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Synopsis: The dynamic impact of alternative livestock sector interventions and spending options in Rwanda

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Abstract

This study evaluates the cost-effectiveness of various livestock interventions—feed, breeding, and health—and budget allocation strategies (balanced, feed-oriented, breeding-oriented, and health-oriented) in the context of Rwanda's economic and livestock systems. Using an economic and livestock systems integrated framework, the research highlights moderate yet sustained impacts on agricultural Gross Domestic Product (GDP) and significant improvements in the livestock sector. Breeding interventions have the largest cumulative effect on agricultural GDP, while health measures, particularly dewormers, yield long-term gains in livestock productivity. Under the balanced scenario, breeding contributes significantly to both meat and milk sector GDP, while feed interventions show a smaller impact overall. The model estimates the economic and livestock systems over a period of five years (t_1-t_5) from a base year at t_0, which corresponds to the Fifth Structural Transformation in Agriculture (PSTA5) period.

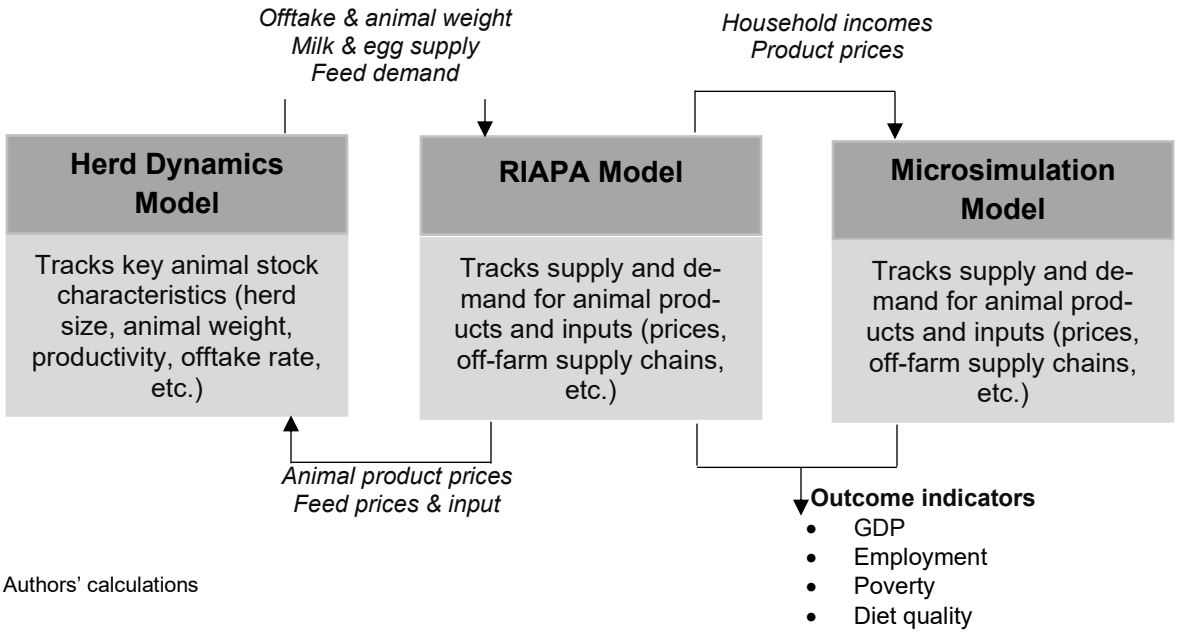
Methodology

We employ a dynamic integrated economic and animal systems model called LEAS (Linked Economic and Animal Systems model) to examine the dynamic impact of alternative livestock sector interventions in Rwanda in the context of the wider economy (Figure 1).[1] Unlike most studies, which focus exclusively on either the crop or livestock, our approach captures the inter-

[1] For a more detailed analysis, see RSSP's Working Paper #15, The dynamic impact of alternative livestock sector interventions and spending options in Rwanda.

dependence of these sectors within an economywide framework, providing a more comprehensive understanding of their interactions. Second, we evaluate various livestock sector interventions in terms of their relative cost-effectiveness in achieving targeted economic outcomes. Third, we not only assess the relative impacts of these measures but also compare alternative budget allocation options (balanced, feed-oriented, breeding-oriented, and health-oriented) in relation to selected indicators, examining their overall effects on both the economic and livestock systems. This holistic assessment of interventions and spending options aims to guide policymakers in promoting the livestock sector for greater impact.

Figure 1. The LEAS modeling framework



Authors' calculations

The HDM (Heard Dynamics Model) is a lifecycle (stock-flow) module that tracks annual herd size disaggregated by age, sex, breed, and agroecology zone. Policy interventions are also embedded within the HDM, such as public provision of medicines to improve animal health or access to improved feed to increase on-farm livestock productivity. Environmental variables, such as forage supply and biophysical carrying capacity, are salient features of the model incorporated to capture the impact of climate on herd stock level and productivity. One novel feature of the integrated model is the systematic link between HDM and the economic model. Using information on consumer demand for animal products and the relative profitability of animal offtake activities from the economywide model, the HDM estimates offtake requirements, remaining herd sizes, and annual feed requirements. The dynamics in the livestock model are linked back to the economywide model through the annual growth rate in the animal production subsectors' (cattle and milk production) capital. As the economic model solves for successive years (from t_0, which is the base year to t_5, which is the final year of the simulation), the accumulated livestock capital in the cattle sector updates every year by the rate of growth in meat offtake calculated in

the HDM. Similarly, livestock capital in the milk production sector in the economic model updates in response to the growth in milk offtake from the HDM.

Scenarios and Results

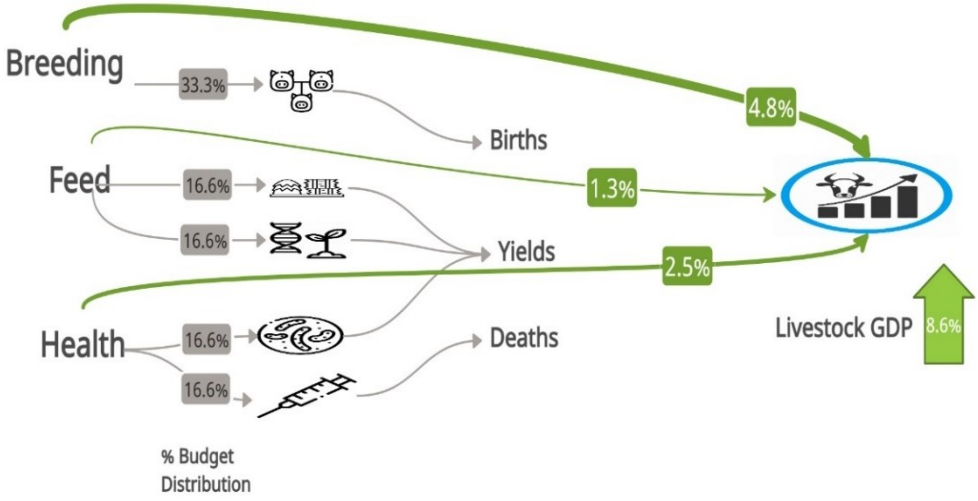
This study explores the effects of alternative livestock sector interventions—namely feed availability, breeding and genetic services, and health—under likely scenarios of biased and balanced spending. We first formulate a *baseline scenario* that reflects the typical performance of Rwanda's crop and livestock sectors as well as the overall economy in the absence of the interventions. In the baseline scenario, we assume the long-term growth trend in Rwanda is maintained, where the crop and livestock sectors grow by 8.0 and 7.0 percent, respectively, resulting in an overall GDP growth of just under 4.0 percent. This long-term growth assumption helps to idealize against the recent erratic agricultural sector performance in Rwanda partly due to ongoing global shocks.

Building off the baseline analysis, we introduced a scenario with three major livestock intervention areas, including feed, breeding, and animal health (see Figure 2). Animal feed constitutes two separate interventions: spending on improved feed and spending on fodder production. These two feed sources differ by source and effect on livestock performance. Likewise, the animal health intervention incorporates vaccines and deworming, which impact the livestock system differently. Whereas vaccines save animals from preventable deaths due to diseases, dewormers principally enhance feed conversion, livestock health and productivity.

For simulation design purposes, we assume one-third (or about $14.5 million) of average annual red meat and dairy value chain development budget indicated in Rwanda's LMP is spent equally in this balanced scenario on the three broad intervention areas, each sharing 33.3 percent (Figure 2). This is also closer to 30 percent of the annual proposed direct spending on livestock during the upcoming PSTA-5 period.

To assess the combined impacts, all three interventions – feed, breeding, and health – are also implemented jointly, acknowledging the possible complex impact interrelationships between the interventions. For instance, both breeding and vaccines may rapidly increase the herd size, and exert pressure on per capita feed availability, whereas the feed intervention may help maintain productivity by availing the required feed for the expanding stock.

Figure 2. Interventions and Contributions to livestock GDP



Authors' calculations

The interventions analyzed have a moderate impact on agricultural GDP, with an immediate (i.e., in t_1) combined effect of 0.8 percent and a cumulative effect of 1.0 percent by the fifth year. Breeding has the largest individual impact on agriculture GDP, both immediately (0.4 percent) and cumulatively (0.6 percent), highlighting its critical role in boosting overall agricultural performance. The livestock sector experiences a cumulative combined effect of 8.6 percent (Figure 2), reflecting sustained improvement over time, particularly driven by breeding interventions.

The immediate and cumulative effects of the interventions on livestock vary across its sub-components. Breeding consistently has the highest impact on milk and dairy, with strong cumulative effects that underscore the long-term benefits of genetic improvement and reproductive efficiency. Health interventions, on the other hand, have significant immediate effects, especially on cattle and meat, highlighting their crucial role in improving productivity, stock size, and output volume. Feed interventions generally have a smaller impact compared to health and breeding. Overall, the cumulative effects are larger than the initial effects, indicating that these interventions lead to sustained improvements over time.

The *biased spending scenarios* do not alter the impact on the agricultural sector significantly. However, effects on livestock and its sub-components markedly vary. Breeding-oriented spending initially outperforms, boosting milk and dairy processing GDP. Health-oriented spending excels in cattle and meat GDP due to reduced deaths and increased liveweight. The cumulative impacts over the spending period grow larger as interventions, particularly breeding, take time to fully influence meat and milk yields. For example, the breeding-oriented scenario results in a cumulative GDP increase of 3.9 percent and 2.5 percent in the raw milk and dairy processing sectors, respectively, compared with the balanced spending scenario, with an overall additional livestock GDP growth of 1.4 percent (Table 1).

Table 1. Percentage point deviation in GDP growth from the balanced spending scenario (%)

	Cumulative effects		
	Feed oriented	**Breeding oriented**	**Health oriented**
Primary production			
Agriculture	-0.2	0.2	0.0
Livestock	-1.5	**1.4**	0.0
Cattle	-1.1	-0.3	1.3
Milk	-3.0	**3.9**	-1.3
Small ruminants	-0.3	-0.9	1.2
Processed production			
Meat	-1.3	-0.3	1.5
Dairy	-1.9	**2.5**	-0.9

Authors' calculations

Conclusion

The livestock sector plays a crucial role in supporting agricultural development, food production, and nutritional security, particularly in developing countries where smallholder producers rely on it for a significant portion of their livelihoods. While governments and development agencies in developing countries have been implementing various strategies to strengthen the livestock sector, these efforts have not been fully evaluated in terms of their impact on improving livestock performance. By situating livestock dynamics within an economywide framework, this research assesses the relative cost-effectiveness of different intervention options (feed, breading, health) and budget allocation strategies (balanced, feed oriented, breeding oriented, and health oriented) using Rwanda as an example.

The analyzed interventions show moderate but sustained impacts on agricultural GDP and significant effects on the livestock sector. The *balanced spending scenario* shows that breeding has the largest individual influence, contributing 0.4 percent immediately and 0.6 percent cumulatively to agricultural GDP, emphasizing its role in boosting productivity. In the livestock sector, the interventions jointly lead to an immediate 6.5 percent GDP impact, with breeding contributing to close to half of this gain. The cumulative effect rises to 8.6 percent, again driven primarily by breeding interventions, while feed interventions have a smaller overall impact. Of the sub-components of feed, improved feed has stronger immediate and cumulative effect on various livestock activities. Dewormers are the health interventions that yield significant long-term productivity gains. The *biased spending scenarios* do not alter the impact on the agricultural sector significantly. However, effects on livestock and its sub-components markedly vary and are detailed in the main paper.

Our findings contribute to the broader literature by offering insights into the potential impact of alternative interventions and spending options on economic and livestock systems performance in low-income contexts, particularly in countries like Rwanda, where existing research is limited. These results are intended to inform policymakers as they seek to revitalize the livestock sector and enhance its resilience to future challenges

Recommendations.

- **Evidence-Based Public Spending Allocation**: Policy makers need to back public spending allocation within the major agricultural sub-sector (crop vs livestock) and across the livestock sector interventions (breeding, feed, animal health, etc.) using robust analytical frameworks such as one used in this study for effective and impactful resource utilization.
- **Enhanced Financial Support for the Livestock Sector**: Increasing targeted financial assistance to the livestock sector stimulates the sector's performance irrespective of how the budget is allocated to the various intervention areas identified in this study.
- **Customized Budget Allocations for Development Objectives**: We noted from this study and other analyses using the same approach that an 'optimal' budget allocation depends on the envisaged development objectives (growth, diet diversity, employment, and poverty reduction) and policy makers relative preference across these objectives. Future study in this area should augment this analysis.

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