Feed interventions under the Rwanda Dairy Development Project–farmer perceptions regarding sustainability and impact

ILRI RESEARCH REPORT
99

Feed interventions under the Rwanda Dairy Development Project –farmer perceptions regarding sustainability and impact

Ronnie Ahumuza[1], Gilbert Mutoni[2], Emily Ouma[1], Ben Lukuyu[1], Joseph Nshokeyinka[3] and Alan Duncan[4]

1. International Livestock Research Institute, Uganda
2. International Livestock Research Institute, Rwanda
3. Rwanda Dairy Development Project
4. International Livestock Research Institute, Ethiopia

January 2022

ILRI thanks all donors and organizations which globally supports its work through their contributions to the CGIAR Trust Fund

Editing, design and layout—ILRI Editorial and Publishing Services, Addis Ababa, Ethiopia.

Cover photo—ILRI/EADD

ISBN: 92–9146–706–3

Citation: Ahumuza, R., Mutoni, G., Ouma, E., Lukuyu, B., Nshokeyinka, J. and Duncan, A. 2022. *Feed interventions under the Rwanda Dairy Development Project–farmer perceptions regarding sustainability and impact.* ILRI Research Report 99. Nairobi, Kenya: ILRI.

Patron: Professor Peter C. Doherty A. C, FAA, FRS
Animal scientist, Nobel Prize Laureate for Physiology or Medicine–1996

Box 30709, Nairobi 00100 Kenya
Phone +254 20 422 3000
Fax+254 20 422 3001
Email ilri-kenya@cgiar.org

ilri.org
better lives through livestock

ILRI is a CGIAR research centre

Box 5689, Addis Ababa, Ethiopia
Phone +251 11 617 2000
Fax +251 11 667 6923
Email ilri-ethiopia@cgiar.org

ILRI has offices in East Africa • South Asia • Southeast and East Asia • Southern Africa • West Africa

Contents

Tables

Acknowledgements

The authors are grateful to the Rwanda Dairy Development Project for financial support. The work was partly funded by the CGIAR Research Program on Livestock.

Executive summary

Improved feeding of dairy cattle has strong potential to lead to improved livelihoods, improved food security, proper nutrition and empowerment of women and youth in resource poor households within the livestock sector in Rwanda. It is against this background that the Rwanda Dairy Development Project (RDDP) has promoted various feed interventions in the form of animal husbandry and nutrition. The interventions were disseminated amongst the dairy cattle farming communities using the Livestock Farmer Field Schools (L-FFS) approach. Using data from 29 sex-disaggregated focus group discussions (FGDs) across the six intervention sites, farmer perceptions regarding sustainability and impact of feed interventions are presented.

Results indicate that forage introductions saved labour, especially for women, which could be diverted to other economic and social activities. The interventions also improved social cohesion at study sites. However, land shortage is a key constraint to feed development in Rwanda and some fresh thinking about feed interventions may be needed (e.g., forage marketing to land scarce farmers).

1 Introduction

1.1 Background

The livestock sector is evolving rapidly in low- and middle-income countries (Baltenweck et al. 2020). The sector has demonstrated potential to be a dependable source of income and improvement in livelihoods of livestock owners and other value chain actors (Herrero et al. 2012).

Demand for livestock products (e.g., meat and milk) is also rising rapidly due to population growth, urbanization and rise in income, particularly in the developing world. At the same time, producing animal-source foods in an environmentally friendly way has become a vital concern (FAO 2021). Strategies for improving livestock productivity are key to minimizing environmental effects by reducing emissions per unit of livestock product.

Low feed availability and poor access to good-quality feeds are key constraints to increasing livestock productivity in many developing countries, particularly those that recently introduced large numbers of cattle with improved genetics, such as the Rwanda case (Iraguha et al. 2015; Mwabonimana et al. 2015). In many parts of Rwanda, animals freely graze on individual or communal grazing lands. This type of system is dominant in lowland Eastern Province, where 40% of the national cattle population is found and the relative availability of grazing land is greater than in other areas. Grazing is also practiced in the western part of the country (Mutimura 2016). Diminishing grazing land, however, is forcing people to gradually shift from open grazing to semi-grazing and zero-grazing, which is most common in the highland areas (Bazarusanga 2008). The semi-grazing system is a hybrid between open-grazing and zero-grazing. It is characterized by a shortage of land that results in a farmer needing to keep few cows in stalls. Such farmers, however, do not always have sufficient money and/or knowledge to feed their cows properly and so they may allow their herd to graze on nearby land part of the time (TechnoServe 2008). This is a transitory state from open-grazing system to zero-grazing. The zero-grazing system is characterized by keeping animals in a shed and feeding by cutting and carrying forage and crop residues to the cows. This production system is increasingly practiced due to the shrinkage of grazing land, which has been widely turned over to crop cultivation in response to increasing population. The Government of Rwanda (GoR) encourages zero-grazing because it avoids over-grazing and consequently reduces land degradation. The main feed available for dairy cattle under this system is Napier grass (Mutimura et al. 2013; Mutimura 2010; Mutimura and Everson 2011). Provision of concentrate feed and conservation of fodder for supplementary feeding in dry seasons remain exceptional in both systems. Insufficient quantities of feed especially during dry spells, and low-quality diets can only support low levels of milk production, and lead to low productivity and high seasonality of production (TechnoServe 2008; Lukuyu et al. 2009, 2018; Maina et al. 2020; McKune et al. 2015).

In Rwanda, shortage of feeds/forages is related to limited land availability for crop and forage production (Bazarusanga 2008). Rwandan agriculture is characterized by small production units with an average land holding size of 0.76 hectares, reflecting the high population pressure on the country's natural resource base (Mutimura 2010). This creates competition in the use of land for livestock feed and crops for human food. This calls for production intensification as the only environmentally sustainable pathway for continued growth of the agricultural sector (Struik and Kuyper 2017). The

small land holdings particularly for smallholders, become a limiting factor for production of forage/fodder for dairy cows, leading to high production costs as farmers must purchase more off-farm feed/forages (Kamanzi and Mapiye 2012).

1.2 The Rwanda Dairy Development Project (RDDP)

The Rwanda Dairy Development Project (RDDP) is an ongoing initiative that was launched in 2016 to contribute to pro-poor economic growth and enhance the livelihoods of poor rural households through dairy farming. The project seeks to promote climate-smart dairy farming practices and empower women and youth by integrating them into the dairy value chain (Habiyaremye et al. 2021). The project is funded by a concessional loan and grant from the International Fund for Agricultural Development (IFAD), private sector/banks, Heifer International, and the Rwandan government through tax exemptions. The Rwanda Agriculture and Animal Resources Board (RAB) is the lead implementing agency in partnership with Heifer International, the Rwanda Cooperative Agency, the Rwanda National Dairy Platform, the Business Development Foundation, and the Rwanda Council of Veterinary Doctors. The RDDP has built on the past achievements in the dairy sector and is has focused on increasing cattle productivity, milk quality, and processing capacity of the dairy industry and strengthening the policy and institutional framework for the sector. To achieve the goal of doubling milk production in 10 years (2010 to 2020), RDDP has initiated different feed resource development interventions being implemented through Livestock Farmer Field schools (L-FFS) and forage seed multipliers.

The International Livestock Research Institute (ILRI) has been providing technical support to the RDDP since early 2019, mainly on feed-related interventions, including follow up support on feed intervention strategies being implemented through the Livestock Farmer Field Schools (L-FFS) approach as well as monitoring of feed interventions. This report presents the results of a study that was conducted in the RDDP sites through focus group discussions and key informant interviews (KIIs) with participants involved in the L-FFS. The objective was to document the processes and elements considered in selecting the feed interventions currently implemented in each site. It also aimed to assess the perceptions of the participants regarding sustainability of the interventions as well as their costs and benefits.

1.3 G-FEAST and identification of interventions being promoted through the L-FFS approach

In the framework of the implementation of the ILRI engagement, following the findings of applying the Gendered Feed Assessment Tool (G-FEAST) in the six ILRI engagement sites, a series of feed interventions were identified in a workshop held in May 2019. Further refinement and prioritization were undertaken during a virtual workshop held in December 2020. During those workshops, participants were from RDDP, RAB, University of Rwanda and the Rwanda Council of Veterinary Doctors. The meetings were facilitated by ILRI staff.

1.4 L-FFS approach used in the implementation of the feed interventions by RDDP

The L-FFS approach is a modification of the formal farmer field school approach. It is an integrated knowledge transfer approach where a lead farmer called the L-FFS facilitator helps fellow farmers to understand good practices in cattle rearing. As outlined by one respondent 'L-FFS is not only about technology transfer but also people development. It brings farmers together to assess their problems and seek ways of addressing them.'

The approach aims to empower dairy farmers with knowledge and skills to make them experts in their own fields; sharpening their ability to make critical and informed decisions so that they can make their farming profitable and sustainable. It also sensitizes dairy farmers to new ways of thinking and problem solving; helping them to learn how to organize themselves and their communities; enhancing the relationships between them, extension staff and researchers, so they work together to test, assess, and adapt a variety of options within the specific local context.

In L-FFS, all activities were organized around the field (for fodder growing) and the cowshed. The animal(s) and the field were the focus for learning. Farmers learned directly from what they observed, collected, and experienced in their fields instead of relying on textbooks, pictures, or other extension materials. Farmers also produced their own learning materials (drawings, etc.) based on what they observed. The advantages of these home-made materials are that they are consistent with local conditions, inexpensive to develop, and owned by the farmers.

2 Methodology

2.1 Survey sites

The study area comprised six RDDP districts in four provinces of Rwanda: East (Nyagatare), North (Gicumbi and Musanze), West (Rubavu and Rutsiro) and South (Nyanza). The six districts chosen for the feed interventions under the ILRI engagement were a subset of the overall RDDP project area. Selection of the targeted districts was based on: (i) current level of cattle population and milk production; (ii) current and projected market for Republic of Rwanda development potential, including investments in milk collection centres, dairy processing plants, animal feed factories, and evolving domestic and export market linkages; and (iii) level of poverty, food insecurity and malnutrition. The entire project area has an estimated population of 4.6 million people and hosts 45% of the national cattle herd (601,479) of which 33% are cross-breeds, 22% purebreds and the remaining 45% are local breeds, mainly Ankole. Total milk production in the covered area in 2015 stood at 326,000 MT, accounting for 45% of national production. The area has 65 of the 100 milk collection centres (MCCs) in the country. Poverty levels in the project area are higher than the national average estimated at 43% in 2014 with targeted districts in the North and West having the highest poverty incidence levels of 52% and 47%, respectively.

2.2 Survey approach and sampling

Twenty-nine sex-disaggregated focus group discussions (FGDs) each comprising 5-10 dairy farmers involved in the L-FFS were conducted between February and April 2021. Sixteen (55%) FGDs comprised female participants while 13 (45%) comprised male participants. In addition, 10 key informant interviews (KIIs) were conducted with RDDP field officers, Heifer International technicians and RDDP master trainers. The FGDs were sex disaggregated to capture the different views of men and women. The FGDs and KIIs were facilitated by an ILRI research technician. The group discussions were recorded using voice recorders and notes created from the recordings. The sampling by the RDDP team was purposive as it targeted members of the L-FFS. A summary of FGDs (29) conducted across the six project sites is shown in Appendix 1.

2.3 Data collection and analytical methods

The FGDs were guided by a semi-structured interview checklist developed by the researchers (Appendix 2). The tool comprised two sections. Section 1 had general questions about the elements considered in selection of the interventions and Section 2 had questions on the sustainability dimensions of the feed interventions and community perceptions. The tool was designed to capture qualitative data for both the focus group discussions and key informant interviews. The data collected was synthesized using Microsoft Excel.

3 Results

3.1 Interventions and rationale for interventions

Several feed-related interventions were implemented across the different project sites. Some of the interventions were husbandry interventions that were supported by nutrition interventions. They included the following:

3.1.1 Zero-grazing as a dairy production system and distribution of improved breeds

In a bid to improve household nutrition and income status through increased milk production, farmers in Rutsiro, Gicumbi, and Musanze districts were introduced to intensive systems of livestock production. The farmers were trained on zero-grazing as a dairy production system and improved cattle breeds were introduced. The improved breeds were provided in the form of a matching grant where farmers contributed 50% of the funds necessary to purchase the breeds and RDDP contributed the remaining 50%. This intervention also enabled the farmers to have sufficient manure to use in crop production for better yields.

3.1.2 Establishment of infrastructure including cowsheds, water tanks for rainwater harvesting and animal feed stores

Infrastructural improvements such as cowsheds, water tanks and animal feed stores were also established on individual farms across all the project sites. The aim was to improve the cattle housing conditions and provide water to the animals. To promote the forage seed business, and ensure farmers kept hay for dry season feeding, they needed access to storage facilities. This was facilitated through a matching grant where farmers constructed stands for the water tanks and RDDP supplied the tanks to the farmers free of charge. RDDP also offered support to the farmers for construction of cowsheds and feed stores in the form of a matching grant.

3.1.3 Forage seed multiplication

Demonstration plots on forage seed production were set up in different livestock farmer field schools. Farmers were trained by master trainers on various agronomic practices for forage production. Master trainers were extension service providers trained by ILRI to support the farmers. After the training and demonstration, forage seeds were distributed to farmers for planting on individual farms as well as the collective farms for forage production. RDDP promoted various forage varieties that were adapted to the agro-ecological conditions in each of the sites. However, there were other forage varieties that were being grown by the farmers in addition to those that were promoted. In Rutsiro, RDDP promoted Kakamega1 Napier grass *(Pennisetum purpureum)*, Rhodes grass *(Chloris gayana)* and greenleaf desmodium

(Desmodium Intortum). In Musanze, RDDP promoted Kakamega1 Napier grass *(Pennisetum purpureum)*, Rhodes grass *(Chloris gayana)*, greenleaf *desmodium (Desmodium intortum)* and silverleaf desmodium *(Desmodium uncinatum).* In Gicumbi, RDDP promoted Kakamega1 Napier grass (*Pennisetum purpureum*) and Rhodes grass (*Chloris gayana*). In Nyagatare, RDDP promoted Kakamega1 Napier grass *(Pennisetum purpureum),* Rhodes grass (*Chloris gayana*), greenleaf desmodium *(Desmodium intortum), Brachiaria (Brachiaria spp), Panicum (Panicum coloratum),* lablab *(Lablab purpureus)* and velvet bean *(Mucuna pruriens).* In Rubavu, RDDP promoted Kakamega1 Napier grass (*Pennisetum purpureum*), Rhodes grass (*Chloris gayana*) and greenleaf desmodium *(Desmodium Intortum).* In Nyanza, RDDP promoted Kakamega1 Napier grass (*Pennisetum purpureum*), Rhodes grass (*Chloris gayana),* greenleaf desmodium *(Desmodium intortum), Brachiaria (Brachiaria spp), silverleaf desmodium (Desmodium uncinatum),* velvet bean *(Mucuna pruriens)* and lablab *(Lablab purpureus).* The forages promoted across the different sites are shown in Table 1.

Table 1: Forage varieties that are promoted across the different project district sites

Forage variety	Rutsiro	Musanze	Gicumbi	Nyagatare	Rubavu	Nyanza
French Cameroon (*Pennisetum purpureum*)	√					
Kakamega1 Napier grass (*Pennisetum purpureum*)	+	+	+	+	+	+
Rhodes grass (*Chloris gayana*)	+	+	+	+	+	+
Guatemala grass (*Tripsacum Laxum*)	√			√		
Setaria (*Setaria sphacelate*)	√					
River tamarind (*Leucaena leucocephala)*	√			√		
Calliandra (*Calliandra calothyrsus*)	√	√		√		
Greenleaf desmodium (*Desmodium intortum*)	+	+	√	+	+	+
Alfalfa (*Medicago sativa*)	√	√	√		√	
Velvet bean (*Mucuna pruriens*)			√	+		+
Brachiaria (*Brachiaria spp*)			√	+		+
Silverleaf desmodium (*Desmodium uncinatum)*		+	√			+
Sudan grass (*Sorghum × drummondii*)			√			
Panicum (Panicum coloratum)			√	+		
Panicum (*Panicum maximum*)			√			
Lablab (*Lablab purpureus*)				+		+
Desmodium (*Desmodium distortum)*				+		+

+ forages promoted by RDDP, √ additional forages grown by the farmers

The beneficiaries of this intervention were all the dairy farmers that were part of the L-FFS in the respective sites. In the key informant interviews, farmers indicated that the intervention was selected to (1) test forage species that are adapted to the area, (2) make different forage species available and accessible to farmers and, (3) meet the nutritional requirements of the animals. Since much of Rwanda is hilly, establishment of forage on contour lines and bunds and as hedges helps to control soil erosion.

3.1.4 Promotion of efficient use of crop residues (from maize and beans) for dairy feeding

The efficient use of crop residues for dairy feeding as a way of integrating both crop and livestock production systems was also promoted in the L-FFS. Farmers were trained on optimal mixtures of the locally available crop residues as a way of supplementing the forages given to the dairy animals.

3.1.5 Forage conservation through production of hay and acquisition of mechanical choppers

To cope with limited feed availability during dry periods, forage conservation through hay making was promoted. Farmers belonging to the different L-FFS were taught how to make dry hay. Additionally, every L-FFS was given at least one fodder chopper by RDDP to facilitate the process of forage conservation.

3.2 Mode of implementation for the interventions

The implementation of the interventions started in 2018 across all the project sites. Some of the initial L-FFS have evolved and led to the formation of other farmer L-FFS through which information and technologies are passed on. The interventions were implemented on both individual and collective farms.

The RDDP project provided inputs such as forage seeds and technical support through training of facilitators for the L-FFS. Farmers offered in-kind contributions in the form of labour to the group plots and L-FFS activities. Additionally, for purposes of sustainability, every farmer contributed RWF500-1,000 every month towards the facilitation of some of the interventions including renting of land for L-FFS activities and purchase of inputs such as fertilizers.

The local authorities provided land for some of the activities of the L-FFS. RDDP provided the farmers with the technical support. To build local capacity, the master trainers were trained by RDDP and they later facilitated the livestock farmer field schools. Forage seed to kick-start the production process was also entirely provided by RDDP. For the cowsheds, water tanks and improved dairy breeds, 60% of the costs were met by RDDP and the remaining 40% of the costs were met by the farmer. The project also provided fodder choppers to the L-FFS and the responsibility for running and maintenance rested solely with the farmers. Other partners including Heifer International were also very prominent in the provision of technical support to the L-FFS in the form of training. In each district, Heifer International had a master trainer to carry out extension services on behalf of RDDP.

The forage/feed interventions were implemented on both individual and group plots. As a result of the project activities, households within the communities adopted some of the forage interventions that were promoted by the different L-FFS. The households within the communities normally received planting materials in the form of splits (vegetative cuttings) as gifts from fellow farmers within the L-FFS. The total land area under forage production and number of households that took part in forage production is shown in Table 2.

Table 2: Total land area under forage production and number of beneficiary households

District	Sector	Cell	Total area under forage production collectively (hectares)	Total area under forage production individually (hectares)	Number of households from the L-FFS (# of households)	Number of households from the community (# of households)
Rutsiro	Boneza	Bushaka, Bihogo, Remera and Nkira	54	9	291	131
Rutsiro	Boneza	Kabujenje and Bunyunju	2	2	60	100
Musanze	Kinigi	Nyonirima	7	12	24	300
Musanze	Nyange	Ninda	4	5	30	70
Musanze	Nyange	Kamwumba	8	30	31	1,000

District	Sector	Cell	Total area under forage production collectively (hectares)	Total area under forage production individually (hectares)	Number of households from the L-FFS (# of households)	Number of households from the community (# of households)
Musanze	Cyuve	Bigeshi	11.7	15	205	70
Gicumbi	Byumba	Kibare	2	2	25	10
Gicumbi	Byumba	Nyamabuye	4	5	100	0
Gicumbi	Shangasha	Bushara	12	1.2	30	10
Gicumbi	Shangasha	Shangasha	3.2	2.4	30	4
Nyagatare	Rwimiyaga	Rwimiyaga	6	9.7	38	50
Nyagatare	Rwimiyaga	Rutungu	29	30	30	8
Nyagatare	Karangazi	Kizirakome	8	12	30	32
Rubavu	Bugeshi	Mutovu	16	3.2	30	200
Nyanza	Busoro	Munyinya	13.75	0.4	18	40
Total			180.65	138.9	972	2,025

3.3 Economic and technical feasibility of these interventions

Conversations with farmers during FGDs indicated that there is adequate demand for the milk that is being produced by the farmers in the project sites. The demand is both local and from the Democratic Republic of Congo (DRC). This was indicated by 24 FGDs accounting for 83% of the total respondents. With the help of RDDP and Heifer International, a milk collection centre was constructed and equipped for a dairy cooperative in Rutsiro and each of the four L-FFS are members. This enhanced milk collection and handling has improved the quality of milk in the area. Currently, the milk collection centre receives over 1,000 litres of milk daily and the unit price received for a litre is RWF140. The farmers assert that there is immense opportunity being generated by the cross-border trade with the DRC as this has created more demand for the milk that is being produced.

However, in Musanze and Gicumbi districts, 5 FGDs (17%) indicated that the demand for the milk is volatile and inadequate and hence most of them sell to their neighbours and shops within their vicinity. The farmers expressed concern that there are challenges with delayed payments from the milk collection centres and many farmers are not supplying the centres because of this challenge. Furthermore, the milk prices being offered to farmers are low and this has discouraged them from adopting some of the technologies that are geared towards improving the quality of milk being produced since adoption incurs a cost to the farmer. The roads leading to the collection centres are also in a poor state making it expensive for the farmers to transport their milk. Some of the farmers must pay an extra RWF15 in transport costs to the market areas.

Interventions in the project sites have led to several benefits for farmers belonging to the L-FFS and to the wider community. First, milk production has increased leading to an increase in income generated from the sale of milk and milk products. Eighty per cent (80%) of the male FGDs stated an increase in milk production and 88% of the female FGDs indicated the same. Second, the manure generated from the animals is applied to the crop fields leading to an increase in yield. Third, the increase in crop yield and milk production has greatly improved the nutritional status of many of the households. The intervention on forage production has generated dual gains for the farmers: the nutritional value of animal feed has greatly improved, and labour demands have also reduced with less time being spent in search of animal

feed since forage is being grown close to households. For example, the farmers in Nyanza said that 'there is a reduced risk associated with cutting and carrying grass for animals from the Anyakuru marshland'. Due to the fodder conservation practices introduced, farmers have access to animal feed all year round and some are generating extra income through the sale of forage seed, fresh forages, and hay to other farmers. The living conditions for the animals have greatly improved due to the construction of cowsheds and tanks for water harvesting. The watering points for the animals are now close to the sheds and farmers can store water to be used during the dry seasons.

On the other hand, the farmers have incurred costs to adopt the various interventions being promoted. The major costs incurred have been costs associated with renting land since many of the farmers have small pieces of land for both crop and livestock production. Some of the interventions have been labour intensive in terms of establishment and maintenance, and much of the labour has been hired. Purchase of forage seed was also a significant cost for the farmers who wanted to scale up the feed interventions since the seed was not readily available. The costs of construction of cowsheds and water tanks was also significant to the farmers since it required substantial capital to invest in infrastructure. Fuelling and maintaining the feed choppers was also costly for the farmers. Inputs such as organic manure and fertilizers were also a major cost. Irrespective of the associated costs, the farmers asserted that the benefits gained from implementing the different interventions outweighed the associated costs. A more detailed quantitative analysis of costs and benefits of feed interventions is underway, and results are pending.

For the feed interventions, land, forage seed, organic manure, inorganic fertilizers, pesticides, and labour were some of the inputs and resources required for their implementation. The services of agro and livestock input dealers, financial institutions, veterinarians, milk collection centres, extension agents, and transport infrastructure were important in the implementation of the interventions.

There are local resources and skills available to scale up the feed technologies. Water is available, but land is in short supply. In terms of access to extension services, there is a need to increase the number of facilitators in order to scale up the interventions to more farmers. For example, one facilitator said that in the whole cell composed of six villages, she was the only one supporting the farmers on the implementation of the various interventions.

3.4 Gender and social equity aspects associated with the interventions

The feed interventions were accessible to both men (100% of FGDs) and women (100% of FGDs) across all the project sites. The women actively participated in all the project activities including the weekly planning meetings held by the different farmer field schools. For both men and women, the introduction of the feed interventions gave them more time to engage in other activities such as nurturing the family and business activities since time and energy that would be spent searching for animal feed was reallocated to other activities. One farmer asserted that 'the day of the farmer field school collective works, many women come to ask if they can join because they are seeing that getting forage easily from the L-FFS requires less labour than spending time and effort to search, cut and carry sufficient forage to feed the cattle.' For this reason, women were willing to commit substantial time to the activities of the L-FFS.

The feed interventions required considerable labour to implement, especially when carrying out the different agronomic practices from land preparation to harvesting. However, according to respondents, compared to the time spent grazing and searching for feed and water for the animals, it was worthwhile to invest in the work required for establishing forages since this saved labour overall.

3.5 Environmental sustainability of the interventions

The interventions promoted had a positive effect on the environment according to respondents. The cultivation of forages fostered soil and water conservation by reducing the levels of soil erosion. Forage legumes also improved soil fertility through fixing of nitrogen into the soil. This was also supplemented with the application of organic manure during the establishment of the forages.

Rainwater harvesting technologies were also very useful in controlling soil erosion. The forage interventions also had a positive effect on the ecosystem and biodiversity. For example, the availability of animal feeds had reduced the disturbances caused to the ecosystem and biodiversity in Gishwati, Akagera and Volcanoes national parks related to livestock grazing activities.

However, the farmers stressed the need to extend the buffer zone between the communities and the national parks to avoid conflict with wild animals that sometimes graze on the forages and crops. The rainwater harvesting technologies increased the amount of water harvested making water available to livestock even in the dry season. However, farmers indicated that forage production was exclusively rain fed so there was no competition for water resources between humans and livestock.

3.6 Social sustainability of the interventions

The feed interventions increased the trust and connectedness among members of the community. One farmer asserted that, 'The Pass on the Gift system[1] for forage seeds and other vegetative material is increasing connectedness with our neighbours.' The adoption of the zero-grazing production system and the subsequent increase in milk yield amongst adopting farmers motivated the establishment of a dairy cooperative in the sector where representatives of the L-FFS meet regularly to plan for development, and this led to the construction of a milk collection centre, which opened more windows of opportunity for the community.

For those who had rainwater harvesting facilities (such as water tanks or dam sheets), the water was shared with the neighbours especially in the dry seasons and this boosted their social capital.

As a result of the activities of the L-FFS, the savings and credit groups formed by the farmers gave them access to affordable capital to invest in the adoption of farming technologies and take care of other necessities at home such as school fees. In Musanze, Rubavu, Nyanza and Nyagatare, every group member had already received RWF15,000 to buy small stock such as poultry, goats and sheep. In Gicumbi, the farmer group had a program where they visited every member for experience sharing and learning, which increased the social inter-relationships within families.

3.7 Infrastructural management of some of the structures that have been set up

In Rutsiro District, the milk collection centre was managed by the dairy cooperative. The management committee comprised 5 members of which 3 were male and 2 were female. In Gicumbi District, the land and mechanical choppers were managed collectively by a committee that comprised 6 members of which 2 were male and 4 were female. However, no training had been conducted for the infrastructure committee to build their capacity in management skills. The maintenance cost for the infrastructure was met by members of the L-FFS through weekly and monthly contributions.

1. 'The Pass on The Gift system' is where farmers give forage vegetative material (splits) to fellow farmers as gifts for multiplication

The farmers were fully aware that for sustainability, they must maintain the infrastructure. However, in Nyanza, the only collective equipment the L-FFS had was a mechanical chopper which was not functional, and they were unable to repair it. They were waiting for RDDP support to repair or exchange the equipment for a new one.

3.8 Challenges associated with implementation of the interventions

Some of the key challenges in the implementation of the interventions from the different project sites include:

1. Within the L-FFS, there was both lack of funds and some unwillingness on the part of some farmers to contribute towards the implementation of the group activities. This was further escalated by mistrust among the group members on the management of pooled resources.
2. Disbursement of RDDP support for some of the interventions was delayed. Some farmers said that even after registration, they had never received the improved breeds of cattle promised by RDDP.
3. Some of the forage varieties that were promoted in some of the sites were unsuitable for the agro-ecological conditions in those sites. For example, ***Desmodium*** and ***Mucuna*** failed to germinate in Rutsiro and Musanze, respectively. This was exacerbated by pests and diseases that affected the forages.
4. Land allocated to forage cultivation was relatively small due to limited knowledge on forage varieties and forage use. There is still much to be done to enhance knowledge and promote different forage varieties in project sites.
5. The inputs necessary to establish forage production plots and other associated technologies were either in short supply or expensive when available. The farmers stated that forage seed was generally unavailable and even when available it was too expensive for them to afford. Even when mechanical choppers were provided by RDDP, farmers indicated that the cost of running and maintaining them was prohibitive and many of them opted to continue with their traditional methods of chopping fodder.
6. Poor infrastructure such as roads made milk transportation and access to markets difficult and expensive. Some of the farmers did not have access to infrastructure such as milk collection centres and this negatively impacted on the prices received by farmers.
7. Prolonged dry seasons were also a major hindrance to forage establishment since crop cultivation is mainly rain fed.
8. COVID-19 restrictions on large gatherings hindered the L-FFS activities since members could not gather to implement some of the activities that required collective efforts including the weekly meetings.

4 Lessons learned from the implementation of the interventions

During the implementation of the interventions, several key lessons emerged.

1. Farmers had gained knowledge and skills on good management practices for dairy animals (forage production, dairy cow feeding, breeding using artificial insemination, dairy hygiene, and disease prevention and control). They also appreciated the need for linkages across the value chain to make dairy farming a profitable venture.
2. Given the right conditions, dairy farming can be profitable and can be used to improve household income and nutrition.
3. Introduction of forages generally reduced the cost of feeding livestock. Farmers came to appreciate the range of forage species available through the intervention program. Furthermore, using conserved forages such as hay maintained milk production even during the dry period. Chopping forage with the help of mechanical choppers eased workload and increased efficient use of animal feed although running costs were an issue. Additionally, there were indications that forage production could be run as a profitable and sustainable business venture.
4. Land allocated to forage production was limited despite the intervention program. It is possible that farmers need more experience on the benefits of forage production before investing more heavily.
5. Intensification through zero-grazing yielded positive results in relation to increased milk production.
6. The cost of animal feeding could be reduced by supplementing existing animal feed with crop residues.
7. Rainwater harvesting technologies reduced cost, distance, effort, and time taken to collect water for livestock use.
8. The L-FFS provided a good learning environment for farmers, making it easier for them to adopt and disseminate the technologies they had learned about.

5 References

Baltenweck, I., Enahoro, D., Frija, A. and Tarawali, S. 2020. Why is production of animal source foods important for economic development in Africa and Asia? *Animal Frontiers* 10(4):22–29.

Bazarusanga, T. 2008. *The epidemiology of theileriosis in Rwanda and implications for the control.* PhD Dissertation. Ghent University.

Bishop, H. and Pfeiffer, D. 2008. Factors effecting reproductive performance in Rwandan cattle. *Tropical Animal Health and Production* 40(3):181–184.

FAO (Food and Agriculture Organization of the United Nations). 2021. *Climate-smart livestock production. A practical guide for Asia and the Pacific region.* Bangkok. Available from: https://doi.org/10.4060/cb3170en).

FAO. 2009. *Livestock keepers – guardians of biodiversity.* Animal Production and Health Paper. No. 167. Rome.

Habiyaremye, N., Ouma, E., Mtimet, N. and Obare, G.A. (2021) A Review of the Evolution of Dairy Policies and Regulations in Rwanda and Its Implications on Inputs and Services Delivery. Front. Vet. Sci. 8:611298. doi: 10.3389/fvets.2021.611298

Herrero, M., Delia, G., Njuki, J., Johnson, N., Enahoro, D., Silvestri, S. and Rufino, M. 2012. The roles of livestock in developing countries. *Animal* 7:1–16. doi:10.1017/S1751731112001954

Iraguha, B., Hamudikuwanda, H. and Mushonga, B. 2015. Bovine mastitis prevalence and associated risk factors in dairy cows in Nyagatare District, Rwanda. *Journal of the South African Veterinary Association.* 86: 1228. http://www.jsava.co.za/index.php/jsava/article/view/1062

Kamanzi, M. and Mapiye, C. 2012. Feed inventory and smallholder farmers' perceived causes of feed shortage for dairy cattle in Gisagara district, Rwanda. *Tropical Animal Health and Production* 44(7):1459-68. doi: 10.1007/s11250-012-0087-3

Lukuyu, B.A., Kitalyi, A., Franzel, S., Duncan, A. and Baltenweck, I. 2009a. Constraints and options to enhancing production of high-quality feeds in dairy production in Kenya, Uganda and Rwanda. ICRAF Working Paper no. 95. Nairobi, Kenya: World Agroforestry Centre. https://doi.org/10.5716/WP16449.PDF

Maina, K.W., Ritho, C.N., Lukuyu, B.A. and Rao, E. J. O. 2020. Socio-economic determinants and impact of adopting climate smart Brachiaria grass among dairy farmers in eastern and western regions of Kenya. *Heliyon* 6(6), e04335. https://doi.org/10.1016/j.heliyon.2020.e04335

McKune, S.L., Borresen, E.C., Young, A.G., Auria Ryley, T.D., Russo, S.L., Diao Camara, A., Coleman, M. and Ryan, E.P. 2015. Climate change through a gendered lens: Examining livestock holder food security. *Global Food Security* 6: 1–8. https://doi.org/10.1016/j.gfs.2015.05.001

Mutimura, M., Lussa, A.B., Mutabazi, J., Myambi, C.B., Cyamweshi, R.A. and Ebong, C. 2013. Status of animal feed resources in Rwanda. Tropical Grasslands—Forrajes Tropicales, 1, 1, 109–110.

Mutimura, M. 2010. *Evaluation of improved Brachiaria grasses in low rainfall and aluminium toxicity prone areas of Rwanda.* MSc Thesis. University of KwaZulu-Natal.

Mutimura, M. and Everson, T. (2011). Assessment of livestock feed resource-use patterns in low rainfall and aluminium toxicity prone areas of Rwanda. African journal of agricultural research. 6. 3461-3469. 10.5897/AJAR10.315.

Mwabonimana, M.F., Rekeraho, J., Ntirenganya, M. and Bimenyimana, F. 2015. Cost benefit analysis of bovine mastitis in Nyabihu and Musanze districts, Rwanda. *International Journal of Novel Research in Life Sciences* 2(4):21–31.

Struik, P.C. and Kuyper, T.W. 2017. Sustainable intensification in agriculture: the richer shade of green. A review. *Agron. Sustain. Dev.* 37: 39 https://doi.org/10.1007/s13593-017-0445-7

TechnoServe. 2008. *The dairy value chain in Rwanda*. A report by TechnoServe Rwanda for the East Africa Dairy Development Program. (Available from: https://cgspace.cgiar.org/bitstream/handle/10568/2410/Dairy%20Value%20Chain%20Rwanda%20Report.pdf;sequence=1).

6 Appendices

Appendix 1: Number of sex-disaggregated focus group discussions conducted per site

District	Sector	Cell	L-FFS name	FGD type	N (#)
Rutsiro	Boneza	Bushaka, Bihogo, Remera and Nkira	Giramata, Indatwa mu Korora Meza, Indashyikirwa mu Bworozi, and Tuzamurane	Female	20
				Male	20
		Kabujenje and Bunyunju	Abadahigwa mu Bworozi, Giramata Meza Mworozi	Female	10
				Male	10
Musanze	Kingi	Nyonirima, Butorwa	Abanyaruhimbi	Female	5
				Male	5
	Nyange	Ninda, Nyarubande	Abakundinka	Female	5
				Male	5
		Kamwumba,	Ntizigasonze	Female	5
				Male	5
	Cyuve	Bigeshi	Ongera Umukamo Zirakamwa	Female	5
				Male	5
Gicumbi	Byumba	Kibare	Abakundankuyo	Female	5
				Male	5
		Nyamabuye	Twongere Umukamo	Female	5
				Male	5
	Shangasha	Bushara	Ingenzi mu Bworozi	Female	5
				Male	5
		Shangasha	Abadahirwa mu Bworozi	Female	5
				Male	5
Nyagatare	Rwimiyaga	Rwimiyaga	Tuzamure Umukamo	Female	5
				Male	5
		Rutungu	Tworore Kijyambere	Female	5
				Male	5
	Karangazi	Kizirakome	Gerakuntego Mworozi	Female	5
Rubavu	Bugeshi	Mutovu	Indashyikirwa	Female	5
				Male	5
Nyanza	Busoro	Munyinya	Zirakamwa	Female	5
				Male	5

Appendix 2: Data collection tool

Feed intervention selection

Introduction

This tool is used to document the process used and elements considered in selecting the feed interventions being implemented in each site in Rwanda under the Rwanda Dairy Development Project (RDDP). The document will provide evidence and case studies that will guide and help researchers, and development agencies who are interested in the uptake and scaling of feed technologies. The tool is to be implemented with key informants and dairy farmers through sex disaggregated FGDs.

Questions

I. General

1. Which specific feed intervention (s) are being implemented in this site (district)?
2. Why has the intervention (s) been selected (generally)?
3. Which specific challenges is the intervention (s) addressing?
4. Who are the beneficiaries of the intervention?
5. When did you start implementing the specific feed intervention?
6. Which entities are meeting the costs of the intervention?
7. Is the intervention implemented on individual farms or through collectives?
8. What is the total land area under the feed intervention (for forage interventions)?
9. How many households are involved in implementation of each feed intervention?
10. Indicate the challenges that have been associated with implementation of the intervention.
11. What are the early lessons learnt regarding its implementation?

II. Dimensions of the feed interventions and community perceptions

A. Economic and technical feasibility:

- Market studies
    - Is there adequate demand for milk and milk products for which the interventions are targeting? (Specify studies)
- Cost-benefit analysis
    - What are the benefits associated with the intervention in a dairy farm? In the community?
    - What are the costs associated with the intervention in a dairy farm? In the community?
    - Do total benefits accruing from up-take of intervention outweigh total associated costs? **This becomes a point of discussion**
- Inputs and services
    - Which specific inputs and resources are required in application of the feed intervention?

- Which services are required in application of the intervention?

- Technical capacity
  - Is there availability of local resources and skills to scale-up the feed technology? e.g., land, water, extension services, etc.?

B. Gender and social equity:

- Equity
  - Is the feed intervention/technology accessible to both women and men equally?
  - Will both women and men have access to and control over the resources including information/trainings associated with the technology/intervention?
- Labour demand
  - How does the technology affect labour demand for various sections of the target community?
  - Do you think the technology is/will be more labour demanding? Whose labour will be more demanded for at implementation of the feed technology.

C. Environmental sustainability:

- Soil and land
  - What is the effect of the feed intervention on soil quality and land degradation?
- Biodiversity
  - What is the impact of the feed intervention on the ecosystem and biodiversity?
- Water
  - How does the intervention impact on water resources?
  - Does the intervention exacerbate the competing use of water for livestock related purposes versus human? If yes, what strategies can be put in place to ensure optimal use for both human and livestock?

D. Social sustainability:

- Social capital
  - How does the feed intervention and its implementation affect trust among members of the community and how does it change the level of connectedness to others in the community?
  - To what extent is it acceptable and supported by local/national leaders?

E. Infrastructural management (for collective infrastructures like valley dams and boreholes)

- How is the infrastructure managed?
- Do you have an infrastructure committee? (gender composition)
- Has the Infrastructure committee been trained? If yes, which are the focus areas of the training and when was it delivered, who delivered the training
- What is the arrangement as regards maintenance – who meets the maintenance costs? (Source of funds)
- Is any plan to maintain the infrastructure functional?

92–9146–706–3

The International Livestock Research Institute (ILRI) works to improve food and nutritional security and reduce poverty in developing countries through research for efficient, safe and sustainable use of livestock. Co-hosted by Kenya and Ethiopia, it has regional or country offices and projects in East, South and Southeast Asia as well as Central, East, Southern and West Africa. ilri.org

CGIAR is a global agricultural research partnership for a food-secure future. Its research is carried out by 15 research centres in collaboration with hundreds of partner organizations. cgiar.org