INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

IFPRI

# AGRIFOOD INVESTMENT PRIORITIZATION

COUNTRY SERIES

**COUNTRY BRIEF 3** | MAY 2025

# UGANDA

## Cost effective options for inclusive and sustainable development

**Emerta Aragie, James Thurlow, Hashim Ahmed and Eleanor Jones**

*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 Uganda'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 rates of undernourishment, and lowering diet deprivation. Additionally, the study assesses their impact on environmental footprints, focusing on water consumption, land use, and emissions. Investments in small and medium enterprise (SME) processors are shown to be the most cost-effective at expanding agrifood GDP and employment, while livestock extension services rank highest among the farmer-facing investments. Most R&D related interventions rank lowest in terms of cost-effectiveness at achieving economic and social outcomes. However, many cost-effective investments have relatively high environmental footprints, highlighting tradeoffs. The study further reveals shifts in the cost-effectiveness ranking of investment options over time and when extreme production shocks occur.

**Keywords**: Investment priorities, agrifood system, economic, social, environment, Uganda

## Introduction

The agrifood system in Uganda is the engine of growth, the main employer, and the source of livelihood for millions. However, it constitutes low-productivity agriculture, which struggles to supply affordable high-quality food for the growing population. This juxtaposition underscores the urgent need for a sustainable transformation of the entire 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, such as poverty, undernourishment, or diet deprivation. Understanding whether tradeoffs exist across these outcomes can help inform policymakers' decisions about resource allocations. Increasingly, policymakers and development partners are also incorporating environmental sustainability considerations into their assessments. This is based on an enhanced awareness that unsustainable production practices contribute to environmental degradation and to climate change, the burden of which will fall disproportionately on future generations of poor people (GLOPAN 2020).

The effectiveness of policies or investments may be affected by unanticipated shocks, such as global commodity market disruptions 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 Uganda (NPA, 2017). Extreme events such as drought and flooding have become increasingly common and are expected to intensify in frequency and severity (Ojara et al., 2024; NPA, 2017). 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 is not evident whether climatic shocks would also alter the prioritization of these policies and investments.

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 Uganda 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 GDP growth, agrifood job creation, poverty reduction, undernourishment reduction, and improvements in diet deprivation. To assess the impacts of these investments on the environment, 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 Uganda.

Results are generated using IFPRI's Rural Investment and Policy Analysis (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 incorporated environment module that computes environmental footprints, including water, emission, 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).

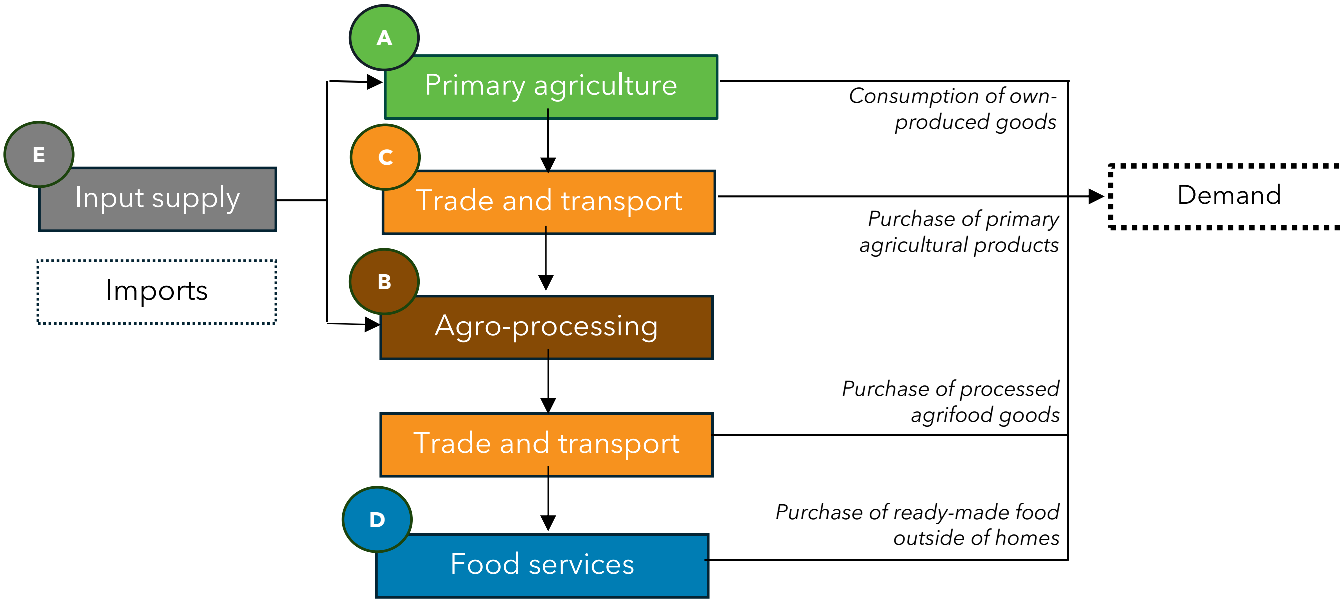
## Country Context

### Structure of Uganda's agrifood system

A country's agrifood 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. We measure the agrifood system from a supply-side perspective, leveraging national accounts and employment statistics to directly simulate changes in growth and employment by investment scenarios and over time. By disaggregating the agrifood system into distinct value chain groups and mapping interventions that target improving some of their bottlenecks, this approach provides valuable insights into the key drivers of agrifood system growth and associated environmental impacts in Uganda.

Figure 1 presents a simplified conceptual framework of the agrifood system, consisting of 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**) is part of the manufacturing sector and includes subsectors that process agriculture-related food and non-food products. Meanwhile, trade and transport (**C**) involve services related to the transportation, wholesaling, and retailing of agrifood products between farms, firms, and final points of sale. Food services, represented in (**D**), include services such as meals prepared in restaurants, food stalls, or hotels. Finally, input supply (**E**) represents the portion of domestically produced intermediate inputs used directly in agricultural and agro-processing production, such as fertilizers and financial services.

**Figure 1:** A simple conceptual framework of the agrifood system



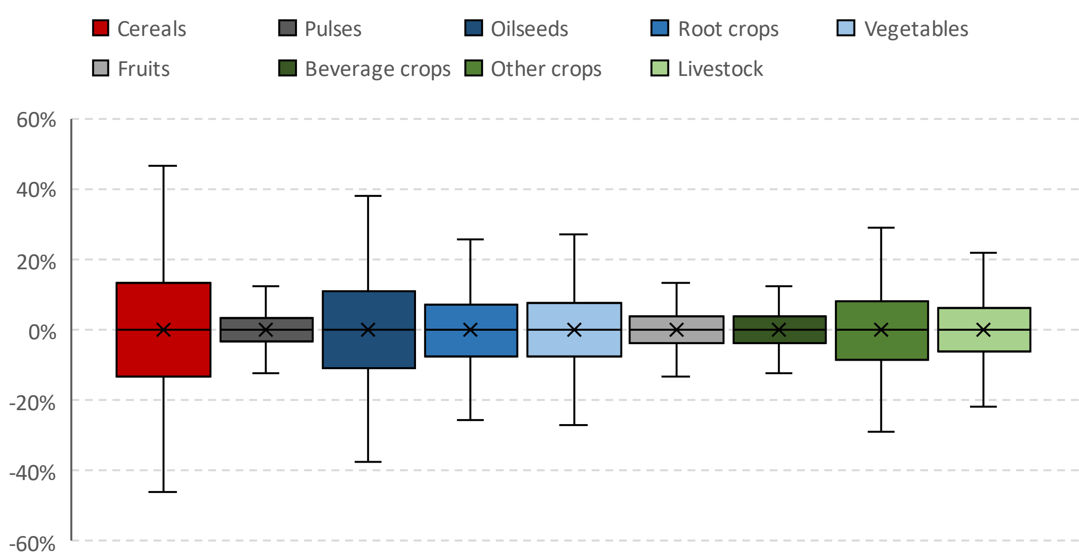

**Source**: Diao et al. (2023)

The agrifood system in Uganda contributes over 41 percent of gross domestic product (GDP), employing about 75 percent of the workforce (Diao et al., 2023). Primary agriculture is the engine of growth, growing moderately by about 3.5 percent annually over the past two decades (World Bank, 2025), and currently contributing 25 percent of GDP (Diao et al., 2023). With appropriate policy reforms and targeted investments together with a stable socio-political environment, the sector has the potential to accelerate its growth and contribute to broader structural change in Uganda. Accelerating growth and sustaining high employment levels have long been central development objectives for countries worldwide, and Uganda is no exception. With a poverty headcount rate of 20.3 percent in 2015 (World Bank, 2023) and notable concerns about diet deprivation, the Ugandan government recognizes the formidable challenges it faces, particularly as it strives to achieve economic development and social progress while simultaneously shifting towards a green economy (NPA, 2017).

## Agricultural production variability in Uganda

Given the predominance of rainfed production systems, Uganda's agricultural sector has historically been exposed to weather-related production 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 seeds (Shah et al., 2024; Kumar and Maiti, 2024). Historical production estimates for Uganda show that cereals and oilseeds yields fluctuate more than pulses or horticulture yields (see Figure 2). For instance, production losses during a 1-in-25-year drought event relative to a "normal" year could range between 8.7 and 9.7 percent for pulses and fruits, and between 27.0 and 33.2 percent for oilseeds and cereals. This variation in yield effect across sectors highlights different degrees of vulnerability of sectors to climatic shocks. Moreover, there is spatial variation both in the severity of drought conditions and sectors distribution in production, both contributing to the national level variation in yield impacts across products.  In our modeling results, we will test the robustness of our investment ranking to climatic shocks using historical 1-in-25-year drought events as indicative of how such shocks will contribute to sectoral yield losses and alter the impacts of investments.

**Figure 2:** Historical production variability for crops and livestock



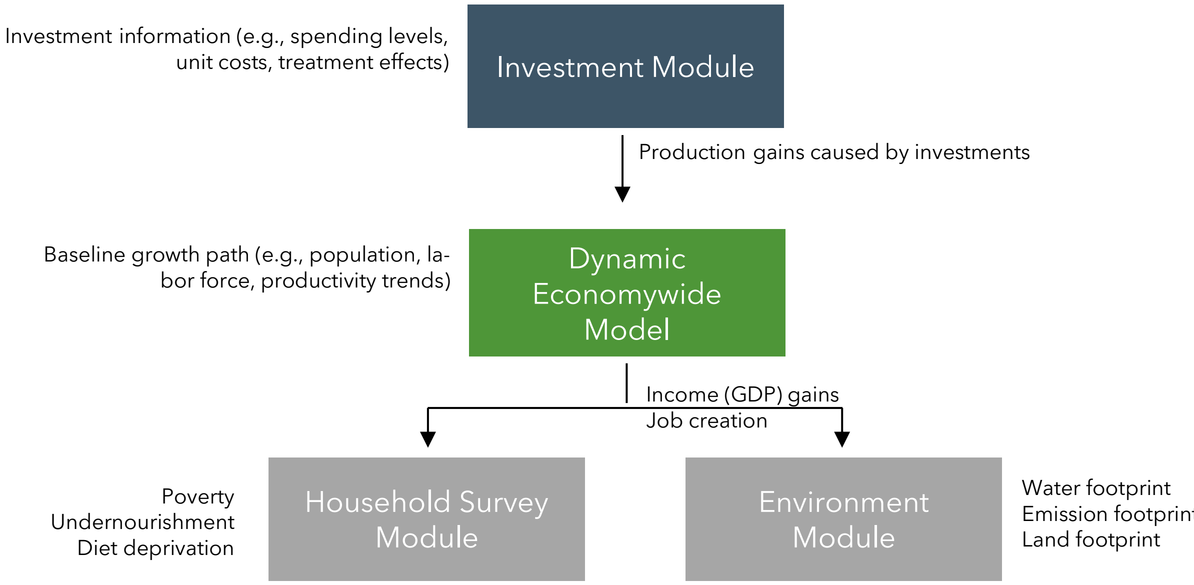

**Note**: The historical variability values are residual fluctuations from the determined production time series for 1990-2021. Fruits, livestock, and beverages are the three main contributors of agricultural GDP, with shares of 33, 19, and 10 percent, respectively. Cereals, vegetables, and pulses follow, contributing 7-9 percent each.

## Method of Analysis

### Modeling approach

This study estimates the impacts of alternative agrifood system investments on the Ugandan economy across key outcome indicators, which are categorized as 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 incorporated environment module that computes environmental footprints, including impacts on water utilization, emission, and land use (Figure 3). This integrated RIAPA framework thus enables a comprehensive assessment of investment impacts.

**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. These models are widely utilized for economic policy formulation and analysis (Dixon and Parmenter, 1996; Devarajan and Robinson, 2010). They capture the interlinkages between sectors, households, and rural-urban economies, making them well-suited for assessing the economywide effects of public policies.

The Uganda 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 32 agricultural sub-sectors, which include 23 individual crops or groups of crops, six livestock production sectors, as well as forestry and fisheries. The model also incorporates 39 industrial sectors–including 23 agro-processing activities–and 12 service sectors, which include food-related areas 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 Uganda model also distinguishes 15 representative households, each of which is an aggregation of a group of households captured Uganda National Household Survey (UNHS) 2016/17 (UBOS, 2018). These households are categorized into rural and urban household groups, with rural households further divided into farm and non-farm groups based on their reliance on agriculture as a primary source of income. Finally, each household group is further disaggregated by per capita expenditure quintiles. 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 levels of economic and sectoral growth, population and labor force growth, and levels of government spending. This "business-as-usual" scenario runs until 2045. All investment scenarios are compared against this baseline. As will be seen later, the temporal feature of the model allows us to examine how the effects of various interventions change over time.

### *The investment module*

The investment module is used to synthesize data from several sources to measure at a detailed sectoral level the expected productivity gains that can be attributed to a unit of expenditure on each of 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 (Aragie et al., 2022; Pauw and Thurlow, 2015; Benfica et al., 2019). The previous version of the investment module was elaborated in Aragie et al. (2024). The updated framework separates agrifood system investments in layers depending on whether they are at the knowledge generation stage (up-stream: 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 18 individual interventions, with many targeting up to six distinct groups of agricultural sectors.

The investment module structures agrifood investments and processes data on the costs and impacts of interventions across targeted sectors. Specifically, it integrates investment details—such as spending levels, unit costs, changes in 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. The productivity gains are then transmitted to the economywide model, which endogenously adjust the targeted sectors' productivity levels. Through direct and indirect economywide linkages, these adjustments drive changes in income, prices, employment levels, and other key economic indicators.

Unit costs are usually obtained from the literature and are retrieved from project planning (such as irrigation master plans) or evaluation documents. Baseline adoption rates and coverage levels are obtained from farm household surveys such as the Uganda's National Panel Survey (NPS) 2019/20 (UBOS, 2021) which reports 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 is considered for each interventions area for cost-benefit comparison 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 necessitates specialized modules. To this end, the CGE model is linked top-down 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 for the fifteen representative household groups in the RIAPA model, are mapped to the corresponding individual households in the 2016/17 UNHS (UBOS, 2018). The new poverty status is computed for all sampled households. Likewise, the undernourishment model uses the same set of households and measures the change in the share of the population below the 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. 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, emission, 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 in the cereal 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 Poor 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 Uganda 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 Uganda CGE model. Uganda had 9.9 million hectares of land under crop cultivation in 2022, the model base year. In addition to this, we incorporate land use for livestock grazing into the land footprint calculation. FAO (2025) reports over 5.3 million hectares of grazing land in Uganda in 2022. In our modeling analysis we assume 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 eighteen different investment areas. We assume a marginal increase of $25 million in spending per year from 2025-2030 for each investment area. The relative effectiveness of each intervention is assessed based on its effect in driving different development outcomes by 2045. To bring future returns to their current equivalent for comparability reasons, we discount the future impacts using a discount rate of 4%. 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, productive agronomic practices, animal breeds, and animal husbandry.
- Extension and advisory services promote the adoption of improved seeds, agronomic practices, livestock inputs (e.g., feed and vaccines), 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, or improve access to credit.
- Risk reduction and resilience interventions support better decision-making by agrifood system actors by providing early warning information, climate forecasting, and productive safety nets.
- Infrastructure investments raise overall value chain productivity through expanding irrigation schemes or feeder roads that connect farmers to input and product markets.

Calibration of the investment module requires a range of data inputs for each of the eighteen investment areas. These 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, as well as yield gains from utilizing those technologies or services. Baseline rates of technology adoption and service 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. Uganda's NPS 2019/20 (UBOS, 2021) is specifically used to estimate adoption and coverage rates for the various technologies and practices modeled in this analysis. The survey shows a generally low rate of input coverage, showing a potential for rapid increase in yield through targeted interventions. IFPRI's crop model (IFPRI, 2024) is used to estimate yield gains from adopting different farm practices. For Uganda, the model reveals stronger cereal yield effects from irrigation infrastructure, followed by information on planting windows and the adoption of improved seeds. These investment module parameters, alongside measures such as value-added and output prices, are important determinants of the returns on investments in different technologies or 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 Uganda is historically 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.

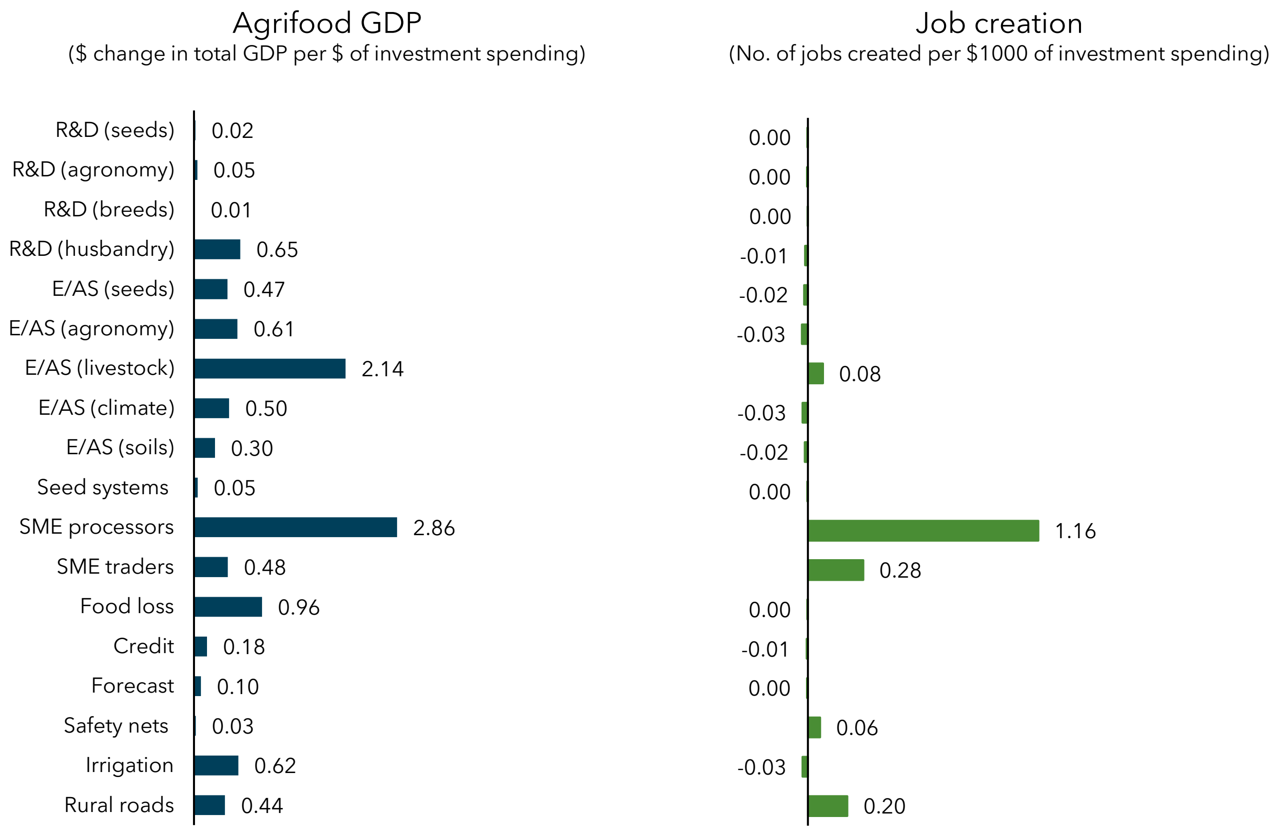
## Cost-Effective Investment Options for Inclusive and Sustainable Transformation

### Comparing the impacts of investments

We start our comparison of investments based on their impact on two standard economic outcomes: agrifood growth and job creation. These outcome indicators are directly obtained from the economywide model (see Figure 3). Results are reported in Figure 4. These reveal relatively stronger growth effects from investments in SME processors, livestock extension and advisory services, and food loss and waste. Specifically, each additional dollar spent on SME processors generates an additional $2.86 in agrifood system GDP, compared to around $2.14 for livestock extension and advisory services. Spending on food loss and waste nearly yields economywide benefits equal to the cost. Other interventions are likely to cause far lower returns in GDP per dollar investment.

Job creation remains an important development challenge for most developing countries, including Uganda, especially given the continued rapid increase in the working-age population. Notably, model results highlight SME processors related interventions as the most effective, generating 1.16 additional jobs per $1000 invested due to their strong backward and forward linkages across the economy. Spending on SME traders and infrastructure development, particularly rural roads, also emerge as a priority investment for job creation. However, most other interventions considered limited employment effects. This is because productivity gains from these investments enable higher output with fewer inputs, potentially reducing labor demand expansion in certain sectors.

**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 quality of household diets. These are obtained from the various household survey-based microsimulation models incorporated into the RIAPA framework. Results show that investment areas differ in terms of their effectiveness in driving these outcomes (Figure 5). Investments in SME processors have the largest impact on poverty and undernourishment, which is partly explained by the strong GDP effects of these interventions and the employment linkages of SMEs to lower-income households. Food loss and waste reduction and productive safety nets are also important for reducing poverty and undernourishment, while R&D in agronomy and investment in irrigation infrastructure have particularly stronger effect on the prevalence of undernourishment. Meanwhile, extension and advisory services on livestock has contrasting results on poverty and undernourishment, significantly reducing poverty but with marginal impact on the latter.

The cost-effectiveness of the interventions appears peculiar to effects on poverty and undernourishment. Extension and advisory services to livestock herders rank the highest on diet impacts since this intervention improves access and availability of food products to which households usually experience a consumption gap. Food loss and waste reduction and R&D in agronomy contribute to greater diet quality improvements 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

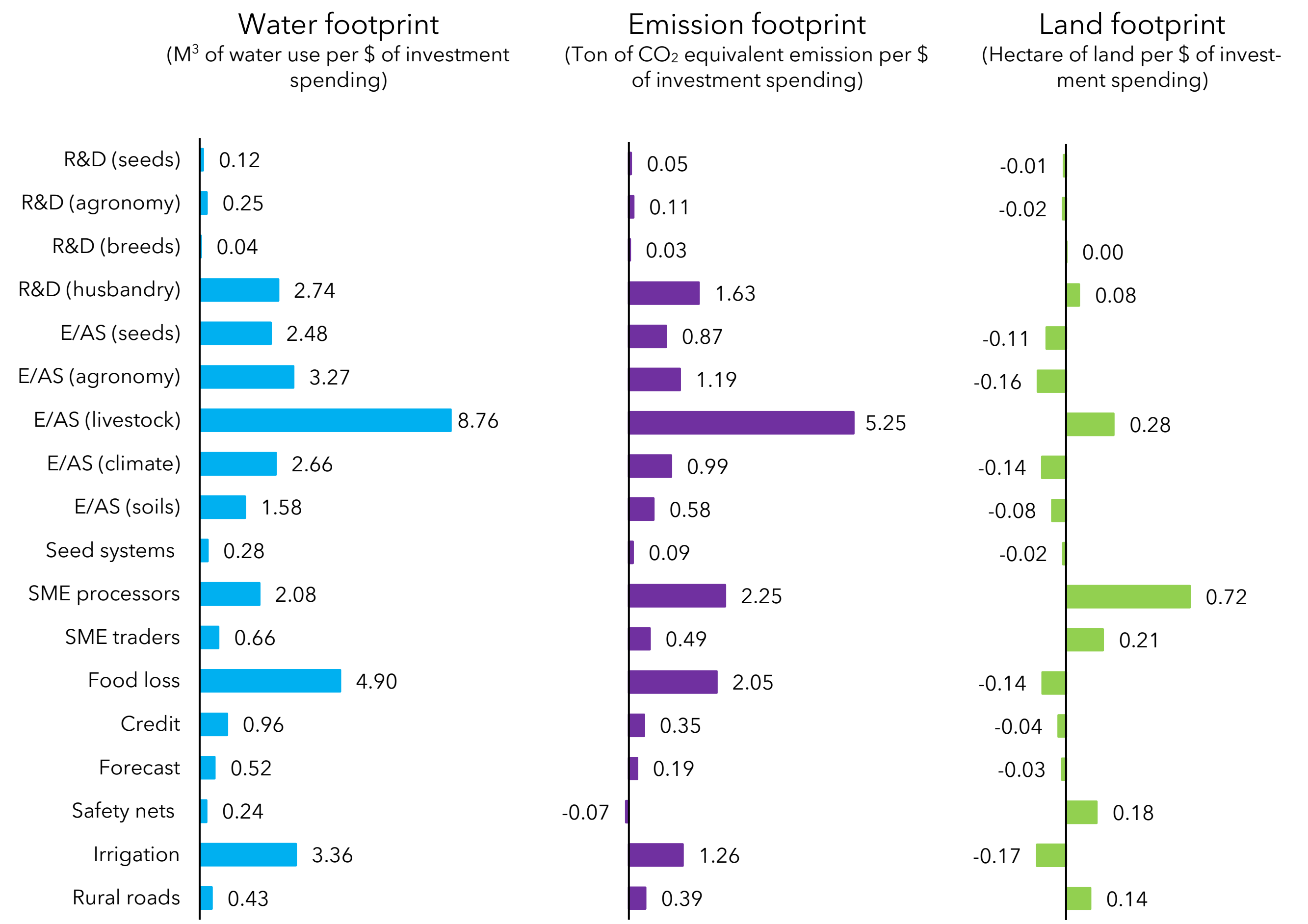

**Source**: RIAPA modeling system

We also evaluated the various investments based on their resource use or environmental impacts, looking specifically at changes in the economywide water, emissions, and land footprints. The changes in environmental footprints associated with investments will depend on the initial resource intensity of sectors the interventions target, 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 are undesirable.

Results from the environment module show investments in livestock, including R&D in animal husbandry and extension services to livestock producers, consistently rank among the highest across the environmental indicators, underscoring the resource intensity of the sector (Figure 6). Off-farm investments in SMEs and food loss and waste reduction, together with irrigation results in a stronger increase in emissions since these interventions promote production in sectors with higher emission footprints. Figure 6 also shows a stronger economywide water use effect from interventions in food loss and waste reduction, and extension services in agronomy practices, climate information and seeds. Investment in irrigation infrastructure is arguably one of the interventions with a stronger water footprint effect, specifically by promoting the expansion of sectors with irrigation practices.

Whereas all interventions cause increases in water and emission footprints at economywide level, land footprints show movements in both directions depending on the change in economywide demand for land due to these investments. Land footprint increases (i.e., more land put under cultivation) when invested in SME processors and traders, livestock and safety nets. These increases in land footprints are likely due to additional opportunities for land-intensive sectors to grow as the economic opportunity changes. By contrast, R&D in agronomy, irrigation, extension services in climate information systems, and food loss reduction help release agricultural land, creating a possibility for environmental regeneration. For example, irrigation infrastructure enhances land productivity, enabling more output from a smaller area and potentially allowing some land to be taken out of agricultural production.

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



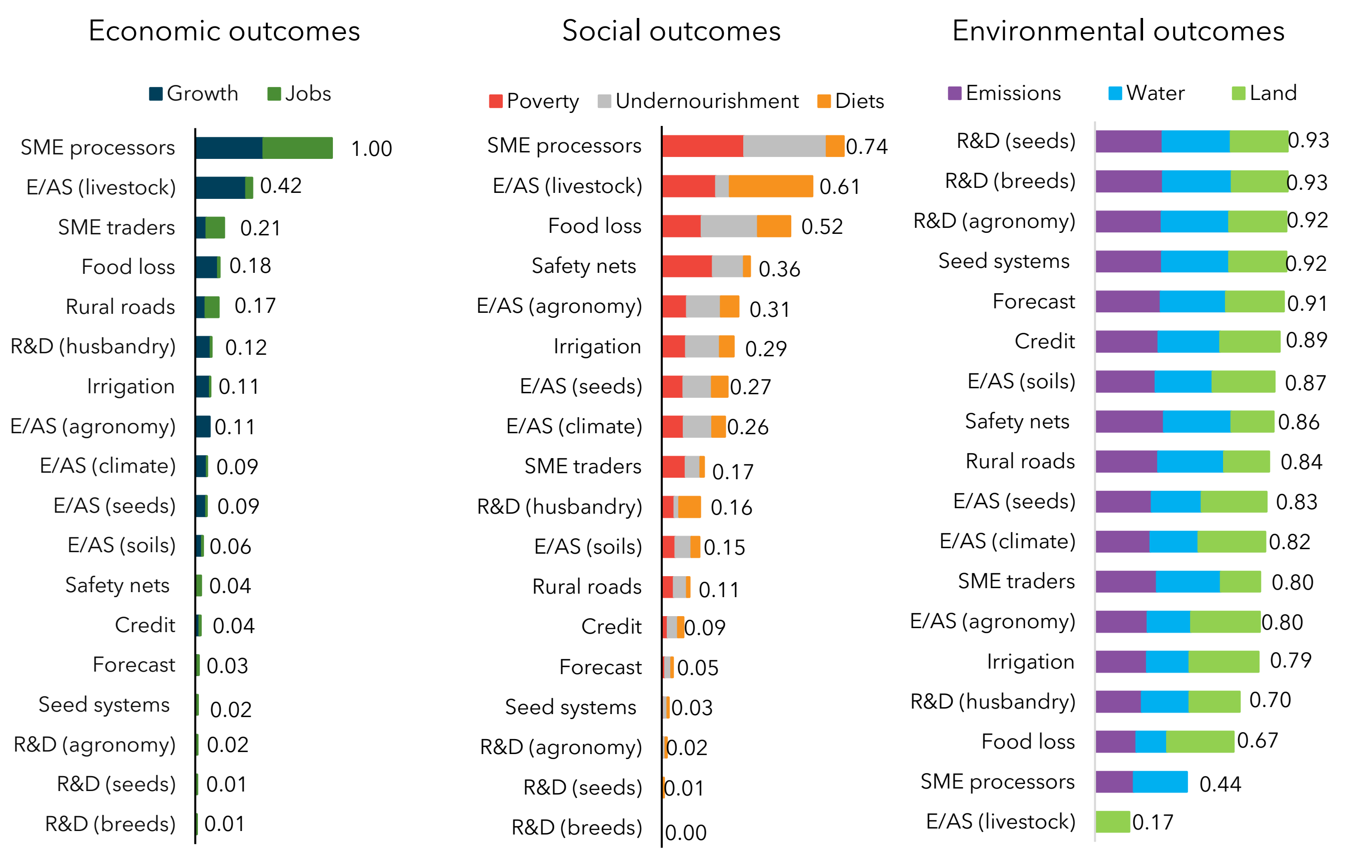

**Source**: RIAPA modeling system

## Composite score of investments by their impact on selected outcome indicators

As presented in the preceding section, investments were ranked by their impacts on a long list of outcomes, grouped into economic, social, and environmental dimensions. We noted from the results that no single intervention was ranked top across all outcomes and that we witnessed potential tradeoffs across these indicators. In this section, we construct composite scores of the interventions by their impact on each group of outcomes. This is done in steps. 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 out-come, an equal weight – 50 percent each – is attached to growth and job creation, assuming equal preference by policymakers for these out-comes. 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 SME processors as the most cost-effective option for jointly expanding agrifood system GDP and employment, with both growth and jobs contributing to its rank in the combined indicator for economic outcomes. Providing livestock extension/advisory services is the most cost-effective farmer-facing investment, mainly driven by faster growth in agrifood system GDP. Investing in SME traders, food loss reduction and rural road expansion are systemic interventions for driving greater economic outcomes. Amongst R&D investments, animal husbandry and agronomy appear more cost-effective regarding their impact on economic outcomes than improved seeds and animal breeds.

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




**Source**: RIRPA modeling system

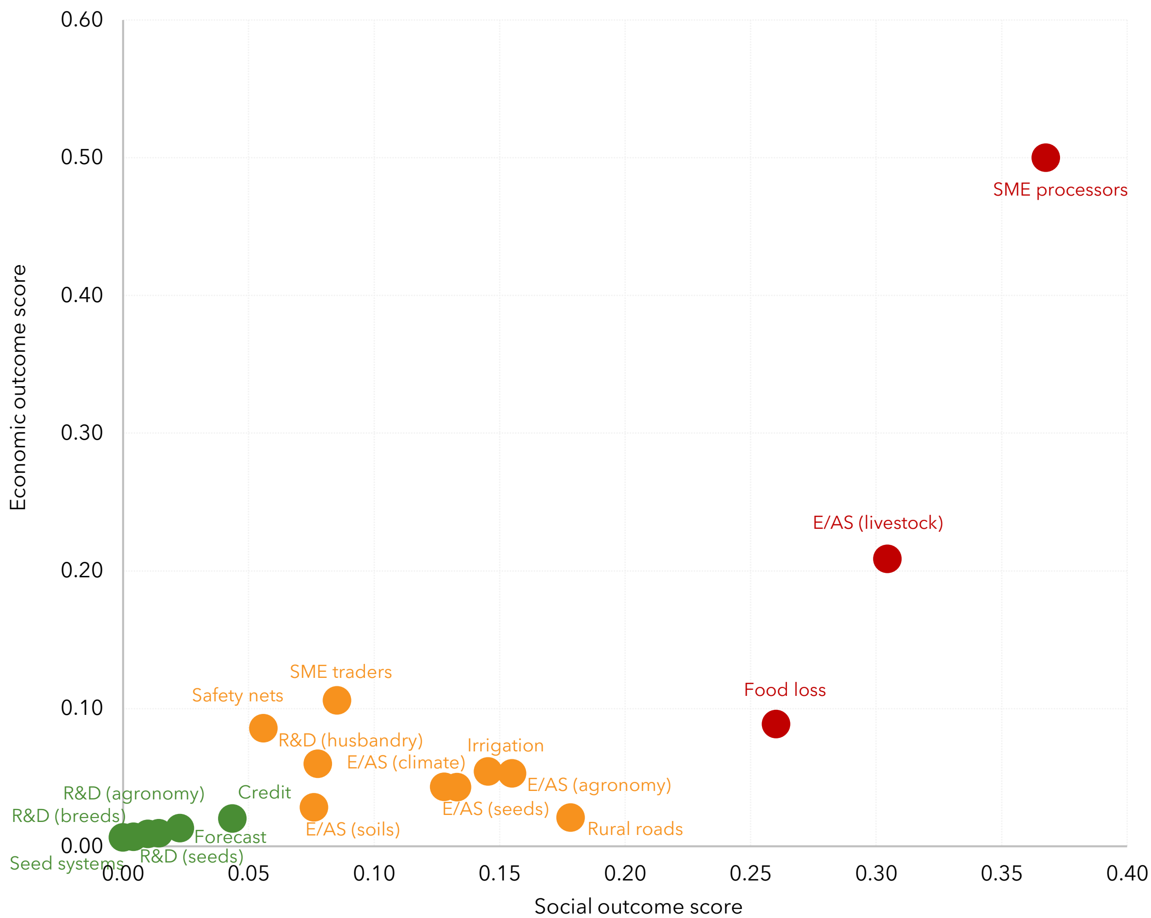
Figure 7 further reports composite scores of interventions based on their overall impacts on social outcomes, summarizing their effects on poverty headcount, prevalence of undernourishment, and diet deprivation. The overall impact is constructed by summing together each indicator's normalized score assuming equal weights. Similar to the economic outcome scores, investing in SME processors ranks as the most cost-effective option for achieving greater progress in all social outcomes combined. At the same time, extension services to livestock farmers, food loss and waste reduction, and safety nets also rank highly.

The last panel in Figure 7 reports the composite score of the interventions based on their overall effects on the three environmental indicators, namely water, emission, and land footprint. Interventions with greater GDP effects tend to have undesirable environmental outcomes, demonstrating an important tradeoff between economic growth and environmental impacts. Livestock-related investments such as farmer-facing extension services and upstream R&D in husbandry appear the most resource-intensive, mainly due to their high water use and emission per unit of output. Market and food system investments such as spending on SME traders and processors and food loss and waste reduction are among the most resource-demanding spending options. By contrast, most farmer-facing interventions such as extension and advisory services on seed, agronomy, and soil management have the least environmental footprint effect, mainly due to limited effect on the economy (see Figure 4 above).

Traditionally, policymakers would have based policy decisions primarily on economic and social dimensions. To create a composite ranking of the investments, these two dimensions are combined attaching 50 percent weight to each and reported in Figure 8. This clearly illustrates the synergies and tradeoffs across investments as far as these two outcomes are concerned. The composite score puts investing in SME processers at the top, mainly because of their impact on economic and social outcomes. Farmer facing interventions such as extension and advisory services on livestock and agronomy and systemic interventions such as food loss and waste reduction and safety nets rank as cost-effective in generating overall gains within the agrifood system in Uganda. However, interventions with greater economic and social outcomes tend to be most resource-using, implying some tradeoffs. In Figure 8, 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. The 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.

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 shows most upstream interventions such as R&D in agronomy, seeds and breeds and some farmer-facing interventions such as extension and advisory services on soils, climate and seeds rank the least cost-effective although they generate the least environmental footprint principally because of overall weaker impacts on production, revealing stronger tradeoffs between the previous two outcomes and the environmental footprint indicator.

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



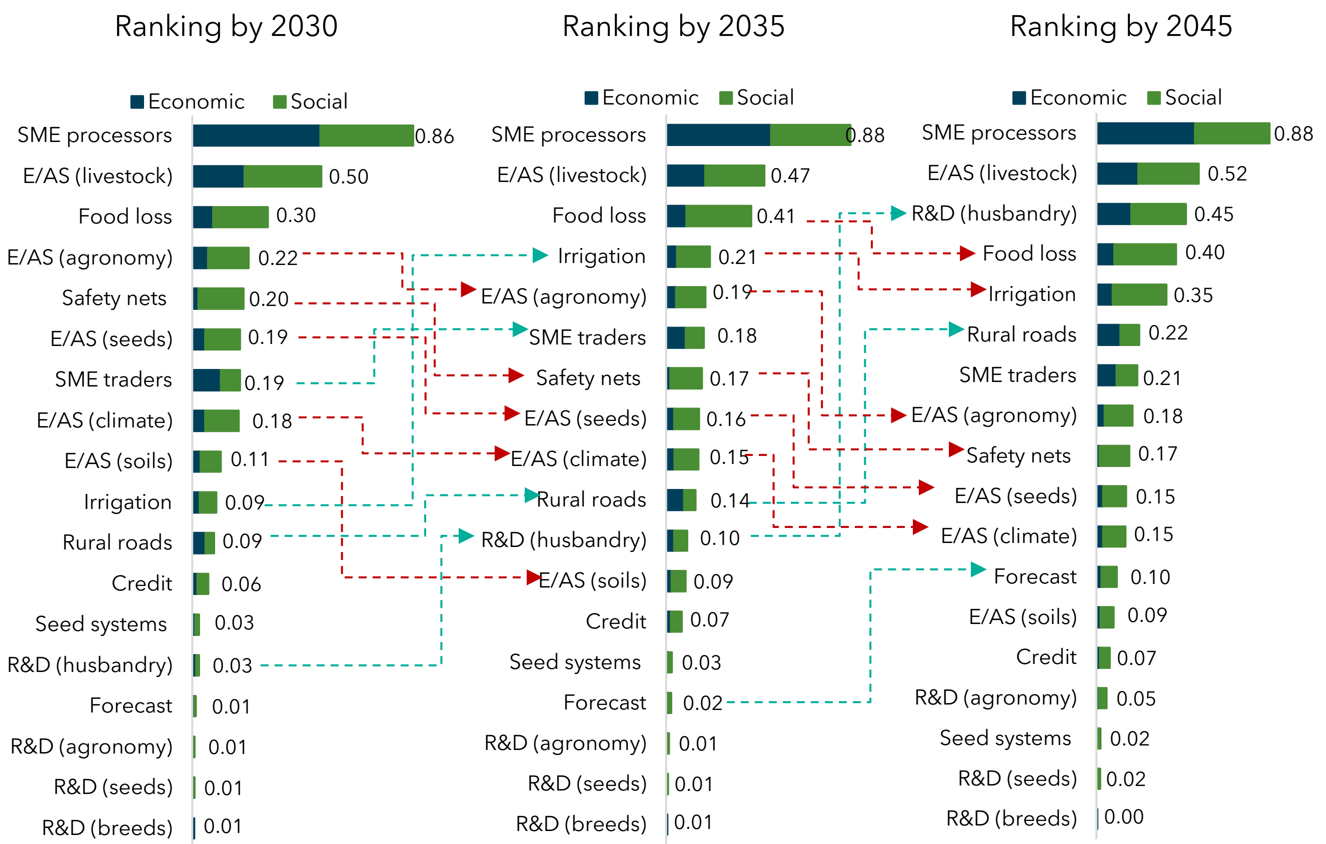

**Source**: RIAPA modeling system

## Do the rankings change over time?

The previous section compares the investments by the end of the simulation period, i.e., 2045. Given differences in the lag time between when a particular investment is made and when it starts having an impact on economic and social outcomes, 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 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).

While the top three interventions retain their ranks in cost-effectiveness, our model results reveal some shifts in the rankings of other interventions. Specifically, R&D-related investments in husbandry and agronomy become increasingly cost-effective over time as their lagged but long-term impacts materialize. Investments on rural roads also show a rise in cons-effectiveness over time as the benefits accumulate. Meanwhile, the relative effectiveness of recurrent farmer-facing investments such as extension and advisory services on seeds, agronomy, climate, and soils gradually declines as benefits of larger, one-off investments start accumulating in future periods.

**Figure 9:** Changes in rankings over time



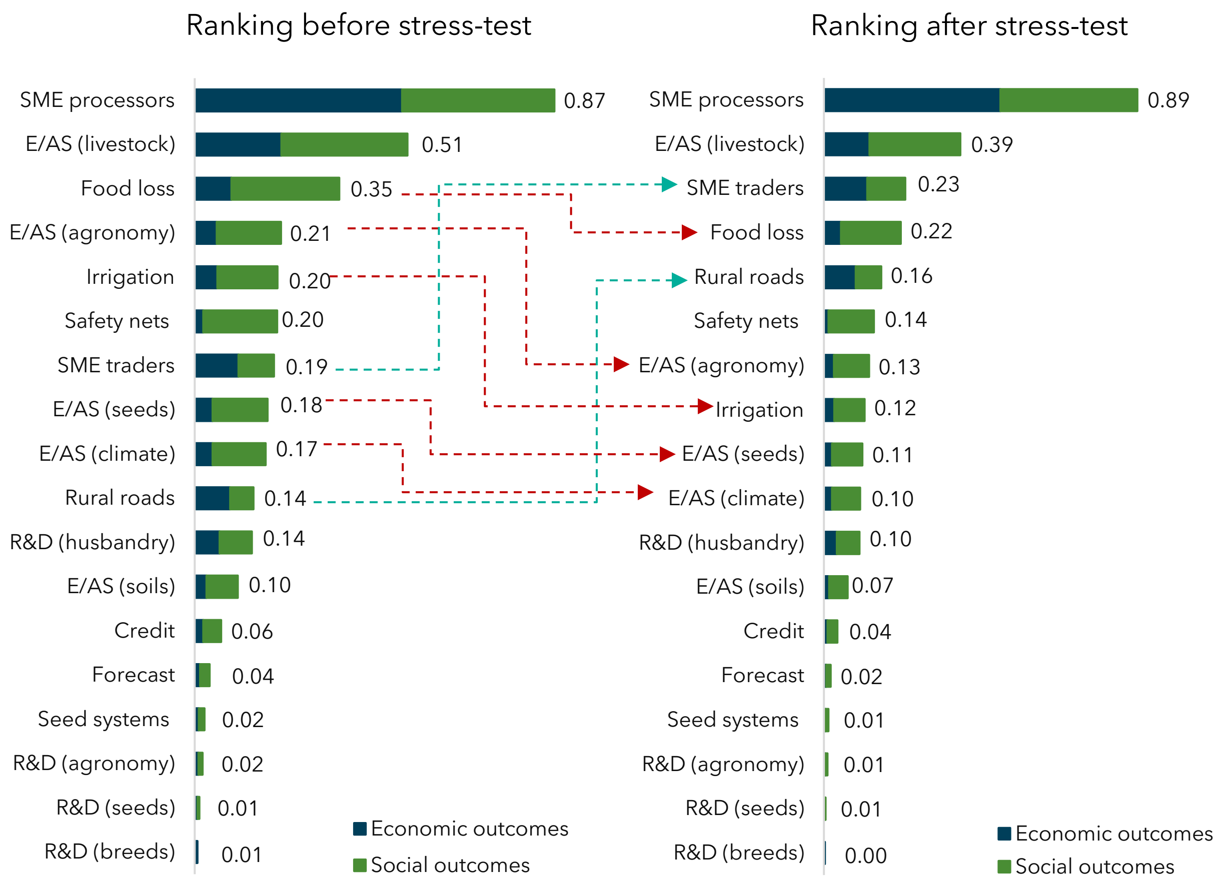

**Source**: RIAPA modeling system

## Stress-testing of investments

This section reports on how investment rankings might change when a 1-in-25-year drought shock permanently slashes the yield gains throughout the simulation period (2025-2045). 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. As shown in Figure 10, the rankings without and with the climatic shock (or stress-test) are markedly different for some interventions. While investments in SME processors and extension services to livestock farmers remain at the top of the list, perhaps because of the strong relative strength in their impacts compared to others, farmer-facing interventions, including extension services on improved seed adoption and climate information together with irrigation face declines in their ranks in cost-effectiveness.

However, the cost-effectiveness of investments on rural roads and SME traders increases markedly due to their impact in connecting upstream and downstream actors, increasing the economies resilience to extreme climatic shocks. Meanwhile, the relative cost-effectiveness of interventions in the lower half of the ranking remains unaffected.

**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 extension and advisory services for agronomic practices is relatively moderate – at 0.23 – when the intervention's impact is evaluated across all targeted sectors. However, its impact on cereals is slightly above this cross-cutting average for cash crops, at 0.24. 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 extension and advisory services for agronomic practices for cash crops shows above-average impact relative to the cross-sector score, it does not fall within the top five intervention areas. Conversely, extension and advisory services for agronomic practices for root crops not only exceeds the average impact score but also is among the top five investment priorities in terms of impacts on cross-cutting investments. Furthermore, Table 1 suggests that concentrating food loss and waste reduction efforts on root crops, pulses and oilseeds, and cash crops—as well as expanding irrigation access for root crop producers—would significantly improve the effectiveness of agrifood system investments. Supporting SME processors and extension and advisory services to livestock farmers also remain one of the top cross-cutting interventions in terms of their impacts 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) | 0.06 | 0.05 | 0.06 | 0.06 | 0.06 | 0.06 |
| | 2 | R&D (agronomy) | 0.07 | 0.05 | 0.07 | 0.06 | 0.07 | 0.07 |
| | 3 | R&D (animal breeds) | 0.05 | | | | | |
| | 4 | R&D (animal husbandry) | 0.18 | | | | | |
| Extension / advisory services | 5 | E/AS (improved seeds) | 0.21 | 0.08 | 0.28 | 0.31 | 0.15 | 0.19 |
| | 6 | E/AS (agronomic practices) | 0.23 | 0.10 | 0.39 | 0.23 | 0.20 | 0.24 |
| | 7 | E/AS (livestock) | 0.53 | | | | | |
| | 8 | E/AS (climate information) | 0.20 | | | | | |
| | 9 | E/AS (climate smart agriculture) | 0.14 | 0.08 | 0.22 | 0.13 | 0.12 | 0.14 |
| Markets and food systems | 10 | Seed systems | 0.07 | | | | | |
| | 11 | SME processors (finance, training) | 0.82 | | | | | |
| | 12 | SME traders (finance, training) | 0.22 | | | | | |
| | 13 | Food loss and waste | 0.36 | 0.09 | 0.52 | 0.42 | 0.31 | 0.40 |
| | 14 | Credit access (financial inclusion) | 0.11 | | | | | |
| Risk reduction and resilience | 15 | Seasonal forecast (early warning) | 0.08 | | | | | |
| | 16 | Productive safety nets | 0.23 | | | | | |
| Infrastructure | 17 | Irrigation infrastructure | 0.23 | 0.10 | 0.42 | 0.12 | 0.19 | 0.25 |
| | 18 | Rural roads | 0.17 | | | | | |

**Source**: RIAPA modeling system

## Summary

Uganda'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, Uganda has an urgent need to transform its agrifood system sustainably. This requires increased levels of technical and financial support to agriculture and 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. In this country brief, we report 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.

Our results reveal that investing in SME processors is the most cost-effective option for expanding agrifood system GDP and employment. Among the farmer-facing investments, providing extension and advisory services of livestock farmers, seed and climate information, and building irrigation infrastructure are the most cost-effective at expanding agrifood system GDP. Investing in SME processors and extension services to livestock also rank highest in reducing poverty and undernourishment and improving the quality of diets. Productive safety nets and food loss reduction rank highly in improving social outcomes. With respect to environmental outcomes, we find that interventions with greater GDP effects tend to be associated with larger increases in water, emissions, and land footprints, thus demonstrating the kind of tradeoffs policymakers will have to contend with as they increasingly factor environmental considerations into their decision-making. Our analysis reveals moderate changes in the ranking of agrifood system investments under climatic shocks, which suggests a need for a more thoughtful planning of interventions in Uganda.

Several general policy messages can be drawn from this analysis. Firstly, not only have we demonstrated 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 of 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. Our analysis highlights the importance of designing appropriate climate adaptation and mitigation policies to help increase the productivity and resource use efficiency of sectors identified as drivers of socioeconomic progress.

## About the Authors

**Emerta Aragie** is a Research Fellow and **James Thurlow** is the Director, and **Eleanor Jones** is Program Manager in IFPRI's Foresight and Policy Modeling Unit, all based in Washington, DC. **Hashim Ahmed** is an IFPRI-Non-Staff Fellow, also based in Washington, DC.

## Acknowledgments

This work was undertaken as part of the "Future Food Systems" project funded by the International Affairs Office at the Presidential Court of the United Arab Emirates and the Gates Foundation. The modeling and data systems and analytical techniques were developed with financial support from the CGIAR Science Program on Policy Innovations. We would like to thank all funders who supported this research through their contributions to the CGIAR Trust Fund (www.cgiar.org/funders).

## References

Aragie, E., Benfica, R., Pauw, K., Randriamamonjy, J. and Thurlow, J. 2024. Assessing Investment Priorities for Driving Inclusive Agricultural Transformation: An Application to Tanzania. *Development Policy Review*, 42(6): e12812.

Aragie, E., Artavia, and Pauw, K. 2019. "Strategic public spending: Scenarios and lessons for Ghana." IFPRI Discussion Paper 1852. Washington, DC: International Food Policy Research Institute (IFPRI). https://doi.org/10.2499/p15738coll2.133332

Aragie, E., Diao, X., Spielman, D.J., Thurlow, J., Mugabo, S., Rosenbach, G. and Benimana, G. 2022. Public investment prioritization for Rwanda's inclusive agricultural transformation: Evidence from rural investment and policy analysis modeling. Rwanda Strategy Support Program. Working Papper 03.

Arndt, C., M. Hussain, E. Jones, V. Nhate, F. Tarp, and J. Thurlow. 2012. Explaining the evolution of poverty: The case of Mozambique. *American Journal of Agricultural Economics*, 9 (94): 854-872.

Benfica, R., Cunguara, B. and Thurlow, J. 2019. Linking agricultural investments to growth and poverty: An economywide approach applied to Mozambique. *Agricultural Systems*, 172, 91–100.

Climate Watch. 2025. Historical GHG Emissions. https://www.climatewatchdata.org/ghg-emissions?end_year=2021&start_year=1990

Christiaensen, L., and W. Martin. 2018. Agriculture, structural transformation and poverty reduction: Eight new insights. *World Development*, 109: 413-416.

Devarajan, S. and Robinson, S. Contribution of Computable General Equilibrium Modeling to Policy Formulation in Developing Countries. In Handbook of Computable General Equilibrium Modeling, Peter B. Dixon, Dale W. Jorgenson (ed), 1: 277-301.

Diao, X., Ellis, M., Pauw, K. and Thurlow, J. 2023. Ethiopia's Agrifood System: Structure and Drivers of Transformation. Country Brief 4. IFPRI

Dixon, P. and Parmenter, B.R. 1996. Computable general equilibrium modelling for policy analysis and forecasting. Chapter 01 in Handbook of Computational Economics, 1: 3-85.

FAO. 2025. FAOSTAT. Food and Agricultural Organization of the United Nations. https://www.fao.org/faostat/en/#data

GLOPAN (Global Panel on Agriculture and Food Systems for Nutrition) 2020. Future food systems: for people, our planet, and prosperity. London, UK. https://www.glopan.org/wp-content/uploads/2020/09/Foresight-2.0_Future-Food-Systems_For-people-our-planet-and-prosperity.pdf.

IFPRI (International Food Policy Research Institute). 2024. Global Spatially-Disaggregated Crop Production Statistics Data for 2020 Version 1.0.0. https://doi.org/10.7910/DVN/SWPENT. Harvard Dataverse. Version 3.

IFPRI (International Food Policy Research Institute). 2024a. 2022 Social Accounting Matrix for Uganda: A Nexus Project SAM. Data Paper. Washington, DC: International Food Policy Research Institute. handle: 10568/155063. https://hdl.handle.net/10568/155063.

IFPRI (International Food Policy Research Institute). 2023. RIAPA Data and Modeling System. Washington, DC. https://www.ifpri.org/project/riapa-model

Kumar, N. and Maiti, D. 2024. Long-run macroeconomic impact of climate change on total factor productivity — Evidence from emerging economies. *Structural Change and Economic Dynamics*, 68: 204-223.

Mekonnen, M.M. and Hoekstra, A.Y. (2010) The green, blue and grey water footprint of farm animals and animal products. Value of Water Research Report Series No. 48, UNESCO-IHE, Delft, the Netherlands. http://www.waterfootprint.org/Reports/Report47-WaterFootprintCrops-Vol1.pdf

NPA (National Planning Authority). The Uganda Green Growth Development Strategy 2017/18-2030/31. Kampala. https://faolex.fao.org/docs/pdf/uga184391.pdf

Ojara, M., Namumbya, S., Ogwang, B.A. and Limbu, P. 2024. Regional and farm level droughts characteristics for southwestern Uganda during 1981–2017. Soil Security, 15: 100148,

Pauw, K., O. Ecker, J. Thurlow, and A.R. Comstock. 2023. Measuring changes in diet deprivation: New indicators and methods. *Food Policy*, 117, Article #102471.

Pauw, K., J. Thurlow. 2015. Prioritizing Rural Investments in Africa: A Hybrid Evaluation Approach Applied to Uganda. *European Journal of Development Research,* 27(3): 407–424. Special Issue on Public Investments in and for Agriculture. https://doi.org/10.1057/ejdr.2015.24.

Pham, T. H., and J. Riedel. 2019. Impacts of the sectoral composition of growth on poverty reduction in Vietnam. *Journal of Economics and Development*, 21 (2): 213-222.

Poore, J. and Nemecek, T. 2018. Reducing food's environmental impacts through producers and consumers. *Science*, 360:987-992.

Shah, UH., Lu, Y., Liu, J., Rehman, A. and Yasmeen, R. 2024. The impact of climate change and production technology heterogeneity on China's agricultural total factor productivity and production efficiency. *Science of The Total Environment*, 907: 168027.

Thurlow, J., J. Kiringai, M. Gautam. 2007. Rural Investments to Accelerate Growth and Poverty Reduction in Kenya. IFPRI Discussion Paper 00723 (October 2007). Washington DC: International Food Policy Research Institute. https://ebrary.ifpri.org/utils/getfile/collection/p15738coll2/id/40627/filename/40628.pdf.

UBOS (Uganda Bureau of Statistics). 2021. Uganda's National Panel Survey 2019/20. Kampala, Uganda: UBOS.

UBOS (Uganda Bureau of Statistics). 2018b. Uganda National Household Survey 2016/17. Kampala, Uganda: UBOS.

World Bank 2025. World Development Indicators. World Bank. https://databank.worldbank.org/source/world-development-indicators

World Bank. 2023. Uganda: Poverty and Equity Brief, Africa Eastern and Southern. The World Bank Group. https://databankfiles.worldbank.org/public/ddpext_download/poverty/987B9C90-CB9F-4D93-AE8C-750588BF00QA/current/Global_POVEQ_UGA.pdf

## **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 |
| **Risk reduction and resilience** | 15 | Seasonal forecast (early warning) | Seasonal weather forecast |
| | 16 | Safety nets | Productive safety nets for the poor |
| **Infrastructure** | 17 | Irrigation infrastructure | Small and medium scale irrigation |
| | 18 | Rural roads | Unpaved feeder roads |

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
*A world free of hunger and malnutrition*
**IFPRI is a CGIAR Research Center**
1201 Eye Street, NW, Washington, DC 20005 USA | T. +1-202-862-5600 | F. +1-202-862-5606 | Email: ifpri@cgiar.org | www.ifpri.org | www.ifpri.info