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Kerstin K. Zander[1,*], Joram M. Mwacharo[2], Adam G. Drucker[3], Stephen T. Garnett[4]

[1] The Northern Institute, Charles Darwin University, Darwin, NT 0909, Australia.

[2] Kenya Agricultural Research Institute, Kiboko Research Centre, P.O. Box 12, Makindu 90138, Kenya.

[3] Bioversity International, Via dei Tre Denari 472/a, 00057 Maccarese, Rome, Italy.

[4] Research Institute for the Environment and Livelihoods, Charles Darwin University, Darwin, NT 0909, Australia.

* Corresponding author: Kerstin K. Zander, The Northern Institute, Charles Darwin University, Darwin, NT 0909, Australia; Phone: + 61 (0)8 8946 7368, Fax: 61 (0)8 8946 7720; Email: kerstin.zander@cdu.edu.au

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ABSTRACT

We surveyed small-scale farmers in Kenya to describe constraints to and changes in livestock production and to assess the extent to which farmers have adopted new technologies promoted by extension services. In the arid area of southern Narok farmers' main constraints were drought and disease. Farmers in Nakuru district, situated in the fertile highlands of the Rift Valley, were also affected by disease but also lacked markets and capital. Although 83% of farmers had regular contact with extension services that provided advice on new technologies and livestock management innovations, only about half of the respondents made the changes advised. Many of those who did change (38%) improved pasture/nutrition/manure management and relatively few (16%) improved their animal breeding practices. Results of a multinomial logit model revealed that, apart from the significant differences between the two districts, the nature of the advice and the expected outcomes had the strongest influence on the probability of successfully implementing changes to livestock production. The results further suggest that adoption of new technologies is limited by lack of knowledge, inadequate support and a failure to target local needs and conditions and empower local people.

Keywords: Breeding technologies; Drought; East Africa; Extension services; Innovations; Multinomial logit model

1. INTRODUCTION

In developed countries technological innovation and its adoption was a major contributor to increasing productivity during the twentieth century (e.g. Garnder, 2002). The innovative adoption of new technologies is pivotal raising the income levels of smallholders (Barham et al., 1995; Schreiber, 2002; Asfaw et al., 2011), producing broad and equitable benefits to society (Godoy et al., 1998; Tilman et al., 2002) and reducing pressure on renewable natural resources (Southgate and Whitaker, 1992; Waggoner, 1995). While direct linkages between farmers and technology generators might have the capacity to have positive impacts on productivity (e.g. Eponou, 1993), traditional 'transfer-of-technology' approaches to agricultural research can no longer keep pace with the complex, diverse, risk-prone and dynamic production environment of resource-poor farmers (Watts et al., 2003). This is partly because of a lack of resources but also because the agricultural research (e.g. Eicher, 1988; Jain, 1992), including the extension services (e.g. Pardey and Roseboom, 1990), has been inappropriate or ineffective (Critchley, 2000).

Problems associated with adoption of new technologies are not always inherent in technology itself or the approach of knowledge transfer and the degree of knowledge inclusion, but could be a direct reflection of the social inequalities and economic disparities that already exist in the society and of environmental challenges and constraints (e.g. Croppenstedt et al., 2011). Recent research on technology adoption to mitigate climate change effects, for instance, has shown that external constraints are the primary reason behind the observed under-investment in technology adoption by resource-poor farmers (e.g. Challinor, 2007; Nhemachena and Hassan, 2007). Furthermore, constraints do not exist in isolation with the presence of one constraint sometimes exacerbating others and increasing barriers to technology adoption. It is therefore necessary to study multiple constraints simultaneously (Jack, 2011).

However, while there has been much research on the adoption of single types of technological innovation by farmers, such as irrigation (e.g. Abdulai et al., 2011) or Bt cotton (e.g. Ali and Abdulai, 2010), research on the simultaneous adoption of multiple technologies is rare. The same holds for research on constraints to technology adoption; most studies investigate the effects of one constraint in isolation of others. In particular we found little research on the effects of extension services, constraints and expectations on the adoption of multiple technologies. Against this background, the aims of this study were 1) to describe constraints that impeded livestock production in two districts in the Kenyan Rift Valley (Narok and Nakuru), 2) to understand the linkages between extension services and farmers, the advice given by extension services and farmers' expectations, and 3) to evaluate the rate at which farmers adopted new innovations/technologies as advised by extension services. Building on an understanding of the constraints to livestock production (cattle, sheep and goats), we analyzed choices made by a sample of farmers over a period of five years (2002-2007). We then considered the socio-economic factors and farmers' expectations that influenced the rate of adoption. We applied a multinomial logit (MNL) model from household data that we collected during interviews. In order to reflect a more realistic scenario of farmers' decision-making, we assumed that farmers are likely to adopt many technologies with different expected benefits for their livestock production. We chose the livestock sector because it contributes an estimated 12% of the entire GDP in Kenya and 47% of the agricultural GDP (GOK, 2007). The sector also employs about 50% of the country's agricultural sector labor-force.

2. MATERIALS AND METHODS

2.1. Study area

About 80% of Kenya is semi-arid or arid being characterized by low, unreliable and poorly distributed rainfall. However, this area supports a quarter of the country's total human population of 40.5 million (World Bank, 2010) as well as 60% of the livestock population and most of the country's wildlife

(Ngugi and Nyariki, 2005). Most of Kenya's mall-scale farmers occupy mainly this region, pursuing traditional livestock production with traditional technologies. These farmers are unlikely to meet the growing demand for food from an increasing population (Leisinger and Schmitt, 1995). The survey was carried out in two districts in Kenya, Narok and Nakuru, both in the Rift Valley Province (Figure 1). In both districts the main livestock enterprises are dairy and beef cattle, sheep, goats, poultry, pigs, rabbits and bee keeping but they have different demographic and environmental backgrounds. The semi-arid lowlands of southern Narok which is sparsely populated with a density of 24 people/km^2, is unsuitable for intensive agriculture because of poor quality soils and unreliable rains (MOLFD, 2006) The area is inhabited by Maasai people who are mainly pastoralists, i.e. at least 50% of their livelihoods depend on domestic livestock (Swift, 1988). Pastoralists differ from livestock rangers by their practice of taking herds to pasture and water, rather than having fodder grown or brought to them (Fratkin and Roth, 2005). Although purely nomadic in the past, many pastoralists are less mobile today (Fratkin and Roth, 2005). In southern Narok, most families move between sedentary and mobile activities. While the larger part of a family, mainly women, children and elderly, have settled down pursuing small scale subsistence farming, some family members (often young men) still take the herds to pastures and water. By contrast, Nakuru district, in the heart of the Rift Valley Province, has a high population density of 181 people/km^2.The city of Nakuru is 1850 meters above sea level on fertile highlands and is surrounded by intensive agricultural enterprises as well as the small-holders in whom we were interested. Unlike Narok, Nakuru district supports intensive livestock production and cropping with the main crops being coffee, wheat, barley, maize and beans. Farmers in Nakuru are livestock ranchers and do no pursue pastoral activities like those practiced in southern Narok.

[Figure 1 here]

2.2. Data collection and sampling

The survey covered a random stratified sample of 149 smallholder farmers with livestock (75 in Nakuru, 74 in Narok). Data were collected in 2007 through individual face-to-face interviews conducted by trained enumerators using a pre-tested (with 20 farmers) structured questionnaire in English or the local language. Because of the complexity of the questionnaire, each interview took about an hour.

The questionnaire consisted of three parts: the first part gathered information about the types of livestock kept, the number of animals of each type, breeding practices, trends in numbers including number of animals bred, bought, sold and that had died over the previous 12 months. Information on income from sales of live animals and animal products was also gathered in this first part. In the second part, data were obtained on the functions fulfilled by livestock (open-ended question with ranking of importance of functions) and on farmers' preferences for specific breeds (open-ended question with ranking of preferred breeds). The third part of the questionnaire dealt with constraints to specific husbandry practices and subsequent changes made. This included the importance of livestock diseases and rate of disease incidence over the previous 12 months, problems with weather conditions and subsequent changes made as well as any other problems farmers had to face as a barrier to their usual animal husbandry. The question on changes also included the adoption of new technologies and innovations over a period of five years (2002-2007) and their likelihood of success. The final part of the questionnaire gained general information about the household, and included questions about age, education, non-farming income, membership of cooperatives etc. We also sought information about the number of visits from any type of extension service to their homes and on visits farmers made to any meeting of extension service providers. We asked about the frequencies of these encounters and the scope of their discussions. We were particularly interested in the type of knowledge that was transferred during these encounters and whether farmers were given advice on new technologies.

2.3. Data analysis

Descriptive data were summarized using frequency classes, means and cross-tabulations. We conducted χ^2 tests and non-parametric Kruskal-Wallis tests to reveal differences in means across farmers in Narok and Nakuru. A multinomial logit (MNL) model was applied to assess relationships between socio-economic attributes, constraints to livestock production, advice given by extension agents and the changes effected by farmers. The MNL model in this case was a baseline-category model (e.g. Agresti, 1990; Chapter 9.1.1) in which the dependent variable y has more than two categories in which pairs of logits of the responses to a baseline are formed. In the model, y was one of the proposed technologies adopted by respondents as recommended by extension services (for frequencies see Figure 3). The dependent variable y was given numerical codes between 0 and 2 as follows:

0 No change made (the baseline)

1 Improved animal husbandry practices

2 Improved animal breeding strategies

The category ‘Improved animal husbandry practices’ (y=1) included the application of manure, proper animal nutrition and improved pasture management, as well as regular application of animal health improvement technologies and finally improved farm infrastructures. The category ‘Improved animal breeding strategies’ (y=2) included the adoption of artificial insemination (AI), even if only temporarily, as well as changes of breeds, improved selection of breeding animals and improvement of breeding plans, not based on AI. The category 0, the baseline, represented ‘no change made/no technology adopted’ (y=0). The model is expressed as:

$$\log \frac{\pi_j(x)}{\pi_J(x)} = \alpha_j + \beta_j x_j \qquad (1)$$

$\pi_j(x)$ is the probability that farmers were in category j out of J possible categories and x_j are the explanatory variables, grouped into three main classes:

- household parameters: district (Narok/Nakuru); education (literate/illiterate); household (small (< 4 persons)/large (> 4 persons) size; source of income (farm or off-farm/employed); age (old/young) and social status (rich/poor) of the respondent.
- production parameters: number of cattle, sheep and goats owned; major constraints to production[1]
- parameters associated with linkages to extension service: expected outcome of technologies adopted[2] and the types of advice given[3]; number of visits by extension services (none, monthly/quarterly/twice a month/weekly or more often); access to credit (yes/no).

The β's were estimated by the MNL model. With three categories two logit functions were estimated: one for y=1 versus y=0 and one for y=2 versus y=0. We further compared y=1 to y=2 by obtaining the difference between the logits of y=1 versus y=0 and y=2 versus y=0 (Hosmer and Lemeshow, 1989; Chapter 8). The odd ratios (ψ_j) were calculated from the fitted MNL model by exponentiation of the estimated slope coefficients (see Formula (1) above; Hosmer and Lemeshow, 1989; Chapter 8). The estimation of the MNL model was achieved via maximum likelihood (ML) (Agresti, 1990) while the standard errors for the estimates of the marginal effects were computed using the delta method. With the exception of number of livestock and age, all explanatory variables were coded as dummy variables i.e. 1/0. Number of stocks and age were coded as the actual numbers. The MNL model implies a certain

[1] We tested the following constraints for all three livestock species: Breeding problems (1), Disease (2), Lack of capital (3), Drought/poor weather (4), Costly animal feeds (5), Expensive labour (6), Lack of knowledge (7), Lack of markets (8), Wildlife menace and thieves (9), Lack of housing for animals (10), Lack of land for grazing (11), Low productivity (12), Transport difficulties (13).

[2] The following expected outcomes were possible: reduced production costs (E1); higher level of production/profit/outcome (E2); reduced mortality/morbidity (E3); reduced labour requirements (E4).

[3] Advice to the respondents by extension services fell into the following categories: artificial insemination (ai) (a1); improved animal health (a2); improved farm structures (a3); pasture improvement (a4); record keeping (a5); breeding/reproductive management (a6); water management (a7); zero grazing (a8); feed supplementation (A9).

pattern of substitution across categories, described by the property of Independence from Irrelevant Alternatives (IIA) (Greene, 2003). To test for IIA violations we applied the test developed by Hausman and Mc Fadden (1984) which involves constructing a likelihood ratio test around different versions of the model where categories are excluded. If IIA holds, then the model estimated on all choices should be the same as that estimated for a sub-set of categories.

3. RESULTS

3.1. Current constraints to livestock production at the farm level

In Narok farmers' two main constraints, drought and disease, accounted for 90% of the total number of constraints mentioned. Disease (Kruskal-Wallis test: H = 9.41, P = 0.0021) and drought (Kruskal-Wallis test: H = 8.04, P = 0.0046) were significantly more often mentioned by farmers in Narok than in Nakuru. In Nakuru the major constraints were fairly evenly spread among disease, expensive animal feeds, lack of capital and lack of markets (Figure 2). The market driven constraints were also significantly different between the two districts: lack of capital (Kruskal-Wallis test: H = 9.04, P = 0.0026); expensive animal feeds (Kruskal-Wallis test: H = 13.27, P = 0.0003); lack of markets (Kruskal-Wallis test: H = 7.86, P = 0.0051). Wildlife menace was a minor constraint in both districts while no farmers saw low productivity as a barrier to their dairy cattle production.

As with dairy cattle production, disease was considered the most severe constraint on sheep production (Figure 2)), and did not differ significantly between the two districts. Farmers in Narok faced drought as a constraint significantly more often than farmers in Nakuru, where no farmer mentioned it as a problem (Kruskal-Wallis test: H = 13.32, P = 0.0003). In Narok only three constraints were mentioned, all related to adverse environmental conditions: drought, disease and wildlife menace. In Nakuru, the most severe constraints other than disease were market driven and included lack of markets, expensive animal feeds and lack of capital. Wildlife menace was also mentioned as most severe in 7% of cases.

Fifty-five percent of all respondents said that disease was the most severe constraint on goat production, a result that is in line with those of cattle and sheep. It was a problem in both Nakuru (56%) and Narok (60%) with concern not differing significantly between the two (Figure 2). Lack of knowledge was considered to be the most severe constraint by 19% of farmers, with those in Narok particularly conscious of it. Drought as a barrier was perceived differently between the two districts (Kruskal-Wallis test: $H = 5.85$, $P = 0.0156$). In Narok, drought was not considered a constraint on goat production at all, unlike for dairy cattle and sheep production, while it was thought to be the most severe constraint in Nakuru. Wildlife menace was mentioned more frequently as a severe constraint than for dairy cattle or sheep, with more farmers in Narok than in Nakuru feeling constrained by it while some farmers in Nakuru also mentioned a lack of markets.

[Figure 2 here]

3.2. Institutional constraints

3.2.1. Access to credit

Only 33 out of the 149 respondents (22%) received financial credit. The amount ranged from Kshs 3,000 to 200,000 with a similar proportion of farmers in each credit bracket (Kshs 3,000-9,999 18%; 10,000-20,000 24%, 20,001-50,000 18%, Kshs 50,001-200,000 18%). The remaining respondents in both districts provided no details or had never received credit. We therefore cannot draw reliable conclusions about whether lack of access to credit impeded livestock production. As stated in the previous section, many respondents lacked capital but it is unclear if respondents tried to access credit, and in doing so were limited by constraints, or if they had never tried. Both credit sources and credit purposes were highly diverse. Respondents said they preferred to obtain credit from co-op and local farmer unions (27%), from friends (18%), the Farm Information System Puani (15%), and the Agricultural Finance Corporation (AFC) (9%). Only 6% obtained credits from banks. Respondents acquired credit for farming and cultivation (18%), education related expenses (15%), animal rearing

(15%), business (12%), and for buying land (6%; 33% of those receiving credit did not say what they used it for).

3.2.2. Farmers' linkages to extension services

Eighty-three percent of all respondents had links to extension services (no significant difference between districts). Most links were with either government agencies or local NGOs, with a few to private companies and international NGOs. Most farmers across both districts were visited at least monthly with three organizations visiting farmers at least weekly. For 48% of farmers this linkage was in the form of training/demonstration seminars or workshops conducted by extension services from NGOs or private companies during which knowledge about innovations/new technologies was disseminated. Thirty percent of farmers visited research stations on so-called 'field days' at which new technologies were demonstrated, 8% of respondents had informal contacts with individual scientists and 7% were contacted during research surveys. For the majority of farmers (86%) the contact with research institutions was organized through farmer groups.

3.3. Changes in livestock production systems and their causes

Over the previous five years (2002-2007) farmers had implemented many changes in their general farming practices. In Nakuru, the number of dairy producers had more than halved over the period 2002-2007 from 65% to 28% (Table 1). In Narok, where the proportion of respondents with dairy cattle was lower than in Nakuru (Kruskal-Wallis test: $H = 18.26$, $P < 0.0001$), this number declined slightly although, the proportion of respondents in Narok who were engaged in dual purpose cattle rearing declined by 24% in the five year period. In Nakuru the number of respondents rearing cattle for both beef and milk remained stable between 2002 and 2007 and was significantly lower than in Narok (Kruskal-Wallis test: $H = 16.95$, $P < 0.0001$). Across both districts 32% of respondents raised sheep and/or goats in 2002 compared with 22% in 2007. This decline was more severe in Narok, where goat and sheep production was significantly more important than in Nakuru (Kruskal-Wallis test: $H = 37.94$, P < 0.0001). In Narok some farmers improved their pasture management by cultivating different grasses and fodder trees (increase of 5%) because the area of land available had declined as human population had increased. Land available for open grazing diminished during the five year period, so many farmers were forced to start cultivating fodder crops for their animals, a practice not traditionally undertaken in purely pastoral systems. In Nakuru not many respondents were engaged in crop production despite the fertile soils. Poultry rearing was almost irrelevant in Nakuru and stayed stable throughout the five year period while in Narok the percentage of respondents producing poultry dropped from 22% to 8%.

[Table 1 here]

Respondents in Nakuru gave marketing problems (29%) and high production costs (15%) most frequently as the reason they had changed their farming practices between 2002 and 2007, while in Narok drought (18%), increased livestock diseases (12%) and a high demand for animals and milk that they could not meet (13%) were most influential (Table 1). Lack of capital affected respondents in both districts almost equally without a significant difference between the two districts. Surprisingly 9% of respondents in Narok ranked 'increased livestock numbers' as the reason for changing farm practices, even though the number of farmers engaged in cattle rearing and dairy production had declined over the previous five years. While fewer farmers were engaged in these two activities, remaining producers may have increased their stock numbers.

3.4. The rate of technology adoption

Thirty-four percent of respondents were given advice to improve animal health, 26% to improve pasture management and 12% to adopt artificial insemination (AI) (Figure 3; black columns signify advises). However the overall adoption rate of technologies about which farmers received advice was at best mediocre with nearly half of respondents (46%) saying that they had not made any changes to their livestock production. These included 34% of respondents who had not implemented any changes despite having received advice. The most frequently adopted innovation/technology (Figure 3; grey columns) related to changes in animal health management (21%), followed by the adoption of AI (13%), changes in pasture management (11%), changes in natural reproductive management, such as selection of better breeding animals and breed substitution (10%), and changes in farm infrastructure (9%). About half of the farmers advised to improve animal health management did so and about a third of those who were advised on how to improve pasture management adopted the recommendations. Advice that record keeping be improved was persistently not adopted, although only a small percentage of respondents were advised to do so. Almost 80% never attempted to keep any form of livestock records and those who did were not those who had been given the advice to do so. Respondents who were given advice on 'breeding and water management' and 'zero grazing' also never implemented these technologies. Some respondents adopted AI although they had not been advised to do so but most of the farmers who adopted AI gave it up after some time or only used it infrequently. Of respondents who gave up AI, 70% said it was because it was either ‘too expensive or not available’.

[Figure 3 here]

Most farmers (81%) adopted a change with the expectation of higher profits/outcome, 18% because they expected to reduce labor costs, 16% because they expected to reduce production costs and only 11% because they hoped to reduce their animals' mortality/morbidity rate. Almost all farmers (93%) who improved their animal health system did so because they expected higher profits from it (Table 2). Many farmers who adopted AI (43%) expected reduced mortality/morbidity and many of those who improved their farm infrastructure (47%) did so with the expectation of reducing labor costs. Only a few farmers adopted changes hoping to reduce production costs, mainly those who adopted AI (17%).

[Table 2 here]

Changes (see Figure 3 and Table 1) were grouped into ‘No changes made’, 'Improved animal husbandry practices' and 'Improved animal breeding strategies’ to estimate the MNL (see chapter 3.3). Because of multiple responses (farmers could have adopted both technologies), 203 observations from 149 individuals were obtained. Forty-six percent of the respondents did not adopt a technology, 38% changed to improved pasture/nutrition/manure management and 16% improved their animal breeding practices. The model fit given by a pseudo R^2 of 0.31 was good (Hensher and Johnson, 1981) (Table 3). Before grouping changes, we investigated if they were independent of each other. The correlation matrix (Table S1 in supplementary material) shows that there was no serious correlation across the changes (i.e. with a correlation >0.70). The highest positive correlation existed between changing the health management and changing the farm structure (r =0.36) and between changing the health management and changing pasture regimes (r = 0.29). On the basis of the Hausman-McFadden test, we found that the IIA property was not violated and the results of the model should not be suspect. This mean that none of the three categories (no change, improved animal husbandry practices, improved animal breeding strategies) can be reasonably substituted with each other because they are dissimilar.

Among the household parameters tested, the district, gender and education were found to influence significantly the probability of adopting one of the two technologies (Table 3). Although the expectation was that, with access to credit, for instance, the probability that respondents adopt new technologies would be high; the source of income was insignificant as was the age and social status of the respondents. Respondents who kept sheep were less likely to adopt both technologies but the number kept was not significant, and nor was the number of cattle and goats. Three out of the four expected outcomes (see footnote 1) significantly affected the likelihood of adopting the technologies; only the expectation of reduced labor requirements (E2) had no significant impact on the likelihood of adopting one of the two technologies. From the list of constraints (see footnote 2) only one for dairy cattle (drought(s)/poor weather) and one for sheep (diseases) were significant and from the list of advised technologies (see footnote 3) only 'AI' and 'Improved farm structure' were significant.

[Table 3 here]

Respondents in Nakuru were less likely ($\psi = 0.23$) to adopt improved health/nutrition/manure/pasture management ($y = 1$) while there was no difference between the two districts in the likelihood of adopting improved breeding practices ($y = 2$) (Table 4). The odds of implementing improved health/nutrition/manure/pasture management compared to improved breeding practices were lower for respondents in Nakuru ($\psi = 0.22$). The odds of adopting health/nutrition/manure/pasture management were more than twice as high ($\psi = 2.40$) for male respondents than for female respondents but there was no difference across gender for the adoption of improved breeding practices. The odds of implementing improved breeding practices were lower for literate respondents than they were for illiterate respondents and the odds of adopting changes in the health/nutrition/manure/pasture management compared to changes in breeding practices were almost three times higher for literate respondents.

Both technologies were less likely to be adopted by respondents who reared sheep ($\psi = 0.22, 0.17$) but more likely to be adopted by respondents who faced diseases as the major constraint on sheep production ($\psi = 4.15, 3.97$). Changes in health/nutrition/manure/pasture management were less likely to be adopted among respondents who faced droughts/poor weather as major constraints on cattle production ($\psi = 0.18$). When the advice to adopt AI (A1) was provided, the odds that respondents adopted any of the two groups of technologies were very low ($\psi = 0.01, 0.04$). While being given the advice to 'Improve farm structures' (A3) did not seem to have any significant influence on the farmers' likelihood of adopting health/nutrition/manure/pasture management, it increased the likelihood of adopting improved breeding techniques ($\psi = 5.72$). Respondents who expected to reduce mortality/morbidity (E4) as an outcome of the change made were 75 times (ψ = 75.19) more likely to adopt changes in health/nutrition/manure/pasture management than those with other expectations. The fact that respondents expected to reduce the production costs/inputs (E1) increased the odds of adopting changes in health/nutrition/manure/pasture management by a factor of five (ψ = 5.08). The odds of adopting improved animal breeding practices over the baseline 'no changes' increased by a factor of 16 (ψ = 16.58) among respondents who expected to reduce mortality/morbidity (E3) as the expected outcome. The odds of adopting health/nutrition/manure/pasture management were higher than improved animal breeding practices for respondents who expected to reduce production costs and reduce mortality from the changes. The likelihood of adopting improved animal breeding practices was lower for respondents who expected higher levels of production (E3) as a result while this expectation had no significant impact on changing the health/nutrition/manure/pasture management. This implies that respondents who expected higher levels of production were the most likely not to change their management practices at all.

[Table 4 here]

4. DISCUSSION

Institutionalized agricultural research and extension have not had the positive impacts anticipated in many developing countries (Anderson and Feder, 2004; Rains et al., 2011).

The most common model to explain farmers’ individual decisions to adopt a technology or not has been the binary choice model. Sharma et al. (2011), one of the few studies to investigate the adoption of multiple technologies, defined the intensity of adoption as the number of technologies adopted by a farmer and regressed the number of technologies against various socio-economic factors using count data models.

4.1. Explaining low adoption rates

Mwacharo and Drucker (2005) concluded that optimization and extension of a breeding program in Southeast Kenya was necessary if productivity was to be boosted in the region. This study, however, demonstrates that, despite delivery of extension, relatively few farmers changed their practices or if they did, few sustained their improvements. Overall about half the farmers tried some of the improvements suggested, particularly those that had the potential to reduce costs, but this figure dropped to just 16% for an intervention like AI, and even then, was practiced only briefly. Our study points to a number of reasons why this might have happened. This can be remedied. Mwacharo and Drucker (2005) found that the adoption of improved breeding strategies among farmers in southeast Kenya can be increased by improving livestock markets and extension services as well as training in knowledge transfer. Similarly Mukuka (1999) suggests that extension still has an important role, particularly in bringing together traditional knowledge and modern technical and scientific knowledge (e.g. Nakashima and Roué, 2002; Sillitoe et al., 2002; Lado, 2004). To bridge the gap it has been suggested that researchers interact directly with farmers, incorporating knowledge from both the developers and the end users of the technologies (Chikozho, 2005) to deliver client-driven approaches to agricultural extension (e.g. Hagmann et al., 1998). Increasingly, the notion of ‘bottom-up’ people empowerment, and a more democratic approach to development, as pioneered by Chambers (1983), has gained acceptance amongst governments and extension agencies.

The first is that, through long experience, the livestock farmers are likely to have been conservative about their livestock management, preferring to hold by community norms when they are unsure about new ideas (Mekonnen et al., 2010). For instance, in contrast to cost reduction interventions, they were relatively uninterested in increasing productivity – in fact the MNL model results suggest that they actively shied away from new approaches that could have increased productivity. This may be that the types of productivity improvements offered tended to be at the more technological end of the spectrum of interventions and often involved in introducing new breeding stock that required additional costs to realize the productivity gains i.e. greater veterinary care and food supplements. Given the frequency of droughts, to which introduced breeds may not be well-adapted, and the prevalence of disease, there may have been a fear that the risk of losing their improved breeds was considered greater than the probability that there would be gains from productivity. Particularly in arid and semi-arid areas like Narok, farmers may well have been aware that the adaptive traits of traditional breeds are likely to result in persistence of their stock through dry years (see e.g. Omondi et al. 2008a,b; Zander and Drucker 2008) when more productive breeds often perish.

The capacity of many of the farmers to understand and implement many of the technologies is also likely to have affected their uptake. For instance, as in Nigeria (Ozowa, 1995), many of the farmers were illiterate so would have been unable to keep breeding records that underpin active management to improve breeds, even if they could afford the stationery on which records would have been kept. Furthermore control of breeding would have required much closer attention to the mating patterns of stock than is commonly the case where many cattle are kept communally, requiring not just the adoption of new technologies but also a change in the social behavior of livestock farmers. This suggests that extension needs to be integrated with education and other support services for farmers if they are to be able to choose effectively the technologies that suit them best.

4.2. Mitigating barriers to livestock production by extension services

We showed that farmers in the two districts faced different barriers to their livestock production. Farmers in arid southern Narok face some constraints that are beyond their control, such as drought, and to some extent wildlife menace. However some barriers said to be a major constraint on farmers in both Narok and Nakuru, such as disease, could be mitigated by providing adequate support. Given that 83% of all farmers had links to extension services at least monthly, and sometimes weekly, suggests that the low rate of uptake of innovation is not because of a lack of contact with extension services but the nature of the message or the way in which it is being delivered.

The results point to various ways in which extension could be made more effective, but it needs to be targeted to the needs of the district. Instead the same advice on, for instance, new breeding technologies etc. was given to all farmers regardless of the district from which they came or the conditions pertaining there. In fact the conditions in the two districts contrasted greatly. For farmers in the densely populated highlands (Nakuru) the major constraints on livestock production were a lack of markets and capital and frequent disease. In the more arid southern Narok droughts and disease were the major constraints on livestock farming. While disease was a common theme, farmers needed quite different advice to solve the other issues.

In Narok disease and drought are so severe that not only had many farmers stopped developing their herds but many had stopped rearing livestock at all. This gradual shift away from pastoralism towards subsistence agriculture may be slowed, however, by increasing knowledge of sheep and goat production though greater training to improve breeding success. Also it is here that the best ways of improving production of local breeds could be promoted, especially among the minority of farmers who had increased the size of their cattle herds. In livestock breeding the best animal or breed is the one fitting the breeding objectives and the farm environment (Bett et al., 2009), yet the advice provided did not appear to acknowledge this.

In Nakuru, where the risk of drought is relatively low, further development of their livestock production through improved breeds could result in long-term gains. However farmers here said that lack of capital was a major barrier to livestock production, so the best way of mitigating constraints on the uptake of innovations may be through greater investment in market development and infrastructure or through offering credit to purchase medication or feed.

4.3. How to increase adoption rates using extension services

Our research suggests that there needs to be much greater knowledge of the livestock farming communities if they are to maintain their livelihoods (see e.g. Tripp, 2001; Reece et al., 2004), especially if droughts become more frequent under climate change. There are various ways in which this could be done. One is to train 'role' farmers from each village to become extension workers (Ozawa, 2009). Another is to engage local farmers and other community members in research on farming practice in their own communities (Garnett et al. 2009). Alternatively it may be possible to develop livestock insurance schemes, modeled on those developed for crops (Dercon and Christiansen, 2011), to reduce the risk of investment in more productive breeds.

However the most important investment is likely to be simply in providing more and more reliable services that follow up on the extension advice. For instance AI was not maintained by many farmers, even though they initially tried the procedure, simply because they could not obtain the necessary technical support as a follow-up to the extension. And to counter disease, the major constraint on livestock production in both districts, extension needs to be followed by the provision of veterinary services, probably subsidized to ensure its availability to the poorest, most vulnerable farmers. Finally farmers are most likely to benefit if the extension services can be better embedded in communities and if they are complimenting traditional knowledge, not replacing it. Targets needs identified by the livestock keepers themselves rather than proselytized by extension workers with little appreciation of local conditions and society. Only 30% of farmers attended so-called 'field days' at which new technologies were demonstrated. Embedded extension could then demonstrate techniques to treat local diseases and ensure recommended medication is administered, could bridge knowledge gaps, identify specific credit shortfalls suggested and promote breeding strategies best suited to local conditions.

5. CONCLUSIONS

We investigated the extent to which new approaches to livestock production were adopted by Kenyan livestock farmers on the advice of extension services. For the farmers disease was the most severe constraint for all types of livestock kept in the two districts studied while low productivity was not considered a major constraint. Differences between districts can be summarized as follows:

- In the poorer district of Narok drought was considered to be the most severe problem for cattle and sheep but not for goats. In Nakuru, drought slightly limited cattle production but did not affect small ruminants.
- Attacks by wildlife had a moderate effect on the productivity of all three species in Narok but only for sheep and goats in Nakuru.
- Lack of knowledge was thought to constrain goat production in Narok.
- Lack of markets and the price of feed constrained dairy cattle and sheep production in Nakuru.

Despite 83% farmers in the study area being linked to some form of extension service, the uptake of advice was surprisingly poor and had little effect on production. Promotion of breeding technologies was particularly ineffective. One reason was probably a failure to match extension advice with local conditions with farmers in both districts receiving the same advice from extension services on how to get better returns from their livestock even though their problems differed. The result was that all but a few farmers in Narok ignored recommendations by research and extension bodies, with advice appearing to lag behind changing conditions. Adoption was better, though still poor, in Nakuru where farmers were more concerned with financial constraints and were more likely to adopt new technologies to increase productivity.

Extension service in the study area might be more successful if they focused on dissemination of diagnostic and disease control measures and provision of supplements to improve animal health and nutrition, building their interventions through empowerment of local communities using local employment in extension and research and by complementing traditional knowledge with their advice. While this study could not establish a significant relationship between access to credit and technology adoption rates, with only 22% of respondents receiving any form of financial credit, adoption of innovations in animal breeding management may be more likely if farmers are financially supported.

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TABLES

Table 1: Changes in farm practices and reasons for changes in two districts in central Kenya between 2002 and 2007 (% of respondents)

	Narok		Nakuru		Total		Significance of difference between districts
	2002	2007	2002	2007	2002	2007	
Changes:							
Crop production	65	70	5	4	35	37	***
Dairy cattle production	7	3	65	28	36	15	***
Beef cattle production	68	42	13	12	40	27	***
Sheep and goat production	58	43	5	1	32	22	***
Poultry production	22	8	3	4	12	6	
Reasons:							
Marketing problems	3		29		15		***
Higher production/ input costs	4		15		9		**
Drought	18		4		11		**
High demand for milk/animals	13		7		10		-
Increased livestock diseases	12		3		7		**
Increased livestock numbers	9		0		5		**
Wildlife menace/security problems	4		0		2		*
Lack of capital/resources	5		7		6		-
Diversification	6		1		4		*
Other reasons	5		8		7		-

*** = 0.01 level of significance; ** = 0.05 level of significance, * = 0.01 level of significance

Table 2: Changes made by farmers in central Kenya as a result of extension advice and the outcomes they expected (% of respondents); multiple responses were possible

Changes made/technology adopted	**Expected outcome**			
	Reduced production costs (E1)	Higher profit/ outcome (E2)	Reduced mortality/ morbidity (E3)	Reduced labor demand (E4)
Manure/ nutrition/ pasture management	5	80	5	29
Reproductive (natural) management	5	84	21	11
Artificial insemination (AI)	17	83	42	8
Animal health improvement	0	93	12	29
Improved farm infrastructures	7	80	7	47

Table 3: Results of a multinomial logit (MNL) model describing factors influencing the adoption of either improved animal husbandry practices or breeding strategies in two districts in central Kenya

Variable	**Coeff.**	**St. Error**	**p-value**
Characteristics in numerator of probability of adopting improved animal husbandry practice [Y = 1]:			
Nakuru	-1.478	0.479	0.0021
Male respondent	0.876	0.428	0.0406
Literate	-0.221	0.549	0.6870
Sheep	-1.502	0.464	0.0012
Drought/poor weather as constraint in cattle production (C4)	-1.721	0.617	0.0053
Disease as constraint in sheep production (CS2)	1.423	0.661	0.0312
Using AI as given advice (A1)	-4.504	1.610	0.0051
Improving farm infrastructure as given advice (A3)	-1.013	0.783	0.1955
Reduced production costs as expected outcome (E1)	1.625	0.492	0.0010
Higher profit / outcome (E2)	-0.412	0.488	0.3978
Reduced mortality/morbidity as expected outcome (E3)	4.320	1.573	0.0060
Characteristics in numerator of probability of adopting improved animal breeding strategies [Y = 2]:			
Nakuru	0.040	0.574	0.9445
Male respondent	-0.207	0.495	0.6755
Literate	-1.279	0.653	0.0503
Sheep	-1.758	0.583	0.0026
Drought/poor weather as constraint in cattle production (C4)	0.461	0.575	0.4230
Disease as constraint in sheep production (CS2)	1.380	0.744	0.0636
Using AI as given advice (A1)	-3.266	1.470	0.0263
Improving farm infrastructure as given advice (A3)	1.744	0.572	0.0023
Reduced production costs as expected outcome (E1)	1.509	0.610	0.0134
Higher profit / outcome (E2)	-0.981	0.564	0.0819
Reduced mortality/morbidity as expected outcome (E3)	2.808	1.691	0.0968
Log likelihood function	-142.64		
McFadden Pseudo R-squared	0.31		
χ^2	127.37		
Degrees of freedom	20		

Table 4: Odd ratios (derived from the MNL model, see Table 3) of adopting changes in either improved animal husbandry (y=1) or improved animal breeding strategies (y=2) in two districts in central Kenya compared to adopting no change (y=0)

Variable	**y=1 vs. y=0 [CI]**	**y=2 vs. y=0 [CI]**	**y=1 vs. y=2 [CI]**
Nakuru	0.23*** [0.09 – 0.58]	1.04 [0.34 – 3.21]	0.22*** [0.07 – 0.51]
Male respondent	2.40** [1.04 – 5.56]	0.81 [0.31 – 2.15]	2.95** [0.05 – 0.31]
Literate	0.80 [0.27 – 2.35]	0.28* [0.08 – 1.00]	2.88* [0.01 – 0.15]
Sheep	0.22*** [0.09 – 0.55]	0.17*** [0.05 – 0.54]	1.29*** [0.02 – 0.17]
Drought/poor weather as constraint in cattle production (C4)	0.18*** [0.05 – 0.60]	1.59 [0.51 – 4.89]	0.11** [0.05 – 0.51]
Disease as constraint in sheep production (CS2)	4.15** [1.14 – 15.16]	3.97* [0.92 – 17.09]	1.04*** [0.37 – 5.79]
Using AI as given advice (A1)	0.01*** [<0.00 – 0.26]	0.04** [<0.00 – 0.68]	0.29*** [<0.00 – 0.17]
Improving farm infrastructure as given advice (A3)	0.36 [0.08 – 1.68]	5.72*** [1.86 – 17.55]	0.06** [0.09 – 1.29]
Reduced production costs as expected outcome (E1)	5.08*** [1.94 – 13.32]	4.52** [1.37 – 14.95]	1.12*** [0.56 – 4.86]
Higher profit / outcome (E2)	0.66 [0.25 – 1.72]	0.37* [0.12 – 1.13]	1.77* [0.04 – 0.32]
Reduced mortality/morbidity as expected outcome (E3)	75.19*** [3.44 – 1641.03]	16.58 [0.60 – 455.94]	4.54** [0.03 – 19.75]

*** = 0.01 level of significance; ** = 0.05 level of significance, * = 0.01 level of significance

CI = 95% confidence interval

FIGURES

Figure 1: Map of the two research areas: Narok and Nakuru in the Kenyan Rift Valley

Figure 2: Constraints to livestock production in Rift Valley Province, Kenya (in percentage of respondents)

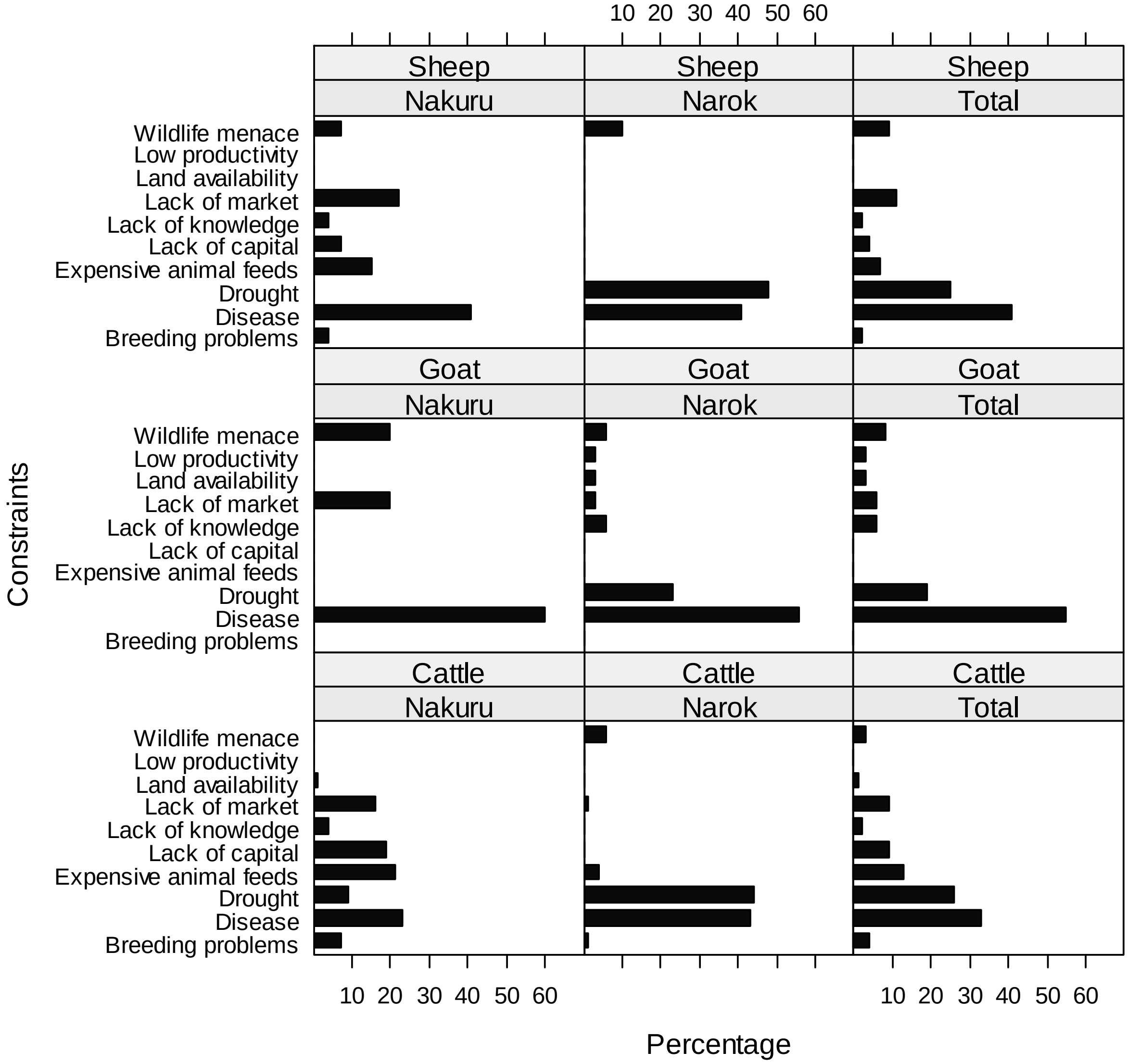

Figure 3: Percentage of farmers in central Kenya receiving advice on different technologies (black) and the percentage adopting them (grey)