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Financial feasibility of selected best-bet interventions along the small ruminant value chains in Ethiopia

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Acronyms

ADA	Austrian Development Agency
BOKU	University of Natural Resources and Life Sciences
CBBP	Community Based Breeding Program
CGIAR	Consultative Group of International Agricultural Research
CRP	CGIAR Research Program
ICARDA	International Center for Agricultural Research in Dryland Areas
ILRI	International Livestock Research Institute
VC	Value chain

Introduction

Small ruminants play a key role in the livelihoods of rural communities in Ethiopia. Despite their importance, the productivity of these animals and the financial rewards for farmers can hardly be considered sustainable. In an effort to improve production and productivity of small ruminants, ICARDA has been implementing various research activities aimed at transforming small ruminant value chain systems in the country since 2012. ICARDA's effort, which is part of the Livestock CGIAR research program [formerly known as Livestock and Fish CRP], have led to many technological and institutional innovations that were tested in comprehensively characterized sites.

The research activities of ICARDA on small ruminant value chain transformation started with a careful site selection process that identified seven sites from five regional states based on various criteria (Kassie et al., 2016). The sites denote different value chains and hence different roles of small ruminants. From the seven sites, four are sheep dominated, 2 are goat dominated and one of them goat and sheep mixed value chains (Table 1). The detailed site selection process was followed by a comprehensive characterization of the value chains with the main purpose of identifying the key challenges and opportunities as well as establishing benchmarks for impact assessment of research and development interventions along the value chains.

The challenges and opportunities identified through the baseline survey were studied carefully and interventions were selected based on empirical evidence within the country and ICARDA's relevant experience. The different interventions identified to address the key challenges included community-based breeding, fattening, dairy hygienic procedures for dairy products, and market sheds.

These interventions have been tested at least for three years in selected sites. The piloting of these interventions has shown that they are technically very sound and farmers are very keen to have access to each one of them. Scaling up of these interventions entails a realistic definition of the costs and benefits to gauge their financial viability. This document therefore presents financial feasibility of the best-bets tested over time and sites. The intention of this analysis is to encourage potential investors to consider commercializing the innovations. The commercialization will benefit both the investors and the other value chain actors.

The document starts with the community-based breeding followed by fattening, dairy products hygienic practices and processing, and market sheds.

Table 1: Sites of the Ethiopian Small Ruminant Value Chain Research for Development

#	VCs	District	Sites/villages/communities	Region
Highlands				
1	Sheep 1	Atsbi	1. Habes 2. Golgol na'ele 3. Gebre kidan	Tigray
2	Sheep 2	Doyogena	1. Serea 2. Bkafa	SNNP
3	Sheep 3	Menz/Molale and Mehal Meda	1. Molale 2. Mehal Meda	Amhara
4	Sheep 4	Horro/Shambu	1. Gitlo 2. Lakku Iggu	Oromia
5	Goat 1	Abergelle	1. Neuraq town, Saka/Sazeba (Amhara) 2. Felegehiwot (Tigray)	Amhara and Tigray
Lowlands				
6	Goat 2	Yabello	1. Eleweya 2. Darito	Oromia
7	Goat/Sheep	Shinelle	1. Gad 2. Degah Jebis	Somali

Part I. Community-Based Breeding Program (CBBP)

Technical description of CBBP

Several approaches have been tried over the years to improve sheep genetic resources in Ethiopia. The efforts exerted so far focused on introducing exotic genes into the livestock population. However, most of the initiatives have failed to achieve their objective of increasing production and productivity of the animals. A new approach gaining global interest is a community-based breeding program (CBBP).

The International Center for Agricultural Research in the Dry Areas (ICARDA), the International Livestock Research Institute (ILRI), and the University of Natural Resources and Life Sciences (BOKU), in partnership with the Ethiopian National Agricultural Research Systems, designed and implemented CBBPs in four sites, namely, Bonga, Horro, Menz, and Afar in Ethiopia through an Austrian Development Agency (ADA) funded project from 2007 to 2011. When the ADA funded project phased out, the more successful breeding programs that were relatively more successful; i.e., in Menz, Horro, and Bonga, continued under the CGIAR Research Program on Livestock and Fish and expanded to Doyogena and Atsbi for sheep and Abergelle for goats.

The three (Bonga, Horro and Menz) CBBPs are being implemented with more than 10,000 sheep. There are currently six communities in the three locations. Each community has on average 60 households. The core in this project is to get community members working together on ram selection, management and use. Two stages of ram selection are applied; i.e., initial screening when first sales of young rams occur (4–6 months) and final decision for admission to breeding at the age of 12 months. Selection at the first stage is based on estimated breeding value of live weight at the age of 6 months (all sites) and twinning rate (Bonga and Horro) of the ewe. Additionally, conformation, coat color, horn and tail type of the animal are considered in the final selection. All young rams are collected at one central place in each community on an agreed screening date and selection is then carried out.

A breeding ram selection committee composed of about 3 to 5 members elected by the community directly involves in the selection process. If, for example, 15 rams were to be selected from 100 candidates, about 20 would be preselected based on their breeding values and the culling of the last five and the ranking of the selected rams would be made by the committee.

One enumerator was employed for each sheep-breeding community for record-keeping. These enumerators reside within the community and closely follow-up the breeding program. This has always been indispensable to run CBBPs where most farmers are illiterate. Other interventions included construction of sheds as stores and candidate rams holding yards.

All CBBPs have established legally recognized breeders' cooperatives that run the breeding programs with technical and financial support from NARS and ICARDA.

Institutional performance

More structured leadership and efficient management of financial resources, and better selection of breeding rams were observed among the registered cooperatives in Bonga and Menz compared to cooperatives in Horro. Registered cooperatives receive free auditing services and training on financial record keeping from district level cooperative promotion offices. In cooperatives that are not yet registered and have no bylaws, complaints among members regarding mismanagement of cooperative resources including breeding rams are common.

Purchasing price of ram is set by the CBBP committee and paid to owners of the selected rams. When the program started, there was the issue of young and fast-growing lambs being sold for cash needs. This caused keeping the best rams in the communities difficult. As a result, the ADA supported project made a revolving fund available to buy young lambs and keep them within the

community. The selected best rams would serve for about two years as agreed by the communities. Bonga cooperative members are happy by the price the committee sets, but there were still a few farmers in Horro and Menz who did not like the prices offered and decided to sell their animals somewhere else. Most farmers, however, believe that the best ram is a product of the genetic gains the cooperative achieved and owners should sell to the cooperative with the price set.

Performance of breeds

The major achievements of the CBBP as recognized by farmers are improvement in body size of newborn lambs, reduced lambing interval, twinning rate and change in coat color towards uniform and preferred color. In Menz, discussion with farmers revealed that wool yield has considerably improved. Ewes in the flock now conceive on regular basis and give birth usually three times in two years, except in Menz where farmers believe feed shortage is undermining the reproductive rate of the animals. The newborn lambs are attractive and grow fast. Body conformation, appearance and other preferred traits of lambs born from beneficiaries of the CBBP flocks are observed to be superior to those from other farmers.

This is the major selection trait in the CBBPs is weight at six month and it has increased over the years in the three sites. The results of a weighted regression of the average breeding value of the animals on the year of birth are summarized in Table 2 below. In Menz, the average increase was 0.14 ± 0.006 kg/year, followed by average increase of 0.26 ± 0.058 kg/year in Bonga and 0.31 ± 0.060 kg/year in Horro. This is quite substantial given the fact that it is from an on-farm condition. The increases were particularly significant in larger framed breeds (Horro and Bonga) compared to Menz sheep, which is relatively small.

Table 2: Estimated breeding values over years for six months lamb weight (kg)

Year	Menz lamb	Horro lamb	Bonga lamb
2009	0.07±0.017		-0.07±0.266
2010	0.08±0.013	-0.03±0.143	0.18±0.189
2011	0.11±0.014	0.06±0.095	0.22±0.158
2012	0.13±0.015	0.24±0.082	0.24±0.139
2013	0.20±0.016	0.36±0.086	0.35±0.112
2014	0.25±0.014	0.28±0.079	0.46±0.082
2015	0.14±0.027	0.52±0.097	0.32±0.065
2016		0.78±0.339	0.38±0.209

*Weight values are given as least squares means in the range of ± one standard error

Another selection trait at some sites is twinning rate. Results of repeated measures fixed effects model show that litter size of lambs increased over the years in both Bonga and Horro (Table 3). The increment was 12% (from 1.28 to 1.46) in Horro and 8% (from 1.48 to 1.61) in Bonga.

Table 3. Mean litter size (kg) in Horro and Bonga CBBPs

	Horro	Bonga
Overall average	1.36±0.010	1.53±0.008
Year	**	**
2009	1.28±0.033	1.48±0.039
2010	1.40±0.020	1.53±0.026
2011	1.37±0.020	1.48±0.022
2012	1.36±0.023	1.58±0.020
2013	1.35±0.023	1.53±0.018
2014	1.31±0.024	1.54±0.015
2015	1.37±0.022	1.53±0.013
2016	1.46±0.039	1.61±0.016

*Litter size values are given as least squares means in the range of ± one standard error

Financial analysis of the Community-Based Sheep Breeding Program (CBBP)

Community-based breeding programs, through selection of high potential off-springs and continuous genetic improvement, are designed to gradually develop best performing animals in a given small ruminant population. The best performing selected animals could also be distributed to other places with similar ecology and farmers' capacity of managing the animals.

Materials and services used in the CBBPs

Rams:The CBBP purchases new rams after selection by the community based on the selection criteria presented above. The selected rams are rotated among the breeding ram groups during the service period but they are either sold as breeding animals for other farmers in other areas or are fattened and sold. Half of the selling price will be paid to the original owner after the initial purchasing price [at lamb stage] is deducted.

Veterinary services: If there are any health-related problems in the CBBP, veterinary service will be provided. Animals are also vaccinated for known diseases.

Labor: payment is made to the enumerators who keep breeding records and oversee the breeding activity on the ground.

Training: the community members have continuously been given awareness creation training on the meaning and importance of CBBP and on management of their rams/ flock.

Profitability Analysis

Initial investment: amount of revolving fund provided for each site that varies according to the site.

Costs: new ram purchasing price, cost of training and cost of enumerator.

Cost-Benefit analysis

The farmers receive 50% of selling price of used rams plus its initial purchasing price. The other source of benefit is 6-month weight increase (in kg/year) multiplied by number of sheep (ram, ewe) in the community multiplied by average price per kg. Increase in twinning rate multiplied by number of ewe lambs multiplied by price at six month with assumption of no additional cost to the household.

The members in the CBBP benefited from selling of candidate rams at higher prices and overall improvement in performance of even the non-selected rams for fattening and twinning rate improvement of sheep. The NPV and IRR values for the three locations are indicated in Table 4.

Sheep CBBP performed the best in Bonga with IRR value of 1429%. This value is registered because of benefit from six-month weight increment, high twinning rate, survival rate improvement and market for the selected rams unlike other sites. In addition, Bonga CBBP center did receive small amount of revolving fund only once throughout the program so far, unlike the remaining two sites. Menz CBBP did not perform well because of high cost of the program by receiving revolving fund several times with high amount and relatively lesser gain from other traits and no twinning rate advantage. Horro CBBP resulted in an IRR value greater than market interest rate.

Table 4: Cash flow analysis of community-based sheep breeding program

	Menz CBBP			Bonga CBBP			Horro CBBP		
Year	Cost	Benefit	Cash flow	Cost	Benefit	Cash flow	Cost	Benefit	Cash flow
2009	14013	8820	-5193	4975	0	-4975	2678	0	-2678.0
2010	26929	33565	6636	6750	71474	64724	3962	19808	15845.5
2011	53778	49577	-4201	51328	212391	161063	311564	44069	-267495.2
2012	73987	51669	-22317	16395	189370	172975	13274	83097	69822.5
2013	118520	83530	-34990	21300	289393	268093	20584	73431	52847.4
2014	141923	177600	35677	24960	428995	404035	15032	105345	90313.2
2015	46738	106813	60075	27472.6	572571	545098	4508	220187	215678.6
2016	163511	126478	-37033	28725	790557	761832	21854	388819	366965.3
	NPV	($5,672)			$1,317,775			$223,040	
	IRR	-2%			1429%			37%	

Source: CBBP centers (Menz, Bonga and Horro)

Part II. Sheep Fattening Program

Technical description of sheep fattening activities

ICARDA has been undertaking a project to modify the existing feeding strategies in sheep flocks in the context of the ongoing Community-Based Sheep Breeding Program in Ethiopia (CBBP) for more than five years. The CBBP embeds farmer participation into selection of breeding rams. Selection is done when rams are six or nine months of age depending on the breed type. Farmers in the program are obliged to sell off non-selected rams to avoid negative selection.

In a phased approach, from 2014 to 2016, the sheep project conducted on-farm improved feeding practices using concentrate supplementation with sheep farmers in the CBBP sites to determine fattening capacity of rams between 6 and12 months.

Phase 1 of the ram fattening project was implemented in four sites namely Doyogena, Horro, Menz and Bonga in August-December 2014. The training involved 191 farmers and the fatting included 363 rams.

A second phase of sheep fattening to modify the existing feeding strategies in sheep flocks within the context of the ongoing Community-Based Sheep Breeding Program in Ethiopia (CBBP) was undertaken between January and April, 2016. It aimed at supplying fattened rams to the Ethiopian Easter festivity. Similar to Phase I, the fattening took place in four value chain sites of Bonga, Doyogena, Menz and Horro. This phase covered 171 farmers and their 381 rams. Forty percent of the farmers and 30% of the rams were controls with no supplementation for fattening in the second phase.

Phase II of the fattening resulted in a completion rate of 95% where participating farmers followed the fattening procedures for the entire recommended period of 105 days (15 days adaptation and 90 days fattening). The project sought to evaluate the fattening performance of rams using locally available supplements. During Phase I, there was the need to lower the costs of fattening to improve the returns per animal. In Phase 2, two ration formulations were compared in Menz, Horro and Doyogena. Locally formulated concentrate ration - mainly made of wheat bran, noug cake, ground maize and wheat, broken lentil, roasted faba bean and barley, local drink residue (*atela*), and salt - was provided as supplementary diet. In addition, basal diet which included natural grazing, wheat/barley straw and false banana (*enset*) was fed to the animals. During the first phase, quite a number of farmers refused to sell their rams immediately at the end of the fattening process. They were anticipating demand to increase and hence receive better prices.

Experiment

All rams were castrated and drenched before the start of the trial. Rams had a minimal body score of 2.5. Body condition score mainly describes the condition of an animal. Feeding took place on farm under individual farmer conditions. Rams were fed concentrates once a day. Ram adaptation time to the feed was for 15 days, with the trial period of 90 days. Rams were individually weighed at the beginning of the trial. Thereafter, body measurements were taken fortnightly by enumerators and assisted by farmers. Basal diets comprised of natural grazing and straws (mainly wheat and barley). Locally formulated concentrate ration that was generally made of wheat bran, noug cake, ground maize and wheat, broken lentil, roasted faba bean and barley, local drink residue (*atela*) and salt, was provided as supplementary diet. In addition, Farmers received one plastic watering bucket and one feeding trough made of car tyre for each participating ram. Rams were fed tailored supplementary diet of 400 to 685 g/day according to their size/age and watered *ad libitum.*

Except in Doyogena, 6-8 month old lambs performed better in average daily body weight gain (ADG) than other age groups followed with 11-12 month old. The 9-10 month old had less average daily

gain during phase I feeding trial (Table 5). During second phase, comparison was between control and supplemented groups (Table 6).

Farmers in the fattening sites complained their fattened sheep did not get fair price. Market linkage received enormous emphasis from the farmers in all sites during phase I. They complained that small traders and brokers are the major sheep price setters in the market and often offer very low prices for their sheep. Some efforts employed during Phase II involved discussing with farmers to collectively act and hence bring their animals together so that traders come and transact at the farm gate. Farmers, however, opted for taking their animals to the open markets expecting better prices as they were doubtful of the price offered as the farm gate. Since price fluctuations are common place in rural livestock markets in Ethiopia, it is imperative that farmers are educated to realize this fact and open up to seeking strategies that would consolidate their bargaining power.

Table 5: Result of Phase I fattening

Breed	Initial age (months)	Average daily gain (g)
Bonga	6-8	100.0
	9-10	85.4
	11-12	88.9
Doyogena	6-8	71.5
	9-10	86.5
	11-12	94.7
Horro	6-8	104.6
	9-10	89.8
	11-12	93.5
Menz	9-10	60.9
	11-12	140.2

Source: Result from the experimental sites

Table 6: Result of Phase II fattening experiment

Breed	Location	**Control**		**Supplemented**		**Average daily weight gain (g)**		
		Initial wt. (kg)	Final wt. (kg)	Initial wt. (kg)	Final wt. (kg)	Control	Supple-mented	Diff.
Bonga	Boka	26.6	32.4	32.6	41.9	64.4	103.3	30.5
	Buta	28.5	31.7	35.6	44.4	35.6	97.8	61.6
	Shuta	24.6	29.4	33	41.8	53.3	97.8	42.2
Doyoge na	Ancha	27.7	38.8	27.9	38.1	123.3	113.3	18.1
	Hawora	-	-	27	35.4	-	93.3	-
Horro	Gitlo	-	-	28.8	34.5	-	63.3	43.6
	Leku	20	21	33.4	42.1	11.1	96.6	85.5
Menz	Mehalmeda	29.3	30	24.7	30.7	7.7	66.6	58.9
	Molalle	24.5	30.4	24.7	28.9	65.5	45.5	-20

Source: Result from the experimental sites

Financial Analysis of sheep fattening project

The fattening activity was entirely on sheep and it has been implemented in Bonga, Doyogena, Menz and Horro sites. Fattening is initiated to utilize those rams that are culled from CBBP to avoid negative selection. In addition, rams that served for two years in the CBBPs were transferred to the fattening program.

Materials and services used in the fattening program

Rams: The CBBP participants in each of the project sites provided rams of different ages and weight for the experiment.

Feeds: There were rams grouped into treated (supplemented) and control in the fattening program. The supplementary diet was feeding of concentrate prepared from local ingredients with potential gain of at least 100g/day/ram and provision of natural grazing through tethering, whereas the control rams depended 100% on natural grazing.

Equipment: concentrate feeding gutter and watering trough were provided to the fatteners.

Veterinary services

Prior to the fattening, rams were already castrated to avoid negative selection under CBBP and were drenched for endo-parasites.

Marketing: Only sheep from households who sold fattened ram on the expected date of selling were considered in the analysis. Fattened sheep that were sold either earlier or later than the 90 days fattening period were not considered in the analysis. This is because only the actual market price of sold rams immediately after finishing the 90 days fattening period was available.

Profit Analysis

Cost-Benefit Analysis

Cost of supplementary feed was computed based on unit price of concentrate fed per day multiplied by the 90 days per ram. In the second phase, in all sites except Bonga, the supplementary ration was of two types. The basal diet was excluded from analysis. Cost of veterinary services and equipment was computed based on the amount of money spent to access the equipment and services. Data on initial price of the rams could not be generated as all of them were selected from the herds of the households themselves. Therefore, we have not considered the initial cost [price] of the rams.

The revenue generated from a fattened sheep was computed by multiplying the average market price of fattened rams with the number of sold sheep.

Net profit obtained from supplementing ration one and two were better off over control for Bonga and Horro (Table 7). Sensitivity analysis was computed for the fattening program by changing cost of fattening and price of selling (Table 8).

Bonga and Menz sheep fattening perform better on ration 1; while Horro perform the least. Based on sensitivity analysis in a scenario of 20% increases in overall cost of production using ration one; Horro sheep did not show positive profits. However, based on ration 2, where Bonga sheep did not participate; Horro sheep was found the best performer even at 20% increase in overall costs of production. Hence, Ration two is the best for Horro.

Table 7: Sheep Fattening Financial Analysis (in Birr)

		Menz	Bonga	Doyogena	Horro
Weight (kg)	Initial weight of average control ram	26.9	26.6	27.7	20.0
	Initial wt. of average supplemented ram	24.7	33.7	27.9	31.1
	Av. final wt. of suppl. ram fed ration one	30.7	42.7	35.4	34.5
	Av. final wt. of suppl. ram fed ration two	28.9	-	38.1	42.1
	Average final weight of ram in the control	30.2	31.2	38.8	21.0
	Fattening days	90.0	90.0	90.0	90.0
Cost	watering trough cost per ram	13.0	13.0	13.0	13.0
	feeding trough cost per ram	40.0	40.0	40.0	40.0
Price	Price per kg of average initial live weight for control group	31.9	36.1	38.8	31.8
	Price per kg of average initial live weight for supplemented group	30.7	33.7	38.3	35.0
	Price per kg of average final live weight for control group	44.2	44.5	49.4	30.0
	Price per kg of average final live weight for supplemented group	48.8	52.9	48.7	45.8
Cost	feed cost for ration one per day	2.58	3.2	2.98	2.03
	feed cost for ration two per day	1.99	-	3.28	2.33
	Total cost based on ration one	1042.3	1476.8	1385.0	1336.6
	Total cost based on ration two	989.2	-	1412.0	1363.6
	Total cost for control	858.4	959.3	1073.4	636.4
Net cost	Net cost of supplemented over control based on ration one	183.9	517.5	311.7	700.2
	Net cost of supplemented over control based on ration two	130.8	-	338.7	727.2
Benefit	Benefit items				
	Final selling price for control group per average ram	1335.1	1385.4	1914.8	629.6
	Final selling price for supplemented ration one per average ram	1498.2	2259.3	1725.0	1580.8
	Final selling price for supplemented ration two per average ram	1410.3	-	1856.6	1929.0
	Profit for control	476. 8	426.0	841.4	-6.8
	Gross revenue per average ram for supplemented ration one over control	163.0	873.9	-189.7	951.2
	Gross revenue for average ram supplemented ration two over control	75.2	-	-58.2	1299.4
Net profit	Net profit for supplementation of ration one over control	-20.9	356.4	-501.4	251.0
	Net profit for supplementation of ration two over control	-55.6	-	-396.8	572.2

Table 8: Sensitivity analysis of change in cost of sheep fattening on its profitability (in Birr)

	Menz	Bonga	Doyogena	Horro	Menz	Bonga	Doyogena	Horro
Scenario	**Normal Cost based on the experiment**				**Normal Benefit based on the experiment**			
Control	858	959	1073	636	1335	1386	1915	630
Ration1	1042	1477	1385	1337	1498	2259	1725	1581
Ration2	989		1412	1364	1410		1857	1929
Scenario	**10% increase in cost**				**20% increase in cost**			
Ration1	1146.2	1624.7	1523.5	1470.7	1254	1774	1662	1604
Ration2	1087.9		1553.2	1500.4	1187		1694	1637
	No change in Benefit							
Ration1	1498	2259	1725	1581	1498	2259	1725	1581
Ration2	1410		1857	1929	1410		1857	1929
	Profit based on increase in cost							
Ration1	351.8	634.3	201.5	110.3	247.6	487.6	63.0	-23.4
Ration2	322.1		303.8	428.6	223.2		162.6	292.2
Scenario	**10% decrease in cost**				**20% decrease in cost**			
Ration1	937.8	1329.3	1246.5	1203.3	834	1182	1108	1070
Ration2	890.1		1270.8	1227.6	791		1129.6	1091
	No change in Benefit							
Ration1	1498	2259	1725	1581	1498	2259	1725	1581
Ration2	1410		1857	1929	1410		1857	1929
	Profit based on decrease in cost							
Ration1	560.2	929.7	478.5	377.7	664	1077	617	511
Ration2	519.9		586.2	701.4	619		727	838

Source: Computed based on scenario developed from Table 7

Part III. Dairy Products Hygienic Practices and Processing

Technical description of hygienic practices and processing of dairy products

Traditional milk production suffers from contamination and waste of products in the dairy value chain. The intervention on hygienic practices includes simple awareness creation on cleaning of udder, milk containers and improved personal hygiene. Traditionally dairy product containers are fumigated with smoke, where residues of smoking material may remain in the container and affect health and reduce demand of dairy products. However, with the introduction of an easy–to-use beekeeping smoker to Abergelle and Yabello areas, it was possible to produce high quality and safe products that satisfy consumers demand.

Wastage of dairy products and inefficiencies in labor utilization are common due to the traditional processing methods and product types with limited option for elongating shelf life and use value. Milk is perishable product that, given the state of technological development, would not be transported to longer distance and cannot stay for longer time without spoilage. Yet, with simple introduction of pasteurization technique bacteria could be killed and shelf life of milk can be increased. Pasteurization of milk leads to safe dairy products, fermented milk with improved texture and products with extended shelf life that could reach market at distant location as well. This technique was implemented by ICARDA in Abergelle and Yabello. Labor utilization efficiency improvement in dairy product processing was approached with introduction of thermometer that helps to determine appropriate temperature for churning of milk and introduction of fat separator.

There are two types of fat separator, the manual fat separator with capacity of 85 liter/hour and electrical fat separator with capacity of 375 liter/hour. Both types of fat separator were introduced to Borena and the manual separator to Tigray and Amhara regions. The manual fat separator with a cost of 200 Euro (including shipping cost) was suggested for Ethiopia goat milk producers. The fat separator removes cream of 40% fat and produces skimmed milk of 0.05% fat content. This process of reducing the fat content has increased the butter amount by 5%. Churning of cream mixed with 20 to 30% water has also reduced labour requirement as it takes much lesser time of at least 70% below the traditional whole milk churning time requirement. Introduction of fat separator also creates possibility of fully utilizing by-product (skimmed milk), which could have otherwise been dumped.

Skimmed milk can be converted into good quality cheese and more consistent and tasty yoghurt than the traditional yoghurt called *Ergo*. Wastage of the by-product (called *Arera*) under traditional method of milk processing especially due to long fasting periods in Ethiopia could be avoided by converting skimmed milk into cheese that can stay up to four months under simple form and may stay for as long as a year if produced in brined cheese form.

Financial analysis for Goat Milk Processing

Farmers keep large number of milking goats (on average 90/farmer) in Abergelle and Sekota areas. The goat's milk is currently processed traditionally like cow milk and converted to butter (*kibe*) and *Arera* (by-product from churned milk). *Arera* does not have market value, but sometimes traditional cheese is extracted from it. Under traditional processing method, churning four liters of milk takes on average two hours. Farmers in Abergelle have three options to utilize goat milk: sell it as whole milk, prepare yoghurt (ergo) and sell, or prepare yoghurt and process it to produce butter (*kibe*). ICARDA introduced advanced method of goat milk processing that can increase household income through minimizing wastage and improving churning efficiency.

Materials and services used for improvement of milk and dairy products

Raw milk, labour, heating, manual fat separator, dairy culture, rennet, smoker, Thermometer and pasteurization.

Cost-benefit analysis

Cost analysis:

Cost of raw milk: as observed in local markets, raw goat milk price is 15 Birr per liter.

Labor cost: labor is required for preparation of dairy products and its cost varies according to the time spent in processing with eight Birr per hour rate.

Manual cream/fat separator cost: this machine is used for removing cream from whole milk and helps to reduce churning time and increase amount of *kibe* produced. The machine also helps to save the almost wasted *arera* under traditional processing. Here, instead of *arera* we can get skimmed milk. The cost of fat separator is around 200 Euro (including shipping cost). If number of fat separator imported increases, shipping cost can be reduced. In this study, it is assumed that a single fat separator costs around 6000 Birr. The fat separator has capacity of separating cream from 85 liters of milk per hour and can be used for 10 years.

Dairy culture cost: dairy culture is used to convert skimmed milk into yoghurt in an improved way. Amount of culture sufficient for a season costs around 300 Birr. For this analysis, three Birr per day is considered based on expert recommendation.

Rennet cost: Rennet costs 0.18 Birr per kg of cheese. Rennet is an enzyme used to convert skimmed milk into cheese with conversion efficiency of 15%. From 100 liters of skimmed milk, 15 kg of cheese with longer shelf life (from 3 to 4 months under farmers' condition) can be obtained. Milk products are not consumed in Abergelle during fasting periods hence, it would be an option for such area to convert skimmed milk into cheese and may sell it in Supermarkets at a price ranging from 80 to 200 Birr per kg.

Cost of beekeeper's smoker: smoker costs 300 Birr per unit and it can be used for about 10 years if properly managed. For this analysis we considered cost of three Birr per day.

Thermometer cost: a thermometer is available in the market at a price of 60 Birr. Thermometer will help to pasteurize milk and to determine whether it is appropriate to process milk or not as temperature has influence on processing efficiency.

Benefit Analysis:

Both traditional and improved methods of milk processing are considered and compared in terms of net profit. The financial analysis shows the improved method is more profitable. Traditional method of milk processing is not profitable due to wastage and inefficiencies in processing.

Yoghurt (*Ergo*) price: the whole milk can be converted into yoghurt and sold in yoghurt form but only in the local market because of its limited durability and high perishability. Yoghurt is available in the local markets at 30 Birr/ liter.

Cheese (*Ayib*) price: Cheese processed from *Arera* can be sold locally at a price of 37.5 per kg. The conversion rate of *Arera* into cheese (*ayib*) is 20%, which means 100 liters of *arera* can be converted to 20 kg of *ayib* after slightly boiling the *arera*.

Butter (*Kibe*) price: due to better shelf life of butter, milk is converted to yoghurt and butter can be produced by churning the yoghurt. Price of butter is 250 Birr/kg in the study areas.

Cheese price: cheese is processed from skimmed milk through use of rennet enzyme with conversion efficiency of 15%. Cheese is sold at average price of 80 Birr/kg but could increase to 200 Birr/kg where supermarket is available in bigger towns/city. However, to sell cheese in a bigger town or city, transport costs need to be included.

***Nitir kibe* (processed butter) price:** rather than selling raw butter on weekly basis it is possible to convert this raw butter of 82% fat content into processed butter of 99% fat and store it for a longer period. In the local markets, *Nitir kibe* fetches *a* price of 350 Birr per kg.

Scenario development for dairy processing

Two scenarios were developed on milk production given information obtained from Wag Himra zone. In the two kebeles, where the study on Abergelle goats milk production and processing was conducted, there was on average 724 lactating does per year. Six per cent of does also gave birth to two calves per year. Milk yield per doe was on average 0.42 liter per day. Average lactation length was only 63 days. Milk price was 15 Birr per liter. These data were used to consider two scenarios for sensitivity analysis of goat milk processing under traditional and improved methods and the results are presented in Tables 10 and 12. The first scenario is based on actual values stated above, while the second is developed assuming increase in total milk yield and in price. The price was assumed to increase from 15 Birr per liter to 25 Birr (which is the current maximum price in the study area). If there is possibility of increasing lactation length through provision of good management from 63 days to 100 days, it will be possible to increase milk yield from 0.42 to 0.5 liter/day/doe and increment of twinning per year from 6 % to 10% of flock. Results of the financial analysis of production of butter & cheese, and butter & yoghurt are presented in Table11.

Table 9: Sensitivity analysis of dairy processing under improved method (in Birr)

		Product type					
	Scenarios	Milk	Cream	Skimmed milk	Yoghurt	Cheese	Butter
Volume	Scenario1	203,067	2516	17,790	17790	2669	1390
	Scenario2	39,820	4934	34,886	34886	5233	2726
Revenue	Scenario1	304,597			533,712	213,485	34,7499
	Scenario2	995,500			1,046,583	418,633	681,429
Rennet cost	Scenario1					480	
	Scenario2					942	
Fat separator cost	Scenario1		179		179	179	179
	Scenario2		351		351	351	351
Labor cost	Scenario1		2218		15,796	19726	3140
	Scenario2		4350		30,975	38681	6158
Dairy culture	Scenario1				300		
	Scenario2				300	193,099	
Return	Scenario1	304,597			517,437		344,180
	Scenario2	995,500			1,014,957	378,659	674,920

Source: Computed based on scenario developed

Table 10: Net return from joint dairy products under improved methods of processing (in Birr)

Joint product type	Return from butter & cheese	Return from butter & yoghurt
Scenario 1	537,279	861,617
Scenario 2	744,789	1,927,581

Source: Computed based on scenario developed

Table 11: Sensitivity analysis of dairy processing under traditional methods (in Birr)

	Revenue	Cost1	Cost 2	Return
Ergo				
Scenario1	609,194	304,597	7897	296,700
Scenario2	1,194,600	995,500	15,486	183,614
Kibe				
Scenario1	279,778	304,597	81226	-106,045
Scenario2	548,631	995,500	159280	-606,149
Ayib				
Scenario1	143,837	0	33562	110,275
Scenario2	282,058	0	65814	216,245
Kibe + Ayib				
Scenario1				4231
Scenario2				-389,904

Source: Computed based on scenario developed

Yoghurt production gives highest return as compared to other dairy products in single product comparison basis under improved method of dairy processing. *Ayib* (local cheese) gave highest return under traditional dairy processing owing to zero cost of raw material (it uses *arera*), which is usually discarded as a waste. Therefore, collection of arera from the villages and converting it into *ayib* is certainly a rewarding business. Under scenario two, only *ergo* and *ayib* productions are financial feasible. have positive If the price of other products remains the same, it is better to sell raw milk as it is much more feasible than converting it into other dairy products both under improved and traditional methods of dairy processing.

Part IV. Small Ruminant Market Infrastructure

Technical introduction to small ruminant market infrastructure

Ethiopia has about 120 government-recognized livestock markets whose performance is suffering from lack of watering, sheds, feeding, resting, and quarantine facilities. Consequent value loss due to animal and human sufferings (meat producers & consumers) is large. To address this, the Ethiopian government formulated a national livestock master plan and market development initiatives. These initiatives, however, suffer high uncertainty due to lack of grass roots level information on the performance of the common facilities. ICARDA, therefore, experimented in nine markets with sheds meant for protecting sheep and goats and the marketers from the scorching sun and the rainfall in nine markets in central Ethiopia. Nine other markets were also monitored to compare the changes in market performances of small ruminant keepers due to the sheds. This document presents the financial feasibility of these sheds given current market prices.

The sheds were of three type based on size. The small sheds were designed for markets with the capacity of 10-300 small ruminants. The medium sheds were for markets where 300 to 600 small ruminants were brought on a given market day. Finally, the large sheds were constructed in markets where 600 to 1000 small ruminants were supplied in a given market day (Table 12).

Table 12: The size of the market sheds built in the nine markets

Market	District	Size category
Mollale	Menz Mama	Large
Mehal Meda	Mehal Meda Town	Large
Zemero	Menz Keya Gabriel	Large
Zeret	Menz Keya Gabriel	Medium
Gey	Menz Gera	Medium
Girar Amba	Gishe	Medium
Shesho	Menz Mama	Small
Ashen	Menz Gera	Small
Kolo Margefia	Menz Mama	Small

Financial Analysis of Market Sheds

We have generated 50 weeks of market monitoring data in the markets with and without market sheds on price of sheep and goats, number of sheep and goat supplied to the market, and proportion of animals sold. The markets considered in this analysis are Girar Amba, Kollo Margefia, Mollale, and Zeret as treatment markets and bash, Wejed, Yigem and Zemero[1] as controls. The cost items of the analysis are the initial investment cost of Birr 870,000.00 and 10% maintenance cost at the fourth and seventh year.

The first four weeks of data collection were considered to be the “before” shed building period and the last four weeks to be the “after” shed building period. Then the differences in male sheep price, and female sheep price were computed using the difference in differences method (Table 13).

[1] There is a shed in Zemero, but the marketers did not start using it until the end of the data collection.

Table 13: Differences in sheep prices between markets with and without sheds

	Average price (Birr/head)		
	Male	Female	Male and Female
Before			
Control	1135.0	795.6	965.3
Treated	972.2	758.8	876.1
Diff (T-C)	-162. 8	-36.9	-89.2
After			
Control	936.3	780.3	858.3
Treated	987.5	706.3	846.9
Diff (T-C)	51.3	-74.1	-11.4
Diff-in-Diff	214.0	-37.2	77.8

Notwithstanding the fact that the actual impact of such interventions takes quite a bit of time to be observed, and hence attribution could be superfluous, we could still see that the price of male sheep has showed positive change due to the sheds and that female sheep showed negative change. In fact, the general average price of sheep has increased by 78 Birr over 50 weeks. This is about 8.9% of the initial average price (Birr 876) in the markets where the sheds were built. A simple before and after comparison has shown that there is a 3.5% increment of effective demand of sheep over 1 year period. We used this as annual growth rate for demand with an initial effective demand level of 147 heads of sheep. Salvage value of 10% of the initial value was also added onto the benefit stream.

The cash flow analysis has shown that the construction of market sheds is very rewarding given the very conservative estimates we used in the cost and benefit streams (Table 14). The net present value of a shed built in an average sized market will be Birr 135,702 and the internal rate of return of the investment on such a shed will be 22% which is much higher than the market interest rate of 10%.

Table 14: Cash flow analysis for a shed in an average market in Menz

Year	Cost (Birr)	Benefit (Birr)	Net benefit
1	870,000	128,788	-741,212
2	0	145,187	145,187
3	0	163,674	163,674
4	87,000	184,515	97,515
5	0	208,010	208,010
6	0	234,497	234,497
7	87,000	264,356	177,356
8	0	298,017	298,017
9	0	3,359,647	335,964
10	0	465,744	465,744
NPV (Birr)			135,702
IRR			22%

Conclusions

To be useful to the target users, technologies need to be feasible both technically and financially. After testing for years over different locations, ICARDA decided to check the financial viability of four interventions that aimed at transforming the small ruminant value chains in Ethiopia. The interventions are community-based breeding programs (CBBPs), sheep fattening, milk processing and hygiene, and market sheds.

Implementing CBBPs in Ethiopia started in 2007. Currently, it is being undertaken in five sites. According to farmers, the CBBPs have resulted in higher body size of newborn lambs, lower lambing interval, higher twinning rate and change in coat color towards uniform and preferred color. Financially, CBBPs were found to be very rewarding in Bonga and Horro. CBPPs in Menz were found to be financially not feasible simply because of the harsh environment which is dominated by mountainous alpines with little or no source of feed for the animals.

Sheep fattening is being practiced by farmers mostly in a traditional way. ICARDA's fattening intervention builds on farmers' practice and combines it with the CBBP. Improved sheep fattening has been tested in Bonga, Doyogena, Menz and Horro sites. The fattening aimed at utilizing the rams culled from CBBP. In addition, rams that served for two years in the CBBPs were transferred to the fattening program. The financial feasibility analysis has shown that fattened rams accrued higher net profit than control rams in Bonga and Horro sites. Fattening of sheep was found to be financially unrewarding in Menz and Doyogena. The costs of the supplementary feeding are quite high and the gross revenue was higher for farmers with rams in the control group.

Milk processing and hygiene interventions focused on advanced methods of goat milk processing that can increase household income through minimizing wastage and improving churning efficiency. The financial analysis showed that yoghurt production is the most rewarding activity in the intervention areas. The analysis also shows that the two product combinations; i.e., butter and cheese as well as butter and yoghurt, are financially rewarding under current production levels and market prices.

The last intervention considered in this study are market sheds. ICARDA experimented in nine markets with sheds meant for protecting sheep and goats and the marketers from the scorching sun and the rainfall in central Ethiopia. There were another nine markets monitored to serve as controls. The markets sheds were found to be financially feasible given the current levels of construction cost and cost of capital. The net present value of a shed built in an average sized market will be Birr 135,702 and the internal rate of return of the investment on such a shed will be 22% (cp. current cost of capital of 17%).

This study has presented the financial soundness of four interventions in different locations within Ethiopia. These are interventions which can easily be scaled up and out across and along small ruminant value chains. The financial analysis can easily be adapted and updated to fit into the context within which an interested party might want to apply any of the interventions. We encourage both private and public actors to consider investing on these technologies as they are certainly rewarding not only financially but also socially.