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Crossbreeding strategies for dairy cattle: Introduction, development and impact on smallholder farms in North Gondar, Ethiopia

(Kreuzungszuchtstrategien bei Milchrindern: Einführung, Entwicklung und Auswirkungen auf kleinbäuerliche Betriebe in Nord Gondar, Äthiopien)

Master thesis

submitted by

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List of abbreviations

AI	Artificial insemination
AFC	Age at first calving
CI	Calving interval
DMY	Daily milk yield
HF	Holstein Friesian
LMY	Lactation milk yield
NSPC	Number of service per conception
SNNPR	Southern Nations, Nationalities, and People's Region
SRMP	Sustainable Resource Management Program in North Gondar
TLU	Tropical Livestock Unit

1. INTRODUCTION

In Ethiopia agriculture remains the major economic sector (Felleke and Geda, 2001). It contributes 50% to the national gross domestic product (GDP). The majority of the labor force, 85% of the Ethiopian population, is employed in the agricultural sector (CIA, 2011). The major agricultural activities are crop farming and livestock production based on small scale holdings (MOARD, 2007). The average land holding size is 1.18 ha with a decreasing trend (CSA, 2005; CSA, 2007; CSA 2009; CSA, 2011). 80% of the population depending on agriculture lives in the highlands of Ethiopia making it the most densely inhabited part of the country. It is characterized by smallholder mixed farming of crop and livestock (CSA, 2011). Even though it only accounts for 40% of the total land area, it accommodates 80% of the total cattle population (SNV, 2008).

Ethiopia has the largest number of livestock in Africa, with a constantly growing cattle population of 53.4 million (CSA, 2011). Livestock plays a central role in sustaining millions of resource-poor farmers in different agro-ecological environments, ranging from pastoral and agro-pastoral to mixed farming systems that entirely depend on draft animals for the cultivation of cereal crops (Effa et al, 2003; Anteneh et al., 2010). Cattle are used for various purposes including milk and meat production, draught power and manure utilization. They have economic security and social status functions as well.

Developing countries, affected by population growth as well as an increase of incomes and urbanization, have to deal with a massive increase in demand for food of animal origin and a change in food habits that is often not satisfied by local production (Delgado et al., 1999; Desta, 2002). Livestock products supply animal protein that improves the nutritional status (CSA, 2011). With an Ethiopian population of over 90 million people growing at an annual rate of 3.2%, 8th rank worldwide (CIA, 2011), pressure on the agricultural sector is constantly increasing**.** Constant population growth demands a better economic performance than in the past to prevent poverty, create employment and ensure food security (CSA, 2011; MOARD, 2007). The demand for animal products is further increasing considerably (Effa et al., 2003).

In general, Ethiopia has great potential for dairy development. Favorable conditions for dairying are the country's large and diverse cattle population, generally adequate rainfall patterns which offer potential for production of high quality feedstuff, the existence of a large labor pool and opportunities for export (Anteneh et al., 2010; SNV, 2008). Particularly the mixed crop–livestock system in the highlands, although resource-limited, offers the best opportunity for dairy development and can support crossbred and pure dairy cattle breeds. A prerequisite is the development of well-designed breeding strategies (Effa et al., 2003; Ketema and Tsehay, 1995; Ahmed et al., 2004; MOARD, 2007). Current impediments of livestock development are poorly developed social sector and economic infrastructure as well as environmentally destructive trends (MOARD, 2007). During the last decade cropping area has increased at the expense of grazing land, especially in Ethiopia's highlands. Decreasing grazing land combined with a rapidly growing livestock population (CSA 2011) is likely to lead to massive overstocking and overgrazing of available pastures and increased land degradation due to soil erosion (Blata, 2010; Tschopp et al., 2010). This stretches pasture capacity beyond its limits; consequently decreasing pasture quality results in low livestock production performance (SNV, 2008).

Because of poor performance the livestock sector is not keeping up with the growing demand for animal products (CSA, 2011; SNV, 2008). Inappropriate technologies, inadequate research and extension support, poor infrastructure and unfavorable external conditions contribute to low livestock sector productivity (Falvey and Chantalakhana, 1999).

Renewable resources, especially farming and grazing land, are limited; for this reason increase in animal productivity must come from productivity gains rather than from a growing number of livestock (Effa et al., 2003). One necessary step to improve productivity of cattle is selection within the local herds (Effa et al., 2003; Tegegne et al., 2010; Philipsson et al., 2011). Another option is the introduction of crossbred animals. First generation crosses (local with exotic dairy breeds) are considered to have a more efficient reproductive performance than local cows in terms of earlier age at first calving and shorter calving intervals (Kiwuwa et al., 1983; Miazi et al., 2007; Ayenew et al.,

2008; Galukande, 2010). Milk production of crossbred cows is generally higher than of local cows (Kiwuwa et al., 1983; Cunningham and Syrstad, 1987; Tadesse and Dessie, 2003). The milk yield of the first crossbred generation (F1) is more than twice as the milk yield of local dairy cattle breed. F1 bring the highest economic returns under poor feeding conditions (Mc Dowell et al., 1996).

Anyhow, crossbreeding has generated much controversy because various factors influence the performance of crossbreds. As crossbred animals are highly susceptible to diseases and less tolerant to tropical climates, husbandry practices need to be improved (Venkatasubramanian and Fulzele, 1996).

In Ethiopia a number of livestock development projects have been carried out, which were working on the introduction of crossbred animals to improve milk productivity and milk market participation for subsistence farmers (Tegegne et al., 2010). This study analyzes a project which was implemented in the North Gondar Zone of Amhara Regional State by the Integrated Livestock Development Project (ILDP). The project was run and financed by the Austrian government from 1998 to 2007 (ILDP, 2007).

2. RESEARCH QUESTIONS

How has crossbreeding been introduced in the study area and what kind of support did farmers get from the implementing organization?

Which differences exist between crossbred and local animals in performance and animal health?

Which effects does crossbreeding have on production system and livelihoods of beneficiaries?

What kind of challenges are connected with the introduction of crossbreeding?

3. OBJECTIVES

The first objective of this study is an analysis of the development of crossbreeding by smallholder dairy cattle keepers who were benefited from the Integrated Livestock Development Project (ILDP).

The second objective is to gain knowledge on the effect of crossbreeding on dairy production systems and livelihoods in the study area.

4. LITERATURE REVIEW

4.1. Dairy cattle sector in Ethiopia

Ethiopia is believed to have the largest livestock population in Africa with a ratio of 0.6 head of cattle/ person and a constantly increasing trend every year (CSA, 2011, CIA 2011; FAOSTAT, 2011; Anteneh et al., 2010). Since the year 2000 the cattle population increased by more than 60% (Fig. 1).

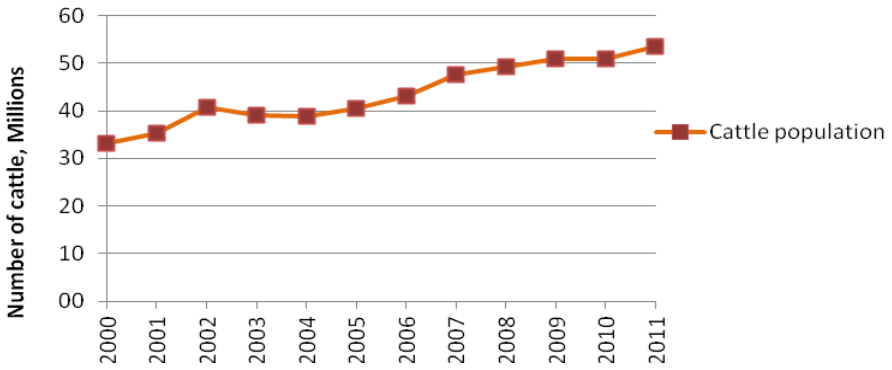

Fig. 1 Cattle population in Ethiopia 2000 – 2011 (FAOSTAT, 2011)

The livestock sector in Ethiopia accounts for 16% of the national and 27-30% of the agricultural GDP. 13% of the country's export earnings are due to leather and live animals exportation (MOARD, 2007).

Cattle herds of most Ethiopian holdings are small ranging from one to nine head of cattle. Larger herd sizes are relatively rare (Table 1).

Table 1. Herd sizes across holdings in Ethiopia (CSA, 2011)

Cattle herd size	Number of holdings	%
no cattle	3,053,376	20.24
1–2 head	4,087,174	27.09
2–4 head	3,941,672	26.12
5–9 head	3,103,524	20.57
10–19 head	755,661	5.01
>= 20 head	146,450	0.97
Total	15,087,857	100

Local breeds comprise 99.26% of the total cattle population. The remaining highly productive exotic breeds (0.13%) and their crosses with local breeds (0.64%) do currently not even reach 1% of the total cattle population (CSA, 2011). Present-day Ethiopian cattle population can be classified in four main groups, the Humpless Shorthorn and Longhorn (*bos taurus*), the humped Zebu (*Bos indicus*), the Sanga (interbreed of Zebu and humpless cattle) and the Zenga (interbreed of Sanga and Zebu type) (Rege et al., 1994; Wuletaw, 2004b). The main indigenous cattle breeds/populations identified, characterized and recognized up to now include Boran, Fogera, Horro, Sheko and Afar (Tegegne et al., 2010; FAO, 2012). Among these, Fogera and Horro are known as milk producers (Anteneh et al., 2010). Other breeds relevant for this study, but not yet recognized, are Dembia, Semein, and Wegera. These local breeds evolved mainly as a result of natural selection influenced by factors like climate, altitude, available feed supply and endemic diseases which made them adapted to harsh environmental conditions (Falvey and Chantalakhana, 1999).

Cattle are kept for many purposes depending on the production system they are situated in. The multifunctionality of cattle is a valuable attribute for smallholder in developing countries. In Fogera woreda (administrative district) of Amhara Region milk production was reported as most important function (Wuletaw, 2004b). Whereas in a livestock breed survey carried out in Oromia Region by Workneh and Rowlands, (2004)

animal traction ranked first in both crop–livestock and agro-pastoral systems; milk and reproduction was of second importance. Manure production as an important by-product should not be underestimated (Workneh and Rowlands, 2004; Anteneh et al., 2010).

The number of dairy cows of 3 to 10 years is estimated to be around 7.4 million (CSA, 2011). FAO estimated a total number of 6.6 million head of dairy cows (FAOSTAT, 2010). Male cattle used for draught comprise 25% of the 3 to 10 year old cattle and is mainly used in the highland areas (CSA, 2011). A detailed cattle population structure in Ethiopia is depicted in Table 2.

Table 2. Number of cattle by sex, breed and purpose, Ethiopia (CSA, 2011)

	Total		**Male**		**Female**	
	number	**%**	**number**	**%**	**number**	**%**
Breed						
Total	53,382,194	100	23,917,347	44.8	29,464,846	55.2
Indigenous	52,989,537	99.3	23,775,083	44.5	29,214,454	54.7
Crossbred	339,646	0.6	125, 245	0.2	214, 401	0.4
Exotic	53, 010	0.1	17,019	0.03	35,991	0.1
Purpose (3-10 years)						
Total	33,967,441	63.6	14,884,790	27.9	19,082,651	35.8
Dairy cows	7,447,238	14			7,447,238	14.0
Draught animals	13,501,418	25.3	13,346,297	25	155,120	0.3
Beef animals	463,918	0.9	390,655	0.7	73,263	0.1
Breeding animals	10,899,324	20.4	635,968	1.2	10,263,357	19.2
Other purpose	1,655,543	3.1	511,870	1	1,143,673	2.1

During the 1961-2000 period the total milk production in Ethiopia increased at an average annual rate of 1.55%. During the last decade it increased at a higher rate of 3%. At the same time per capita production declined as a result of high population

growth rate (SNV, 2008; FAO, 2003). An increased coverage of extension services, increased use of improved inputs (e.g. crossbred heifers or feedstuff) and policy changes promoting dairy production have contributed to faster growth of this sector (Ahmed et al., 2004).

The national cow milk production estimated by CSA (2011) is 4.06 billion liters (excludes milk suckled by calves). FAO estimated the total cow milk production to be around 1.77 billion liters (FAOSTAT, 2010). In general, milk production in Ethiopia is low. The average lactation period at country level is estimated to be around 6 months. The average daily milk yield per cow is about 1.85 liters (CSA, 2011). Table 3 illustrates milk productivity differences between Ethiopia and three developed dairy countries. The average daily milk yield in New Zealand, Germany and the USA is 6 to 12 times higher compared to Ethiopia (Table 3).

Table 3. Comparison of average daily and lactation milk yield in Ethiopia, New Zealand, Germany and the USA (FAO, 2010; FAOSTAT, 2010)

	Ethiopia	New Zealand	Germany	USA
Average daily milk yield / cow (in kg)	1.85	11.2	19.5	23
Average yearly lactation / cow (in kg)	269	3635	7083	9593

Multipurpose, indigenous zebu cows produce 400-680 kg of milk during one lactation period with a peak of about 2 to 5 kg per day depending on the breed. The average lactation period of a local cow is 239 days (Anteneh et al., 2010). There is great variation in milk performance between indigenous cattle breeds and genetic potentials are still not fully exploited. High producing crossbred cows produce 1120-2500 liters over a 279-day lactation period (Anteneh et al., 2010; Wuletaw, 2004b).

There are a number of reasons for low average milk yield of local cows. These factors include breeding for draught purpose, disease resistance, tolerance to tropical climates and poor nutrition (Desta, 2002). In general large variations in climate and vegetation and shortage of feed across the country are major constraints to dairy production.

Further constraints are poor infrastructure, milk collection problems, lack of technical support, institutional constraints (e.g. lack of education, extension and consulting; inexperienced staff, problem with leadership competence, slow development of cooperatives), lack of access to land and credit (SNV, 2008; Desta, 2002).

Improvement of animal productivity, animal health and better management of pastures and animal feed of higher quality are essential. Designing sustainable breeding schemes for genetic improvement through selection in local herds is a necessary step to improve productivity (Philipsson et al., 2011; Tegegne et al., 2010; Effa et al., 2003). An alternative approach to achieve higher production levels is the introduction of crossbred animals. Crossbreeding of local, adapted cattle with high-yielding breeds from the temperate zone enhances productivity and improves livelihoods of resource-poor farmers in a relatively short period of time (Wuletaw, 2004a; Tegegne et al., 2010). Exotic breeds, which are imported and crossed with the indigenous cattle breeds, are mainly Holstein Friesian and Jersey (Mureda and Zeleke, 2008; Tegegne et al., 2010).

According to Falvey and Chantalakhana (1999) milk consumption in developing countries is estimated to increase by 138% from 1993 to 2020. Per capita consumption is estimated to increase from 38 to 62 kg/person. In Ethiopia average annual milk consumption is only 19 kg per capita, whereas world average annual milk consumption is 100 kg per capita (SNV, 2008; FAOSTAT, 2003). The demand for milk in rural areas is mainly satisfied by home production or neighborhood production that supplies the informal milk market. The informal market is characterized by direct delivery of milk and milk products from producer to consumer and accounts for 95% of milk marketed. Only 5% of the production is marketed as fresh milk. Difficulties for marketing fresh milk in rural areas are limited transportation and underdeveloped market channels (Felleke and Geda, 2001; SNV, 2008)

The main milk market is in urban centers where communities have the highest purchasing power. Hence, large commercial enterprises and market oriented small-holder peri-urban dairy farms have developed and there still is potential for further development (Desta, 2002). In these urban and peri-urban areas milk is often sold

through formal milk markets (governmental and private milk channels). Smallholder farmers in rural areas are given a chance to profit from new established milk cooperatives by increasing participation in fluid milk markets (Ahmed et al., 2004; Falvey and Chantalakhana, 1999). In 2000 97% of milk consumed was produced by smallholder farmers. The contribution of smallholder production to total consumption has increased by 30% from 1985 to 2000 (SNV, 2008).

4.2. Dairy production systems in Ethiopia

In the traditional milk producing regions, especially those of Africa, milk production is mainly occuring on small farms. Smallholder dairy production systems, where milking is done manually, are highly labour intensive and heavily rely on family labour (Anteneh, 2010). Dairying uses feed resources efficiently and as milk is produced and sold daily, provides regular income to the producer (Ayenew et al., 2008). Milk is perishable and bulky, that is why it requires strict quality regulations and has high transport cost (Walshe et al., 1991). A large variety of high quality milk products is produced which are highly palatable and nutritious and provide added value (Ayenew et al., 2008). With increasing distance to market processed, long life dairy products are replacing milk as major product (Falvey and Chantalakhana, 1999).

The dry zones and highlands of Ethiopia have a long tradition of cattle keeping. Zonal differences in production systems reflect dietary and cattle keeping habits of local population (Falvey and Chantalakhana, 1999). The Ethiopian dairy sector has been classified in various ways. Ketema and Tsehay (1995) distinguishes four major systems of milk production. These are the pastoralist system, rural highland smallholder dairy farming, urban and peri-urban small scale farming and intensive large-scale systems. Relevant for this study were the rural highland smallholder and the urban/ peri-urban small scale dairy farming systems.

4.2.1. Pastoralism

Pastoralism is the major system of milk production in the low lands. These areas comprise 60% of the total land area and have altitudes below 1500m.a.s.l. About 12.2%

of the total Ethiopian human population (Hussen et al., 2008) and 30% of the livestock population is found in pastoral areas (Ketema and Tsehay, 1995; Effa, 2003). Pastoralists are primarily dependent on livestock production which is considered as means of survival. It provides all consumable and saleable produce and is regarded as insurance against adversities. Cattle dominate the livestock population with 55.4% of the TLU, followed by camels (15.3%), goats (13.7%) and sheep (6.4%) (Hussen et al., 2008). Because of extreme variability and unreliability of rainfall patterns, resulting in scarcity and seasonal variability of vegetation, milk production per unit is low and highly seasonal (Ketema and Tsehay 1995; Desta, 2002; Hussen et al., 2008; Hogg, 1997). Draughts occur once every 4-5 years (Hogg, 1997). The regions are also characterized by tribal conflicts, poorly developed infrastructure and lack of adequate social services and institutions. Even though pastoralists are efficient rangeland and livestock managers who developed coping mechanisms to survive in these harsh environments, they become more and more vulnerable in a growing process of impoverishment (Futterknecht, 1997; Effa, 2003)

4.2.2. Large scale intensive dairy farming

This system is characterised by specialized, market oriented dairy operations run by the state and increasingly by private persons. Most of these farms are located in and around Addis Ababa and other regional capitals and mostly use exotic high grade (more than 87,5% exotic blood) or pure exotic dairy stock (Ketema and Tsehay, 1995; Anteneh et al., 2010; Desta, 2002; SNV,2008). The average holding size is 8.9 ha managing 17 cows. Inputs such as improved genotypes, artificial insemination (AI), improved forage production, improved housing, concentrate feeding, veterinary care among others are used (Tegegne et al., 2007). A few milk-processing plants supply fresh processed milk and dairy products to major urban centers. Although these urban and peri-urban farms are important and regular suppliers of milk to major urban centers, they produce only 2% of the total milk production of the country (Anteneh et al., 2010; SNV, 2008).

4.2.3. Urban and peri-urban small-scale dairy farming

This system is developed in and around major cities and towns located mainly in the highlands of Ethiopia. It comprises of small and medium sized dairy farms which are capable of keeping improved dairy stock. Cattle are housed in improved shelters made of locally available materials (Desta, 2002). As farmers have limited access to farming or grazing land, they are often based exclusively on livestock under stall feeding conditions (Ayenew et al., 2008). The main feed resources are agro-industrial by-products and purchased roughage. The primary objective of milk production is generating additional cash income (Ketema and Tsehay, 1995; Aneteneh et al., 2010; Desta, 2002). This production system serves as the main milk supplier to the urban market (Ayenew et al., 2008; Ahmed et al., 2004). Milk is either sold to dairy cooperatives, on the local informal market or directly to consumers from the farmers' gates (Tegegne et al., 2007). Of all urban producers 71% sell milk directly to consumers (Tsehay, 2001).

4.2.4. Rural highland small-holder dairy farming

The Ethiopian highlands cover over 40% (approx. 490.000 km^2) of the country and are the largest of their kind in Sub- Saharan Africa. Most parts of the highlands are used for both crop and livestock production (mixed farming) within subsistence smallholder farming systems (Ketema and Tsehay, 1995; Anteneh et al., 2010). Food crop production is considered as the main agricultural activity, whereas livestock in the traditional farming system serve as source of draft power and manure for improvement of soil fertility, utilisation of crop residues and as a source of cash (Tesfaye et al., 2001; Effa, 2003). Draught animals play a key role in aquiring national food security as motorization is not yet developed (De Leeuw and Reid, 1995). Opportunities for dairy development offered by the mixed farming system have not been fully utilized yet (Ketema and Tsehay, 1995; Ahmed et al., 2003; Anteneh et al., 2010); that is why the National Dairy Research Strategy Document prioritizes this zone for dairy development (Effa et al., 2003).

Livestock is mainly grazed on natural pastures of non-arable or fallow land between crop fields and additionally fed crop residues (SNV, 2008; Desta, 2002; Tesfaye et al., 2010). Green fodder accounts for about 58.67% followed by crop residues with 29.19%. Hay (7.35%) and by-products (0.83%) are also used as animal feed. Improved concentrate feed accounts for only 0.25% (CSA, 2011). During wet season an increase of animal weight and milk production is achieved. During dry season productivity losses can be observed as quantity and quality of feed are restricted (Walshe et al., 1991; Falvey and Chantalakhana, 1999). The size and quality of communal grazing lands have been substantially reduced during the past five years across all areas studied by Tesfaye et al. (2010). Most natural pastures do not provide adequate nutrition and would rarely support milk-yields of over 3 to 4 kg per cow per day (Walshe et al., 1991; SNV, 2008). Diets based on crop residues are often deficient in protein, energy, minerals and vitamins (Falvey and Chantalakhana, 1999). Apart from the productivity problems already mentioned, these constraints also result in biodiversity loss and high cost of feed (Tesfaye et al., 2010; Ahmed et al., 2004). Introduction and cultivation of improved forages like grasses, fodder trees, shrubs and legumes could improve feeding value and milk yields (Walshe et al., 1991).

There are two types of dairy systems in the highlands: the traditional and the market oriented system. The traditional system is based on indigenous breeds which have low production performance (Ketema, and Tsehay, 1995; Desta, 2002). The milk produced is mainly used for home consumption and feed requirements are entirely satisfied from native pasture, crop residues, stubble grazing or agricultural by-products (Falvey and Chantalakhana, 1999; Ketema and Tsehay, 1995; Anteneh et al, 2010). During the night livestock are kept outside in corrals (Desta, 2002). The market oriented system is based on improved crossbred dairy cattle where milk is an important source of cash income (Ahmed et al., 2003). Only a very small part of milk is used for processing and home consumption (Desta, 2002; Ketema and Tsehay, 1995). Farmers need to feed their cows additionally with concentrates and agro-industrial by-products such as brewery residues, wheat bran, oilseed cakes, mineral mixtures and molasses (SNV, 2008) and keep their cattle in improved shelters. These technologically improved farms are

generally concentrated in areas with good infrastructure close to major markets (Walshe et al. 1991).

4.3. Impact of dairy production on natural resources

In the Ethiopian highlands population and livestock pressure (up to 120 people and 130 TLU/km^2) is a key contributor to environmental degradation (de Leeuw and Reid, 1995; Effa et al., 2003). Due to a growing response to the demand for livestock products and an increase in cropland area, larger concentrations of animals have led to degradation of rural grazing areas and the clearing of forests. Collective establishment of grazing restrictions and regulations of use of common grazing lands are necessary strategies to reduce damage (Delgado et al., 1999; Benin and Pender, 2006). Statistical information on land utilization in Amhara Region can be an indication on how severely this area is affected by ecological degradation. Around 87% of the total land area is crop land (temporary and permanent crop production), 5.7% is grazing and 2.4% is fallow land. Wood lands comprise 0.9% and 4.1% is used for other purposes. The average holding size is 1.5 ha and the average household size is 4.9 (CSA, 2011).

In a study by Tschopp et al. (2010) carried out in SNNPR (Southern Nations, Nationalities, and People's Region),- Amhara and Oromia Region the majority of farmers stated that they needed to prioritize cropland to feed their growing families and that high stocking density on communal land led to overgrazing of pastures.

Grazing in a proper way maintains soil fertility and improves soil cover. Overgrazing contributes substantially to desertification, land degradation, soil compaction through trampling, decrease in soil fertility and loss of water infiltration and storage (Delgado et al., 1999; de Leeuw and Reid, 1995). Heavy grazing reduces plant regrowth vigour and capacity thus decreases protective plant cover (Hiernaux, 1994).

Fig. 3 Soil erosion in Ethiopia's highlands I (Kluszczynska, 2011)

Fig. 2 Soil erosion in Ethiopia's highlands II (Kluszczynska, 2011)

"Climate change related hazards have severe impacts on agriculture. Erratic rainfall and excessive evapo-transpiration due to extended drought season causes drastic crop failures, decreased biomass yield, low carrying capacity of grazing lands and loss of biodiversity" (Mengistu, 2009). Flooding, erosion and siltation of lakes and watercourses has become a common scenario in Ethiopia (Desta, 2005; Smit, 2012). Rapidly diminishing ground water supplies and emerging conflicts over shared resources could deteriorate the situation in future (Tschopp et al., 2010; Tesfaye et al., 2010; Effa et al., 2003).

Fig. 5 Siltation of the Blue Nile River (Kluszczynska, 2011)

Fig. 4 Siltation of water courses (Kluszczynska, 2011)

These trends further result in limited feed resources for both human and livestock, associated health problems and migration to urban areas. Poverty and food insecurity are widespread. In Ethiopia 38.7% of the population lives below the poverty line (CIA,

2011) and 41% of the total population has been undernourished in 2006-2008 (FAO, 2011).

According to Blata (2010) farmers are aware of on-going soil erosion on their farming land, but mainly perceived causes are high rainfall and steep slopes. Further causes mentioned were lack of maintenance and wrongly designed soil and water conservation structures. Most farmers did not associate overstocking, excessive tillage practices, deforestation and poor soil cover with soil erosion.

Ways must be found by which livestock production in fragile environments can be increased in a sustainable manner, without disturbing the delicate balance of the interaction between livestock and environment (Ethiopian Society of Animal Production, 2009; Falvey and Chantalakhana, 1999). The use of exotic and crossbred cattle genetics is considered as a rapid and potentially sustainable path to higher productivity (SNV, 2008).

4.4. Animal health management and constraints

In Ethiopia, health service is the responsibility of the government with limited involvement of the private sector and NGOs (Walshe et al., 1991; Tegegne et al., 2010; Admassu, 2003). Private veterinary practitioners, most notably drug shop owners, are increasing in number, whereas the availability of clinical and diagnostic services is limited and concentrated around Addis Ababa (Admassu, 2003). The estimated number of vaccinated cattle per year is about 17.34 million. Vaccinations mainly target diseases like anthrax, blackleg, pleuro-pneumonia and hemorrhagic septicemia. Out of 8.96 million cattle suffering from disaeses, about 5.10 million were treated (CSA, 2011).

Constraints in the provision of animal health service are limited infrastructure and accessibility, uncontrolled cross-border animal movement, insufficient disease surveillance and poor communication facilities (Rutebarika et al., 2003). Livestock keepers complain about shortage of qualified staff, lack of information flow, inadequate and unreliable supply of drugs, poor diagnostics capability and lack of confidence in service quality (Tegegne et al., 2010).

It is essential to ensure that producers have access to an efficient, reliable veterinary service, which is of particular importance when less resistant crossbred animals are being introduced (Walshe et al., 1991). As markets for milk from smallholder farmers become more sophisticated and infrastructure improves, the provision of health inputs becomes more widespread and affordable. Initially this happens through cooperatives and with government support, but as markets develop private vets can provide these services and goods (Falvey and Chantalakhana, 1999). A lot of basic veterinary work could be carried out by agro-vets, veterinary assistants or livestock extension staff under the supervision of a veterinarian (Walshe et al., 1991).

4.5. Milk marketing and constraints

Smallholder farmers have a weak and vulnerable situation on the market and are strongly dependent on the milk price. They are able to adjust to market changes in a limited, gradual and slow way. Farmers need a secure outlet and a guaranteed price; therefore the processing industry is very important to the sector (Falvey and Chantalakhana, 1999).

In Ethiopia only 15.4% of the produced milk is sold, 54.7% of the milk is consumed at home and 29.5% is processed. In Amhara Region only around 7% of the produced milk is sold, 43% is used for home consumption and 50% is processed (CSA, 2005)

There are large seasonal fluctuations in supply (due to changeable weather conditions) and demand (during fasting periods) (Walshe et al., 1991). Ethiopia's milk yield falls by more than 50% during drier periods which last up to 6 months per year. Due to limited capacity to process milk into dairy products with a long shelf-life, Ethiopia experiences predictable periods of scarcity, with part of the deficit filled by imported dairy products (SNV, 2008). Poor market access due to remoteness restricts smallholder farmers to reach markets and high transportation and transaction costs reduce farm-gate prices (Ayenew et al., 2008). Ahmed et al. (2003) indicated that such impediments rather reduce participation in economic transactions and result in subsistent rather than market-oriented production systems.

The expansion of market participation is both a challenge and an opportunity to organise small-scale dairy producers into milk groups or producer-owned milk cooperatives (Ahmed et al., 2004). This action has the potential to mitigate transport costs, increase bargaining power and create an opportunity to obtain new inputs and technologies (Effa, 2003).

4.6. Breeding practices

For current and future challenges, it is imperative to develop and implement cattle genetic improvement strategies in Ethiopia which are sustainable and suitable to prevailing production systems (Effa et al., 2003). The most productive and adapted animals for each environment must be identified for breeding purposes (Philipsson et al., 2011). Dairy cattle breeding methods can generally be classified into pure breeding and crossbreeding systems.

4.6.1. Pure breeding/ Selection within breeds

A characteristic of pure breeding systems is mating of individuals within one population with the result of increased homozygocity and steady performance of purebreds (Willam and Simianer, 2008). The goal is to exploit additive allele gene effects, identify individual superior genotypes and multiply them in the next generation (Payne and Hodges, 1997). A selection program should include a central nucleus herd based on pedigree information and progeny testing which tests bulls by measuring the milk yields of their daughters (Syrstad and Ruane, 1998; Mason, 1982). Good results of breed improvement by pure breeding were achieved in temperate countries through sophisticated selection programs (Mason, 1982). In the tropics acceptable results were reported in case of Sahiwal cattle (Ilatsia et al., 2011).

Constraints of pure breeding systems in the tropics are reduced intensity of selection because of low reproductive rates, high calf mortality and prolonged generation interval of indigenous breeds (Syrstad and Ruane, 1998). Furthermore, lack of infrastructure, communication and production intensity in the tropics is often not compatible with requirements for an effective selection program (Mason, 1982). A nation-wide milk

recording scheme and cooperation between smallholders, AI system, and well trained extension service is needed.

4.6.2. Crossbreeding

Crossbreeding is mating of individuals from two or more different populations, in order to combine traits (combination effect) and to make use of genetic effects which do not appear in pure breeding (Baumung, 2005). Crossbreeding in tropical countries is undertaken to combine superior hardiness, heat tolerance, disease resistance and environmental adaptability of indigenous cattle with superior high milk yield, faster growth rates and early maturity of exotic, temperate breeds (Walshe et al., 1991; Falvey and Chantalakhana, 1999; Tadesse and Dessie, 2003).

Any crossbreeding option requires purebred populations. To be successful, selection in the contributing pure breeds or the resulting synthetics is integral (Cunningham and Syrstad, 1987; Mason et al., 1982; Swan and Kinghorn, 1992). Furthermore, a crossbreeding program should be relatively simple and in harmony with other aspects of the production system (Willam and Simianer, 2008).

Ethiopia received its first exotic cattle (Holstein Friesian and Brown Swiss) in the 1950's from the UN Relief and Rehabilitation Administration and since then started commercial liquid milk production on government stations (Ahmed et al., 2004). Crossbreeding itself did not start until 1967/1968 when the Chilalo Agricultural Development Unit (CADU) was formed at Asela station. This project, established jointly by the Ethiopian and Swedish Governments, made the first steps in introducing crossbreeding at smallholder farm level (Kiwuwa et al., 1983). After recognizing the genetic improvement possibilities, similar dairy-development programs were implemented in Ethiopia with assistances from international agencies (MOARD, 2007).

4.6.2.1. Genetic background

The basic objective of crossbreeding is the exploitation of additive and non-additive allele gene effects. The additive component is a combination of separate strains or traits and an accumulation of genes from generation to generation. It is proportional to the

gene contribution from each strain (Cunningham and Syrstad, 1987). Crossbred animals are expected to represent an additive genetic merit by being the mean of both parental breeds (Swan and Kinghorn, 1992). This additive component can be divided into paternal and maternal additive genetic effects which lead to improvement (Willam and Simianer, 2008).

The non-additive effect or heterosis (hybrid vigor) is the phenomenon that crossbred offspring perform better than the average of the purebred parental breeds (Dalton, 1985; Swan and Kinghorn, 1992). Crossbreeding increases heterozygocity, which means an increase in the proportion of heterozygous loci (McDowell et al, 1996). Heterosis is fully exploited when non-related breeds are crossed or when parental genotypes differ significantly from each other (Dalton, 1985; Payne and Hodges, 1997).

The genetic base of heterosis are dominance (interaction within loci) and epistatic effects (interaction between loci). When the genetic performance of crossbred offspring (heterozygous) is higher than mean performance of parents (homozygous), it is referred to as dominance effect (Baumung, 2005). As favorable genes generally dominate unfavorable genes (McDowell et al., 1996), dominance usually has a positive effect, especially in fitness traits with low heritability and results in higher adaptability to stressful environments (Swan and Kinghorn, 1992). Epistasis is the interaction of alleles at more than one neighboring loci which can have negative effects in crossbreeding (Cunningham and Syrstad, 1987; Baumung, 2005). Pure breeding over many generations with selection for a specific trait (e.g. increased milk yield in HF) might have accumulated favorable epistatic interactions between genes at different loci. Through crossbreeding (e.g. HF with Boran unselected for milk), this balance is out of harmony (Swan and Kinghorn, 1992). Favorable epistatic interactions between genes might break down due to free recombination process during meiosis (Demeke et al., 2000; Madalena, 2005). Furthermore when crossbred animals are mated among each other (crossing over), the heterosis effect will be reduced (Willam and Simianer, 2008; Baumung, 2005).

4.6.2.2. Crossbreeding in practise

In the starting phase of a crossbreeding program there is a significant improvement in performance due to the heterotic superiority of the first cross generation (F1) compared to the mean value of both origin breeds (Cunningham and Syrstad, 1987; Walshe et al., 1991; Kahi, 2002; Mc Dowell et al., 1996). Crossbreds have higher milk yields, increased lactation lengths, shorter calving intervals and calve at a younger age than the indigenous stock (Mc Dowell, 1985; Galukande, 2010). Calf mortality and health costs of calves are lower in F1 generations compared to other crossbred grades (Madalena et al., 1995; Teodoro et al., 1994).

Further upgrading through producing second generation crosses (F2) by inter se mating of F1 generations, or backcrossing (B1, B2) through crossing F1 to one of its parent breeds, results in serious deterioration of performance compared to F1. This effect is ascribed to reduction in heterozygosity and loss of beneficial epistatic effects (Cunningham and Syrstad, 1987; Syrstad and Ruane, 1998).

Results from a study in Ethiopia in Table 4 andTable 5 illustrate the superiority of crossbreds to local Boran in milk production and reproductive performance (= direct individual heterosis) and indicates the inferiority of F2 and backcrosses to F1 generations (= negative direct epistatic effects).

Table 4. Milk production performance of local, crossbred and exotic cattle in Ethiopia (Demeke et al., 2000)

Breed	DMY (kg)	LMY (kg)	LL (days)	Location
Boran (B)	3.4	771	198	On station
Holstein Friesian (H)	9.8	3311	335	On station
F1 (H x B)	6.2	2278	374	On station
F2 (HB x HB)	5.6	1947	348	On station
B1 (5/8H3/8B)	6.3	2194	339	On station
B2 (3/4H1/4B)	6.9	2312	348	On station

DMY= daily milk yield, LMY= lactation milk yield, LL= lactation length

Table 5. Reproductive performance of local, crossbred and exotic cattle in Ethiopia (Demeke et al., 2004)

Breed	AFC (month)	CI (days)	NSPC	Location
Boran	42.5	473	1.71	On station
Holstein Friesian	37.3	459	1.73	On station
F1 (H x B)	36.0	417	1.49	On station
F2 (HB x HB)	39.6	435	1.60	On station
B1 (5/8H3/8B)	38.5	426	1.41	On station
B2 (3/4H1/4B)	36.7	444	1.70	On station

AFC= age at first calving, CI= calving interval, NSPC= number of services per conception

When comparing performance of different grades of crosses, various reports show different results. The majority of scientific studies indicate that performance is always improving until 50% inheritance of *bos taurus* genes (Cunningham and Syrstad, 1987; Falvey and Chantalakhana, 1999; Galukande, 2010). Further upgrading (>50% *bos taurus* genes) does not show a clear trend (Cunningham and Syrstad, 1987; Walshe et al., 1991; Galukande, 2010).

Some reports indicate that lactation milk yield (LMY) and daily milk yield (DMY) normally remain approximately constant between 50% and 100% exotic inheritance (Kahi, 2002; Ahmed et al., 2007). Some study results show that increasing *bos baurus* genes beyond 75% resulted in decreased LMY and herd life (Katpatal, 1977; Goshu, 2005; Galukande, 2010).

Reduction of age at first calving (AFC) with increasing levels of exotic genes up to a level of 67% exotic inheritance has been reported (Kahi, 2002). Ahmed et al. (2007) on the other hand reported the earliest AFC (41.56±2.16 months) in a 37.5% exotic genes group while the latest AFC (49.01±1.29 months) was recorded for the 62.5% exotic genes group. Lactation length (LL) increased with increasing exotic inheritance (Kahi, 2002; Ahmed et al., 2007). Calving interval (CI) followed the pattern of lactation length

(Kahi, 2002). Other results were reported by Rege (1998): the shortest CI was observed for animals with 50% exotic genes.

Performance of crossbreds can differ because of large environmental and socio-economic variations that exist in the tropics and the genotypes involved (Galukande, 2010; Kahi, 2002).

4.6.2.3. Types of crossbreeding

Before implementation of a breeding strategy it is necessary to oppose operational costs against the genetic benefits resulting, which depend on the exploitation of the additive and non-additive effects. Three crossbreeding schemes applicable in the tropics are as follows.

4.6.2.3.1. Grading up

Grading up (or topcrossing) is a crossbreeding strategy common in the tropics because of its relatively simple implementation. Usually indigenous female animals are mated with exotic males through AI (Galukande, 2010). Continues grading up with exotic animals leads to replacement of more than 90% of the local genotype. In many instances grading up to a certain percentage of exotic blood is desirable taking prevailing local conditions and requirements into account (Cunningham and Syrstad, 1987).

4.6.2.3.2. Composite breeding

“The aim of composite breeding is to develop a new, composite or synthetic breed made up of two (or more) component breeds and to benefit from combined favorable characteristics of the different breeds” (Willam and Simianer, 2008).

A synthetic population can be formed either by continuous inter se mating of F1 individuals or through backcrossing to the superior breed. The synthetic breed is always inferior to the original cross from which it was formed (Cunningham and Syrstad, 1987); that is why successful composite breeding requires consistent selection within the

crossbred population (Mc Dowell et al., 1996; Philipsson et al., 2011). After a certain number of generations the performance level of the population is balanced and the animals can be considered as purebred (Willam and Simianer, 2008). Examples of synthetic breeds are the Jamaica Hope (3/4 Jersey), the Cuban Sibovey (5/8 Holstein Friesian), the Australian Milking Zebu (3/4 Jersey) and the Brazilian Pitanqueiras (5/8 Red Poll) (Mc Dowell et al., 1996)

In small scale dairying Syrstad and Ruane (1998) suggest the composite breed strategy as the most practical approach because of its organizational simplicity. Kahi et al. (1999) point out that a sufficient breeding population size is necessary to achieve efficient genetic improvement in a synthetic breed and emphasizes that more attention should be given to the use of synthetics.

4.6.2.3.3. Rotational crossing

This mating system rotates purebred sires from each breed used in the crossbreeding system to inseminate female animals. The sires allow genetic gain in a population (Willam and Simianer, 2008). Ideally tropical sires should come from an improved local breed under selection and temperate sires should be selected from a herd bred in the local environment (Thorpe et al., 1995). Two and three-breed rotational crossing can be differentiated. Such systems allow continuous raising of replacement heifers on farm, which keeps replacement costs in rural areas low. Disadvantages are less exploitation of heterosis and additive effects as well as wide fluctuations in breed characteristics between generations (Cunningham and Syrstad, 1987; Kahi et al., 1999). Rotational crossing leads to somewhat better dairy performance compared to synthetics, mainly because of more heterozygocity. Cunningham and Syrstad (1987) consider rotational crossing as a suitable strategy for large farms but less practical for small farmers because of organizational and management problems. Thorpe et al. (1995) on the other hand suggest that where AI service is available and efficient, rotational crossing on herd basis can also be applied for smallholder systems. Some difficulties can be encountered when farmers are reluctant to use semen from local bulls once they realize the superiority of crossbreds and continue repeated mating with exotic bulls.

4.6.2.4. Critical aspects and challenges of crossbreeding

The performance of crossbreds at organized farms and institutional herds, where optimum inputs and health care are available, is good. Very few reports were obtained on performance under village conditions (Venkatasubramanian and Fulzele, 1996; Singh, 2011). Crossbreeding comes with arguments in favour and against its implementation (Venkatasubramanian and Fulzele, 1996). Before the introduction of any genetic improvement program all aspects of a production system need to be analyzed. Agricultural and land use policies, market information and access, environmental conditions, characteristics of animal populations and infrastructure available are examples of such factors (Philipsson et al., 2011). Crossbreeding requires a package approach which supports farmers with fitting techniques in various management aspects and support of well-trained local extension service personel (Madalena, 2005). Crossbreeding requires an increase of inputs in health service, mating service, improved nutrition, shelter provision, and therefore results in higher workload and investment costs (Mureda and Zeleke, 2008; Manoharan et al., 2003). A prerequisite for good market access and the adoption of new technologies is good infrastructure (roads, transportation, public utilities, research facilities) (Falvey and Chantalakhana, 1999; Juma, 2011). Success stories are clearly available from countries that possess good infrastructure (Madalena, 2005; Juma, 2011) and were management of animals is good (Bee et al., 2006; Galukande, 2010; Demeke *et al.,* 2004). Many crossbreeding programs failed because they were too complicated to conduct in practice (Philipsson et al., 2011).

Crossbreds are more susceptible to diseases such as foot and mouth disease, infectious bovine rhinotracheitis, brucelosis, tuberculosis, mastitis, hoof disorders and laminitis (Singh, 2011). In a study by Molalegne and Shiv (2011) reproductive problems like metritis, abortion, retained fetal membrane, dystocia, repeated breeding, anoestrous and vaginal and uterine prolapse occurred more often in crossbreds (43.7%) than in local cattle (24.5%). Under identical field conditions local cattle are less infested with ticks compared to crosses (Wambura et al., 1998). Therefore resistance traits of local cattle used as base population are required in early stages of an upgrading program

(Falvey and Chantalakhana, 1999). Not sufficiently adapted genotypes (e.g. HF) are most severely affected by heat stress (Falvey and Chantalakhana, 1999). If heat depresses appetite or poor fodder cannot support lactating animals, energy deficit and stress reduce cow fertility, fitness, and longevity (King et al., 2006). Inappropriate input supply (e.g. prophylactic vaccines, cut-and-carry system) can worsen health problems and can lead to lower growth rates and reproductive inefficiency of crossbred animals (Mureda and Zeleke, 2008; Lobago et al., 2007; Agarwal et al., 2007, Mc Dowell et al., 1996).

Appropriate exotic blood levels of crossbreed animals have to be determined in conformity with the agro-ecology and management capacity of target area and user group (MOARD, 2007). Upgrading to high levels of exotic blood (mainly through use of AI) in an environment that cannot support such animals, results in a decline of productivity and is not advisable (Madalena, 2005; Philipsson et al., 2011). Many crossbreeding programs based on AI have lacked long-term strategies on how to maintain a suitable exotic blood level (Philipsson et al, 2011).

A serious constraint in breeding programs including smallholders is the incompleteness or absence of performance recording systems (Lobago et al., 2007; Desta, 2002; Falvey and Chantalakhana, 1999) and lack of clearly defined breeding objectives. For this reason breeding value estimation and selection for various traits is difficult (Desta, 2002).

Crossbreeding can be a reason for erosion of livestock genetic recource in some areas (Syrstad and Ruane, 1998).

4.7. Mating options

Variouse options for mating of dairy cattle can be used to fit different production systems and situations.

4.7.1. Natural mating

The use of bulls for natural service remains widespread in Ethiopia. Mating often occurs randomly on communal grazing grounds and often there is no strict selection of mating pairs (Bittner et al., 2000). Many farmers believe that natural mating results in higher pregnancy rates (Desta, 2002). According to Malik et al. (2012) the pregnancy rate of postpartum oestrus synchronized beef cattle was higher in the natural service group (28.6%) than in the AI group (18.0%). Haile-Mariam et al. (1993) and Mwatawala and Kifaro (2009) reported that calving interval of Boran cows inseminated by natural service was shorter compared to cows for which AI serviced has been used. Furthermore heifers mated with bulls were younger at first calving. Many factors contribute to this such as poor heat detection skills of farmers and improper timing of AI service. Cows mated naturally conceive earlier because bulls have a natural advantage of stimulating oestrus activity and detecting heat in cows (Mwatawala and Kifaro, 2009; Malik et al. 2012). It is indicated that numbers of services per conception (NSPC) is lower under uncontrolled natural breeding and higher when hand-mating or artificial insemination is used (Mwatawala and Kifaro, 2009).

Results from a study conducted in Florida (de Vries et al., 2005) show that there is no significant difference of pregnancy rates and milk production between cows served by natural breeding and by AI. This could be an indicator for a better functioning AI service in the study area.

Good quality breeding bulls are available in Ethiopia and bull service has been efficiently utilized by both smallholders and commercial dairy farmers. It is considered as best solution when there are problems with AI service (MOARD, 2007). First bull stations were established by CADU and some NGOs in the 1960's.

An important negative aspect of natural mating is the risk of infection with venereal diseases. There are several sexually transmitted bacterial, protozoal, viral and mycoplasmal infections common in Ethiopia which can result in infertility or abortions (Desta, 2002).

4.7.2. Artificial insemination

AI service in Ethiopia is mainly provided by a government institution named National Artificial Insemination Centre (NAIC) which was established in Kaliti in 1981 (Tegegne et al., 2010). Cattle breed improvement and multiplication centres were established with the aim to distribute improved animals to smallholders (Tegegne et al., 2010). From 1997 - 2000 most of the inseminations were done in Addis Ababa (33.7%) and Oromiya (37.5%) followed by Amhara (13.9%) and SNNPR (9.4%).

Benefits from the use of AI are numerous. Frozen semen can be transported globally and stored for a long period of time. The risk of disease infection and injury is minimized (Desta, 2002). From a genetic improvement point of view AI is beneficial because it increases selection intensity of bulls and allows efficient bull usage (Cunningham, 2010).

While successful in developed countries, AI has failed in many developing countries due to lack of infrastructure, communication, inefficiency of AI service and high costs of liquid nitrogen transport and storage (Desta, 2002; Philipsson et al., 2011). In Ethiopia during semen handling procedures at field level 11% of semen is lost and semen quality can be seriously affected (Desta, 2002). Mekonnen T. et al. (2010) further state factors like poor heat detection skills, absence of insemination service on holidays, shortage of experienced inseminators, poor feeding and management of dairy cows/heifers, early embryonic mortality and ovarian cysts as possible reasons for poor AI efficiency. For effective delivery of input services Ergano and Duncan (2010) proposed decentralization of semen production to regions and creation of awareness.

4.7.3. Embryo transfer

Embryo transfer (ET) is an advanced reproductive technology wich increases the reproductive rate of cows (more than fivefold per lifetime) and allows higher selection among females. Before transferring the embryo from the donor cow to the recipient cow, multiple ovulation and oestrus synchronization are induced (Seidel and Seidel, 1991).

The application of ET in Ethiopia is currently very restricted because it is costly and requires high technology. Debre Zeit Research Station initiated an ET program with the objective to produce animals for research purposes only (Desta, 2002).

4.8. The Integrated Livestock Development Project (ILDP)

The agreement to implement the ILDP in North Gondar was signed in January 1998 between the Bureau of Agriculture Amhara National Regional State and the Austrian Embassy Development Cooperation as a bilateral cooperation (ILDP, 2007).

The project has been implemented for a period of almost 10 years (1998 to 2007) with the overall objectives to improve living standards of households through increased livestock productivity, to conserve natural resources and to contribute to food security in North Gondar. The project covered 14 woredas among the 18 woredas of the zone with different intensity and targeted 225,000 households (63% of households).

A number of strategies were implemented. Mapping of possible intervention areas with potential for dairy development was a primary task. Support covered a wide scope of aspects from training to input supply. The project integrated local knowledge and used innovations sequentially. Five project components can be distinguished. All information on the project was gathered from ILDP mid-term evaluation report (2003) and ILDP terminal report (2007).

4.8.1. Feed resource development and environmental protection

As adequate feed is a prerequisite for improving livestock productivity, project activities targeted: pasture improvement (pasture management, stock exclusion, use of improved grass-legume mixtures and application of fertilizer) and production of improved fodder crops. 880 farmers were involved in seed and seedling production on base of contract seed production agreements. This covered 95% of the total seed demand of the project. Approaches taken towards environmental protection were compost production and gulley rehabilitation. Activities included: development of soil and stone bunds, strip planting and fencing. Further activities included introduction of hay and silage making,

use of urea molasses blocks and supply of by-products of Dashen brewery from Gondar.

4.8.2. Improvement of animal health service

In this package activities included: service provision by community based animal health workers, mobile animal health service, support of ill-equipped government animal health clinics, promotion of preventive vaccination and prophylactic treatment, studies on ethnological veterinary practices and water provision. Trained para-vets now cover 129 *kebeles* which increased previous coverage of the project area by 33%. 310 water bodies were treated with *Phytolacca dodecandra* (Endod), a plant species found naturally in Ethiopia causing mortality of leech populations. In the project regions this saved around 488,700 animals from being infected by leeches. However this natural pesticide has to be applied carefully as it is toxic for other aquatic animals like fish and frogs (Eguale et al., 2010).

4.8.3. Animal genetic resource improvement

To improve the productivity of local cattle, selection and breeding were chosen approaches. One action was the distribution of 461 selected Fogera, Barka and Highland Wogera bulls to appropriate areas. Crossbreeding of Fogera bulls with local highland cattle resulted in the production of faster growing, early maturing and large framed animals that have more traction power and meat production. Furthermore the project has started a Fogera breed conservation program.

Crossbreeding with Holstein-Friesian and Jersey sires on the other hand has improved milk production in the project area. Implementation was based on promotion of AI, distribution of crossbred bulls and contractual cattle breeding. Bulls and AI were used in 12 milk shed areas preceded by the construction of 2 rural AI centers and AI technician training including farmer AI technicians. More than 15,480 cows were inseminated and an estimated 4500 to 5,200 cross breeds have been produced. Crossbred breeding bulls were distributed to farmers (often in remote areas) resulting in the establishment of private bull stations. Around 650 crossbred heifers were distributed to selected

beneficiaries within the contractual breeding arrangements on credit base. An innovative and flexible credit system allowed farmers to pay back in kind, mainly through their first offspring. This was designed to improve the supply of crossbred animals in the project areas.

Castration of bulls was used to reduce the risk of uncontrolled mating and consequently genetic dilution and to control the expansion of the program. Some 2400 households introduced backyard stall-feeding which significantly reduced free grazing and its impact on land degradation.

4.8.4. Improving market outlets for livestock and livestock products and cooperative development

Formation of farmers' cooperatives to increase their capacity and to link farmers to markets was an important target. Achievements include construction of 9 cattle fattening associations and 11 dairy associations. Ten milk units have been constructed and dairy equipment was supplied on credit base. One small scale milk processing plant was established, and 5 private milk dealers started with milk collection, processing and marketing.

4.8.5. Capacity building, networking and gender

Thousands of farmers were effectively trained on different aspects of animal genetic resource improvement, improved techniques in livestock husbandry and forage production. Farmers made visits and shared experiences on selected activities. It was ensured that women participated and benefited from all activities. Formal and on the job training was provided for project staff, AI technicians and experts which created capacity to extend ILDP activities into non-project areas. Farmers who had adopted innovations on their own farms were trained and used as model farmers to spread practical knowledge and enhance technology adoption among their peers. ILDP organized study tours for farmers on local and regional level.

4.9. Innovation theories on the example of agriculture

Innovation is an idea, practice or object which is new to an individual (Rogers, 2003). An innovation system is a network of different actors, individuals, organizations and enterprises focused on putting these new technologies into use in order to gain a significant improvement in production efficiency or product quality (Asenso-Okyere and Davis, 2009). Interactions between these actors are influenced by economic and social institutions, policies, incentives and norms (Assefa and Fenta, 2006).

4.9.1. Innovation-development process

The innovation-development process consists of phases from recognition of a problem, through research and development, commercialization of innovation, diffusion and adoption by users to its consequences (Rogers, 2003).

Appropriate science-based technology, investment in education and infrastructure are key drivers for improved food security, sustainable agriculture and reduction of rural poverty (Van Crowder et al., 1999; Asenso-Okyere and Davis, 2009). Farm innovations are usually developed by public research stations focused on farmer's needs and local conditions. State extension specialists link agricultural researchers to extension agents, who then diffuse the technology among farmers and rural people at local level (Davis et al., 2006). Agricultural extension service is of major importance in smallholder innovation processes in developing countries and where innovations are complex (e.g. crossbreeding technology) (Spielmann et al., 2008; Rogers, 2003).

There is also evidence of ineffectiveness of extension in the field. Examples are poor targeting and inefficient allocation of extension, bad quality of interaction between extension agents and farmers, highly centralized service and exclusion of the poor (Gautam, 2000). Worldwide women farmers receive only 5 percent of extension services (Asenso-Okyere and Davis, 2009). Spielmann et al. (2008) found out that in Ethiopia there is little contribution of other innovation system actors (e.g. private industry, entrepreneurs, civil society, etc.) on smallholder innovation processes and he suggests that entry of these actors should be encouraged. It is also important to keep in

mind that there is evidence suggesting that new technologies, if introduced improperly, can harm indigenous people and their cultures (Servaes et al., 2007).

4.9.2. Innovation-decision process

The individual's decision about the adoption of an innovation does not happen instantaneous, it is a process. First of all individuals have to feel the need for innovation. This need may also be developed when the individual learns that an innovation actually exists; consequently motivation for its adoption can be created. Innovation has to be consistent with existing attitudes and beliefs; anyhow it might also encounter people's strong values. Diffusion typically takes a number of years. The innovation-decision process starts with first knowledge gain and formation of an attitude (=persuasion), over decision to adopt or reject, to implementation and finally confirmation of decision (Rogers, 2003).

Sources of information about new technology can be numerous and associated with a wide range of actors (Davis et al., 2006). Each actor has a unique ability to translate this information into functional knowledge (Cohen and Levinthal, 1990). Farmers can learn from their own experimentation (Conley and Udry, 2001) or from interpersonal or mass media communication channels. In developing countries interpersonal channels (face-to-face, two-way exchange) are heavily used, compared to mass media which is available to a very low degree. Interpersonal channels can be local or cosmopolite. Cosmopolite channels include extension agents, visits or visitors from outside the local community (Rogers, 2003). Local channels include learning processes appearing in a social group (e.g. village) which help spreading subjective evaluations of an innovation from peer to peer (Conley and Udry, 2001; Rogers, 2003). Knowledge can be carried on when farmers meet at social functions and discuss issues of concern (Asenso-Okyere and Davis, 2009) or while observing neighbor's farming experiments. Other farmers' experience is an important factor in the persuasion phase and influences strongly the adoption decision (Conley and Udry, 2001). As farmers have to adjust to changing conditions, they are also actively struggling themselves for new ideas to make a living from agriculture. They are innovative on their own initiative without pressure or support

from research or extension (Abay et al., 2009; Bedasso, 2008). This complex learning process can result in modification of innovations and creation of knowledge that meets particular needs of smallholder farmers (Davis et al., 2006). Rogers (2003) explains this phenomenon, which takes place in the adoption and implementation phase, as re-invention. He emphasizes that re-invention can be beneficial, as it shapes the innovation to fit more appropriately to local situations and changing conditions. Re-invention is more likely to occur when innovations are complex and difficult to understand, when communication between farmers and extension agents is poor, or the innovation is supposed to solve a wide range of problems.

4.9.3. Characteristics of an innovation and rate of adoption

The rate and speed of adoption depend on a range of factors that are likely to vary between studies (Floyd et al., 2003; Batz et al., 1999). Farmers adopt a new technology if its characteristics promise a higher utility than the traditional technology (Batz et al., 1999; Abdulai and Huffman, 2005). Rate of adoption further depends on perceived benefits like economic profitability (less important for smallholders in developing countries) and status aspects (more important in developing countries) as well as compatibility, observability, trialability and the degree of interconnectedness in a social system of an innovation (Rogers, 2003). According to Monge et al. (2008) farmers in Bolivia are influenced by persuasion, nature of communication channels and competition.

In agriculture usually a cluster of innovations is required. For example, in case of crossbreeding technology it is absolutely essential to adopt further innovations simultaneously in order to get the total yield effect plus the interaction effect. This complexity can lead to slow diffusion of technologies. Risk of innovation is negatively correlated with adoption. Farmers who face labor shortage and are poorly educated may be reluctant to adopt complicated technologies that require additional labor input (Batz et al., 1999).

4.9.4. Innovativeness and adopter categories

In diffusion research a prime focus is placed on innovativeness as one of the best indicators for successfulness of development programs. “Innovativeness is the degree by which an individual or other unit of adoption is relatively earlier in adopting new ideas than other members of a social system” (Rogers, 2003). Attention should be given upon identifying and supporting innovative farmers (Assefa and Fenta, 2006).

Based on the degree of innovativeness Rogers (2003) differentiates between five adopter categories: the innovators, early adopters, early majority, late majority and laggards (Fig. 6). The adopter distribution tends to follow a normal bell-shaped curve on frequency basis (number of individuals adopting each year).

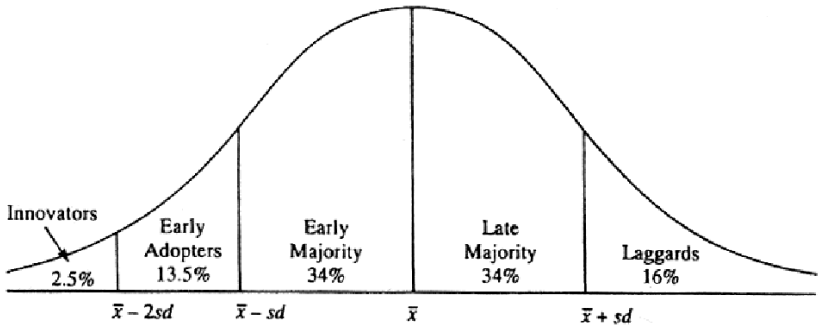

Fig. 6 Adopter categorization based on innovativeness (Rogers, 2003)

Innovators are interested in the new, risky, cosmopolite and venturesome. They have the ability to control financial resources and a complex technical knowledge (Rogers, 2003). Innovators play an important role in the diffusion process as they are the first who adopt an innovation that comes from external sources (Diederen et al., 2003). Early adopters are more integrated into the local social system compared to innovators. They serve as role models and have the greatest degree of opinion leadership. Early adopters are sought by extension agents as they speed up the diffusion process substantially. Individuals in the early majority category adopt innovations before the average does. These people often interact with peers and follow their role models but seldom take leadership positions. The late majority of innovators adopt an innovation

after the average does. They act with skepticism and caution, mainly because of scarce resource availability. They often adopt out of an economic necessity or because of network pressure. Laggards are the least innovative individuals in a social system. Because of limited resources, they are resistant, extremely cautious and suspicious of innovations. They value tradition and past experiences and posses no opinion leadership (Rogers, 2003).

Socioeconomic status influences innovativeness of farmers to a high degree and affects each step in the innovation-decision process. Early adopters are generally better educated, have a higher social status, a rather commercial than subsistence economic orientation, are wealthier, more specialized and have larger-sized farms (Rogers, 2003; Diederen et al., 2003). Further variables which influence innovativeness but are difficult to measure in field interviews are personality and communication behavior (Rogers, 2003).

5. MATERIALS AND METHODS

5.1. Study area

The participants in this study are located in study sites in 3 project woredas (Gondar Zuria, Lay Armacho and Debark) of North Gondar Zone of the Amhara Regional State of Ethiopia. The area lies on an elevated plateau ranging from 1920 to 2860 m above sea level. In Gondar city the average annual temperature ranges from 9 to 29 °C. Three seasons can be differentiated; the short rainy period (February to May) which receives an average of 91 mm of precipitation/month, the main rainy period (July to October) with 113 mm rainfall/month and the dry period (November to January) with 39 mm of rainfall/ month. June is considered as transition phase between the two rainy seasons with slightly lower rainfall (NMA, 2012).

Fig. 7 Map of Ethiopia with study area located in North Gondar Zone of Amhara Regional State (www.reliefweb.int, 2012)

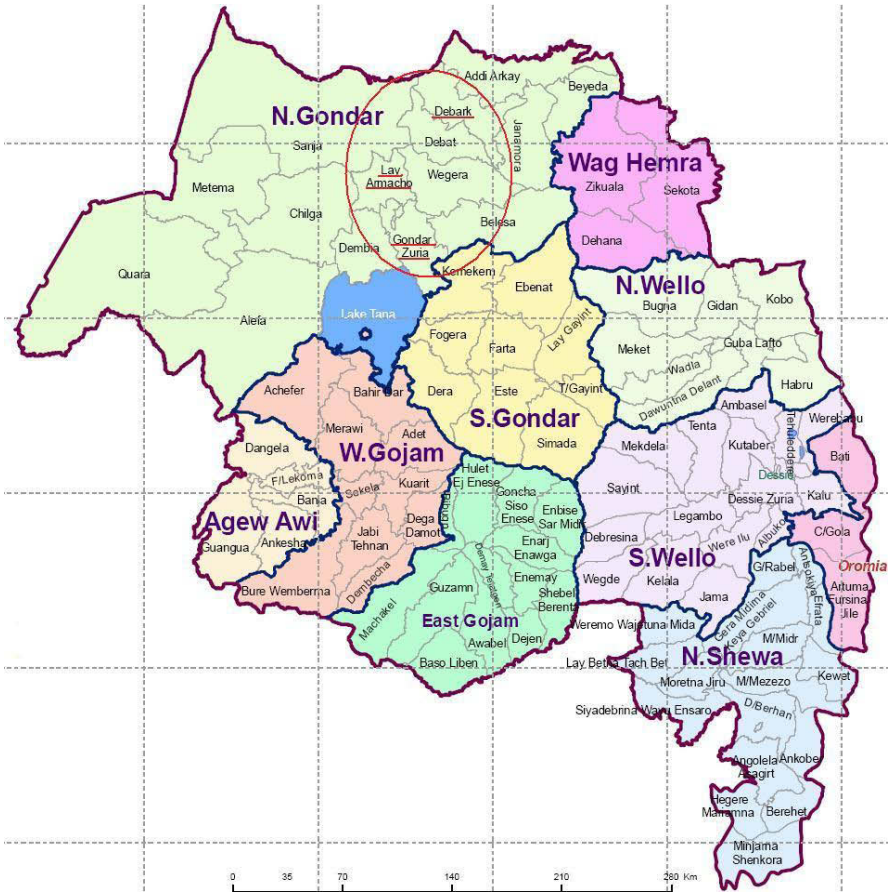

Fig. 8 Map of Amhara Region with study area located in Gondar Zuria, Lay Armacho and Debark woreda of the North Gondar Zone (www.ethiodemographyandhealth.org/Amhara.html, 2012)

The current population in North Gondar Zone is more than 3.24 Mio (SRMP, 2007) and the area covers 867,037 ha of land from which 93,1% is crop land, 2.5% is fallow land, 2.8% is grazing land and 0.2% is wood land. There are 617,815 households with an average size of 1.4 ha and a household size of 5.17 persons (CSA, 2011). There are an estimated 2.44 million head of cattle. Studies indicate that four to five different cattle breeds can be located in North Gondar Zone (ILDP, 2003). In Amhara Region the majority (98.5%) of the cattle population is found in rural areas, while a very small proportion is accounted for urban areas (1.5%) (CSA, 2011).

5.2. Data-collection

The present case study was conducted using qualitative research methodology which aimed at understanding the research problem from the local peoples' perspective. It allowed gathering of information about farmers' perceptions of their farming practices,

livelihoods and their real opinion about the project where they have been beneficiaries (Mack et al., 2005).

Data was collected during interviews with household heads using a detailed, pre-tested qualitative and quantitative questionnaire, which was previously developed and used for a different region in Ethiopia. For this study the questionnaire was adapted according to prevailing circumstances before data collection.

The survey included closed and open questions allowing multiple responses in some cases. Data was collected on farming system characteristics, diffusion of crossbreeding, impacts of crossbreeding, adaptation of innovations, management strategies in dairy cattle husbandry, breeding practices, market access and performance differences of breeds.

The interviews were conducted in local language (Amharic) and translated into English by a junior animal scientist from ARARI (Amhara Regional Agricultural Research Institute). All given answers were written down and additionally recorded for further control. The interviews took place either at respondents' farms, *woreda* or *kebele* Agricultural Development Offices.

Field work was conducted from mid August 2011 to mid September 2011. A total of 60 dairy farmers, beneficiaries of ILDP, were included in this survey. In each of the three sampling sites 20 households were randomly selected from the list of ILDP beneficiaries upon consultation with the District Agricultural Development Offices and ILDP experts. The study was based on smallholder farms mainly found in rural areas and to a lower extent in urban and peri-urban areas. Surveyed farmers had to have dairy cattle before they started crossbreeding and a minimum of 8 years experience with crossbreeding to be included in sample. The establishement of these criteria was necessary to receive information on differences in performance and management of both local and crossbred cattle.

5.3. Data-analysis

Data was entered and coded using Microsoft Excel. Coding (categorization of data into segments) prepared and facilitated statistical software analysis which was conducted using the Statistical Analysis System SAS 9. 1. (SAS, 2000). Qualitative data was analysed using the procedure frequency (proc freq) to gain percentages or frequencies. For continuous data procedure means (proc means) to compute minima, maxima and means, and the general linear model (GLM) to compute least square means were used. The objective was to analyse differences between study sites by comparing least squares means of variables using Tukey's Test multiple comparison or by determining the degree of relationship between random variables using Chi-square Test or Fisher's Exact Test (when Chi-square test was not suitable). Statistical significance between variables was examined using P-values at critical probability of $P<0.05$.

6. RESULTS

6.1. Household description

The overall mean for household size in the study area is 7.55. Average household sizes and number of family members working on farm are presented for all 3 study sites respectively (Table 6). In all areas the number of family members actively working on farm is lower than the household size.

Table 6. Mean, maximum and minimum values of household size and family members working on farm across study sites

	Gondar Zuria (n=20)			Lay Armacho (n=20)			Debark (n=20)		
	mean	min	max	mean	min	max	mean	min	max
Household size	8.3[a]	3	12	6.5[b]	3	10	7.9[ab]	4	10
Family members working on farm	6.5	3	10	5.7	2	10	5.3	0	10

Of all respondents 13 (21,67%) household heads are female. The average age of the respondents is 48.23 years and ranges from 26 to 73 years. The educational levels of household heads which are presented in Figure 10 do not differ significantly (P>0.05) between regions. The major part of household heads (70%) has primary school education.

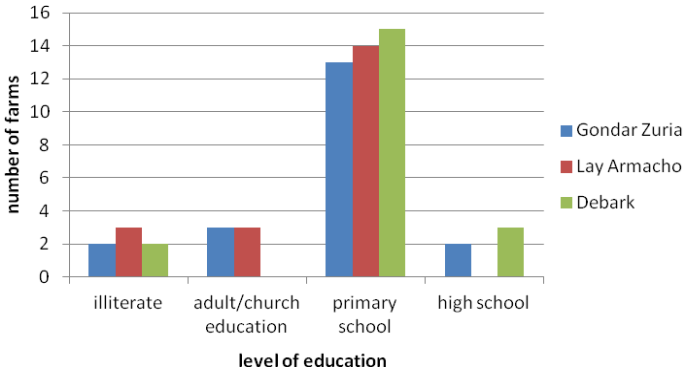

Fig. 9 Educational level of household heads across study sites

6.2. Farm description

Average farm size in the study site is 1.71 ha. Mean values for farm sizes in each study area are compiled (Table 7). The average farm size in Gondar Zuria is significantly higher than in Lay Armacho and Debark. The highest land holding of 8 ha is found in Gondar Zuria and the lowest land holding of 0 ha is found in Lay Armacho.

Table 7. Least square mean farm size in ha across study sites

Region	N	Mean	Std Dev	Min	Max
Gondar Zuria	20	2.4[a]	1.52	0.1	8
Lay Armacho	20	1.5[b]	1.03	0	3
Debark	20	1.2[b]	0.61	0.25	3

The number of years during which respondents have been in charge of their farms differs slightly by site. In Gondar Zuria farmers have the longest farm management experience. In Lay Armacho the distribution is more even with a peak at 21 to 30 years. In Debark heads are in charge of their farms for the shortest time which is further indicated by lowest average age of respondents.

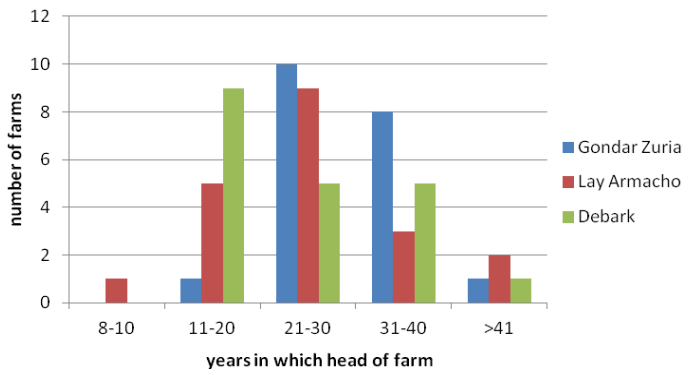

Fig. 10 Farm management experience of respondents indicated by years in which head of farm

Of all households 70% are involved exclusively in on farm agricultural activities on farm, whereas 30% have additional off-farm income. The significantly ($P<0.05$) highest number of farmers with off-farm income (13) is found in Lay Armacho. Sources of off-

farm income include house or store rent, construction work, local beer production, wood and sheep trade, guard work and running of butcher shops, small restaurants or hotels.

The main agricultural activity for 50% of total surveyed farmers is crop production. For 31.67% livestock plays the most important role and an additional 8.33% of farmers solely depend on livestock. For 10% livestock and crop production are equally important (Fig. 9). In Gondar Zuria, were crop production ranked highest in importance, the outcome is significantly ($P<0.05$) different than in Lay Armacho were livestock is considered as most important and in Debark were importance of livestock and crop production is balanced. In addition to dairying fattening of cattle, apiculture, sheep and chicken husbandry is also practiced. Crops produced in Gondar Zuria include teff, sorghum, chickpea, wheat, barley, maize, lentils, finger millet and beans. Lay Armacho additionally produces geisho (*rhamnus prinioides)* which is used in traditional beer brewing. Farmers from Debark cultivate mainly wheat, barley and beans. Farming activities of less importance are forestry (eucalyptus plantations) and horticulture (e.g. mango, potato, coffee).

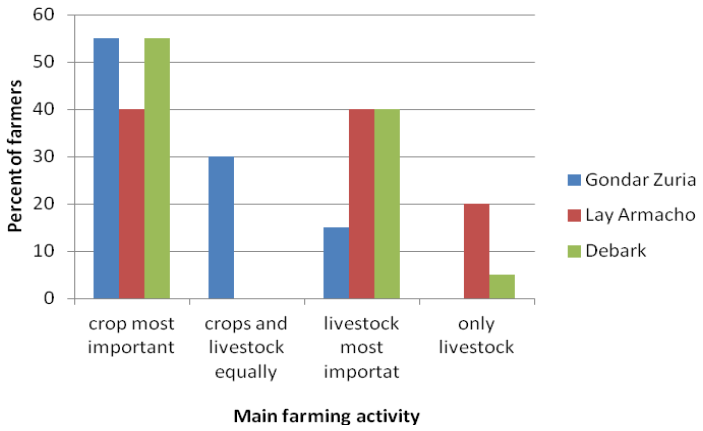

Fig. 11 Main farming activities across study sites

Total yearly income from all farming activities (livestock, crop, horticulture, forestry) varies between sites (Table 8). Farmers in Lay Armacho earn most, followed by Gondar Zuria. Farmers in Debark have the lowest income. According to Chi-Square test a significant ($P<0.05$) difference was found between Lay Armacho and Debark.

Table 8. Total yearly farm income

	Gondar Zuria (n=20)		Lay Armacho (n=20)		Debark (n=20)	
Income in Birr/year	frequency	%	frequency	%	frequency	%
<1000	0	0	0	0	3	15
1001-3000	2	10	0	0	7	35
3001-5000	5	25	1	5	2	10
5001-7000	1	5	4	20	1	5
7001-9000	2	10	0	0	2	10
9001-10000	0	0	2	10	1	5
10001-20000	6	30	9	45	4	20
20001-40000	4	20	3	15	0	0
>40000	0	0	1	5	0	0

The involvement of household members in dairy activities across study sites is shown in Table 9. Herding is usually the responsibility of children in all sites, substituted by other household members when children are in school. Fodder harvest is mainly done by head, children and hired labourers. Feeding of cattle is done by all family members likely. Milking is the main responsibility of head and spouse. It is common that children are in charge of transport of milk to cooperative or nearest market. Processing of milk is often considered as womans work that is why female spouses and daughters of respondents are mainly responsible for processing activities. If dairy products are sold, they are transported to market mainly by female spouses or female heads. In some cases in Lay Armacho dairy products were picked up by customers from the producer's gate. It is apparent that in all study sites breeding decisions are mainly made by male heads, in some occasions in consolidation with spouse, seldomly with children.

Table 9. Involvement of household members in dairy activities across study regions

	Gondar Zuria						Lay Armacho						Debark					
	Participation (%)						Participation (%)						Participation (%)					
Activity	head	spouse	children	hired labourers	relatives	all family	head	spouse	children	hired labourers	relatives	all family	head	spouse	children	hired labourers	relatives	all family
Herding	0	20	60	40	0	5	20	35	45	25	5	15	15	10	70	20	0	15
Fodder harvest	65	5	40	50	0	0	75	20	20	10	0	0	75	0	30	40	0	5
Feeding	40	50	25	5	0	5	50	45	30	15	5	0	20	60	45	10	0	10
Milking	85	35	5	5	0	0	85	55	5	10	0	0	55	70	10	10	0	5
Transport of milk	15	5	65	5	5	5	20	15	65	5	0	0	30	10	75	10	0	0
Processing of milk	20	70	45	0	0	0	20	60	40	5	0	0	10	85	55	10	0	0
Transport of dairy products	20	45	15	5	0	0	10	50	0	0	0	0	10	45	30	5	0	0
Breeding decisions	90	30	25	5	0	10	100	70	0	0	0	0	80	40	5	5	0	20

6.2.1. Cattle herd size and composition

In Gondar Zuria farmers own local cattle from Fogera breed or Dembia cattle type, whereas in Lay Armacho and Debark local cattle are known as Wegera and Semien type. The cattle herd size is similar in Lay Armacho and Debark, but was significantly ($p<0.001$) higher in Gondar Zuria. The higher number of local cattle in this region is responsible for the difference. Local oxen comprise a higher proportion of the herd in Gondar Zuria and in Lay Armacho than in Debark (Table 10). The number of local bulls is highest in Lay Armacho. The total number of crossbred cattle is comparable in all areas. There are less crossbred than local oxen in all regions. Crossbred cows, heifers and calves comprise the highest proportion of the herds. The number of crossbred bulls in Debark and Gondar Zuria is higher than the average of all regions.

Table 10. Cattle herd size and composition across study regions

	Gondar Zuria			Lay Armacho			Debark		
Cattle breed and type	Mean	%	Range	Mean	%	Range	Mean	%	Range
Total herd size	**10.6[a]**	**100**	**2 - 22**	**5.9[b]**	**100**	**2 - 10**	**5.85[b]**	**100**	**2 – 20**
Nr of local cattle	**5.7[a]**	**53.7**	**0 - 10**	**1.6[b]**	**27.1**	**0 – 7**	**1.05[b]**	**18.0**	**0 – 4**
Cows	1.75	30.7	0 – 4	0.35	21.9	0 – 3	0.45	42.9	0 – 2
Heifers	0.95	16.7	0 – 3	0.15	9.3	0 – 1	0.2	19.0	0 – 1
Bulls	0.4	7.0	0 – 1	0.3	18.8	0 – 2	0.05	4.8	0 - 1
Oxen	1.6	28.1	0 – 3	0.6	37.5	0 - 2	0.15	14.3	0 – 1
Calves	1	17.5	0 – 4	0.2	12.5	0 – 2	0.2	19.0	0 – 1
Nr of crossbred cattle	**4.9**	**46.2**	**1 - 12**	**4.3**	**72.8**	**1 – 9**	**4.8**	**82.0**	**1 – 19**
Cows	1.45	29.6	0 – 4	1.75	40.7	1 – 4	1.6	33.3	0 – 8
Heifers	0.7	14.3	0 – 2	0.7	16.3	0 - 3	1.35	28.1	0 – 6
Bulls	0.55	11.2	0 – 2	0.2	4.7	0 – 2	0.65	13.5	0 – 2
Oxen	0.75	15.3	0 - 3	0.3	7.0	0 – 1	0.15	3.1	0 – 2
Calves	1.45	29.6	0 – 4	1.3	30.2	0 - 4	1.1	22.9	0 - 3

The crossbred genotypes (proportion of genes from the exotic breed) of cattle owned by respondents are portrayed in Table 11. The majority of crossbred cows in all study regions had 50% or 75% of exotic blood. In Debark the highest proportion of cows with exotic blood levels of more than 75% were found. In Gondar Zuria the majority of crossbred heifers as well as crossbred bulls had an exotic inheritance of 50%, whereas in Lay Armacho and Debark the majority was found to have exotic inheritance of 75% and above. The majority of crossbred oxen had blood levels of 50% in Gondar Zuria, 75% in Lay Armacho and 25% in Debark. Overall the majority of crossbred calves had exotic blood levels of 50% and above; calves with highest exotic inheritance (>75%) were found in Lay Armacho.

Table 11. Genotype composition of crossbred cattle

		Gondar Zuria		Lay Armacho		Debark	
Exotic blood level (%)		**Mean**	**%**	**Mean**	**%**	**Mean**	%
cow	**<25**	0	0.0	0.05	1.2	0	0.0
	25	0.05	1.0	0.05	1.2	0	0.0
	25-50	0	0.0	0.05	1.2	0	0.0
	50	1.2	24.5	0.9	20.9	0.65	13.8
	50-75	0	0.0	0	0.0	0.05	1.1
	75	0.2	4.1	0.6	14.0	0.45	9.6
	>75	0	0.0	0.1	2.3	0.45	9.6
heifer	**<25**	0	0.0	0	0.0	0	0.0
	25	0.05	1.0	0.05	1.2	0	0.0
	25-50	0	0.0	0	0.0	0	0.0
	50	0.35	7.1	0.1	2.3	0.05	1.1
	50-75	0.1	2.0	0	0.0	0.1	2.1
	75	0.15	3.1	0.4	9.3	0.8	17.0
	>75	0.05	1.0	0.15	3.5	0.4	8.5
bull	**<25**	0	0.0	0	0.0	0	0.0
	25	0	0.0	0	0.0	0.1	2.1
	25-50	0.05	1.0	0	0.0	0	0.0
	50	0.35	7.1	0.05	1.2	0.15	3.2
	50-75	0	0.0	0	0.0	0.1	2.1
	75	0.15	3.1	0.05	1.2	0.1	2.1
	>75	0	0.0	0.1	2.3	0.2	4.3
oxen	**<25**	0	0.0	0.05	1.2	0	0.0
	25	0.05	1.0	0	0.0	0.1	2.1
	25-50	0	0.0	0	0.0	0	0.0
	50	0.35	7.1	0.05	1.2	0	0.0
	50-75	0.1	2.0	0	0.0	0	0.0
	75	0.1	2.0	0.15	3.5	0.05	1.1
	>75	0	0.0	0.05	1.2	0	0.0
calve	**<25**	0	0.0	0	0.0	0.1	2.1
	25	0.3	6.1	0	0.0	0.05	1.1
	25-50	0.1	2.0	0.05	1.2	0.05	1.1
	50	0.45	9.2	0.15	3.5	0.3	6.4
	50-75	0.2	4.1	0.05	1.2	0.2	4.3
	75	0.45	9.2	0.6	14.0	0.15	3.2
	>75	0.1	2.0	0.5	11.6	0.2	4.3
Total crossbred herd		**4.9**	**100%**	**4.3**	**100%**	**4.7**	**100%**

6.3. Diffusion of crossbreeding and extension support

The main source of innovation for the majority of respondents was ILDP, which was the initiating organisation that enabled farmers to start with crossbreeding. Two farmers started following their own initiative before ILDP‘s implementation. Both farmers bought

their first crossbred cattle in the city of Gondar. They received their first information from a family member residing in Gondar and from a crossbred bull presentation in the local school respectively. From the farmers' memories few believed in advantages at that time; awareness and diffusion of the new technology increased when ILDP started it's program.

The majority of farmers in all study areas (93.33%) received their first information on crossbreeding in a face-to-face exchange during workshops organized by extension agents. In Gondar Zuria and Lay Armacho farmers attended a workshop which was organized by ILDP and the responsible District Agricultural Development Office. In Debark the District Agricultural Development Office gathered participating farmers to give introductory training on crossbreeding before ILDP started its workshop. In the innovation-decision process the majority of farmers (85% in Gondar Zuria, 70% in Lay Armacho, 100% in Debark) sought further information from their peers, mainly other farmers but also extension staff and family members. Significantly ($P<0.05$) more farmers asked for further information in Debark than in Lay Armacho. The mean length of the innovation-decision period, measured from first information about crossbreeding until adoption, shows significant differences between regions (Table 12). Gender, age and education level of household head did not influence the length of this period significantly ($P>0.05$).

Table 12. Innovation-decision period (years) across study regions

Site		First information (years*)		Adoption decision (years**)		Innovation-decision period (years)	
	N	Mean	Std dev	Mean	Std dev	Mean	Std dev
Gondar Zuria	20	11.40[a]	0.99	9.50[a]	2.24	1.90[ab]	2.17
Lay Armacho	20	11.95[ab]	2.96	10.70[a]	3.23	1.26[a]	1.16
Debark	20	13.40[b]	1.85	10.20[a]	2.26	3.1[b]	1.70
Total	60	12.25	2.23	10.13	2.62	2.12	1.89

* number of years from first information until interview date

** number of years from adoption of crossbreeding until interview date

Table 13. Reasons for adoption of crossbreeding

Reason for adoption	Gondar Zuria (n=20)		Lay Armacho (n=20)		Debark (n=20)	
	freq	% of farmers	freq	% of farmers	freq	% of farmers
Generation of income	6	30	0	0	1	5
Higher milk production of crossbreds	9[a]	45[a]	2[a]	10[a]	0[b]	0[b]
Better reproductivity of crossbreds	2	10	0	0	0	0
General higher potential of crossbreds	10	50	7	35	8	40
Trust in advice	8[a]	40[a]	16[b]	80[b]	18[b]	90[b]

Multiple responses were given by surveyed farmers when asked about reasons for adoption of crossbreeding (Table 13). Significant ($P<0.05$) differences between study regions are indicated. Due to differences in statistical procedures, the outcome of the two-sided P-value can differ from the table probability. This is the case for “income generation”. In this cases table probabilty showed significant differences between regions, whereas pairwise comparison did not indicate statistical significance.

Respondents in Gondar Zuria realized the general productive and reproductive potential of crossbreds and the chance for increasing income. Trust in advice from the information source was an important decision factor in all areas under study, but particularly in Lay Armacho and Debark. It was based on the awareness building training received from extension agents as well as on other farmers‘subjective opinions and positive experiences with the adoption of crossbreeding.

After 2007, once the project support from ILDP had stopped, farmers were supported through advice, monitoring and AI services by the District Agricultural Development Offices as well as the Sustainable Resource Management Program in North Gondar (SRMP).

6.3.1. ILDP technology package

The majority of respondents (98%) received extension support in form of information and functional knowledge gain, advice, monitoring, access to AI or bull service as well as veterinary service. More than half of respondents (52%) mentioned that they had access to crossbred heifers and took part in training lessons on different aspects of the production system. Training covered feeding and nutrition, forage development, differentiation of feedstuffs, breeding and breed characteristics, housing, health management, animal husbandry, grazing system, marketing and market access, milk hygiene and handling, apiculture and fattening.

About 95% received farming inputs from the initiating organisation. Farming inputs included (in descending order): forage seeds and feedstuff (90%), medicine and parasite prophylaxes (87%), crossbred heifers or local heifers inseminated with exotic semen (65%), fertilizer (7%), water tanker (5%), supportive technology for biogas plant construction (2%) and modern beehives (2%). Provided inputs were mostly charged for or provided in form of credit. Construction and organization of farmer's milk cooperative and supply of processing machines was free of charge.

6.3.2. Satisfaction with ILDP

The majority of farmers (95%) was satisfied with the way ILDP was realised.

Eight important reasons determined farmers' satisfaction with the project (Table 14). In all regions farmers were mostly satisfied with received training and access to better animals. The third most important reason for satisfaction of farmers in Lay Armacho was the information flow (assistance, supervision, advice, experience sharing with other farmers, organization of milk day and awareness creation for milk consumption). In Gondar Zuria farmers mentioned that they liked the approach of ILDP to address many issues of the production system (expressed as "full package"). In Debark input supply was of third importance. Furthermore in all areas farmers mentioned improvement of livelihood as positive aspect of the program. This included the possibility for children to attend school, since they were not needed for herding following the introduction of stall-

feeding. “The project is considered as means of survival” was expressed by a female respondent. Reasons given infrequently (less than 2 answers per region) were introduction of animal services (health improvement, construction of animal clinic, AI service) and change from traditional to more intensive animal production. Information flow, access to better animals and improvement of livelihood were answers which differed significantly between regions according to table probability, but did not show significant difference using pairwise comparison.

Table 14. Main reasons for satisfaction with project

Reason for satisfaction	Gondar Zuria (n=20)		Lay Armacho (n=20)		Debark (n=20)		Across regions (n=60)	
	frequency	% of farmers	frequency	% of farmers	frequency	% of farmers	frequency	% of farmers
Full package	5	25	1	5	3	15	9	15
Animal services	0	0	1	5	1	5	2	3
Information flow	2	10	10	50	2	10	14	23
Input supply	4	20	7	35	11	55	22	37
Access to better animals	12	60	16	80	20	100	48	80
Training	16	80	12	60	16	80	44	73
Improvement of livelihood	1	5	6	30	8	40	15	25
Change of farming system	2	10	0	0	0	0	2	3

Less than 50% of farmers mentioned negative aspects of the project. The number of answers did not vary significantly ($P>0.05$) between regions: A considerable proportion of respondents (45% in Lay Armacho, 30% in Debark, 10% in Gondar Zuria) would like the project to upscale in time and scope. Respondents stated that non-beneficiary farmers need support from ILDP which is considered as superior to support given by other farmers. In each study region 5% of respondents would expect more training. Farmers think that SRMP, the subsequent program to which ILDP has been linked, is

not performing well in the livestock sector and that the advisory service is insufficient. In all regions few farmers (5 - 15%) stated that once the project support was gone it was difficult to receive certain inputs (e.g. concentrate feed, crossbred heifer, water tanker) or some inputs (AI, concentrate feed) were more expensive.

In Gondar Zuria marketing is a problem for 15% of farmers. The distance to markets is long or the market is thought to be unsustainable because ILDP has stopped working.

6.3.3. Interpersonal communication channels

Overall, respondents used to a high degree cosmopolite as well as local interpersonal communication channels to receive and pass on information about crossbreeding. The majority of respondents in all study areas (73%) were visited by other farmers or experts, whereas 50% visited farms in other places themselves. These exposure visits were majorly organized by ILDP. Shared information mainly concerned positive effects of the crossbreeding technology (productivity and income increase, livelihood improvement) as well as general management aspects including advice on feeding, grazing, housing of cattle etc. A number of respondents (18%) participated in training at milk cooperatives. Experience gained on processing of milk was shared with other members of the community.

6.4. Cattle breeding and mating strategies

In this chapter breeding practices, preferred exotic inheritance levels in crossbred cattle, sources of first crossbred cows aqcuired and existing mating practices by individual farmers are presented.

6.4.1. Breeding strategies and preferences in exotic blood levels

An exotic blood level of 50% is preferred by the majority of respondents in Gondar Zuria (65% and 70% for cows and bulls respectively). In Lay Armacho (90% and 85%) and Debark (70% and 65%) the majority of farmers prefer a 75% blood level for cows and bulls respectively. These preferences are found to be very similar for cows and bulls, but vary significanlty between all regions ($P<0.05$).

Major reasons for preferences of certain exotic blood levels in both cows and bulls are (ranked number of farmers who stated so):

- Animals are adequately adapted to the environment (n=37): ability to satisfy feed requirements in both quantity and quality is given. Animal health status is satisfactory. Animals can graze because the infection risk is lower than at higher blood levels. There is no occurrence of walking difficulties in mountainous regions.

- More income from higher yielding cows (n=29).

- Blood level is manageable (n=27): 2 farmers additionally stated that it is easier to manage a higher exotic blood level in town compared to countryside because the availability of inputs is better (veterinary service, feedstuff etc.).

- Trust in recommendation of various livestock experts (n=2).

In the case of crossbred bulls farmers additionally mentioned to a lower extent:

- Fulfillment of breeding strategy (n=4): to keep a constant blood level in the herd.

- AI service offers semen from exotic bulls exclusively (n=1): no option for a crossbred bull.

Most of the farmers in Lay Armacho (95%), Debark (95%) and Gondar Zuria (75%) did not continue crossbreeding the same way they started with. This means they did not keep the initial proportion of exotic genes in their herd constant. No significant ($P>0.05$) variation was observed between study regions concerning breeding practices (Table 15). Upgrading of exotic blood level was the most practiced strategy in all regions. Those farmers who backcrossed with local bulls did so because of lack of awareness knowledge about exotic inheritance.

Table 15. Crossbreeding practices across study regions

Breeding practices	Gondar Zuria		Lay Armacho		Debark	
	frequency	%	frequency	%	frequency	%
Upgrading	7	35	14	70	13	65
Backcrossing with local bull	2	10	1	1.67	0	0
First upgrading than backcrossing	2	10	1	1.67	0	0
First backcrossing than upgrading	1	5	2	3.33	2	10
No clear trend/ fluctuating	2	10	1	1.67	4	20
Not specified	1	5	0	0	0	0
Not applicable	5	25	1	1.67	1	5

Overall, 53% of respondents changed their breeding practice because they consider the current blood level as managable. Nearly half of the farmers (47%) preferably use AI because it is easily available and cheap. As semen used in AI is usually obtained from exotic bulls, the exotic blood level of the herd increases. Another 42% mentioned that they changed breeding strategy with regard to increasing profits from higher milk yield or increased traction power. About 15% stated that they had no other mating option. This means that they either had to back cross by using a local bull if AI service was not available or they had to upgrade using AI service because there was no crossbred bull available. 13% were not aware of blood level change or did not have enough knowledge about blood levels. They either based their mating decision on recommendations from other farmers or unconsciously mated back their crossbred cows to local bulls. Unsuccesfull breeding using AI or crossbred bulls which led to use of local bulls was encountered by 8%.

6.4.2. Initial sources of crossbred cattle

Most farmers in Lay Armacho (70%) and Debark (75%) received either a crossbred heifer or a local heifer inseminated with exotic Holstein Friesian or Jersey semen on

credit from ILDP. In Gondar Zuria it was more common to breed from local stock by AI (55%) and only 40% of farmers in Gondar Zuria received a heifer which was significantly (P<0.05) lower compared to the other regions. In both Lay Armacho and Debark 10% of farmers bred from own stock by using AI. The crossbred heifers acquired from program either came from multiplication centers or other ILDP beneficiaries who already had crossbred offspring on farms. The remaining 5% (Gondar Zuria), 20% (Lay Armacho) and 15% (Debark) of farmers purchased crossbred animals on markets, from traders or other farmers.

Of all farmers 93.3% are aware of two exotic breeds: Holstein Friesian and Jersey. Overall 32% of respondents used both breeds. In Gondar Zuria the significantly (P<0.05) highest number of farmers (55%) used Jersey additionally to Holstein Friesian. The majority (93.3%) are interested in trying other exotic breeds for crossbreeding. 70% of farmers would try because they are curious about breed differences and would like to compare breeds in terms of performance and body condition. 23% trust in the recommendation of experts, government workers and other farmers. In order to get animals with better qualities fitting to the environment 13% would like to try a different breed. Milk from Jersey cows is considered as richer in fat content than Holstein Friesian's milk and is therefore preferably used for butter production. This is of importance in remote areas where distance to market is long, because butter is easier to transport than milk. Holstein Friesians on the other hand are preferred in areas where market is close or were transport is not a problem. Some farmers knew about the existence of those two breeds, but they did not have knowledge about breed characteristics.

6.4.3. Crossbreeding using natural service

Of all respondents 48% mate their cows naturally with crossbred bulls and 16.6% use local bulls. In Debark, Gondar Zuria and Lay Armacho 60%, 50% and 15% of farmers own at least one crossbred bull respectively and the number is significantly (P<0.05) lower in Lay Armacho. The highest number of crossbred bulls is found in Gondar Zuria and Debark although the difference is not significant (Table 16). About 40% of

respondents in Gondar Zuria own a local bull, whereas in Lay Armacho only 20% do so. In Debark respondents do not own local bulls, which is significantly (P<0.05) lower compared to Gondar Zuria. In Gondar Zuria the highest mean number of local bulls was found, followed by Lay Armacho (Table 16).

Table 16. Mean number of crossbred and local bulls/farm across study regions

Region	Crossbred bulls/farm				Local bulls/farm			
	mean	Std dev	min	max	mean	Std dev	min	max
Gondar Zuria (n=20)	0.65	0.75	0	2	0.4[a]	0.50	0	1
Lay Armacho (n=20)	0.2	0.52	0	2	0.3[ab]	0.57	0	2
Debark (n=20)	0.65	0.59	0	2	0[b]	0	0	0
Across regions (n=60)	0.5	0.65	0	2	0.25	0.47	0	2

Out of the available crossbred bulls, in Gondar Zuria 60% are used for breeding (out of these 83% for own cows, 17% for other farmer's cows), 10% might be used for breeding in future and 30% are used for other purpose. In Lay Armacho 50% of crossbred bulls are used for breeding (only other farmer's cows) and 50% are planed to be used for breeding in future. In Debark 50% of crossbred bulls are used for breeding (out of these 50% for own cows, 34% for other farmer's cows, 16% are bred to local cows only), for 33% the purpose is not decided yet and 17% are not used for breeding.

In Gondar Zuria out of these local bulls 38% are kept for draft, 25% for breeding, 25% for both draft and breeding, and 13% for fattening and selling purpose. Local breeding bulls are mainly used for mating with local cows, only one farmer used local bulls for mating with crossbred cows. In Lay Armacho local bulls are kept for draft (80%) and for breeding (20%). Breeding bulls are used for mating local cows only, except one accidental breeding of crossbred cow.

Crossbred bulls come from the own herd (16.7%) or other owners (31.7%), which are mainly neighbouring farmers, seldom bull stations or schools. In Debark it was more common to use other farmers bulls (0.75) compared to Gondar Zuria (0.45) and Lay

Armacho (0.4), but the difference was not significant (P>0.05). This is due to utulisation of a crossbred breeding bull which was offered by ILDP to one of the beneficary farmer. Farmers in Gondar Zuria and Lay Armacho, who used bulls from other owners, always used 50% exotic blood level bulls. In Debark the exotic blood levels ranged between 25% and 75%.

Local bulls used for breeding came from the own stock (3.3%) or from other farms (13.3%). Some farmers (4) stated that mating happened by accident on communal grazing ground. Gondar Zuria was the only woreda in which farmers used own local bulls for breeding. Local bulls from other farmers where used to a low extent (less than 3 per region) in all three woredas.

Genotypes of crossbred bulls used for breeding vary according to region, but are not significantly different (P>0.05) (Table 17). Out of the crossbred bulls in Gondar Zuria the majority has an exotic blood level of 50%. In Lay Armacho most bulls have more than 75%. In Debark the distribution is varying from 25% to more than 75% exotic blood level.

Table 17. Exotic blood levels of crossbred bulls used for breeding

Exotic blood level (%)	Gondar Zuria	Lay Armacho	Debark
	% of farmers	% of farmers	% of farmers
25	0	0	17
25-50	10	0	0
50	60	33	33
50-75	0	0	8
75	30	0	17
75-100	0	67	25

Table 18 contains criteria by which bulls are being chosen for breeding in different study areas. Significant (P<0.05) variations between regions are indicated. The majority of farmers in Gondar Zuria and Debark use information on bull quality (good confirmation and morphological characteristics, individual performance, health status and desired

color). Trust in recommendation of extension staff was an important factor influencing decision in Debark. For easy availablity (e.g. own, family members' or neighbours' bull) and crossbred genotype of bull there were significant differences between regions but pairwise comparison did not give further details. A statistical problem depending on the application of different procedures. In Gondar Zuria and Debark the most important criteria for selection is the fact that the breeding bull is a crossbred. Occasionally a breeding bull was used as an alternative option for AI when there was repeated breeding or no possibility to visit AI service.

Table 18. Criteria by which the breeding bulls are being chosen

Selection criteria	Gondar Zuria		Lay Armacho		Debark	
	frequency	% of farmers	frequency	% of farmers	frequency	% of farmers
Quality of bull	10[a]	43[a]	0[b]	0[b]	7[a]	33[a]
Trust in recommendation	0[a]	0[a]	0[a]	0[a]	5[b]	24[b]
Alternative option for AI	0	0	1	20	1	5
Easily available	9	39	4	80	2	10
Has to be crossbred	4	17	0	0	6	29

6.4.4. Access to AI and bull services

All respondents had access to AI service and about 95% have already used it. Only one farmer used bull service (these bulls were either provided by the District Agricultural Development Offices or by private farmer bull stations). Table 19 indicates significant ($P<0.05$) differences in both current price and maximum price ready to pay for AI service between study regions. In Lay Armacho average service charge is highest. Overall, payment per insemination service costs 2 to 6 Birr. Transportation costs vary from 8 to 46 Birr according to distance. The current exchange rate of 1 Euro is 23.32 Ethiopian Birr (4 November 2012). All farmers who used AI service were satisfied with the price and consider it as cheap and fair. Farmers in all study sites are ready to pay more for AI service if necessary (Table 19); with farmers in Lay Armacho showing highest willingness. Farmers included into the price possible repeated breeding and

transportation cost. Some farmers stated that if there would be no other choice for exotic or crossbred semen they will pay even more, because they see great advantages in crossbreeding.

Table 19. AI service price and maximum price ready to pay across study sites

Cost for AI service	Gondar Zuria				Lay Armacho				Debark			
	N	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max
Current price/ AI service (in Birr)	20	3.7[a]	2	12	19	18.1[b]	2	50	17	3.5[a]	2	4
Maximum price ready to pay/ AI service (in Birr)	20	27.5[a]	4	100	19	111.6[b]	10	400	17	57.9[ab]	5	100

6.4.4.1. Satisfaction with services

Out of the farmers who have used AI or bull services 89% are satisfied, 7% are not and 4% show no clear trend. All farmers not satisfied with AI service are found in Gondar Zuria. The main reason for dissatisfaction is distance (e.g. 1 hour) which farmers have to walk with their cows to reach the AI technicians working place. In this woreda the AI technician is working from the District Agricultural Development Office and is not visiting farms.

Table 20. Overall assets and drawbacks of AI services stated by respondents

Assets	frequency	Drawbacks	frequency
Available when needed/ closeby	41	Unreliable service	14
Overall good service	18	Repeated breeding	9
AI technician uses cell phone	8	Shortage of AI technicians	4
AI technician is a good person	5	Shortage of semen	4
Affordable service	3	AI technician is not coming to farms	3
Pregnancy check	1	AI service is too far away	2
No repeated breeding	1	Farmers need to cover fuels costs	1

Table 20 presents assets and drawbacks of the AI service as perceived by respondents in all study regions.

6.5. Performance differences between local and crossbred cows

Across study regions the difference in reproductive performance between local and crossbred cows was statistically significant (P<0.0001). Crossbred cows have earlier mean age at first calving and a shorter calving interval than local cows in all study regions (Table 21). Study region did not have significant (p>0.05) effect on AFC and CI in local and crossbred cows.

Table 21. Reproductive performance of local and crossbred cows across study regions

		AFC (years)					CI (years)				
Region	**Breed**	**N**	**mean**	**Std dev**	**min**	**max**	**N**	**mean**	**Std dev**	**min**	**max**
Gondar Zuria	local	19	4.6	0.71	3	6	20	2.4	0.47	2	3
	cross	19	2.6	0.82	1.5	5	19	1.3	0.28	1	2
Lay Armacho	local	20	4.5	1.06	3	7	20	2.6	0.80	1	4
	cross	20	2.8	0.65	2	4	19	1.3	0.37	1	2
Debark	local	20	4.3	0.91	3	6	20	2.6	0.54	2	3.5
	cross	20	3.1	0.83	2	6	18	1.5	0.33	1	2
Across regions	local	59	4.4	0.90	3	7	60	2.5	0.62	1	4
	cross	59	2.8	0.78	1.5	6	56	1.3	0.33	1	2

AFC= age at first calving, CI= calving interval, Std dev= standard deviation

The average daily milk yield from local and crossbred cows is presented (Table 22). Significantly (P<0.0001) higher milk yields were obtained from crossbred cows in all study sites. Milk yields of crossbred cows averaged 3 to 4 times higher than of local cows. Study site did not have a significant (p>0.05) effect on daily milk yield.

Table 22. Mean daily milk yield of local and crossbred cows across study regions

			Daily milk yield (l)			
Region	**Breed**	**N**	**mean**	**Std dev**	**min**	**max**
Gondar Zuria	local	20	2.4	0.84	1	4
	cross	19	8.4	2.93	3	14
Lay Armacho	local	20	2.6	0.67	2	4
	cross	20	9.9	4.63	2	20
Debark	local	20	2.5	1.39	1	6
	cross	20	7.8	2.29	4	14
Across regions	local	60	2.5	1.00	1	6
	cross	59	8.7	3.49	2	20

Fig. 12 and Fig. 13 provide a depiction of number of AI services necessary per conception for local cows and crossbred cows respectively, according to farmers' perceptions. Farmers from Gondar Zuria had significantly ($P<0.0001$) more experience with insemination of local cows. For a successful pregnancy the majority of farmers inseminated their local cows 2 to 3 times, whereas the number of services per conception was lower in crossbred cows. In Lay Armacho the majority of farmers experienced crossbred cows to conceive after first insemination. In Debark crossbred cows required the highest number of services. Between regions these differences were not significant ($P>0.05$).

From farmers' experience the pregnancy success rate is higher when the cow is mated naturally with a bull; usually there is no repeated breeding. Some farmers mentioned that they used a bull as an alternative option when cow did not conceive with AI. They also added that there is more repeated breeding during dry season.

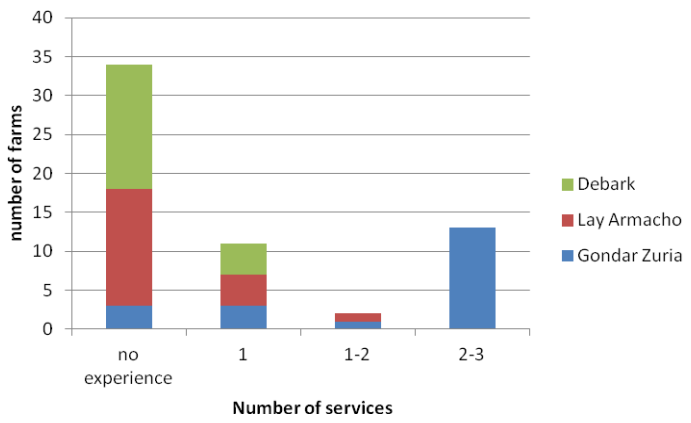

Fig. 12 Number of AI services necessary for a succesfull insemination of a local cow

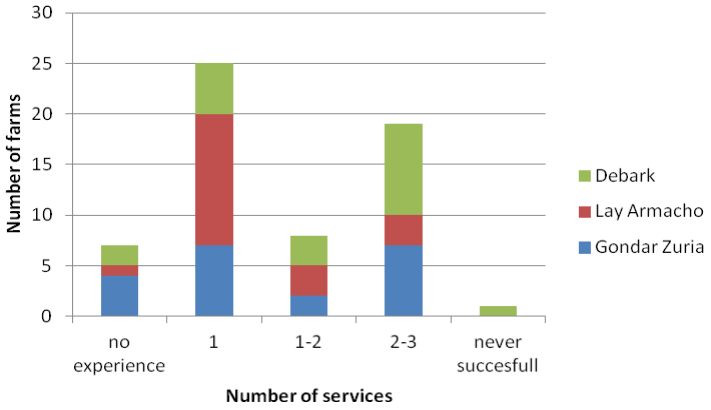

Fig. 13 Number of AI services necessary for a succesfull insemination of a crossbred cow

6.6. Adoption of innovations in animal husbandry

6.6.1. Feed resource improvement

Overall, 95% of respondents adopted new feedstuffs after starting with crossbreeding and continued their cultivation or purchase. Adoption levels across study regions are presented (Table 23). The Chi-square statistics result showed that land size did not significantly (P>0.05) influence adoption of feedstuff.

Table 23. Adoption levels of feeding technologies among ILDP beneficiaries across study regions

	Gondar Zuria		Lay Armacho		Debark	
Feedstuff category	**frequency**	**% of farmers**	**frequency**	**% of farmers**	**frequency**	**% of farmers**
Improved forage plants	17	85	15	75	19	95
Industrial/household byproducts	18	90	19	95	20	100
Grain/fodder crops/crop residues	4[a]	20[a]	3[a]	15[a]	19[b]	95[b]

In all study sites more than 75% of farmers introduced improved forage plants as well as industrial and household products. Improved forage plants included the multipurpose and locally available fodder trees chibha (*ficus thonningii*) and wanza (*cordia africana*) and fodder shrubs like tree lucerne (*chamaecytisus palmensis*); furthermore vetch and desmodium species, sesbania (*sesbania sesban*) and napier grass (*pennisetum purpureum*) are classed in this category. Local fodder trees chibha and wanza were common in Gondar Zuria and Lay Armacho, whereas tree lucerne was common in Debark. Industrial and household products included the commonly used oil seed cake, by-products of home made beer (atella) and industrially produced beer (Dashen brewery), cotton by-products, wheat bran, lentil bran, bean concentrates, salt, molasses and chicken bone meal.

Fig. 14 Local fodder tree Ficus Thonningii I (Kluszczynska, 2011)

Fig. 15 Local fodder tree Ficus Thonningii II (Kluszczynska, 2011)

Feedstuffs belongig to the category of grain (oat, maize, barley), fodder crops (beet, potato) and crop residues were introduced and significantly ($P<0.001$) more common in

Debark. Urban farmers from Lay Armago woreda introduced industrial and household products exclusively which included oil seed cake, cotton and brewery by-products, beans and lentil bran. Most farmers (58.33%) who owned local and crossbred cattle at the same time did not differentiate in feeding their animals. The remaining 41.67% usually fed their crossbred cows additional or higher amounts of feedstuff. Before ILDP implemented new feed resources, feeding of local cattle was based on roughages (hay, straw), salt and by-products of home brewed beer (*tella*).

6.6.1.1. Grazing and feeding strategies

In Gondar Zuria 95% and in Debark 85% of interviewed farmers feed their local cattle differently than their crossbred, whereas in Lay Armacho 70% of farmers use the same feeding strategy for both local and crossbred cattle. There is a significant difference ($P<0.05$) between Lay Armacho and the other regions. Farm size did not have a statistically significant effect on feeding patterns ($P>0.05$). Feeding strategies, which differ significantly between study regions ($P<0.05$) are compiled in Table 24. In all study sites crossbred cattle have restricted grazing time; none can graze freely. Some farmers stated that during this shortened grazing time crossbred cattle are herded in order to prevent unwanted mating, intake of harmful plants and water which is infected with leech. The remaining time cattle are stall-fed. Farmers were aware that stall-feeding prevents diseaseses and protects cattle from heat stress and heavy infestation with parasites. Crossbred cattle graze mainly on private land, seldomly on communal grazing grounds. In all sites, but especially in Gondar Zuria crossbred cattle graze seasonally, which means they either graze during rainy season or they graze on crop aftermath. 0 grazing is practised to a lower extent in all regions. By comparison, much more local cattle are found to graze freely on communal grazing grounds.

Table 24. Feeding strategies for local and crossbred cattle across study regions

	Gondar Zuria		Lay Armacho		Debark	
	% of farmers		% of farmers		% of farmers	
Feeding strategies	**local**	**crossbred**	**local**	**crossbred**	**local**	**crossbred**
All day free grazing	60	0	25	0	55	0
Restricted grazing/ few hours	0	15	55	80	35	90
0 grazing/ stall-feeding	10	20	15	10	10	15
Seasonal grazing	40	70	10	15	5	10
Graze on communal land	65	30	15	10	40	20
Graze on private land	50	55	55	85	10	85

6.6.2. Shelter provision

In 96.7% of the households new shelters for cattle were introduced within the project's framework. In the past farmers were kepping their cattle outside in corrals which did not provide protection from waether. The remaining respondents already possessed shelter for their cattle before the project's implementation.

6.6.3. Veterinary service and animal health improvement

The data in Figure 15 shows that in Gondar Zuria and Debark farmers experience local cattle to be more robust and generally healthier than crossbreds. In Lay Armacho the majority consider that there is no difference in health between the two genotypes. A small part of respondents strictly clarified crossbreds to be healthier. Some farmers did never experience health problems neither with local nor with crossbred cows.

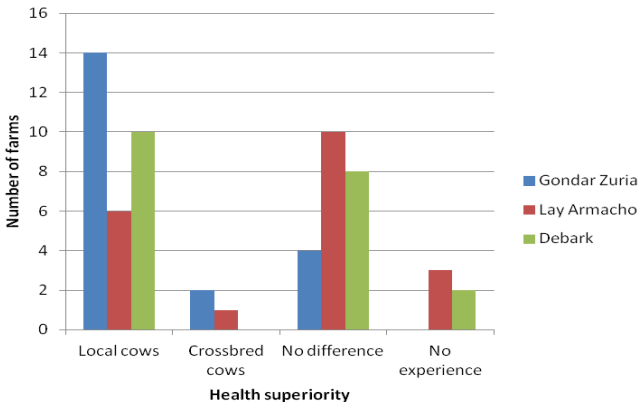

Fig. 16 Health superiority of local versus crossbred cows as perceived by farmers

In general local cows were considered as more robust; crossbreds on the other hand as more susceptible and less resistent to diseases and ticks. However, it is obvious that management affects the occurance of diseases substantially. As managament of animals improved, farmers did not experience considerable health differences between the two genotypes. On the contrary, a notable proportion of farmers mentioned a health improvement for all animals. Few farmers considered crossbreds as healthier because of better environment they are offered, compared to locals which graze freely and bear a higher risk of getting infected by pathogens. Farmers mentioned that disease outbreaks occured more often before the implementation of crossbreeding and the new management system.

The change in demand for veterinary service, as shown in Table 25 can be interpreted in various ways. Respondents who claimed that a decrease in demand for veterinary service has occured, at the same time stated that there were more disease outbreaks before the introduction of crossbreeding. This trend can be explained on account of the availabilty of vaccinations and other prophylactic treatments. Hence, animals do not get diseased and overall demand for veterinary service decreases. The use of vaccinations had wide application among respondents in all regions (98% adoption levels). The application of prophylactic treatment against parasites was significantly ($P<0.05$) higher in Gondar Zuria (90%) and Debark (100%) compared to Lay Armacho (70%). Treatment of various illnesses was significantly ($P<0.05$) lower in Debark (30%) compared to Gondar Zuria (100%) and Lay Armacho (95%).

Table 25. Change in demand for veterinary service

	Gondar Zuria		Lay Armacho		Debark	
	frequency	%	frequency	%	frequency	%
Increased	6	30	4	20	2	10
Decreased	6	30	8	40	2	10
Now more often because no vet service before	8	40	5	25	15	75
No vet service available at the moment	0	0	1	5	0	0
No need for vet at all	0	0	2	10	0	0
Not specified	0	0	0	0	1	5

The occurance of various diseases in local and crossbred cattle reported by farmers is compared in Table 26. Infectious diseases clearly occurred more often in local cattle. This is attributed to the introduction of veterinary service. Common infectious diseases included anthrax, blackleg, mastitis and CBPP (Contagious bovine pleuropneumonia). The prevalence of mastitis (so called “disease of intensification”) was higher in crossbred cattle. Anthrax and blackleg were more common in locals than in crossbreds. The finding of foot and mouth disease, brucellosis, hematuria (blood in urin), foot rot and rinderpest was low in this study; there was only one incident in local cows for each disease respectively. One crossbred cow died because of rabies. Decreased well being and heat stress were common in both local and crossbred cattle, whereas crossbreds were attributed to suffer more when overexposed to sun and heat. Associated with these symptoms were depression, weakness, loss of appetite and swellings on body. Problems with digestive tract, which occured in both local and crosses similarly, included bloating (caused by excess intake of the prevalent clover plant *trifolium quartinianum*) and diarrhea. Overall, there is little parasite occurance (mites, flies, leeches, worms) in the studied regions; crossbreds are considered to be more susceptible to parasites. Crossbreds were more affected by tick borne diseases than indigenous. It is considered that they have thinner skin, which causes swellings and pain at places where ticks are being removed.

Higher variation in diseases among crossbred cattle can be observed. Further illnesses only crossbreds suffered from included abortion, swellings on body parts, milk fever symptoms. Some farmers attributed crossbred cattle to be less tolerant and adapted to environment, which was presented in terms of lameness, less selective grazing and higher frequency of illnesses.

Table 26. Overall disease occurance in local and crossbred cattle

Diseases local cattle	frequency	Diseases crossbred cattle	frequency
Infectious diseases	**47**	Infectious disease	**26**
Decreased well- being/ heat stress	**25**	Decreased well-being/ heat stress	**24**
Problems with digestive tract	**12**	Problems with digestive tract	**8**
Internal/ external parasites	**5**	Internal/ external parasites	**5**
Tick borne disease	**4**	Tick borne disease	**10**
Lameness	**2**	Less tolerant/ adapted	**4**
		No clear symptoms	**3**
		Abortion	**2**

The statistical analysis of disease occurance in local and crossbred cattle found that there are few significant differences between study sites. Heat stress and decreased well-being among local cattle occured significantly ($P<0.05$) more often in Lay Armacho (55%) and Debark (60%) than in Gondar Zuria (10%). Significantly ($P<0.05$) more infectious diseases in crossbred cattle were found in Gondar Zuria (90%) compared to Lay Armacho (20%) and Debark (20%).

Treatment of local cattle was commonly practiced by veterinary in Gondar Zuria (90%) and Lay Armacho (60%). In Debark traditional is more common (50%) than veterinary treatment (35%). Before crossbreeding there were traditional indigenous methods of healing animals in all regions (45% in Gondar Zuria, 45% in Lay Armacho, 30% in Debark); mainly because there was often no access to veterinary service. In some regions there was also veterinary service available before crossbreeding (30% in Lay

Armacho and 20% in Debark). Crossbred cattle, on the contrary, in all study regions are treated by veterinarian exclusively.

6.7. Impacts of crossbreeding technology on the production system

The traditional production system has undergone remarkable changes, which were triggered by the introduction of crossbred dairy cattle and linked technologies. The effects of innovation on herd size, workload, income and livelihood were analysed.

Overall mean herd size of the study region has increased by around 15% from 6.4 to 7.4 head of cattle. While in Lay Armacho mean herd size slightly decreased, it increased to a great extent in Gondar Zuria and Debark (Table 27).

Table 27. Change in cattle herd size before and after the adoption of crossbred animals across study regions

	Gondar Zuria			Lay Armacho			Debark		
Herd	**N**	**Mean**	**Range**	**N**	**Mean**	**Range**	**N**	**Mean**	**Range**
Size before crossbreeding	20	9.65[a]	1 - 40	20	5.9[ab]	1 - 18	20	3.65[b]	0 - 10
Size now	20	10.6[a]	2 - 22	20	5.85[b]	2 - 10	20	5.8[b]	2 - 20

The impact of the changing production system on workload was substantial. All households, except one, experienced a workload increase. Few farmers (5%) stated that workload both increased and decreased in different managing aspects. Most additional workload (stated by 90% of respondents) arose in areas connected with forage production and feed management, cleaning of shelter and milk production (milking, processing, and transport to market). A rise in workload for animal care (watering, cleaning and herding of animals) was indicated by 5% of farmers. Several farmers added that even though workload increased, they were satisfied as their livelihoods had improved. Two households earned enough income to either purchase donkeys or employ additional labourers for farm operations. This reduced workload during fodder harvest, transport of fodder and herding.

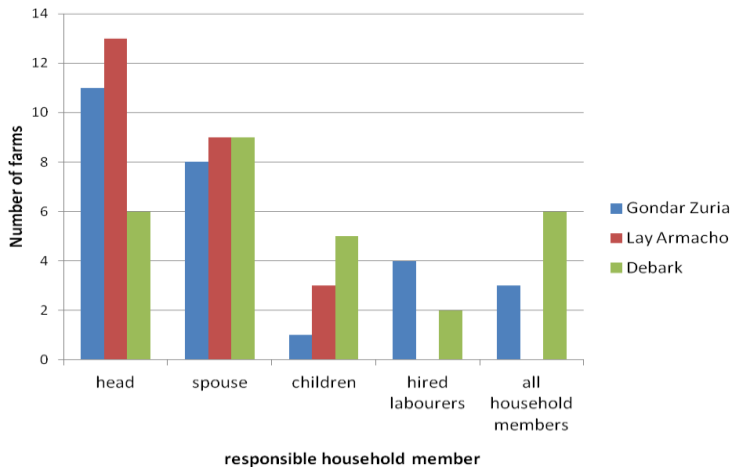

Fig. 17 Division of additional workload between household members

The increased labour demand has almost entirely been met by an increase of workload for head and spouse. To a lesser extent new workload has been added on children or additionally hired labourers. Significantly ($P<0.05$) more farmers in Gondar Zuria (80%), compared to Debark (45%) and Lay Armacho (35%), had to hire at least one additional labourer. The overall mean number of labourers hired permanently is 0.63 with a range from 0 to 6; those being hired seasonally is 16.82 ranging from 0 to 250. There was no significant regional difference in number of permanent or seasonal labourers hired. In Gondar Zuria and Debark it was more common to hire seasonal labourers for peak work during weeding, harvesting, ploughing and sometimes herding. In Lay Armacho and Debark it was common for a few families to form working groups („webera“) to handle all kind of farming activities. Groups of women were usually responsible for manual weeding, groups of men for harvesting of crops and fodder.

The most frequently reported impacts of dairy production on farms are higher income, improved livelihood and improvement of nutrition through higher productivity of crossbreds (Table 28). There was no significant difference in impacts between study regions.

Table 28. Impact of milk production on household as perceived by farmers

Impact of milk production on farm	% of farmers	Comments
Income generation	97	Higher income (N=40) House construction or improvement (N=36) Payment of school fees (N=34) Livelihood improvement (N=18) Payment of living expenses (N=11) Purchase farming inputs (N=10) New work opportunities for family (N=1) Payment of hired laborers (N=1)
Improved family nutrition	17	Improved family nutrition (N=10) Higher home consumption of milk (N=4)
Impact on family life	10	Children live own life (N=6)
Change of farming system	5	Decreased flock size (N=1) Strong crossbred oxen for ploughing (N=1) More dung for energy (N=1)

The adoption of crossbreeding entailed an income increase for all farmers who sold livestock products, which indicates the increasing role of cattle rearing as source of income in the study regions. Except one farmer who did not sell dairy products, all respondents (98.33%) reported an increase in income from dairy. All farmers expressed that crossbreeding pays off and that they benefited from its adoption. All respondents would advice other farmers to start crossbreeding.

6.8. Milk processing and marketing

No significant differences in herd milk production, amount of milk sold and amount used for home consumption were observed between study regions (Table 29). In all study sites higher amounts of whole milk were sold than used for home consumption.

Table 29. Average herd milk production, amount of milk sold and amount of milk used for home consumption

	Gondar Zuria			Lay Armacho			Debark		
Milk production and use categories	**N**	**mean**	**Std dev**	**N**	**mean**	**Std dev**	**N**	**mean**	**Std dev**
Milk production of herd (l/d)	20	16.7	11.01	20	20.6	18.24	20	12.3	7.84
Milk for sale (l/d)	17	7.1	9.13	15	6.4	3.56	17	5.1	6.48
Home consumption (l/d)	19	5.9	4.15	18	6.1	3.39	20	4.7	2.28

Before the introduction of crossbreeding the majority of farmers (95%) across all regions practised butter churning. In Lay Armacho and Debark 85-90% of farmers produced cheese and yoghurt which was asignificantly ($P<0.05$) higher number than in Gondar Zuria (50-60%). After introduction of crossbreeding, processing of milk increased in all study regions. Butter, cheese and yoghurt were produced by 97%, 92% and 90% of farmers respectively.

An increase in marketing of dairy products could be observed. Before crossbreeding butter was predominantly sold by 50%, 35% and 65% of farmers in Gondar Zuria, Lay Armacho and Debark respectively. After introduction of crossbreeding it increased to 70%, 70% and 80% respectively. Cheese and yoghurt were sold by 0-10% of farmers before crossbreeding. While marketing of cheese did not increase after introduction of crossbreeding, marketing of yoghurt increased to 25%, 20% and 5% in Gondar Zuria, Lay Armacho and Debark respectively.

Before crossbreeding 4% of farmers were selling milk. ILDP created milk consumption and marketing awareness among farmers through training, organization of milk days and establishment of milk cooperatives. Results show that 80% of Gondar Zuria‘s, 70% of Lay Armacho‘s and 75% of Debark‘s farmers aqcuired new market access after ILDP’s implementation. The results are not significantly different between regions ($p>0.05$).

Milk producers used various outlets to sell their milk and milk products (Table 30). The largest milk outlets in the studied areas were milk cooperatives. In each of the study

region ILDP launched one milk cooperative. In Gondar Zuria exclusively, some farmers additionally sold their milk on market places at village level or in next bigger towns. In Lay Armacho significantly more farmers (P<0.05) sold their milk directly from home to customers compared to Debark. Marketing of milk to hotels or government workers on contract basis was common in Gondar Zuria and Debark. In all study regions dairy products were mostly sold at market places in the next bigger towns. Significanlty (P<0.05) more farmers in Gondar Zuria sold their dairy products at village level compared to Debark.

Table 30. Market places for milk and dairy products across study regions

	Milk						Dairy products					
	Gondar Zuria (n=20)		Lay Armacho (n=20)		Debark (n=20)		Gondar Zuria (n=20)		Lay Armacho (n=20)		Debark (n=20)	
Types of milk and dairy products outlets	**freq**	**%**	**freq**	**%**	**freq**	**%**	**freq**	**%**	**freq**	**%**	**freq**	**%**
At village level	4^{a}	20^{a}	0^{b}	0^{b}	0^{b}	0^{b}	8^{a}	40^{a}	2^{ab}	1^{ab}	0^{b}	0^{b}
Next bigger town	2	10	0	0	0	0	7	35	9	45	15	75
Directly from farm to customers	6^{ab}	30^{ab}	9^{a}	45^{a}	1^{b}	5^{b}	2	10	3	15	0	0
Dairy marketing cooperative	10	50	14	70	17	85	1	5	0	0	0	0
Hotels/ government workers on contract base	3	15	0	0	2	10	1	5	1	5	1	5
Not selling at the moment	4	20	5	25	3	15	4	20	5	25	4	20

Since adoption of crossbreeding 50%, 70% and 45% of farmers in Gondar Zuria, Lay Armacho and Debark faced new marketing challenges. The differences are not significant between regions. New challenges as perceived by farmers are presented in Table 31. During religious fasting periods marketing is difficult for farmers in all study regions. Fasting periods are characterised by low consumer demand for dairy, cooperatives refusing to collect milk and low milk prices paid by cooperatives. Farmers

have to overcome these challenges by finding alternative markets, like selling milk to private customers instead of cooperatives and by processing excess milk to increase shelf life. Some farmers stated that cooperatives accept milk but throw away the excess. Long distances to markets as well as lack of transport were problems in Lay Armacho and Debark. In Lay Armacho the milk cooperative checks quality of milk and occasionally refuses to accept milk. From farmers' experience milk contamination increases during dry season. In Lay Armacho and Debark farmers stated that in the beginning demand for milk was low and their customers believed that milk from local cows was of superior quality than milk from crossbreds. Awareness of people concerning the benefits of milk consumption in general was slowly created in the course of the ILDP.

Table 31. New marketing challenges faced by farmers since adoption of crossbreeding

	Gondar Zuria (n=20)		Lay Armacho (n=20)		Debark n=20)	
Marketing challenges	**frequency**	**%**	**frequency**	**%**	**frequency**	**%**
Problems during fasting periods	10	50	6	30	6	30
Transportation problem	0	0	5	25	2	10
Quality problem	0[a]	0[a]	4[b]	20[b]	0[a]	0[a]
Low awareness of benefits of milk consumption	0	0	2	10	2	10
Low milk price	0	0	2	10	0	0
Processing machines at cooperative wear out	0	0	0	0	1	5
No problems	10	50	6	30	11	55

6.9. Challenges with crossbreeding

Main challenges related to crossbreeding across study regions are summarized in Table 32. The differences between regions were not significant. Some of the main challenges were health, reproductive and adaptation problems. Farmers stated that heat detection is more difficult and that heat period is shorter in crossbred than in local cows.

Furthermore, repeated breeding and abortion occured. Eight respondents experienced death of one of their crossbred animals. Problems connected with marketing included marketing difficulties during fasting periods, lack of transport and increasing feed but low milk price. Major constraints hindering the development of dairy technologies necessary for crossbreeding were unsatisfactory AI and veterinary services, shortage of inputs (e.g. forage seeds, feedstuff, medicine and semen) after ILDP stopped and shortage or bad quality of natural resources. Farmers stated that there was a common lack of land for forage production and water shortage during dry season. Leech-infested watering places resulting in poor water quality were also problematic. Farmers were aware that storage of feedstuffs must improve in order to improve feed quality.

Table 32. Challenges and constraints connected with the introduction of crossbreeding

	Gondar Zuria (n=20)		**Lay Armacho (n=20)**		**Debark (n=20)**	
Challenges and constraints	**frequency**	**%**	**frequency**	**%**	**frequency**	**%**
Health, reproductive and adaptation problems	8	40	5	25	7	35
Marketing/ financial problems	6	30	8	40	2	10
Unsatisfactory services	6	30	1	5	6	30
Lack or bad quality of natural resources	5	25	5	25	4	20
Shortage of inputs	1	5	1	5	5	25
No challenges	3	15	4	20	4	20

7. DISCUSSION

In the following chapter own results are analyzed, interpreted and discussed in light of findings from literature.

7.1. Household description

The overall mean household size in this study is 7.55 persons, which is higher than the 4.9 person average in rural Ethiopia (CSA, 2007). The mean age of household heads (48.23 years; range 26 to 73 years) is similar to results found by Anteneh et al. (2010) for the case of Fogera woreda (mean 44 years; range 22 to 77 years). Overall illiteracy rate (11.7%) was lower than the rate reported by Ayenew et al. (2008) in urban and peri-urban areas of Bahir Dar and Gondar (27.7%). Percentage of household heads with higher education (8.3%) was lower than the level found by Ayenew et al. (2008) (19.6%).

7.2. Farm description

Two dairy production systems were identified in the study: the rural highland smallholder mixed farming system and the urban and peri-urban livestock farming system. A considerable proportion of respondents in Lay Armacho woreda (8 out of 20) were farmers from an urban and peri-urban setting with limited access to farming land. This region had the highest number of farmers with off-farm income. Similar characteristics of urban farmers were reported by Yoseph et al. (2003) in Addis Ababa, Lobago et al. (2007) in Sellale and Ayenew et al. (2008) in Gondar and Bahir Dar. Mean farm sizes in Gondar Zuria (2.4 ha) were larger than the Ethiopian average of 1.18 ha (CSA, 2011). The average farm size in Debark (1.2 ha) was similar to the Ethiopian average.

Total yearly income from all farming activities was highest in Lay Armacho and lowest in Debark. Such differences in earnings between study sites might have resulted from a variation in access to input services, livestock and land productivity, herd size and farm size. Higher income in Lay Armacho could be the reason for willingness to pay higher prices for AI services.

The overall herd size varied significantly between regions. The higher number of cattle in Gondar Zuria results from the higher proportion of local cattle in the herds. This result could be connected to the larger farm sizes occurring within this region compared to the other two study regions. These results are comparable with Ayenew et al. (2008) who reported a larger number of cattle kept by crop-livestock farmers, like in Gondar Zuria, than by livestock farmers in peri-urban and urban sites. Further reason for larger herd sizes in Gondar Zuria is the considerable number of oxen present. Oxen provide draught power which is imperative for cultivation and reflects the importance of cropping in this region (Tesfaye et al., 2001; Starkey and Faye, 1990). This result is in agreement with reports of Abdinasir (2000), Getachew et al. (1993) and Desta (2002). By comparison, in Debark, a high altitude area, there is a long tradition of using horses instead of oxen for traction on light soils (Wuletaw, 2004b).

The distribution of dairy cattle managament activites between household members and hired labourers is in agreement with findings from Anteneh et al. (2010). Transport of milk to milk cooperatives or nearest markets was usually the responsibility of children which opposes results reported by Aneteneh et al. (2010) who found that mainly adult males and females were responsible for this activity.

7.3. Diffusion of crossbreeding and extension support

The main source of information for project beneficiaries was ILDP which cooperated with the District Agricultural Development Offices and extension agents. Rogers (2003) and Spielmann et al. (2008) expressed that agricultural extension is of particular importance in smallholder innovation processes in developing countries and for complex innovations such as crossbreeding technology.

Furthermore according to Conley and Udry (2001) passing on innovation knowledge and experience from peer to peer as well as observation of neighbor's farming experiences strongly influences the adoption decision of farmers in developing countries. This is in agreement with the present study, as the majority of farmers sought further information from their peers before adopting an innovation.

The overall innovation-decision-period was 2.12 years (std.dev.: 1.89 years). It was significantly longer in Debark (3.1 years) than in Lay Armacho (1.26 years). The reason for this was, that in Debark the District Agricultural Development Office held introductory trainings on crossbreeding technologies a long time before ILDP started to introduce them. By comparison the average innovation decision period of organic vegetable farming among smallholder farmers in Nepal recorded by Kafle et al. (2011) was one year (range: 3 months to 4 years). Crossbreeding is regarded as a complex cluster of innovations which requires the introduction of various other complementary inputs to be successful (Rogers, 2003). When innovations are introduced simultaneously, the adoption decisions for various innovations are interrelated and might justifiably take more time (Feder et al., 1985).

The necessity that farmers needed to understand interactions between crossbreeding and complementary inputs and were able to access these inputs, put great demands on project and extension. The overall satisfaction with ILDP and the fact that in ten years of implementation participants received extensive training, acquired a variety of farming inputs and access to services indicates, that technologies were delivered successfully to farmers in the study area through intensive promotion.

Some difficulties with acquiring certain farming inputs arose after the project ended. However, for successful keeping of crossbred animals it has to be assured that high-input technologies can be delivered in a sustainable way (Kebede, 2003). Therefore farmers actively have to search for markets to buy their farming inputs after the project support is gone. Especially in areas where infrastructure is less developed and major markets are far, this poses a challenge (Walshe et al., 1991). These results might indicate that ILDP in some cases did not put enough emphasis on strongly linking farmers to sustainable markets were they can obtain their farming inputs or poor road infrastructure and transportation problems inhibited farmers to find markets. Further research however is needed to understand the relationship.

7.4. Breeding and mating practices

7.4.1. Breeding practices

High exotic blood levels in crossbred offspring (Table 11) and the fact that the majority of respondents stated “grading up” as their breeding strategy indicates that AI is more widely used than crossbred bulls. This result is in line with Kahi (2002) who mentioned that smallholders practice systems of upgrading indigenous breeds to higher exotic grades without following a defined crossbreeding program. As less than full replacement of local genes with exotic genes is desirable (Cunningham and Syrstad, 1987), it has to be questioned if appropriate crossbreeding methods and effective dissemination schemes enabling maintenance of desired exotic blood levels were established by ILDP (Gebremichael, 2008). A considerable percentage of farmers (25%) did not show a clear trend in breeding practices (fluctuations of exotic blood level), 13% were not aware of blood level change which resulted in breeding decisions based on others’ recommendations or unconscious back crossing with local bulls), further 5% of farmers used local bulls for back crossing on purpose. This results in a wide variety of crossbred genotypes and lack of an appropriate breeding strategy. Kahi (2002) emphasizes that in the smallholder sector attention has to be paid to matching the genotype to the environment. Utilisation and improvement of the desired crossbred population can only be efficient in situations where breeding programmes with well-defined breeding objectives are developed; which is often lacking at smallholder level in the tropics (Kahi, 2002). Due to results of this study it is unclear if ILDP did not promote clear breeding objectives and the maintenance of a certain exotic blood level or if information-flow between extension and farmers was insufficient. Ineffectiveness of agricultural extension service in the field and poor targeting were indicated by Gautam (2000) in Kenya.

Gautam further reported that farmers rarely applied agents’ recommendations for complex practices and that the primary reason was lack of information. In the present study this argument could be supported by the fact that very few farmers based their breeding bull selection on recommendations from extension staff.

Further possible reasons for fluctuations of exotic blood level are numerous: Lack of knowledge led to random breeding decisions. Bulls were used as alternative option if AI technicians or semen was not available or AI service failed repeatedly. It was indicated that AI service offered semen from exotic bulls exclusively. Some farmers did not know the exotic blood level of the bull which their cows were inseminated with.
However there is clear evidence that the majority of farmers have some kind of knowledge about exotic inheritance, experiment themselves and search for the appropriate level of exotic blood in their herd. As farmers explain the appropriate level depends on the animals' adaptation to the environment and their individual management potential (ability to satisfy feed and health requirements). Rogers (2008) explains this phenomenon as re-invention, which is a way of making an innovation well fit to own realities.

An on-farm survey like this one does not result in an exact determination of blood levels but gives an important insight into farmer's knowledge on herd composition. These results depend on farmers memories and can never replace laboratory analyses using biochemical or molecular techniques to study genetic diversity, determine distinctiveness of breeds and measure genetic distances among populations (Rege et al., 2006).

7.4.2. Mating practices

In this study AI was the most common method for mating crossbred cows (used by 95% of farmers), followed by crossbred bulls (48%) and local bulls (16.6%). Another report (Bitew et al., 2011) that differentiated between high, medium and low market quality sites (market quality refers to the effectiveness and efficiency of market chains) indicated that AI was the most common breeding method in low quality markets, whereas improved bulls were most common in medium and high market quality sites. Breeding of crossbred cows with indigenous bulls occurred seldom in this study.

AI service is well known for its various advantages, but can be an expensive undertaking if not used efficiently (Wuletaw, 2004a). The results of this study indicate that farmers in all regions had very good access to AI service and that the majority

(89%) was satisfied with the availability and the service they received. Timely insemination was facilitated by use of mobile telephones, available infrastructure and use of car or motorbikes by AI technicians. This efficient AI service is mainly linked to ILDP's work but not a matter of fact in other regions in Ethiopia or the tropics. As an example Desta (2002) and Abdinasir (2000) reported a wide use of AI service in areas with good infrastructure for AI close to cities but very low application far from cities. In this case natural service was recommended as best practical option in remote areas. Nearly half of farmers (46.7%) in Addis Ababa had problems with AI according to Desta (2002).

The price for AI service varied significantly between study sites due to additional transport cost in remote areas. For this purpose cars or motor bikes were used by AI technicians. In spite of the higher prices farmers in all study sites were willing to pay higher prices for this service, because they saw great advantages in it, which is a further indicator for the positive attitude towards AI.

Exotic semen from both Holstein Friesian and Jersey was used for insemination in the study regions with only 32% of farmers using Jersey semen additionally to Holstein Friesian. According to Wuletaw (2004a) in the project region nearly 90% of the inseminations were done using Holstein Friesian semen. He criticized the low utilization of Jersey even though the breed showed better adaptive potential and overall suitability in mid altitude areas. Furthermore, the overall interest of farmers (93%) to try a different breed with better qualities fitting the environment, the long distances to markets and a present good market outlet for butter would be in favour of the Jersey breed.

Breeding bulls are mainly selected by farmers according to their availability, quality (body conformation, good performance, desired color) and level of exotic blood, rarely as alternative option for AI. Different results were obtained by Desta (2002) who in a survey asked farmers more specifically about their preferred performance traits for breeding bulls. High daily milk yield was the most important preferred performance trait followed by high fat content and short age at first calving. Bitew et al. (2011) further

reported that crossbred bulls were used as an alternative mating option in situations in which AI was not reliable.

7.5. Performance differences between local and crossbred cows

In this study breed had a statistically significant effect on both productive and reproductive performance. Farmers experienced crossbreds of indigenous cattle with Holstein Friesian or Jersey to have higher daily milk yield, earlier age at first calving and shorter calving interval. This is in agreement with previous reports from Ethiopia (Kiwuwa et al., 1983; Abdinasir, 2000; Desta, 2002; Demeke et al., 2004; Bitew et al., 2011) and other developing countries (Galukande, 2010).

7.6. Adoption of subsequent innovations

In this case study innovations included development of feed resources and feeding strategies, introduction of cattle housing, improvement of animal health service, access to AI service, techniques for environmental protection, and improvement of market linkages and development of market outlets (ILDP, 2007).

7.6.1. Feed resources and feeding strategies

The majority of farmers adopted a variety of new feedstuffs which included forage plants, industrial or household by-products (mainly oil seed cake), fodder crops, crop residues and grain. Dissemination of seeds and seedlings of multipurpose fodder trees was carried out by ILDP to serve as supplementary feed for animals in milk-shed areas and areas distant from urban centres and for soil conservation (Wuletaw, 2004a). Whereas fodder tree Ficus thonningii and Cordia africana were adopted in Gondar Zuria and Lay Armacho, Chamaecytisus palmensis (tree lucerne) was exclusively adopted in Debark. The reason is that tree lucerne adapts well in the extreme high altitudes of this region (Mekoya, 2008).

Dairy producers in the urban areas in Lay Armacho, who lack farming land, mainly adopted industrial and household by-products and less forage seeds. This is in agreement with Yigrem et al. (2008) who reported that urban farmers mainly purchased

roughage and concentrate feeds along with non-conventional feeds like atella (by-product of homemade beer). Bitew et al. (2011) reported that agro-industrial by-products and concentrates were mainly used in high market quality sites. All three cases show that on one hand urban and peri-urban farmers are not able to produce forage plants but on the other hand profit from better market access as a pathway to feed intensification and increased animal productivity.

Overall, farmers intensified their farming practices shifting from free grazing (traditional for local cattle) to semi-intensive backyard dairying and controlled grazing or zero-grazing (common for crossbreds). This finding is in agreement with reports by Bitew et al. (2011). Benin et al. (2003) and Bitew et al. (2011) substantiate this fact and highlight that the use of communal and private grazing lands declined in the past 20 years. In the present study 97% of farmers introduced new shelters for the purpose of stall-feeding. This is in line with Benin et al. (2003) and Bebe et al. (2003) who found that 80% and 75% of smallholder farmers respectively adopted improved breeds together with stall-feeding.

While in Gondar Zuria and Debark the majority of farmers used different feeding strategies (grazing, stall-feeding) for local and crossbred cattle, farmers in Lay Armacho did not differentiate between the two genotypes. The reason for this lack of distinction is the restricted access to grazing land in the urban and peri-urban setting of Lay Armacho.

7.6.2. Veterinary service and animal health improvement

Reasons for the variation in occurrence of diseases and health problems between local and crossbred cows might be linked apart from genotypic factors to management practices, available veterinary service and access to inputs.

While in Gondar Zuria and Debark farmers experienced local cattle to be generally healthier than crossbreds, the majority of farmers in Lay Armacho experienced no health differences between genotypes. Significantly lower application of prophylactic treatments against parasites in Lay Armacho can be explained with the higher

proportion of stall-feeding in urban areas resulting in less exposure to parasites. In Lay Armacho and Debark some farmers did not experience any cattle health issues. The reason for this could be the higher altitude (>2000m.a.s.l.) compared to Gondar Zuria (<2000m.a.s.l.). Significantly lower treatment of illnesses in Debark probably relates to this being the highest altitude area sampled (around 2800m.a.s.l.). According to Benin et al. (2003) one of the reasons for human and livestock settlements in the highland areas (especially in the 2300–3200m.a.s.l. range) was the absence of diseases.

The occurrence of common infectious diseases, including anthrax, black leg and contagious bovine pleuropneumonia is in agreement with results of Benin et al. (2003) in Amhara Region. The reason why infectious diseases occurred more often among local than crossbred cattle was insufficient access to veterinary service and vaccinations before ILDP. Before crossbreeding local cattle were more often treated with traditional indigenous methods. After ILDP granted farmers access to veterinary services, traditional healing methods lost their importance. Crossbred cattle are exclusively treated by veterinarians. Even though farmers experienced crossbred cattle to be more susceptible, the overall occurrence of infectious diseases decreased due to introduction of veterinary services. An improvement in access to animal health service was also witnessed by Benin et al. (2003). However there is evidence that with increasing production level diseases of intensification (e.g. mastitis, reproductive disorders) might increase.

Local cattle are less affected by tick borne diseases than their crosses, which is in agreement with other reports (Wambura et al., 1998; Ali and De Castro, 1993).

Results on reproductive disorders in the present study are limited to two abortion cases and repeated breeding in crossbred cows. Few farmers stated that heat detection is more difficult and that heat period is shorter in crossbred cows. Whereas in studies carried out by Molalegne and Shiv (2011) and Shiferaw et al. (2005) 26.5% and 39% of cows were diagnosed positive for reproductive disorders respectively.

7.7. Impacts of crossbreeding technology on the production system

The results of this study showed that income generation and livelihood improvement were the most important impacts milk production had on households, irrespective of the study area. The fact that adoption of crossbred dairy cows significanlty increases household income was also witnessed by Patil et al. (1997), Nicholson et al., (1999), Ahmed et al. (2002), Udo et al. (2010) and Bitew et al. (2011). Of second importance was the improvement of family nutrition which was in agreement with survey results from Nicholson et al. (1999) and Ahmed et al. (2002).

The overall increase of herd size by 15% can be regarded as an undesirable effect of the introduction of crossbreeding as it entails possible triggers for land degradation (Delgado et al., 1999). Furthermore the ability to meet higher feed requirements for cattle has to be investigated. In Lay Armacho herd size slightly decreased. Reasons could be shortage of adequate land for dairy production and limitations in number of animals allowed to be kept in urban environments. Ayenew et al. (2008) stated the problem of proper manure disposal in urban areas.
While the present results show that 58.33% of households increased their herd size, the contrary was revealed by Bitew et al. (2011) who reported that 55-67% of milk producers decreased their herd size. Benin et al. (2006) and Udo et al. (2010) suggested that an increase in milk production should be achieved by replacing local stock with fewer improved animals and better feeding and management practices rather than by increasing herd size to reduce pressure on already degraded resources (Delgado et al., 1999).

The increase of workload resulting from introduction of crossbreeding was almost entirely carried by heads and spouses, to a lesser extent children or hired labourers. It is necessary to consider the effect of additional workload on women who already carry an enormous labor burden. Additional workload might result in severe overwork situations. Women in Ethiopia are responsible for labor intensive and time consuming on farm activities in agricultural production (Mekonnen H. et al., 2010); while at the same time their access to land, agricultural extension, technology and decision making

power is critically impeded (Frank, 1999). In the present study it was found that women had less say in breeding decisions, even though ILDP was promoting gender equality, which is in agreement with findings from Yisehak (2008) from Jimma Zone. Worldwide, according to Asenso-Okyere and Davis, (2009), women farmers receive only 5 percent of extension services. This situation severely restricts the productive ability of women, especially female household heads who consequently have difficulties in achieving household food security through agriculture.

The adoption levels of technologies as well as the effect crossbreeding had on the dairy production system is summarized in Table 33. High adoption levels of feedstuff, feeding strategies and housing strongly suggest that technologies have been introduced effectively in the study area. New access to milk markets and overall income increase demonstrate the transition smallholder farmers have made to market-oriented production. Farmers perceived an overall benefit from crossbreeding. In remote areas dairying has become the farmer's only source of income. However, according to Peters (1991) an increase in production intensity in association with breed improvement programs changes cost-benefit ratios and exposes to production risk. To reduce risk a reliable access to high-input technologies and market outlets simultaneously is required.

Table 33. Adoption levels of technologies and change in production system (% of interviewees)

Adoption levels/ production system change (%)	New feedstuff	New feeding strategies	New housing	New milk market access	Income increase	Workload increase
Gondar Zuria	95	95	95	80	95	95
Lay Armacho	100	30	95	70	100	100
Debark	100	85	100	85	100	100

7.8. Milk processing and marketing

Sales of milk were formerly not common practice; on the contrary in some regions selling was restricted by traditional taboos (Yigrem et al., 2008). Before crossbreeding only 4% of farmers in the study area were selling milk. After ILDP's long process of

creation and implementation of milk consumption awareness and marketing, the majority of farmers acquired new market access. In total a higher amount of milk was sold than used for home consumption. These results show that smallholders moved from subsistence to market-oriented dairy production (Ahmed et al., 2004). For comparison in the year 2005 in Amhara Region only 7% of the milk produced was sold, 43% was used for home consumption and 50% was processed (CSA, 2005).

Ahmed et al. (2003) demonstrated how adoption of dairy technologies (crossbred cows, improved feed and management practices) enhanced market participation and raised per capita income, expenditure on food and non-food items and nutrient consumption. These findings are in line with the present study results.

Ahmed et al. (2003) stated also that the success of market oriented production depends on availability of marketing infrastructure to encourage smallholders' market participation. In this case study infrastructure in form of milk cooperatives was established by ILDP. The majority of ILDP beneficiaries (68%) used this given chance and started marketing of milk through these cooperatives. Informal ways of milk sale were consequently reduced. This contrasts other studies like Yigrem et al. (2008) who stated that the major dairy marketing system found was informal, direct sale to customers on contract basis. Staal and Shapiro (1996) also reported that about 90% of the milk marketed in sub-Saharan Africa is delivered informally to consumers. As reported by many authors, dairy cooperatives play a key role in market development as they provide a continuous milk outlet (Holloway and Ehui, 2002; Zegeye, 2003; Yigrem et al., 2008). Furthermore they can supply farmers with essential inputs such as AI, veterinary services and concentrate feeds (Yigrem et al., 2008). Facilitations in production, processing and sale are reasons why farmers in this study prefer cooperatives to informal milk marketing.

The major marketing challenge faced by farmers is a lower demand during religious fasting periods. This is in agreement with findings from Walshe et al. (1991), Zegeye (2003) and Ayenew et al. (2008) who likewise reported a decrease in consumer demand and low milk price during fasting periods. The Ethiopian orthodox church alone has a total of 250 fasting days during which foodstuffs of animal origin are forbidden (Ayenew et al., 2008). Farmer's solution is to provide milk to muslims during orthodox

fasting and vice versa. However farmers need a secure outlet and stable milk price therefore according to Falvey Chantalakhana (1999) the processing industry is very important. For instance the storage stability of butter (4 to 6 weeks) is much longer than that of fresh milk and allows temporal flexibility for consumption and marketing (Yigrem et al., 2008). Results of this study have shown that ILDP's intervention led to a substantial increase in milk processing and marketing of these dairy products.

Further challenges were poor market access due to remoteness and lack or high cost of transport which is in agreement with Ayenew et al. (2008). In some cases cooperatives refused to collect milk after obtaining unsatisfactory results from milk quality checks. This result indicates poor hygienic quality which was clearly demonstrated by Tassew and Seifu (2006) using microbiological analysis of milk collected from farmers and milk cooperatives in Bahir Dar Zuria. Ayenew et al. (2008) attributes this situation to a common lack of access to milk storing and processing technologies and bad quality of water used for cleaning. He highlights that basic handling and health education would probably lead to improvement of milk product quality.

7.9. Challenges with crossbreeding

Various reports (Davis et al., 2006; Mekonnen H. et al., 2010; Bitew et al., 2011) affirm that crossbreeding is attached to a multitude of challenges, which have to be overcome by farmers in order to be successful. Major constraints are health and adaptation problems, market situation, AI and veterinary services and availability of resources and inputs. These findings are similar to those of Bitew et al. (2011) and Mekonnen H. et al. (2010) in Amhara region and reflect the seriousness of resource, service and input related problems in the area.

Shortage or bad quality of land, fodder and water in the study area is in line with prior studies (Patil et al., 1997; Mekonnen H. et al., 2010; Bitew et al., 2011). According to farmers in Debark quality and availability of pasture decreased as the number of project participants increased. This argument reflects an issue raised by Abdulai and Huffman, (2005) who stated that with a growing number of adopters the expected benefit from

adoption declined. Benin et al. (2006) found that both availability and quality of communal grazing land in Amhara Region has been declining between 1991 and 1999. Furthermore the use of woodlots, forests, homestead and private pastures declined. Lack of feed can have serious effects on crossbreeding strategy development in the region. Developments need to be monitored intensively to prevent feed deficiency.

High cost and low availability of inputs became problematic once the project support was gone which is in agreement with findings from Mekonnen H. et al. (2010) and Bitew et al. (2011) from other parts of Amhara Region. In the present study farmers in Debark had difficulties to acquire forage seeds, concentrates, medicine and semen. Berhanu et al. (2009) demonstrated that the sources of many concentrate feed ingredients lie outside farmers' villages. In comparison, dry fodder is available at village level (Benin et al., 2206; Berhanu et al., 2009). A solution would be that milk marketing cooperatives supplied lacking inputs to milk producers. However when farmers encounter big problems with satisfying feed demand of cattle, this might seriously challenge the implementation of crossbreeding. Depending on seriousness of this problem crossbreeding might either not be an appropriate strategy or the utilization of other exotic breeds like Jersey that do not have such high feed demands should be advocated.

8. CONCLUSIONS

Our findings indicate that it is worthwhile for smallholder farmers to keep crossbred cattle when a sustainable provision of farming inputs, services and improved management practices are given. Crossbred animals should only be introduced if complementary inputs are accessible. Crossbreeding activities are succesful for farmers in areas with good accessibility, were market linkage is strong, animal health and AI services are provided efficiently, feed demand can be satisfied and other infrastructure supports crossbred animals. This complex and generally higher input system which is susceptible to disturbances requires continuous monitoring and strengthening. Therefore a long-term commitment from organizations to provide technical support is required.

Extension support given by ILDP was in fact advanced (granted access to a complete dairy technology package). Regarding high adoption levels of dairy technologies, significant improvement in performance and positive opinions of participating farmers it can be concluded that ILDP's overall performance was successful. Lessons can be learned from ILDP for upscaling of services and further development of crossbreeding programs.

Further actions in research should investigate indicated negative impacts of crossbreeding e.g. overburdening of household members through increasing workload, constant degradation of grazing land and feed scarcity through increasing cattle herd size.

The promotion of a clear breeding strategy was found to be missing in this study. In future it will be a challenge, however essential, to develop crossbreeding programs with well-defined breeding objectives and systematic performance recording in a way which is cost-efficient and easy to conduct at smallholder farm level in developing countries.

9. SUMMARY

Ethiopia is confronted with an increasing demand for food of animal origin as the human population keeps increasing. A number of livestock development projects have been carried out with the objective of introducing crossbred animals to improve milk productivity and milk market participation of subsistence farmers. The present study analyzes ILDP (The Integrated Livestock Development Project), a project that introduced crossbreeding in North Gondar Zone. It has been implemented for almost 10 years under collaboration with the District Agricultural Development Offices to support farmers by supplying technology packages covering a wide scope of aspects from training to input supply.

The study was carried out 5 years after ILDP had finished with the aim to analyze the development of crossbreeding and its effect on dairy production systems and livelihoods in the study area. Results give insight into farmers' innovation processes which took place during the project's implementation as well as during the 5 years after project end.

The field data collection was conducted from mid August to mid September 2011 and covered a total of 60 dairy farms who had participated in the project and were located in 3 project districts in North Gondar Zone (Gondar Zuria, Lay Armacho and Debark) of the Amhara Regional State. Data was collected during interviews with household heads using a questionnaire.

The study revealed a significant superiority of crossbred cows to indigenous cows in terms of milk production and reproductive performance. Crossbred cows have higher daily milk yields, earlier age at first calving and shorter calving intervals. For smallholder farmers participating in this study crossbreeding is a way out of poverty into a better livelihood. It improves food security and enables a transition from subsistence to small-scale commercial farming. Through production system changes and increased livestock productivity dairying becomes an important farming activity and source of income for farmers benefiting from ILDP.

However in order to experience benefits from this innovation, a reliable access to farming inputs, services and improved management practices is required. Adoption of dairy technologies provided by ILDP has been successful considering the high adoption levels of new feedstuffs, feeding strategies and shelter improvement. Market linkage has a lower success rate and indicates the need for further strengthening. An overall trend in reduction of diseases can be explained on account of expanded animal health service provision through ILDP. However the fact that farmers experience crossbred cattle to be more susceptible to diseases requires continuous health monitoring and a sustainable provision of drugs and veterinary services. The positive performance of AI service initiated under the ILDP framework, which is perceived as reliable, inexpensive and constant source of genetic improvement of cattle, sets a good example for other regions in Ethiopia.

Negative impacts of crossbreeding are discussed in the study. It was found that crossbreeding led to an increase of workload, which might indicate overburdening of household members, especially women. An overall increase in herd size might contribute to erosion and deteriorate quality of already degraded grazing land and result in feed scarcity. An increase in production intensity requires a higher input system and reliable market outlets. High cost and low availability of inputs became indeed problematic in some areas once the project support was gone and low demand for dairy products during religious fasting periods was found to be one of the major marketing challenges. Hence these challenges might expose to production risk. The wide variety of crossbred genotypes found in the study indicates lack of an appropriate breeding strategy set up by ILDP or ineffectiveness of extension service in the field.

10. ZUSAMMENFASSUNG

Da die Bevölkerung in Äthiopien stetig ansteigt, ist das Land mit einer wachsenden Nachfrage nach tierischen Lebensmitteln konfrontiert. Bereits abgeschlossene Viehzuchtprojekte zielten darauf ab, Rinder aus Kreuzungen zwischen lokalen und hochleistenden westlichen Rassen einzuführen. Ziel war die Milchleistung und den Milchmarktzugang von Subsistenzbauern zu steigern. Die vorliegende Diplomarbeit untersucht ILDP (Integrated Livestock Development Project), ein Projekt das Kreuzungszucht in der Nord Gondar Zone etablierte. Das Projekt wurde in Zusammenarbeit mit den District Agricultural Development Offices realisiert indem es Technologiepakete bereitstellte, die einen weiten Bereich, von Weiterbildung bis zu Versorgung mit landwirtschaftlichen Produktionsmitteln, abdeckte.

Die Untersuchung wurde 5 Jahre nach Projektende mit dem Ziel durchgeführt, die Entwicklung der Kreuzungszucht durch Bauern und den Einfluss auf Milchproduktionssystem und Lebensverhältnisse der Bauern darzustellen. Die Ergebnisse geben Einblick in bäuerliche Innovationsprozesse welche während des Projektes, sowie in den 5 Jahren nach Projektende, stattgefunden haben.

Die Daten wurden von Mitte August bis Mitte September 2011 anhand von fragebögengestützten Interviews mit 60 Landwirten, Teilnehmern an ILDP, erhoben. Das Studiengebiet umschloss 3 Projektregionen in der Nord Gondar Zone der Amhara Region (Gondar Zuria, Lay Armacho und Debark).

Die Resultate belegen eine signifikante Überlegenheit der Kreuzungstiere gegenüber den einheimischen Rassen in Bezug auf Milch- und Reproduktionsleistung. Kreuzungskühe haben eine höhere Tagesmilchleistung, niedrigeres Erstkalbealter und kürzere Zwischenkalbezeiten. Für Kleinbauern die am ILDP teilgenommen haben ist Kreuzungszucht ein Weg, Armut zu überwinden und ihre Lebensgrundlage zu verbessern. Weiteres wird die Ernährungssicherheit erhöht und ein Wechsel von Subsistenz auf marktorientierte Landwirtschaft ermöglicht. Nach erfolgter Änderung im Produktionssystem und Steigerung der Produktivität, entwickelte sich die Milchwirtschaft zu einer wichtigen Einkommensquelle für ILDP Teilnehmer.

Um Nutzen aus dieser Innovation zu ziehen, ist jedoch der verlässliche Zugang zu landwirtschaftlichen Produktionsmitteln, Diensten und verbesserten Produktionsmethoden unerlässlich. Die Einführung von Milchproduktionstechnologien durch ILDP war erfolgreich, betrachtet man die hohen Adoptionsraten von neuen Futtermitteln, Fütterungsstrategien und Stallverbesserungsmaßnahmen. Die Anbindung der Bauern an Absatzmärkte muss hingegen verbessert werden. Ein Rückgang von Rindererkrankungen konnte beobachtet werden, welcher auf durch ILDP ausgedehnte tierärztliche Leistungen zurückzuführen ist. Dennoch muss, aufgrund der höher eingeschätzten Krankheitsanfälligkeit der Kreuzungstiere, eine kontinuierliche Gesundheitsüberwachung und ein ständiger Zugang zu Veterinärdiensten und Arzneimitteln sicher gestellt werden. Das Besamungsservice, das im Rahmen von ILDP initiiert wurde, wird als verlässlich, preisgünstig und konstante Quelle genetischen Fortschritts wahrgenommen.

Mögliche negative Auswirkungen der Kreuzungszucht werden in der Studie diskutiert. Es wird aufgezeigt, dass Kreuzungszucht zu einer erhöhten Arbeitsbelastung führt, welche zur Überlastung von Familienmitgliedern, besonders Frauen, führen kann. Die Vergrößerung der Herden kann zu Bodenerosion und Qualitätsverschlechterung bereits degradierter Weidestandorte und folglich zu Futtermangel beitragen. Die Steigerung der Produktionsintensität verlangt einen erhöhten Betriebsaufwand und zuverlässige Absatzwege. In einigen Regionen wurden allerdings die nach Abschluss des Projektes bestehenden hohe Kosten und geringe Marktverfügbarkeit von Betriebsmitteln als problematisch angesehen. Die größte Herausforderung in der Vermarktung von Milch und Milchprodukten war die geringe Nachfrage während religiöser Fastenzeiten. Solche Probleme können das Produktionsrisiko erhöhen. Die Vielzahl an unterschiedlichen Genotypen deutet auf das Fehlen einer Zuchtstrategie des ILDP oder die Wirkungslosigkeit des Beratungsdienstes in diesem Bereich hin.

Die Studie konnte zeigen, dass Bauern mit einer umfangreichen Unterstützung den Umstieg auf eine mehr marktorientierte Milchviehaltung schaffen. Der Ansatz des ILDP könnte auch Anwendung in anderen Regionen Ätiopiens finden.

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14. ANNEXES

14.1. Questionnaire

Division of Livestock Sciences
Crossbreeding strategies as innovation: a case study of dairy cattle in Gondar, Ethiopia
Questionnaire for farmers

Study Area: **Gondar, Ethiopia**

Please mark ☒ where possible; otherwise insert answers/numbers given.

1. Site: _____

2. Name of town/village:_____

3. Name of respondent:_____

4. Dairy cattle before crossbreeding? **a:** yes ☐ **b:** no ☐

5. At least 8 years of experience with crossbreeding? **a:** yes ☐ **b:** no ☐

1. Farm profile and dairy operation characteristics

6. How long have you been the **head** of your farm?_____

7. How big is your farm? (approximately; in ha) _____ha

8. What are your main farming activities? What is most important?

a: crop ☐ _____

b: livestock: ☐ _____

e: others ☐ (specify): _____

9. How many family members work on your farm?_____

10. How many paid labourers work on your farm (insert number)?

a: permanent:_____ **b**: seasonal:_____

11. How much did you earn from crops last year? _____

12. How much did you earn from livestock/dairy last year? _____

13. How much milk did your cows produce on a usual day? _____

14. How much milk did you sell on a usual day? _____

15. How much milk is processed on your farm on a usual day?

16. What is the most important impact milk production has on your farm?

_____

_____

_____

17. Who is responsible for following dairy management activities:

Herding: _____

Fodder harvest: _____

Feeding:_____

Milking: _____

Transport of **milk** to market/cooperative_____

Processing on farm: _____

Transport of **dairy products** to market _____

18. Who is responsible for cattle breeding decisions on your farm?

a: head ☐ **b**: spouse ☐ **c**: other ☐ (specify)_____

1.1. Herd structure

19. Please specify the composition of your herd: Tell me how many animals per category you own:

type	**breed**			
	1: crossbred (n= _____)[1]	**2**: Fogera (n =_____)[2]	**3:** other local breed (n =)[3]	**3**: exotic (n =_____)[4]
a: cows				
b: heifers				
c: bulls				
d: oxen				
e: calves				

20. Please tell me how many crossbred cattle of each of exotic blood level category you have? (divided by cattle type **1-5**)

type of cattle	**exotic blood level**				
	a: <25%	**b**: 25%	**c**: 50%	**d**: 75%	**e**: 100%
1: cows					
2: heifers					
3: bulls					
4: oxen					
5: calves					

[1] Enter total number of crossbred animals.

[2] Enter total number of Fogera.

[3] Enter total number of other local.

[4] Enter total number of exotics. Sum all breeds up as validation after respondent has given specific information on types of cattle.

2. Adoption of crossbreeding local cattle x Holstein Friesian

21. When did you first hear of crossbreeding of local cattle with "exotics" (Holstein Friesian)? (year) _____

22. Who first told you of crossbreeding and what was this persons' position (please mark ☒)?

a: farmer ☐ _____

b: extension staff ☐ (specify extension organisation)_____

c: NGO staff ☐ specify NGO: _____

d: scientist ☐ (specify scientific institution) _____

e: community member ☐ _____

f: other ☐ (specify)_____

23. How did you get the first information on crossbreeding?

a: workshop ☐ where: _____ b: someone came to my farm ☐

c: I went to another farm ☐ d: at the cooperative ☐

e: other ☐ specify: _____

24. Did you ask also other people for more information about crossbreeding?

a: yes ☐ **b**: no ☐

25. Which other people did you ask for information on crossbreeding?

a: farmer ☐ **b**: extension staff ☐ **c**: NGO staff ☐ **d**: scientist ☐

e: community member ☐ **f**: other ☐ (specify) _____

_____

26. Did you get support with crossbreeding (full package from ILDP; heifers or AI)?

a: yes ☐ **b**: no ☐

27. **When** did you start with crossbreeding?_____

28. **Why** did you start with crossbreeding?

_____

_____

_____

_____

29. **How** did you get your first crossbred cow?

a: received crossbred heifer ☐ **b:** own local cow X artificial insemination ☐ **c**: own local cow X crossbred bull ☐ **d**: bought crossbred animal ☐

30. **Where did you get your first crossbred cow from?**

a: other farmer ☐ **b**: Market ☐ **c:** other ☐_____

31. How much was the highest milk production of one of your crossbred cows **in one day**?

_____

32. How many crossbred heifers did you receive in total?

_____

33. History of crossbred heifer/cow received

nr of xbred heifer/cow	exotic blood level (%)	origin	age at first calving	fate: what happened to it?	which age?	why?	nr calves

34. Calves histories

mother is heifer/cow	nr calve	sex calve m/f	exotic blood level (%)	conceived: bull (breed and %) AI (% exotic)	fate: What happened to the calve	which age?	why?	Kept replac-ement

35. Did you get support for the implementation of crossbreeding from an individual/organisation?

a: yes ☐ specify which: _____

b: no ☐

36. How did the organisation which implemented crossbreeding **support** your breeding activities? (multiple answers possible!)

a: information ☐ **b**: crossbred heifers ☐ **c**: crossbred calves ☐

d: access to bull ☐ **e**: artificial insemination ☐ **f**: training on management ☐

g: veterinary services ☐

h: training (specify which training)☐ _____

i: other ☐ specify**:**_____

_____

37. Which farming **inputs** did you receive from the implementing organisation?

_____

_____

38. Have you been satisfied with the way the program was handled? **a**: yes ☐ **b**: no ☐

39. What did you like about the program?

_____

_____

_____

_____

_____

40. What did you dislike about the program?

_____

_____

_____

_____

_____

41. Have you continued with crossbreeding?

a: yes ☐ **b**: no ☐

42. What were the reasons why you continued/stopped crossbreeding?

_____

_____

_____

_____

_____

43. Have you received any assistance with crossbreeding from other individuals/organisations?

a: yes ☐ **b**: no ☐

44. If yes which individuals/organisations did assist you?

_____

45. How did the other individual/organisation assist you?

_____

_____

_____

_____

_____

3. Current breeding activities

46. Do you own one (or more) bull(s)?

a: yes ☐ number of bull(s): _____ breed of bull(s):_____

☐ number of bull(s): _____ breed of bull(s):_____

b: no ☐

47. If you do not own a bull, in which other way do you mate your cows?

a: bull from other farmer ☐ **b:** research/bull station bull ☐ **c:** artificial insemination ☐

d: other source ☐ (specify)_____

48. If you keep a **local** bull, why? _____

49. If you keep a **crossbred bull**, why? _____

50. How do you choose the bull(s) you use for breeding?

a: bull easily available ☐ **b**: bull fits breeding strategy ☐ **c**: bull belongs to a family member ☐

d: no other option ☐ **e:** other reason ☐ specify: _____

51. If you use other bulls than your own specify on breed and owner:

☐ breed of bull:_____owner of bull:_____

☐ breed of bull:_____owner of bull:_____

☐ breed of bull:_____owner of bull:_____

☐ breed of bull:_____owner of bull:_____

52. Is there an artificial insemination service/bull available for you?

a: yes ☐ **b**: no ☐ (***specify***: **AI** service ☐ **bull** service ☐)

53. How much does the artificial insemination/bull service cost per service? _____

54. Is this an acceptable price for you? _____

55. What is the maximum price you would be ready to pay for artificial insemination/bull service?

_____

56. How many services are necessary on average for a successful insemination?

local cow: _____

crossbred cow: _____

57. Are you satisfied with the AI/bull service available for you? **a**: yes ☐ **b**: no ☐

58. Why are you satisfied/not satisfied with the AI service?

_____

59. Which level of exotic blood do you prefer in cattle you use for breeding?

breeding animal	**preferred exotic blood level**				
	a: <25%	**b**: 25%	**c**: 50%	**d**: 75%	**e**: 100%
1: heifers and cows					
2: bulls/AI					

60. Why do you prefer these levels of exotic blood for heifers/cows and bulls?

heifers/cows _____

_____

bulls/AI: _____

_____

4. Adaptation of crossbreeding

61. Have you continued crossbreeding the same way you **first started with** it? (any blood level other than the first crossbred animal)

a: yes ☐ (continue question **64**) **b**: no ☐ (continue question **62**)

62. **Why** have you **changed** the way you use crossbreeding?

_____

_____

_____

63. **How** have you changed your crossbreeding strategy?

_____

_____

_____

_____

_____

64. Are you aware of other exotic breeds than Holstein Friesian?

a: yes ☐ **b**: no ☐

65. Which other exotic breed(s) are you aware of?

_____

66. How did you learn about this other exotic breed(s)?

_____

_____

67. Have **you** used a different exotic breed for crossbreeding with local cattle?

a: yes ☐ **b**: no ☐

68. Which other breed have you used for crossbreeding?

_____

69. Would you be interested in using a different breed for crossbreeding? If yes which breed(s)?

a: yes ☐ specify breed:_____

b: no ☐

70. Why would you like to try this other exotic breed?

_____

_____

5. Effects of crossbreeding on production system – subsequent innovations

71. Did your herd size changed after you started with crossbreeding? a: yes ☐ b: no ☐

72. How big was your herd **before** crossbreeding?_____

73. How big is your herd **after** crossbreeding? _____

74. Which age at first calving do local cows/crossbred cows have?

local cows: _____

crossbred cows: _____

75. Which daily milk yield do your cows have?

local cows: _____

crossbred cows: _____

76. Which calving interval do your cows have?

local cows: _____

crossbred cows: _____

77. Which longevity/replacement time do your cows have?

local cows: _____

crossbred cows: _____

78. What did/do you feed local cows?

_____

_____

79. What do you feed crossbred cows?

80. Do you use new feedstuffs since you started with crossbreeding? **a:** yes ☐ **b:** no ☐

81. Which new feedstuffs have you introduced?

82. How did you learn about these new feedstuffs?

83. How do you graze local cattle?

84. How do you graze crossbred cattle?

85. How did you learn about new grazing methods? Who told you?

86. How did you house your cattle before crossbreeding??

87. How do you house your cattle now?

88. How did you learn about the new housing option? Who told you?

89. Are local cows or crossbred cows healthier?

90. Do you need the veterinarian more often now or before crossbreeding?

1: **now** more often ☐ **2**: **before** more often ☐

91. For what do you need the veterinarian more often?

a: vaccinations ☐ **b:** treatment of sick animals ☐ **c:** prophylaxes against parasites ☐

d: help for calving difficulties ☐ **e:** other ☐ _____

92. Which diseases do local cattle have?

_____

_____

93. How do you treat local cattle?

_____

_____

94. Which diseases do crossbred cattle have?

_____

_____

95. How do you treat crossbred cattle?

_____

_____

96. Are there diseases that **ONLY crossbred** cattle get?

_____

_____

97. Has crossbreeding changed the workload you have to deal with? **a:** yes ☐ **b:** no ☐

98. How has your workload changed? **a**: increased ☐ **b**: decreased

99. In which areas has the workload changed (eg. milking, processing, transport produce, feeding, cleaning)?

_____

_____

100. Who is carrying most of the new workload **caused by crossbreeding**?

_____

101. Did you have to hire additional labourer(s) after crossbreeding? **a:** yes ☐ **b:** no ☐

102. Did you market **milk** before you started with crossbreeding? **a:** yes ☐ **b:** no ☐

103. Where did you market **milk** before you started crossbreeding?

_____

104. Do you market **milk** now? **a:** yes ☐ **b:** no ☐

105. Where do you market your **milk** now?

_____

106. How did you learn about these new markets?

_____

107. Which dairy products have you **produced before** crossbreeding?

_____

108. Which dairy products did you **sell before** crossbreeding?

109. **Where** did you sell dairy products **before** crossbreeding?

110. Which dairy products do you **produce now**?

111. Which dairy products do you **sell now**?

112. **Where** do you sell your dairy products **now**?

113. Do you face new challenges in milk marketing?

114. Has crossbreeding changed your household income from the dairy business?

a: yes ☐ **b**: no ☐

115. How has crossbreeding changed the household income from your dairy business?

income before crossbreeding_____

income now_____

116. If some other farmer would come to you for advice: Would you recommend crossbreeding to him/her? **a**: yes ☐ **b**: no ☐

117. What are the most difficult challenges of crossbreeding for you?

118. Which experiences with crossbreeding have you shared with others? With who have you shared you knowledge about crossbreeding?

119. Overall: does crossbreeding pay off for you? Is it worth all the trouble and expense?

a: yes ☐ **b:** no ☐

6. General information

120. Respondent's relation to household head:

a: head ☐ **b**: spouse ☐ **c**: brother ☐ **d**: sister ☐ **e**: son ☐
f: daughter ☐

g: other ☐ (specify) _____

121. Gender of household head:

a: female ☐ **b**: male ☐

122. Age household head (in years):

a: not known ☐ **b**: < 20 ☐ **c**: 20-29 ☐ **d**: 30-39 ☐ **e**: 40-49 ☐

f: 50-59 ☐ **g**: > 60 ☐

123. How many persons live in your household?(total number)_____

124. Household composition

household member	sex	age	educational level	occupation
head				
spouse				

a: Illiterate; **b**: adult education; **c**: church education; **d**: high school; **e**: higher education:
1: employed just on farm; **2**: seasonally employed outside farm; **3**: permanently employed outside farm; **4**: currently

idle; **5**: retired; **6**: student; **7**: child **8**: other

125. Wealth status household: **a:** low ☐ **b:** medium: ☐ **c:** rich: ☐

126. Any other income apart from farm? **a:** yes ☐ **b:** no ☐

127. How much off farm income/year: _____

Thank you very much for your time and patience!!!