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Characterizations of livestock manure market and the income contribution of manure trade in Mukogodo, Laikipia, Kenya

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The use of livestock manure in African agriculture supports a market system that links pastoral and agricultural communities, but has been little studied. We investigated this market in central Kenya. Out of 60 households interviewed, all had livestock and 81% were involved in livestock manure trade. Livestock manure from rangelands is marketed directly to individual traders or brokers (76%), farmers (20%), and horticultural growers (4.6%). There was a significantly greater demand by farmers for small ruminant manure than for cattle manure. The mean annual livestock manure sales per household were 10.8 and 5.7 metric tonnes (MT) for small ruminant and cattle manure, respectively. Mean annual household gross income for small ruminant and cattle manure was KShs. 3,450 and 1,350, respectively. In 2006, livestock manure brokers were receiving a mark-up of 90% from sale of small ruminant manure at an agricultural town. Local government levies KShs. 92.90 per MTof livestock manure and received a total of Kshs. 54,532 from the sale of 587 MT of manure during the study period. Other beneficiaries to the livestock manure business included truck loaders who received an average wage of between KShs. 200 and 270 per MT.Themost important variables determining the quantities of livestock manure per metric tonne (MT) were household size, number of goats and sheep, income from manure sale, prices of small ruminant manure per MT, hypothesized to influence the quantities of manure sold. The most important variables determining the livestock manure income were number of goats and sheep, amount of small ruminant manure (MT) sold, prices of small ruminant manure per MT and income from livestock sale.

Key words: Manure, rural markets, cattle, goats, Mukogodo, Laikipia, Kenya.

INTRODUCTION

Pastoralists derive their livelihoods from livestock and livestock by-products such as meat, milk, blood and to some extent bones, skins and hides. Climatic limitations, occurrence of prolonged droughts, environmental degradation, high population, and increasing costs of living have given rise to increased socio-economic needs of the pastoral communities. Alleviating poverty amongst the pastoral communities remains one of the most serious challengesin Africa. As a result, pastoralists have developed and adopted various livelihood coping mechanisms.

Traditionally, Maasai pastoralists have regarded livestock manure as a burden rather than a valuable output (Baars, 1999), but recently a market for

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livestock manure has emerged. In high potential agricultural areas, smallholder farmers often mine their soil nutrients through crop extraction, removal of weeds, grazing livestock, cutting forage to feed livestock, or selling fodder (Powell et al., 2004). Kenyan agricultural soils nutrients have been seriously depleted (Sheldrick et al., 2003) and (after limited soil moisture), "low soil fertility is the most important constraint limiting crop productivity in sub-Saharan Africa" (Gicheru, 2012; Fischer and Qaim, 2012). Farmers in high potential areas have sought to alleviate these shortfalls through both man-made and organic fertilizers (Gicheru, 2012), but run into problems using man-made fertilizers because of their high costs (Heisey and Mwangi, 1996). Substituting local farmyard manure for man-made fertilizers can be effective (Otinga et al., 2013), but the use of their own livestock manure in these agricultural areas is limited by low supply (Hoffmann, 2002).

This has led to the importation of livestock manure from drier areas to croplands thereby creating a market for the manure generated in the drylands. However, this new market has received little research attention (Pell, 1999; Sheldrick et al., 2003), or is even not recognized (Herrero et al., 2013). The availability of livestock manure markets in rangelands (Lekasi et al., 2001) has given crop growers an opportunity to improve soil fertility and structure in their farms. In Kenyan highlands, farmers purchase livestock manure from distant grazing lands such as the Rift Valley and Laikipia after exhaustinglocal supply (Lekasi et al., 2001). In northwest Nigeria, pastoralists exchange livestock manure with crop residuals to feed their livestock (Hoffmann, 2002). In some areas prone to high degradation, e.g., Gambia, livestock manure production is highly valued (Alice, 1999).

The growing trend of livestock manure exportation from rangelands to croplands has given rise to the need to characterize and analyze the contribution of this export trade from the rangeland ecosystem to the cropping systems in Kenya. This study describes the marketing of livestock manure trade and the economic aspects of manure trade in Mukogodo, Laikipia, Kenya. Specifically, we examined the quantity, price and income parameters of traded manure.

STUDY AREA AND METHODS

This study was carried out in Mukogodo Division (0°N, 37°E) of Laikipia in the Rift Valley Province (now County) of Kenya in 2006. Mukogodo is located at an elevation of ~1700 masl, and experiences mean annual rainfall of ~350 mm. The population of ~35,000 is mainly Maa-speaking people practicing traditional pastoral techniques, although they have in recent years been organized into group ranches. Livestock are kept each night in enclosures ('bomas') for protection from predators and stock theft. Dung accumulates in these exclosures, facilitating its collection and sale. The Division center, Doldol, is located 50 km from the nearest large town, Nanyuki, accessible by an all-weather road, of which 20 km is paved. The area around Nanyuki hosts some agriculture and flower faming. Major agricultural areas ~50 km to the south are accessible on paved roads.

Interview methodology

In order to understand the patterns and pathways of livestock manure transferfrom rangelands to croplands, we first determined the marketing chain of livestock manure from drier areas to cultivated lands in central Kenya. Astructured questionnaire with open- and closed-ended questions was administered in face-to-face interviews to a randomly selected sample of 60 households in four locations of Mukogodo Division.

Each interview targeted the householdhead and in case of his/her absence, the spouse or oldest son/daughter, in that order. The household was the sampling unit. Since households are sparsely located in the pastoral areas, a transect walk (Ng'ethe et al., 1998) was made across each location and sampling was made of every third household. If it was not possible to get a household head/representative, the next household was taken as a substitute.

Community interviews were also carried with unstructured interviews from key community informants, namely community representatives of youth, women and elders, assistant chiefs and agricultural extension officers. Further interviews were carried out with truck drivers, truck loaders, county council officials, horticultural farm managers and farmers. Focused group discussions (FGDs) were also used to obtain auxiliary information and to validate the information derived through the questionnaire. Participants in the informal interviews were not included in the focused group discussions, which allowed the groups to discuss their views freely without the influences of participants of the informal interviews. Local Maa and Kiswahili languages were used during interviews. Detailed notes taken by the researcher (AK) were later compared and discussed with the participants to ensure that all issues raised had been recorded. In addition to interviews, direct observations (Yin, 1989) were employed to obtain additional information on the livestock manure trade in the study area.

Several follow-up trips were made with trucks transporting manure from study area to cultivated lands in central Kenya. This helped to identify middlemen and the end-users of livestock manure in the croplands. Secondary data on livestock manure sales for each division were gathered from the district county council to complement the collected primary data.

Data analysis

Multiple regression analysis was carried out to establish the relationship between key variables hypothesized to influence the manure trade, and (a) quantities of livestock manure sold and (b) per capita income from livestock manure. The variables included in the models are shown in Table 3. Additional data analysis was carried out using SPSS version 12.0 statistical package (SPSS, 1999). Analysis of variance (ANOVA) was used to test the significance of the differences between means of several sampled variables.

RESULTS AND DISCUSSION

General characteristics of Mukogodo division inhabitants

Consumption per adult equivalent (AE) was used as the index of individual welfare (Government of Kenya, 2000). The concept of adult equivalent (AE) is based on the

differences in nutrition requirements according to age and gender (ICRC, 2005). An adult male over 16 years old equals 1 AAME (Africa Adult Male Equivalent), an adult female over 16 years old is given a value of 0.8 AAME and a child of either sex less than 16 years old is given a value of 0.6 AAME.

The mean household size in Mukogodo division is 7.67 AAME. Over 90% of Mukogodo inhabitants practice pastoralismas their major source of subsistence. The primary livestock species are cattle (*Bosindicus*), sheep (*Ovis aries*), and goats (*Capra hircus*), and occasionally camels (*Camelus bacterianus*) and donkeys (*Equus asinus*). The average household herd size composition was 15.1, 6.0 and 5.0TLU of cattle, goats and sheep, respectively. Tropical Livestock Unit (TCU) is scaled to an animal of 250 kg live weight (Jahnke, 1982). The mean herd composition in TLU per household is 58% cattle, 23% goats and 19% sheep.

Traditional use of livestock manure among pastoral communities

Respondents reported varying traditional uses of livestock manure. About 50% of the respondents reported that cattle dung was used for plastering many attas (traditional mud huts). In addition, 30% of the respondents burn their manure to prevent human diseases such as coughing, which is attributed to inhaling dusty goat and sheep manure during the dry season. Burning manure also done to reduce cover for wild animals that hid behind manure heaps as well as to prevent livestock raiders from estimating your livestock numbers by the quantities of manure. Two respondents (3%) reported that small ruminant manure is placed under their beddings to provide warmth. It is also traditionally believed that evil people use manure for witchcraft purposes leading to livestock deaths and therefore some pastoralists burn manure as they migrate to new grazing areas (Samuel Putunoi, personal communication).

Goat and sheep manure is sometimes swept from the bomas to prevent fungal infection of livestock hooves which is attributed to wet manure. The remaining 15% of the respondents leave manure on the compound. In addition to the above uses, 18% of the respondents who live in neighborhood to the adjacent Mukogodo forest use manure on their gardens. Another 5% of the respondents spread it on degraded lands for purposes of improving soil fertilityand controlling soil erosion through improved rainfall infiltration. Spreading of manure was also reported to encourage shrubs and grasses growth during rainy season to improve dry season grazing pastures.

Livestock manure value in the study area

A large majority of the respondents (82%) participated in livestock manure trade. The remaining 18% expressed the willingness to participate, although they were constrained by lack of access roads, buyers, livestock mobility and low livestock numbers.For those households that were selling manure, 80% sold small ruminants manure, 17% sold cattle manure. Fully 22% of the pastoralists reported that they had been in the business for more than 20 years. The importation of manure from Mukogodo was facilitated by its proximity to cropping areas, the availability of manure and need for income from its sale.

Surveys revealed that the sale of manure among the Mukogodo communities is regarded as a women's affair because it is they and school-aged children who are involved in collecting and heaping the manure. However, due to the increasing market value of livestock manure, there is growing interest among men in participating in the manure business, which generates conflicts over manure ownership in families (Jane Sejura, personal communication).

Livestock manure marketing chain

Livestock manure from rangelands is marketed through various channels (Figure 3). The four key parties involved are the pastoralists, brokers, farmers and horticultural farms. Of the respondents who sold manure, 75% sold to individual traders or brokers, 20% sold directly to farmers, and 5% sold it directly to large and small horticultural farms.

There is an emerging relationship between pastoralists and small-scale farmers. In central Kenya, farmers are organized into groups that send one member of the group to buy manure. These farmers also purchase manure from brokers either for their own use or for selling in 20 kg bags to vegetable farmers. Similarly, manure brokers sometimes buy manure for purpose of storing it at their homes to sell in 20 kg bags at a price of KShs 10/= per kilogram (Table 2). Women and school-aged children provide most of the labor in collecting and marketing of manure.

Pricing livestock manure in the study area in 2006

The price of livestock manure differed depending on manure type, lorry size, and distance from the road. Livestock manure is transported in 3-, 7-, and 9-tonne lorry trucks, representing 12, 72, and 5% of households, respectively (12% were not aware of the size of the lorry trucks). Livestock manure buyers noted that smaller lorries were less economical than large lorries, due to long distances and capacity.

The manure of small ruminants fetched higher prices than cattle manure. The mean farm gate prices for livestock manure in Mukogodo division were KShs. 237 and 320/MT for cattle and small ruminant manure,

Table 1. Cost (in 2006 KSh) and profits(%) of livestock manure value chain from rangeland to farming areas per metric tonne.

Manure type	Farm-gate/ton	Loading cost and offloading/ton	Local council fee/ton	Transport cost/ton (Karatina)	Transport cost/ton (Nanyuki)	Off-loading cost/ton	Total cost/ton	Selling price/ton (Karatina)	Profit margin	Mark up (%)
Small ruminant manure	320	158	92.9	1,027	-	50	1,648	3,153	1506	91.4
Cattle manure	238	219	92.9	-	185	50	784	1,000	216	27.5

respectively. The preference for the small ruminant manure, according to the farmers' interviewed, is due to its fine texture, which makes it easy to apply, especially when they mix mineral fertilizers with manure to facilitate even distribution. Further, farmers believe that cattle manure has 'burning' effect on crops, which discourages its use. It was also perceived that small ruminant manure breaks down more slowly in the soil than does inorganic fertilizers, and acts as a slow-release fertilizer that lasts for one or two more growing seasons (Harris, 2001).

Manure is a livestock by-product and a source of cash income. It is a profitable venture and, as such, a significant number of people are involved in its production and marketing. They include the pastoralists, farmers, distributors or brokers and loaders. Taxes levied on the manure "export" from the study site are an important source of revenue for the local government as well. Mean livestock manure sale per household per year was 10.8 and 5.7 metric tonnes (MT) of small ruminant and cattle manure, respectively. Small ruminant manure accounted for 88% (519 tonnes) and cattle manure 12% (68 tonnes) of the total manure sold. A total of 587 tonnes of livestock manure valued at KShs. 182,050 (US$ 2758) was sold from the study area in 2006 (Table 1). Based on the local county council records, an estimated total of 1,324 tonnes of livestock manure were sold from entire Mukogodo division in 2006.

In Karatina, an agricultural town in central Kenya, one tonne of small ruminant manure sold at KShs. 3,153 by the brokers who thereby received a mark-up of 90%. Farmers who purchase small ruminant manure either from pastoralists in Mukogodo rangelands or brokers and sold in quantities of 20 kg bag at KShs. 200 received a mark-up of up to 500%. Manure brokers selling cattle manure to horticultural farms at Nanyuki, received a 28% mark-up.

The seasonal livestock manure sale from rangelands to croplands shows the ecological inter-dependence of manure flow and planting season in the farming areas. According to local county council statistics, the peak period of livestock manure harvesting was in the month of March, with a total of 373 tonnes (Figure 1). This is the period when majority of smallholder farmers in central Kenya are preparing their farms for planting for the rains in April.

Livestock manure terminal markets in 2006

The central Kenya highlands, which are the largest market for small ruminant manure from rangelands in the country, accounted for over 80% of the formally marketed livestock manure from Mukogodo division. Most of the terminal markets for Mukogodo manure are located in the neighboring districts of Meru Central, Nyeri, Murang'a, and Kirinyaga, with Nyeri being the largest market. In these terminal markets, dry small ruminant manure was sold at a price of KShs. 3,150 per metric tonne, similar to prices in India (KShs. 2,400 to 2,800 per metric tonne; Madhusudan, 2005).

The larger horticultural farms closer to Mukogodo were buying manure in bulk purchase at prices ranging from KShs. 1,000 to 1200 per metric tonne. For these farms, cattle manure is preferred to goat and sheep manure due to incidences of food poisoning bacteria, such as *Escherichia coli* and *Salmonella*, which are common when manure is not well decomposed. Horticultural farms also report applying livestock manure to kill nematodes in the soils.

Secondary sources of livestock manure income and value

A majority (82%) of the respondents incurred very little cost other than their time spent in gathering manure into heaps. Quantification of the exact costs was however not possible.

Livestock manure buyers, namely, farmers, group of farmers and brokers, hire manure loaders from Nanyuki town. Their work is to guide the vehicle owner to places where manure is found as well as do the loading. These loaders are paid an average of KShs. 210 and 270 for loading a truck with small ruminant and cattle manure, respectively. This is over two times the daily farm wage labor in the area. A 3-tonne mini-lorry is loaded by three men and 7-and 9-tonne lorries are loaded by six men (Figure 2). Manure loaders use no protective devices and they

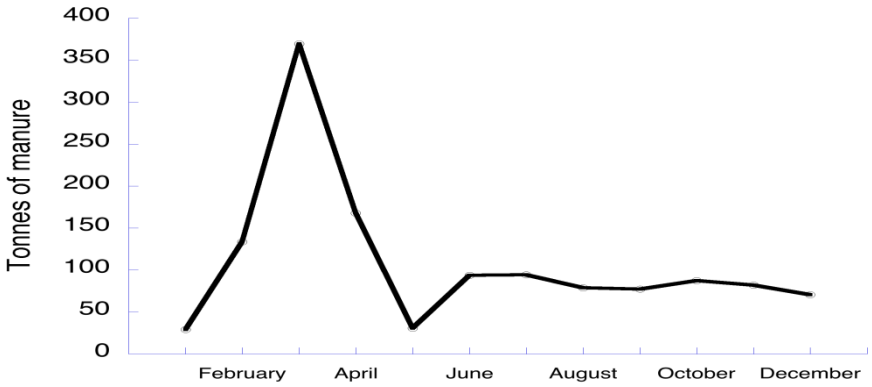

Figure 1. Tonnes of livestock manure sold from Mukogodo division in 2006.

Figure 2. A 9-tonne lorry being loaded with livestock manure by six men at Doldol, Mukogodo Division in 2006.

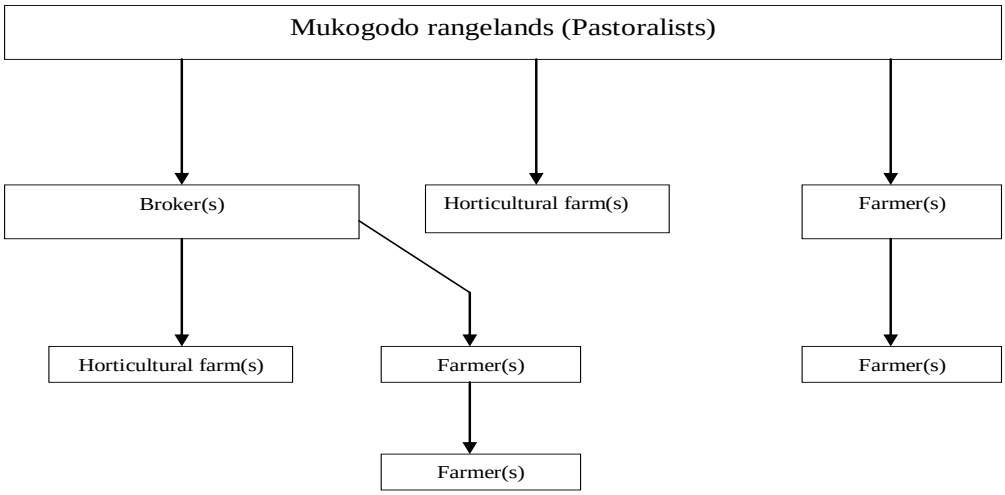

Figure 3. Livestock manure marketing chain.

Table 2. Tonnes of livestock manure sold and income from the sale of manure from the study area in Mukogodo Division in 2006.

Type of manure	Number of households	Tonnes (1000 kg)	Income (KShs)	Income/household (KSh)
Small ruminant manure	48	519	165,900/=	3456/=
Cattle manure	12	68	16,150/=	1346/=

Table 3. Regression coefficients for quantity of livestock manure sold and income from livestock manure sale from the study area in 2006.

Variable/parameter	Amount of livestock manure sold (Y_1)	Income from livestock manure (Y_2)
X_1 - Household size in adult equivalent (AE)	0.50 (2.65)**	-54.80 (-3.96)**
X_2 - Number of cattle in Tropical Livestock Unit (TLU)	-0.30 (-1.97)**	-6.07 (-0.68)
X_3 - Number of goats and sheep (TLU)	0.29 (2.37)**	14.90 (1.95)**
X_4 - Income from goat and sheep manure (KShs/AE),	0.007 (3.17)**	
X_5 - Number of goat and sheep (TLU) sold	-0.93 (-1.68)*	-69.02 (-2.20)**
X_6 - Number of cattle (TLU) sold	1.82 (3.54)**	4.38(0.16)
X_7 - Income (KShs/AE) from cattle manure	0.020 (1.98)**	
X_8 - Income (KShs/AE) from cattle sales	0.00 (-2.04)**	0.002 (0.14)
X_9 - Income (KShs/AE) from goat and sheep sales	0.00 (0.53)	0.043 (2.61)**
X_{10} - Years of settlement	-0.037 (-0.67)	
X_{11} - Price (KShs/tonne) of goat and sheep manure	0.005 (0.82)	1.81 (5.78)**
X_{12} - Price (KShs/tonne) of cattle manure	-0.007 (-0.45)	-0.42 (-0.47)
X_{13} - Tonnes (MT) of goat and sheep manure		32.52 (4.00)**
X_{14} - Tonnes (MT) of cattle manure		39.94 (1.29)
X_{15} - Years of selling manure		-9.04 (-1.86)**
Overall R^2	0.84	0.92
F	20.34**	33.81**

Results are for regressions identified in the table, with parameters indicated in the left–hand column; the t ratios are in parenthesis: *, significant at 0.1 level; **, significant at 0.05 level.

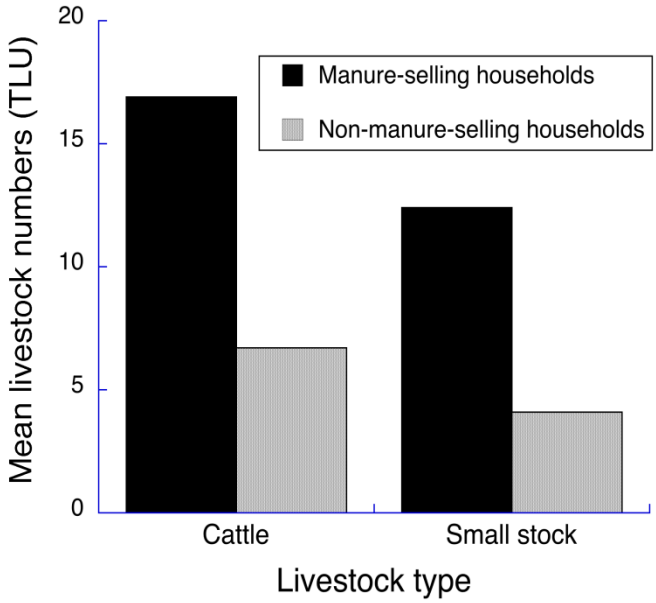

Figure 4. Comparison of livestock numbers between manure selling and non-manure selling households in the study area in 2006.

they report that as result they are prone to common colds, coughing, and eye sicknesses due dusts from manure when loading, transporting and offloading.

For revenue generation, the local council imposes a levy of KShs. 93 per metric tonne of livestock manure. This translated to KShs. 54,500 in income in 2006.

Some households spread livestock manure on degraded areas around their homesteads to encourage germination and growth of *Amaranthus hybridus* L. and *Solanum nigrum* L., which are used as vegetables. The spreading of manure also increases the growth of *Acacia tortilis* (Forsk) Hayne and species of grasses vital for rangeland rehabilitation and livestock forage.

There was a significant difference between small stock (TLU) of manure selling and non-manure selling households (Figure 4). Poor families with few livestock numbers, especially goats and sheep, did not consider manure trade as a worthwhile venture since it takes a long time to gather significant amounts. Although livestock manure sale did not make a significant contribution to the income of the rich households, manure-selling households earned an average total income of KShs. 653 per AAME per year, more than other

livestock by-products such as bones, hides and skins. A majority (72%) of the respondents spent their income on food while 12% spent it on livestock drugs.

Regression analysis for the tonnes of livestock manure sold from study area in 2006

Regression analysis produced a model that explained 84% of the variation inamount of manure sold. The amount of manure sold was significantly positively affected by household size, which is correlated with the number of cattle, goats and sheep.

Income from the sale of cattle was also significantly positively correlated with the amount of manure sold. This income may have been used to purchasing of more goats and sheep, which lead to increases of manure from small ruminants. The majority of cattle sold are not milking cows and calves that provide manure for sale but those grazed far from homesteads where manure cannot be collected for sale.

Interestingly, the amount of manure sold was significantly negatively associated with the number of cattle owned by the household. We suggest that very large herds tend to overgraze the area near and around homesteads and as a result herders move the cattleto more distant grazing areas. The only milking cows and calves left grazing near homesteads and are not able to accumulate significant amount of livestock manure for sale.

During drought, small ruminants, particularly goats, have higher survival rate than cattle (Powell et al., 2004), the rapid reproduction of small ruminants allow flocks to be reconstituted much faster than cattle herds after drought. As a result, availability of manure not only decreases during drought, but the manure from small ruminants is more available than of cattle (Powell et al., 2004).

The length of time that a household had been resident at the site was not significantly related to the quantity of manure produced. We suggest that long period of settlement results in overgrazing and consequent land degradation. This would lead to migration of livestock to far grazing pastures thereby reducing the livestock population retained in overnight bomas for manure production.

Regression analysis for income from livestock manure

Regression analysis produced a model that explained 92% of the variation inthe per capita income generated from sale of livestock manure. Per capita income from the sale of livestock manure was significantly negatively associated with household size. Although the total manure sold increased with household size (see above), it apparently did so less than linearly, resulting is less income per family member.

Income from manure was significantly positively correlated with the number of small stock and the amount of dung from small stock sold, but not for either of these traits for cattle. Small ruminant manure accounted for over 88% of the livestock manure sold from study area. Moreover, goats and sheep manure fetched higher prices than cattle manure. Conversely, income from livestock manure sale was negatively associated with the number of sheep and goats (but not cattle) cattle sold. Selling goats and sheep resulted in reduction of manure, which consequently reduces the income.

Both of these regression models highlight the importance of small stock over cattle in the manure trade and its positive impacts of pastoral families.

Management implications of livestock manure regression models

The regression models are potential tools for predicting the future amount of livestock manure production and income from livestock manure based on the parameters considered in the models. The study has suggested that livestock manure trade is a productive investment that generates income to many households while at the same time contributing to sustainable fertility management of heavily exploited croplands (Olayide et al., 2009).

Livestock manure production for sale will be increased by more households investing in livestock, especially goats and sheep. Our analysis has also showed that long period of settlement in a given area affect the amount of manure produced and income from manure negatively, likely due to overgrazing and subsequent movement of livestock to new areas where manure cannot be recovered for trade due to poor roads infrastructure. Therefore construction of good roads network in the pastoral areas will enhance livestock manure collection and transportation, ideally in combination with extension services relating to stocking rate and carrying capacity.By so doing, pastoralists are more likely to get fair prices from manure and invest more on livestock manure by deploying more family labor in manure collection and selling rather than burning it. The availability of manure to crop farmers will result in improved soil fertility, higher crop yields and eventually improved national food security.

Conclusions

The major land use in Mukogodo division is rangeland, and pastoralism is the main local source of subsistence. There is a vibrant livestock manure market chain from rangelands to cropping areas in central Kenya. Livestock manure is marketed directly to farmers, horticultural

farms and to individual traders or brokers who also sell their product to farmers or horticultural farmers.

A majority of the households are involved in livestock manure trade. Those not selling manure are hopeful to start the business soon but are constrained by livestock mobility and a lack of access roads, buyers, and sufficient livestock numbers near homesteads to accumulate significant amounts of manure. Currently, the livestock manure trade does not make a major contribution to total householdincome. At the household level, income from the sale of livestock manure can influence investment in assets such as sheep and goats, indirectly allowing poor households to improve their nutritional status and to improve their labor productivity. Small stock more than cattle seems to drive manure profitability for Mukogodo pastoralists,

In addition, livestock manure serves as a source of revenue to the local government and thus a catalyst for economic growth. In nearby agricultural areas, livestock manure can also serve as an alternative source of cheaper organic fertilizers, providing a benefit for farmers, and stimulating its demand. The sale of livestock manure is therefore likely to be of increased economic importance to both pastoralists and small- and large-scale farmers in this era of high fertilizer costs, especially during dry periods when demand for manure is highest.

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