



# Technology uptake and scaling synthesis report for Uganda, Tanzania and Vietnam

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# Acronyms and abbreviations

|          |   |
|----------|---|
| ADGG     | African Dairy Genetic Gains   |
| AI       | Artificial insemination   |
| ANM      | Agent Network Model   |
| ASAM     | Agriculture Scaling Assessment Matrix   |
| ASAT     | Agriculture Scalability Assessment Tool   |
| ASDT     | Agriculture Scaling Decision Tree   |
| ASF      | African swine fever   |
| AMR      | Antimicrobial resistance  |
| BFS      | Bureau of Food Security   |
| GEBV     | Genomic Estimated Breeding Value  |
| CAEC     | Continuing Agricultural Education Center  |
| CBBP     | Community-Based Breeding Program  |
| CIAT     | International Center for Tropical Agriculture   |
| CIMMYT   | International Maize and Wheat Improvement Center  |
| CLEANED  | Comprehensive Livestock Environment Assessment for improved Nutrition, secured Environment, and sustainable Development |
| COVID-19 | Coronavirus disease 2019  |
| CRP      | CGIAR Research Program  |
| DM       | Dry matter  |
| DMI      | Dry matter intake   |
| DMHs     | Dairy market hubs   |



---

|         |   |
|---------|---|
| DPRC    | Dairy Performance Recording Centre                              |
| ECF     | East Coast fever  |
| FGD     | Focus group discussion  |
| GDP     | Gross domestic product  |
| GIZ     | Deutsche Gesellschaft für Internationale Zusammenarbeit         |
| GHG     | Greenhouse gases  |
| G-FEAST | Gendered Feed Assessment Tool                                   |
| HHM     | Herd health management  |
| ICARDA  | International Center for Agricultural Research in the Dry Areas |
| ICT     | Information communication technology                            |
| ILRI    | International Livestock Research Institute                      |
| IMM     | Integrated manure management                                    |
| ITM     | Infection and Treatment Method                                  |
| I@S     | Impact at Scale   |
| KAP     | Knowledge, attitudes and practices                              |
| KII     | Key informant interview   |
| MAAIF   | Ministry of Agriculture, Animal Industry and Fisheries          |
| MSPs    | Multi-stakeholder platforms                                     |
| MWE     | Ministry of Water and Environment                               |
| NaLIRRI | National Livestock Resources Research Institute                 |
| NARS    | National Agricultural Research System                           |
| ODK     | Open Data Kit   |
| PRA     | Performance recording agents                                    |
| PRRS    | Porcine Reproductive and Respiratory Syndrome                   |
| RHoMIS  | Rural Household Multi-Indicator Survey                          |
| SLU     | Swedish University of Agricultural Sciences                     |
| SmaRT   | Small Ruminants value chain Transformation                      |

---

|       |   |
|-------|---|
| SR    | Small ruminant                                      |
| ToC   | Theory of change                                    |
| UNBS  | Uganda National Bureau of Standards                 |
| USAID | United States Agency for International Development  |
| USB   | Ultimate Business Strategies and Enterprises Uganda |
| VC    | Value chain   |
| WHO   | World Health Organization                           |

# Executive summary

This synthesis report captures the strategies devised, procedures adopted and processes followed to enhance the uptake of best-bet technologies by the smallholder farmers in the laboratory countries of the CGIAR Research Program on Livestock (CRP Livestock). The report also documents the outcomes achieved by the end of 2021 and synthesizes the lessons learned during identification, selection, scaling assessment, and adoption of technologies. Considering the importance of livestock for the livelihoods of smallholder farmers in developing countries, the CRP Livestock was introduced in four selected countries (Uganda, Tanzania, Vietnam, and Ethiopia) as a laboratory to test the best-bet technology bundles and strategies for their uptake. Based on the learnings from the previous phase of the CGIAR Research Program on Livestock and Fish (CRP Livestock and Fish), the identified best-bet technologies were bundled after stakeholders' consultation to enhance the buy-in by the key livestock value chain actors and ensure their sustainable adoption. Similarly, a systematic approach was used for scaling assessment of the rolled out best-bet technologies in the project countries.

The annual countries' reports, published articles of the program, workshops' reports, presentations, and other unpublished material are reviewed, consulted, and analysed to synthesize information. The areas covered include the types of technology bundles introduced in the four country projects, processes adopted and challenges faced in the integration of intervention bundles and uptake, and contribution of technology bundles in improved productivity and livelihoods of the smallholder livestock producers and keepers in the project countries. The delivery mechanisms documented best practices, and lessons learned are collated, connected, and associated to derive the final consideration and way forward for the program partners, donors and researchers.

Under the umbrella of CRP Livestock, different projects have been rolled out in the selected four countries. The project in Uganda introduced an integrated intervention package for improved productivity of pigs to enhance the incomes of the pig farmers. In Tanzania, the focus is on inclusive dairy development through enhanced uptake of technology by introducing institutional approaches that involve inclusive agribusiness models for the improved livelihood of smallholders. The 'Livestock-led interventions towards equitable livelihoods and improved environment' project seeks to stimulate the system transformation to empower highland farming communities through bundled livestock-based interventions in the northwest highlands of Vietnam. The 'SmaRT- Small Ruminant value chain transformation in Ethiopia' project, on the other hand, intends to improve the livelihoods of women and men farmers in Ethiopia through consolidation, testing, and promotion of SmaRT pack at the producer level while facilitating equitable access to input supplies and services through community action and political support. Detailed information on the Ethiopia project are not included in this report. Lessons learned on the overall approach across the four priority countries can be found in Kruijsen et al. (2021).

Due to the COVID-19 pandemic, the implementation progress remained slower than that was planned in all four countries. The four countries have completed the selection of best-bet technology bundles. The scaling assessment of some of the introduced technologies has also been conducted in Ethiopia, Uganda and Tanzania. The rolled-out technology bundle in Uganda consists of community-based artificial insemination (AI), heat-tolerant forages and feed/food crops, certification business model for small-scale commercial feed producers, strengthening of multi-stakeholder platforms and a PigSmart<sup>1</sup>

<sup>1</sup> An ecosystem of digital players for advisory services to value chain actors.

extension platform for promoting best practices and tools in pig farming support that includes disease reporting and drought herd health management, suitable pig feeding, balanced least-cost feed rations using breeds and breeding, management of heat stress, and record-keeping to assess the financial performance of the Feed Calculator application, training and enterprise. In Tanzania, the best-bet technologies included in the intervention bundle are a digital platform for e-extension services, forage options, agent network model for extension services, Rume8 tool to specify total mixed rations, manure management, East Coast fever vaccine, and genomic evaluation of dairy cattle based on a digital herd recording platform. Similarly, community-based AI of pigs and cattle, herd health management, feed and feed baskets, inclusive market arrangements, and African swine fever vaccination are made part of the technology bundle introduced in Vietnam. The characterization and selection process of best-bet technologies in Ethiopia included community-based breeding programs, certified breeding sires, fertility improving package for sheep and goat production, vaccination and treatment calendar for common small ruminant (SR) diseases, integrated herd health management, health certification of breeding rams, business-oriented sheep fattening, forage options, marketing models, multi-stakeholder platforms for collective actions, and policy advocacy.

During the first year of implementation, the uptake of best-bet technologies has been witnessed in Uganda and Tanzania. With the private sector engagement, the establishment of a digital ecosystem in the form of the PigSmart platform in Uganda and a digital platform for e-extension and marketing in Tanzania have been widely adapted by the livestock value chain actors in both countries. Assessments and experimentation during the projects in Uganda and Tanzania have helped to determine the existing state of feed and forages and explore the potential economical feed and forage options. Based on the experimentation, improved and locally-grown forages and feed options significantly reduced the cost of feeding in both countries. Additionally, the training and certification of small-scale feed producers in Uganda has succeeded to standardize the quality of commercial feed production and induced more farmers to use certified commercial feed from certified small-scale feed producers.

The substantial involvement of the public and private sectors has been instrumental in the implementation of various components of integrated packages in the project countries. The partnerships have been established with the digital solution service providers, academia, and government agencies for the implementation and sustainability of the interventions introduced by the projects. Despite slow progress in the implementation of projects, there are important successes and lessons from Uganda and Tanzania that could be worthwhile for Vietnam and Ethiopia to successfully implement technologies and enhance their uptake.

The establishment of digital platforms in Uganda and Tanzania for advisory and e-extension services has been successful in terms of interest and adoption by the key value chain actors. Similarly, forage options for dairy and pigs, and community-based AI interventions in both of these countries are being widely adopted and becoming beneficial to the smallholder farmers.

# 1 Introduction

## 1.1 Importance of technology uptake for smallholder livestock producers

Enhancing uptake of technology by the smallholder livestock farmers is a promising strategy to improve livestock productivity and the livelihoods of the producers. The interventions that involve empowered and appropriately skilled agri-entrepreneurs offer auspicious avenues for enhanced uptake of technologies and services, thus leading to increased productivity, competitiveness, and income of the smallholder producers. In contrast to a single intervention, an integrated bundle of interventions – that focus on the underlying determinants of technology uptake and equitable access – predominantly is likely to result in the improved and sustained livelihoods of the livestock producers. The smallholder livestock producers often lack access to essential knowledge, inputs and services to increase productivity and profitability. Therefore, the uptake of technology by the farmers has always remained a prolonged process. Multiple risks, including disease, climate, and market shocks, can limit their ability and willingness to innovate. Simultaneously, gender disparities hold women back, while young people's involvement in livestock enterprises gets constrained by lack of access to capital (land, finance) and cultural norms. Thus, the uptake of technology in livestock farming remains limited due to financial constraints (Mtimet et al. 2018) encountered by smallholders and keepers.

Generally, livestock productivity is low in developing countries, with yield gaps of up to 300%. Livestock's low productivity is due to inadequate and poor-quality feed supply, high incidence of diseases leading to increased morbidity and mortality. The absence of organized smallholders breeding programs, lack of technical and business capacity of the producers, and a dearth of research and extension support systems further add to the list of impeding factors to productivity in the developing countries. Owing to a lack of capacity, skills and infrastructure for breeding programs in the national system, women and men farmers face enormous challenges in accessing genetically improved livestock in developing countries. The smallholder producers have limited knowledge about the best practices in husbandry, disease prevention and control. Also, they have inadequate access to quality veterinary inputs and advisory services. Low and seasonal variability of feed supply is another challenge the farmers face. Additionally, the producers and livestock extension agents lack knowledge on feed formulation and feed quality, so the available feed resources are utilized ineffectively. Usually, the functional feed quality control mechanism does not exist, which results in low trust of the produces in commercial feeds.

Market inefficiencies exacerbate the livestock value chains that further limit the farmers' access to technology adoption benefits, thereby, disincentivizing its uptake. Input and output markets' inefficiencies impede the farmers' access to affordable quality feeds and profitable markets. Poor value chain performance is attributed to the lack of innovative institutional arrangements to enhance poor farmers' access to input and marketing services. Linkages between farmers and other value chain actors are mostly weak leading to inadequate access to quality inputs, credits, technical knowledge, and business skills. The small-scale livestock keepers and producers face enormous challenges to exploit the growing markets. The evidence

shows that overcoming market inefficiencies provides incentives to them to adopt promising technologies in livestock farming, value addition and marketing.

Livestock and their products play essential roles in contributing to most households' incomes in developing countries. The livestock assets are usually a way to save and insure against multiple risks to the families. The households predominantly invest these assets in off-farm enterprises to diversify and multiply livelihood opportunities. The income generated from various sources is often used for children's education, contributing to generational escape from poverty. Simultaneously, the demand for meat, milk, and eggs is increasing rapidly, especially in developing countries. Over half a billion small-scale producers, the majority of them women, currently meet most of the demand for most animal commodities. Also, women's role is instrumental in keeping and marketing a small stock of livestock that is usually their most important income source to feed their families. Additionally, livestock value chains also provide employment opportunities for input suppliers, service providers, and traders.

Work under the CRP Livestock spans across Africa, the Middle East, Southeast Asia, and South and Central America. The learnings from the CRP Livestock proposed a focus on locally-adapted farming systems, which respond more flexibly to variations in landscape, climate, and socio-economic and political conditions. Such locally-oriented integrated interventions have the added benefit of providing local solutions to the farming community's issues. Therefore, the four priority countries – three African (Ethiopia, Tanzania, Uganda) and one Asian (Vietnam) – were selected as a laboratory for CRP interventions to demonstrate the integration of technological and institutional innovations that enhance technology uptake and scaling amongst the smallholder livestock producers.

This synthesis report reviews the types of technology bundles introduced in the four-country projects, processes adopted, and challenges faced in the integration of intervention bundles and uptake, and their contribution to improved productivity and the livelihoods of the smallholder livestock producers and keepers in the project countries. The delivery mechanisms, best practices, and lessons learned – documented by the project teams in each country – are collated, connected, and associated to derive the final consideration and way forward for the program partners, donors and researchers. This report is divided into five chapters. Chapter 1 provides an introduction and objectives of the synthesis report. The methodology and data collection for collating, organizing, and synthesising the information from secondary and primary sources are given in Chapter 2. Chapter 3 is the core part of the report that summarizes the results achieved by the countries so far. Chapter 4 is devoted to synthesizing the critical lessons learned through highlighting successes and areas of improvement. Based on the lessons learned, the final consideration and way forward are given in Chapter 5.

## 1.2 Purpose and objectives of the report

Based on the principle that the evidence collated and constructed systematically improves decision-making and ultimately outcomes, this report summarizes the approaches, methods, progress, and results attained by the four countries' projects. It synthesizes the lessons learned relevant to the need of program partners, decision makers and researchers. The report also proposes final consideration and a way forward for the policymakers, donors and researchers to decide what methodological approaches and concerns need to be implemented for appropriately and adequately addressing the question of technology uptake by the smallholder livestock farmers.

The specific objectives of the report are:

- To review, extract, and collate information related to progress, achievements, challenges, practices, and lessons documented by the project countries in the form of reports, presentations, research articles, assessments, and evaluations.
- To organize and structure the collated information under areas/themes of consideration and connect to analyse and synthesize the information for the program partners, stakeholders, researcher and decision makers.
- To propose final consideration and a way forward for equitable and adequate uptake of the technology by the smallholder farmers that could lead to sustainable and improved livelihoods.

## 2 Methodology and data collection

### 2.1 Data collection

This synthesis report is constructed using secondary data in the form of the published and unpublished substance of the four countries' projects. Similar to the baseline and midline reports of the four country projects; progress reports periodically submitted by the project country teams; glimpses of stakeholders' reflections documented in various stakeholders' workshops; presentations made by the implementing partners on the activities performed and outputs delivered; published research articles in peer-reviewed research journals; and other unpublished documents related to the program were used as sources. The links of the papers, reports and presentations consulted are given in the body of the report and listed in the references. Besides the secondary data specific to the projects, other relevant literature was also reviewed to analyse the practices, challenges, and learnings of the four-country projects in the broader context.

### 2.2 Data analysis and synthesis approach

The synthesis report was constructed by reviewing the documents of four country projects. A systematic approach was used to collate, extract, organize and connect information related to the specific areas, themes and concepts. For that purpose, a synthesis matrix was constructed with columns labelled 'countries', and each row labelled 'important area', 'concept', and 'theme' that recurred across all or most of the countries (see Table 1).

**Table 1: Synthesis Matrix**

| Areas / themes/ concepts – across all four countries |   |
|--|---|
| Goal   | Project proposal  |
| Objective  | Project proposal  |
| Technology characterization                          | Stakeholders' workshops/ consultations/ previous learning |
| Intervention bundles                                 | Identified in the progress report                         |
| Implementation mechanism                             | Proposal and implementation reports                       |
| Progress   | Periodic reports  |
| Practices  | Multiple sources (secondary and/or primary)               |
| Lessons  | Synthesized from the above themes across countries        |
| Way forward  | Derived from lessons learned                              |

The desired information from the source documents was then extracted and added against the relevant themes in the synthesis matrix to relate them across the countries/cases. Except for the goal and objectives of the individual country project, all other themes were connected and linked from different aspects across the countries to discern meaningful information and synthesize the successes and areas of improvement. Under the technological characterization theme, the process,

considerations, and challenges were looked at across the countries. Similarly, the rationale and composition aspects of intervention bundles provided the basis for cross-country connectivity and association. Simultaneously, the implementation mechanisms were associated with the perspectives of delivery approaches, partners, and support mechanisms put in place by the country projects. The connectivity and relationship in the projects' progress were looked at from the efficiency and efficacy perspectives in attaining the intended outputs and outcomes. The practices adopted by the country projects were associated with the stage, context, and evolving situations. The final considerations and way forward were derived from the synthesized lessons learned for decision makers, donors, and other relevant stakeholders.

## 2.3 Limitations of the report

This report is synthesized from the information contained in the form of reports, brochures, presentations, and papers. It has the following limitations.

- This report is primarily built on the annual country progress reports (2020) of the four CRP priority countries and their projects proposals.
- The annual reports of the CRP countries were incomplete either due to delay in the kick-off of the projects in those countries or implementation constrained due to the COVID-19 pandemic. The majority of the countries were either at the stage of finalization of technology bundles or had just rolled out the best-bet technologies at pilot sites.
- Very minimal evidence on outcomes-related indicators has been documented by the countries so far.
- The majority of the work so far has been done on the preparation and identification of the intervention packages in most of the priority countries. Therefore, the synthesis of the lessons learned at the level of implementation and results was only partially covered in this report.



## 3 Progress

### 3.1 Uganda

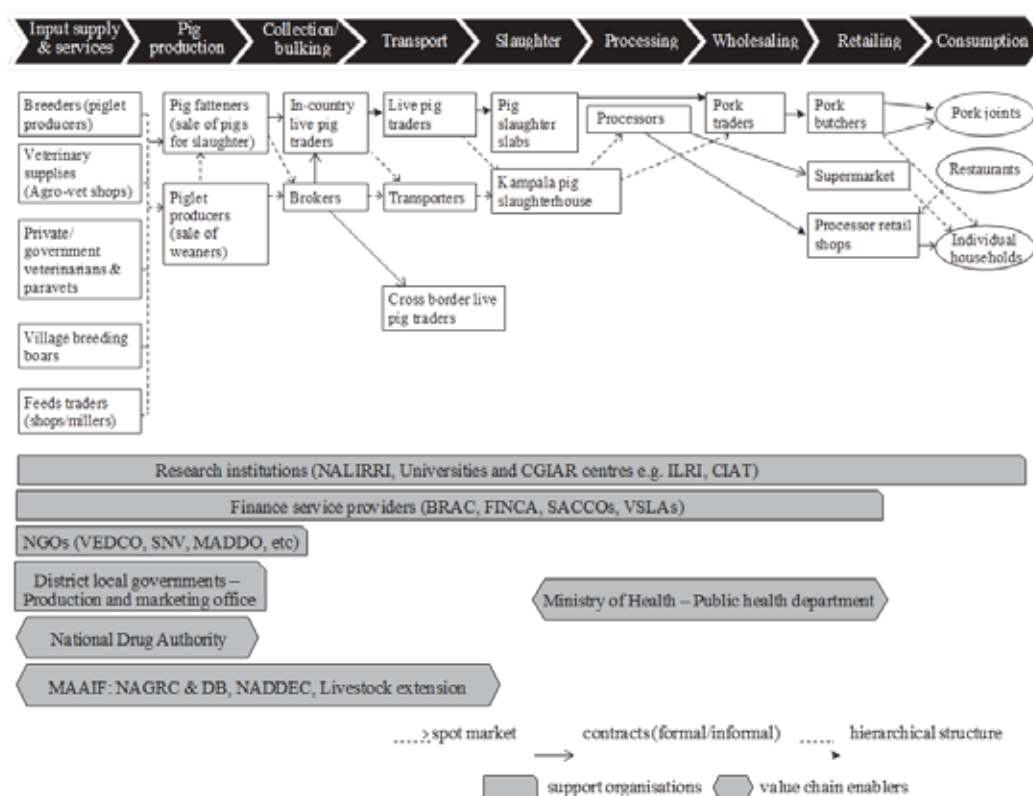
The livestock subsector is one of Uganda's important growth sectors with prospects of improving the livelihoods of the rural poor. The small livestock (such as chickens, goats and pigs) are particularly important 'insurance' and 'living banks' for poor households, which they sell to enable them to cope with shocks and stressors (Scott et al. 2016) and to meet planned financial needs such as school fees obligations. The sector contributes 17% of agriculture value-added and 4.3% of gross domestic product (GDP) (UBOS 2018).

Of the livestock subsectors, the piggery especially presents a tremendous opportunity for rural households to generate income and to move out of poverty because it requires low capital investment and gives relatively quick and attractive returns. Therefore, more poor women and men are taking on pig rearing because of a guaranteed market. The growth in pig production has been on an upward trend since 2008 with a population of 3.2 – 4.4 million pigs in 2019 (UBOS 2020). The pig sector is largely dominated by smallholders, who collectively constitute more than 90% of the agricultural system. The smallholders rank pig and crop production as a highly important source of livelihoods and guaranteed income-generators for women. The average productivity of pigs in Uganda is poor compared to the other regions of the world, but not different from that of East Africa and Africa as a whole. The estimated average carcass weight is 60 kg/animal in Uganda compared to 47.9kg/animal in East Africa and 48.8 kg/animal in Africa (Twine and Njehu 2020).

Pig-keeping in Uganda is categorized into three basic management systems; i) intensive, ii) semi-intensive, and iii) extensive (small-scale subsistence). In the intensive system, the pigs are kept housed all-time in a small place where they are provided with feed, water, and protection from extreme weather (Mutetikka 2009; Pezo and Waiswa 2012). This system is characterized by higher demand for labour and other inputs, but higher farm outputs are vital for commercial production. The intensive system accounts for a small proportion (less than 10%) of the pig production. This management system requires significant capital, management skills, and aggressive marketing arrangements. However, this system allows easy selection of breeding stock, faster growth of pigs, effective control of diseases/internal parasites, good hygiene in the pens, and eventually minimum mortality rate of piglets and pigs. In a semi-intensive management system, the pigs are partly housed and partly kept outdoors on pasture (Mutetikka 2009). Though this pig management system is rare, it can be found in areas where pork is highly remunerative. Limited space in this system provides opportunities to improve feeding, growth rate, disease control of heat stress and enhancement of mating to have better-quality animals (Pezo and Waiswa 2012). The extensive pig management system is the simplest and most common system in Uganda (almost 90% of the pigs are kept this way). Pigs are kept outside on the pasture all the time. This system is often practised by the very poor who invest in low-cost/low-output farming systems.

The pig value chain is not well regulated in Uganda and typically operates under informal market arrangements. There are several intermediaries between the production and consumption nodes, which tend to lengthen the chain. There are generally no standards to adhere to in the value chain (Ouma et al. 2017). The value chain is characterized by the limited availability of end-market information on prices and there is a lack of transparency in transactions performed.

Figure 1: Uganda pig value chain map.



Source: Ouma et al. 2017.

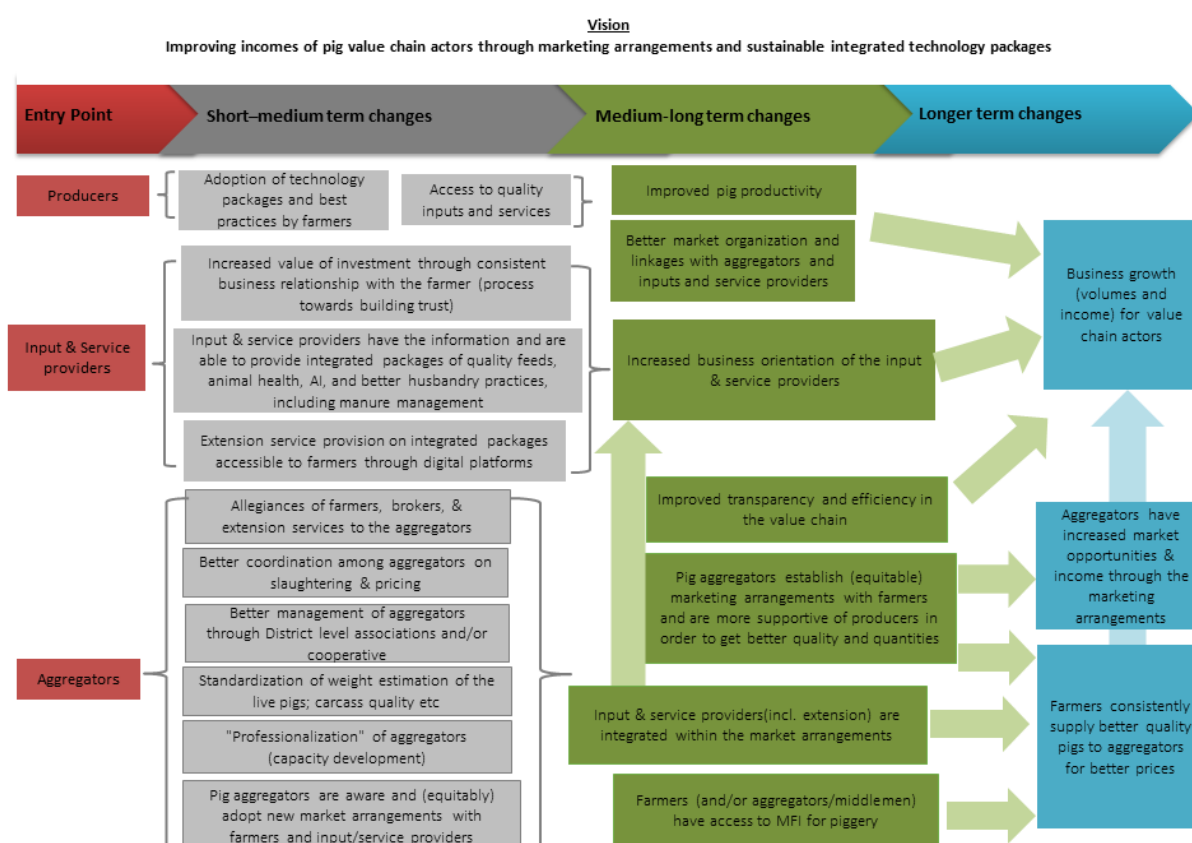
### 3.1.1. Project and objectives

Aimed at improving pigs' productivity and incomes of the value chain actors, the CGIAR Research Program on Livestock rolled out the 'Improving pig productivity and incomes through environmentally sustainable and gender-inclusive integrated intervention package' project in the country, with the following specific objectives:

- Piloting and evaluating innovative market arrangements at the level of pig aggregators to strengthen the market linkage between them and pig farmers, and link the farmers to input and service providers.
- Implementing and evaluating an integrated package for improving pig productivity and performance comprising of pig herd health practices, reproductive management, improved genetics, and better feeding for the farmers participating in the market arrangements.

The theory of change (ToC) for the project is intended to address the problem of low income for pig value chain actors in Uganda through market arrangements and the introduction of integrated technology packages. The entry points for the project interventions are considered to be producers, input service providers and aggregators. Development of a well-designed digital ecosystem for agriculture, informed and trained value chain actors regarding innovative technology packages, available extension services for use and adoption of technologies, and the existence of required coordination amongst the value chain actors are set as short-medium term changes to be brought about by the project. The establishment of the systems, setting up of institutional arrangements, and uptake of technology packages by the value chain actors are some of the key medium-long term changes to be brought about by the project. And the expected long-term changes are set to be business growth, increased market opportunities, and income of the value chain actors and farmers.

Figure 2: Theory of change of the Uganda CRP Livestock project.



### 3.1.2. Selection and scaling assessment of technology package

Beginning in 2012, under the CRP Livestock and Fish, ILRI tested best-bet technology interventions to address specific pig value chain constraints in Uganda. The best-bet interventions then tested included feeding options, capacity building of the value chain actors, biosecurity control of African swine fever (ASF), and waste management. But the results showed limited uptake of the best-bet interventions due to financial constraints of the farmers to invest in them (Mtimet et al. 2018). The inefficiencies at input and output markets and limited access to veterinary services further disincentivized farmer uptake of these profitable technologies.

#### Characterization and selection of technology package

The identified best-bet technological interventions, under the CRP Livestock and Fish, were first tested in small-scale pilots. Then the integrated technology packages were finalized for enhancing pigs' productivity and incomes of the pigs' aggregators. The technology packages covered health, genetics, feed and forages, livelihood, and environmental aspects of the pigs' production and value chain. The technology packages included:

- Community-based artificial insemination for improved breeds of pigs.
- Capacity building of pig farmers and other value chain actors in disease control.
- Promotion of good animal husbandry through the utilization of PigSmart for disease reporting and advisory services.
- Selection of heat-tolerant forages and feed/food crops or nutritious, affordable, and accessible feeds and forages for pigs' production.
- Balanced least-cost rations.

- Introduction of a certification business model for small-scale commercial feed producers to improve the feed quality.
- Multi-stakeholder platforms for pigs' value chain at national and international levels and catalyzation of lower-level multi-stakeholder platforms (MSPs).

The intervention packages were built on reducing the pigs environmental footprint through assessment of different packages of interventions in terms of water and land, competition with human food, and future climate change. The best-bet interventions were developed, tested, and evaluated on reduced environmental footprint through waste management, and adapting to heat stress.

## Scaling assessment of best-bet technologies

A systematic approach was applied to scaling individual technologies and the integrated package. The approach comprised of structured assessments of scaling suitability of individual technologies and integrated packages through scaling frameworks and implementation arrangements. That approach helped in the systematic navigation of the complexities involved in the implementation of the intervention package.

The Impact at Scale program (I@S) assessed the scaling readiness (Sartas et al. 2020) and developed a scaling plan for the 'training and certification of small-scale feed producers' through holding a stakeholders' consultative workshop. Scaling readiness is a decision support system designed to support CGIAR projects and programs to improve the use of innovation at scale. I@S assessed the scaling-readiness (Sartas 2020) of two components a) 'Piloting and evaluating a training and certification business model to improve feed quality for small-scale commercial feed producers in Uganda,' and b) 'Marketing arrangement intervention.' The assessment covered intervention profiling, innovation profiling, innovation package profiling, and scaling strategy/plan. The intervention profiling described and assessed the characteristics of the component by giving the rationale, with a snapshot of facts and diagnosis. The innovation profiling explained the critical innovation component and assessed its characteristics in terms of its potential to achieve use at scale. The innovation package profiling highlighted all other innovations necessary to use the program at scale in a specific (Uganda) context and covered assessment of those other innovations. Finally, the scaling strategy brought all three together and provided a recommendation for improving the use of training and certification programs at scale in Uganda. Each step covered the rationale with a snapshot of the facts and concluded the diagnosis. The assessment concluded that improving the content of the training and certification program will not be sufficient to increase the use of the program at scale.

However, the specific recommendations made by the assessment for the piloting and evaluating a training and certification business model to improve feed quality for small-scale commercial feed producers in Uganda were to:

- Study the experience of 'feed certification implementation group' and establish a group to support with the same mandate.
- Study the experiences of 'feed standard associations' in a similar context and prepare organizational establishment statements and business plans for new associations.
- Share the plan of the implementation group with the partners and other stakeholders working in the feed sector.
- Support testing of the PigSmart digital extension platform and its dissemination to the stakeholders working on an extension in the pig sector.
- Create learning on quality and safety aspects of feed production training to make commercially viable and superior feed mixes.
- Design a training curriculum based on the findings of knowledge, attitudes and practices (KAP) analysis with a flexible scheduling and input-output approach.
- Convert the conceptual model of combining training, certification, and licensing into an application model by detailing the plan.
- Present the curriculum based on the findings of KAP with flexible scheduling to other components and initiatives working on the feed research and development.

- Include a training curriculum as a commercial course in the Continuing Agricultural Education Centre (CAEC) of Makerere University.
- Collaborate with other organizations or projects providing role-based training.

The specific recommendations made by the assessment for the marketing arrangement intervention in Uganda were to:

- Conduct desktop research on successful implementations of openly sharing market-related information in livestock value chains in East Africa.
- Validate existing evidence-based logistical arrangement approaches in pig value chains and tailor them for use in Uganda at scale.
- Validate existing effective hands-on-brokerage techniques in pig value chains and tailor them for implementing them at scale in Uganda.
- Conduct desktop research on existing transportation best-practices in pig value chains and design a blueprint of how they can be implemented in Uganda.
- Validate how existing pig health, weight and other price and quality-related inspection practices can perform in Ugandan pig value chains and design an application that combines the effective practices.

### 3.1.3. Strategies for technology uptake

The project developed and tested an environmentally sustainable and gender-inclusive integrated intervention package. The package contained innovative market arrangements at the pig market aggregators level to strengthen the market linkages between them and the pig farmers and link the farmers with input and service providers. Such market arrangements were made to incentivize the uptake of productivity-enhancing technologies, including herd health practices, reproductive management, improved genetics, and better feeding. This section covers the steps, strategies, and approaches taken and adopted by the project to ensure and enhance the uptake of profitable technologies by the smallholder farmers and other value chain actors.

#### Inclusive market arrangements

A scoping study was conducted to assess the existing business models utilized by the pig aggregators, input suppliers and service providers to further support the design of the intervention (Sebatta et al. 2020). The assessment explored the existing pig aggregator business model operating in the project area. The study findings note that the smallholder farmers mostly sell live pigs to holding units (abattoirs). The large farmers sell live pigs either directly to the holding units or to village middlemen who then sell to abattoirs. There also exists a typical pork aggregator/butchery model. Abattoirs sell fresh pork to butchers and consumers as fresh cuts. The abattoirs sell off-cuts to the traders. The smallholder farmers directly sell live pigs to pork joints (butcherries). While pork is directly sold to butcherries by the farmers, small and large abattoirs sell to butchery. The butcherries then sell fresh and fried pork to the ultimate consumers.

The scoping study also profiled veterinary practitioners, and drug and feeds suppliers to the smallholder farmers. The study findings noted that the veterinarian had the least membership of associations and all the sampled veterinary stockists were serving the pigs. The proportion of the total drugs dispensed for various pig diseases by the stockists appeared mainly for African swine fever (82%), followed by worms (71%) and mange (53%). The main barriers that affected drug stockists' businesses were i) poor roads that delayed delivery of drugs, ii) high taxation and license fees that resulted in high cost of operation, and iii) unreliable energy supply that led to spoilage of drugs needing refrigeration. The assessment suggested i) ensure stable and reliable energy supply, ii) reduce energy tariffs for small businesses, iii) revise taxes levied on veterinary distributors, iv) organize veterinarians into associations, v) provide additional training in veterinary drug management and disease investigation, and vi) scrap off non-effective drugs.

The study also documented that the feed processors/stockists involved in commercial feed production had adopted different innovations along with feed processing. The feed industry was providing technical advisory services in feed formulation, feed requirements for different livestock, feed storage, proper housing hygiene, proper feeding regimes, disease management, and bio-safety measures. Stakeholders also have strategized to cope with the changing market through maintaining the quality of the products and adapting to the prevailing market situation by introducing new innovative products in the market such as concentrates. The main constraints impeding the businesses of feed processors/stockists were related to policy issues, adulteration of feeds, inappropriate feed formulation resulting in poor-quality feeds, highly priced commercial feed ingredients (concentrates), price fluctuations, and competition with imported feeds. Therefore, the assessment suggested that the government enact a Feed Bill to regulate the feed industry, conduct content analysis of commercial compounded feeds and concentrates, regulate the export of maize, support traders to stock feed raw materials, set up ceiling price, give credit to farmers, and enter into contractual agreements with the farmers.

A situation analysis study (Twine and Njehu 2020) assessed the conditions within which the pig value chain actors operate in Uganda and provided an overview of past trends, current status, and future directions in the pig value chain. The assessment also identified challenges being faced by the different value chain actors and the opportunities for improvement. The study witnessed the increasing demand and market for pork across all regions of the country and found a potential demand for pig meat in neighbouring countries such as South Sudan. But the dominance of subsistence, smallholder pig production systems, and lack of organized farmer groups to collectively access the extension services, inputs, and credits were identified as the limiting factors for large-scale and quality commercial production of pig meat in Uganda.

Considering the findings of the scoping study and situation analysis, the project adopted a market system approach by supporting strong and more profitable linkages between pig aggregators (buyers) and pig producers. Those market arrangements strengthened the backward linkages with the inputs and services suppliers that incentivized the adoption of best-bet interventions. A service provider, Ultimate Business Strategies (UBS), was engaged in mentoring pig aggregators, input suppliers, and service providers in market arrangements and strengthening their entrepreneurial capacities. A training manual was developed for the value chain actors to be used for training on market system development. A series of training, coaching, and mentoring sessions were carried out with various value chain actors.

Aimed at improving the pig market system through enhancing knowledge in the market system approach, a virtual six-day training on market system development for 19 CRP Livestock country staff and key partners was conducted by a private partner (UBS). UBS applied a mix of approaches while introducing the concept of market systems development and training 59 aggregators from Mukono and Masaka, and 24 feed and drug stockists from the same sites. To strengthen the entrepreneurial and business capacities of women-led businesses, a private sector partner (Enterprise Uganda) was contracted. The focus of the intervention predominantly remained on the capacity building of pig aggregators, feed, and drugs stockists. The interventions included customized and specialized entrepreneurship training, one-on-one and/or group mentoring, networking, and peer learning engagements. Moreover, the project trained 30 extension agents as trainers of trainers (ToT) on the use of the gross margin calculator for the small-scale farmers to understand their businesses.

## Herd health management and biosecurity

Poor management and husbandry practices increase the risk of transmission of highly infectious diseases such as ASF (Dione et al. 2020b). Poor biosecurity and breeding practices also contribute to disease transmission. The lack of functional livestock disease surveillance mechanisms in the country has compounded the problem of disease control. On disease control and modelling, a systematic review of the 'Status of research and gaps on respiratory diseases of swine in Africa' (Oba et al. 2020) highlighted knowledge and information gaps related to the epidemiologic and economic impact of various pathogens on pigs. The review revealed that limited research had been conducted in Africa on respiratory pathogens. No study was found looking at the economic impact of any of the pathogens on pig productivity in Africa. Similarly, the review further informed that the surveillance systems, specific to respiratory pathogens, were either weak or non-existent. Most of the national surveillance systems were found focusing on a single disease, such as ASF, instead of undertaking a more holistic approach to gauge the

breadth of pig diseases and their impact to get better insights for targeting interventions. Limited investment in animal health was seen as alarming and needed to give attention to the control of diseases that affect productivity and threaten the livelihood of smallholder farmers.

A disease transmission simulation model framework, developed in Vietnam, was adapted to tackle porcine reproductive and respiratory syndrome (PRRS) in Lira District. Results were reported in a paper that was submitted for publication. A modelling analysis to assess the global incidence and prevalence trends of *Taenia solium*/porcine cysticercosis globally was carried out with a subset of Uganda dataset collected from Masaka and Lira districts to better understand the geographical heterogeneities in its transmission and support post-2020 World Health Organization (WHO) targets.

Research related to single infectious diseases generated useful information and knowledge to characterize the pig health status (Dione et al. 2014; Ouma et al. 2015; Roesel et al. 2017; Dione et al. 2018). But the wider herd 'ecosystem' has health issues related to feeding strategies, co-infection, and reproductive management. Thus, herd health management (HHM) is a method to optimize health, welfare, and production in the herd. HHM does not focus on a single infectious disease, rather on general farm conditions such as feed strategies, biosecurity, general health, reproductive management, husbandry and management skills to ensure sustainable production and maximize profit. The project strengthened advisory services to the value chain actors (farmers, traders and butchers) on herd health and best practices in biosecurity with value chain actors. Information communication technology-based (ICT-based) dissemination of information to the actors and players involved in the pig value chain was used by the project. A publication on 'Assessment of gender perspective of pig husbandry and disease control among smallholder pig farmers in Uganda' was published in *Agrigender* (Dione et al. 2020a). The paper recommended measures to improve ASF control and better disease management.

A training course was designed to equip the Uganda veterinarians (known as 'vet champions') in skills on HHM. Five vet champions received two weeks of intensive training at the Swedish University of Agricultural Sciences (SLU), Uppsala, Sweden. The training course provided an opportunity for the vet champions to exchange knowledge and experiences with Swedish veterinarians and learn from them. After training, the vet champions provided support, training, and mentorship to fellow veterinarians in applying herd health principles at the farm level.

The project developed an integrated training manual on herd health management and biosecurity for smallholder pig value chain actors. The manual informed the herd-health module of the PigSmart platform for dissemination of the messages for various value chain actors. A training module on prudent and efficient use of antibiotics was also developed. All the five animal health champions were trained on the module and then supported the smallholder value chain actors. SLU, together with pig herd health champions and Makerere University, developed a mixed on-site/remote training format for prudent and efficient use of antibiotics.

## Community-based artificial insemination

Uganda lacks pig registration of known breeds that can allow pig keepers to select pig breeds of their preferences. The registration and certification of animal breeds, breeders, and breeding centres is yet to be put in place for pigs. Pig farmers, therefore, face significant constraints in the genetic improvement of their stocks. They have limited access to high-productivity pig breeds, information about high productivity traits, and there is inability to keep and record mating practices. Pig breed types are considered at the level of local, exotic, and cross-bred (Muhanguzi et al. 2012).

The project introduced a community-based model for artificial insemination (AI) of pigs to support the uptake of improved breeds of pigs. For the implementation of the intervention (AI), collaboration was sought with the local partners for the capacity building of farmers on AI, and linkages were developed with the local service providers for AI services and semen supply. A survey of pigs' aggregators was administered to know their perceptions of the community-based AI approach. Comprehensive training materials on pig breeds and breeding were developed and tailored to the context of Uganda in four local languages (Marshall 2020). Online service providers delivered AI services and pieces of training to the farmers.

Also, partnerships were built with the National Agriculture Research System (NARS), government ministries and agencies, particularly the National Livestock Resources Research Institute (NaLIRRI); Makerere University; Ministry of Agriculture, Animal Industry and Fisheries (MAAIF); Ministry of Water and Environment (MWE) and the Office of the Prime Minister (OPM) in specific aspects of the project. For training and mentorship of PhD and MSc students for various flagships, partnerships and collaboration were made with the local research and academic institutions such as NaLIRRI and Makerere University.

## Digital solution to advisory services

In the era of global connectivity, the digital solutions/digital ecosystem was conceived as a better approach towards enhancing awareness, outreach, accessibility, and effectiveness of the best-bet interventions. An ecosystem of digital players was established in the form of the 'PigSmart' platform. Based on the assessment of the knowledge, attitude, practices (KAP), and needs of the pig value chain actors (Dione et al. 2020b), the best-bet interventions were designed and embedded in the PigSmart innovation, which provided multiple digital solutions to the growers, aggregators and other value chain actors of the pig value chain. Under the umbrella of that digital innovation, a 'feed calculator' was introduced through a mobile-based app to compute the least cost and balanced feed for livestock. Similarly, a 'gross margin calculator' was developed for the farmers to calculate input cost and output prices to promote the concept of farming as a business and bring efficiency in pig farming. While an EzyAgric application served as a hub of knowledge and an e-commerce platform for production, produce, marketing, and financial access of all the stakeholders involved in the pig value chain. PigSmart also provided a data-driven and inclusive platform to link the community-based cooperatives and individual farmers with the input suppliers and service providers.

The engagement of the private sector companies in the PigSmart digital innovation was seen as a sustainable mechanism. The companies engaged included Single Spark Ltd. for a feed calculator mobile-based app, AgriTech Talk International for the gross margin calculator, Akorion Company Limited or EzyAgric for the digitized financial and market information bundle, and Vetline services Ltd for AI services.

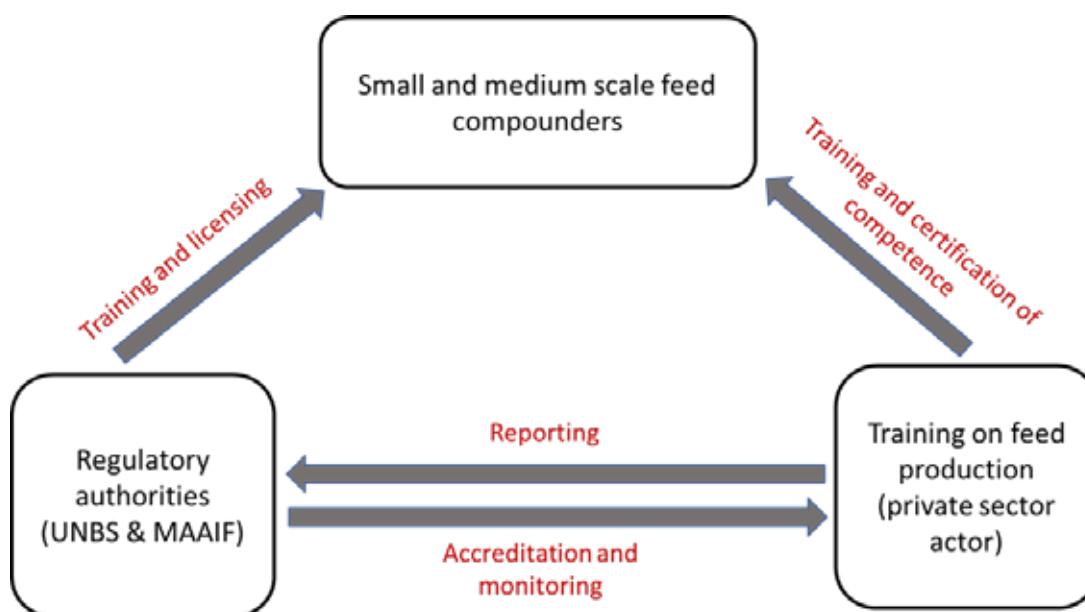
## Training and certification model for small-scale commercial feed producers

The small-scale commercial feed producers have dominated (75%) the production of compounded feeds in Uganda. But they have lacked the basic knowledge of feed ingredients, formulation, and production. The farmers, more often than not, complained about the poor and inconsistent quality, and high cost of such mixed feeds. Moreover, enforcement of rules and regulations in commercial feed production was almost non-existent. Therefore, training and certification of small-scale commercial feed producers' model was initiated by the project. The main purpose of the initiative was to improve feed quality, maximize feed utilization and grow markets of commercial feeds to support farmers in improving pig nutrition and get value for their money. The training and certification business model was piloted and evaluated through a collaboration with Makerere University, Lira University, MAAIF, Uganda National Bureau of Standards (UNBS), and feed companies (Lukuyu 2020). The model encompassed training courses and manuals on feed-formulation, mixing and feed safety. Best-practice protocols and guidelines were developed for small-scale feed production to put in place a quality assurance system (by bringing on board Reco Industries Ltd). The small-scale producers were selected and trained in feed formulation, production, and best practices. The baseline and end-line knowledge, attitude, and practices (KAP) of small-scale feed producers and the quality of the feed produced were assessed during the training and certification intervention and the result was certification of trainees and catalysing of the formation of a feed manufacturers association for self-regulation.

Under the capacity building interventions, 16 extension staff and other village agents were trained on the Feed Calculator app to formulate feed rations based on the local feed ingredients. Then, those agents supported farmers' groups in the formulation of quality feed rations for pigs.



Figure 3: Business model for improving quality of commercial feed.



Source: Authors

## Feed calculator for balanced and least-cost feed rations

Research evidence shows that the cost of feeds accounts for 60-70% of the total variable cost of producing pigs in the country (Mutetikka 2009; Lule et al. 2014). The major feed constraints include high cost, poor-quality of commercial feed, and lack of knowledge on low-cost preparation of feed rations by using the cheap and abundant local feed ingredients (Pezo et al. 2014; Ouma et al. 2015; Lule and Lukuyu 2017). These constraints are further exacerbated by strong seasonal effects that result in fluctuations in feed quantity, quality, and price (Pezo et al. 2014).

The previous studies note that the more commonly used feeds in Uganda include maize bran obtained from local millers, crop residues, kitchen waste, cut-and-carry green forages and farm weeds (Mutetikka 2009). The feed types used by the farmers vary depending on the season (Lule and Lukuyu 2017). In the rural areas, pig farmers mostly rely on sweet potato vines, maize bran, weeds, and cassava leaves to feed pigs in the dry season. Other feed types used in small amounts include home-mixed rations, swill, and cassava roots. In the urban areas, maize bran is more commonly used, constituting nearly half (45%) of the pig diets, followed by home-mixed rations, swill, and sweet potato peels.

The project introduced the Feed Calculator app through the PigSmart digital platform in partnership with Single Spark Ltd (a private sector service provider). The service provider recruited, trained, and backstopped the farmers and feed producers on using the Feed Calculator app. Sixteen extension agents were trained on the Feed Calculator app for making feed rations. Those agents supported farmers, through groups, in the formulation of quality feeds for pigs. A total of 30 extension agents were trained as ToTs on the use of the gross margin calculator tool for the small-scale pig farmers to understand their pig businesses. Improved forages were promoted through farmer field schools, radio messages, and the distribution of extension messages through word of mouth. Also, business models for forage seed production were tested.

## Heat stress and environmental impact

Heat stress is a global issue constraining livestock production and potentially intensifying future climate change. When the cows and pigs get exposed to continuous heat stress, their bodies lose the ability to cool themselves effectively, resulting in lowered productivity, weakened immune systems, and, at times death. A journal article, 'A methodology for mapping current and future

heat stress risk in pigs' (Mutua et al. 2020a) mapped heat stress risk and quantified the number of pigs exposed to heat stress using 18 global circulation models and projected impact in the 2050s. The results showed that more than 800,000 pigs would be affected by heat stress in Uganda in the future and provided evidence for policy formulation and resource allocations in the livestock sector of the country.

The International Centre for Tropical Agriculture (CIAT) conducted heat stress mapping for dairy, beef, pig, sheep, goat, and poultry across East Africa. The exercise identified hotspot areas that could significantly affect livestock production in the absence of adaptation and mitigation measures. In the light of the heat stress mapping study for dairy and pig, an adaptation-planning stakeholders' workshop identified the effects of the heat stress on pig production and value chain (Mutua et al. 2020b). The list of effects predominantly were change in the design of the structure, increase in disease prevalence, change in transportation pattern, and reduced volume of trade. The list of ongoing adaptation measures that the pig value chain actors used to take were the use of microorganisms as feeding methods, promotion of heat stress-tolerant breeds, transportation of animals during night-time, and increased establishment of pig market associations. To cope with and mitigate the listed effects of heat stress, the stakeholders suggested enhancing knowledge and information sharing among the pig value chain actors, catalysing smart innovations, and increasing investment and funding. They also emphasized conducting more research on animal welfare, tree species for pastures and silvopastoral systems, and climate-resilient livestock breeds and forages/pastures.

As a part of multi-stakeholder learning series around livestock and climate change, a policy briefing workshop was organized in Kampala on 10 December 2020 (Mutua et al. 2020c). The 'Reducing climate-induced heat stress in pigs in Uganda: Policy actions,' workshop was co-hosted by MAAI and MWE and attended by 59 participants (including 15 women). The briefing focused on heat stress in pigs and its anticipated adverse impacts on the pig sector in Uganda. The presented analysis of the historical climate data and simulation predicted a gradual shift towards severe heat stress conditions in most parts of the country. The pigs were found to be more vulnerable to heat stress because they do not have functional sweat glands. The heat stress distorts the pigs' feed intake, growth, and reproduction, thus making them more vulnerable to diseases. The research, therefore, suggested that the adaptation of smallholder pig production systems to heat stress needs to be a policy priority and recommended policy options for agricultural extension, national- and local-level policymakers, and development donors and organizations. The policy briefing workshop recommended coordinated national- and local-level policymaking, promotion of heat stress coping and adaptation measures at farm level, preparation of action plans at various stages of the value chain, close cooperation and information sharing between research and policy, and creation of an enabling environment for the farmers to adapt and mitigate heat stress in pigs.

Involving MAAF, Ministry of Water and Environment (MWE), and NaLIRRI, the project conducted a Comprehensive Livestock Environment Assessment for improved Nutrition, secured Environment, and sustainable Development (CLEANED) virtual training. In addition, a knowledge exchange and transfer consultation workshop on heat stress was held, which was attended by 30 participants from policy, research, the private sectors, and civil society. A technical training manual on the management of heat stress in pigs was compiled in partnership with Makerere University.

### 3.1.4. Outcome

- An inclusive market arrangement is put in place at the project sites that ensures forward linkages of pig producers with pig aggregators and backward linkages with input suppliers and service providers who are incentivized to adopt best-bet interventions. Moreover, the value chain actors, particularly pig aggregators, feed and drug stockists are trained on market system development and are skilled enough to expand and sustain profitable businesses. The outcomes include:
  - a. Strengthened intra- and inter-actor relationships. The majority of the pig aggregators unanimously agreed on the need to foster new relationships with various value chain actors as well as amongst themselves to harness the opportunities within the various relationships. Most pig aggregators had weak relationships with farmers and consumers and almost non-existent relationships with the district local governments, vet service providers, and input suppliers. UBS identified the relationship gaps and identified and implemented

intentional activities aimed to close the gaps. Several meetings were held between the aggregators and the pig farmers/pig farmer cooperatives to identify the needs and chart a way forward to address the needs including linkages with input and service providers.

- b. Improved market linkages. UBS supported pig farmers to establish mutually beneficial long-term relationships with aggregators through engagements between the farmers and aggregators. It also fostered the emergence of relationships between aggregators, inputs dealers and pig farmers to incentivise the uptake of good-quality inputs and services through the farmer-aggregator-input service provider meetings.
  - c. Increased uptake of improved business management practices. Pig aggregators and feed producers were coached and mentored. The individual aggregator business sessions were intended to improve the value chain actors' business management practices. This interested them to grow their businesses by being more customer-centric and also to consider possibilities of managing agent retail networks.
  - d. Strengthened capacity of industry associations. UBS supported the institutionalization of industry associations to develop and enforce a code of conduct. Five associations have been supported to emerge.
- The farmers are practising AI and benefiting from the AI service providers and semen suppliers. The outcomes are yet to be documented.
  - A digital ecosystem is established in the form of a PigSmart platform that is providing multiple digital solutions to the growers, aggregators, and other value chain actors. One of those digital solutions is a 'feed calculator app' that is being used by smallholder farmers and small-scale feed producers for the formulation of nutritious and balanced feed for livestock from the locally available cheap feed ingredients. The 'gross margin calculator app' is also being used by the farmers to calculate the gross margin of their farming business through feeding input cost data and output prices. This app has succeeded to promote the concept of farming as a business entity amongst the smallholder farmers. Moreover, all the value chain actors now have access to information regarding production, produce, marketing, and financing through an e-commerce platform in the shape of an EzyAgric app that is embedded in the digital ecosystem, the PigSmart. Altogether, introducing the digital solution to technical advisory services has strengthened the overall pig value chain system in the target areas. The aggregate demands of the farmers for input supplies and services have started to be delivered to the individual farmers and groups at competitive market rates by the quality-assured resources.
  - Training and certification of small-scale feed producers have standardized the quality of commercial feed production and have induced more farmers to start using certified commercial feeds from small-scale feed producers. The long-term results in the form of improved growth and productivity of pigs is likely to be achieved and documented soon.
  - The insights from the policy brief attracted high-level political participation from the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF), MWE, and the Office of the Prime Minister. The policy actors, international and national organizations gave comments for improving the brief, which will be updated soon.
  - The substantial involvement of public and private sector partners has been instrumental in the implementation of various components of the integrated package and has emerged as a sustainable mechanism. New partnerships have been established with digital solution service providers, capacity-building service providers, academia, and government functionaries for the implementation and sustainability of interventions introduced by the projects.

### 3.1.5. Lessons learned

- The scoping study and situation analysis of the pig value chain helped determine the existing mechanism for marketing of live pigs and pork; delivery of veterinary services, drugs and feeds to smallholder farmers; addressing barriers and challenges to the drug stockists, feed processors, and veterinary services providers; and the operational environment for pig value chain actors in Uganda. A scaling readiness approach was used to assess the scalability of best-bet technologies – training and certification of small-scale feed producers. This evidence-based approach in setting up market arrangements guided targeted activities and actions that led to the development of profitable linkages between pig aggregators and pig producers. Similarly, a consultative approach in the assessment of scaling readiness of best-bet technologies, through stakeholders' workshops, helped to thoroughly review the pros and cons of the technologies' scale-up to address potential

barriers in implementation and opportunities for the actors involved to maximize the benefits from the technology. The scaling readiness approach guided the relevant stakeholders towards ensuring the sustainability of the assessed technological interventions.

- The digital platform (PigSmart) has proved to be beneficial for the farmers in balancing feed for pigs and running of better performing businesses. It also has been instrumental in enabling access to information and knowledge for the producers and other dairy value chain actors. The sustainability of such a platform has yet to be ensured after the withdrawal of project support. However, the engagement of the private sector in the development, troubleshooting, and operationalization of the digital platform has provided a good opportunity to find a mechanism that ensures that the current level of stakeholders' coordination and the financial viability of the digital innovation introduced by the project is sustained.

## 3.2 Tanzania

Tanzania has the third largest livestock population in Africa, with about 30 million cattle. The livestock sector contributes about 7% to the national GDP. Though the sector contributes merely 1.5% to the national GDP, it is critical to the rural economy for being a source of income, employment, nutrition, and food security of more than 2.3 million people in the country. There are two main systems: improved dairy that comprises only 3% of the national herd yet produces 30% of the milk; and the traditional, or pre-commercial, livestock production system.

Dominated by the smallholder farmers, the dairy sector in Tanzania struggles for a variety of reasons. The prevalence of poor management practices and seasonal fluctuations in the availability of forage and feed preclude many smallholder farmers from accessing affordable extension and veterinary services. The lack of high-quality inputs, such as parasite control, nutritious feed, vaccines, and AI, are at the heart of the problem.

Given the dependence of the country on natural resources, the dairy sector is highly vulnerable to climate change. Although, climate change is a global phenomenon, dairy farming is a climate-sensitive economic sector. Drought is the most serious climate-change factor that affects feed and water availability, animal health, and in turn milk production. Usually in Tanzania, a dry season's decline in milk production exceeds 40% due to feeding scarcity. Thus, adaptation solutions in the form of policies, strategies, and plans are needed to cope with the ever-changing climate. Since a healthy economy and a healthy environment go hand-in-hand, both are needed for the survival and prosperity of the sector and populace.

### 3.2.1. CRP Livestock project and objectives

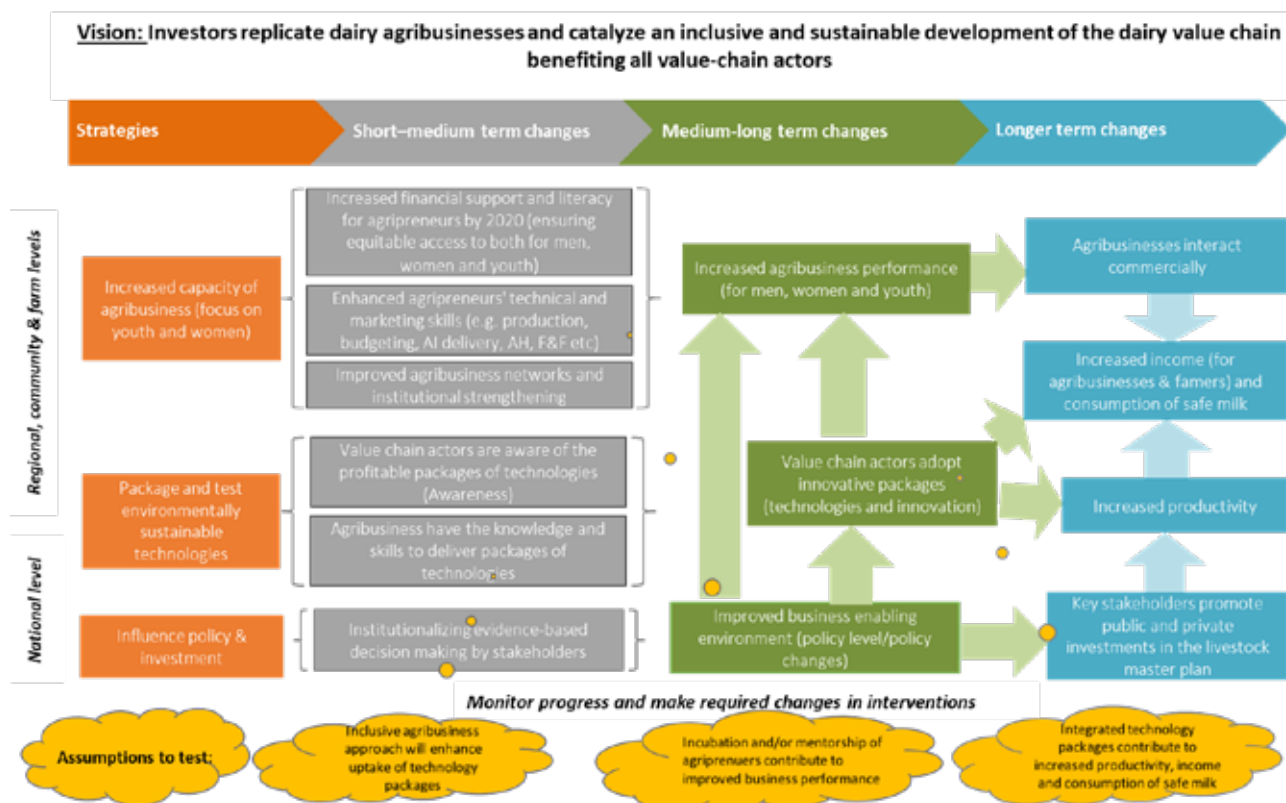
Commercialization of smallholder dairying in Tanzania was seen as a critical mechanism for improved productivity of smallholder livestock farmers and dairy development. The building of pre-commercial dairy market hubs (DMHs) and innovation platforms (IPs) around enterprising value chain actors, in the previous phase of Maziwa Zaidi were found to be promising entry points for creating and growing linkages among the value chain actors for improved access to market, inputs, and services. At the same time, sustained investment in the promotion of proven dairy technologies and innovations yielded significant results in Kenya and Rwanda, wherein dairy contributed around 6–8% of their national GDPs. Based on the previous experience, a project titled, 'Agri-entrepreneurship, technology uptake and inclusive dairy development in Tanzania' was designed to catalyse uptake of dairy technology packages through institutional approaches that involved inclusive agribusiness models for improved livelihoods of smallholders and environmental sustainability. Beyond the traditional value chain model, the project adopted a market-system approach that emphasized and upgraded the inclusive value chain for overall economic growth.

The specific objectives of the project are:

- Smallholder women and men farmers have reliable and consistent access to quality inputs and services to achieve high milk productivity efficiently.

- Smallholder men and women farmers have access to inclusive, reliable, well-coordinated, and efficient dairy products' marketing arrangements with resultant improvement in household income and livelihoods.
- Poor consumers have improved access to quality, safe, and nutritious dairy products at affordable prices, reflected by an increase in their per capita consumption of safe dairy products.

Figure 4: Theory of change – Tanzania CRP Project.



Source: CRP Livestock project proposal 2019

### 3.2.2. Selection and scaling assessment of technology package

#### Characterization and selection of the technology package

An interactive and participatory approach was adopted in the identification and scaling of profitable dairy intervention packages. The identification process was initiated through consultation with the agri-entrepreneurs, national researchers, service providers, and delivery organizations in a workshop held in October 2019. With stakeholders' input, the basic structure and protocol for the characterization of two principal types of packages (delivery and enabling) were designed and developed. Each package essentially contained a technical product (intervention/innovation), institutional and delivery mechanisms, and a set of actions to grow the technical and business capacities of the target actors. The delivery packages integrated product, services, and technical know-how. Eventually, four dairy interventions and support mechanisms were identified that could be profitably delivered to the producers and value chain actors.

The four technical products selected for the delivery packages included Brachiaria grass (or other forage options), manure management, East Coast fever (ECF) vaccine, and AI. The institutional arrangements and delivery mechanism for the delivery packages included capacity development of agri-entrepreneurs and agribusinesses that were supporting market access, safe products, and effective collective action. The package also included the establishment of institutional arrangements for digital platforms to be used for farmers' profiling and e-extension services for the smallholder producers. The enabling packages

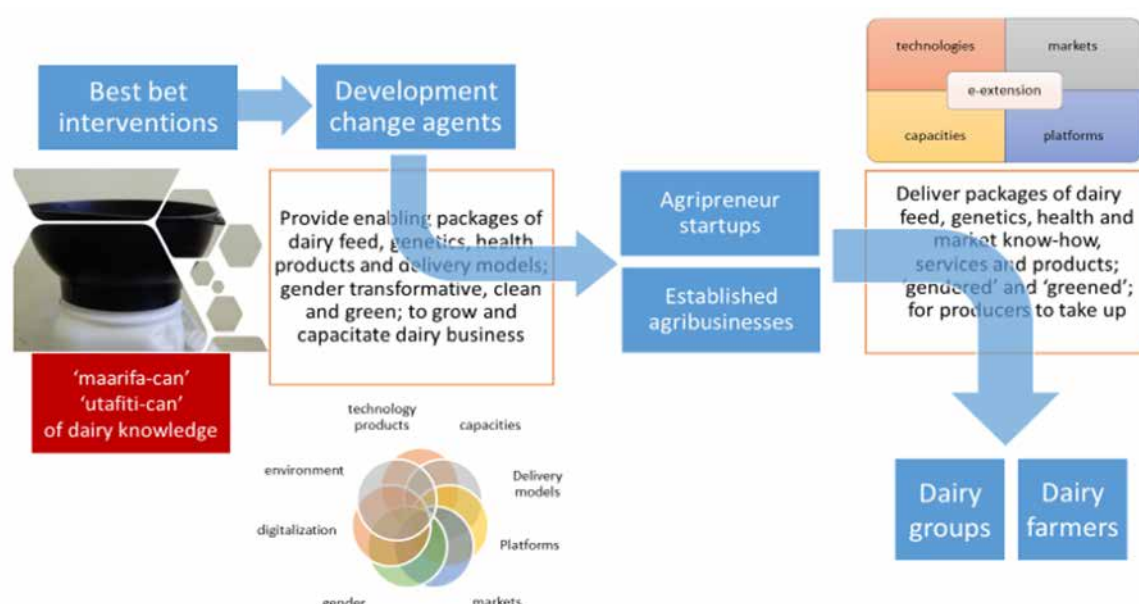
involved the change agents and partners to provide services to the agri-entrepreneurs and agribusinesses in the form of technical know-how, and business and soft skills that were necessary for the dairying to be a profitable business.

Capacitated agri-entrepreneurs working through Agent Network Model, Dairy Farmer Assistant Model, and DMHs were conceived as the potential delivery mechanisms for enhancing uptake of demand-driven technology packages. The presence of partners, farmers with dairying potential, sustainable markets, processors, unmet demand, and conducive agro-ecological factors for dairying were considered in the selection of sites for the implementation of the project. The group of smallholder dairy producers as well as individual producers were targeted. Parallel assessments were planned to support the piloting and evaluation including the 'environmental assessment of selected packages', 'participatory system modelling', and 'scaling readiness'.

## Scaling assessment of best-bet technologies

Building on the work of the previous workshop (Omoro et al. 2019), another two-day scaling scan workshop was organized with the dairy value chain stakeholders in February 2020 (Dror et al. 2020). The scaling scan workshop was attended by the public and private sector dairy value chain actors as well as Livestock CRP staff. The participants in the workshop were selected in a two-stage process from the workshop of October 2019. The workshop sensitized them on the concepts, dimensions, and role of non-technical factors on the 'scaling mindset' in research and project planning. The non-technical factors included value chain development and capacity building of value chain players. The workshop outputs were based on the stakeholders' ambitions, assessment, and potential for scaling of the four targeted intervention packages. The challenges, critical factors, and potential solutions to scale up the intervention packages were deeply assessed by the workshop participants. The tools used by the activity were the Scaling Scan tool developed by PPP Lab and International Maize and Wheat Improvement Center (CIMMYT), Agriculture Scalability Assessment Tool (ASAT) developed by the E3 Analytics and Evaluation project, which is led by Management Systems International (MSI) for the United States Agency for International Development (USAID) Bureau of Food Security (BFS) and published in June 2018. The process included two steps: i) Agriculture scaling decision tree (ASDT) to assess the willingness and capacity of different sectors, ii) Agricultural scalability assessment matrix (ASAM) to identify critical information gaps with a more detailed analysis of the strengths and weaknesses of the innovation based on the selected scaling pathway.

Figure 5: Actors and models involved in scaling process.



Source: Omoro et al. (2019).

The Scaling Scan tool was used to formulate a realistic and responsible scaling ambition by identifying the challenges and opportunities that need to be addressed. Ten scaling ingredients<sup>2</sup> were used to evaluate each technical product at a 1 to 5 scale

2 1. Technology/practice, 2. Awareness and demand, 3. Business cases, 4. Value chain, 5. Finance, 6. Knowledge and skills, 7. Collaboration, 8. Evidence and learning, 9. Leadership and management, 10. Public sector governance

(where a high score means more confidence in reaching the ultimate objective). Three types of interventions, with relatively great potential for scaling, were identified in this order: AI, forages, and East Coast fever vaccine. Of the bottlenecks assessed on the scaling ingredients, 'finance' emerged at the top, followed by 'evidence and learning', 'leadership and management', and 'public sector governance', whereas the key strengths mentioned in order of importance were: 'technology/practice', 'awareness and demand' and 'knowledge and skills.'

Key officials from the public and private sector partners reviewed the results of ex-ante modelling of environmental impacts and prioritized opportunities for scaling environmental management interventions in the dairy sector (Ngoteya et al. 2020a). For genomic evaluations of the animals, an index developed by the African Dairy Genetic Gains (ADGG) project allowed for the selection of animals to be used for breeding that had an improved rate of milk production with constant body weight. The project used the results from the genomic estimated breeding value (GEBV) for milk production and bodyweight of the animals, conducted under ADGG.

### 3.2.3. Strategies for technology uptake

The involvement of the private sector in key commodity value chains and the participation of smallholders in input markets was very limited in Tanzania. There were no efficient ways to promote rural commercialization as a key mechanism for improving dairy productivity and livestock-dependent livelihoods. Moreover, integration of scale-ready innovations to enhance their uptake by the smallholders was almost non-existent. In that backdrop, the project engaged empowered agri-entrepreneurs as entry points for service provision and focal points for packaging of technologies. Strong business-oriented partnerships were built to enable skills training for youth and women, and delivery of bundled technologies to the targeted value chain actors and smallholder dairy farmers.

#### Digital platform and e-extension services

The use of digital technologies in agriculture provides digital platforms to access information on needs and demands for services that support agricultural farming. The digital platforms link data on many farmers, crops, animals, and technologies to evaluate productive potential and set benchmarks for increased productivity. The CRP Livestock projects leveraged the ADGG digital platform for e-extension and maximizing market access. The users of the digital platform included feed suppliers, milk producers, AI service providers, and animal health service providers. The ADGG project developed an agile and scalable web-based data platform to collate and sort data obtained from the small-, medium-, and large-scale farmers by the performance recording agents (PRA)/livestock extension officers. The PRAs pay monthly visits to collect dairy productivity data and support farmers in the dairy management system. The PRAs relay the data to the ADGG data platform using tools developed on the ODK data platform. The collated data are verified, linked, and analysed through the ADGG platform and mirrored on the servers of the Dairy Performance Recording Center (DPRC). The feedback on animal productivity is then shared with farmers through one-on-one interaction or SMS messages facilitated by the i-Cow platform. The ADGG has delivered training and refreshers to PRAs on data collection using the ODK tool.

Moreover, in collaboration with Farm.ink, two digital training courses were developed and digitized to turn the static course content into a fun and an engaging web app for dairy farmers on the Learn.ink platform. Training apps were developed for use in the training of the value chain actors and producers on calving management and milk hygiene. The apps were implemented through a digital marketing campaign. The assessment of the piloted web apps reported 9,937 users that went through digital training tools and attained an average score of 90% in the post-lesson quiz. The users rated digital training courses at 4.7/5 stars.

#### Brachiaria grass/forage options

Feed and feeding are the most important input for increased productivity of livestock. Therefore, access to good quality forages for dairy and beef animals is key. A review report on the forage seed system in the pilot sites of Tanzania (Ngunga

and Mwendia 2020) highlighted the existence of a weak formal forage production system. The report further pointed out the limited involvement of the private sector for sustainability, while seed production of limited forage species was mainly carried out on public sector farms and in research institutes. Complete reliance on the public sector for seed availability and lack of awareness have constrained access to seed by the farmers. Therefore, the review report identified the inaccessibility of quality feed as a major factor that contributed to the low productivity of livestock in East Africa.

*Brachiaria* grass has played a key role in transforming livestock sectors across the tropics, except in Africa. It is a native African grass that produces high amounts of quality biomass. It is adapted to drought and low fertility soils. Moreover, *Brachiaria* can be grown in all types of soils from 0–2,400 metres in altitude while requiring 800mm rainfall. It is also not susceptible to frost. From an environmental perspective, the *Brachiaria* grass sequesters atmospheric carbon dioxide, protects soil erosion, and reduces greenhouse gas emissions. Empirical evidence (Ghimire et al. 2019) showed that the *Brachiaria* grass extended forage availability up to three dry months, increased milk production of cows between 15–40% c those fed on local forage and contributed to 50% more body weight gain of heifers fed on *Brachiaria* grass plus concentrate compared to those fed on Napier grass plus concentrate. Based on the reported evidence, a poster was published highlighting the benefits and opportunities for scaling up *Brachiaria* grass in the project areas. The poster pointed out the availability of products and hay-making technologies for the *Brachiaria* grass and the existence of demand for *Brachiaria* seed to convert that into an opportunity for women and youth to generate income with limited assets.

Another assessment was conducted to seek forage options for the Southern Highlands of Tanzania. Using ‘Targeting Tools’ – a web geographic information system (GIS) – the context-specific varieties were tested in three districts namely, Mufindi, Njombe and Rugwe with farmers’ participatory approach. The tested forages included two *Cenchrus purpureus* (*Syn. Pennisetum purpureum*) cultivars, two *Urochloa* (*Syn. Brachiaria*) hybrids, and *Chloris gayana*. Where applicable, the grasses were intercropped with three forage legumes–*Lablab purpureus*, *Stylosanthes guianensis* and *Desmodium intortum*, while *Tripsacum andersonii* (*Syn. Tripsa- cum laxum*), a grass, was planted as a local check. The assessment observed clear differences amongst the three districts and treatments. Dry matter (DM) accumulation (t ha<sup>-1</sup>) in the districts, and across the various forage treatments was higher in Rugwe followed by Mufindi and Njombe. Most DM accumulation was by Napier grass intercropped with *Lablab purpureus* that was closely comparable to *Chloris gayana-Desmodium* intercrop (Mwendia et al. 2019).

Sustainable dairy production systems need greater quantities of home-grown quality forages that can greatly reduce livestock production costs without compromising productivity. Therefore, the project evaluated the impact of improved Napier grass and maize stover-based diets on milk yield under smallholder conditions. The evaluation used 23 farms as experimental units and 24 lactating cows as replicates. The study findings noted that the Napier grass supplemented with bean haulms resulted in milk yields similar to those the Napier grass supplemented with concentrate feed. Thus, mixing Napier grass with legume crops’ residues has the potential to increase milk yields on farms. While the cows fed on maize stover-based diets had low dry matter intake (DMI), which affected the milk yield of animals, this indicates maize stover should not be relied on as a basal diet for feeding milking cows due to low palatability and high fibre content.

## Agent network model for extension services

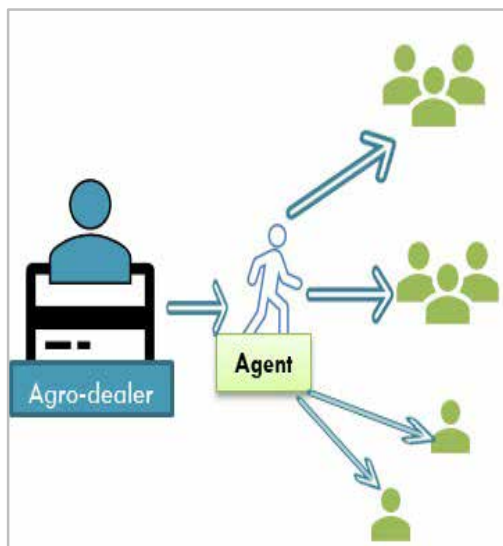
A general lack of knowledge on husbandry practices and the higher cost of procuring inputs (time plus transportation) by the individual farmers discourage the use of appropriate technology and husbandry practices, which are essential to enhance the productivity of smallholder dairy farmers. An agent network model (ANM) provides a link between agro-dealers and farmers. In the ANM model, qualified personnel were engaged as agents to train farmers on husbandry practices, technologies and create awareness about the agro-dealers products. The agents receive bulk orders from farmers and coordinate delivery by saving time and transportation costs of inputs. The agents are incentivized for offering training and creating demand in the form of commission on the volume of sales.

Based on reviews and evidence, the project team developed a poster for advocacy of the ANM model as a cost-effective modality by reducing transaction costs of inputs procured by the farmers. The ANM approach has also enhanced the



knowledge base of the farmers on animal husbandry and delivered more value to agro-dealers in creating demand for their products. Therefore, the poster (Figure 6) suggested the establishment of a strategic alliance between business-focused agro-dealers and qualified service providers/extension agents to access geographically clustered farmers via cooperatives. The ANM approach is seen as a sustainable mechanism where cooperatives' members are clustered across villages, service providers are readily linked to the farmers and the farmers appreciate the value of improved husbandry.

Figure 6: Agent network model poster.



## Rumen8 - a tool to specify total mixed rations

Unbalanced feeds for cows are prevalent across Tanzania, which has led to the low productivity of cows. Allowing cows to access adequate nutrients is key to exploiting the maximum production potential of animals. Limited tools exist to optimally ration feed through the best combination of available feedstuffs. Rumen8 is a tool that is widely used for rationing feed in countries with developed dairy production such as Australia. The tool was improved by including tropical feedstuffs that fitted in the smallholder dairy context. The tool uses traffic lights to identify the required level of a nutrient that could compound TMRs using available feedstuff at minimum cost and set production levels. The Rume8 tool can easily be downloaded and installed in smartphones free of charge. The tool is versatile with up to 230 feedstuff options relevant for tropical context. The tool is ideal for use by enterprising youth and producers of dairy rations.

## Manure management

Integrated Manure Management (IMM) preserves nutrients for crops, prevents transmission of certain diseases, reduces detrimental environmental effects of manure (greenhouse gas [GHG] emissions and pollution of water), and offers economic benefits through biogas for cooking fuel and lighting (replacing firewood and charcoal). The agro-dealers and extension agents are best suited for the delivery of flexi-biogas units and training to the farmers. IMM is suitable for livestock-keeping households in all agro-ecological conditions, free-range systems, deep litter systems, mixed crop, and dairy farming systems.

## East Coast fever (ECF) vaccine

East Coast fever (ECF) is a major constraint to improving livestock productivity in Tanzania. This disease is responsible for about two-thirds of calf mortality in the country and is more serious in improved breeds than in zebu breeds. The Infection and Treatment Method (ITM) vaccine against ECF, following a single vaccination, give life-long immunity to cattle and reduces mortality by 95%. ITM also allows smallholder farmers to keep improved dairy animals in ECF endemic areas with a considerably reduced risk of loss. The agrovet dealers, AI service providers, producer organizations, and private veterinarians were identified as the best-suited facilitators in the delivery of the ITM vaccine.

## Genomic evaluation of dairy cattle

Cost of feed is the most important variable in rearing dairy cattle. The feed consumed by the dairy cattle is used for milk production and maintenance of the body. The quantity and type of feed consumed by the dairy cattle also influence the composition of milk. Therefore, countries such as New Zealand, Netherlands, Finland and the United Kingdom (UK) have developed indices for dairy cattle that reduce feed intake by constraining animal body size. For the first time in Tanzania, the body weight of mature animals was evaluated to get their genomic estimated breeding value (GEBV) for genomic prediction under the Africa Dairy Genetic Gains (ADGG) project. By using the results of GEBVs for milk production and body weight, the ADGG project developed an index to allow for the selection of animals that improve the rate of milk production but keep body weight constant. The CRP Livestock researchers leveraged the genomic evaluations conducted under ADGG in testing integrated packages. The resultant higher producing crossbred and purebred dairy sires were publicized for use through dairy cooperatives, dairy agri-entrepreneurs, and other value chain actors.

## Environmental impact of improved feeding

The environmental footprints (land, soils, water use, GHG emissions) of the intensive livestock production system are a big challenge. A stakeholder workshop around environmental management opportunities was held that highlighted the scarcity of research on environmental aspects of livestock production in the country. The stakeholders emphasized synergizing livelihood and environmental objectives and called for sustainable livestock intensification through improved feed and forage to reduce the ecological footprint of, and improve, livestock production. The stakeholders recommended that the research be embedded in appropriate financial incentives, institutional settings, and capacity building of involved stakeholders. Tropical forages were considered an excellent case to explore and demonstrate research on multidimensional impacts and trade-offs compared with mixed crop-livestock systems (Paul et al. 2020a). So, the drivers, barriers, and incentives required to create an enabling environment for uptake and adoption of tropical forage technologies required accelerated research attention.

Evidence on climate and soil co-benefits of improved forage grasses was generated through biophysical research by employing integrated modelling techniques and quantitative review methods. The biophysical research was conducted at various sites of Tanzania to explore the co-benefits of the improved planted forages such as Napier and Brachiaria grasses. The climate benefits included a reduction in greenhouse gas emission intensity, increase in soil organic carbon, reduction in soil erosion, and positive nutrient balances (Paul et al. 2020b).

## Public and private sector engagement

Public and private investors in the dairy sector collaborated in the implementation of the integrated interventions. Key government officials were engaged to review initial results of ex-ante modelling of environmental impacts and to prioritize opportunities for scaling environmental management interventions in the dairy sector. SNV was engaged through their project on empowering women and youth for income and employment in Kilimanjaro; Solidaridad through their project on climate-smart dairy farming in Tanga; Abt Associates through their evaluation role in the AgResults Dairy Productivity Challenge Project, a multi-donor initiative promoting the uptake of bundled inputs and services; Land O Lakes V37 through their roles in both the AgResults project and the Dairy Nourishes Africa initiative, and a multi-donor initiative through the Global Dairy Platform composed of dairy companies, associations, scientific bodies and other partners that collaborate on responsible food production and sustainable agriculture.

### 3.2.4. Outcome

- Capacitated agri-entrepreneurs who are excited about new business prospects as they engage in the delivery of demand-driven technology packages. Evaluations of the incubation process ranked the program content and participatory approaches used in training as 'very good and effective'. The effectiveness was partly enabled by co-learning and exchange with facilitators on gender-responsive training facilitated by the Dutch Royal Tropical Institute (KIT). The boot camps that

crystallized this excitement involved 66 participants, including 50 agri-entrepreneurs who were selected from pilot project sites. About 42% were women and 60% youth aged 19-35 years (31 from Kilimanjaro and 19 from Tanga) and District Livestock and Fisheries Officers (DLFOs) from project districts and a consortium of facilitators/trainers took part.

- Easy and quick access to digital course contents on calving and milk hygiene, which were uploaded at the learning portal and web apps, attracted the people already engaged in dairying and agriculture farming. These apps have made a significant contribution in raising awareness and imparting skills amongst the smallholder livestock keepers to deliver clean, safe, and quality milk to the distributors and ultimate consumers.
- Higher producing crossbred and purebred sires have been identified through genomic evaluation of dairy cattle. The technology has allowed for the provision of high-producing dairy sires to dairy farmers through dairy cooperatives, agri-entrepreneurs, and other value chain actors.
- Rural commercialization has become part of the core of the national agricultural development strategy of the country. The partners' engagement to influence policy and invest for scaling innovations, and the role of empowered agri-entrepreneurs to act as glue for integration of demand-driven technology packages have earned acceptability at both government and private levels.
- The public and private sector partners are engaged from identification, composition, and scaling assessment of integrated packages to their implementation at different levels. The areas of engagement include digital solution services, bundling and delivery of technology packages, capacity building of partners, and learning and knowledge management. This approach is serving the intended purpose and seems an effective arrangement for the sustainability of introduced interventions.
- High milk-producing forages are identified based on the locally available feed options that are a cheap source of quality feed for smallholder dairy farmers. This has provided economically viable feed and forage options for the smallholder farmers.

### 3.2.5. Lessons learned

- In Tanzania, delivery and enabling packages were designed for dairy groups and development change agents, respectively. Packages covered integrated technical products, delivery mechanisms, services, and know-how/knowledge about the technology uptake through capacity building interventions. Going for such a comprehensive package required identification of multi-level stakeholders, development of a coordination and consultation mechanism, and provision of a common platform to access, interact, and be informed of the progress and latest developments in the dairy value chain. The multi-stakeholder engagement in the process of identification and scaling up of technologies, through stakeholders' workshops, provided platforms for actors, facilitators, and enablers to interact and exchange their views, thoughts, and limitations to reach mutually acceptable, doable, and sustainable solutions. The technical approach, adopted in scaling scan assessment of the identified and piloted technical products remained instrumental in the selection of scalable technologies. Additionally, the technologies identified and scaled up through such a large-scale consultation earned more acceptability and adoptability amongst the stakeholders that were engaged in the livestock value chain.
- The data-driven digital platform for e-extension services and training of the dairy value chain actors remained instrumental in accessing information and knowledge for the producers and other dairy value chain actors. The sustainability of such a platform has yet to be ensured after the withdrawal of project support. The engagement of the private sector in the development, troubleshooting, and operationalization of the digital platform has provided a good opportunity to look for a mechanism that ensures the current level of stakeholders' coordination as well as the financial viability of the digital innovation introduced by the project. Moreover, there is a need to look at the synchronization of the database/information with the country-level databases to use for the development of a national-level dairy and agriculture development strategy.
- As opposed to the use of simple illustrations, the use of photos in the digital course content on calving management and milk hygiene emerged as a key drivers for engagement of the value chain actors and the producers. However, based on users' feedback, continuous improvement in the training contents and creation of new course materials are required to meet the changing needs and demands of the users. Moreover, digital marketing has proved to be a cheap and effective way to recruit new users in online training. But the consistent follow-up is required to re-engage the users who have not completed their courses. So, automation of the follow-up for re-engagement of the users via SMS and in-app notifications is required to derive course completion.
- Systematic reviews and experimentation during the life of the project helped to determine the existing state of feed and

forages in the project sites and explore the potential economical feed and forage options. Eventually, the focus on the improved and locally grown forages and feed options greatly reduced the cost of feeding dairy animals. It also created business avenues for women and youth to develop seed businesses for locally grown improved forages.

- Joint platforms for the private and public sector actors who are interested and involved in forage seed production are vital to address the challenges of seed availability and exploring potential for seed production. The training and technical support to the commercial growers on seed production, purity, and handling are equally essential.

## 3.3 Vietnam

In Vietnam, 12 million households are engaged in livestock production, most of which is by smallholder farmers. Between 1990 and 2019, Vietnam's cattle (beef and dairy), goat, pig, poultry, and sheep populations increased, while those of buffalo and horses decreased slightly. In 2017, poultry comprised 91.6% of Vietnam's total livestock population, followed by pigs (6.5%), cattle (beef and dairy) (1.34%), and buffalo (0.59%). The average annual growth rate of Vietnam's livestock sector between 2007 and 2017 was 4.92% (General Statistical Office of Vietnam 2019a). The consumption of livestock products—especially pork, cow milk, and eggs—increased dramatically between 2010 and 2020, with growth rates in Vietnam leading all countries in the Southeast Asian region (World Bank Group 2016). The total production quantity of meat in the country has increased by 152% between 2007 and 2016, from 3.29 to 5.02 million tons. The production of cattle and poultry meat products has grown 174% faster than the average output of all animal populations, equivalent to 8.6% per year over the same period. In terms of quantity, pork comprises 73.0% of total livestock production, with 3.7 million tons produced in 2019. However, this is down 25.5% from the previous year due to the spread of African swine fever. In the same year, poultry accounted for 960,000 tons, or 19.1% of total livestock production, while meat products from buffalo and beef comprised 6.1% and 1.7%, respectively (General Statistical Office 2019b).

The country is deficient in feed and imports 3 million tons of it per year for livestock. The prevalence of poverty is 2.7 times higher (70%) in the Northwest (NW) region than that in the rest of the country. More than one-third (35%) of the children in the region have stunted growth. The ethnic minorities make up 80% of the total population in the NW region comprising nearly 30 groups, mainly Tay, Thai, Hmong, and Dao. Over 94% of the land is sloping land, in which 87% is above 25°. The province of Son La, in the NW, was selected for the project due to the high density of ethnic minorities, high levels of relative poverty, high livestock density, and pressing problems of environment, market, and livestock production.

The district of Mai Son offers a diversity of farm types from grazing and extensive systems at the top of mountains to intensive farms, integrated with crop-livestock, at the bottom valleys. The commonly reared livestock species include buffaloes, beef cattle, pigs, goats and poultry. In a baseline survey conducted in early 2020, livestock species ownership did not differ among farm types, with nearly all farms owning chicken, around 50% owning cattle and 50% owning pigs (Hammond et al. 2021). The livestock is fed on natural grazing areas, planted forages, maize, cassava, sugar cane, and natural forest. There is a wide variety of socio-economic and ecological conditions that can broadly be categorized into three types;

- An intensive system with good access to market and relatively better capacity for innovation
- Mixed crop-livestock systems
- Remote extensive systems with low access to the market.

### 3.3.1. CRP Livestock project and objectives

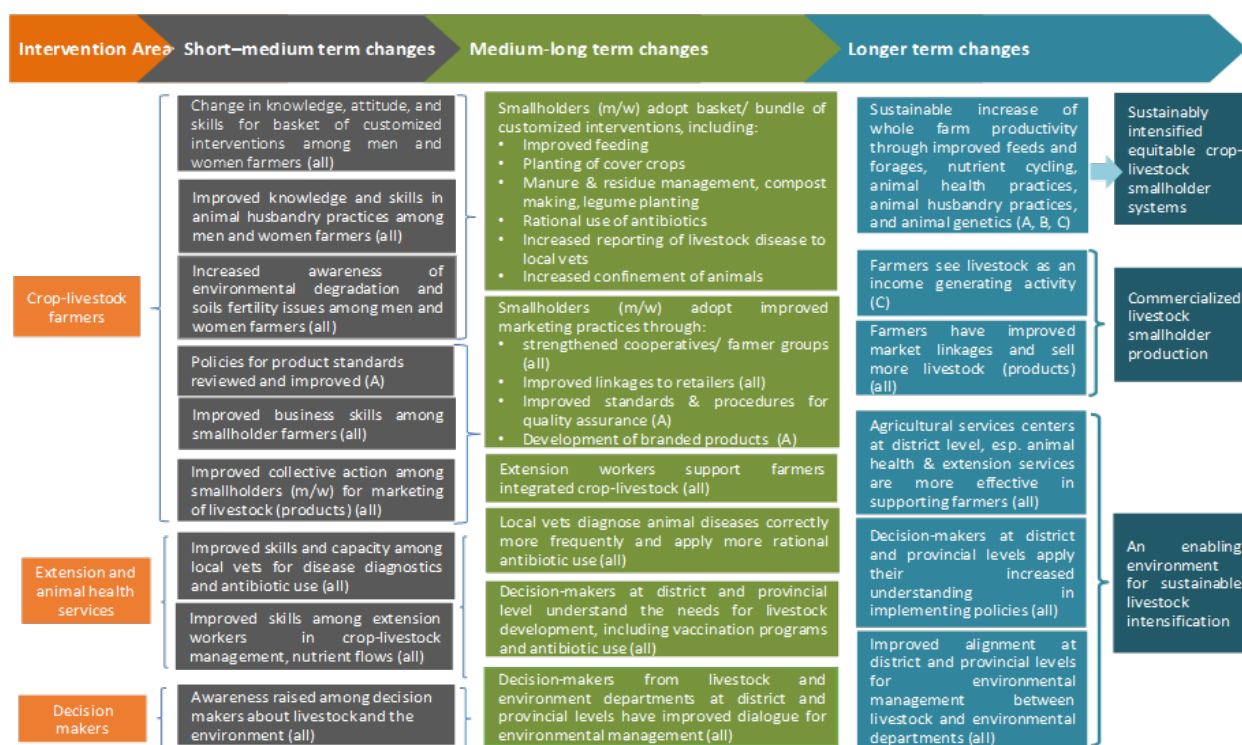
Li-chăn, the 'Livestock-led interventions towards equitable livelihoods and improved environment in the North-West Highlands of Vietnam,' the Livestock CRP priority country project in Vietnam, aims at stimulating system transformation (livelihoods, environment, equity, and market access) to empower highland farming communities through bundled livestock-based interventions in the NW highlands. The project, short-named 'Li-chăn', which means 'livestock is good' in the local

language, is characterized by a system and landscape approach, a focus on multiple species (large ruminants and local pigs), and community-based activities in agreement with government plans. The project's theory of change is shown in Figure 7.

The specific objectives of the project are:

- To intensify equitable and sustainable smallholder crop-livestock production through
  - identifying, testing, and evaluating bundled livestock-based interventions
  - improving knowledge and skills in animal husbandry
  - increasing awareness of environmental degradation
- To identify, facilitate and evaluate institutional innovations that stimulate local livestock product development, market linkages, and effective service delivery for sustainable commercialization benefiting equitably to all gender and ethnic groups.
- To identify and promote inclusive inter-sectoral environment and agriculture policy dialogue and interactions at different levels that address trade-offs and synergies and lead to more conducive and effective policy attention to smallholder crop-livestock systems.

Figure 7: Theory of change for Vietnam Li-chăn Project.



Source: CRP Livestock Project proposal 2019

### 3.3.2. Selection and scaling assessment of technology package

#### Characterization and selection of technology package

Integrated bundles of interventions were designed after multiple consultations with the stakeholders. Different activities were carried out to identify the potential alternative bundles and likely constraints in their uptake and work out the mechanism for sustainable and equitable access to smallholders. The activities and considerations included the G-FAEST assessment (Otieno et al. 2021), forage seed system analysis (Leyte et al. 2021), genetic improvements, value chain mapping, and land use and forage suitability mapping through Targetool and RCP8.5 scenario (IPCC 2013).

Aligned with the three farming systems in the NW region of the country, different bundles of interventions were identified for intensive systems in the lowlands, mixed crop-livestock systems in the mid-altitudes, and extensive systems in the high altitudes. Having better market access and innovation capacity, market-driven interventions were identified for lowlands to produce branded, healthy, and sustainable 'green' livestock-source products. The intervention package included farmers' training on livestock breeds, breeding, animal health, and biosecurity; ii) capacity building of animal health professionals; iii) introduction of improved livestock feeding practices and their evaluation; and vi) capacity building of farmers in nutrient management. Interventions were also supplemented by the Comprehensive Livestock Environment Assessment for Improved Nutrition, Secured Environment and Sustainable Development (CLEANED) approach, and awareness-raising on environmental issues. Further, market research to assess the potential demand for high-value livestock products and participatory identification of suitable value chain interventions at farm and market levels were made part of the project interventions.

The integration approach for the identified interventions included shared activities by stocktaking, diagnosis, activity planning, baselining, common monitoring and evaluation, and engagement of local authorities and community. Inter-flagship collaboration, having common farming systems' understanding considering multiple indicators, and common beneficiaries, were made at field-level.

### 3.3.3. Strategies for technology uptake

A rapid multi-indicator survey was carried out in 622 households to establish a baseline of the targeted indicators in the Mai Son District (Hammond et al. 2021). The survey tool, the Rural Household Multi-Indicator Survey (RHoMIS), was built on specific indicators related to AI, breeding, African swine fever (ASF), animal health, veterinary care, feed-basket, and feeding practices, and soil fertility management. Local partners and authorities jointly selected villages, activities, and communities for interventions.

#### Community-based artificial insemination (AI) of pigs and cattle

Particular attention was given to choosing the animals' genetics, both at the breed and individual level, to produce the animals that are productive and adapted to the local environmental conditions. The project gave a subsidy of up to 1,000 inseminations to different groups of communities at different times. The genetic interventions also focused on building capacity on cattle and pig AI at the levels of AI service provision, semen provision, and smallholder use of AI as a breeding strategy. To that end, a series of training sessions were held, supported by training material developed for the local context and inclusive of material in the local language of the Hmong ethnic minority. Training, related to cattle and pig breeds and breeding was delivered to 125 farmers (51% women, 44% Hmong ethnicity). Similarly, training on AI in pigs and cattle, boar semen collection, and preparation for AI were attended by 73 persons (52% women, 15% Hmong ethnicity), including veterinary workers, and boar and bull keepers. From the training on cattle AI, 19 persons (7 women) were accredited as AI service providers. Additionally, 3 Ban (local breed) boars breeders were trained for semen collection.

#### Herd health management

The farmers were trained on biosecurity, the use of vaccines and antibiotics, and farm management. The animal health professionals were oriented on common animal diseases, biosecurity, vaccines and antibiotics, outbreak investigation and management, and risk communication. Around 110 farmers attended the training with 50% being females from the project sites.

Fifteen demo farms were established in the six target villages, with frequent monitoring through farmers diaries. Some farmers are willing to invest in farm renovation (e.g. construction of new pen and water system). A KAP survey showed that animal health control measures (e.g. biosecurity and farm management) were more practised after than before the training sessions

## Feed and feed-baskets

The Gendered Feed Assessment Tool (G-FEAST) was conducted in six intervention villages to identify feed opportunities and constraints among different household types concerning feeding practices and uptake of feed interventions. One hundred and thirty-seven (137) people participated in 24 focus group discussions and 110 individual interviews were conducted with key informants. Based on the G-FEAST assessment, feed basket options were tailored for different types of farming systems. The options covered integration of legumes in trees' plantations, rotation of staple crop fields, and introduction of improved grasses. Appropriate solutions for winter storage of fodder were also provided to the farmers and their impact tested based on key indicators of sustainable intensification domains.

Improved livestock management and productivity in Mai Son La can be achieved through better feed management and increased cultivation of improved forages, to meet animal nutrition demand. A study was conducted by Atieno et al. (2021) aimed at assessing feed intervention strategies to address context-specific feed-related challenges, mainly winter-feed shortage for improved animal nutrition and livestock productivity. These interventions included promoting the uptake of improved forage varieties (grasses and legumes) and capacity building on animal nutrition techniques including feed processing and preservation, feed mix and feeding regimes for cattle and pigs.

One hundred and forty-five (145) farmers (70 men and 75 women) from across six intervention villages participated in animal nutrition training sessions, which included both theoretical overviews through poster presentations and practical demonstrations. Poster presentations were also done to introduce selected forage varieties as well as their environmental benefits. After the training, willing farmers selected forage varieties from those proposed and were provided with seeds and planting materials to grow on their farms. The proposed varieties included four types of grass (Mulato II, Mombasa guinea, green elephant grass and Ubon paspalum), and three legumes (Ubon stylo, Arachis pinto and rice bean). These varieties were selected as they are high yielding, high quality and cold-tolerant, characteristics best suited to address feed challenges in the study area. Farmer-led field trials were set up with a total of 155 farmers across the six villages. Field demonstrations on different ways of growing forages were conducted in each village, after which the farmers applied the same techniques in their farms. A total of 25 ha were planted with improved forages, a significant increase in the area grown with forages from 0.01-0.02 ha per household to about 0.05 ha per household. Data collected during trial monitoring and follow-ups reported increased farmers' awareness of feed technologies, increased biomass yield, and availability of high-quality feed for their livestock.

## Environment

By the end of 2021, training on erosion control, soil fertility and biomass recycling, as well as animal manure and crop residue composting was given to 145 farmers in the six villages of project intervention. The CLEANED assessment revealed that high nitrogen mining and erosion are key issues in the Mai Son district (Douxchamps et al. 2021). A nitrogen flow study on six case study farms showed that nitrogen balances were positive in high and middle access farms, with 35 to 177 kg N/ha. In contrast, the balances were negative in the most remote farms, with -18 kg N/ha in average. The application of mineral fertilizer was a key game changer, accounting for an average of 83% of the N inputs across the six farms. The burning of crop residues contributed strongly to nutrient losses, especially on remote farms. The nitrogen recycling intensity was 13% on average, except for one farm which produced a lot of its livestock feed and reached a nitrogen recycling intensity (NRI) of 64%. Proper manure management, and production and use of improved forages are recommended across the systems. The addition of cover crops and contour farming is highly recommended in highland areas to improve soil water retention and minimize erosion. The use of organic inputs should be encouraged and burning should be avoided, especially on sloping lands. Legume species should be better integrated into the system, for example as multipurpose forages (Douxchamps et al. 2021).

## Inclusive market arrangement and value-added livestock products

A market study was conducted to understand current market structures and interactions amongst the value chains of the targeted livestock species (large ruminants, local pigs), and to identify opportunities for standardized and specialized livestock

products. In that regard, 10 FGDs with producers and 20 key KIs with downstream value chain actors were conducted. The study findings identified the need to link farmer groups directly to the preferred collectors/traders or butchers with more stable demand and better-offered prices. Based on the study findings, the project developed a mechanism to enhance direct linkages of the farmers' groups with the collectors or butchers to ensure consistent demand and competitive prices of their produce and products.

The formation of common interest groups (CIGs) was facilitated by an experienced consultant. A series of introductory meetings were organized at different levels (district, commune, village) to convey the concept and benefits of CIGs and to identify the demand from local authorities and value chain actors towards this initiative. This was followed by two intensive training sessions on detailed steps of establishing and operating CIGs for the most enthusiastic farmers (three to five farmers selected in each village) and representatives of local associations (i.e. farmer unions, women unions). Thirty (30) participants joined these two sessions of training, of which 16 were males and 14 were females. After the training, they went back to their villages and invited others to be part of their community of interest. Five CIGs have been established in the study sites with the involvement of 60 farm households.

Moreover, awareness of food safety, quality, and environmental footprints of livestock products was raised amongst the consumers and producers through the market research component.

## African swine fever vaccination

The International Livestock Research Institute (ILRI) conducted a modelling exercise to assess the economic impact of ASF under different scenarios. The simulation model revealed that;

- ASF outbreaks pose adverse impacts on national pork supply and demand, especially in the traditional sector. The national pig supply falls by nearly 27.8% in the traditional sector with 5% negative demand shock and by 33.2% with 20% negative demand shock in the simulated scenarios compared to the non-outbreak scenarios.
- The modern sector is less likely to be affected and may even benefit from the ASF outbreak. Compared to the non-outbreak scenarios, the national pig sector's income from the modern sector increases by 16.9% with 5% negative demand shock and by 14% with 20% negative demand shock in the simulated scenarios. The results are driven by the modern sector's strict biosecurity practices and high technology growth.
- ASF outbreaks tend to accelerate the restructuring process of the pig industry towards the faster expansion of the commercial and modern pig sectors and the shrinking of the traditional sector.

## 3.3.4. Outcomes

- Provision of subsidy and training to the farmers on AI have induced community-based AI practice in the project sites. Similarly, the safe handling of semen collection through training of AI service providers has minimized the losses of semen and the probability of failure in breeding buffaloes, cattle and pigs.
- The beneficiary farmers of herd-health management intervention are better managing the health farm-related issues of their livestock. The long-term impacts of the intervention in terms of morbidity, mortality, and production are yet to be documented.
- The identified and advised feed and forage options are being availed by the farmers in project sites. Appropriate storage solutions for feed and forages in the off-season (winter) are ensuring year-round availability of feed for livestock in the project sites.
- A market mechanism has been established that ensures stable demand and competitive prices to the farmers' groups for their produce and products.
- The findings that the ASF outbreaks are more likely to affect the traditional sector and accelerate restructuring of pig industry towards commercialization and modern sectors has triggered policy debate to create employment opportunities for smallholders to ensure sustainable livelihoods for them.



- The photovoice tool was used to, among other things, stimulate discussions amongst farmers regarding the technologies disseminated in the project, spread word about the tool amongst the community members as well as attract the interest of local authorities to support further project interventions and scaling.

### 3.3.5. Lessons learned

- Scientific impact assessment of ASF outbreaks through simulation models helped informed decision-making for the formulation of national-level policies and strategies.
- The awareness, knowledge, and inclination of the farmers towards value-added livestock products has remained instrumental in the development and growth of the off-farm industry and enterprises at the project site. This could accelerate economic activity in the target areas and create more livelihood opportunities for the smallholders and the community in the project areas.
- Combining theory with field practice attracts ethnic farmers to attend the technical training courses.
- The successful cases of pilots after training promoted local farmers and vet workers in the adoption of innovations.
- From the demonstration farms, indicators such as productivity, mortality/morbidity rate, vaccination rates and use of antibiotics were used to review behaviour change.
- There was a high preference for three grass varieties (Napier, Mombasa Guinea and Ubon paspalum) due to their high germination rate, biomass, and palatability and there was moderate preference for forage legumes (Ubon stylo, rice bean, Arachis pinto) and Mulato II. Farmers have expressed willingness to expand the land area used to grow improved forages.
- COVID-19-related restrictions limited follow-up to guide farmers on forage management and utilization. However, forage fact sheets were developed and adapted to address issues raised by farmers such as appropriate cutting time, feed mix and use.
- Maintaining gender balance during flagship activities saw more female farmers actively participating in practical training sessions.
- Proper manure management, and production and use of improved forages is recommended across the systems.
- Production of improved forages can minimize water lost through evapotranspiration.
- The addition of cover crops and contour farming is highly recommended in highland areas to improve soil water retention and minimize erosion.
- Recycling of organic matter should be encouraged to improve soil fertility.
- Residues burning should be avoided.
- The use of appropriate approaches for involving active actors as change agents in the early stage of common interest groups (CIGs) should be emphasized.
- Integration with other flagships is vital for laying a good foundation for the establishment of CIGs.
- The need for capacity building for CIG members on developing CIGs.
- Development of linkages among newly established CIGs for knowledge sharing and potential shared activities.
- The involvement of local authorities is crucial for the sustainability of CIGs.

## 4. Synthesis on lessons learned

### 4.1 Successes

#### 4.1.1 Characterization, selection and scaling assessment of technologies

In Uganda, the ‘scoping study’ and ‘situation analysis of pig value chain’ helped determine the existing mechanism for marketing of live pigs and pork; delivery of veterinary services, drugs and feeds to smallholder farmers; barriers and challenges to the drug stockists, feed processors and veterinary services providers; and operational environment for pig value chain actors. This evidence-based approach in setting up market arrangements guided targeted activities and actions that led to the development of profitable linkages between pig aggregators and pig producers. Similarly, a market study was used to guide decisions to enhance direct linkages of the farmers’ groups with the collectors or butchers to ensure consistent demand and competitive price of their produce and products in Vietnam.

Moreover, consultative approaches in the assessment of scaling readiness of best-bet technologies, through stakeholders’ workshops, helped to thoroughly review the pros and cons of the technologies’ scale-up, potential barriers in implementation, and opportunities for the actors involved to maximize the benefits from the technology in both Uganda and Tanzania. The scaling readiness approach guided the relevant stakeholders in working toward the sustainability of the assessed technological interventions.

In Tanzania, delivery and enabling packages were designed for dairy groups and development change agents, respectively. Both technology packages covered integrated technical products, delivery mechanisms, services, and know-how/knowledge about the technology uptake through capacity-building interventions. Going for such a comprehensive package required identification of multi-level stakeholders, development of a coordination and consultation mechanism, and provision of a common platform to access, interact, and be informed of the progress and latest developments in the dairy value chain. The multi-stakeholders were engaged in the process of identification and scaling up of technologies through stakeholders’ workshops that provided platforms for actors, facilitators, and enablers to interact and exchange their views, thoughts, and limitations to reach mutually acceptable, doable, and sustainable solutions. The technologies identified and scaled up through such a large-scale consultation earned more acceptability and adoptability amongst the stakeholders engaged in the livestock value chain.

In Vietnam, a different approach was adopted for characterization, selection, and scaling of technologies and the intervention bundles were aligned with three different farming systems through G-FEAST assessment, forage seed system analysis, value chain mapping, and land use and forage suitability mapping. Similarly, market-driven interventions were identified for lowlands for having better market access and innovative capacity to produce and develop branded, healthy, and sustainable ‘green’ livestock-source products.

## 4.1.2 Digital solution for training, e-extension and advisory services

In Uganda, a digital ecosystem, established in the form of a PigSmart platform, is providing multiple digital solutions to the growers, aggregators, and other value chain actors. One of these digital solutions is a ‘feed calculator app’ that is being used by the smallholder farmers and small-scale feed producers for the formulation of nutritious and balanced feed for livestock from the locally available cheap feed ingredients. Another app named ‘gross margin calculator’ is being used by the farmers to calculate the gross margin of their farming business through feeding input cost data and output prices. This app has succeeded to promote the concept of farming as a business entity amongst the smallholder farmers. Moreover, all the value chain actors have now access to information regarding production, produce, marketing, and financing through an e-commerce platform in the shape of an EzyAgric app that is embedded in the digital ecosystem, the PigSmart. PigSmart has proved to be beneficial to farmers in balancing feed for pigs and running profitable businesses. It also has been instrumental in accessing information and knowledge of the producers and other dairy value chain actors. Largely, introducing the digital solution to technical advisory services has strengthened the overall pig value chain system in the target areas. The aggregate demands of the farmers for inputs supplies and services have started to be delivered to the individual farmers and groups at the competitive market rate by the quality-assured resources.

The data-driven digital platform for e-extension services and training of the dairy value chain actors has remained instrumental in accessing information and knowledge for the producers and other dairy value chain actors in Tanzania. Easy and quick access to digital course contents on calving and milk hygiene, which are uploaded on to the learning portal and web apps, has attracted those already engaged in dairying and crop farming. As opposed to the use of simple illustrations, the use of photos in the digital courses on calving management and milk hygiene has enhance the engagement of the value chain actors and producers throughout the courses. Moreover, digital marketing has proved to be a cheap and effective way to recruit new users and online training participants.

## 4.1.3 Feed and forage options for livestock

Training and certification of small-scale feed producers in Uganda have succeeded to standardize the quality of commercial feed production and have induced more farmers to start using certified commercial feeds from small-scale producers. Moreover, the Feed Calculator app through the PigSmart digital platform in Uganda has promoted the concept of profitable businesses and the entrepreneurial mindset of small-scale pig farmers. In Tanzania, systematic reviews and experimentation helped to determine the existing state of feed and forages in the project sites and explore the potential economical feed and forage options. Eventually, the focus on the improved and locally-grown forages and feed options has greatly reduced the cost of feeding dairy animals. It also has created business avenues for women and youth to develop seed businesses in their locally grown improved forages.

In Vietnam, the G-FEAST assessment guided the formulation of a feed-basket for cattle and pigs in different types of farming systems. The options covered, integration of legumes in trees’ plantation, rotation of staple crops fields, and introduction of improved grasses. The feed-basket options were tailored after the G-FEAST assessment.

## 4.1.4 Public-private partnerships for services and implementation

The substantial involvement of public and private sector partners has been instrumental in the implementation of various components of the integrated package in Uganda. The partnerships have been established with digital solution service providers, capacity building service providers, academia, and government functionaries for the implementation and sustainability of interventions introduced by the projects. The engagement of the private sector in the development and troubleshooting, and operationalization of the digital platform has provided a good opportunity to find a mechanism that ensures sustainability of the current level of stakeholders’ coordination and the financial viability of the digital innovation introduced by the project in both Uganda and Tanzania.

### 4.1.5 Policy shifts in program countries

Rural commercialization has become part of the core national agricultural development strategy of Tanzania. The partners' engagement to influence policy and invest in scaling innovations, and the role of empowered agri-entrepreneurs to act as a glue for integration of demand-driven technology packages have earned acceptance at both government and private levels. At the same time, in Vietnam scientific-based impact assessment of ASF outbreak through simulation models helped in informed decision-making for the formulation of national-level policies and strategies.

#### 4.1.6 Community-based artificial insemination

Provision of subsidies and training to the farmers on AI in Vietnam have induced community-based AI practice in the project sites. Similarly, the safe handling of semen collection through training of AI service providers has minimized the losses of semen and the probability of failure in breeding buffaloes, cattle and pigs.

## 5 Final considerations and the way forward

- Despite the COVID-19 pandemic, significant progress was seen in Uganda and Tanzania. In both countries, the technology bundles have been selected and rolled out. The learnings from both countries could be helpful for the project teams of Vietnam and Ethiopia to expedite the implementation of technology bundles. The strategies and procedures adopted in Uganda and Tanzania could provide a road map to follow with slight tailoring following the context and emerging situations of the remaining two countries struggling to implement the technology packages.
- Experimental designs to see the impact of various interventions were proposed and planned in all four countries. The progress in this regard is not documented and reported by any country. There is a need to establish a baseline of outcome and results' level indicators to see the overtime improvement and ultimate impact after the program. There is a good opportunity for inter-countries comparison to see the enabling, contributing, and constraining factors in technology uptake, and achievement of intended outcomes and ultimate results.
- There is no alternative to data-driven decision-making. The establishment of digital platforms in Uganda and Tanzania for advisory and e-extension services are steps towards the use of innovative techniques for informed decision-making. The way livestock value chain actors have shown interest and adopted the digital platform in Uganda and Tanzania is a landmark achievement, albeit, with room to increase the scope of digital services and sync them with the national databases for data-driven policy formulation and progress tracking. The rest of the countries need to follow the strategies devised and followed by Uganda and Tanzania for the establishment and uptake of digital solutions for advisory and e-extension services.
- Community-based artificial insemination, though at a nascent stage in Vietnam, Uganda and Tanzania, is another potential intervention that can gain widescale adoptability by the smallholder farmers. The engagement of the private sector in AI service provision looks to be a sustainable arrangement for scaling up the intervention to enable as many farmers as possible to get the benefit.
- Though the overall focus is on the improvement of smallholders through enhanced productivity of livestock, the targeted type of livestock varies across the laboratory countries (the interventions are targeting piggery in Uganda, dairy animals in Tanzania, pigs and cattle in Vietnam, and small ruminants in Ethiopia). With varying genetic requirements for different livestock types, the cross-country comparison of progress in the achievement of specific output and outcome level indicators seems difficult. However, the variation in the best practices and adopted strategies for uptake of technologies across the laboratory countries would be the most relevant yardsticks to gauge the success of the projects across countries.

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