International Scholars Journals

International Journal of Agricultural Economics and Extension ISSN 2329-9797 Vol. 5 (3), pp. 277-283, March, 2017. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Determinants of small ruminant keepers' input use and marketing practices and small ruminant productivity under six small ruminant production systems in Ethiopia

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Accepted 15 March, 2017

Information on variations in producers' input use and marketing strategies as well as in the level of small ruminant productivity across farming systems is essential for better targeting agricultural research and development interventions. The purpose of the current study was to identify important determinants of small ruminant productivity and farmers' decisions on input use and marketing across the six small ruminant systems identified in the mixed crop-livestock system in Ethiopia. The study was based on analysis of data collected on 2621 small ruminant keepers from four regional states, fitting a generalized regression model to the data. The results showed that there are variations among the identified six systems in the level of small ruminant productivity and producers' input use and marketing strategies. Households' socioeconomic characteristics such as gender and literacy status and scale of production (e.g. flock size and land holding) were found to determine input use and marketing behaviors of producers. Productivity was found to be determined by availability and use of external inputs and land holding. The impacts of the various determinants varied across production systems. This calls for system-specific targeting approach for small ruminant development as well as a value chain approach addressing constraints at critical leverage points across the small ruminant value chain and targeting appropriate value chain actors (gender, literacy, etc.) for introducing technological interventions.

Keywords: Small ruminant, production system, household characteristics, productivity, input use, marketing.

INTRODUCTION

Classifications of livestock production systems commonly consider the degree of intensification, as measured by market orientation and intensity of factor use, and in terms of importance within the household economy, as measured by contribution to household income, size and value of livestock holdings (McDermott et al., 1999). Such anapproach for description of farming systems implies that there are variations in input use and marketing strategies among topologies of farming systems. Gross categorization of livestock keepers may obscure intrinsic variations among livestock keepers and could lead to blanket recommendation of livestock interventions resulting in low adoption rate of interventions by the intended users. Thus information on such variations is essential for better targeting agricultural research and development interventions. It has been found that household socioeconomic and farm characteristics as well as geographic locations determine

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Table 1. Explanatory and dependent variables used in to identify determinants of input use, productivity and marketing practices of smallholder farmers in Ethiopia.

Explanatory/dependent	Category/Variable	Unit
	Input use	
Explanatory/Dependent	Purchased inputs used for small ruminant production	%
Explanatory/Dependent	Purchased inputs used for small ruminant fattening	%
Explanatory/Dependent	Concentrate supplement	kg/day/animal
Explanatory/Dependent	Crop residue supplement	kg/day/animal
Explanatory variables	Availability of hay in PA	categorical
Explanatory variables	Availability of purchased concentrate in PA	categorical
Explanatory variables	Distance to nearest veterinary service	minute
Explanatory variables	Distance to nearest water source in dry season	minute
	Productivity	
Dependent	Annual reproduction rate (number born per female joined)	%
Dependent	Lamb/kid Mortality rate	%
	Household head characteristics	
Explanatory variables	Gender (male or female)	Categorical
Explanatory variables	Primary occupation (livestock keeping or other)	Categorical
Explanatory variables	Literacy (read/write or not)	Categorical
Explanatory variables	Household size	Number
Explanatory variables	Household head age	number
	Farm characteristics	
Explanatory variables	Ratio of private grazing to total land	ratio
Explanatory variables	Stocking rate (number of small ruminants per ha)	number
Explanatory variables	Household land holding	ha
Explanatory variables	Small ruminant flock size	number
	Marketing practices	
Dependent	Offtake rate	%
Dependent	Proportion of young animals sold	%
Dependent	Proportion of adult animals sold	%

use and demand for inputs (Diego et al., 2015; Moti et al., 2015; Samuel, 2015ab).

Small ruminant production systems in Ethiopia has been classified broadly as mixed-crop livestock system and pastoral system. Classification of small ruminant production systems in the highlands of Ethiopia (unpublished data) shows that there are variations among the six identified small ruminant systems in the level of input use, small ruminant productivity and marketing strategies. Targeting agricultural research and development interventions requires understanding of the determinants of livestock productivity and producers' input use and marketing strategies. Determinants also need to be identified within livestock systems. The purpose of the current study was to identify important determinants of small ruminant productivity and farmers' decisions on input use and marketing across the six small ruminant systems identified in the highlands of Ethiopia.

MATERIAL AND METHOD

Description of data

This study was based on analysis of data collected by the international Livestock Research Institute's (ILRI) Livestock and Irrigation Value chains for Ethiopian Smallholders (LIVES) project in 2014 in Ethiopia. The survey covered four regional states (Oromia, Tigray, SNNPR and Amhara), 31 districts, 497rural *kebeles* (smallest administrative unit in Ethiopia) and 5004 households. Two types of data were collected: household level (household crop and livestock production, input use and marketing characteristics) and community level (agro-ecological variables from ILRI GIS service, grazing resources including total communal grazing land in a *kebele* and private pasture/hay land, and livestock data). Both household and community data were utilized for this study. Data from 2621 households which keep either or both sheep and goat were used for the analysis. New variables were derived from original variables in the survey questionnaires. These included flock descriptor variables, flock productivity (annual reproduction rate and mortality rates) and net commercial offtake rates. Original and derived variables are shown in Table 1. The variables were used as either explanatory, dependent or both as explanatory and dependent variable depending on the type of analysis.

Data analysis

Factors that would determine small ruminant productivity, producers' input use and marketing strategy (Table1) were analyzed. The factors broadly included producers

Table 2. Small ruminant systems identified in the highlands of Ethiopia.

Sub-systems	Agro-ecology			Grazing resources		Cropping pattern				Flock characteristics				
	Alt. (m)	Temp	Rainfall	CGL	PP	Cereal (ha)	Coffee (ha)	Enset (ha)	Cereal (kg/ha)	Sheep1	Sheep2	Goat1	Sheep flock	Goat flock
I. Sheep extensive system	2524	15.7	660	0.11	0.09	1.9	0.00	0.00	295.3	0.29	70.7	0.13	6.7	6.7
II. Sheep semi-extensive system	2352	15.8	1279	0.08	0.11	4.7	0.007	0.00	392.3	0.23	75.4	0.09	5.6	4.4
III. Sheep tethering/semi-intensivesystem	2593	14.1	1404	0.03	0.14	2.5	0.06	0.78	301.0	0.24	86.5	0.05	3.4	2.6
IV. Sheep-Goat tethering system	1959	17.9	1530	0.04	0.07	2.7	1.01	0.37	356.4	0.17	65.0	0.09	2.3	2.1
V. Goat-Sheep extensive system	1940	18.7	859	0.10	0.07	5.4	0.002	0.00	299.8	0.15	42.0	0.20	5.4	6.6
VI. Goat extensive system	1287	22.1	1045	0.14	0.03	6.9	0.09	0.05	233.0	0.03	12.8	0.22	4.4	4.5

Sheep/goat1: ratio of sheep/goat to cattle; sheep2: per cent of sheep in small ruminant flocks (relative to goats); Sheep flock: sheep flock size; CGL: Ratio of communal grazing land to total land; PP: Ratio of private grazing land to total land; Cereal (ha): area of household under cereal plot. Enset: *Enseteventricosum.*

characteristics, access/use of inputs/services, and farm scale. The data was analyzed fitting a generalized regression model as implemented in SPSS version 20 (2011) with log transformation of the data since the data did not conform to normal distribution. Two types of analyses were conducted, namely overall analysis across the six systems in the mixed crop-livestock system and nested design analysis where exploratory variables were nested within six systems to identify system-specific constraints. The systems are described in Gizaw *et al*. (2016) and summarized in Table 2. The six systems identified were I. Sheep extensive system, II. Sheep semi-extensive system, III. Sheep tethering/semi-intensive system, IV. Sheep-Goat tethering system, V. Goat-Sheep extensive system, and VI. Goat extensive system. Sub-system I is found in the dry highlands and subalpine region where crop production is unreliable and sheep is highly important; Sub-system II covers the high rainfall highlands and midlands with intense cereal production and sheep is still important; Sub-system III is characterized by high population pressure, less grazing communal grazing lands, enset (*Ensete ventricosum*) based system where small ruminant fattening with tethering practice is common; Sub-system IV is found in wet and moist midland, cash crop coffee dominated area, where small ruminants are less important generally; Sub-system V, dry and moist midlands, less potential for cropping, extensive grazing, small ruminant are highly important numerically and economically, both predominantly goat but also sheep are found; Sub-system VI, lowland areas, moisture areas, less suitable for cropping, goat are predominantly important.

RESULTS AND DISCUSSION

Use of inputs/services

Our results showed that there are variations among the identified six systems in the level of input use (Table 3). Generally, use of purchased inputs/services was higher for small ruminant production than fattening. Per cent of purchased inputs/services that was used for production of small ruminants was higher in systems I and II, and lower in the perennial crop (i.e. Enset-based system, Subsystem III) and the cash crop coffee growing areas (Subsystem IV). Use of supplementary concentrate feeds was higher in systems where small ruminants are numerically and economically more important (Sub-systems I, II and IV), whereas as use of crop residues was highest in high crop potential areas (Sub-systems II and III). Percentage of purchased inputs used for livestock activities, among other factors, is a criterion commonly used to characterize livestock production systems (McDermott et al., 1999). Planned use of inputs could also indicate the degree of producers' market orientation, which is planned production involving planned use of inputs/services with a market insight

Table 3. Producers' input use and marketing strategies and productivity of small ruminants in six small ruminant systems in the mixed crop-livestock system in Ethiopia.

	Systems*					
	I	II	III	IV	V	VI
Input use						
Purchased inputs for production (% HH)	24.346	30.528	19.03	11.607	19.736	18.1
Purchased inputs for Fattening (% HH)	2.025	2.969	1.336	1.688	1.504	0
Concentrate supplement (kg)	0.339	0.567	0.151	0.182	0.275	0.006
Crop residue supplement (kg)	1.566	1.964	1.706	0.583	1.395	0.635
Marketing						
Offtake rate	19.7	26.8	24.4	18.2	19	13.2
Young animals sold as % of total sold	8.9	25.8	32.9	20.8	11.4	12.4
Adults sold as % of total sold	55.5	44.7	55.1	47.3	43	31.6
Productivity						
ARR (sheep)	0.369	0.362	0.339	0.244	0.436	0.301
Mortality (sheep)	0.147	0.08	0.067	0.253	0.109	0.122
ARR (goat)	0.382	0.491	0.327	0.18	0.454	0.367
Mortality (goat)	0.184	0.093	0	0.141	0.112	0.079

* Systems are described in Table 2. HH household.

supported by market information. Besides farmers' rational decision on use of improved inputs and services, use of inputs is also determined by their access to inputs and services. And access is determined by geographic locations and the natural endowment of the area. Thus level of input use may not always be an intrinsic characteristics of a production system.

Besides to the explicit influence of availability of inputs/services on input use, hidden relationships could also exist between producers' socioeconomic characteristics, their farm scale (flock size and wealth status/land size) and their level of input use. These relationships were investigated overall across the six systems and separately for each system using nested design for some of the variables (Table 4). Although it was difficult to explain some of these relationships, the analysis clearly showed that there is a clear relationship between most of the factors studied and input use. Women-headed households used more inputs for small ruminant production, whereas male-headed households used more inputs for fattening than women did. Literate household heads used significantly more inputs for fattening, whereas those whose primary activity was livestock production used more inputs for small ruminant production. The data also showed that use of external inputs/services (as proportion of total purchased) for small ruminants decreases by 0.064 and 0.01 with a unit increase in family size and household head's age. Although the relationships varied with the type of input used, there were significant tendencies for input use to increase with flock size. This would mean that producers with larger flocks manage their flocks better with improved inputs. These results are generally consistent with previous results from a study in the Ethiopian highlands where crop residue use increased with flock size (Moti et al., 2015). The relationships between land holding and input use was largely negative, probably since larger land holding could be associated more with focusing on crop production. Getahun (2008) also found curvilinear relationships where input use declined beyond four ha of land ownership.

It has been reported that agro-ecology and cropping pattern in the Ethiopian highlands (Moti et al., 2015) and crop intensity-livestock density in Africa including Ethiopia (Diego et al., 2015) influence crop residue utilization. Analysis of producers' management practice in terms of input use across the whole mixed crop-livestock system in Ethiopia may thus not be appropriate as there could be variation among systems. For instance, the relationships between determinants of input use and producers' decision on input use varied across the six systems identified in this study (Table 3); input use increased significantly ($P<0.05$-0.001) with increasing flock size in system II and III, which are relatively semi-intensive systems (See Part I of this paper). On the other hand, less input was used by producers who had larger plot of land in high crop potential and cash crop systems (Sub-system III and IV). This may indicate that small ruminants are less important in these systems, as opposed to the extensive Sub-system I where input use was positively related with landholding, though the relationship was not statistically significant.

Marketing strategies

Degree of producers' market orientation could be measured in terms of their marketing strategy, for which offtake rates could be considered as a proxy. Variations were observed in offtake rates across systems, which was highest in the highland/midland tethering system and

Table 4. Producers' socioeconomic characteristics and farm resources/scale as determinants of input use and marketing decisions and Variations across systems.

	Input use				Marketing
	Purchased inputs for production	Purchased inputs for fattening	Use of crop residue	Use of concentrates	Offtake Rate
Parameter	*B*	*B*	*B*		*B*
Gender	-.342*	1.463	-.040	-.025	-.096
Primary occupation	.236*	-.485	-.075	-.199	-.023
Literacy	-.077	1.763*	-.055	-.195	-.121
Household size	-.064**	-.001	-.013	.009	.006
Household head age	-.010*	-.066*	.001	-.012	-.002
Land holding (ha)	.007	.065	.010*	.028*	-.006
Flock size	.011	-.021	.024***	-.009	-.008*
Nested design					
Land holding [System I]	.016	-.402*	.114*	-.150	-.036
Land holding [System II]	-.007	.072	.028***	.014	.008
Land holding [System III]	-.086**	.094	-.004	.031	.000
Land holding [System IV]	-.162*	-.386***	-.058**	-.048	-.020
Land holding [System V]	-.019*	.016	.008	.040*	-.014
Land holding [System VI]	-.051	-.180***	-.013	-1.553	-.029*
Flock Size [System I]	.002	.130*	.013	.006	-.006
Flock Size [System II]	.041***	.027	.019*	-.008	.009
Flock Size [System III]	.073	-.222	.059*	-.061	.025
Flock Size [System IV]	.106	.594***	-.034	-.072	.029
Flock Size [System V]	.005	-.043	.023***	-.023	-.013*
Flock Size [System VI]	.013	-.093***	.003	1.456	-.013

PP: Private pasture or hay plot. Stocking rate: number of small ruminants per ha of communal grazing land.
*, **, *** Differences are statistically significant at 5, 1 and 0.1% level of significance.

semi-extensive system (Table 3). The contrast estimates calculated as deviations from the overall mean were 0.072 (P<0.01), 0.054 (P<0.05) and -0.115 (P<0.001) for systems II, III and VI, respectively. The high offtake rate in Sub-system III can be explained by the farmers' small ruminant production and marketing strategies. Farmers in this system keep small flocks, some keeping only fattening sheep/goat and/or a few breeding stock which are tethered around the homesteads. The practice can be described as a planned market-oriented farm enterprise. On the other hand, the lower offtake rates in the extensive systems, where large flocks are kept, is an indication to an important saving/insurance/cultural function of livestock in traditional systems.

The current data also showed that in general with an increase in one unit of small ruminant in flock size, offtake rate would decrease by 0.008% (Table 4). The decline in offtake rates with increasing flock size could be explained by disproportionate offtakes with the increase in flock size. This relationship also indicates that traditional livestock keepers, such as pastoral communities, use livestock as capital store as well. Thus increase in reproduction and flock sizes may result in increased offtakes, but may not necessarily translate to increased offtakes proportional to the increase in flock sizes, which is required for a positive relationships between flock size and offtake rates. However, the relationships between flock size and producers' marketing behavior varied across systems as shown in the nested model analysis (Table 4). There was a tendency for a positive relationship between flock size and offtake rate in the intensive cropping areas (Subsystem II and III), which are relatively market oriented. On the other hand, farmers in the drier areas where large breeding flocks are kept tended to keep more of their animals (Subsystems I, V and VI). This result is in agreement with Getahun's (2008) findings where offtake rate was by far higher in an intensive tethering/fattening area with smaller flock size than a less intensive production area with larger flock size.

Small ruminant productivity

The overall annual reproduction rate and lamb/kid mortality in the mixed crop-livestock system was calculated to be 0.39 lambs/kids born per year per ewe/doe and 11.6%, respectively. However, there was variation across the identified six systems (Table 3). Reproduction was higher in extensive systems with larger flocks compared to the tethering systems which keep small flocks. Yet, mortality was higher for some of the extensive systems.

Productivity could be determined by the genetic merits of the breeds kept, the natural production environment and

Table 5. Household head gender and literacy status as determinants of small ruminant reproductive and mortality rates.

(I) Gender*Literacy	(J) Gender*Literacy	ARR[1]	Young mortality	Adult mortality
[Male]*[Literate]	[Male]*[Illiterate]	.052*	-.37	-.98
	[Female]*[Literate]	-.034	-5.32	-4.47
	[Female]*[Illiterate]	.031	-3.54	-3.31*
[Female]*[Literate]	[Male]*[Illiterate]	.087	4.94	3.49
[Female]*[Illiterate]	[Male]*[Illiterate]	.022	3.17	2.34
	[Female]*[Literate]	-.066	-1.78	-1.15

* Differences are statistically significant at 5% level of significance.
[1] ARR: annual reproductive rate

Table 6. Access to inputs/services, use of inputs/management level and farm resources as determinants of productivity and marketing behavior

	ARR	Lamb mortality	Adult mortality
Parameter	*B*	*B*	*B*
Access to inputs/services			
Availability of hay in PA	.023	-.012	-.457**
Availability of purchased concentrate in PA	-.025	.245	.107
Distance to nearest veterinary service	.000	.000	.001
Distance to nearest water source in dry season	.001	-.004	
Use of input/Management level			
Crop residue supplement	.020	-.030	-.034
Concentrate supplement	.028	.030**	.128*
Proportion of external inputs used for sheep/goat production	.000	.000	.000
Proportion of external inputs used for sheep/goat fattening	-.001	-.028**	-.010
Farm resources/characteristics			
Flock size	-.009	.009	.022*
Land holding	.014*	-.002	-.008
Stocking rate	-.002	-.00008	.000009

*, **, *** Significantly different from zero at 5, 1 and 0.1% significance level.

availability and use of improved inputs/services. Producers characteristics, access to livestock development inputs/services (availability of hay and purchased concentrate feeds and distance to veterinary services and watering points during the dry season), use of on-farm produced and purchased inputs, and farm resources (scale of production/flock size and wealth status/land size) were analyzed to see the significance of these production factors on flock productivity. Analysis of the gender and literacy status of the sample households showed that there were differences between male-and female-headed households as well as between literate and illiterate household heads. Further, although there was no significant differences between male and female farmers, there was a significant interaction between gender and literacy (Table 5). Females who could read/write were better in managing the reproductive performance of their flocks as compared to male literates, male illiterates and female illiterates. However, flocks owned and managed by women had higher mortality rates. Age of household heads and household size were also included as covariates in this analysis. With a unit increase in family size, ARR increased by 0.034 lambs/kids (P<0.05) and there was a tendency for lamb/kid mortality to decrease with increased family size. ARR was significantly determined by land holding, which could be explained by the higher opportunity of farmers owning larger plots to produce more crop residues and cultivated fodder and provide better nutrition to their flocks. The data also showed that mortality, particularly adult mortality, was lower by about 0.46% in farms which had access to hay. There was a tendency for producers having larger flocks to have lower lamb mortality but significantly higher adult sheep and goat mortality. The data showed that with an increase in one unit of sheep/goat, adult sheep/goat mortality would increase by 0.022% per year (Table 6).

CONCLUSIONS

We found that small ruminant productivity is determined not only by the use of improved inputs/services but also by the characteristics of the value chain actors. Producers' input use and marketing practices are in turn determined by their socio-economic characteristics and

scale of production. There is high variation in small ruminant productivity and producers' input use and marketing decisions across the six small ruminant systems in Ethiopia. This calls for system-specific targeting approach for small ruminant development as well as a value chain approach addressing constraints at critical leverage points across the value chain and targeting appropriate value chain actors (gender, literacy, etc.) for introducing technological interventions.

ACKNOWLEDGEMENT

The data for this study was collected by the International Livestock Research Institute's (ILRI) Livestock and Irrigation Value Chain for Ethiopian Smallholders project (LIVES). LIVES project is financed by Global Affairs Canada (GAC).

Conflict of Interest Statement

The authors declare that they have no conflict of interest.

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