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Optimizing community-based breeding for indigenous goat breeds in Ethiopia

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Declaration

I hereby declare that this doctoral thesis is a result of my personal work and that no other than the indicated aids have been used for its completion. All quotations and statements that have been inferred literally or in a general manner from published or unpublished sources are marked as such. Furthermore, I assure that the work has not been used, neither completely nor in part, for achieving any other academic degree.

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AAP	Arid agro-pastoral
BC	Benefit of consumption
BecA	Biosciences eastern and central Africa
BM	Benefit of manure
CBBPs	Community-based breeding programs
CCPP	Contagious caprine pleuropneumonia
CE	Choice experiment
CL	Conditional logit
CR	Cash revenue
DDS	Dietary diversity score
ETB	Ethiopian birr
FAO	Food and agriculture organization
GM	Gross margin
HC	Heteroscedasticity consistent
HDDS	Household dietary diversity score
HMCL	Highland mixed crop livestock
ILRI	International livestock research institute
MLE	Maximum likelihood estimates
NB	Net benefit
RP	Revealed preference
RUT	Random utility theory
SAAP	Semi-arid agro-pastoral
SBC	Schwarz Bayesian criteria
SE	Standard error
SNA	Social network analysis
SP	Stated preference
TLU	Tropical livestock unit
USD	US Dollar
VC	Variable cost
WTP	Willingness to pay

1. General introduction

1.1 Background and research objectives

Goats are indispensable sources of meat, milk, manure, income and social security for poor smallholder farmers living in dry and harsh environments of tropical regions (Aziz, 2010). With the current goat population size of 28 million (FAOSTAT, 2016), Ethiopia stands third in Africa and sixth in the world accounting for 9% and 3% of the African and global goat population, respectively. Over the last decade, the goat population in Ethiopia increased more rapidly (134%) than the sheep (65%) and cattle (38%) population, shifting the sheep to goat ratio from 1.3 in 2003 to 0.9 in 2013 (FAOSTAT, 2016). Goat meat production in Ethiopia also increased by 2% between 2005 and 2012 and is expected to rise to 4% in 2016 due to increased domestic and export market demand for goat meat (Legese and Fadiga, 2014). Goat skins are also valuable row materials of leather products in which local highland goats produce thick, flexible and high quality skins with high price premium in the international leather products market (Solomon et al., 2014). Given the large resource base and significant role of goat production in the national and household economy, current livestock improvement strategies gave emphasis to enhance red meat production by improving smallholder goat production (Shapiro et al., 2014).

Ethiopia is home to genetically diverse goat populations that are widely distributed across all agro-ecologies. Based on morphological parameters and geographical distributions, about 12 different goat populations were identified in Ethiopia (Farm Africa, 1996) while 8 distinct genetic clusters were recognized by using 15 microsatellite markers (Tucho, 2004). The eight identified clusters include: Abergelle, Arsi-Bale, Woyto-Guji, Gumuz, Keffa, Afar, Central Highland (or Highland goats), and eastern and southeastern goats (formerly named as Hararghe highland, long-eared and short eared Somali, by Farm Africa, (1996)). Exotic and crossbreed goats accounted for insignificant proportion (0.01%) of the total goat population in Ethiopian (CSA, 2015). Among the introduced exotic goat breeds, Anglo-Nubian, Toggenburg, Saanen and more recently Boer goats are the major ones (Solomon et al., 2014). The predominant sheep and goat production systems in the country are sub-alpine sheep cereal system (>3000 m.a.s.l.), highland mixed crop livestock system (1500 to 3000 m.a.s.l.), pastoral and agro-pastoral systems in the arid and semi-arid agro-ecologies (Gizaw et al., 2008; Gizaw et al., 2010). These production systems are subsistence oriented and virtually depend on traditional management system with no or very limited external inputs (Gizaw et al., 2010).

Despite the current boom of goat population and increased meat production in Ethiopia, goats contributed only 11.0% and 1.4% of the national meat and milk production, respectively in the year 2013 (FAOSTAT, 2016). Moreover, the average income from goat export earnings obtained between the years 2005 and 2012 was about 3.3% of the total live animal export revenue (Legese and Fadiga, 2014), which was much lower than the contribution of cattle (42.1%), sheep (41.8%) and camels (12.8%). Carcass yield of local goats remained at about 8 kg per head between the year 1999 and 2008, which was below the East African (11 kg) and the world (12 kg) average carcass yield during the same years (Legese and Fadiga, 2014). Slow growth rates of goats managed under smallholder conditions, high mortality rate and low commercial off-take rate were the major challenges of smallholder goat production in Ethiopia (Solomon et al., 2014; Talore et al., 2015). These could be attributed to prevalence of diseases resulting in high mortality, lack of adequate feed resources, absence of appropriate breeding systems to exploit the diverse genetic potential, poor access to infrastructural and institutional supports (Gizaw et al., 2010; Solomon et al., 2014).

In order to overcome some of the constraints of smallholder goat production, designing a sustainable community-based breeding program (CBBP) which considers local breeds, farmers' trait preferences and local organizational setups is a promising entry point (Mueller et al., 2015). Since the role of goats for the household economy is multifaceted including provision of tangible benefits such as cash income, food and manure as well as intangible socioeconomic benefits such as insurance, finance and prestige (Kosgey et al., 2004; Solomon et al., 2014) understanding farmers' priorities in utilizing such benefits across the diverse goat production systems may help in designing adapted CBBPs. Even though considerable attention was given in valuing intangible benefits of small ruminants so far (Ayalew et al., 2003; Kosgey et al., 2004) the economic role of such benefits across production systems along with farmers' strategies to exploit them was not adequately investigated.

Identifying breeding objective traits and their relative economic importance through participatory approaches is crucial for the success of CBBPs (Kosgey et al., 2006; Wurzinger et al., 2011). So far, choice experiments (CE) were employed as one option to identify breeding objective traits and elicit their economic values (Scarpa et al., 2003; Omondi et al., 2008a and 2008b; Roessler et al., 2008; Kassie et al., 2009; Duguma et al., 2011; Tada et al., 2013), but limited information is available (Scarpa et al., 2003; Kassie et al., 2012) in providing a comprehensive understanding of trait preferences from producers and market perspectives. Furthermore, sustainable genetic improvement programs not only focus on the technical feasibilities, but also analyze the organizational aspects of the breeding scheme under specified framework conditions (Roessler et al., 2012). The breeding organization analysis methods developed and implemented so far (Herold et al., 2012a and 2012b; Roessler et al., 2012) lack social network analysis (SNA) component which enables identification of well-connected and prominent actors and vice versa within social structures.

The study therefore aims to contribute for designing optimized goat community-based breeding programs that consider the multiple functions of goats, producers' trait preferences, market demands and organizational frameworks by taking into consideration of the diverse goat production systems. In order to achieve the overall objectives, the following specific objectives were addressed.

1. Analyzing factors affecting contributions of goat farming to household economic success and household dietary diversity in three production systems of Ethiopia.
2. Identifying goat breeding objectives and economic values of traits based on revealed and stated preference information.
3. Formulating alternative breeding options that consider the economic values of traits in three production systems of Ethiopia.
4. Identifying major stakeholders, organizational networks and other elements of organization and their influence on the establishment and successful operation of community-based goat breeding.
5. Indicating options on linking the goat community-based breeding program with the existing organizational frameworks.

The specific objectives lead to the formulation of the following research questions:

A. To what extent does goat production contribute to household income and food security in three production systems of Ethiopia?

B. What are the important factors affecting economic success of goat production and how farmers' strategies differed between production systems in terms of utilizing tangible and intangible benefits of goats?

C. What are the most preferred goat traits by producers and market actors? How can information be generated from choice experiments and combined with market transaction surveys in order to estimate economic values of traits?

D. What are the existing organizational structures, the key stakeholders and their influence on a successful implementation of goat CBBPs? Which organisational setting would best match the necessities of a community-based breeding program taking into account production systems' circumstances and what changes are needed to adapt the current organizational setups?

1.2 Study framework and methodology

This study is part of the ILRI-BeCA collaborative research project *"Harnessing genetic diversity for improved goat productivity"*, which targets genetic improvement of local goats through sustainable community-based breeding programs in five districts of Ethiopia (Dessie et al., 2014). Initially, a comprehensive goat production system study was conducted (Netsanet 2014, Alubel, 2015) followed by phenotypic and molecular characterization of local goats (Dessie et al., 2014). Furthermore, on-farm productivity monitoring which involved a total of 3500 goats in 600 households was conducted to evaluate performance of local goats under the traditional management systems (Dessie et al., 2014). Preliminary results of the on-farm productivity monitoring study indicated marked differences in growth and reproductive performances among indigenous goat breeds of Ethiopia (Zergaw et al., 2016). The present study contributes for designing sustainable goat CBBPs by providing information on factors affecting economic success of goat production in three production systems, identifying goat breeding objectives and estimation of economic values of traits as well as investigating the organization of goat breeding at village levels. Besides, the present study contributes to the scientific knowledge by indicating implications of differences in utilizing tangible and intangible benefits of livestock on defining breeding objectives and designing production system specific CBBPs. Moreover, by using willingness to pay (WTP) values the relative economic weight of traits under low input farming systems were identified. The application of social network analysis (SNA) tools for investigating breeding organizations at village levels broadened methodological approaches to analyze enabling environments for CBBPs.

From the five districts, in which this project was implemented, for the purpose of this study, three districts (Fig. 1) and two villages from each district were selected based on diverse agro-ecologies and production systems, potential of the areas for goat production, and accessibility. The selected districts were: Abergele, Konso and Meta Robi, representing arid agro-pastoral (AAP), semi-arid agro-pastoral (SAAP) and highland mixed crop-livestock (HMCL) systems, respectively. The Abergele district is characterized by a dry and hot climate with annual precipitation ranging from 300 to 496 mm with average daily minimum and maximum temperatures of 21 and 41°C, respectively. While, in Konso district, the climate is semi-arid with a daily average minimum and maximum temperature of 12 and 33°C, respectively, the mean annual rainfall ranges from 400 to 1000 mm. Meta Robi receives an average annual rainfall of 1100 mm and the daily annual temperature ranges between 15 and 32°C. In Abergele and Konso districts, crop farming is practiced around homestead areas with seasonal movements of livestock during feed shortage periods. While, in Meta Robi district, settled farming with high integration of crop and livestock is the predominant system. Abergele, Woyto-Guji and Central highland goat types are predominantly reared in Abergele, Konso and Meta Robi districts, respectively (Tucho 2004; Hassen et al., 2012).

Figure 1.1. Locations of the study areas: Abergele, Meta Robi and Konso districts (source: maps.google.de)

Data collection methods included a questionnaire survey using a semi-structured questionnaire, a choice experiment, a goat market transaction survey, informal group discussions, key informant interviews and social network analysis (SNA). The questionnaire survey involving 180 households was conducted between December 2013 and February 2014. The survey mainly focused on generating empirical data on income and costs of the major household agricultural enterprises including goat production as well as dietary diversity of households by using a 24-hour recall method based on 12 food group model (FAO, 2013).

The choice experiment was based on eight desired traits of breeding bucks and does identified from the previous goat production system studies (Netsanet, 2014; Alubel, 2015) and group discussions with farmers. A total of 36 goat profiles for each sex (18 choice sets) were generated and further blocked into two groups. Nine choice sets for each sex were sequentially presented to a total of 360 respondents and each respondent was asked to hypothetically purchase one of the goat profiles for breeding purposes. Furthermore, in order to understand buyers' revealed preferences for goat traits, market data of 796 goat transactions including: selling price, goats' age, body weight, sex, coat color, body condition, reason for buying and selling, buyers and sellers occupations were collected.

So as to investigate the goat breeding organization from village to national levels, a total of six focus group discussions as well as stakeholder meetings which involved farmers, development agents, local administration, researchers and traders were conducted to map the social network structure of smallholder goat production and marketing systems. In addition, forty key informants belonging to private, public and non-governmental organizations were purposively selected and interviewed. Desk work was also part of the study which included screening of national agricultural and livestock breeding policies.

Besides descriptive statistics, analytical tools such as linear mixed model, Wilcoxon-Mann-Whitney test, ordinal regression, conditional logit modeling, hedonic regression as well as social network analysis were employed to evaluate and analyze the different data set by using SAS version 9.3 (SAS Institute Inc., 2011), NLOGIT 4 (Greene, 2007) and Social Network Visualizer (Kalamaras, 2015).

1.3 Structure of the thesis

Chapter 2 of the thesis focuses on "Optimizing contributions of goat farming to household economic success and food security in three production systems", and was published in Journal of Agricultural and Rural Development in the Tropics and Subtropics 117 (2016). This chapter presents the contribution of goats for household income and food security, analyses factors affecting economic success of goat production and explores farmers' goat marketing strategies along with their priorities in utilizing tangible and intangible benefits of goats across three production systems of Ethiopia. Goat traits which are in line with farmers' marketing strategies in specific production systems were identified and recommended for further genetic improvement.

Chapter 3 addresses "Combining revealed and stated preferences to define goat breeding objectives and optimize selection indices in Ethiopia" and has been submitted to Livestock Science. This chapter identified goat breeding objectives and economic values of traits by combining stated and revealed preference information. The part worth value of a trait (relative importance of a trait) in a specific production system was calculated based on the farmers willingness to pay (WTP) for improvement of the trait. Alternative breeding options, which are in line with farmers' trait preferences and market demands, were suggested for each production system investigated.

Chapter 4 corresponds to "Optimizing organization of smallholder goat breeding in Ethiopia" and was submitted to Animal Genetic Resources. The study investigated major stakeholders, organizational networks and their influence on the establishment and successful operation of goat CBBPs. Emphasis was given on assessing the organization of goat breeding at village levels, identifying formal and informal farmer organizations engaged in goat production and marketing, exploring the available support services and highlighting their achievements and limitations. The major actors which play influential role in the social network structures of goat production and marketing were identified by using social network analysis. The enabling environments in terms of agricultural and livestock breeding policies were also reviewed. Options of integrating the goat CBBPs with the existing breeding organizations and social networks were discussed.

Chapter 5 discusses the relationship between socio-economic role of goats, economic values of traits and organizational aspects of goat breeding by consolidating findings of the three research components. This chapter also highlights the strength and limitations of the applied research methodologies. Chapter 6 presents a summary of the major research findings in English, while chapter 7 provides the same information in German language.

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Chapter 2: Optimizing contributions of goat farming to household economic success and food security in three production systems in Ethiopia

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2.1 Abstract

The study aims to analyze factors affecting contributions of goat farming to household economic success and food security in three goat production systems of Ethiopia. A study was conducted in three districts of Ethiopia representing arid agro-pastoral (AAP), semi-arid agro-pastoral (SAAP) and highland mixed crop-livestock (HMCL) systems involving 180 goat keeping households. Gross margin (GM) and net benefit (NB1 and NB2) were used as indicators of economic success of goat keeping. NB1 includes in-kind benefits of goats (consumption and manure), while NB2 additionally constitutes intangible benefits (insurance and finance). Household dietary diversity score (HDDS) was used as a proxy indicator of food security. GM was significantly affected by an off-take rate and flock size interaction ($P<0.001$). The increment of GM due to increased off-take rate was more prominent for farmers with bigger flocks. Interaction between flock size and production system significantly ($P<0.001$) affected both NB1 and NB2. The increment of NB1 and NB2 by keeping larger flocks was higher in AAP system, due to higher in-kind and intangible benefits of goats in this system. Effect of goat flock size as a predictor of household dietary diversity was not significant ($P>0.05$). Nevertheless, a significant positive correlation ($P<0.05$) was observed between GM from goats and HDDS in AAP system, indicating the indirect role of goat production for food security. The study indicated that extent of utilizing tangible and intangible benefits of goats varied among production systems and these differences should be given adequate attention in designing genetic improvement programs.

Keywords: dietary diversity, economic success, goats, intangible benefits, off-take rate

2.2 Introduction

In developing countries, huge goat resources are present (Aziz, 2010) and the demand for meat products is strongly increasing (Narrod et al., 2011). Thus, goat farming could play a considerable role in improving the livelihoods of poor African farmers (Peacock, 2005). Ethiopia’s estimated goat population was about 25 million in 2013, accounting for 7.2% and 2.6% of the African and global goat population, respectively (FAOSTAT, 2015). Among ruminants, goats are less numerous as compared to cattle and sheep in Ethiopia; however, the sheep to goat ratio decreased from 1.29 to 1.06 within the last 20 years (FAOSTAT, 2015). The country is home to genetically diverse goat populations that are widely distributed across all agro-ecologies (Hassen et al., 2012).

Despite the huge genetic diversity and valuable contributions of goats to the livelihoods of farmers in rural areas, the sector has been given low research and development attention at global (Aziz, 2010) and national (Solomon et al., 2014) levels. This is mainly due to an inadequate recognition of the contributions goats make to the livelihoods of the poor, resulting in underutilization of the diverse goat genetic resources (Aziz, 2010). Community-based breeding programs (CBBPs) are considered as a promising tool for livestock genetic improvement under smallholder tropical conditions (Mueller et al., 2015). Presently, a research project is underway to improve goat productivity in Ethiopia and Cameroon by CBBPs (BecA-ILRI, 2013). This research paper is part of the recent initiative in Ethiopia.

Improved knowledge on the economic value and roles of goats that influence the overall benefits for smallholders will help in designing optimized breeding programs that consider both, tangible and intangible benefits (Kosgey et al., 2004). It was reported by a number of studies that intangible benefits, such as finance and insurance, comprise a sizable portion of the overall benefits of livestock in different parts of Africa (Ayalew, 2000; Kosgey et al., 2004; Moll, 2005). Even though considerable attention was given in valuing intangible benefits of small ruminants so far, the economic value of such benefits across production systems along with farmers' strategies to exploit them was not adequately investigated.

The different contributions of goats to smallholder families include their role in improving household food security. A number of studies reported a significant association between dietary diversity and the nutritional status of children in developing countries (Moursi et al., 2008). Likewise, dietary diversity was also reported to be correlated with caloric intake, even though the strength of relationship varies among different studies (Maxwell et al., 2014). The objectives of the present study were to analyze factors affecting contributions of goat farming to household economic success and household dietary diversity as a proxy for food security in three largely differing production systems of Ethiopia.

2.3 Materials and methods

2.3.1 Description of the study area and production systems

The study was conducted in three districts of Ethiopia, namely Abergele, Konso and Meta Robi, representing arid agro-pastoral (AAP), semi-arid agro-pastoral (SAAP) and highland mixed crop-livestock (HMCL) systems, respectively. The AAP system is characterized by a dry and hot climate with annual precipitation ranging from 300 to 496 mm with average daily minimum and maximum temperatures of 21 and 41°C, respectively. Crop farming is practiced around homestead areas with seasonal movements of livestock during feed shortage periods. Abergele goat types are the most predominant goats in this district (Hassen et al., 2012). In the SAAP system, the climate is semi-arid with a daily average minimum and maximum temperature of 12 and 33°C, respectively, while mean annual rainfall ranges from 400 to 1000 mm. Farmers in this system practice agro-pastoralism with some periodic movement of satellite goat flocks. Woyto-Guji goats are the most predominant breeds in the area (Tucho, 2004). The HMCL system is characterized by settled farming with high integration of crop and livestock. The area receives an average annual rainfall of 1100 mm and the daily annual temperature ranges between 15 and 32°C. The climate is conducive for crop farming. The central highland goat breed is widely reared in this system (Tucho, 2004).

2.3.2 Sampling and data collection

The study is part of an ongoing goat CBBP (BecA-ILRI, 2013) which is being implemented in five districts. For the purpose of this study, three districts and two villages from each district were selected based on diverse agro-ecologies and production systems, potential of the areas for goat production, and accessibility. In each district, two villages were selected based on advice from key informants from the district's office of Agriculture and Rural Development. Farmers, who owned at least five goats, were identified from the list of farmers in collaboration with development agents and village administrators. Systematic random sampling was used in the last step to select 30 households from the pre-selected farmers, i.e. 60 households per district and a total of 180 households for the study. In addition, in each village a few farmers were put on a waiting list. Three households from Abergele and two from Meta Robi, which were sampled for data collection, but had very few or no goats were replaced by households from the waiting list.

Data were collected between December 2013 and February 2014 by using a semi-structured questionnaire, which captured socio-economic and demographic variables, livestock holdings, income generated and costs incurred by the major agricultural enterprises including livestock, crops and off-farm activities within the last 12 months, number of livestock slaughtered for meat consumption and amount of home-produced and consumed crops

2.3.3 Household dietary diversity

Based on a 24-hour recall method (FAO, 2013), farmers were asked to describe the type of food consumed by members of the household during the previous day. Mixed meals were described by each ingredient. The food items consumed were grouped into 12 food categories including cereals, legumes (pulses and peanut), vegetables, white tubers (potato, sweet potato), fruits (domestic and wild), meat (beef, poultry, sheep and goat), fish, oil and fat, sweets (sugar and honey), milk and milk products, eggs and spices. In each district, two enumerators, who could speak the local language were recruited and trained to assist during data collection.

2.3.4 Income and costs

The income from goat production comprises cash revenues (CR) from the sale of kids, bucks, does and castrated goats. CR from the sale of other livestock species was also calculated. Sales of dairy products (mainly butter) were also considered for estimating CR from cattle, which was not the case for goat milk, because farmers in the study area did not sell or process goat milk. Sheep milk was neither consumed nor marketed in any of the study areas.

In-kind benefits included goat meat, milk and manure. The monetary value of goat meat consumption was estimated by multiplying the number of goats slaughtered per year with the average yearly price of goats during the study period. Average lactation milk off-take was estimated based on average milk off-take (346 ml/day) and lactation length (12 weeks) of Abergele goats (Alubel, 2015). The milk off-take was multiplied by the average price of milk during the study period. Manure was valued by estimating the daily dry matter faecal output of goats by using a regression formula developed by Fernandez-Rivera et al. (1995) cited by Ayalew (2000). The average nitrogen and phosphorus contents of the goats' faecal dry matter reported by Schlecht et al. (1997) and Somda et al. (1995) cited by Ayalew (2000) were used to calculate the annual nitrogen and phosphorus outputs. The unit price of nitrogen and phosphorus was derived from the average price of diammonium phosphate (DAP) and urea during the study period.

Intangible socio-economic benefits of goat production, i.e. financial (F) and insurance (I) functions of goats, were estimated. The financial benefit of a goat flock per household was valued by the following equation:

$$F_i = \gamma P_i \tag{1}$$

Where F_i is the financial benefit of a goat flock in the i^{th} household, γ is the opportunity cost of alternative financial sources, such as costs to obtain formal or informal credits (Moll, 2005), and P_i is the monetary value of the goat flock (number of goats owned x market price of goats) of the i^{th} household in the year 2012. Interest rate of micro-finances in the study area (0.10) was used to estimate γ.

The insurance value of goats was estimated by the equation suggested by Moll (2005):

$$I_i = \alpha(P_i + P_i^*)/2 \qquad (2)$$

Where I_i is the insurance value of the goat flock of the i^{th} household, P_i and $P*_i$ are the average monetary values of the goat flock of the i^{th} household in the years 2012 and 2011, respectively, and α is the insurance function. The size of α is usually determined based on existing alternative insurance systems. Guesstimates criteria based on climatic condition as suggested by Moll (2005) were implemented. Considering the annual rainfall and temperature in the study sites, insurance factors of 0.05, 0.075 and 0.1 were assigned for the HMCL, SAAP and AAP systems, respectively.

The major variable costs of goat production included veterinary costs, feed and hired labor costs for herding. Veterinary costs comprised costs for vaccination, deworming and medication, while feed costs included expenses for purchased feedstuffs used for supplementation. Since browsing is the major source of feed for goats in the study area, costs for supplementation from own sources were ignored. Hired labor cost included the wage payment and/or the monetary value of in-kind payments given for the herders. Fixed costs such as depreciation of housing and machineries were not considered in the study, because goats are mainly housed in simple fenced barns, caves (e.g. AAP system) or in the main house together with the family members in some cases.

The economic parameters were calculated by using the following equations:

$$\text{GM (ETB household}^{-1}\text{ year}^{-1}) = \text{CR-VC} \qquad (3)$$

$$\text{NB1 (ETB household}^{-1}\text{ year}^{-1}) = \text{(CR+BC+BM)-VC} \qquad (4)$$

$$NB2\ (\text{ETB household}^{-1}\ \text{year}^{-1}) = (CR+BC+BM+F+I)-VC \tag{5}$$

Where: GM is the gross margin (not including in-kind and intangible benefits of goats), CR are cash revenues, VC are variable costs, NB1 is the net benefit including in-kind benefits of goats, BC is the benefit of consuming goat products, BM is the benefit of using manure, NB2 is the net benefit including in-kind and intangible benefits of goats, F is the financial function, and I is the insurance function.

2.3.5 Data analysis

The contribution of goat farming to household income was assessed by the proportion of gross margin (GM) generated from goats to all other household income sources. Goat flock sizes (TLU), off-take rates, costs and economic efficiency parameters were not normally distributed. Hence, the Wilcoxon-Mann-Whitney test was employed for detecting significant differences between production systems. The P-values were estimated by using Monte-Carlo simulation methods due to the presence of tied observations in the data set.

A linear mixed model with villages as random effect was used to analyze the effects of production system, use of veterinary services, supplementation of goats before selling, flock size, off-take rate (percentage of total sales of goats per annual average flock size) and fecundity (total number of kids born per total number of mating does) (Rosa et al., 2007) on the economic success of goat keeping. At first, fixed effects and all possible two-way interactions between factors were screened by backward selection procedure of GLMSELECT procedure in SAS (SAS Institute Inc., 2011), whereas factors showing minimum contribution to model variation were removed based on Schwarz Bayesian criteria (SBC). Finally, all factors involved in significant interactions and the random village effect entered the linear mixed model. The normality of residuals and the homogeneity of error variance were tested. The final reduced models employed were the following:

$$y_{ijk} = \beta_0 + S_i + \beta_1 t_{ijk} + \beta_2 f_{ijk} + \beta_3 t_{ijk} f_{ijk} + \beta_{4i} f_{ijk} + z_j + \varepsilon_{ijk} \tag{6}$$

With y_{ijk} = NB1 and NB2 of the k^{th} household, β_0 = intercept, β_1- β_4 = regression coefficients, S_i = effect of production system (i = AAP, SAAP, HMCL), t_{ijk} = off-take rate treated as a continuous variable, f_{ijk} = flock size treated as a continuous variable, $t_{ijk}f_{ijk}$ is interaction between offtake rate and flock size, $\beta_{4i}f_{ijk}$ interaction between i^{th} production system and flock size, z_j = the random effect of village, (j = 1, 2, 3, 4, 5, 6) and ε_{ijk} = random error term.

$$y_{jk} = \beta_0 + \beta_1 t_{jk} + \beta_2 f_{jk} + \beta_3 t_{jk} f_{jk} + z_j + \varepsilon_{jk} \quad (7)$$

Y_{jk} = GM for the k^{th} household and the variables as previously explained.

The food categories consumed by the household were summarized into terciles of lower (0-3), medium (4-5) and higher (6-7) diversity, following the procedure suggested by Swindale & Paula (2006). An ordered logit model was fitted to analyse effects of socio-economic variables to predict terciles of households' dietary diversity.

$$y_{ij}^{*} = \beta_0 + \beta_1 x_{1ij} + \beta_2 x_{2ij} + \beta_3 x_{3ij} + \beta_4 x_{4ij} + \beta_5 x_{5ij} + \beta_6 x_{6ij} + \beta_7 x_{7ij} \quad (8)$$

Where y^{*}_{ij} = latent dietary diversity terciles of the j^{th} household, β_0 = intercept, β_1- β_7 = coefficients of regression, x_{1ij} = production system of the j^{th} household (i = 0 for AAP, i = 1 for SAAP and i = 2 for HMCL), x_{2ij} = gender of the j^{th} household head (i = 1 for male, and 0 for female), x_{3ij} = literacy of the j^{th} household head (i = 1 for literate, and 0 for illiterate), x_{4ij} = family size of the j^{th} household (i = 0 for ≤ 7, and 1 for >7), x_{5ij} = cultivated land of the j^{th} household (i = 0 for < 1 ha, i = 1 for 1-2 ha and i = 2 for >2 ha), x_{6ij} = livestock holding in tropical livestock units (TLU)[1] of the j^{th} household (i = 0 for ≤ 9 and 1 for > 9), x_{7ij} = goat (TLU) holding of the j^{th} household (i = 0 for ≤ 1.7 and 1 for >1.7). The Pearson's correlation coefficient was used to determine the association between income from goat production and household dietary diversity in the three production systems. All analyses were carried out using SAS version 9.3 (SAS Institute Inc., 2011).

[1] Conversion factors used were 0.7, 0.5, and 0.1 for cattle, donkey and small ruminants, respectively (Janke, 1982)

2.4 Results

2.4.1 Household characteristics

Goat owners in the study area indicated that 91% of the households were male-headed with a mean household size of 6.9 (2 to 14) persons. The literacy rate among the household heads was 23.7% and similar across production systems. The average TLU owned per household was 7.3, of which small ruminants accounted for 32.5 %. Goats accounted for 23.9% of the total TLU and 74.2% of the total small ruminants. In the AAP system, small ruminants represented the majority of the total TLU (48.9%) followed by cattle (39.2%). In contrast, the proportion of cattle was higher than small ruminants in both, HMCL (72.0% vs 21.5%) and SAAP (68.0% vs 26.0%) systems. The average goat flock size per household was significantly ($P<0.001$) different among production systems. It was highest in the AAP (27.3), followed by the SAAP (16.5) and HMCL (8.6) systems.

2.4.2 Contribution of goats to household economy

Cattle provided 44.8% of household GM, representing the biggest contributor, while goats contributed 23.2% and 30.9% to the total GM and livestock GM of the surveyed households, respectively (Figure 2.1). On average, goats provided a 3.4 and 1.6 times higher GM in the AAP system than sheep and cattle, respectively. However, the contribution of goats to household GM was 2.5 and 3.5 times lower than for cattle in the HMCL and SAAP systems, respectively. It is worth noting that goats contributed more than sheep to household GM in all production systems.

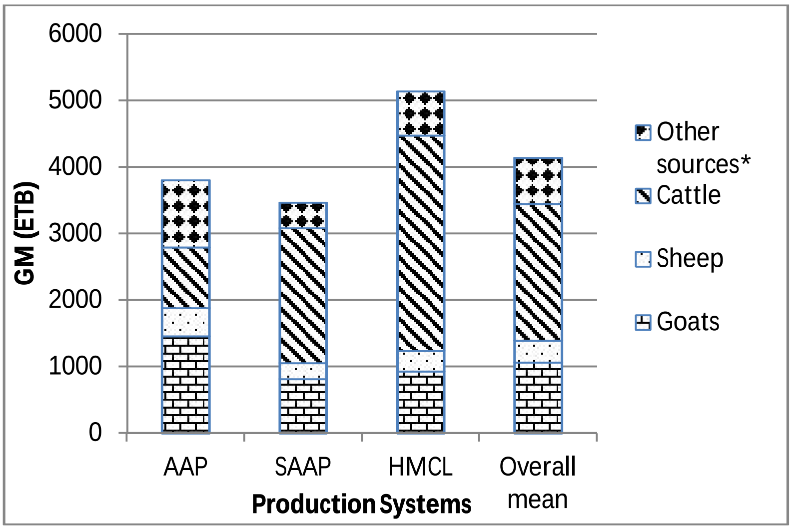

Figure 2.1. Contribution of livestock to the household gross margin (GM) in arid agro-pastoral (AAP), semi-arid agro-pastoral (SAAP) and highland mixed crop-livestock (HMCL) systems of Ethiopia. ETB= Ethiopian birr, 1 USD ≈ 19 ETB in 2012. Other sources include income from sale of poultry and honey bee products.

The estimated monetary values of goat benefits to the households in each production system are presented in Table 1. The highest benefit from keeping goats in the surveyed households were from live sales of goats, followed by intangible benefits, manure and milk consumption. Economic benefits from goat meat consumption were the lowest in all production systems. Only 12% of the surveyed households slaughtered goats at least once per year, mainly as a sacrifice during holidays and social events such as weddings and remembrance days. Goat milk was found to be an important commodity for home consumption only in the AAP system, contributing 20.3% to the total value of goat benefits, whereas in the SAAP and HMCL systems, goat milk was neither consumed nor marketed.

Table 2.1. Estimated goat benefits (GV) from live sales, meat and milk consumption, manure and intangible functions to the households in three production systems of Ethiopia in the year 2012

Benefits (GV)	Production systems					
	AAP		SAAP		HMCL	
	Value (ETB)	% of total	Value (ETB)	% of total	Value (ETB)	% of total
Live sales	1645.0	32.4	920.2	38.4	1014.7	57.8
Milk	1029.1	20.3	0.0	0.0	0.0	0.0
Meat	200.8	4.0	192.0	8.0	176.9	10.0
Manure	599.6	11.8	368.4	15.4	166.5	9.5
Financial	1064.2	21.0	608.0	25.4	264.5	15.1
Insurance	532.1	10.4	305.0	12.7	132.2	7.5
Total	5070.8		2393.6		1754.8	

AAP=arid agro-pastoral, SAAP=semi-arid agro-pastoral, HMCL=highland mixed crop livestock, GV=gross value. ETB= Ethiopian birr, 1 USD ≈19 ETB in 2012.

The goat marketing strategies of farmers differed across production systems (Figure 2.2). In the HMCL system, goat kids of less than one year were sold most frequently (54.2%), followed by mature males (30.5%), while does (10.2%) and castrated goats (5.1%) had a lower share of sales. In contrast, almost an equal proportion of kids, bucks and does were sold in the AAP system. The average annual off-take rate for live sale of goats was significantly ($P<0.01$) higher in HMCL system (21.5%) than AAP (11.7%) and SAAP (10.0%) system, while no significant difference were detected between the AAP and SAAP systems.

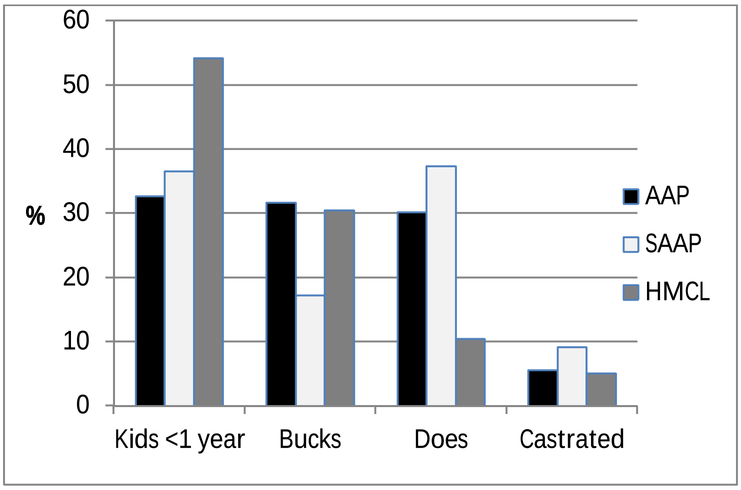

Figure 2.2. Proportion of goat types sold within one year in arid agro-pastoral (AAP), semi-arid agro-pastoral (SAAP) and highland mixed crop livestock (HMCL) systems in Ethiopia

Costs and economic efficiency of goat keeping across the production systems is presented in Table 2. The total variable costs varied significantly between production systems ($P<0.05$). Veterinary expenses accounted for the biggest share of total variable costs in the SAAP (68.5%) and HMCL (71.7%) systems, whereas it was significantly lower in the AAP (13.7%) system. Hired labour costs accounted for the biggest share (68.1%) of the total variable costs in the AAP system. Feed costs were not significantly different among production systems. Only 18.0% of all farmers purchased additional supplements for goats. The major feedstuffs purchased were crop residues, mainly used for the fattening of goats. On average, 5.0%, 16.7% and 25.0% of the farmers in the HMCL, AAP and SAAP system, respectively, had a negative GM, while a positive NB1 and NB2 was obtained for all of the surveyed farmers.

Table 2.2. Variable costs and economic efficiency of goat rearing in three production systems of Ethiopia in the year 2012

Parameters (ETB)	Production systems						P-value*
	AAP		SAAP		HMCL		
	Mean	Median	Mean	Median	Mean	Median	
Variable Costs							
Feed costs	34.2	0.0[a]	18.4	0.0[a]	12.1	0.0[a]	0.17
Veterinary costs	25.9	0.0[a]	71.4	35.0[b]	61.6	6.0[a]	< 0.01
Hired labor costs	128.5	0.0[a]	14.5	0.0[a]	12.2	0.0[a]	0.09
Total variable costs	188.6	27.0[b]	104.3	48.0[b]	85.9	6.0[a]	0.05
Economic Efficiency							
Total variable costs/goat	8.4	1.5[a]	7.4	3.3[b]	9.8	1.4[ab]	0.04
GM/goat	71.1	61.2[a]	68.6	34.8[a]	180.9	84.9[b]	0.01
NB1/goat	149.0	132.4[b]	109.3	73.2[a]	233.7	130.0[b]	< 0.01
NB2/goat	208.2	188.1[b]	163.9	130.1[a]	277.9	192.1[b]	< 0.01

AAP=arid agro-pastoral, SAAP=semi-arid agro-pastoral, HMCL=high land mixed crop-livestock, GM= Gross margin, NB1= comprise GM and in-kind benefits NB2= comprise GM, in-kind and intangible socio-economic benefits, [abc] Medians with different superscripts within a row differ significantly ($P<0.05$), *Estimated by Monte Carlo simulation method, ETB= Ethiopian birr, 1 USD ≈19 ETB in 2012.

2.4.3 Factors affecting economic success of goat keeping

The interaction between off-take rate and flock size significantly affected GM and revealed a positive regression coefficient (Table 2.3). Thus, the increase in GM due to an increase in flock size depended on off-take rates and vice versa. For instance, the increment in GM through increasing the flock size was more pronounced for farmers, who had off-take rates >12% than compared to those with lower off-take rates. The interaction between production system and flock size significantly affected both NB1 and NB2 (Table 2.3). For instance, in the AAP system, an increase in flock size by only one head caused a rise in NB1 and NB2 by 45 and 95 ETB, respectively, while in the

HMCL system the increment was only 4 and 56 ETB, respectively. Moreover, increasing flock size by one head in the AAP system resulted in a 2.5 and 1.3 times higher NB1 and NB2, respectively, than in the SAAP system. As illustrated in Figure 3, the rise in NB2 with increased flock sizes followed a different pattern among production systems. In the AAP system, NB2 continuously increased nearly up to a flock size of 50 heads, while the curve started to flatten thereafter. In contrast, the NB2 curve started to flatten at smaller flock sizes in the other production systems (Figure 2.3).

Table 2.3. Factors affecting gross margin (GM) and net benefits (NB1 and NB2) of goat farms in the year 2012

Parameters	Coefficient (β)	SE	P-value
GM			
Intercept	8.55	66.09	0.897
Flock size	-13.09	2.71	< 0.001
Off-take	10.07	2.92	0.001
Off-take*Flock size	6.26	0.27	< 0.001
NB1			
Intercept	72.91	224.81	0.767
Production systems			
AAP	170.41	309.66	0.523
SAAP	-28.98	306.69	0.925
HMCL	Reference		
Flock size	4.45	7.33	0.545
Flock*Production system			
Flock size*AAP	40.59	7.47	< 0.001
Flock size*SAAP	13.44	8.18	0.103
Flock size*HMCL	Reference		
Off-take rate	11.52	3.52	0.001
Off-take rate *Flock size	6.46	0.32	< 0.001
NB2			
Intercept	-39.65	164.35	0.825
Production systems			
AAP	315.27	219.09	0.152
SAAP	64.67	214.35	0.763
HMCL	Reference		
Flock size	56.38	7.85	< 0.001
Flock size*Production system			
Flock size*AAP	38.64	7.98	< 0.001
Flock size*SAAP	14.59	8.74	0.096
Flock size*HMCL	Reference		
Off-take rate	13.02	3.74	0.001
Flocks*off-take rate	6.68	0.34	< 0.001

AAP=arid agro-pastoral, SAAP=semi-arid agro-pastoral, HMCL=high land mixed crop-livestock, GM= gross margin, NB1= includes GM and in-kind benefits NB2= includes GM, in-kind and intangible socio-economic benefits.

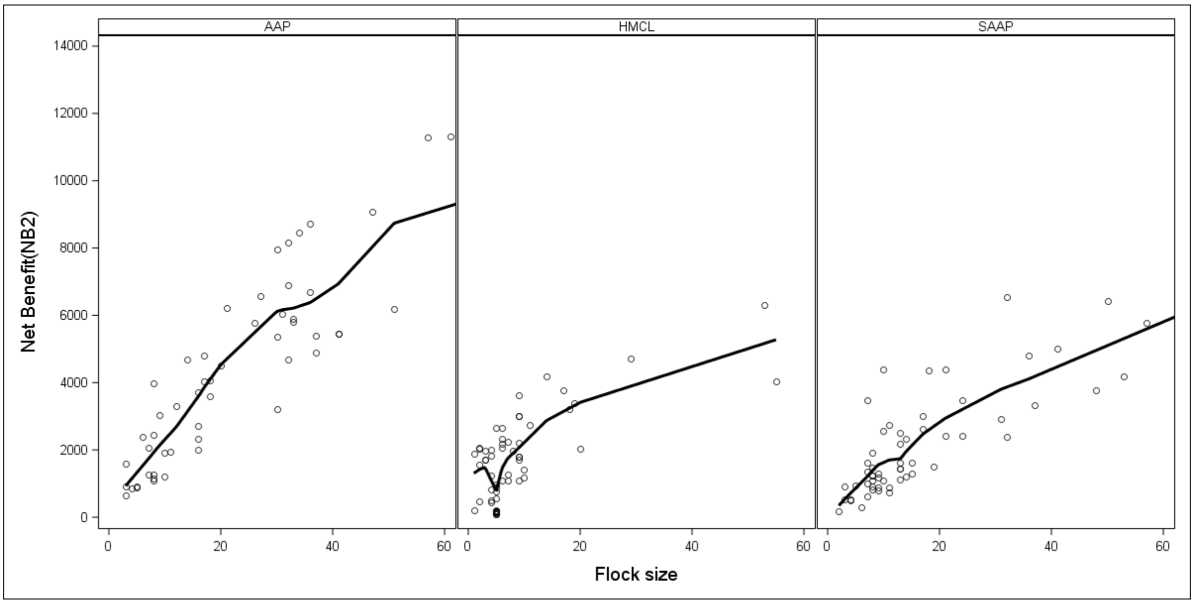

Figure 2.3. Trends in net benefits (including in-kind and intangible benefits of goats, NB2) with increasing flock sizes in arid agro-pastoral (AAP), semi-arid agro-pastoral (SAAP) and highland mixed crop-livestock (HMCL) systems of Ethiopia

2.4.4 Food security contribution of goats

The diets of the surveyed household members were composed of cereals, spices, grain legumes and vegetables. Consumption of animal products in the study areas was low and constituted only a small fraction of the diet (Figure 4). Milk, meat and egg products were only consumed by 21.0%, 10.0% and 3.0% of the household members, respectively. When considering the production systems separately, milk consumption by household members was higher in the AAP (35.0%) as compared to the SAAP (13.6%) and HMCL (16.7%) systems. About 25.0% of the total households, who consumed milk in the AAP system, reported that the source of milk was from goats, while cow's milk was the sole source of milk in SAAP and HMCL systems. Goat milk in the AAP region was consumed mainly by children, who are responsible for herding the goats. Only 13.0% of the total households, who consumed meat as part of their diet, used their own goats as a source of meat.

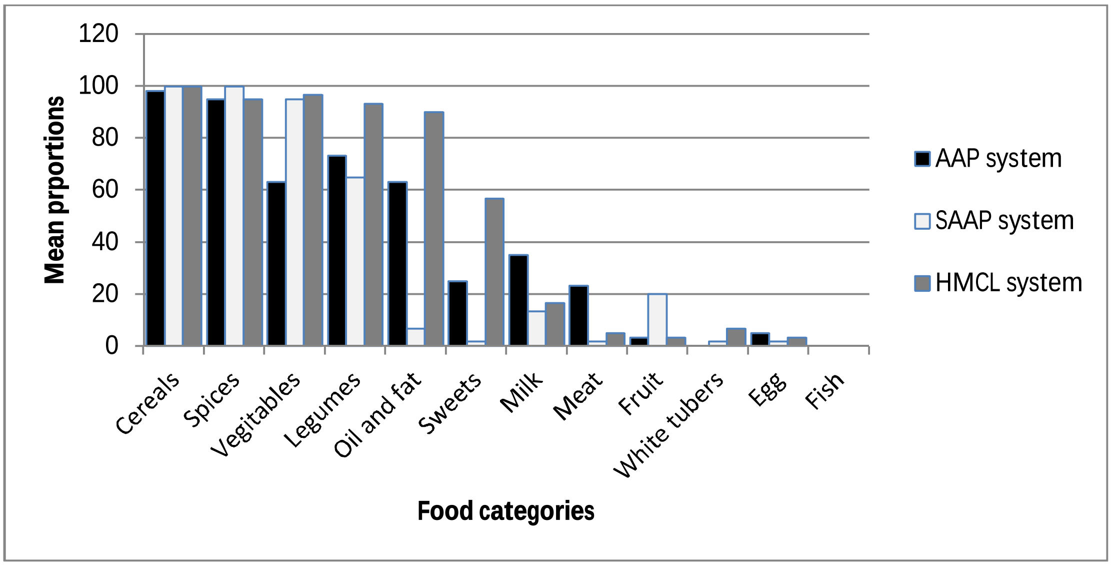

Figure 2.4. Proportion of food categories consumed by household members in arid agro-pastoral (AAP), semi-arid agro-pastoral (SAAP) and highland mixed crop-livestock (HMCL) systems of Ethiopia

The average dietary diversity score (DDS) of the surveyed households was 4.9 (Range: 2 to 8). The highest average diversity score was 5.7 in the HMCL system, followed by 4.9 in the AAP and 4.1 in the SAAP system. The ordered logit analysis showed that production system and gender of household head significantly affected household dietary diversity, while literacy, family size, livestock holding, area of cultivated land and goat flock holding were not significant (Table 2.4). Households in the HMCL system had a six times higher chance of being in the upper DDS terciles as compared to the AAP system. Male-headed households had five times higher chances of consuming more diversified diets than female-headed households. A significant positive correlation was detected between HDDS and GM, NB1 and NB2 from goats in the AAP system (Table 2.5), while correlations were either not significant ($P>0.05$), or negative in the SAAP and HMCL systems, respectively.

Table 2.4. Effect of socio-economic characteristics on household dietary diversity score (HDDS)

Parameters	Lower HDDS (%)	Medium HDDS (%)	Upper HDDS (%)	Odds ratio (P-value)
Production systems				
AAP	13.3	6.7	13.3	
SAAP	24.4	4.4	4.4	0.2 (0.00)
HMCL	2.2	10.0	21.1	6.1 (0.00)
Gender				
Female	7.2	1.1	1.1	
Male	32.7	20.0	37.8	5.0 (0.01)
Literacy				
Illiterate	33.9	15.0	29.4	
Literate	28.2	28.2	43.6	1.2 (0.61)
Family size				
≤ 7	27.2	13.3	22.2	
>7	12.7	7.8	16.6	1.7 (0.13)
Cultivated land				
< 1 ha	13.4	2.2	7.8	
1-2 ha	10.6	8.4	16.7	1.2 (0.71)
> 2 ha	16.2	10.1	14.5	0.6 (0.33)
Livestock TLU				
≤ 9	26.1	13.3	26.1	
> 9	13.8	7.8	12.8	2.0 (0.50)
Goat TLU				
≤ 1.7	27.7	11.7	26.1	
> 1.7	12.2	9.4	12.8	1.3 (0.55)

HDDS=Household dietary diversity score, TLU= Tropical livestock unit, conversion factor of 0.7, 0.5, and 0.1 for cattle, donkey and small ruminants, respectively (Janke, 1982).

Table 2.5. Pearson correlation coefficient between economic success of goat keeping and HDDS in three production systems of Ethiopia

	Production systems					
	AAP		SAAP		HMCL	
	HDDS	P-value	HDDS	P-value	HDDS	P-value
GM	0.26	0.04	-0.03	0.82	-0.27	0.04
NB1	0.33	0.01	0.02	0.86	-0.26	0.05
NB2	0.32	0.01	0.05	0.69	-0.24	0.06

AAP=arid agro-pastoral, SAAP=semi-arid agro-pastoral, HMCL=highland mixed crop-livestock, HDDS=Household dietary diversity score, GM= gross margin, NB1= includes GM and in-kind benefits NB2= includes GM, in-kind and intangible socio-economic benefits.

2.5 Discussion

Net benefits from goat production were positive for almost all farmers in the present study, which was mainly due to low variable costs. The net benefit reported in this study would probably be slightly reduced by inclusion of family labour and fixed costs. The lower proportion of feed costs and the relatively higher proportion of veterinary costs observed in the HMCL system is in agreement with Legesse et al. (2010) who reported that veterinary costs accounted for a great share (60%) of small ruminant production under similar production conditions. In contrast, reports from Kenya (Ogola et al., 2010) and Jordan (Al-Khaza'leh et al., 2015) stated feed costs as major expenses of smallholder goat production. Moreover, the high proportion of veterinary expenses observed in the SAAP and HMCL systems were in agreement with Netsanet (2014) who reported that diseases such as contagious caprine pleuropneumonia (CCPP), trypanosomiasis, internal and external parasites are the major constraints of goat production in the same study areas. The higher economic efficiency in terms of GM per goat observed in the HMCL system is probably due to lower total variable costs per goat and better market accessibility and subsequently higher selling prices of goats in this system as compared to the other systems.

The higher goat off-take rate observed in the highland areas than in agro-pastoral production systems could be a reason for absence of significant differences in GM among production systems despite the differences in flock size. Moreover, increasing flock size at a low off-take rate did hardly influence GM, mainly due to high VC to maintain larger flock sizes. Still, farmers in agro-pastoral systems (AAP and SAAP) continued to keep larger flock sizes at low off-take rates, deliberately foregoing economic gain in terms of GM, even though adequate goat markets are accessible. Kosgey et al. (2004) also argued that pastoralists in tropical environments continue to build larger flock sizes despite the net financial losses.

On the contrary, when in-kind and intangible benefits are considered in the evaluation of economic success, farmers in the AAP system attained an increased NB1 and NB2 by keeping larger flock size mainly due to utilization of more products from goats, such as milk, as well as the higher insurance and financial benefits of goats in this production system. This implies that intangible benefits of goats are effectively exploited in AAP and SAAP systems through keeping larger flock sizes. Barrett et al. (2004) also observed that pastoralists in Northern Kenya and Southern Ethiopia keep larger flock sizes for socio-cultural reasons and to reduce risks during drought periods rather than increasing off-take rates. Lack of responsiveness of goat sales to changes in price was also reported in Botswana (Seleka, 2001). In contrast, the relatively higher off-take rate and the tendency of farmers to sell more growing kids in the HMCL system indicates that the major purpose of keeping goats in this system is generation of cash income through increased commercial off-take. In the AAP system, where in-kind and intangible benefits of goats are highly valued, benefits in goat production could therefore be optimized by the incorporation of adaptive traits, such as fertility and disease resistance, in goat breeding objectives. However, a thorough investigation is required in cost and benefits of a higher disease resistance (Bishop & Morris, 2007). Whereas, targeting reproduction traits such as improving fertility rate could be a better option in the HMCL system. Although, disease resistance/tolerance abilities of goat breeds in the investigated systems were not yet studied, the higher twining rate (46.9%) of central highland goats in HMCL system (Netsanet, 2014) than Abergele (4.0%) and Woyito Guji (15.1%) goats (Alubel, 2015; Netsanel 2014) depicts the potential of selecting central highland goats for improved reproductive efficiency.

The average HDDS observed in this study (4.9) is similar to the dietary diversity score of 4.6 reported by Mersha (2014) for mixed crop-livestock systems of Ethiopia, but higher than the average dietary diversity score of 2.7 for Borana pastoral communities (Megersa et al., 2014). This variation in dietary diversity is mainly due to the dependence of pastoralists on cereals and milk as the main source of their diet (Villa et al., 2011; Megersa et al., 2014), while additional foodstuffs including legume pulses, vegetables, oil and fats are consumed in the mixed crop-livestock systems. The higher probability of households consuming diversified food diets in the HMCL system than in the other systems is mainly due to better access of the households to diverse foodstuffs and a higher GM from agricultural activities (Figure 2.1).

Contrary to other findings (Demeke et al., 2011; Megersa et al., 2014) the number of livestock owned in general and goats in particular were not determinant factors of household dietary diversity, this is probably due to a limited direct contribution of livestock products to food diets in the study area (Figure 2.4). Nevertheless, the significant positive correlation ($P<0.05$) between GM and HDDS in the AAP system could indicate that cash income generated from goat sales is used to purchase other foodstuffs to diversify diets. This points to an indirect function of goat keeping to possibly increasing dietary diversity and thus, household food security. The negative correlation between income from goats and HDDS in the HMCL system could partly be explained by the observation that goats played a less important role in determining HDDS of farmers in this system, contributing only 9.0% to the total GM (Figure 2.1). Furthermore, farmers owning a higher number of goats were relatively poorer, because better-off farmers kept more cattle and depended on crop production as a major source of household income.

The cultural habit of consuming goat milk and its exclusive use for nourishing children and the elderly in the AAP system indicates the potential of improving nutritional status of children by improving goat milk production through improved management of the available feed resources and genetic improvement of goats for milk production. In contrast, consumption of goat milk is considered as a cultural taboo in the HMCL system. This implies that goat traits to be included in defining breeding objectives should also consider the culture and norms of the society. The higher dietary diversity of male-headed households compared to female-headed households could be an indicator of gender to be an important predictor of food security. This is mainly because female headed households are mostly single households; as a result the endowment with household family labor is severely affected.

2.6 Conclusions

The farmers' strategies to utilize tangible and intangible benefits of goats were found to be different among production systems. Thus, during the design and implementation of goat genetic improvement programs, differences in marketing strategies of farmers across production systems, as well as their priorities in utilizing tangible and intangible benefits should be taken into consideration. Intangible benefits of goats should be considered in defining goat breeding objectives in agro-pastoral systems, while in mixed crop-livestock systems more attention should be given improving reproductive efficiency to increase the number of marketable goats and optimize benefits from goat farming. Since the current profitability of goat keeping by smallholders relies on low variable costs; a cost-benefit analysis would be suitable which considers the cost and benefits of any intervention.

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Chapter 3: Combining revealed and stated preferences to define goat breeding objectives in Ethiopia

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3.1 Abstract

In order to design a sound community-based genetic improvement program, identifying breeding objective traits and their relative importance is a prerequisite. The study aims to identify goat breeding objectives in three production systems of Ethiopia based on revealed and stated preference information. Market transaction surveys as well as choice experiments (CE) were conducted in three production systems of Ethiopia. Relationships between goats' attributes and prices were estimated by hedonic modeling, while economic values of traits included in the CE were estimated by conditional logit (CL) model. Part worth value of a trait which indicates the relative importance of a trait was calculated based on the implicit prices farmers were willing to pay (WTP) for an improvement of a trait. The hedonic regression results showed that body weight was a consistent determinant of goat price in all observed markets. While, attributes such as body condition, age and season had heterogeneous effect on market prices of goats. The CL analysis indicated that farmers living in harsh environments valued functional traits such as disease resistance more than performance traits. Based on revealed preferences and choice models, alternative breeding options, which are in line with farmers' trait preferences and market demands, were suggested. The suggested alternative trait combinations and their economic values could be used as an input for optimization of the breeding schemes after considering heritability, genetic and phenotypic correlations.

Key words: revealed preference, stated preference, breeding objectives, goats, production systems

3.2 Introduction

In recent years, a paradigm shift was observed in livestock genetic improvement approaches by incorporating local communities and institutions into the design and implementation process of breeding programs in low-input agricultural systems. A considerable number of community-based breeding programs (CBBPs) were designed and implemented with some success but also shortcomings within the last two decades (Mueller et al., 2015). Understanding the breeding objectives of livestock keepers is a prerequisite to design sound CBBPs that consider farmers' priorities and trait preferences that are tailored by specific production systems and agro-ecologies (Valle Zárate and Markemann, 2010; Sölkner et al., 2008).

Choice experiment (CE) is one of the stated preference (SP) tools widely used for valuation of non-marketed goods and services (Hoyos, 2010; Hensher et al., 2005). The tool was mainly used in transportation industry (Train, 2009), environmental resource valuation (Hoyos, 2010) and health care services (Bekker-Grob et al., 2012). In the livestock sector, a number of researchers applied SP tools to identify trait preferences and estimate economic values for the traits in various parts of the world. For instance, some researchers employed CE to investigate producers' trait preferences and estimate economic values of the traits for cattle (Tada et al., 2013; Kassie et al., 2009; Ruto et al., 2008; Scarpa et al., 2003a), small ruminants (Duguma et al., 2011; Omondi et al., 2008a and 2008b) and pigs (Roessler et al., 2008; Scarpa et al., 2003b). These studies indicated that breed or trait preferences varied across production systems, agro-ecologies and different levels of market access. Other studies used revealed preferences (RP) tools by applying hedonic pricing to investigate attributes affecting market price of livestock (Terfa et al., 2013; Kassie et al., 2011; Barrett et al., 2003). These studies showed that selling prices of livestock were affected by attributes such as age, sex, body size, body condition and color as well as other factors including season, reason of buying and selling, buyers and sellers' occupations and market locations.

Despite the booming number of researches in SP and RP of livestock attributes, only limited information is available (Kassie et al., 2012; Scarpa et al., 2003a) in providing a comprehensive understanding of trait preferences from producers and market perspectives by combining both, SP and RP findings. Both approaches have their own advantages and disadvantages. RP represent the real market transactions, and take market and personal constraints into consideration and hence have high face validity (Louviere et al., 2000), but are limited in the number of attributes and attribute levels that can be included and possibly suffer from invariance and multicollinearity (Hensher et al., 2005; Louviere et al., 2000). SP allow evaluating utility functions of attributes, which are not directly valued through market transactions such as genetic attributes bundled within phenotype (Scarpa et al., 2003a), but they are criticized for being hypothetical and fail to consider real market and personal constraints (Louviere et al., 2000). Combining SP and RP information allow improving the strengths and reducing the weaknesses of each approach (Louviere et al., 2000). The combination of RP and SP can be either merging of the data generated from the same sample (Kassie et al., 2012; Hensher et al., 2005) or merging the SP and RP approaches from different samples but the same population (Kassie et al., 2012). For this study the latter approach was implemented, because it generated wide range of information on goat trait preferences by taking into account both hypothetical and real market conditions.

In livestock breeding programs, economic values of traits are usually derived by using profit equations or bio-economic models which consider cost and benefit components to measure effects of genetic changes on profitability of the enterprise (Nielsen et al., 2011). Such detailed economic data are hardly available in low input systems and these approaches overlook values of phenotypic appearances (Sölkner et al., 2008) and animal welfare issues (Nielsen et al., 2011). The SP approach is an alternative option to derive economic values of traits in such conditions (Nielsen and Amer, 2007). For instance, Tano et al. (2003) and Siddo et al. (2015) derived part worth values of traits (relative importance of traits) from a conjoint study, while Byrne et al. (2012) used choice experiments to drive part worth utility values of traits in the Irish sheep industry. In the present study, willingness to pay (WTP), which is the implicit price farmers are willing to pay for a unit increase in trait level, was used to derive part worth values. The objectives of the present research were to identify breeding objectives of goat producers in three largely differing production systems of Ethiopia based on revealed and stated preference information.

3.3. Materials and methods

3.3.1 Description of the study area

The study was conducted in Meta Robi, Abergele and Konso districts of Ethiopia representing three different agro-ecologies and production systems. While Meta Robi represents a highland area characterized by a mixed crop-livestock (HMCL) system with settled farmers, Abergele and Konso districts represent arid agro-pastoral (AAP) and semi-arid agro-pastoral (SAAP) systems, respectively, in which farmers periodically move with their livestock during periods of feed shortage. Climatic conditions and predominant goat breeds kept in the three study locations are given in Table 3.1.

Table 3.1. Climatic conditions, predominant goat breeds and production systems in the three study locations

Districts	Annual range of precipitation (mm)	Annual range of temperature (°C)	Goat breeds	Production systems
Meta Robi	850-1100	15 and 32°C	Central highland	Highland mixed crop livestock (HMCL)
Abergele	300 to 496	21 and 41°C	Abergele	Arid agro-pastoral (AAP)
Konso	400 to 1000	12 and 33°C	Woyito-Guji	Semi-arid agro-pastoral (SAAP)

3.3.2 Experimental design and data collection

3.3.2.1 Revealed preference data

The market data collection was carried out in one rural livestock market of each district. Two enumerators were recruited and trained for market data collection at each market location. The information collected for each observed goat transaction included: selling price, goats' age (using dentation method), body weight (using hanging scale of 100kg x 200g), sex, coat color, body condition, reason for buying and selling, buyers and sellers occupations. The body condition grading was done based on three levels (poor, good and excellent). This grading system is the most commonly used method by the local market actors in the study areas. Market data of 796 goat transactions were collected from October 2013 to March 2014. From the total observed transactions, 40.7%, 34.8% and 24.5% were in AAP, HMCL and SAAP systems respectively.

3.3.2.2 Stated preference data

For the CE, a preliminary list of preferred goat traits was extracted from detailed goat production system studies (Netsanet, 2014; Alubel, 2015) conducted in similar locations. Focus group discussions in each study area were conducted to select the most important goat traits and set levels for the selected traits (Table 3.2). Consequently, a total of eight desired traits and price levels (body size, disease resistance, libido, coat color, milk yield, mothering ability, twinning ability, kidding interval and price) were selected. The price levels were set based on quartiles of market prices of goats suggested by farmers during the group discussion.

Table 3.2. Buck and doe traits and levels used in the choice experiment (CE) design

Traits	Animals considered	Trait levels	Base level
Body size	Bucks and does	Small, medium and large	Small
Disease resistance	Bucks and does	Low (sick three times a year)	Low
		Moderate (sick two times a year)	
		High (sick one time a year)	
Libido	Bucks	In-active, active	In-active
Coat color	Bucks	Black, brown and white	Black
Milk yield [a]	Does	0.5, 1 and 1.5 cup[b] per milking	0.5
Mothering ability [c]	Does	Poor, good	Poor
Twinning ability	Does	Singles, twins	Singles
Kidding interval	Does	Long (1 kidding per year)	Long
		Moderate (3 kidding in two years)	
		Short (2 kidding per year)	
Price (ETB)[d]	Does	380, 505, 635 and 760	380
Price (ETB)	Bucks	500, 665, 835 and 1000	500

[a] Milk yield was considered only in AAP and SAAP systems, [b] 1cup=250ml, [c] mothering ability was considered only in HMCL system, [d] Ethiopian currency (1 USD≈19.00 ETB in 2013).

By considering the total number of traits with two to four levels, the full factorial design can possibly generate a total of 648 (34 x 21 x 41) doe profiles for AAP and SAAP systems, and 432 (33 x 22 x 41) for HMCL systems. The variation of the factorial designs among production systems is due to differences in breeding doe trait preferences (Table 3.2). For instance, milk yield is considered important trait in AAP & SAAP systems but not in HMCL system, while mothering ability was important trait in HMCL system. Similarly, a total of 216 (33 x 21 x 41) buck profiles could be generated for each production system. However, choice tasks with such huge number of profiles would be time consuming and place a heavy burden to the respondents in terms of answering the questions. The fractional factorial design described by Kuhfeld (2010) was employed to limit the number of profiles, while ensuring the estimation of main effects independently. Accordingly, a randomized 36 goat profiles for each sex (18 choice sets) were generated by using %MktEx macro (Kuhfeld, 2010) in SAS, which were further blocked into two groups with nine choice sets each. Each choice set contained two goat profiles and an opt-out option, in case the respondent is not interested in either of the profiles. Pictorial illustrations were used to describe all traits in the choice set.

The CE survey was conducted between October and December 2013 by involving a total of 360 households (120 from each district), who were previously selected based on their willingness to participate in the goat community-based breeding programs and ownership of at least five breeding does. Each respondent was presented with a sequence of nine choice sets for each sex and asked to hypothetically purchase one of the goat profiles for breeding purposes. If the respondent was not interested in either of the goat profiles presented, he/she could select the opt-out (no purchase) option.

3.3.3 Analytical framework

3.3.3.1 Revealed preference

The relationship between goats' attributes and prices were estimated by the hedonic pricing method. Hedonic models consider price as function of multiple attributes (Rosen, 1974). During transaction of a good, the selling price predicts the utility of the good for the buyer which is derived from the multiple attributes of the good (Rosen, 1974), in this case, goats. The standard linear regression model employed was as follows:

$$\ln P_i = \alpha + \beta_1 X_{1i} + \beta_2 X_{2i} \ldots\ldots\ldots \beta_n X_{ni} + \varepsilon_i \quad (1)$$

Where, P_i is the natural log-transformed selling price of goat 'i', α is the constant term, β denotes the parameter estimates, X_i are the independent variables including goat attributes, season and buyers characteristics of the i^{th} observation, ε_i is the error term that is assumed to be independently and identically distributed (i.i.d.).

The i.i.d assumption states that the distribution of the error term has zero means, constant variance and co-variance. Each model used for the estimation of attribute parameters in this study was tested for homoscedastic error term. The White test (White, 1980) rejected the null hypothesis at α=0.05, indicating absence of homoscedastic error term. Accordingly, the heteroscedasticity consistent (HC) standard error was employed to correct for heteroscedasticity. Four HC standard error alternatives (HC0, HC1, HC2 and HC3) are widely used for this purpose. HC3 standard error was used to correct for heteroscedasticity as recommended by Long and Ervin (2000) for a sample size of ≤ 250.

3.3.3.2 Stated preferences

CE's are based on the random utility theory (RUT), which states that every individual chooses an alternative with the highest level of utility (McFadden, 2001). By making repeated choices, it is assumed that a farmer is maximizing utilities and reflects on his/her trait preferences of a breeding goat. According to Hensher et al. (2005), the overall utility (U) is composed of an observed systematic component, which depends on the attributes of the alternatives and an unobserved random component. Thus, the basic axiom of RUT is:

$$U_{ni} = X_{ni}\beta + \varepsilon_{ni} \qquad (2)$$

Where, n represents individuals, $n=1,\ldots, N$, X_{ni} is the vector of attributes for alternative i and individual n, β is the conformable vector for the unknown parameters of the explanatory variables, and ε_{ni} is unexplained random component.

The probability of an individual choosing alternative i over alternative j after considering every attribute in a choice set can be expressed as:

$$Prob_{ni} = prob\ [(X_{ni}\beta + \varepsilon_{ni}) \geq X_{nj}\beta + \varepsilon_{nj})\forall j \in \text{j} = 1{,}2 \ldots, \text{J; i} \neq \text{j}]$$

$$= prob\ [(\varepsilon_{nj} - \varepsilon_{ni}) \leq X_{ni}\beta - X_{nj}\beta)\forall j \in \text{j} = 1{,}2 \ldots, \text{J; i} \neq \text{j}] \qquad (3)$$

In discrete choice analysis, the unexplained random component is assumed to be independently and identically distributed with an extreme value type I distribution. The density of each unobserved component is given as:

$$prob\big(\varepsilon_{nj} \leq \varepsilon\big) = exp^{(-exp-\varepsilon)} \qquad (4)$$

A further integration and mathematical manipulation of the above equation results in the standard logit probability model (Louviere et al., 2000). The choice of a farmer for a breeding goat represented by a profile i out of j alternatives can be expressed by the conditional logit model (McFadden, 1974).

$$Prob_{ni} = \frac{exp\ X_{ni}\beta}{\sum_{j=1}^{J} exp\ X_{nj}\beta} \qquad (5)$$

Since cost was one attribute included in the CE, it was possible to indirectly estimate the willingness to pay or willingness to accept compensation for the goat traits included in the CE. The willingness to pay (WTP) indicates the "implicit price" farmers are willing to pay for a unit increase in trait level assuming that all other attributes remained the same. The implicit price of a trait was calculated as follows:

$$WTP = -1\left({}^{\beta_x}/_{\beta_{Price}}\right) \tag{6}$$

where, β_x is the coefficient estimate for any trait in the MNL model and β_{price} is the coefficient estimate for price. The part worth of a trait within a production system was calculated as a ratio of the implicit price of a trait divided by the sum of all implicit prices of traits included in the CE.

$$R_{xs} = \left({}^{WTP_{mxs}}/_{\sum WTP_{mxs}}\right) \tag{7}$$

Where, R_{xs} is the part worth value of trait x in the s^{th} production system, WTP_{mxs} is the WTP for the m^{th} level of the trait x in the s^{th} production system, $\sum WTPmxs$ is the sum of WTP for all traits in the s^{th} production system. The part-worth value of a trait indicates how much the respondent valued a certain trait in relation to another trait within a certain production system.

The econometric software NLOGIT, Version 4.0 (Greene, 2007) was used to obtain standard maximum likelihood estimates (MLE) of the parameters (β). Goodness of fit of the model was evaluated by McFadden pseudo-R^2. The independence of irrelevant alternatives (IIA) assumption which states that the ratio of choice probability is independent on presence or absence of other alternative in the choice set (Hensher et al., 2005) was checked by the Hausman test in NLOGIT 4.0.

3.4 Results

3.4.1 Revealed preferences

The hedonic regression results showed that body weight is a consistent determinant of goat price in all observed markets. An increase in body weight of one kg resulted in a 3-4% price premium for both, bucks and does with highest effect in the HMCL system. Body weight did not only affect selling price of goats (Figure 3.1), but also explained 79.2 to 91.0% of the variation in price for bucks and 64.1 to 84.7% for does. Body condition was also found to be an important price determinant. Goats in excellent body condition realized higher prices of 28.2% for does in the AAP system up to 37.4% for bucks in the SAAP system as compared to animals in poorer conditions. Age was considered by buyers to the effect that mature goats fetched significantly higher prices than young ones. However, coat color did not significantly affect market price of goats in any of the production systems investigated. Overall, the goat attributes included in the hedonic regression models explained 85.9 to 94.8% of the variation in price for bucks and 75.5 to 85.5% for does.

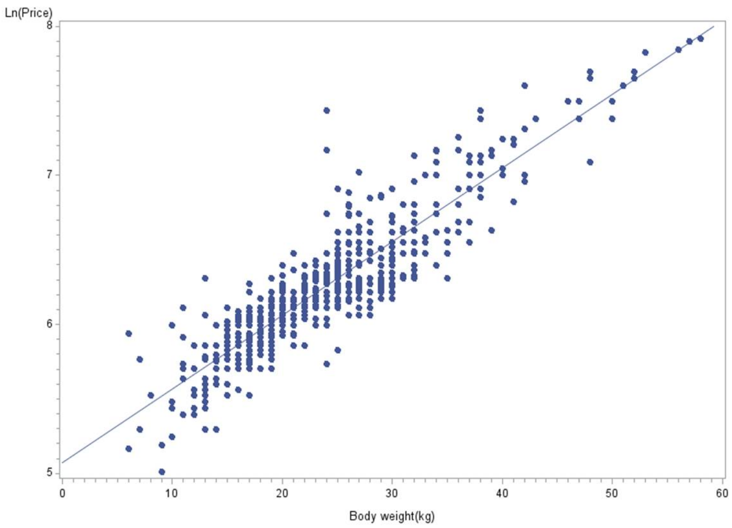

Figure 3.1. Relationship between body weight and natural log transformed selling price of goats (R^2= 82.56)

Next to the goat attributes, the buyers' primary occupations as well as the season of selling were found to be key determinants of goat prices. Among the total sampled buyers, 34.3%, 5.7%, 42.2%, and 17.8% were farmers, farmer-traders, traders and others (e.g. consumers and butchers). In the HMCL system, farmers paid significantly lower prices for does as compared to other buyers (Table 3.3). During Christmas season, male and female goats in Abergele district (AAP system) fetched price premiums between 8.6% and 9.2%, respectively, while at the same time in Konso district (SAAP system) significant discount in sales prices for does of 10.3% were observed. In contrast, the fasting season, during which Orthodox Christians abstain from eating livestock products for nearly two months, had a negative effect on selling prices of goats. The discounts for bucks ranged from 5.1% in Konso district (SAAP system) to 6.6% in Abergele district (AAP system) and from 3.0% in Konso district to 10.9% for does in Abergele and Konso districts, respectively. In Meta Robi district, does command a price premium of 7.3% during the fasting season than compared to the non-fasting season.

Table 3.3. Coefficient estimates for factors affecting price of male and female goats in three production systems of Ethiopia

Variables	Coefficient (SE)					
	AAP		SAAP		HMCL	
	Male	Female	Male	Female	Male	Female
Constant	5.27*(0.068)	5.34*(0.199)	5.09*(0.209)	5.27*(0.133)	5.11*(0.135)	5.14*(0.087)
Body weight	0.04*(0.003)	0.03*(0.005)	0.04*(0.006)	0.03*(0.006)	0.04*(0.007)	0.04*(0.004)
Body condition						
Poor	0	0	0	0	0	0
Good	0.05(0.026)	0.24*(0.172)	0.38‡ (0.189)	0.12(0.070)	0.04(0.036)	0.03(0.032)
Excellent	0.15†(0.052)	0.28*(0.176)	0.37‡ (0.189)	0.22†(0.077)	0.19(0.100)	0.03(0.069)
Color						
Black	0	0	0	0	0	0
Brown	0.03(0.032)	0.01(0.085)	0.07(0.066)	-0.08(0.043)	0.11(0.084)	-0.05(0.053)
White	0.02(0.047)	0.03(0.085)	-0.01(0.079)	-0.05(0.038)	0.05(0.062)	0.01(0.052)
Mixed	-0.01(0.020)	-0.05(0.044)	-0.02(0.056)	0.03(0.051)	0.08(0.069)	-0.03(0.056)
Age						
<1 year	0	0	0	0	0	0
1-2 years	0.07*(0.013)	0.14† (0.055)	0.11(0.063)	0.12‡(0.057)	0.10(0.054)	0.06(0.064)
2-3 years	0.14*(0.022)	0.16†(0.059)	0.29*(0.082)	0.17†(0.054)	0.27(0.156)	0.07(0.063)
3-4 years	0.20*(0.049)	0.21*(0.075)	0.38*(0.099)	0.23*(0.060)	0.28(0.249)	0.05(0.063)
> 4 years	0.24†(0.078)	0.16‡(0.069)	0.42*(0.155)	0.26*(0.070)	-	0.05(0.088)
Buyers						
Consumers	0	0	0	0	0	0
Farmers	-0.01(0.015)	-0.03(0.034)	-0.12(0.088)	-0.10(0.052)	0.02(0.023)	0.06*(0.028)

Traders	0.01(0.011)	-0.04(0.031)	-0.10(0.081)	-0.10(0.027)	-0.04(0.030)	0.05(0.030)
Farmer traders	-0.01(0.016)	0.03(0.086)	-	-	0.04(0.056)	$0.14^{‡}$(0.066)
Season						
Casual	0	0	0	0	0	0
Christmas	0.09^{*}(0.021)	$0.09^{‡}$(0.045)	0.04(0.057)	-0.10^{*}(0.001)	0.04(0.055)	
						0.04(0.052)
Non-fasting	0	0	0	0	0	0
Fasting	-0.07^{*}(0.014)	-0.11^{*}(0.031)	0.05^{*}(0.001)	-0.03^{*}(0.062)	0.05(0.001)	$0.07^{‡}$(0.035)
R^2	0.93	0.81	0.86	0.80	0.94	0.89
Adj. R^2	0.92	0.77	0.84	0.76	0.93	0.87
N	232	92	103	92	138	139

* , †, ‡significantly different at α= 0.001, 0.01 and 0.05 respectively, AAP=arid agro-pastoral, SAAP=semi-arid agro-pastoral, HMCL=highland mixed crop-livestock. All standard errors are HC3 SE.

3.4.2 Stated preferences

The coefficient estimates and WTP for breeding bucks and does traits in the three production systems are shown in Tables 3.4 and 3.5. The study revealed that active libido, large body size, high disease resistance, white coat color in SAAP and HMCL systems and brown coat color in AAP system are the most desired traits of breeding bucks. Libido was the most preferred trait in HMCL system and farmers were willing to pay 623.5 (32.8 USD) and 804.5 ETB (42.3 USD) more than farmers in the AAP and SAAP systems for a breeding male with an active libido, respectively. Farmers derive high utility from large body-sized breeding bucks in all production systems and from does in the SAAP and HMCL systems (Table 3.4 and 3.5). These findings converged with the results of the revealed preference whereby buyers consistently paid high price for goats with higher body weight (Figure 3.1). In contrast to the RP results, which showed no significant differences in price regarding different coat colors, the CE results indicated that coat color is an important trait considered in choosing breeding bucks. However, this trait was not considered to be important for selecting breeding does (Table 3.2). The preferred coat colors also varied among production systems. A brown coat color was highly preferred over a black color in the AAP system, while white goats were more favored than black ones in the SAAP and HMCL systems.

The value attached to disease resistance also varied across the production systems studied. For both bucks and does, a high economic value was assigned to disease resistance traits in the AAP system. Goat breeders in this system were willing to pay nearly three times more than those in the SAAP and HMCL systems for breeding bucks with high disease resistance ability. Furthermore, they were willing to pay 216 ETB (11.4 USD) more for does with high disease resistance ability than farmers in the SAAP system, while this trait was not considered as a determining factor for selecting breeding does in the HMCL system. Next to disease resistance, milk yield was the most preferred trait of breeding does in the AAP system, while it was not considered an important trait in the SAAP and HMCL systems.

Twinning ability of does was also valued differently across production systems. Goat producers in the HMCL system were willing to pay nearly 1249 ETB (65.7 USD) and 1161 ETB (61.1 USD) more than farmers in the AAP and SAAP systems, respectively for a doe with twinning ability. Similarly, the utility derived from short kidding intervals was highly significant (P<0.0001) in all production systems and farmers in HMCL system were willing to pay a much higher price for this trait than farmers in AAP and SAAP systems.

Table 3.4. Coefficient estimates and willingness to pay for breeding buck traits in three production systems of Ethiopia

Trait levels	AAP			SAAP			HMCL		
	Coef.	SE	WTP	Coef.	SE	WTP	Coef.	SE	WTP
Libido	0.957*	0.105	319.0	0.552*	0.120	138.0	1.885*	0.116	942.5
Large size	1.387*	0.091	462.3	1.386*	0.114	346.5	0.524*	0.524	262.0
Medium size	-0.293*	0.062	97.7	0.006	0.064	-	0.089	0.089	-
Brown color	0.488*	0.087	162.7	-0.133	0.085	-	0.047	0.078	-
White color	0.123	0.099	-	1.576*	0.117	394.0	0.744*	0.101	372.0
High DR	0.933*	0.073	311.0	0.381*	0.076	95.3	0.249*	0.063	124.5
Moderate DR	-0.105	0.075	-	-0.221‡	0.076	-	0.092	0.068	-
Price	-0.003*	0.001	-	-0.004*	0.000	-	-0.002*	0.000	-
Log likelihood	-660.182			-586.764*			-695.136		
Pseudo R^2	0.39			0.46			0.35		
N	1078			1080			1080		

* , †, ‡ significantly different at α= 0.001, 0.01 and 0.05 respectively, Coef= coefficient, DR= disease resistance, AAP=arid agro-pastoral, SAAP=semi-arid agro-pastoral, HMCL=highland mixed crop-livestock, WTP=

Willingness to pay in Ethiopian Birr (ETB), 1 USD ≈19 ETB in 2013.

Table 3.5. Coefficient estimates and willingness to pay for breeding does traits in three production systems of Ethiopia

Trait levels	AAP			SAAP			HMCL		
	Coef.	SE	WTP	Coef.	SE	WTP	Coef.	SE	WTP
Large size	0.141	0.093	-	0.520*	0.073	104.0	0.991*	0.095	991.0
Medium size	0.069	0.088	-	0.487*	0.081	97.4	-0.202‡	0.079	-202.0
Twinning	0.223‡	0.111	74.3	0.810*	0.095	162.0	1.323*	0.148	1323.0
Moderate KI	-0.039*	0.107	-13.0	-0.405*	0.081	-81.0	0.092	0.085	-
Short KI	0.412*	0.087	137.3	0.378*	0.070	75.6	0.892*	0.089	892.0
High MY	0.558*	0.103	186.0	0.112	0.074	-	-	-	-
Moderate MY	-0.143	0.103	-	-0.116	0.097	-	-		-
Mothering ability	-		-	-		-	1.267*	0.119	1267.0
High DR	1.045*	0.094	348.3	0.204*	0.076	40.8	0.089	0.106	-
Moderate DR	0.071	0.107	-	0.012*	0.095	-	0.354†	0.096	-
Price	-0.003*	0.002	-	-0.005*	0.003	-	-0.001*	0.003	-
Log likelihood	-637.741			-661.413			-597.792		
Pseudo R^2	0.45			0.41			0.48		
N	1080			1078			1080		

* , †, ‡ significantly different at α= 0.001, 0.01 and 0.05 respectively, Coef= coefficient, KI= kidding interval, MY= milk yield, DR= disease resistance, AAP=arid agro-pastoral, SAAP=semi-arid agro-pastoral, HMCL=highland mixed crop-livestock, WTP= Willingness to pay in Ethiopian Birr (ETB), 1 USD ≈19.00 ETB in 2013.

3.4.3 Part-worth values of traits

The part-worth values of traits which were calculated based on the 'implicit prices' of traits are shown in Table 3.6. The part worth values were calculated only for the top three preferred traits at each production system. Inclusion of more traits could be possible depending upon the feasibility of recording systems at the farmers' levels. In AAP system, the traits with the highest part worth values were large body size and disease resistance for bucks and does, respectively. While, brown coat color and twinning ability were highly valued for bucks and does respectively in SAAP systems. Similarly, twinning ability was the most valued trait for does in HMCL system, while libido was given the highest part worth value in this production system. Results of the part worth values also indicated that high disease resistance ability was only considered as a top priority trait only in AAP system. These relative weights of the traits can be used as economic weights in formulation and optimization of goat breeding schemes for the specific production systems.

Table 3.6. Part worth values of the three top ranked traits of breeding bucks and does in three production systems of Ethiopia

Breeding bucks	Traits	AAP	SAAP	MCL
	Libido	0.29	0.16	0.60
	Large size	0.43	0.39	0.17
	Coat color	-	0.45	0.23
	High DR	0.28	-	-
	Total	1.00	1.00	1.00
Breeding does	Large size	-	0.30	0.28
	Twinning ability	-	0.47	0.37
	Short KI	0.20	0.22	
	High MY	0.28	-	
	Mothering ability	-	-	0.35
	High DR	0.52	-	-
	Total	1.00	1.00	1.00

AAP=arid agro-pastoral, SAAP=semi-arid agro-pastoral, HMCL=highland mixed crop-livestock, KI= kidding interval, MY= milk yield, DR= disease resistance

3.5 Discussion

Combining SP and RP information revealed the convergence and divergence of goat trait preferences between the breeders and the market. Both the RP and SP results indicated that bigger body size is a desired trait of goats except for does in AAP systems. Higher preferences of breeders for bigger body size of sheep in Ethiopia (Duguma et al., 2011) and Kenya (Omondi et al., 2008a), cattle in Ethiopia (Kassie et al., 2011; Kassie et al., 2009) and elsewhere (Tada et al., 2013; Ruto et al., 2008; Ouma et al., 2007; Scarpa et al., 2003a) and pigs in Vietnam (Roessler et al., 2008) were previously reported. Yet, the SP and RP findings diverged in goat color preferences. Coat color was not a price determinant factor in any of the production systems studied, and this finding is in-contrast to some previous studies (Terfa et al., 2013; Kassie et al., 2011), who found coat color to be an important determinant of revealed livestock prices in different parts of Ethiopia. However, the CE results indicated low preference of producers for black coat color compared to white and brown coat colors, mainly because in some areas black color is traditionally associated with bad spirits. Hence, the SP brings important additional information; apart from market values, the reasons for farmers' preferences may be multifold, even sometimes beyond rational explanations.

The RP approach also indicated seasonal variations in goat pricing which could not be captured by the SP method. Previous studies reported that seasonal occasions such as religious holidays significantly affected livestock pricing (Terfa et al., 2013; Kassie et al., 2011; Barrett et al., 2003) but the current study indicated that the seasonal effect varied between locations and sex of the goats. The relatively higher price discount for bucks and does during fasting periods and higher pricing during Christmas in the Abergele district, which represents AAP system is mainly because almost all inhabitants of the district are Orthodox Christians, while the proportion of Orthodox Christians is lower in Konso and Meta Robi districts (Netsanet, 2014). The price discount for does during Christmas season in Konso district indicates the reduced demand of female goats in this area for such occasions.

The SP method revealed differences in economic values of non-marketable goat traits such as disease resistance among production systems. The higher economic values assigned for disease resistance in agro-pastoral systems in the present study is in agreement with Omondi et al. (2008), who reported that disease resistance traits were of higher value than other traits for goat producing pastoralists in Northern Kenya. Likewise, pastoralist/agro-pastoralists in the southern part of Ethiopia also rated adaptation traits of goats such as disease resistance and drought tolerance higher than performance traits (Berhanu et al., 2012). The reasons behind assigning high utility values for disease resistance in the AAP system compared to the other systems could be due to the significant role of goats in sustaining the farmers through generation of cash income and significantly contributing for household food security, so that farmers give high value for the health and survival of the goats, in addition to their performances. Even though, prevalence of diseases is one of the challenges of goat production in Ethiopia in general (Solomon et al., 2014) and the study areas in particular (Alubel, 2015; Netsanet, 2014), adequate veterinary services are not available in the remote and harsh environments of the AAP system and diseases such as PPR (Peste des petits ruminants), pasteurellosis, sheep and goat pox and internal and external parasites are rampant (Alubel, 2015), as a result, farmers are in favor of hardy goats which are less susceptible to the prevalent diseases in the area.

The cultural habit of consuming more goat milk in AAP system than other systems is a prime reason for high economic values assigned for milk yield. It has been reported that milk yield was the most preferred trait of does among pastoral and agro-pastoral communities of Afar (Misbah et al., 2015), Somali (Gebreyesus et al., 2012) and Hammer (Berhanu et al., 2012) in the arid and semi-arid agro-ecologies of Ethiopia. The absence of competition between humans and suckling goats for milk as well as the availability of better feed resources in the HMCL system could be reasons for farmers driving high utility from twinning ability of does in contrast to the harsh environments of the AAP system. Marked differences between breeds regarding twinning rates were reported in the study areas. The average twinning rate for central highland goats was indicated to be about 46.9% (Netsanet, 2014), for Abergele goats it was 4.0% to 9% (Alubel, 2015; Belay et al., 2014) and for Woyito guji goats it was 15.1% (Netsanet, 2014). The lower twinning ability of Abergele goats indicates presence of human and/or natural selection against twinning ability of Abergele goats.

Based on the results of the RP and SP, alternative breeding options can be formulated for each production systems investigated. Results of the RP showed that body weight played a pivotal role in determining market price of goats under all production conditions, hence it should be considered in alternative breeding options designed for goat genetic improvement at all the production systems studied. Accordingly, the first breeding option is considering only an improvement in body weight targeting marketing of goats. Since marketing of goats is not the only purpose of goat keeping in the study areas, additional options should be taken into consideration. The second alternative breeding scheme is body weight plus one other trait with the highest part-worth value from each production system. As indicated in Table 3.6, these traits are: disease resistance, twinning ability and libido in the AAP, SAAP and HMCL systems, respectively. The third alternative breeding scheme is option two plus the trait with second highest part-worth value, which are libido, coat color and twinning ability in the AAP, SAAP and HMCL system, respectively. Inclusion of additional trait such as milk yield in AAP system can be considered based on the feasibility of the recording systems. The suggested alternative trait combinations and their economic values could be used as an input for optimization of the breeding schemes after considering heritability, genetic and phenotypic parameters.

3.6 Conclusion

Combining of SP and RP data shades light on differences and similarities of goat trait preferences from the market and producers perspectives. Based on revealed preferences and choice models, alternative breeding options, which are in line with farmers' trait preferences and market demands, were suggested for community-based genetic improvement of three indigenous goat breeds in Ethiopia. The breeding options will contribute towards improving farmers' income without losing the preferred non-marketable goat traits.

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Chapter 4 Optimizing organization of smallholder goat breeding in Ethiopia

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4.1 Abstract

The study aims to identify major stakeholders, organizational networks and other elements of organization and their influence on the establishment and successful operations of goat community-based breeding programs (CBBPs) in Ethiopia. Focus group discussions with 68 goat keepers, key informant interviews with ten public and seven private institutions and a social network analysis (SNA) were conducted in Abergele, Konso and Meta Robi districts, representing arid agro-pastoral (AAP), semi-arid agro-pastoral (SAAP) and highland mixed crop-livestock (HMCL) systems, respectively. The identified famers' organizations linked to goat production and marketing includes multipurpose cooperatives (450-1200 members), farmer development groups (20-30members) and farmer networks (6 members). The SNA indicated that district extension officers had the highest values of degree and closeness centrality indicating their trustful relationship with goat keepers and best accessibility. The small flock size, poor institutional presence and lower prices of breeding goats in HMCL and SAAP systems makes establishing CBBPs less feasible, while the active institutional support, larger flock size with better marketing opportunities in AAP system makes goat CBBPs more promising. District extension officers should play major facilitation and liaison roles in the establishment and operation of the CBBPs due to their prominent position in the social network.

Keywords: breeding organizations, production systems, goat, social networks

4.2 Introduction

Small ruminant genetic improvement under smallholder conditions is hampered by technical and infrastructural limitations including small flock sizes, difficulties in controlled breeding and performance recording, limited access of farmers to basic infrastructures such as extension and credit services, road and communication facilities (Kosgey and Okeyo, 2007). Community-based breeding programs (CBBPs) incorporating local breeds, farmers' trait preferences and local institutions were proposed as a feasible strategy under low-input farming conditions (Mueller et al., 2015). Such breeding efforts do not only focus on the technical feasibility, but also analyze the organizational aspects of the breeding schemes under specified framework conditions (Roessler et al., 2012).

The advancement and expansion of modern breeding technologies such as artificial insemination, embryo transfer and genomic selection eased transfer of animal genetic resources across countries exacerbating concentration of breeding enterprises within few multinational companies (Roessler et al., 2012; Herold et al., 2012a). This situation already induced pressure on the competitiveness of local and regional breeding cooperatives in developed countries (Herold et al., 2012a) and will further challenge developing countries due to the current trade liberalization policies (Roessler et al., 2012). In order to cope with the internal and external changes in breeding environments, pro-active organizational studies should be an integral part of designing and implementing livestock breeding programs (Herold et al., 2012a and 2012b).

Although the need for organizational studies in animal breeding is acknowledged in the literature (Herold et al., 2012a and 2012b; Mueller et al., 2015), only few studies were conducted (Kahi et al., 2005; Roessler et al., 2012) taking into consideration the prevailing farmer organizations, social networks and available support services. Therefore, the objectives of this study were to identify major stakeholders, organizational networks and further elements of organization and their influence on the establishment and successful operation of goat CBBPs and to indicate options in linking the breeding programs with the existing organizational setups.

4.2.1 Conceptual framework

The present study defines organization following the theory-based approach provided by Herold et al. (2012a), thereby looking at the organization of smallholder goat breeding as part of a system, which is affected by institutions and other organizational elements at different levels. According to

Herold et al. (2012a), animal breeding organizations are broadly categorized into private and public areas. The private area includes cooperative and commercial breeding companies, while the public sector constitutes breeding organizations and performance testing institutions. In addition, the same authors described institutions related to breeding in the private and public areas. In the private sector, these included companies involved in trading of breeding products and provision of services, and also comprise actors involved in marketing and utilization of livestock products. In the public sector, institutions related to breeding constitute local and international breeding policies and legislations, as well as support services including research and education. Even though functional and structured breeding organizations as described by Herold et al. (2012a) were not available in the investigated areas of Ethiopia, private and public institutions that are linked to goat breeding and marketing on village to national level were identified and corresponding key informants interviewed.

Social network analysis (SNA) was used to analyze information flow of command and control, patterns of input and knowledge transfer within the social network. The SNA is a useful tool to visualize and measure relationships among multiple stakeholders operating within a social framework (Borgatti, 2006). Each actor in the social network is called a “node” and the links between the nodes are termed as “ties.” The centrality analysis is a key component of SNA, which identifies the actors’ level of connectedness, their role and influence within a social network. The two main centrality measurements used for the purpose of this study were degree centrality and closeness centrality. Degree centrality measures the number of ties a node has in relation to the number of ties in the entire network (Spielman et al., 2011). It indicates the most active and well-connected actor within a network. Closeness centrality measures the reciprocal of the geodesic distance (shortest path connecting two nodes) of a node to all other actors in the network (Spielman et al., 2011). Thus, it identifies an actor, who is in a better position to access information or any other resources from the network (Spielman et al., 2011).

4.3 Methods

4.3.1 Study area and investigated institutions

The study is part of the ILRI-BeCA collaborative research project “Harnessing genetic diversity for improved goat productivity”, which targets genetic improvement of local goat breeds through a community-based breeding approach. The project was implemented in five districts of Ethiopia. For the purpose of this study, three districts and two villages from each district were selected based on diversity of production systems and the potential of the area for goat production. The selected districts were Abergele, Konso and Meta Robi representing arid agro-pastoral (AAP), semi-arid agro-pastoral (SAAP) and highland mixed crop-livestock (HMCL) systems, respectively. A total of six focus group discussions were conducted with randomly selected farmers from the list of participants, who were previously selected to be involved in the goat CBBPs (Table 1). In each village, one stakeholder meeting was conducted which involved farmers, development agents, local officers, researchers and traders in order to map the social network structure of smallholder goat production and marketing systems. In addition, 40 key informants belonging to private, public and non-governmental organizations (Table 4.2) were purposively selected and interviewed.

Table 4.1. Characteristics of the focus group discussion participants

	Districts		
	Abergele	Konso	Meta Robi
Number of villages	2	2	2
Number of participants	20	22	26
Mean group size	10	11	13
Female participants (%)	9.5	13.4	16.0
Mean age (years)	42.9 (25 to 76)	38.1 (26 to 72)	44.1 (29 to 65)
Mean education (years)	0.9 (0 to 6)	2.5 (0 to 10)	3.5 (0 to 12)
Mean goat flock size	29.9 (8 to 98)	14.5 (5 to 35)	8.4 (7 to 29)

Values in the parentheses indicate minimum and maximum observations

Table 4.2. Categories of institutions approached in the survey

Institutions	Sum	Categories
District and zonal BoARD	6	Public
Agricultural research centers	3	Public
University	1	Public
Farmer cooperatives	3	Private
Goat traders	3	Private
Non-governmental organizations	2	International
Export abattoir	1	Private

BoARD = Bureau of Agriculture and Rural Development

Data were collected from October 2013 to March 2014 by using open-ended discussion guidelines and semi-structured questionnaires. The major issues addressed during group discussions included organization of goat breeding at village level, identification of formal and informal farmer organizations linked to goat breeding and marketing, achievements and constraints of the existing farmer organizations and attitudes of farmers towards working as a cooperative/group. During the stakeholder meetings, the key actors in goat breeding and marketing were identified and flows of information, inputs and command between actors were mapped. Data on current flock sizes, breed composition and the major goat research and development focus of three agricultural research centers as well as one university were collected by using questionnaires sent on-line to key informants. In addition, desk work was part of the study, which included screening of national agricultural and livestock breeding policies and other published documents.

Descriptive statistics were used to analyze data generated from key informant interviews. Social Network Visualizer (SocNetV) software (Kalamaras, 2015) was used to visualize the social network structures and analyze the degree of centrality and closeness between stakeholders within each social network.

4.4 Results

4.4.1 Goat breeding organization at village level

The results of the focus group discussions indicated that smallholder farmers in all studied areas keep indigenous goat breeds with an average flock size per household ranging from 8 to 98 in Abergele district which represent AAP system and 6 to 63 in Konso and 5 to 35 in Meta Robi districts representing SAAP and HMCL systems, respectively. Breeding goats were mainly taken from own and neighboring village flocks, purchased from local markets, acquired as a gift from relatives and in few cases from NGOs and agricultural research centers. The extent of using breeding bucks from own flocks differed among villages and districts. In the two investigated villages of Abergele district (AAP system) 14 out of 20 discussion participant farmers kept their own goat flocks separately and in most cases bucks from their own flocks were used for breeding. By contrast, in Konso (SAAP system) and Meta Robi (HMCL system), all the discussion participants indicated that goat flocks belonging to different households of a village are kept together in a common browsing area, so that any breeding buck within the same village can serve any of the breeding does.

The Abergele agricultural research center, which is closely located to the two investigated villages in Abergele district, is one source of breeding goats. Since 2010, the center dispatched nearly 160 F1 (Boer X local breed) and 60 pure Begait goats (local goat breed introduced from the northern part of the country targeting the improvement of milk production) to the surrounding households. The dispatched crossbred goats are progenies of Boer goats imported from South Africa by an USAID-financed project of the Ethiopian Sheep and Goat Production Improvement Program (ESGPIP). Apart from the involvement of the agricultural research center in distributing breeding goats, the French ACF (Action Contre La FAIM) International was involved in restocking of local goats by providing five does and one breeding buck per household. Indigenous goat breeds purchased from local market were used for restocking purpose. In 2013, about 20 households were benefited from this scheme in one of the investigated villages in AAP system. In SAAP and HMCL systems, neither agricultural research centers nor NGOs supplied breeding animals to the household goat flocks.

4.4.2 Farmer organizations

During the group discussions with farmers, a number of formal and informal farmer organizations, which were directly or indirectly linked to goat production and marketing were identified (Table 4.3). Most of the formal organizations were state-induced and served as a link to transfer agricultural inputs, information and political directives between the state and the local communities. These organizations included: farmer multipurpose cooperatives, farmer development groups and farmer networks. The farmer multipurpose cooperatives were established with the aim of modernizing rural markets and a subsequent commercialization of smallholder agriculture. Among the focus group discussion participants, nearly 54% were members of multipurpose cooperatives. According to the farmers, the cooperatives supplied agricultural inputs such as fertilizers, seeds and other farm equipment to members and non-members (all districts), marketed consumable household commodities on cash and credit basis (2 villages of AAP system and 1 village of HMCL system), supplied oil seed crops such as sesame to export markets and collected and supplied goats to an export abattoir (2 villages in AAP system). The multipurpose cooperatives in AAP system were engaged in more diverse marketing activities than those in SAAP and HMCL systems. Shortcomings raised by the farmers included suspicion of corruption among leaders of the cooperatives (all districts) delays in re-paying credits (SAAP and HMCL systems), low profitability and small dividends that subsequently reduced motivation to be a member of the cooperative in SAAP system.

Farmer development groups and farmer networks are also government-directed structures that exist in every village of the country. Farmer development groups comprise a group leader and 20-30 households. These groups are further divided into four farmer networks, which constitute a group leader and five household heads. According to farmers, in collaboration with the district’s Bureau of Agriculture and Rural Development (BoARD), these groups organized training in goat husbandry in AAP and SAAP systems, natural resource management in AAP system and crop agronomic practices in SAAP and HMCL systems. Furthermore, in AAP system, by using the discussion platform created through the farmers’ development group, communities established a self-initiated and managed rangeland enclosure protected from grazing. According to the discussion participants of the three districts, limitations of the farmer development groups and networks were mainly focusing on trainings on political than on agricultural issues.

The attitude of farmers towards working as a cooperative or a group in community-based goat genetic improvement programs was heterogeneous. About half of the agro-pastoral farmers, who practiced periodic movement of goats in AAP and SAAP systems showed little interest towards working as a group (12 out of 20 participants in AAP system and 9 out of 22 in SAAP system) because of restricted freedom in flock movement, fear of losing independency in decision-making and lack of interest in mixing their own flock with others. In contrast, the vast majority of the farmers in HMCL system (19 out of 22 participants) showed interest towards working as a group. The anticipated advantages were better opportunities to access selected breeding bucks from any of the group members, better prices for selected breeding animals in the future and improved access to training and other extension services.

Table 4.3. Summary of formal and informal farmer organizations in the study area

Farmer organizations	Formal/Informal organization	Members (range)	Membership fees (ETB)	Functions
Multipurpose cooperatives (All production systems)	Formal	450-1200	50-1000	Facilitate marketing of agricultural inputs and outputs;
Farmer development groups (All production systems)	Formal	20-30	-	Organize training on livestock husbandry practices and other new agricultural technologies; Facilitate natural resource management
Farmer networks (All production systems)	Formal	6	-	Support each other in any agricultural activities; Monitor and evaluate farmers' plans and accomplishments; Organize farmers' group activities
Iqqub (2 villages in AAP, 1 village in HMCL)	Informal	5-30	-	Rotating saving and credit association
Eddir (All production systems)	Informal	50-250	15-20	Assist families during mourning processes
Mahiber (2 villages in AAP, 1 village in HMCL)	Informal	15-120	-	Religious associations gathering during specific holidays (Orthodox Christians)

AAP=arid agro-pastoral, SAAP=semi-arid agro-pastoral, HMCL=high land mixed crop-livestock systems

4.4.3 Support services

4.4.3.1 Markets

In each of the investigated villages, at least one local market was accessible for buying or selling of goats. The marketed goats included growing kids, breeding does and bucks, culled bucks and does as well as fattened goats. In AAP and SAAP systems, apart from a small-scale trader, who purchases 3-5 goats for re-selling purposes, a single medium to large-scale trader purchased between 50 and 150 goats in a market day to supply other traders in larger towns, export abattoirs and live goat exporters. In AAP system, the multipurpose farmer cooperatives were directly involved in collecting and supplying goats to Abergele international export abattoir. The export abattoirs purchase goats on body weight basis unlike in the local market, where goat transactions are made by "eyeball estimation". The market price of breeding dose ranges from 450 ETB (23.7 USD) in Konso district to 800 ETB (42.1 USD) in Abergele district, while breeding bucks fetched an average price ranging from 420 ETB (22.1 USD) in Meta Robi district to 1000 ETB (52.6 USD) in Abergele district. Marketing of exotic or crossbred goats for breeding or consumption purposes was not observed in any of the local markets.

4.4.3.2. Extension services

The structural framework of the agricultural extension services is organized in such a way that agricultural technical and vocational education and training (ATVET) centers train development agents (DAs), who will in turn train farmers and facilitate transfer of agricultural technologies. In each kebele (the smallest administration unit) three DAs are deployed by the extension system, each trained in animal production, plant production and natural resource management. The DAs use farmer training centers (FTCs) for demonstration of new agricultural technologies and training of the farmers. The extension service in each village is managed and organized by the district BoARD. This agricultural extension framework is similar across the investigated districts.

The agricultural extension services provided to goat owners were limited to training, advisory and veterinary services. According to the key informants of the district BoARD, the training topics offered so far by the extension workers included: methods of selecting breeding bucks and does from own flocks based on phenotypic appearances (all districts), exchange of breeding bucks between villages to reduce incidences of inbreeding (AAP system), and culling strategies of unproductive bucks and does to reduce overgrazing (AAP and HMCL systems). The extension services rather focused on supporting cattle and poultry production through the provision of artificial insemination (AI) of cattle in SAAP and HMCL systems, village-based breeding bull services in AAP system, provision of forage seeds and introduction of exotic chickens to subsidized costs in SAAP and HMCL systems, respectively. At all districts, development agents use the farmer development groups and networks to deliver the extension services to reach larger number of farmers. No goat artificial insemination services were provided by private or public institutions in any of the investigated districts. According to the extension service providers, lack of innovative technologies targeting small ruminant production, reluctance/resistance of farmers to adopt introduced technologies, and logistical constraints such as limited budget and scarcity of inputs were the major challenges of the extension services at all districts. Each investigated village had access to at least one publicly owned veterinary clinic, however, the key informants indicated that inadequate supplies of vaccines, medications as well as shortage of veterinarians hampered services. No privately owned veterinary clinics were observed in the rural areas of the investigated villages.

In addition to the extension services, governmental cooperative promotion centers facilitate the establishment, operation and regulation of cooperatives. The Federal Cooperative Agency is the highest level in cooperative promotion hierarchy and branched to regional, zonal and district levels. In each of the investigated districts, there is one cooperative promotion office, which registers, organizes, and regulates cooperatives and provides technical backstopping to its members.

4.4.3.3 Breeding institutions

In Ethiopia, most livestock breeding research activities and multiplication of improved genotypes have been conducted in publicly owned ranches, agricultural research centers and universities. At present, there are ten ranches of which nine are publicly owned. Seven of the publicly owned ranches are mainly used for cattle breeding and multiplication, while the remaining two have been used for breeding and multiplication of two local sheep breeds targeting the improvement of meat and wool production. Yet, there is no single public or private ranch specifically used for genetic improvement of goats, except for few breeding activities in agricultural research centers and universities.

The current goat flock sizes of agricultural research stations were found to be small, ranging between 63 and 367 heads. On average, local goat breeds constitute the majority (82.6%) of the total goat flock, with, Arsi-Bale goats accounting for the highest share (63%), followed by Abergele (25.4%), Begait (8.4%) and Somali (3.4%) goat breeds. Eighty-nine percent of the exotic breeds kept by the studied institutions were crosses of Boer and local goats (128 heads) while pure Boer goats accounted for the smallest share (11%) with a total of 17 heads. Goat breeding was found to be the major research topic of the investigated institutions, accounting for 52% of the total research projects in goat production and marketing. About eighty percent of the breeding research topics mainly focused on performance evaluation of crossbred goats managed either under on-station or on-farm conditions, whereas few research topics focused on genetic improvement of local goat breeds. Other research topics addressed by the research institutes were on-farm demonstration of different technologies (14.9%), feeds and feeding research (9.5%), improving reproduction efficiency of local goats (9.5%), veterinary research (9.5%) and production systems studies (4.5%). It was also observed that the majority (67%) of the goat researches have been conducted under on-farm conditions. According to the key informants of the studied research institutions, a total of 94 pure Boer goats and 420 crossbreds (Local X Boer) were distributed to farmers, NGOs and small-scale commercial goat producers since 2009. Detailed information on biological and economic performance of the exotic/crossbred goats under smallholder farmers' management conditions were lacking and no clear strategies were in place to sustain the supply of exotic goats and to control indiscriminate crossbreeding between introduced and local goats.

4.4.4 Social network analysis

Findings of the SNA indicated that the number and the diversity of actors involved in smallholder goat production and marketing differed between the investigated districts. The network size was biggest in AAP system with 16 nodes (Figure 4.1), followed by SAAP with 15 nodes (Figure 4.2) and HMCL with 13 nodes (Figure 4.3). Agricultural research institutes and NGOs were missing in HMCL system social network structure (Figure 4.3). In addition, brokers, traders and consumers were the major goat marketing actors without involving export abattoirs.

Information of command and control flows from district administration offices to smallholder farmers through development agents, village administrators, farmer development groups and farmer networks. This pattern was found to be similar across the investigated districts (see Figure 4.1, 4.2 & 4.3). Since research institutions and NGOs were not directly linked to cooperatives and other farmer organizations, information and input from these institutions reached smallholder farmers either directly or through the district BoARD and development agents. Farmer development groups and farmer networks were linked in all of the social networks of the investigated districts. However, the multipurpose cooperatives were not linked to the farmer development groups and networks at any of the district, rather cooperatives were linked with private actors such as traders in AAP and SAAP as well as with public actors such as district BoARD and cooperative promotion centers.

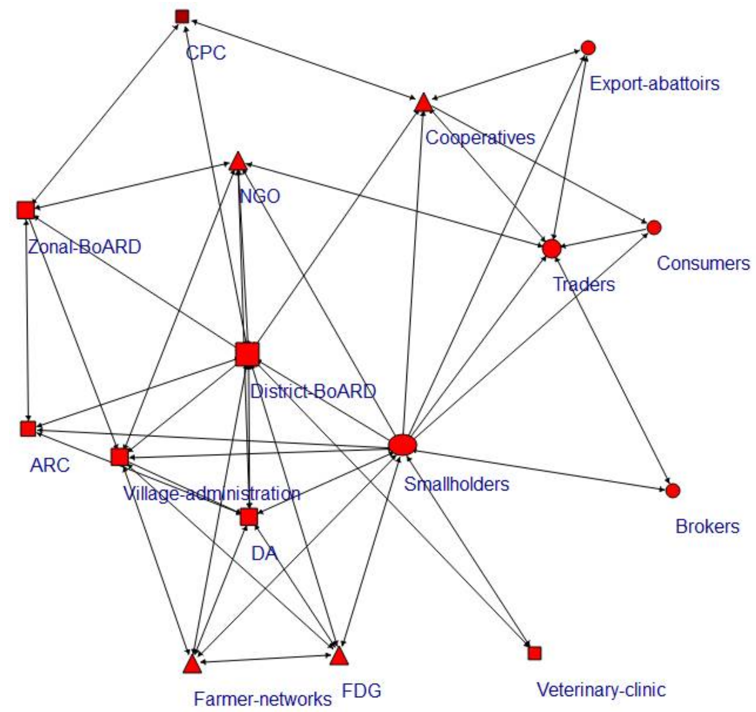

Figure 4.1. Social network structure of actors involved in goat production and marketing in arid agro-pastoral (AAP) system in Abergele district. ARC= Agricultural Research Center, BoARD= Bureau of Agriculture and Rural Development, NGO= Non-Governmental Organization, FDG= Farmer Development Group, CPC= Cooperative Promotion Center. Note: size of nods in the network determined by the nods' degree centrality. Squares, triangles and circles represent public, civil societies and private sectors, respectively.

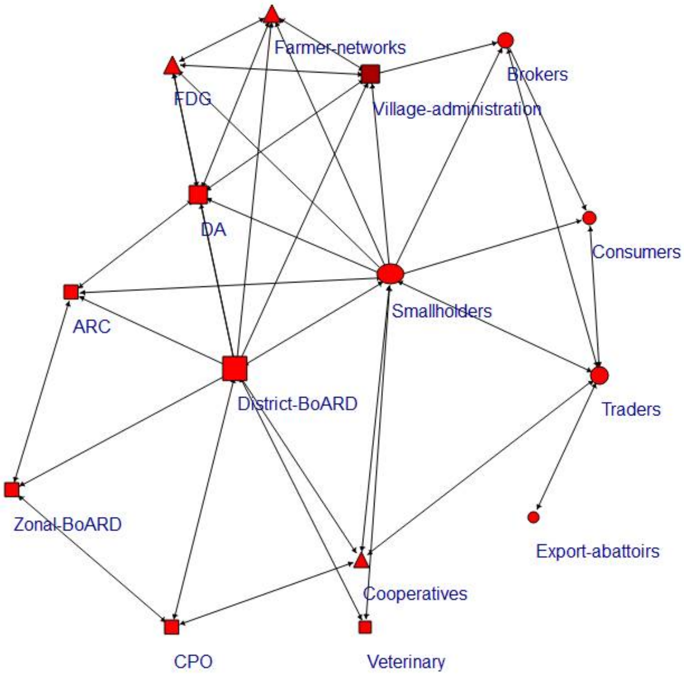

Figure 4.2. Social network structure of goat production and marketing actors in semi-arid agro-pastoral (SAAP) system in Konso district. ARC= Agricultural Research Center, BoARD= Bureau of Agriculture and Rural Development, NGO= Non-Governmental Organization, FDG= Farmer Development Group, CPO= Cooperative Promotion Office. Note: size of nods in the network determined by the nods' degree centrality. Squares, triangles and circles represent public, civil societies and private sectors, respectively.

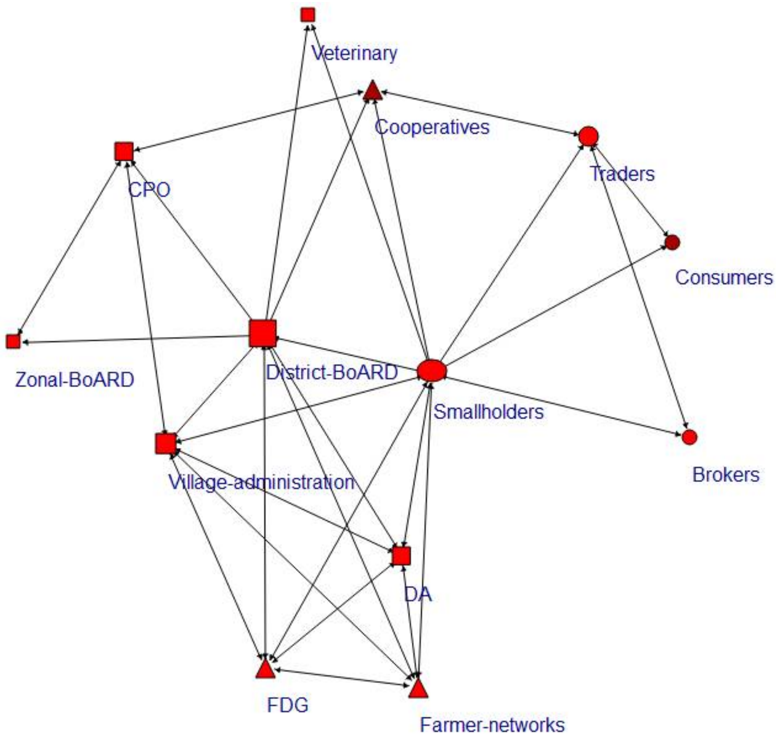

Figure 4.3. Social network structure of goat production and marketing actors in highland mixed crop livestock (HMCL) system in Meta Robi district. ARC= Agricultural Research Center, BoARD= Bureau of Agriculture and Rural Development, NGO= Non-Governmental Organization, CPO= Cooperative Promotion Office, FDG= Farmer Development Group. Note: size of nods in the network determined by the nods' degree centrality. Squares, triangles and circles represent public, civil societies and private sectors, respectively.

Findings of the SNA indicated that public actors such as the districts' BoARD and development agents had the highest centrality and closeness values signifying their close connections to each other and to farmers (Table 4.4). The district BoARD is an actor with the highest degree centrality ranging from 71.4 in SAAP to 75.0 in HMCL systems, indicating that this actor is connected to 71% and 75% of the actors involved in goat production and marketing in these systems. While, the private sector actors such as traders, brokers and export abattoirs were in a peripheral position of the network with low degree centrality and closeness values. Moreover, the public sector had limited or no connections with the private sector, but actors of the private sector were rather connected with each other

Table 4.4. Degree centrality and closeness measurements of actors in the goat production and marketing network in three production systems of Ethiopia

Actors	AAP		SAAP		HMCL	
	Degree	Closeness	Degree	Closeness	Degree	Closeness
Smallholders	86.7	88.2	78.6	82.4	83.3	85.7
District-BoARD	73.3	78.9	71.4	73.7	75.0	80.0
Zonal-BoARD	33.3	53.6	21.4	46.7	8.3	46.2
DA	46.7	65.2	42.9	60.9	41.7	63.2
Village admin.	46.7	65.2	42.9	60.9	50.0	66.7
Cooperatives	40.0	62.5	58.3	58.8	33.3	60.0
CPO	20.0	53.6	50.0	50.0	25.0	60.0
FDG	33.3	60.0	58.3	58.8	41.7	63.2
Farmer networks	33.3	60.0	58.3	58.8	41.7	63.2
ARC	26.7	57.7	28.6	56.0	-	-
NGO	40.0	62.5	-	-	-	-
Veterinary clinic	13.3	53.6	14.3	51.9	16.7	57.1
Traders	25.0	62.5	35.7	58.3	33.3	57.1
Brokers	13.3	50.0	28.6	53.9	16.7	50.0
Export abattoirs	20.0	54.6	7.1	37.8	-	-
Consumers	20.0	53.6	21.4	51.9	16.7	50.0

AAP=arid agro-pastoral in Abergele district, SAAP=semi-arid agro-pastoral in Konso district, HMCL=high land mixed crop-livestock systems in Meta robi district, BoARD = Bureau of Agriculture and Rural Development, DA= Development Agent, ARC= Agricultural Research Center, FDG= Farmers Development Group, NGO= Non-Governmental Organization, *Iqqub*= a local saving and credit association, CPO= Cooperative Promotion Office. Note: the highest possible value for degree centrality and closeness is 100

4.4.5 Agricultural policies

The national policies implemented in Ethiopia recognized agriculture as an engine for growth and sustainable development. Since the 1990s, agricultural development-led industrialization (ADLI), that targeted improving agricultural extension service, promotion of domestic and export markets, enhancing natural resource management and improving access to financial services, have been implemented (Chanyalew et al., 2010). Between 2005/6 and 2009/10, a new policy for accelerated and sustained development to end poverty (PASDEP), which aimed at facilitating transformation of subsistence agriculture to commercialization (MoARD, 2006) succeeded the ADLI. Among others, the basic elements of the PASDEP included capacity building of farmers through training, development and adoption of high-yielding agricultural technologies, increase of agricultural diversification and establishment and promotion of marketing channels. The PASDEP achieved an average of 11% GDP growth per annum and the share of agriculture in the economy was reduced from 47% to 41% (Chanyalew et al., 2010). The PASDEP was followed by a five-year (2010/11-2014/15) growth and transformation plan (GTP) which set a growth target of the national GDP at a minimum rate of 11% per annum and targeted to meet the millennium development goals (MoFED, 2010). Smallholder agriculture continued to be the central focus of the GTP; nonetheless, large-scale commercial farms were also promoted and supported to boost agricultural productivity and foreign direct investment.

The existing agricultural and livestock development policies of Ethiopia create enabling environments to improve local goat genetic resources through CBBPs. The draft on the livestock breeding policy of Ethiopia (MoA, 2014) encourages improving indigenous breeds through within-breed selection and crossbreeding. Moreover, due emphasis was given to characterizing less known local breeds, the establishment of multiplication centers for improved livestock breeds, introduction of national recording systems and conservation of local genetic resources (MoA, 2014; Shapiro et al., 2015). The policy document still awaits national parliament approval (Shapiro et al., 2015). Likewise, the MoA issued a policy document that specifies procedures, standards, and criteria for the import and export of livestock genetic resources (MoA, 2012). The livestock master plan, which is a more recent initiative in formulating a road map for developing the livestock sector in the country (Shapiro et al., 2015) invigorated community-based breeding programs as one feasible strategy to improve small ruminant production.

4.5 Discussion

Smallholder goat production in Ethiopia is determined by local goat breeds reared on small-scale family farms with very limited support from public or private institutions. As such, local goats constitute 99.96% of the national goat population of Ethiopia (CSA, 2015) and nearly 100% of the investigated districts (Alubel, 2015; Netsanet, 2014). Access of farmers to well adapted and improved local breeding stocks is limited due to the current focus of goat breeding research on exotic breeds and few numbers of improved local goats maintained in governmental breeding institutions coupled with the absence of artificial insemination or village breeding buck services. Consequently, smallholder goat breeding is dependent upon unimproved village flocks. This justifies the need for the establishment of functional village-based breeding cooperatives that produce and market selected breeding goats.

Alternative options of designing and organizing community-based breeding programs were documented by Mueller et al. (2015). The methods include rearing of selected animals in central governmental stations (Wurzinger et al., 2008), organizing farmers to keep breeding males (Roessler et al., 2012), mass selection of breeding males and females by considering village flocks as single breeding units (Gizaw et al., 2014), and the establishment of centralized or dispersed nucleus breeding schemes by organizing few farmers as breeder groups and supplying the selected animals to the base population (Mueller et al., 2015).

In addition to the limitations of cooperatives identified in this study, socio-political challenges such as suspicion and uncertainty due to bad experiences of farmers with functional cooperatives during the previous socialist regime in Ethiopia, lack of transparency and inclusiveness in cooperative formation and decision-making processes were reported by Bernard and Spielman (2009). Addressing these challenges during the establishment of the village-based breeding cooperatives by ensuring active participation of farmers starting from the early stage of cooperative formation throughout the whole process of selection and use of breeding animals will improve transparency and inclusiveness of the cooperatives.

The support of effective extension services is crucial for the successful operation of village-based breeding programs. The prominent role of the district BoARD in the social network indicates its better accessibility to smallholder farmers than any other actor in the network. Hence, it should play a facilitation and liaison role in the establishment and operation of the village-based breeding cooperatives. The presence of agricultural research institutes at the reach of two of the investigated systems is a good opportunity to provide technical backstopping in record keeping, data processing and selection of candidate breeding goats. However, the absence of a research institute operating in HMCL system is a major obstacle for establishing functional village-based breeding programs. Furthermore, the poor inclination for cooperative breeding in AAP system is a challenge in establishing a goat CBBP. Provision of incentives through extension and veterinary services would be a feasible strategy to motivate farmers during the early stages of cooperative formation (Kahi et al., 2005). The role of informal farmer associations to mobilize and engage communities in development activities has been argued to be effective in developing countries (Rooy 1998; Teshome et al., 2013). According to Teshome et al. (2013) such informal associations are indispensable social platforms for dispute resolution, risk sharing and social interactions. The presence of at least one informal farmer association in the study areas offers an opportunity to facilitate information and knowledge transfer among farmers, researchers and extension workers.

Moreover, the selection and exchanging mechanism of breeding animals can be facilitated by using such social platforms.

The noticeable influence of the public actors and the limited role of private and civil societies in the goat production and marketing networks in the present study were consistent with the smallholder rural innovation networks in Ethiopia (Spielman et al., 2011; Asres et al., 2012). As compared to the dairy production and marketing network in Ethiopia (Asres et al., 2012) the ties between the public and private actors were week or nonexistent in the goat production and marketing networks. Moreover, medium and large scale goat producers are completely absent in the social networks of goat production in Ethiopia as compared to the dairy production networks (Asres et al., 2012) indicating the minimal involvement of entrepreneurs in goat production and marketing.

The present goat breeding research activities in Ethiopia mainly focused on performance evaluation and dissemination of crossbred goats, even though exotic goats accounted for an insignificant proportion of the national goat population. The Ethiopian Sheep and Goat Productivity Improvement Program (ESGPIP), which was implemented between 2007 and 2011 was the most recent initiative aiming to increase small ruminant productivity and enhancing farmer food security (Teffera, 2009). By the year 2007, the ESGPIP imported 105 Boer goats, multiplied them in two nucleus sites and distributed them to ten sites for further multiplication and dissemination of crossbred goats (Awgichew and Gipson, 2009). Apparently, this program draws limited lessons from the previous goat genetic improvement initiatives, because the distribution of crossbred goats without devising a pro-active strategy to ensure a sustainable supply of pure exotic males (for instance organizing few farmers as suppliers of pure exotic goats (Peacock et al., 2011)) appears to be the major limitation of the recent initiative. Rather than putting much effort on few exotic goat breeds, the research and development institutions could contribute to the success of the CBBPs by offering continuous technical support for the on-farm record keeping and selection procedures as well as allocating some of their resources and infrastructures for multiplication of selected local breeding goats.

Integration of village-based breeding cooperatives with an innovative market supply chain enhances benefits from the breeding programs (Herold et al., 2010). Linking the village breeding cooperatives through contractual agreements with the already existing marketing cooperatives, traders and export abattoirs will facilitate the marketing of goats produced by the breeding cooperatives and reduce exploitation by middlemen, who claim the biggest share of profits in the goat value chain (Umeta et al., 2011). Moreover, the NGOs currently engaged in supplying breeding animals to the resource-poor farmers in AAP system can be linked with the village-based breeding cooperatives to widen the supply and accessibility of breeding goats to non-cooperative members.

4.6 Conclusions

It is concluded that less emphasis was given by the national extension and research organizations to genetically improve local goat breeds, and hence smallholder goat breeding is mainly dependent on unimproved village flocks. Heterogeneities in organizational setups, famers' willingness to work as group and production systems should be considered in the design and optimization of breeding programs. The small flock size, poor institutional presence and lower prices of breeding goats in HMCL and SAAP makes establishing CBBPs less feasible, while the active institutional support for goat production and marketing as well as larger flock size with better marketing prices makes goat CBBPs more viable in AAP system. District extension officers should play major facilitation and liaison roles in the establishment and operation of the CBBPs due to their prominent position in the social network.

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5. General discussion

5.1 Optimizing contributions of goat production to household income and food security

In low input and subsistence oriented agricultural systems, goats are kept for multifaceted functions comprising tangible benefits such as source of cash income, food, manure and intangible benefits including source of saving, insurance, cultural ceremonies and prestige (Ayalew et al., 2003; Kosgey et al., 2006; Verbeek et al., 2007). Apart from the direct outputs of livestock, the economic values of intangible benefits comprise a sizable portion of the overall benefits for the smallholder farmers (Bosman et al., 1997; Ayalew et al., 2003; Kosgey et al., 2004; Moll, 2005). The need of considering such benefits in livestock genetic improvement programs under tropical conditions (Kosgey et al., 2004; Nielsen et al., 2014) were duly emphasized.

The multipurpose role of goats in the livelihoods of smallholder farmers as well as the marked differences of farmers' priorities across the diverse production systems in utilizing tangible and intangible benefits (Chapter 2) have an implication in defining breeding goals and designing sustainable breeding programs. Giving due considerations for farmers' specific needs and socio-cultural circumstances along with the prevailing ecological limitations are crucial in defining breeding goals and formulating breeding programs in the marginal regions of the tropics and sub-tropics (Valle Zárate, 1996; Sölkner et al., 1998). Virtually, too simplistic breeding objectives without analyzing the complex role of livestock in the livelihoods of smallholder farmers resulted in failure of most breeding programs (Sölkner et al., 1998; Kosgey et al., 2006; Wurzinger, et al., 2011). Analysis of the socio-economic role of goats in the diverse goat production systems (Chapter 2) as well as the differences in economic values of goat traits (Chapter 3) indicated that farmers in the diverse goat production systems value production and functional traits differently and those differences should be considered in formulating goat genetic improvement programs in the specific production system.

Previous studies indicated that pastoralists/agro-pastoralists in East Africa tend to build large goat flocks to display prestige and to reduce household vulnerability during drought periods (Barrett et al., 2004; Tadesse et al., 2014). Moreover, Kosgey et al., (2003) argued that pastoralists in Kenya delayed sales of animals by targeting constant level of commercial off-take rate in order to exploit intangible benefits of livestock. Results in section 2.3.3 have also depicted that, farmers living in the harsh environment, which was represented by the AAP system, had significantly low goat commercial off-take rate and keeping of large flock size was more beneficial in terms of overall net benefit (comprising tangible and intangible) in this system than in mixed crop livestock system. In contrast, farmers in the settled mixed crop livestock system had significantly higher goat commercial off-take rate and they tend to sell growing goats (< 1 year) more frequently than matured ones, and keeping large goat flock in this system was economically less efficient than in the agro-pastoral systems (Table 2.3, Figure. 2.3). These scenarios indicate that risk aversion and provision of food for the family are the primary purposes of goat keeping in the harsh environments of the agro-pastoral system, while generating of cash income through increased off-take rate was the major priority in the mixed crop livestock system. Likewise, marked differences in purpose of goat keeping between pastoral and agro-pastoral communities in Ethiopia were also previously reported (Berhanu et al., 2012; Hassen and Tesfaye, 2014).

In the arid and semi-arid regions of Asia and Africa, besides generation of cash income, goats contributions for the nutritional and food security of the resource-poor smallholders were widely acknowledged (Aziz, 2010; Devendra, 2012; Liang and Devendra, 2014). However, little is known on the relationship between goat production and household food security across diverse production systems and agro-ecologies. Since food security is affected by a wide range of socio-economic factors (De Cock, 2013; Megersa et al., 2014; Mango et al., 2014) effects of livestock ownership, literacy, gender of household head, family size and other socio-economic factors were also considered in the present study (Chapter 2).

Dietary diversity is a qualitative approach of assessing food consumption that reflects household access to a variety of food stuffs (FAO, 2013). As compared to measuring direct caloric intake, HDDS indicates the nutritional quality (Goshu et al., 2013; Mango et al., 2014) as well as access and economic capacity of households to consume diversified foods (Hoddinot and Yohannes, 2002; Smith and Subandoro, 2007; Mango et al., 2014). Likewise, various studies documented that HDDS is positively correlated with caloric and micronutrient intake (Kennedy et al., 2007; Goshu et al., 2013) and nutritional status of children (Moursi et al., 2008).

In contrast to other findings (De Cock, 2012; Megersa et al., 2014; Mongo et al., 2014) neither the number of livestock owned nor the goat flock size affected HDDS in the present study due to the minimal contribution of livestock products to the diets of the investigated households (Figure 2.4). Yet, gender of household heads was found to be an important determinant of HDDS. The significantly lower chance of female headed households to consume diversified diets than male headed ones (chapter 2) confirmed findings of Modirwa and Oladele (2012), De Cock et al. (2013) and Lawsen (2014) who reported high incidence of poverty and food insecurity among female headed households in the rural areas of the developing countries. Results of the present study and other overwhelming evidences showed the vulnerability of female headed households for poverty and food insecurity which requires targeted affirmative actions towards improving their socio-economic status.

Due to the prominent role of goats in the livelihoods of farmers in Abergele district, which represent the arid environments of the agro-pastoral system, the existing farmer organizations such as multipurpose cooperatives and farmer development groups were more actively engaged in goat production and marketing than farmer organizations in the other districts (Chapter 4). Moreover, the tendency of farmers in the arid-agro pastoral system to keep their goat flocks separately and the skepticism towards sharing their breeding bucks to other fellow farmers (Chapter 4) signifies the attachment of goat production to their livelihoods. As such, agricultural research institutes and NGOs were also directly involved in supplying breeding animals and restocking of household goat flocks in this production system (Chapter 4). Since the role of goats in household income and food security in the other two production systems were minimal, focus of the existing farmer organizations as well as other public and private institutions towards goat production and marketing was limited (Chapter 4). Goats played marginal role in household income and food security of farmers in the highland mixed production systems; rather, contributions of cattle were more prominent than small ruminants (Chapter 2; Mersha, 2014).

5.2 Defining breeding objectives by incorporating traits preferred by farmers and their economic valuation

Analysis of farmers' priorities in terms of utilizing tangible and intangible benefits as well as understanding food security role of goats shades some light on farmers' production objectives and functions of goats in the diverse goat production systems of Ethiopia. However, this information neither provide detailed insight on the economic values of traits nor the tradeoffs farmers were willing to make among the preferred traits. Many of the benefits of adapted indigenous livestock breeds to their owners are non-marketable and the economic values of such benefits could not be captured by the classical profit functions which are derived based on direct costs and revenues of traits (Nielsen et al., 2014). To this end, alternative methods and tools were extensively reviewed (Drucker et al., 2001; Roosen et al., 2005) and applied for economic valuation of animal genetic resources.

The most popular stated preference tools widely applied for eliciting economic values of livestock traits in developing countries were choice experiments (Sy et al. 1997; Tano et al 2003; Scarpa et al., 2003a and 2003b; Ouma et al., 2007; Nielsen and Amer, 2007; Kassie et al., 2009; Roessler et al., 2008; Ruto et al., 2008; Zander and Drucker, 2008; Zander et al., 2009; Duguma et al., 2011;

Byrne et al., 2012; Tada et al., 2013; Siddo et al., 2015), followed by ranking/rating methods (Drucker and Anderson, 2004; Mwacharo and Drucker, 2005; Wurzinger et al., 2006; Markemann et al., 2009). The advantage of using choice models over ranking/rating is the possibility of converting marginal utility values into willingness to pay (WTP) estimates if prices/costs are included as an attribute in the choice set (Hoyos, 2010). Apart from the stated preference approaches, other studies applied revealed preferences tools by employing hedonic regression to estimate implicit prices of livestock traits (Barrett et al., 2003; Kassie et al., 2011; Terfa et al., 2013). Advantages and drawbacks of the stated and revealed preference approaches have been discussed in chapter 3. Combining both approaches reduces limitations of each method and provides more compressive information which considered both hypothetical and real market situations (Chapter 3; Louviere et al., 2000).

The detailed study on estimating economic values of goat traits by combining stated and revealed preference approaches shades some light on the trait preferences of producers and market values of goat attributes. The observed differences in farmers' priorities for utilizing tangible and intangible benefits of goats (Chapter 2) were also reflected on their trait preferences. Farmers in the arid agro-pastoral system assigned higher economic values for functional traits such as disease resistance abilities (Chapter 3). They were willing to pay better prices for both breeding bucks and does with high disease resistance abilities. The reasons for assigning high utility values for disease resistance in this systems could be due to the significant role of goats in sustaining the farmers through generation of cash income and indirectly contributing to food security (Chapter 2) so that they give high value for the health and survival of the goats, in addition to their performances. Likewise, except for milk production traits, pastoralists/agro-pastoralists living in harsh environments of the arid and semi-arid regions of the tropics also valued adaptive and survival traits more than production traits (Omondi et al., 2008; Berhanu et al., 2012). This indicates the need of inclusion of survival traits such as fecal egg count (FEC) and packed cell volumes (PCV) in addition to the performance traits in formulating breeding goals in the harsh environments of the arid agro-pastoral systems. In the mixed crop livestock system, where generation of cash income through increased commercial goat off-take is the prominent farmers' priority, improving reproductive performances to increase the number of marketable goats was highly valued (Chapter 3). The high twinning rate and prolificacy of central highland goats (Netsanet, 2014) as well as the willingness of farmers in the mixed crop livestock system to pay significantly higher prices for breeding does with high twining ability and short kidding interval than farmers in the agro-pastoral systems (Chapter 3) indicates the wish to improve reproductive efficiency of central highland goats in the mixed crop livestock system. Details of the recommended trait combinations based on their economic values at each production system have been presented in Chapter 3.

The WTP information obtained from the stated preference models can be used as an alternative option to derive economic weights of non-marketable traits in formulating livestock breeding goals (Olesen et al., 2006; Biermann et al., 2016) and estimation of consumers' WTP for animal welfare (Lagerkvist and Hess, 2011). Biermann et al. (2016) employed a stated preferences approach to estimate the implicit prices of optical and sensorial meat quality traits of the endangered Bunte Bentheimer pig breed in Germany based on consumers WTP for different meat quality classes. The WTP values were then used to derive economic values and designing alternative breeding strategies to conserve the endangered pig breed (Biermann et al., 2016). Likewise, the part worth values of traits generated based on WTP for various traits in the present study (Chapter 3) are useful to prioritize traits to be included in the breeding goal definition and provide a foundation to design alternative breeding strategies that considered both marketable and non-marketable traits. In order to compose an overall breeding objective for optimized selection, heritability of the suggested traits as well as genetic and phenotypic correlations need to be considered. Methodically, the question of combination of traits with tangible and intangible economic benefits in an optimized selection index and the practical application of such schemes in low-input agricultural systems is left open for further investigations.

5.3 Organization of smallholder goat breeding

Analyzing the multipurpose functions of goats in diverse production systems as well as understanding the goat trait preferences of producers and market actors provide an input to design optimized CBBPs; however, breeding programs in low input agricultural systems could hardly be successful without taking into consideration the organizational aspects in addition to the technical issues (Valle Zárate and Markemann, 2010; Herold et al., 2012a and 2012b; Roessler et al., 2012). Lack of stable breeding organizations and local support services as well as unforeseen changes in government policies hampered the successful implementation and progress of CBBPs in developing countries (Peacock et al., 2011; Mueller et al., 2015).

Farmer organizations such as multipurpose cooperatives, farmer development groups, farmer networks and informal associations linked with goat production and marketing were identified in the investigated districts (Chapter 4). Public, private and civil societies were also among the actors of goat production and marketing networks. The public actors played a central role in the social network structure of goat production and marketing, while private actors were at the periphery of the network. Moreover, the weak link observed between the private and the pubic actors (Chapter 4) attests to the findings of Spielman et al. (2011) and Asres et al. (2012) who reported that involvements of the private sector in the agricultural innovation system in Ethiopia were marginal.

The Ethiopian government promoted cooperatives as an engine to commercialize the subsistence oriented agriculture and to reduce poverty among the resource poor smallholder farmers (Abebaw and Haile, 2013). To this end, the Federal Cooperative Commission (FCC) was established in 2002, among others, the commission envisaged to enhance agricultural commercialization by establishing at least one multipurpose cooperative at each *kebele* (the smallest administrative unit) by the year

2010 (FCA, 2005). In 2014, a total of 54,000 cooperatives were legally registered in Ethiopia with approximately 8.3 million members (Tesfamariam, 2015). The agricultural cooperatives in Ethiopia were mainly involved in marketing of agricultural inputs such as seeds, fertilizers and pesticides as well as outputs including coffee, cereals and oilseeds, dairy and honey products (Emana, 2009). Cooperatives specifically organized for goat production and marketing were not observed so far, however, the multipurpose cooperatives collected and supplied goats for export abattoirs (Chapter 4).

The studies conducted so far on the impact of cooperative membership in Ethiopia not only presented evidences of positive effects but also pointed out shortcomings. The positive impacts of agricultural cooperative membership on farmers income and saving (Bernard et al., 2008; Getnet and Anullo, 2012; Chagwiza et al., 2016), technology innovation and adoption (Abebaw and Haile, 2013; Chagwiza et al., 2016), better bargaining power and lower price risk (World Bank, 2003; Bernard et al., 2008) have been widely reported. Yet, only 9% of all smallholders are members of cooperatives in Ethiopia and even when cooperatives were accessible, merely 17% of the households were members (Bernards and Spielmann, 2009). The same authors also argued that the poorest of the poor farmers had less chance to be member of such organizations and decision making processes tend to exclude them. Even though cooperatives improved income of members, there was not enough evidence to attest their impact on agricultural commercialization (Bernard et al., 2008). Suspicion of corruption among leaders of cooperatives, reduced motivation for membership due to low profitability and small dividends were also reported in the present study (Chapter 4).

Organizing farmers into cooperatives or any other form of associations may contribute to the sustainability of CBBPs through facilitating record keeping, marketing of breeding animals and improving access to basic services (Hiale et al., 2011; Peacock et al., 2011). For instance, Meru

Goat Breeders Association in Kenya helped to manage breeding programs by organizing marketing of breeding animals and building capacity of its members through provision of technical advices (Peacock et al., 2005). The Boran cattle breeders' society in Kenya organized the genetic improvement of Boran cattle through maintaining standards and soliciting potential markets for the breed (Rewe et al., 2008). In Vietnam, Huyen et al., (2016) showed the potential benefits of organizing smallholder local Ban pig producers into marketing cooperatives that targeted niche markets of the nearby big cities. Since smallholder goat breeding in Ethiopia generally depends on un-improved village goat flocks with a minimal support from the public and private institutions (Chapter 4) the need of establishing village-based breeding cooperatives that produce and market selected breeding goats is sensible. The differences in terms of institutional support and market opportunities among production systems shade some light on the enabling environment for implementing goat CBBPs (Chapter 4). In the AAP system where cooperatives are more engaged in goat marketing activities and institutional support for goat breeding is available (Chapter 4) implementing CBBPs is promising. While, small flock size per household coupled with poor institutional presence in HMCL and SAAP systems (Chapter 4) makes establishing goat CBBPs less promising. The existing marketing opportunities in the diverse production systems need to be investigated more thoroughly by distinguishing between different categories of goats such as breeding animals, young animals before fattening and slaughtering.

The application of social network analysis (SNA) tools to visualize social structures in the present study augmented the theoretical based definition of breeding organization that described breeding organization as part of a system which is affected by institutions and other organizational elements at different levels (Herold et al., 2012a; Roessler et al., 2012). The SNA enabled to identify well connected and prominent actors in the social structures of goat production and marketing.

5.4 Methodological discussion

In order to optimize the economic and food security role of goat production, the present study analyzed factors affecting economic success of goat keeping by taking into consideration tangible benefits such as cash income, consuming goat products, benefits of using manure, and intangible benefits including insurance and financial functions of goats. The data was generated by using a questionnaire survey based on retrospectively recalled information. Such data could be considered as imprecise as compared to data collected on a continuous basis; nonetheless, economic success and efficiency of goat production reported in the current study are comparable with other findings from the tropical environments (e.g. Legesse et al., 2010) indicating the reliability of the findings. Beegle et al. (2012) also showed that quality of previous season agricultural data generated retrospectively did not suffer significantly from recall biases.

In the present study, interest rate of microfinance was considered for estimating financial benefits of goats. However, Kosgey et al. (2004) argued that formal financial institutions may not be attractive to farmers living in remote areas due to transportation and other additional costs. If those costs were considered, the financial benefits from goat keeping will be higher than the current estimates. Furthermore, insurance factors between 0.05, and 0.1 were used based on guesstimates criteria which considered climatic condition as suggested by Moll (2005). Other studies considered insurance premium rates of formal institutions (Al Baqain and Valle Zárate, 2011; AI-Khaza’leh et al., 2015) while in highlands of Ethiopia, Ayalew et al. (2000) estimated the insurance benefits of goats based on pay-outs of informal insurance groups. The subjective estimation of the insurance and finance functions due to absence of real markets for such services could be considered as limitation of the present study.

In the present study, the explanatory power of the conditional logit (CL) models was good with pseudo-R^2 ranging from 0.35 to 0.46 for bucks and 0.41 to 0.48 for does (Chapter 3). A model fit with pseudo R^2 value of 0.2 could be considered as acceptable (Hoyos, 2010), while above 0.3 is a decent model fit for choice experiments (Hensher et al., 2005). Even though, conditional logit model is a popular discreet choice model (McFadden, 1974) it is not without its own inherent limitations. CL imposes the precondition that the error component is independently and identically distributed (IDD) (Hensher et al., 2005); but, this assumption is restrictive and does not allow correlations between error components of different alternatives as compared to nested and mixed logit models (Hensher et al., 2005). The coefficient estimates of the CL model exhibited the expected signs except for medium body size and moderate disease resistance traits. This might be due to difficulties of some farmers to distinctively differentiate between the different trait levels from the drawing illustrations. Such observations were also reported elsewhere (Roessler et al., 2008; Kassie et al., 2009). Reducing number of traits and trait levels as well as using real photograph illustrations instead of drawings could have improved farmers' abilities to clearly distinguish between the trait levels.

Besides the questionnaire survey, group discussions with farmers were conducted to understand local breeding organizations, identify formal and informal farmer groups and willingness of farmers to work as a cooperative breeding unit. The group discussion enabled to obtain detailed information on the prevailing differences between production systems in terms of organizational setups and farmers' ideas and attitudes towards working as cooperative units. During the group discussions, few participants who occupied higher status within the community tended to dominate the discussion, although considerable efforts were made to make the discussion participatory. Since most farmer organizations were government driven and linked with political issues, discussion participants were cautious in publicly uttering the weaknesses of such organizations. The data generated through the group discussions were cross-checked against information generated from key informant interviews to improve its reliability.

5.5 General conclusion

The present study indicated that economic and food security role of goats as well as trait preferences of goat keepers are heterogeneous and production system specific. The higher in-kind and intangible benefits of goats in AAP system coupled with high economic values attached to adaptive traits indicates the need of inclusion of disease resistance traits such as fecal egg count (FEC) in addition to the performance traits in formulating breeding goals in the harsh arid environments. In the mixed crop-livestock system, where generation of cash income through increased commercial goat off-take is the prominent farmers' priority and twinning abilities of goats were highly valued, improving reproductive performances to increase the number of marketable goats should be targeted. The suggested alternative trait combinations and their economic values could be used as an input for optimization of the breeding schemes after considering heritability, genetic and phenotypic correlations.

The marked differences in enabling environment for smallholder goat breeding between production systems underlined the need of giving due attention to organizational aspects of breeding in addition to technical aspects. The insignificant economic role of goats and poor institutional presence and lack of controlled breeding practices in HMCL and SAAP systems makes establishing goat CBBPs less feasible, while the substantial contribution of goats for household income and their indirect role for household food security coupled with active institutional support for goat breeding in the AAP system makes goat CBBPs more promising. District extension officers should play major facilitation and liaison roles in the establishment and operation of the CBBPs due to their prominent position in the social network.

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6. General summary

Goats are vital sources of meat, milk, manure, income and social security for poor smallholder farmers living in harsh and dry environments. Over the last decade, goat population in Ethiopia increased more rapidly than sheep and cattle population. Despite the current boom of goat population, contribution of goats for national meat and meat production as well as for export earnings is minimal. Moreover, the carcass yield of local goats remained below the East African and the world average over the last decade. Slow growth rates of goats, high mortality rate and low commercial off-take rate were the major challenges of smallholder goat production in Ethiopia. In order to overcome some of the these constraints, designing a sustainable community-based breeding program (CBBP) which considers local breeds, farmers' trait preferences and local breeding organizations is a promising entry point.

Understanding the multifaceted functions of goats across diverse production systems and identifying breeding objective traits and their relative economic importance are crucial for designing and implementing CBBPs. So far, choice experiments (CE) were employed as one option to identify breeding objective traits and elicit their economic values, but limited information is currently available in providing a comprehensive understanding of trait preferences from producers and market perspectives. Furthermore, sustainable genetic improvement programs not only focus on the technical feasibilities, but also analyze the organizational aspects of the breeding scheme under specified framework conditions.

The overall objective of the study is to contribute for designing optimized goat community-based breeding programs that consider the multiple functions of goats, producers' trait preferences, market demands and organizational frameworks by taking into consideration of the diverse goat production systems. The specific objectives are (i) to analyze factors affecting contributions of goat farming to household economic success and household dietary diversity in three goat production systems, (ii) to investigate goat breeding objectives and economic values of traits based on revealed and stated preferences and (iii) to identify major stakeholders, organizational networks and other elements of organization and their influence on the establishment and successful operation of community-based goat breeding.

The study was conducted in Abergele, Konso and Meta Robi districts of Ethiopia representing arid agro-pastoral (AAP), semi-arid agro-pastoral (SAAP) and highland mixed crop-livestock (HMCL) systems, respectively. Household interviews using semi-structured questionnaires were conducted involving 180 households. The survey focused on income and costs of the major household agricultural enterprises as well as dietary diversity of households. Gross margin (GM) and net benefit (considering tangible and intangible benefits) were used as indicators of economic success of goat keeping. Linear mixed model (SAS version 9.3) was employed to analyze factors affecting economic success of goat keeping and ordinal regression was used to predict effects of socio-economic variables on households' dietary diversity. A choice experiment (CE) involving 360 farmers was conducted to identify farmers' trait preferences across diverse goat production systems. Besides, in order to understand buyers' revealed preferences (RP) for goat traits, market data of 796 goat transactions were collected. Relationships between goats' attributes and prices were estimated by hedonic modeling, while economic values of traits included in the CE were estimated by conditional logit (CL) model. Part worth value of a trait which indicates the relative importance of a trait was calculated based on the implicit prices farmers were willing to pay (WTP) for an improvement of a trait. NLOGIT 4.0 econometric software was used for analyzing the CE and RP data. The organization of smallholder goat breeding from village to national level were investigated through six focus group discussions with 68 goat keepers, key informant interviews with personnel of ten public and seven private institutions and social network analysis (SNA) of goat production and marketing structures. Descriptive statistics were used to analyze data generated from key informant interviews. Social Network Visualizer (SocNetV) was employed to visualize the social network structures.

Goat keepers living in the harsh environment, which was represented by the AAP system, had significantly lower goat commercial off-take than those in SAAP and HMCL systems. Interaction between flock size and production system significantly ($P<0.001$) affected the net benefits from goat keeping. The increment of net benefit by keeping larger flocks was higher in AAP system, due to higher in-kind and intangible benefits of goats in this system. In contrast, farmers in the HMCL system had highest goat commercial off-take rate and they tend to sell growing goats (< 1 year) more frequently than matured ones. Effect of goat flock size as a predictor of household dietary diversity was not significant in any of the investigated production systems. Nevertheless, a significant positive correlation was observed between income from goats and dietary diversity in AAP system, indicating the indirect role of goat production for food security.

Results of the revealed and stated preference studies showed that farmers derive high utility from large body size breeding goats in all production systems and buyers consistently paid high price for goats with higher body weight. In the AAP system, high economic values were assigned to adaptive traits such as disease resistance for both bucks and does. Goat breeders in this system were willing to pay nearly three times more than those in the SAAP and HMCL systems for breeding bucks with high disease resistance ability, while this trait was not considered as a determining factor for selecting breeding does in the HMCL system. Goat producers in the HMCL system were willing to pay more than farmers in the AAP and SAAP systems for a doe with twinning ability.

Results of the breeding organizational analysis showed that own and village flocks were the major sources of breeding goats in all districts. In AAP system, however, NGOs and research centers also supplied breeding goats to farmers. The identified famers' organizations linked to goat production and marketing includes multipurpose cooperatives, farmer development groups and farmer networks. The multipurpose cooperatives in the AAP system were engaged in more marketing activities than those in the SAAP and HMCL systems. Key stakeholders such as research institutes and NGOs were absent in HMCL system. The SNA indicated that district extension officers had the highest values of degree and closeness centrality indicating their trustful relationship with goat keepers and best accessibility.

The higher in-kind and intangible benefits of goats in AAP system coupled with high economic values attached to adaptive traits indicates the need of inclusion of survival traits in addition to the performance traits in formulating breeding goals in the harsh arid environments. In the mixed crop-livestock system, where generation of cash income through increased commercial goat off-take is the prominent farmers' priority and twinning abilities of goats were highly valued, improving reproductive performances to increase the number of marketable goats should be targeted. However, poor institutional presence and insignificant economic role of goats in HMCL and SAAP systems makes establishing goat CBBPs less feasible, while the active institutional support and better marketing opportunities in the AAP system makes goat CBBPs more promising. District extension officers should play major facilitation and liaison roles in the establishment and operation of the CBBPs due to their prominent position in the social network.

7. Zusammenfassung

Ziegen sind für arme Kleinbauern in rauen und trockenen Regionen wesentliche Quellen für Fleisch, Milch, Dünger, Einkommen und soziale Sicherheit. Die Zahl der Ziegen in Äthiopien stieg im letzten Jahrzehnt deutlich schneller an als die Zahl der Schafe und Rinder. Trotz des derzeitig starken Anstiegs, ist der Beitrag der Ziegen zur nationalen Fleischproduktion sowie zu den Exporteinnahmen gering. Zusätzlich blieb die Schlachtausbeute der lokalen Ziegen im letzten Jahrzehnt unter dem ostafrikanischen und dem Weltdurchschnitt. Langsame Wachstumsraten der Ziegen, hohe Sterblichkeitsraten und geringe Verkaufsraten zählen zu den größten Herausforderungen für die kleinbäuerliche Ziegenhaltung in Äthiopien. Ein vielversprechender Ansatz, um einige dieser Einschränkungen zu überwinden, ist die Gestaltung eines nachhaltigen, dörflichen Zuchtprogramms (CBBP), das sowohl lokale Rassen als auch Merkmalspräferenzen der Landwirte und regionale Zuchtorganisationen berücksichtigt.

Unverzichtbar für die Gestaltung und Umsetzung der CBBPs ist einerseits das Verständnis der vielfältigen Funktionen der Ziegen über die verschiedene Produktionssysteme hinweg und die Identifizierung der Zuchtzielmerkmale und deren relative ökonomische Bedeutung andererseits. Zur Bestimmung der Zuchtzielmerkmale und der Feststellung des jeweiligen ökonomischen Wertes wurden bislang Choice Experiments (CE) eingesetzt. Derzeit sind jedoch nur begrenzt Informationen, die ein umfassendes Verständnis der Merkmalspräferenzen aus Sicht der Produzenten und des Marktes bieten, verfügbar. Nachhaltige Programme für eine genetische Verbesserung fokussieren zusätzlich nicht nur auf die technische Umsetzbarkeit, sondern analysieren auch die organisatorischen Aspekte des Züchtungsschemas unter bestimmten Rahmenbedingungen.

Das übergeordnete Ziel dieser Studie ist es, zur Gestaltung eines optimierten dörflichen Ziegenzuchtprogramms, welches die vielfältigen Funktionen der Ziegen, die Merkmalspräferenzen der Produzenten, die Marktanforderungen, die organisatorischen Rahmenbedingungen und die vielfältigen Ziegenproduktionssysteme berücksichtigt, beizutragen. Die spezifischen Ziele sind (i) die Bestimmung der Faktoren, die den Beitrag der Ziegenhaltung zum ökonomischen Erfolg und der Nahrungsmittelvielfalt des Haushaltes in drei Ziegenproduktionssystem beeinflussen, (ii) die Evaluierung der Ziegenzuchtziele und der ökonomischen Werte der Merkmale, basierend auf offenbarten und angegebenen Präferenzen und (iii) die Bestimmung der wichtigsten Interessensvertreter, organisatorischen Netzwerke und weiteren Organisationselementen und deren Einfluss auf die Einrichtung und das erfolgreiche Betreiben einer dörflichen Ziegenzüchtung.

Die Studie wurde in den Bezirken Abergele, Konso und Meta Robi in Äthiopien durchgeführt. Diese repräsentieren aride agro-pastorale (AAP), semi-aride agro-pastorale (SAAP) und gemischte Ackerbau-Viehhaltungs-Systeme des Hochlands (HMCL). Die Interviews umfassten 180 Haushalte, die mittels teilstrukturierter Fragebögen durchgeführt wurden. Die Befragung zielte auf das Einkommen und die Kosten der bedeutendsten landwirtschaftlichen Aktivitäten sowie die Ernährungsvielfalt der Haushalte ab. Bruttogewinn (GM) und Nettogewinn (unter Berücksichtigung materieller und immaterieller Vorteile) wurden als Indikatoren für den ökonomischen Erfolg der Ziegenhaltung verwendet. Zur Analyse der Faktoren, die den ökonomischen Erfolg der Ziegenhaltung beeinflussen, wurde ein lineares gemischtes Modell verwendet. Eine ordinale Regression wurde zur Prognose der Effekte der sozioökonomischen Variablen auf die Ernährungsvielfalt der Haushalte benutzt. Mittels eines Choice Experiments, das 360 Ziegenhalter umfasste, wurden deren Merkmalspräferenzen über die verschiedenen

Ziegenproduktionssysteme hinweg bestimmt. Um die offenbarten Präferenzen (RP) der Käufer für Ziegenmerkmale zu verstehen, wurden außerdem Marktdaten von 796 Ziegenverkäufen erfasst. Zusammenhänge zwischen Eigenschaften und Preise der Ziegen wurden durch hedonische Modellierungen bewertet, während ökonomische Werte der Merkmale inklusive des CE durch ein Conditional Logit (CL) Modell beurteilt wurden. Der Teilnutzwert eines Merkmals gibt die relative Wichtigkeit eines Merkmals an. Er wurde basierend auf den impliziten Preisen, die Landwirte für eine Verbesserung des Merkmals bereit waren zu bezahlen (WTP) berechnet. Die Ökonometrie-Software NLOGIT 4.0 wurde zur Analyse der CE und RP Daten verwendet. Die Organisation kleinbäuerlicher Ziegenzucht von dörflicher bis zu nationaler Ebene wurde auf Basis von sechs Fokusgruppen-Diskussionen mit 68 Ziegenhaltern, Befragungen wichtiger Akteure (aus zehn öffentlichen und sieben privaten Instituten) und der sozialen Netzwerkeanalyse (SNA) der Ziegenhaltung und Marketingstrukturen ermittelt. Die Daten aus den Befragungen wichtiger Akteure wurden mittels deskriptiver Statistik analysiert. Social Network Visualizer (SocNetV) wurde zur Visualisierung der sozialen Netzwerkstrukturen verwendet.

Ziegenhalter die in einer rauen Region leben, repräsentiert durch das AAP System, hatten signifikant geringere Ziegenverkäufe als diejenigen in SAAP und HMCL Systemen. Die Wechselwirkung zwischen Herdengröße und Produktionssystem beeinflusste signifikant ($P<0.001$) den Nettogewinn der Ziegenhaltung. Die Steigerung des Nettogewinns durch die Haltung größerer Herden war im AAP System, aufgrund größerer materieller und immaterieller Vorteile der Ziegen in diesem System, höher. Im Gegensatz dazu hatten Ziegenhalter im HMCL System höhere Ziegenverkaufsraten und tendierten dazu Zicklein (< 1 Jahr) eher zu verkaufen als ausgewachsene Ziegen. Der Effekt der Herdengröße als Einflusswert für die Ernährungsvielfalt des Haushaltes war in keinem der untersuchten Produktionssystemen signifikant. Dennoch wurde eine signifikante, positive Korrelation zwischen dem Einkommen aus der Ziegenhaltung und der Ernährungsvielfalt in AAP Systemen festgestellt, die auf eine indirekte Rolle der Ziegenhaltung für die Ernährungssicherheit hinweist.

Ergebnisse der offenbarten und angegebenen Präferenzstudien zeigten, dass Ziegenhalter in allen Produktionssystemen großen Nutzen von großen Körpergrößen der Ziegen ableiten und Käufer einheitlich höhere Preise für Ziegen mit höherem Körpergewicht bezahlten. Im AAP System wurden hohe ökonomische Werte für Anpassungsmerkmale wie Krankheitsresistenz sowohl für Böcke als auch für Zicken bestimmt. Ziegenzüchter in diesem System waren bereit, für Böcke mit hohem Krankheitsresistenzvermögen nahezu dreimal so viel zu bezahlen wie Züchter in SAAP und HMCL Systemen. Dieses Merkmal wurde jedoch in der Selektion von weiblichen Zuchtziegen im HMCL System nicht als maßgeblicher Faktor betrachtet. Ziegenhalter im HMCL System waren bereit für Zicken mit hoher Zwillingsrate mehr zu bezahlen als Ziegenhalter in den AAP und SAAP Systemen.

Ergebnisse der Zuchtorganisationsanalyse zeigten, dass eigene und dörfliche Herden die Hauptquellen für die Ziegenzüchtung in allen Regionen sind. Im AAP System haben jedoch auch NGOs und Forschungszentren Zuchtziegen für die Ziegenhalter gestellt. Die ermittelten bäuerlichen Organisationen, die mit Ziegenhaltung und Marketing verknüpft sind, beinhalteten auch multifunktionale Genossenschaften sowie bäuerliche Entwicklungsgruppen und Netzwerke. Die multifunktionalen Genossenschaften im AAP System waren in mehr Marketingaktivitäten eingebunden als in den SAAP und HMCL Systemen. Wichtige Akteure wie Forschungsinstitute und NGOs fehlten im HMCL System. Die SNA zeigte, dass die Beratungsbeamten der Gebiete die höchsten Werte für Grad und Verbundenheit der Zentralität haben, was auf deren vertrauensvolle Beziehung mit den Ziegenhaltern und die beste Erreichbarkeit hindeuten.

Die höheren materiellen und immateriellen Vorteile der Ziegen im AAP System verbunden mit höheren ökonomischen Werten, aufgrund der höheren Bewertung der Anpassungsmerkmale, weisen auf die Notwendigkeit der Einbeziehung von Überlebensmerkmalen zusätzlich zu den Leistungsmerkmalen hin für die Formulierung der Zuchtziele in rauen, trockenen Regionen. In den gemischten Pflanzenbau-Viehhaltungs-Systemen ist die Erzeugung von Bareinnahmen durch erhöhte Ziegenverkaufsraten die herausragende Priorität der Ziegenhalter und die Zwillingsrate der Ziegen hat einen hohen Stellenwert. In diesem System sollte die Verbesserung der Fortpflanzungsfähigkeit und die Steigerung der Anzahl der vermarktungsfähigen Ziegen anvisiert werden. Jedoch erschweren die geringe institutionelle Präsenz und die unwesentliche ökonomische Rolle der Ziegen in HMCL und SAAP Systemen die Umsetzung des CBBP wohingegen die aktive institutionelle Unterstützung und die besseren Vermarktungsmöglichkeiten in den AAP Systemen ein Ziegen CBBP vielversprechender macht. Vor allem Beratungsbeamte der Bezirke sollten aufgrund ihrer herausragenden Rolle in den sozialen Netzwerken eine Rolle als Wegbereiter und Verbindungsperson bei der Gründung und im Betreiben der CBBPs übernehmen.

CURRICULUM VITAE

PERSONAL INFORMATION

Name	Tatek Woldu Belete
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Language Skill	Amharic, Afaan-Oromo, English and Limited German
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UNIVERSITY EDUCATION

September, 2012 to July, 2016	Ph.D. candidate in Agricultural Sciences, under structured “Global Food Security” program of the University of Hohenheim, Germany. Dissertation: Optimizing community-based breeding for indigenous goat breeds in Ethiopia
September 2007–July 2010	M.Sc. in Animal and Range Sciences, Hawassa University, Ethiopia. M.Sc. thesis: Analysis of Artificial Insemination (AI) delivery systems in Adami Tulu district, Ethiopia.
September 1997–July 2000	B.Sc. in Animal Science, Alemaya University, Ethiopia.

PROFESSIONAL EXPERIENCE

September, 2010 – August 2012	Lecturer at Jimma University College of Agriculture and Veterinary Medicine, Ethiopia.
January, 2001– August 2010	Researcher at Oromia Agricultural Research Institute, Adami Tullu Agricultural Research Center, Ethiopia.

Specific jobs undertaken include:

- Offering animal breeding, dairy production and forage production courses to undergraduate students at Jimma University, Ethiopia.
- Worked as professional advisor during establishment of "Kito Furdisa Dairy Farm" at Jimma University, Ethiopia.
- Developing and executing research projects and publishing the outputs in peer reviewed journals and conference proceedings.
- Coordinating workshops, trainings and field day events at Adami Tulu Agricultural Research Center, Ethiopia.

AWARDS AND SCHOLARSHIPS

- Ph.D. fellowship award by Food Security Center (FSC), University of Hohenheim.
- JICA-FRG project scholarship for M.Sc. students in Ethiopia.

PUBLICATIONS

Publications on Peer reviewed journals

T. Woldu, A. Markemann, C. Reiber, P.C. Muth and Anne Valle Zárate. 2016. Optimizing contributions of goat farming to household economic success and food security in three production systems in Ethiopia. *Journal of Agriculture and Rural Development in the Tropics and Subtropics, 117: 73–85.*

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PROFESSIONAL TRAINING

- Leadership development, ZEF-FSC, workshop, Bonn, Germany (15–20 June, 2014)
- Working with political contexts, ZEF-FSC, workshop, Berlin Germany (12–17 January, 2013)
- Intercultural seminar, ZEF-FSC, workshop, Bonn, Germany (7–9 December, 2013)
- Molecular characterization of small ruminant genetic resources, ILRI, Addis Ababa, Ethiopia (16–21 September, 2013)
- Research project preparation and consultancy services vending, DeMar Ethio-Africa PLC Addis Ababa Ethiopia (11–15 April, 2011).
- International training in dairy technology, Ghent University, Belgium (01 August–31 October, 2006)

OTHER SKILLS

- Competent in SAS, SPSS and NLOGIT statistical packages and basic knowledge of ZPLAN+ software.

REFERENCES

- Prof. Dr. Anne Valle Zárate. Animal Breeding and Husbandry in the Tropics and Subtropics (490h), University of Hohenheim. Garben Str. 17, 70593, Stuttgart. Email: Anne.Valle.Zarate@uni-hohenheim.de . Tell. 0711 45924210
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