprivation. To assess the impacts of these investments on nature capital, we calculate the associated environmental footprints, focusing on water, emission, and land.

We also analyze how these investment-rankings shift when the system is exposed to climatic shocks with varying adverse crop yield effects across the agricultural sub-sector (the design of these sensitivity scenarios is informed by observed historical climatic shocks). This additional layer of analysis ensures policy recommendations are not only effective under normal conditions but also resilient to external risks, providing a more robust framework for guiding agricultural investments in Ghana.

Results are derived from the IFPRI's Rural Investment and Policy Analysis (RIAPA) modeling system (IFPRI, 2023) which offers a uniquely integrated framework for assessing investment impacts. The system includes: (i) an investment module that translates proposed investments into changes in productivity at the subsector level; (ii) a household survey-based microsimulation module that estimates changes in poverty, undernourishment, and diet deprivation; and (iii) a newly added environment module that computes environmental footprints, related to water use, greenhouse gas emissions, and land. As such, this integrated RIAPA framework provides a comprehensive assessment of investment impacts. The RIAPA modeling system has been widely applied to evaluate the economywide impacts of various public expenditure options across different contexts (Thurlow et al. 2007; Pauw and Thurlow 2015; Benfica et al., 2019; Aragie et al., 2019; Aragie et al., 2024).

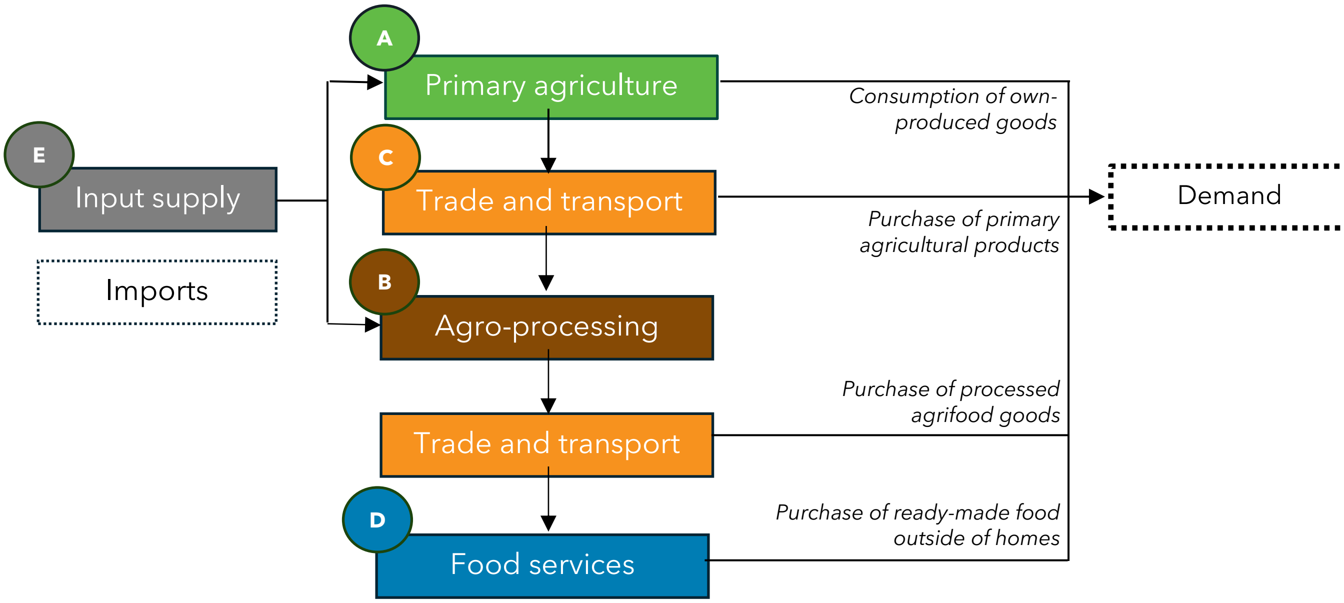
Country Context

Structure of Ghana's agrifood system

A country's agrifood system involves a complex and dynamic network of actors linked to each other through their roles in producing, distributing, processing, and consuming primary agricultural and agro-processed products. We measure the agrifood system from a supply-side perspective, leveraging national accounts and employment statistics to directly simulate changes in agrifood GDP growth and job creation under alternative investment scenarios and over time. By breaking down the agrifood system into distinct value chain groups and mapping targeted interventions aimed at addressing specific bottlenecks, this approach provides valuable insights into the main drivers of agrifood system growth and associated environmental impacts in Ghana.

Figure 1 presents a simplified conceptual framework of the agrifood system, comprising five key components labeled **A** to **E** (see Diao et al., 2023). Primary agriculture (**A**) encompasses the supply and demand for all agricultural products, including crops, livestock, fisheries, and forestry products. Agro-processing (**B**) refers to the manufacturing sector and includes subsectors that process agriculture-related food and non-food products. Meanwhile, trade and transport (**C**) capture the demand for services that facilitate the movement, wholesaling, and retailing of agrifood products across farms, firms, and final points of sale. Food services, represented in (**D**), include services such as meals prepared in restaurants, food stalls, or hospitality venues. Finally, input supply (**E**) represents the portion of domestically produced intermediate inputs - such as fertilizers, seeds, and financial services - used directly in agricultural and agro-processing operations.

Figure 1: A simple conceptual framework of the agrifood system



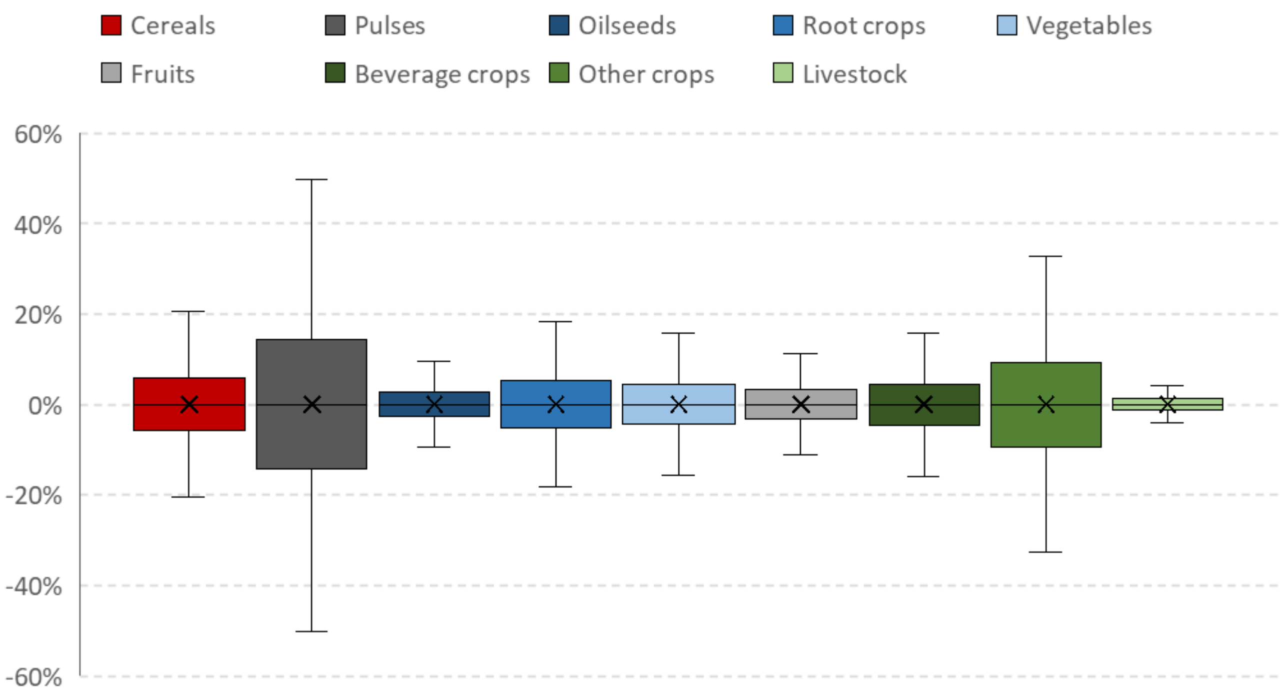
Source: Diao et al. (2023)

The agrifood system in Ghana plays a central role in the national economy, contributing over 33.6 percent of GDP and employing about 45.9 percent of the workforce (Diao et al., 2023). Primary agriculture has been a consistent driver of growth, expanding at a modest average annual rate of 4.6 percent over the past two decades and currently contributing a considerable 18.5 percent of GDP (Diao et al., 2023; World Bank, 2025). With appropriate policy reforms and targeted investments, together with a stable socio-political environment, the sector has a significant potential to continue its rapid growth and contribute to broader structural transformation in Ghana. Accelerating growth and sustaining high employment levels have long been central development objectives for countries worldwide, and Ghana is no exception. Yet, with a poverty headcount rate of 23.4 percent at the national poverty line (World Bank, 2025), and notable concerns about diet deprivation, the Ghana government recognizes the formidable challenges it faces, particularly as it strives to its ambition to pursue economic development and social progress while transitioning towards a green economy (Ali et al, 2021; MoF, 2024).

Agricultural production variability in Ghana

Despite its substantial contribution to the country's GDP, agriculture remains a critical engine of social and economic outcomes in Ghana. The sector's heavy reliance on rainfed production systems makes it particularly vulnerable to weather-related shocks. These shocks adversely affect the efficacy of technologies; for example, several studies have shown that extreme events can lower the expected yield gains from using modern inputs such as fertilizer and improved seeds (Shah et al., 2024; Kumar and Maiti, 2024). Historical data for Ghana reveal that yields for pulses and cash crops such as cocoa and cotton are significantly more volatile than livestock or oilseeds (see Figure 2). For instance, production losses during a 1-in-25-year drought event relative to a "normal" year could range between 3.0 and 6.7 percent for livestock and oilseeds and between 23.4 and 35.7 percent for fruits and root crops. This variation across sectors highlights different degrees of vulnerability of sectors to climatic shocks. Moreover, spatial variation both in the severity of drought conditions and sectoral composition contribute to the national-level variation in yield impacts. In order to assess the resilience of investment strategies, our modeling framework tests the robustness of investment rankings to climatic shocks using historical 1-in-25-year drought scenarios as indicative of how such shocks may influence sectoral yield losses and alter the impact of investments.

Figure 2: Historical production variability for crops and livestock



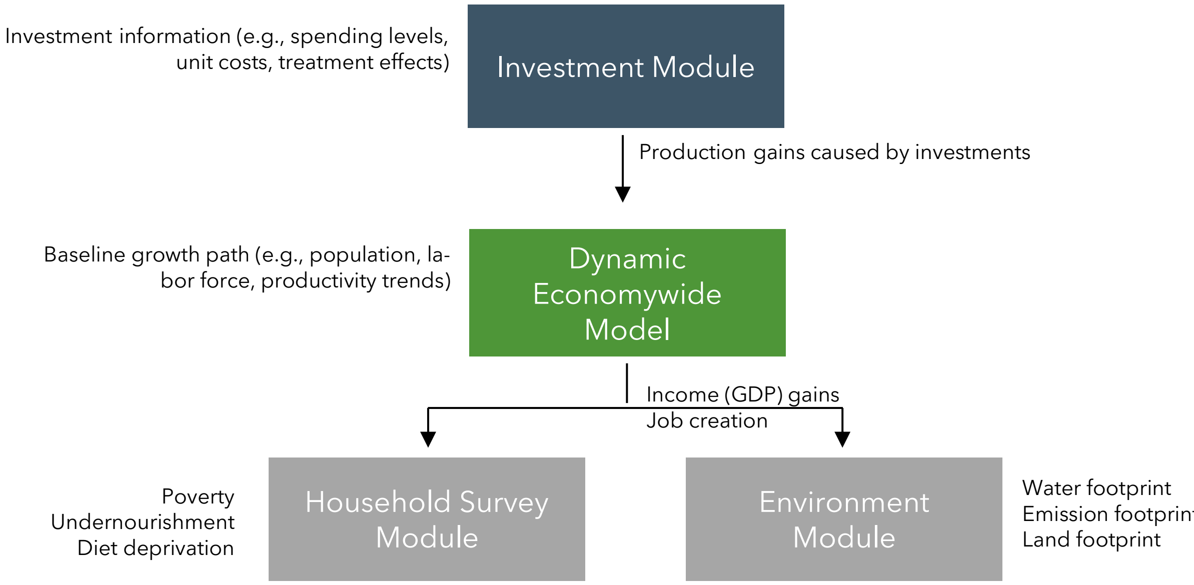
Note: The historical variability values are residual fluctuations from the determined production time series for 1990-2021. Pulses, cereals, and vegetables are the three main contributors of agricultural GDP, with shares of 22, 16, and 16 percent, respectively. Livestock and roots follow, contributing 12 and 14 percent to the sector's GDP (IFPRI, 2025).

Method of Analysis

Modeling approach

This study estimates the impacts of alternative agrifood system investments on Ghana's economy, focusing on three categories of outcome indicators: economic, social, and environmental/resource use. We apply IFPRI's RIAPA modeling system (IFPRI, 2023) which uniquely integrates an investment module that translates identified investments into changes in productivity at the subsector level; a household survey-based microsimulation module that estimates changes in poverty, undernourishment, and diet deprivation; and a newly added environment module that computes environmental footprints, including impacts on water use, greenhouse gas emissions, and land utilization (Figure 3). This integrated RIAPA framework thus enables a more comprehensive assessment of investment impacts across sectors and time horizons.

Figure 3: An integrated model for agrifood system investment and outcomes analysis



The economywide model

At the core of the integrated RIAPA framework is IFPRI's standard, recursive-dynamic computable general equilibrium (CGE) model, a widely used tool for economic policy formulation and analysis (Dixon and Parmenter, 1996; Devarajan and Robinson, 2010). They capture the complex interlinkages between sectors, households, and rural-urban economies, making them well-suited for evaluating the broad economywide effects of public investments and policy reforms.

The Ghana model is calibrated to a 2022 Social Accounting Matrix (SAM) for the country (IFPRI, 2024a). The calibrated model represents the economy through a set of disaggregated sectors, encompassing 29 agricultural sub-sectors, which include 20 individual crops or groups of crops, six livestock production sectors, as well as forestry, captured fisheries, and aquaculture. The model also incorporates 35 industrial sectors, including 17 agro-processing activities, as well as 12 service sectors, which include food-related activities such as trade, transport, and restaurant services. This detailed representation of both the on-farm and off-farm components of the broader agrifood system permits detailed analysis of agrifood value chains, from primary producers to processors and traders to final consumers.

The Ghana model also distinguishes 20 representative household groups, each of which is an aggregation of a group of households captured in the 2016/2017 Ghana Living Standards Survey (GLSS7) (GSS, 2019). These households are categorized into rural and urban household groups. Finally, each household group is further disaggregated by per capita expenditure deciles. In the model, households earn labor income and receive returns on their assets, which include land and capital, as well as domestic or foreign transfers.

The CGE model is used to produce a baseline that follows historical trends of broader economic and sectoral growth, population and labor force growth, and levels of government spending. This "business-as-usual" scenario runs until 2045 and serves has benchmark for evaluating all investment scenarios. As will be seen later, the temporal feature of the model allows us to explore how the effects of various interventions unfold and evolve over time.

The investment module

The investment module is used to synthesize data from multiple sources to measure, at a detailed sectoral level, the expected productivity gains that can be attributed to a unit of expenditure associated with a range of agricultural transformation investments. The module used in this study is a newly updated version of the framework previously adopted in various contexts (Pauw and Thurlow, 2015; Benfica et al., 2019; Aragie et al., 2019). The previous version of the investment module was elaborated by Aragie et al. (2024). The updated framework categorizes agrifood system investments in layers depending on whether they are at the knowledge generation stage (upstream: e.g., R&D) or innovation dissemination stage (midstream, e.g., seed system), or at the farmgate level (downstream: e.g., seed application at farmer level). In this study, the investment module tracks 20 distinct individual interventions, many of which targeting up to six different agricultural sector groups.

The investment module structures agrifood investments and processes data on the costs and impacts of interventions across targeted sectors. Specifically, it integrates investment parameters - such as spending levels, unit costs, adoption rates, and impact coefficients (or marginal effects)—as inputs and generates corresponding productivity gains as outputs. Whereas unit costs measure costs per area of farmland or head of animal, adoption rates refer to the extent to which new technology is implemented, expressed as a percentage of the target area or number of animals. These productivity gains are then fed into the economywide model, which endogenously adjusts the targeted sectors' productivity levels. Through direct and indirect economywide linkages, these adjustments lead to changes in income, prices, employment levels, and other key economic indicators.

Unit cost estimates are typically drawn from existing literature and are retrieved from project planning (such as irrigation master plans) or evaluation reports. Baseline adoption rates and coverage levels are sourced from farm household surveys such as the 2018-2019 Ghana Sociaeconomic Pannel Survey (ISSER, 2023) and the 2017-2018 Ghana Census of Agriculture (GSS, 2020) which report the number of farmers with access to certain technologies and practices, or the cropland covered by those technologies and practices. Likewise, impact coefficients—which measure the change in productivity resulting from the adoption of a specific technology or practice—can be estimated using these types of surveys or sourced from existing literature.

Alternatively, crop models, which simulate how crops interact with their environment and respond to various factors, can provide usable impact estimates for many crops and interventions. Given these fundamental features of sector-investment combinations, the final productivity gains for each sector will be determined by the level of spending on each intervention. In this brief, an equal amount of hypothetical spending for each intervention area is considered for cost-benefit comparisons. An actual budget allocation pattern can also be evaluated using spending data from ministries of agriculture or ministries of finance.

The household survey module

While major economic indicators – changes in economic growth and job creation – are directly calculated from the core economywide model, assessing changes in social and environmental indicators requires specialized modules. To this end, the CGE model is linked in a top-down fashion with household survey-based microsimulation modules measuring changes in poverty, the prevalence of undernourishment, and diet deprivation. Real income changes for different household groups result in diverse effects on these social outcomes.

Changes in poverty are calculated by linking a poverty microsimulation module to the outcome variables of the CGE model—namely, household income, prices, and consumption—following the methodology of Arndt et al. (2012). The changes in real consumption across commodities, observed by the fifteen representative household groups in the RIAPA model, are mapped to the corresponding individual households in GLSS7 (GSS, 2019). The new poverty status is computed for all sampled households. Likewise, the undernourishment module uses the same set of households and measures the change in the share of the population below a certain minimum dietary energy requirement per capita per day.

The process for estimating changes in diet deprivation is similar to that for poverty in that survey households are linked to their respective representative household groups in the CGE model. In this instance, however, modeled changes in real food consumption across six food groups are used to compute changes in the Reference Diet Deprivation (ReDD) Index (Pauw et al., 2023), which serves as a multidimensional indicator of a household's diet quality. The ReDD Index, which is a deprivation gap measure, quantifies shortfalls in consumption relative to a recommended consumption threshold. A decline in the deprivation gap indicates improvement in overall diet deprivation.

The environment module

The environment module uses information on water, greenhouse gas emissions, and land intensities of sectors to calculate changes in total water, emission, and land footprints of the economy. These footprints change as the structure or size of the economy changes over time. For instance, the expansion of a water-intensive sector, such as rice, can potentially increase the total water footprint of the cereals sector. However, this shift may also result in resource reallocation—such as the increased availability of cheaper animal feed—which could, in turn, accelerate growth in more emission-intensive sectors like livestock.

The data used to calibrate the environment module come from various sources. Whereas the water footprint data for agricultural sectors come from the Water Footprint Network (Mekonnen and Hoekstra, 2010), this source only reports aggerate water footprints for industrial sectors and municipal water withdrawals. In the absence of sector-specific data, we assume water use is distributed across non-agricultural sectors in proportion to their sectoral output shares. Given our focus on agrifood system investments, this assumption, while crude, has little bearing on our results.

Sectors also differ in terms of their emissions intensities. We use total emission data (in tons of CO_2 equivalent) obtained from FAO (2025) and Climate Watch (2025). FAO (2025) reports total emissions generated in the rice sector, other cereals, and livestock sub-sectors, including milk and meat production. We complement this with global-level estimates of emission per kilogram (CO_2 equivalent) for a comprehensive list of commodities compiled by Poore and Nemecek (2018). Climate Watch (2025) reports emissions generated by major manufacturing and service sectors. The resulting emission coefficients for all sectors included in the Ghana SAM are then scaled using the corresponding sector's output to match total emissions in agriculture, industry, and services.

The land footprint calculation uses the FAO (2025) cropland allocation estimates to calibrate the Ghana CGE model. Ghana had over 8.5 million hectares of land under crop cultivation in 2022, the model base year (FAO, 2025). In addition to this, we incorporate land use for livestock grazing into the land footprint calculation. FAO (2025) reports over 5 million hectares of grazing land in Ghana in 2022. Our modeling analysis assumes total agricultural land expands by one percent per annum. Land use by sector may, however, adjust in line with relative changes in land productivity and output.

Scenario design

This study assesses the impact of 20 different investment areas; each modeled with an annual incremental spending of $25 million between 2025 and 2030. The relative effectiveness of each intervention is assessed based on its effect in driving various development outcomes projected through 2045. To ensure comparability across time, all future benefits are discounted to present value using a 4 percent discount rate. Investments are grouped into five broad types of interventions: (i) research and development (or R&D), (ii) extension and advisory services, (iii) markets and food systems, (iv) risk reduction and resilience, and (v) infrastructure. Annex Table 1 includes a detailed list of interventions considered. In short, the interventions include the following:

- R&D investments contribute to the development of improved seed varieties, enhancement of productive agronomic practices, and advancement of animal breeds, and animal husbandry.
- Extension and advisory services promote the adoption of improved seeds, agronomic practices, livestock inputs (e.g., feed and vaccines), climate information systems, and climate-smart agricultural practices.
- Markets and food system investments are designed to strengthen seed systems, enhance the productivity of small and medium enterprise (SME) processors and traders through access to finance and training, reduce food loss and waste, improve access to credit, or direct provision of inputs such as improved seeds and fertilizer.
- Risk reduction and resilience interventions support better decision-making among agrifood system actors by developing improved climate forecasting.
- Infrastructure investments raise overall value chain productive efficiency by expanding irrigation schemes and mechanization, and constructing feeder roads that connect farmers to input suppliers and product markets.

Calibrating the investment module requires a diverse set of data inputs for each of the 20 investment areas. Key parameters include adoption rates (or coverage rates), which specify the number of farmers that use a specific technology or service or the area of land on which technology is applied, and the corresponding yield gains. Baseline adoption and coverage rates were obtained from farm household surveys. Productivity impacts of the respective interventions across the targeted sectors are derived from impact evaluation documents and crop and livestock models. Ghana's Census of Agriculture (GSS, 2020) is specifically used to estimate adoption and coverage rates for the various technologies and practices modeled in this analysis. The survey shows high fertilizer adoption in horticulture production, at about 58 percent of cropland, followed by cash crops and cereals at 48 and 26 percent, respectively. Coverage is lowest among pulses and oilseeds. Meanwhile, Ghana Socio-economic Panel Survey (ISSER, 2023) shows that improved seed adoption is highest for horticulture (31 percent) and pulses (25 percent). IFPRI's crop model (IFPRI, 2024b) is used to estimate yield gains from adopting different farm practices. For Ghana, the model reveals stronger cereal yield effects from irrigation infrastructure, followed by information of planting window and the adoption of improved seeds. These investment module parameters, alongside measures such as value-added and output prices, are important in determining the returns on investments across different technologies and services.

Investment unit costs measure the financial cost of expanding input coverage (e.g., increasing irrigated land by one hectare). These are primarily sourced from impact evaluation studies, sector development plans, and existing literature. A key enhancement in this version of the investment module, compared to its most recent predecessor described in Aragie et al. (2024), is its ability to track the time lag between investment spending and its eventual impact (e.g., for rural roads or irrigation projects that take a number of years to become operational) as well as the duration of that impact (this accounts for depreciation or time-bound interventions). This distinction is crucial, as some investments yield one-time effects while others generate sustained benefits over multiple years.

The agrifood system in Ghana has historically been exposed to production shocks that can reduce the efficiency of technologies and practices. An alternative situation of a permanent decline in yield gain from a 1-in-25-year drought is also considered to test how the rankings of interventions change by 2045 when the system is faced with large climatic shocks.

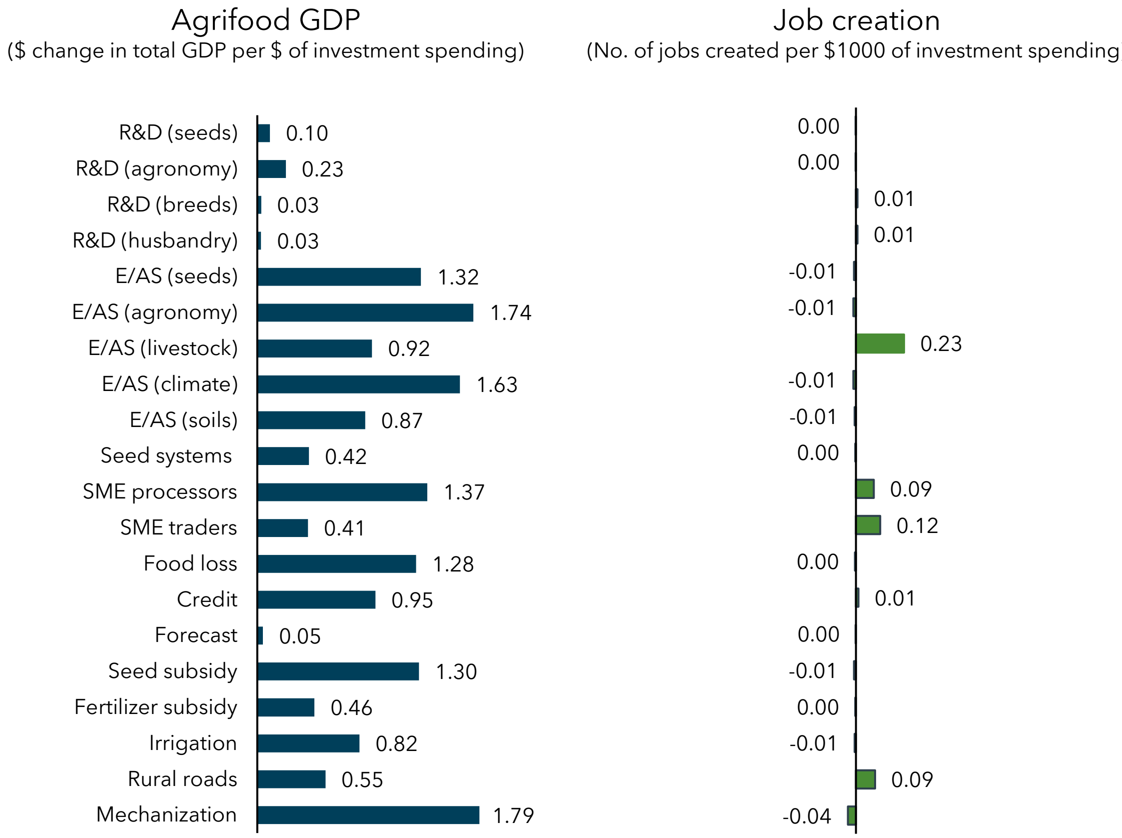
Cost-Effective Investment Options for Inclusive and Sustainable Transformation

Comparing the impacts of investments

The analysis starts by comparing investments based on their effects on two standard economic outcomes: agrifood GDP growth and job creation. These indicators are directly derived from the economywide model (see Figure 3), with results reported in Figure 4. These results reveal relatively stronger growth effects from investments in mechanization, and advisory services in agronomy and climate. Specifically, each additional dollar spent on mechanization yields an additional $1.79 in agrifood system GDP, compared to around $1.63 from supporting advisor services in climate (Figure 4). Spending on advisory services in seeds, support to SME processors, food loss reduction, and seed subsidy also yield economywide benefits just above the cost, suggesting their potential in transforming the agrifood system in Ghana if the services are provided in a more efficient way.

Job creation remains an important development challenge for most developing countries, including Ghana, especially given the continued rapid increase in the working-age population. Notably, model results highlight extension and advisory services in livestock as the most effective, generating about 0.23 additional jobs per $1000 invested through their backward and forward linkages across the economy. Market and infrastructural development, particularly SME traders and processors and rural roads, also emerge as priority areas of investment for job creation.

Figure 4: Comparison of investments based on their cost-effectiveness on economic outcomes



Source: RIAPA modeling system

The three social indicators considered in this study are the poverty headcount, prevalence of undernourishment, and household diet deprivation. These are obtained from the various household survey-based microsimulation modules incorporated into the RIAPA framework. Results show that investment areas differ in terms of their effectiveness in driving these outcomes (Figure 5). Investing in extension and advisory serves in agronomy and SME processors rank among the highest in reducing poverty and undernourishment, partly explained by their strong GDP effects and underlining the role of sectors linked to these investments on the livelihoods of the lower income-quintile households in Ghana. Additionally, support for SME traders and the expansion of rural road infrastructure are among the top-performing spending options with particularly strong impacts on poverty reduction.

Regarding the effects on the prevalence of undernourishment, mechanization, advisory services in seeds and climate, and seed subsidy stand out among the most cost-effective interventions, delivering substantial improvements. Other impactful investments include food loss reduction and advisory services on soil management. While only a few agrifood interventions show strong benefit-cost ratios particularly for poverty outcomes, a broader set of interventions prove highly cost-effective in improving diet diversity. Notably, expanding access to extension services on livestock, agronomy and climate, and post-harvest food loss reduction all have strong impacts on reducing diet deprivation by enhancing productivity, and improving access to food products—particularly fruits and vegetables, which are often lacking in household diets.

Figure 5: Comparison of investments based on their cost-effectiveness on social outcomes

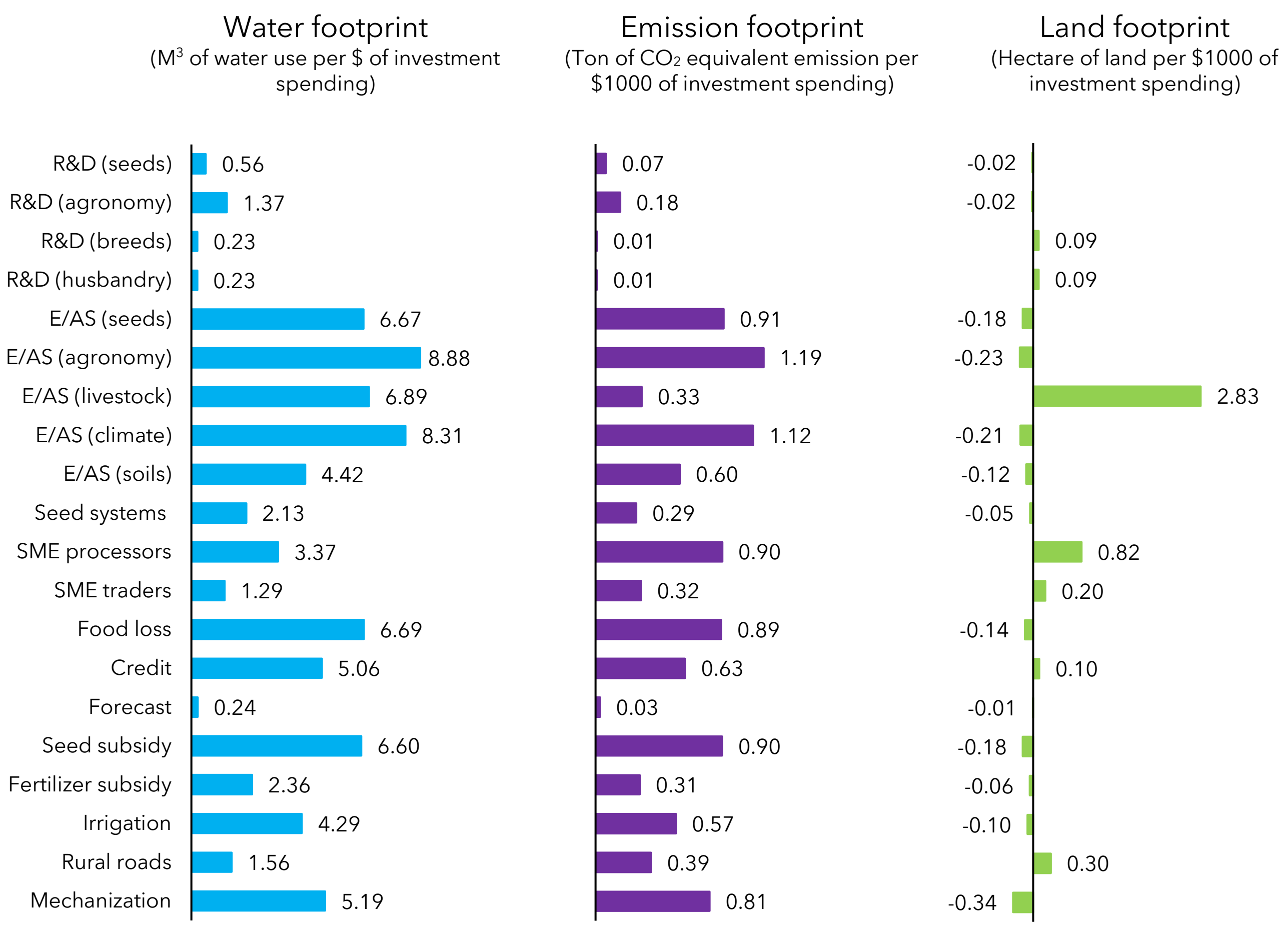
Source: RIAPA modeling system

We also evaluated the various investments based on their resource use or environmental impacts, looking specifically at economywide changes in water use, emissions, and land footprints. These changes in environmental footprints are associated with three main factors: the baseline resource intensity of the targeted sectors, the changes in sectoral activity as a result of the interventions, and any indirect adjustments in the economy outside the targeted sector due to economywide linkage effects and changes in resource reallocation. The basic principle here is that increases in environmental footprint per dollar of spending is considered undesirable.

Figure 6 presents the results from the environment module indicate that investments in extension services in agronomy, climate, livestock, and support to SME processors consistently rank highest across the three environmental indicators, underscoring the resource intensity of sectors that experience significant expansion due to these interventions. Among them, advisory services in agronomy emerges as the most emission intensive investment per dollar spent in Ghana, followed by similar services in climate and seeds. These interventions have strong emission effects because they specifically promote production in sectors with higher emission footprints in addition to their stronger overall production effects. Figure 6 also highlights a stronger economywide water use effect from spending on extension services on agronomy, climate, seeds, and investments in food loss reduction efforts.

Land footprint can show movements in both directions depending on how investments reshape economywide demand for land. In the case of Ghana, land footprint increases strongly (i.e., more land put under cultivation) when investments in livestock extension, SME processors, and rural roads are considered. These increases in land footprints are due to additional opportunities for land-intensive sectors to grow as economic opportunity changes. Similar increases in land footprint are also observed with investments in SME traders and farmers' credit. In contrast, advisory services on agronomy, seeds, climate, and soils, along with investments in mechanization, food loss reduction, and seed subsidy are associated with land-saving effects likely due to improved efficiency and reduced pressure on land resources.

Figure 6: Comparison of investments based on their cost-effectiveness on environmental footprint



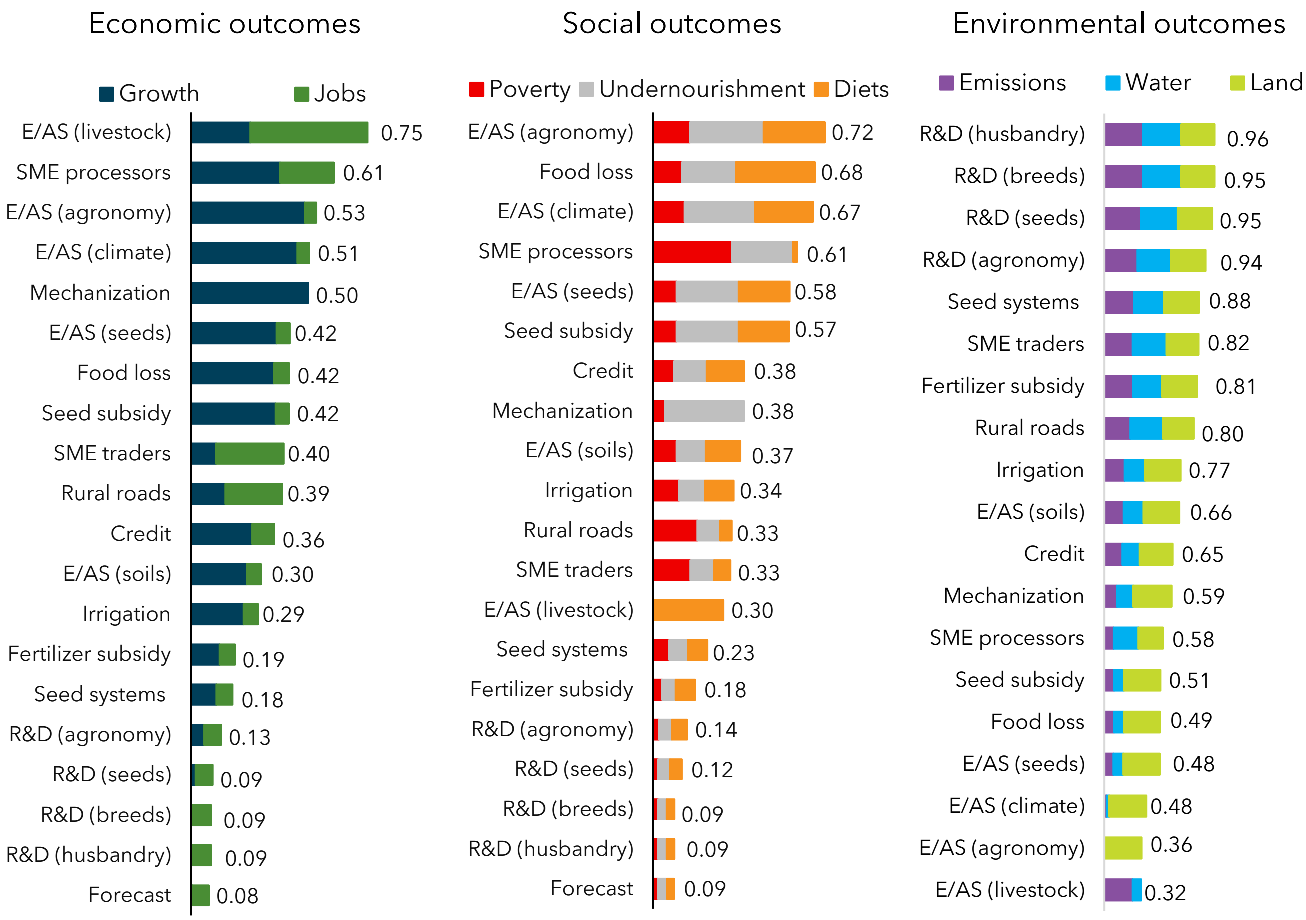
Source: RIAPA modeling system

Composite score of investments by their impact on selected outcome indicators

As outlined in the preceding section, investments were ranked by their impacts across a range of outcomes, grouped into economic, social, and environmental dimensions. The results revealed that no single intervention was ranked the highest across all outcomes, highlighting potential tradeoffs among these indicators. In this section, to better understand overall performance, we constructed composite scores for each intervention within each outcome group using a three-step process. First, we normalize the intervention scores for each outcome, attaching a value of 1 to the most cost-effective and 0 to the least cost-effective. Second, we then attach equal weights to each outcome in a group. Third, we sum up the weighted scores of the outcomes for each intervention to use it for ranking the interventions based on their overall impact. For example, when creating the composite score for the interventions based on their overall economic outcome, an equal weight – 50 percent each – is attached to growth and job creation, assuming equal preference by policymakers for these outcomes. Finally, for each intervention, we sum the weighted scores for growth and job creation to produce an overall score, which is then used to rank all interventions.

Figure 7 ranks investing in extension and advisory services in livestock as the most cost-effective option for jointly expanding agrifood system GDP and employment, with the employment indicator contributing to most of the change in this combined indicator for economic outcomes. Supporting SME processors and agronomy extension/advisory services are also cost-effective investments—market- and farmer-facing, respectively— both driven by faster growth in agrifood system GDP. Amongst R&D investments, agronomy appears more cost-effective regarding its impact on economic outcomes than improved seeds, breeds, and husbandry. Investing in mechanization, post-harvest food loss reduction, SME traders, rural roads, and micro credit to farmers are among the more cost-effective market and infrastructural investments.

Figure 7: Composite scores on economic, social, and environmental outcomes by investment area



Source: RIAPA modeling system

Figure 7 further reports composite scores for each intervention based on their overall impacts on social outcomes, specifically poverty headcount, prevalence of undernourishment, and diet deprivation. The overall impact is constructed by summing together each indicator's normalized score assuming equal weights. Notably, the top four investment options for economic outcomes also rank at the top in the social outcome scores, albeit in a different order. Specifically, investments in advisory services in agronomy rank as the most cost-effective option for achieving greater progress in all social outcomes combined. Extension and advisory services in climate and seeds rank highly, driven largely by their strong effects on reducing undernourishment. Meanwhile, investments in food loss reduction and SME processors are also crucial for achieving better social outcomes mainly through their effects on diet deprivation and poverty, respectively.

The last panel in Figure 7 reports the composite scores for each intervention based on their overall effects on the three environmental indicators: water, emission, and land footprint, each receiving an equal weight. A clear trade-off emerges, as interventions with greater GDP effects tend to have undesirable environmental outcomes. Selected farmer-facing extension services – such as on agronomy, climate, seeds, and livestock – appear most resource-intensive, mainly due to their higher output effects on sectors with higher emission and water use intensities. Similarly, market and food system investments such as spending on SME processors and post-harvest food loss reduction are among the most resource-demanding spending options. In contrast, most upstream R&D interventions—such as those targeting seeds and agronomy—as well as climate forecast, exhibit the smallest environmental footprint, primarily due to their limited overall impact on the economy (see Figure 4 above).

Policymakers have traditionally based policy decisions primarily on economic and social dimensions. To create a composite ranking of the investments, these two dimensions are combined, assigning equal weight (50 percent) to each (Figure 8). This clearly illustrates the synergies and tradeoffs across investments as far as these two broader outcomes are concerned. The composite score puts supporting SME processers, investing in extension and advisory services in agronomy, climate, and livestock as top performing interventions. Whereas investing in advisory services on livestock is more cost-effective at generating better economic outcomes, advisory services in agronomy are particularly good for greater social outcomes. Systemic interventions—such as support to SME processors and extending credit—are also among the most cost-effective strategies for generating broad gains across the agrifood system.

These two dimensions – economic and social – remain important and may still dominate decision-making in many countries. However, a broader agrifood systems approach requires policymakers also to consider the environmental footprint of their policy or investment choices. Figure 8 also reports a comparison of investments' environmental outcomes against their economic and social outcome scores. Interventions with red markers have a high environmental footprint, those with orange markers have a medium-level environmental footprint, and those in green have a lower footprint. This grouping of interventions by their environmental impact is determined by first calculating their Z-scores and then identifying those with the highest and lowest impacts as outliers from the data using a specified standard deviation threshold.

We find that interventions that deliver strong economic and social outcomes tend to be the most resource-consuming, revealing important tradeoffs. For instance, advisory services in agronomy, climate, and livestock have the strongest impacts on the economic and social outcome indicators, while at the same time causing higher environmental footprints. In contrast, most upstream interventions such as R&D in breeds and seeds, and systemic investments such as climate forecast and seed systems rank as the least cost-effective although they generate among the least environmental footprint principally because of overall weaker impacts on production. This tradeoff between economic and social impacts, on one hand, and environmental impact, on the other, highlights the need to improve the resource-use efficiency of interventions that yield strong economic and social benefits.

Figure 8: Composite scores on economic and social outcomes by investment area

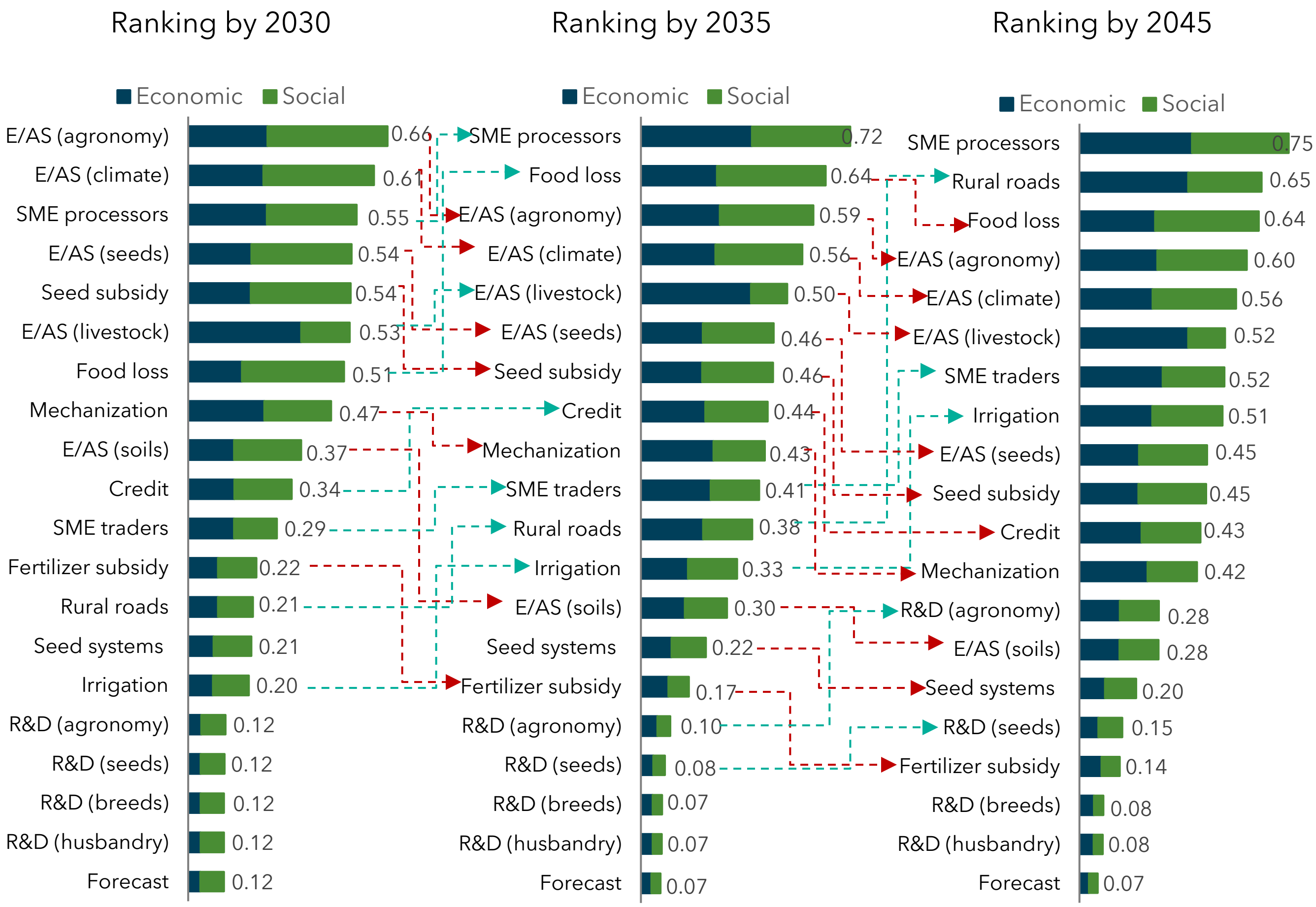
Source: RIAPA modeling system

Do the rankings change over time?

The previous section evaluated the impact of the 2025-2030 investments at the end of the simulation period, i.e., 2045. Since different types of investments exhibit varying lag times between when they are made and when economic and social outcomes materialize, it is of interest to consider whether investment priorities change depending on the time horizon of the policymaker. Notably, most politicians or line ministries in governments may have a shorter time horizon (i.e., matching the typical 4-5 years of the political cycle). In contrast, national planners may have much longer planning horizons (often several decades). The modeling framework adopted in this study accounts for these time delays between when an investment is made and when its effect materializes. This section assesses the magnitude of changes in composite scores by investment area over time. We specifically compared the rankings by 2030, 2035, and 2045 (Figure 9).

Model results indicate that R&D investments in agronomy and seeds become increasingly cost-effective over time as their delayed but long-term impacts materialize. Similarly, market and infrastructural investments such as rural roads, irrigation, and credit access demonstrate substantial improvements in relative cost-effectiveness as their cumulative impacts take effect. By contrast, farmer-facing and recurrent investments—such as extension and advisory services on agronomy, climate, seeds, and soils—gradually decline in relative effectiveness as long-term, high-impact investments assume a greater role in driving economic and social outcomes.

Figure 9: Changes in rankings over time



Source: RIAPA modeling system

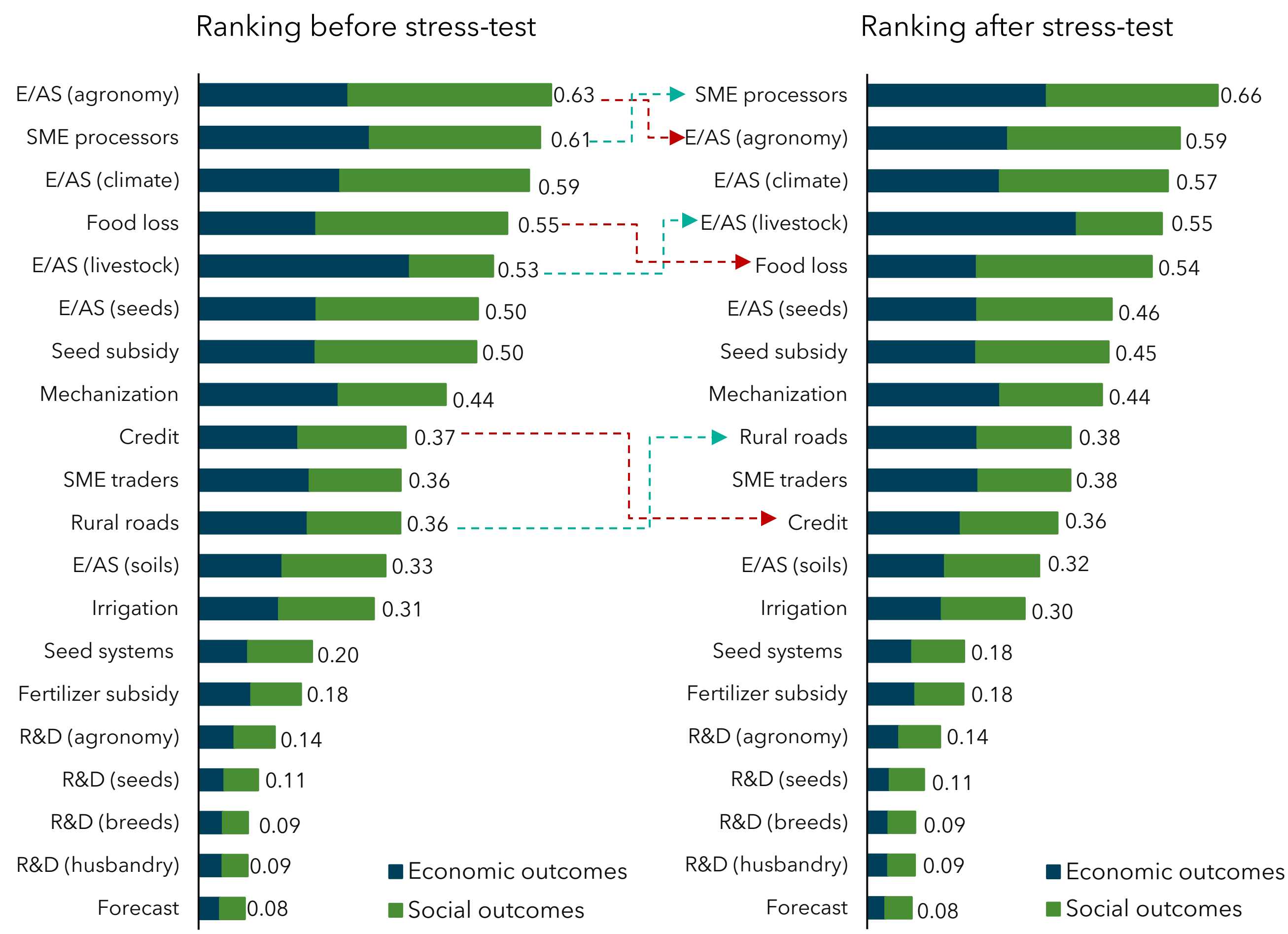
Stress-testing of investments

This section reports on how investment rankings might change when a 1-in-25-year drought shock slashes the yield gains throughout the simulation period (2025-2045).[1] Of course, climatic shocks are unanticipated events, and so these simulations should not necessarily influence policymakers' decisions, but they do shed light on the robustness of the ranking results. The Ghana case demonstrates modest changes in rankings (Figure 10). Top three cost-effective investments—advisory services in agronomy and climate, and support to SME processors—remain in the top three in their high benefit-cost rankings even after accounting for the production risks previously discussed although there is a slight shift in relative ranking. This is because targeted sectors like livestock have historically shown the least yield variability in response to climate change or have only been indirectly and minimally affected by on-farm production losses (see Figure 2).

[1] A drought shock causes a temporary but significant drop in yield, which can reduce productivity over an extended period if it becomes frequent, by affecting resource quality. However, we proxy the yield effect of the drought shock through a shift in yield gain throughout the simulation period since it is difficult to determine the year when the shock may occur. We noted that the timing of the weather shock affects the relative effectiveness of the investments. Since the permanent yield effect is considered for each investment option, the results generated from this analysis remain insightful.

Meanwhile, a moderate shift is observed in the rankings of some of the top half ranked interventions. In particular, the relative cost-effectiveness ranking of some food-system interventions including food loss reduction and micro credit access to farmers decline slightly due to the disproportionate impact of the simulated 1-in-25-year production shock on targeted sectors as effects ripple through the economy. In contrast, infrastructural interventions, including rural roads, and farmer-facing interventions such as extension and advisory services in livestock, show a marked improvement in relative effectiveness under conditions of extreme shocks.

Figure 10: Rankings of interventions after stress-testing



Source: RIAPA modeling system

Unpacking priorities by sub-sector

In the previous sub-sections, we present the cost-benefit rankings of interventions that also target various sub-sectors. For example, food loss reduction measures can focus on cereals, cash crops, or root crops. In this section, we consider a dual approach and provide a much deeper analysis of the ranking of interventions based on the sectors they target. The investment-sector combinations are compared using their normalized composite scores using their effects on economic and social indicators (Table 1).

The blue-shaded cells in Table 1 identify value chains or sectors where the impacts of a given intervention exceed the overall average impact score of the cross-cutting investment. For instance, the composite score for R&D in improved seeds is relatively low – at 0.13– when the intervention's impact is evaluated across all targeted sectors. However, its impact is well above the average for cash crops, at 0.20. Meanwhile, the green-shaded cells denote sector–investment combinations ranked among the top five in terms of potential impact. These indicate priority areas where targeted investment could substantially enhance the overall performance of the cross-cutting intervention. As such, although R&D in improved seeds for cash crops shows above-average impact relative to the cross-sector score, it does not fall within the top five crop-specific intervention areas. Conversely, extension and advisory services in improved seeds to horticultural crops not only exceed the average impact score of such interventions in seeds but also are among the top five investment priorities for greater agrifood system performance. Furthermore, Table 1 indicates that prioritizing extension and advisory services focused on agronomic practices for root and horticultural crops, alongside support for food loss and waste reduction and increased investment in seed subsidies within the horticulture sector, would substantially enhance the overall effectiveness of investments in the agrifood system. Support to SME processors and advisory services to livestock and in climate information also remain the top cross-cutting (non-crop-specific) interventions in terms of their impact on social and economic outcomes.

Table 1: Composite scores by investment area and crop sector

			Cross-cutting	Cereals	Root crops	Pulses and oilseeds	Horti-culture	Other cash crops
R&D	1	R&D (improved seeds)	0.13	0.13	0.13	0.13	0.13	0.20
	2	R&D (agronomy)	0.14	0.13	0.14	0.13	0.16	0.32
	3	R&D (animal breeds)	0.13					
	4	R&D (animal husbandry)	0.13					
Extension / advisory services	5	E/AS (improved seeds)	0.32	0.22	0.37	0.35	0.41	0.32
	6	E/AS (agronomic practices)	0.38	0.24	0.43	0.32	0.51	0.39
	7	E/AS (livestock)	**0.33**					
	8	E/AS (climate information)	**0.36**					
	9	E/AS (climate smart agriculture)	0.23	0.15	0.26	0.23	0.30	0.27
Markets and food systems	10	Seed systems	0.18					
	11	SME processors (finance, training)	**0.47**					
	12	SME traders (finance, training)	0.31					
	13	Food loss and waste	0.32	0.18	0.34	0.29	0.59	0.31
	14	Credit access (financial inclusion)	0.25					
	15	Seed subsidy	0.32	0.20	0.37	0.35	0.41	0.32
	16	Fertilizer subsidy	0.16	0.12	0.21	0.14	0.22	0.17
Risk reduction and resilience	17	Seasonal forecast (early warning)	0.12					
Infrastructure	18	Irrigation infrastructure	0.23	0.15	0.27	0.21	0.29	0.25
	19	Rural roads	0.31					
	20	Mechanization	0.32	0.22	0.40	0.35	0.12	0.12

Source: RIAPA modeling system

Summary

Ghana's agrifood system is an important source of livelihood for households, an engine of economic growth, and a key sector of employment, particularly in rural areas. Despite encouraging progress, Ghana has an urgent need to transform its agrifood system sustainably. Achieving this requires greater technical and financial support to agriculture and its allied sectors. Policymakers can benefit greatly from data- and model-driven insights on the impacts of agrifood system investments on economic, social, and environmental outcomes, including for different planning horizons and under conditions of uncertainty and risk. This country brief presents results from a systematic evaluation of a range of agrifood system investment options. We rank investment choices based on their cost-effectiveness in delivering multiple development outcomes, including agrifood GDP growth, agrifood job creation, poverty reduction, undernourishment reduction, and improvements in diet deprivation. We also considered the environmental implications of these investments, focusing on water, emissions, and land footprints.

Model results indicate that investments in SME processors, post-harvest food loss reduction, and micro credit to farmers are the most cost-effective means for improving social outcomes, such as reducing poverty, undernourishment, and diet deprivation. These investments also perform strongly in terms of expanding agrifood GDP and employment. Similarly, extension and advisory services in agronomy, climate, livestock, and seeds emerge as high-impact, farmer-facing interventions. Additionally, the study identifies investments in infrastructure—particularly those targeting mechanization, rural roads, and irrigation—as cost-effective strategies for promoting inclusive agrifood transformation. However, many of these high-performing investments are associated with relatively high environmental footprints, highlighting the tradeoffs between development outcomes and the environment. The analysis reveals moderate changes in the ranking of agrifood system investments under climatic shocks, suggesting the robustness of the ranks.

Several general policy messages can be drawn from this analysis. Firstly, it demonstrates not only that integrating data- and model-driven insights into policy and investment prioritization decisions is feasible, but it is also important to do so given synergies and tradeoffs across these investments on development outcomes. Secondly, considering the environmental implications of policy and investment decisions is critical to ensure that the adverse effects of climate change or environmental degradation do not fall disproportionately on future generations of poor people. Finally, the analysis highlights the importance of designing appropriate climate adaptation and mitigation strategies to help enhance the productivity and resource use efficiency of sectors identified as key drivers of socioeconomic progress.

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Annex Table 1: List of investment scenarios considered

Broad category	Number	Scenario	Description
Research and development (R&D)	1	R&D (improved seeds)	R&D into improved seed development
	2	R&D (agronomic practices)	R&D into improved agronomic practices
	3	R&D (animal breeds)	R&D into improving breeds
	4	R&D (animal husbandry)	R&D into improved husbandry practices
Extension / advisory services	5	E/AS (improved seeds)	Advising improved seed use
	6	E/AS (agronomic practices)	Advising improved agronomic practices
	7	E/AS (livestock)	Advising improved livestock handling
	8	E/AS (climate information)	Providing climate information system
	9	E/AS (climate smart agriculture)	Advising on climate smart practices
Markets and food systems	10	Seed systems	Extended seed system
	11	SME processors (finance + training)	Finance and training for SME processors
	12	SME traders (finance + training)	Finance and farming for SME traders
	13	Food loss and waste	Food storage and transport
	14	Credit access (financial inclusion)	Micro-credit access for farmers
	15	Seed subsidy (direct input provision)	Provision of improved inputs to farmers
	16	Fertilizer subsidy (direct input provision)	Provision of chemical fertilizer to farmers
Risk reduction and resilience	17	Seasonal forecast (early warning)	Seasonal weather forecast
Infrastructure	18	Irrigation infrastructure	Small and medium scale irrigation
	19	Rural roads	Unpaved feeder roads
	20	Mechanization	Farm mechanization and technology

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