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Optimising contributions of goat farming to household economic success and food security in three production systems in Ethiopia

Tatek Woldu [a,b,*], André Markemann [a], Christoph Reiber [a], Philipp C. Muth [a], Anne Valle Zárate [a]

[a] *University of Hohenheim, Institute of Agricultural Sciences in the Tropics (Hans-Ruthenberg-Institute), Department of Animal Breeding and Husbandry in the Tropics and Subtropics, Stuttgart, Germany*

[b] *Jimma University College of Agriculture and Veterinary Medicine, Jimma, Ethiopia*

Abstract

The study aims to analyse 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 utilising 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

1 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).

* Corresponding author
University of Hohenheim, Department of Animal Breeding and Husbandry in the Tropics and Subtropics, Institute of Agricultural Sciences in the Tropics (Hans-Ruthenberg-Institute), Garbenstr. 17, 70599 Stuttgart, Germany
Email: tatekwbelete@yahoo.com; Phone: +4917635963643

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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 underutilisation 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 (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 optimised 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 Kebede, 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 analyse 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 Materials and methods

2.1 *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 characterised 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 characterised 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).

2.2 *Sampling and data collection*

The study is part of an ongoing goat CBBP (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 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.

2.4 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 Fernández-Rivera *et al.* (1995) cited by Ayalew Kebede (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 Kebede (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 × 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):

$$I_i = \alpha\,(P_i + P_i^*)/2 \tag{2}$$

Where Ii 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 labour 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 labour 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 (in ETB household^{-1} year^{-1}):

$$GM = CR - VC \tag{3}$$

$$NB1 = (CR + BC + BM) - VC \tag{4}$$

$$NB2 = (CR + BC + BM + F + I) - VC \tag{5}$$

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. All the economic parameters are given in ETB (Ethiopian birr) whereby 1 USD ≈ 19 ETB in 2012.

2.5 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 analyse 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:

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

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 summarised 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.

$$\begin{aligned} y^*_{ij} = \; & \beta_0 + \beta_1 x_{1ij} + \beta_2 x_{2ij} + \beta_3 x_{3ij} + \\ & \beta_4 x_{4ij} + \beta_5 x_{5ij} + \beta_6 x_{6ij} + \beta_7 x_{7ij} \end{aligned} \quad (8)$$

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).

3 Results

3.1 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

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

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.

3.2 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 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.

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.

The goat marketing strategies of farmers differed across production systems (Figure 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.

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.

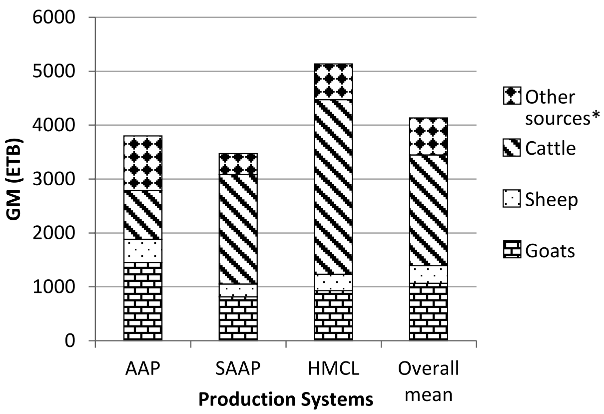

Fig. 1: *Contribution of livestock to the household gross margin (GM) in arid agro-pastoral (AAP), semi-arid agro-pastoral (SAAP) and highland mixed crop-livestock (HMCL) systems of Ethiopia. ETB= Ethiopian birr, 1 USD ≈ 19 ETB in 2012. Other sources include income from sale of poultry and honey bee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

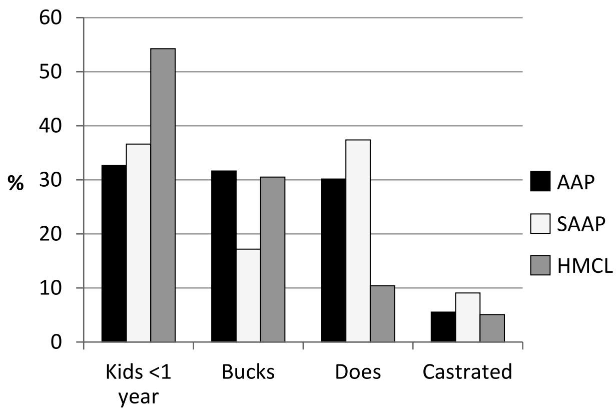

Fig. 2: *Proportion of goat types sold within one year in arid agro-pastoral (AAP), semi-arid agro-pastoral (SAAP) and highland mixed crop livestock (HMCL) systems in Ethiopia.*

Table 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.

Table 2: *Variable costs and economic efficiency of goat rearing in three production socio 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 labour 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.

3.3 *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 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 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 3).

3.4 *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 pro-

Table 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.

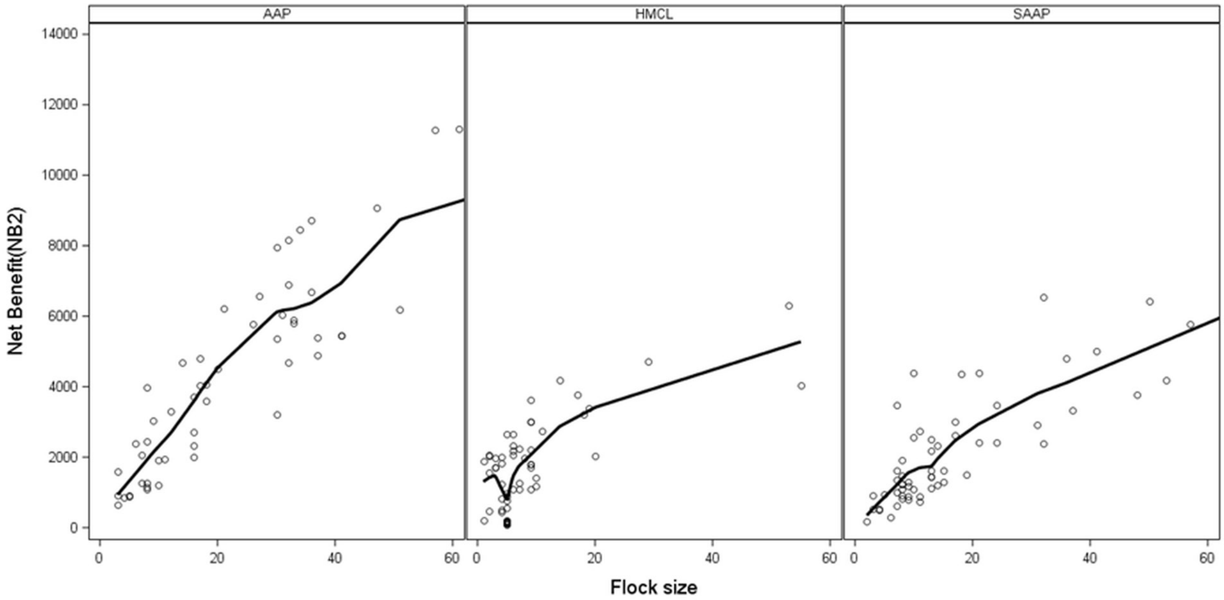

Fig. 3: *Trends in net benefits (including in-kind and intangible benefits of goats, NB2) with increasing flock sizes in arid agro-pastoral (AAP), semi-arid agro-pastoral (SAAP) and highland mixed crop-livestock (HMCL) systems of Ethiopia.*

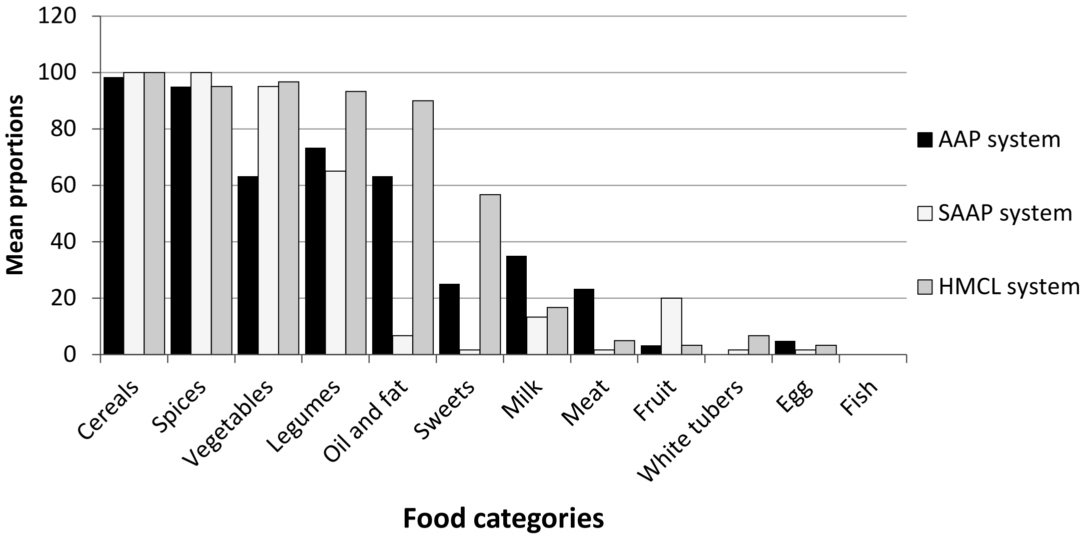

Fig. 4: *Proportion of food categories consumed by household members in arid agro-pastoral (AAP), semi-arid agro-pastoral (SAAP) and highland mixed crop-livestock (HMCL) systems of Ethiopia.*

duction 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.

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 4). Households in the HMCL system had a six times higher chance of being in the upper DDS terciles as compared to the

Table 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 (Jahnke, 1982).

Table 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.

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 5), while correlations were either not significant (P>0.05), or negative in the SAAP and HMCL systems, respectively.

4 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 utilisation 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 optimised 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; Netsanet, 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 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 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 point 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 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 labour is severely affected.

5 Conclusions

The farmers' strategies to utilise 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 utilising 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 optimise 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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