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LIVELIHOOD DIVERSIFICATION STRATEGIES, INCOMES AND SOIL MANAGEMENT STRATEGIES: A CASE STUDY FROM KERIO VALLEY, KENYA

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Abstract: African farmers diversify their livelihood strategies through on-farm and off-farm activities. We cluster households according to similar livelihood diversification strategies and explore the implications for income levels and sustainable soil management practices. Five main livelihood diversification strategies were being pursued. Households with off-farm income, and those pursuing higher return agricultural activities earned more than twice as much as the lowest income groups, which were the least diversified. They also were more likely to implement soil conservation measures. Policies aimed at improving household well-being need to take into account a wide range of household asset endowments and livelihood strategies being pursued. Copyright © 2007 John Wiley & Sons, Ltd.

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1 INTRODUCTION

Most rural populations in Africa face both high poverty levels and environmental degradation problems. These are the symptoms; understanding and tackling the underlying causes continues to be a huge challenge for researchers, development practitioners and policy makers. Since the late 1990s, researchers have been exploring the ways in which African households diversify their livelihood strategies, including on-farm (crop, livestock) and off-farm activities, to mitigate risks (Ellis, 1998, 2000; Bryceson, 2002). This research trend resulted in governments and aid agencies formulating policies for

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poverty reduction and sustainable development that recognised how and why African farmers pursue diversified livelihoods (Ellis and Biggs, 2001). A number of conceptual debates and empirical studies have emerged aimed at facilitating and evaluating policies (Ashley and Carney, 1999; Ellis, 2000; Ellis and Freeman, 2004; Homewood, 2005).

One of the contributions of these studies is a better understanding of poverty processes in rural Africa, where the levels of diversification are more extensive than in other developing regions (Anderson and Deshingkar, 2005). Diversification has been understood to be a rational response to lack of opportunities for specialisation. Recent studies indicate that rather than promoting specialisation within existing portfolios, improving returns to existing activities and expanding upon them to augment income could be more realistic and relevant for poverty reduction (Barrett *et al*., 2001; Ellis and Freeman, 2005). Another set of studies conceptualises linkages between poverty and environment using capital asset concepts (Reardon and Vosti, 1995). In studies investigating the decisions of households to implement resource management, the level of capital asset endowment is often assumed to affect the capacity of farmers (Clay *et al*., 2002).

Several recent empirical studies have investigated heterogeneities in livelihood strategies across regions, their association with resource management technologies, as well as the effects of agro-ecological factors, population and market conditions (Staal *et al*., 2002; Pender *et al*., 2004; Kristjanson *et al*., 2005; Kruseman *et al*., 2006). The underlying theme is that natural, physical and social capital assets are key factors that determine livelihood options available to households. However, heterogeneities in livelihood diversification strategies among households sharing similar biophysical conditions and their implications for sustainable natural resource management have rarely been empirically investigated.

Detailed community-level case studies are needed in order to more adequately address policy concerns about poverty and at the same time, environmental sustainability. First, we would like to know what the effects of households' human and financial capital asset levels are with respect to the adoption of relatively high-return, sustainable agricultural activities. Some micro-level studies have revealed that households pursuing highly diverse income diversification strategies, usually including off-farm options, are more likely to take up new farming technologies. These households are relatively well endowed with respect to education and skills (Evans and Ngau, 1991). This implies that for poverty alleviation, meso-/macro-level development policies and strategies need to be multi-sectoral, and encompass education and farm as well as off-farm activities. Second, research at the community level has revealed skewed access to, and dependence on, communal natural resources among community members (Abbot, 2005). Relative to higher income households, lower income groups are more likely to depend on exploiting natural resources for survival while rarely undertaking natural resource management activities. Such unsustainable practices are likely to degrade the resource base of the whole community. These findings suggest that policies aimed at enhancing the diversity and profitability of livelihood portfolios of the poor as well as those aimed at augmenting their capital asset bases may be more effective than efforts solely focused upon restricting access to common property resources as is often the case.

Given the wide variation in assets held by rural households across most rural African communities (Jayne *et al*., 2003), it is useful to develop criteria for categorising households into groups with similar asset bases, welfare status and natural resource management objectives. The appropriateness of one criterion versus another is debatable, while cost-effective means of capturing the livelihood strategies of the poor are required to good policy design (Ellis, 2000). Development agencies have tended to use agricultural resource endowment as a major criterion, but this has resulted in poor categorisation as the relative importance of off-farm income activities continues to increase (Reardon, 1997; Barrett

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et al., 2001; Bryceson, 2002; Tittonell *et al*., 2005). While a household's asset base substantially affects its capacity and willingness to invest in agricultural resources (Kristjanson *et al.*, 2005), even households with similar resource endowments demand different technologies because of differences in preferences, objectives, constraints and incentives attached to certain livelihood activities (Barrett *et al*., 2002; Place *et al*., 2002). Thus a range of observable on-farm and off-farm activities needs to be taken into account when categorising households.

In this paper, we develop an approach for categorising households into important livelihood strategies being pursued in a fairly typical Kenyan mixed crop–livestock farming community located in Kenya's Rift Valley. It is aimed at practical policy formulation as it identifies similar groups of households that can be targeted with appropriate interventions and local policies and actions aimed at alleviating the root causes of poverty and unsustainable natural resource management practices. We identify livelihood diversification strategies of households and link them with welfare status and adoption of soil management practices. The specific objectives of the paper are:

- to identify the main livelihood strategies being pursued and cluster households accordingly;
- to identify the socio-economic factors that explain these major livelihood strategies;
- to investigate how different livelihood strategies affect household decisions to invest in soil management practices;
- to explore local policy and other intervention implications for finding 'win-win' solutions that address both poverty and environmental sustainability concerns and the trade-offs facing households pursuing different livelihood strategies.

2 STUDY AREA, HYPOTHESES AND METHODS

2.1 Study Area

Kenya's diverse socio-economic and biophysical environments provide ample opportunities for research on livelihoods and environment. Tiffen *et al*. (1994) suggested that in central Kenya, diversification and accumulation of capital in the long term helped farmers to respond to environmental challenges under population pressure by adopting sustainable soil management practices. Studies in central Kenya (Evans and Ngau, 1991), south western Kenya (Freeman *et al*., 2004; Freeman and Ellis, 2005) and western Kenya (Tittonell *et al*., 2005) support the idea that diversification into high-return non-farm/off-farm[1] activities enable households to undertake high-return farming activities and to

[1]Some authors prefer the term 'non-farm' activities to 'off-farm', while both terms are often applied in seemingly synonymous ways. According to Barrett *et al*. (2001), farm income is derived from the production or gathering of unprocessed crops or livestock or forest or fish products from natural resources while non-farm income refers to all other sources of income, including processing, transport or trading of unprocessed agricultural, forest and fish products. Farm/non-farm assignment concerns only the nature of the product and the types of factors used in the production process. On the other hand, the distinction between farm income and off-farm income concerns the location where the activity takes place (in the domicile, on the farm premises, in town, abroad). Activities such as formal employment (teachers and officials), business and migrant labour are non-farm as well as off-farm activities. According to the above definition, charcoal making is non-farm because it involves processing of forest products, while temporary agricultural wage employment is farm but 'off' own farm. In this paper, we use the term 'off-farm' to refer to these activities.

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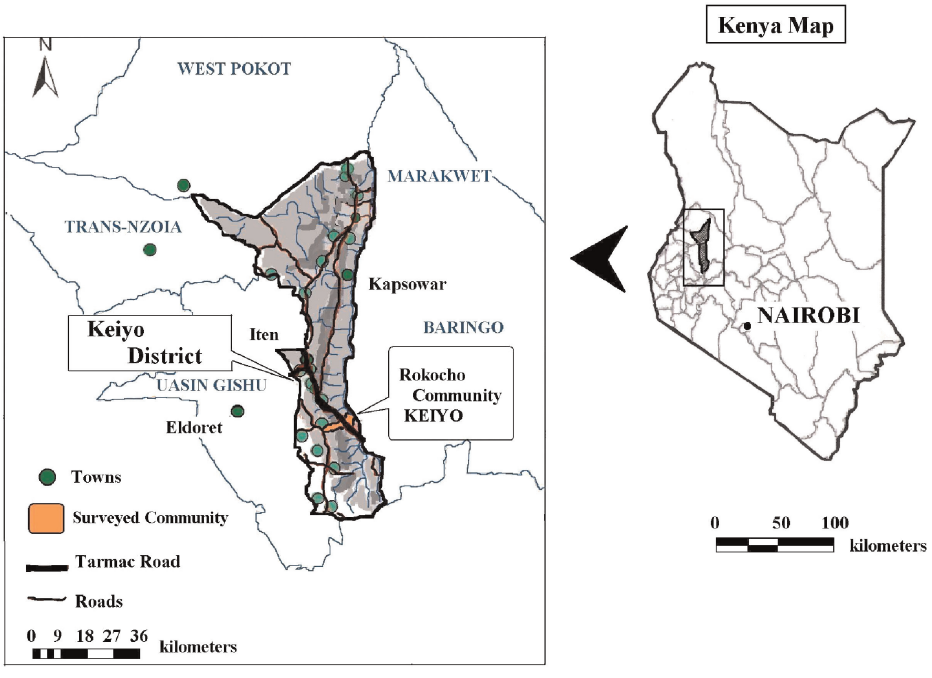

Figure 1. Map of the Study Area. This figure is available in colour online at www.interscience.wiley.com/journal/jid

invest in good resource management practices. In contrast, results from Francis and Hoddinott (1993) and Francis (2000) show that in western Kenya, migrant remittance has promoted investment in education rather than in farming activities due to very limited ability to access urban markets.

Our study area is located in Keiyo District in the Rift Valley Province of western Kenya (Figure 1). Keiyo District can be roughly subdivided into three agro-ecological zones—the highlands (altitude 2500–3000 m) to the west, the escarpment (1300–2500 m) in the central region and the lowland or valley floor to the east (1000–1300 m). This study focuses on households representing part of the valley floor community. Under the customary tenure system, land from the valley floor up to the highlands principally belongs to one clan, thus households in the valley floor sometimes have plots on the escarpment and highlands as well. Clan land is usually subdivided among extended families and further into parcels owned by nuclear families. Before independence in the early 1960s, it was considered unviable to conduct farming activities in the basin since there were no permanent sources of water. After the 1970s, people slowly started to settle in the valley. With the construction of a tarmac road in the mid-80s, non-governmental organisations (NGOs) have stimulated development by providing villagers with training and capital for horticulture and exotic livestock breeds. The water projects have further fostered the development trend (Mizutani *et al*., 2005; Iiyama, 2006a).

Keiyo District consists of 16 sublocations, with each occupied by a different clan. Rokocho sublocation, consisting of 177 households, was randomly selected for this study and a census survey covering all 177 households was carried out. A major tarmac road traverses the sublocation in a north–south direction along which a Christian mission with a training centre is located. The valley floor is warm for most of the year, with temperatures

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varying between 22°C and 31°C. Average annual rainfall ranges between 700 and 1000 mm (SARDEP, 2002). On-farm and off-farm activities are both important livelihood activities in Rokocho sublocation as in other areas in western Kenya (Freeman *et al*., 2004; Tittonell *et al*., 2005). On-farm activities include grain production (maize, beans, and sorghum), horticulture and livestock (indigenous, exotic). Off-farm activities include regular (formal employment, business) and casual (charcoal making) activities, while remittance is less a dominant source of income in the study area, unlike similar case studies in western Kenya by Francis and Hoddinott (1993) and Francis (2000).

2.2 Hypotheses

Even within a small area, households can pursue heterogeneous livelihood diversification strategies. Some may depend virtually solely on crops (often only maize and beans), or mostly on livestock, while others grow crops, have goats and a dairy cow, plus grow fruit and have some off-farm income. We define livelihood diversification strategies as combinations of livelihood activities which contribute to income. Dominant livelihood activities can be further classified into subgroups with different economic returns and resource management incentives.

In identifying target groups, agricultural resource endowment is not a sufficient criterion to categorise households into groups with similar welfare status and engagement in soil management, since most rural households derive a substantial amount of income from off-farm activities (Barrett *et al*., 2002; Bryceson, 2002; Freeman *et al*., 2004; Freeman and Ellis, 2005). Some researchers use both resource endowment variables and proxies for degree of income diversification. For example Evans and Ngau (1991) use non-farm revenue, the number of income sources and livestock asset values separately as proxies for income diversification. Tittonell *et al*. (2005) first attempted to categorise households solely based on resource endowments (land, labour, livestock), but as this resulted in poor categorisation, they added other variables, such as production orientation (self-consumption vs. market orientation), main constraints faced (capital, land or labour), position in farm cycle (age of the head, family size) and main source of income. These criteria are comprehensive but too complicated to be readily applicable for identification of target groups without the use of extensive surveys. Instead, we propose that how a household derives income from a combination of observable activities, that is subgroups of crop, livestock and off-farm activities, with different economic returns and management incentives, is a simpler approach for grouping households pursuing similar livelihood diversification strategies.

At the same time, capital asset endowments of households will also affect their choice of livelihood diversification strategy (Reardon and Vosti, 1995). Within a small area, it is probable that households are relatively homogenous in terms of natural (rainfall, temperature, vegetation) and physical (infrastructure, markets) capital asset endowments. On the other hand, they will be highly heterogeneous in terms of human (labour, skill, knowledge) and financial (land, livestock)[2] capital asset endowments. Indeed, Freeman and Ellis (2005) found that poorer households lacking in education and specialised skills are

[2]While land (or its soil fertility) is often considered as one of natural capital assets, we treat land holdings of a household (whether it owns, hires or borrows), as one of financial capital assets, together with livestock. While the land tenure system in the study area has been customary in that plots have never been registered with formal title deeds, there have been occasional transactions of plots or land can be liquidated.

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compelled to diversify into low-return livelihood diversification strategies in farm and off-farm activities. Access to social institutions and kinship networks, or social capital asset endowments, also defines the constraints and options of households. While much of the social capital literature acknowledges that local elites are better positioned with respect to social capital (Ellis, 1998, 2000), it is difficult for outsiders to measure or interpret differential access to implicit social capital assets between households. In our study, we examine whether a household's choice of adopting a particular livelihood diversification strategy is influenced by their human and financial capital asset endowments, assuming they are relatively homogeneous with respect to natural and physical capital assets, but we do not explore the implications of differential social capital asset endowments.

We then explore whether a household's choice of livelihood diversification strategy helps explain whether they undertake soil management practices such as terracing and mulching. Engagement in market-oriented farming activities may be more associated with intensive soil management practices than engagement in subsistence farming activities, as the former gives households incentives to invest in maintaining the resource base from which they derive income flows. Engagement in off-farm income activities should also substantially influence household investment in resource management (De Jager *et al*., 2001; Place *et al*., 2002; Tittonell *et al*., 2005). Cash flows from off-farm income activities allow households to invest in capital-intensive technology but limit the time allocated to such investment (Morera and Gladwin, 2006). At the same time, the physical characteristics of plots or land that households can access, such as slope and soil type, also affect choices households make in adopting resource management measures (Clay *et al*., 2002; Freeman and Coe, 2002; Place *et al*., 2002; Herrero *et al*., 2007).

2.3 Research Methods and Data Processing

The household survey was conducted between July and September 2006 and consisted of administering a structured questionnaire to all 177 households in the community. The questionnaire was designed to collect variables capturing income-earning activities, household characteristics, soil management practices including mulching and terracing and physical characteristics of the farmland (slopes and soil types) accessible to households.

Major income-earning activities include

- crop: drought-resistant (sorghum, millet), staple (maize, beans), fruits, commercial (wheat, etc.);
- livestock: traditional (indigenous cattle, sheep, goats) or exotic (improved cattle, dairy goats);
- off-farm: regular (business, formal), casual (charcoal making, day labour), remittance.

In the study area, plots were located either on lower or upper parts of valleys, on escarpments or highlands. These locations indicate physical characteristics of farms:

- Lower valley: flat and dry with sandy soils, ideal for staple and drought-resistant crops; livestock graze freely in open areas.
- Upper valley: homesteads are located here on relatively flat to moderately sloped land with sandy and clayey soils; horticulture is currently practised here.
- Escarpment: very steep, but staple or drought-resistant crops are cultivated there.

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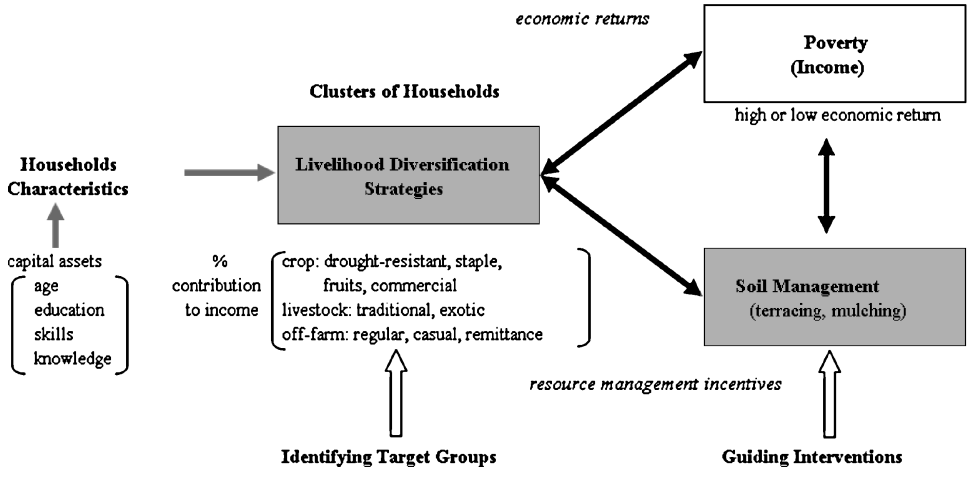

Figure 2. Analytical Framework

- Highlands: moderately sloped, cool with sufficient precipitation, ideal for commercial crops.

2.4 Analytical Steps

The conceptual framework applied in this analysis is illustrated in Figure 2. First, the 177 households were classified into groups pursuing similar livelihood strategies. While livelihoods include not only cash earnings of a household, but also food produced and consumed at home (Ashley and Carney, 1999; Ellis, 2000), we focus here on the income-earning aspects of livelihood diversification strategies (see Subsection 2.2), following the approach of Freeman and Ellis (2005). They developed typologies of household livelihood strategies based on subcategories of income-earning activities (on-farm or off-farm, high-return or low-return). As income from crop and livestock sales arises out of the produce not consumed at home, households earning income have generally already met their home consumption requirements.[3] Therefore, income portfolios also reflect home consumption aspects. In this study, the percentage contribution towards total cash income from each subcategory of livelihood activities[4] was used to group households

[3]Freeman and Ellis (2005) looked at the ratio of home consumption per selected crop and livestock type (such as maize, sorghum, millet, beans and livestock in general). As most crops were found with high shares of the produce consumed at home, subcategories of income earning activities from farming were treated as low-return livelihood activities. In our study area, the home-consumption ratios are very different among subcategories of crop and livestock production. For example the self-consumption ratios for crops (the value of crops consumed divided by the total value produced) are 0.80 for drought-resistant crops, 0.46 for staple crops, 0.11 for fruits and 0.10 for commercial crops. Most milk from indigenous cattle is consumed at home as the production is very little (0.90 L per day) while half of the milk of exotic cattle is consumed at home with the rest sold (produced 2.6 L per day on average)(Iiyama, 2006b).

[4]In calculating 'incomes' from farming activities, gross revenues from crops or livestock products sold were estimated. Crop incomes were measured in terms of the cash value of produce sold or gross revenue, rather than the imputed value of all produce including the unsold part retained for home consumption (see the previous footnote and Iiyama, 2006b) as done by Evans and Ngau (1991). Livestock income was the sum of the cash value of animals sold and the cash value of milk sold. Since we were calculating 'gross' rather than 'net' incomes, costs for crop and livestock activities (labour, purchasing) were not subtracted, since it was difficult to estimate the labour and input costs incurred to earn off-farm incomes (regular, casual or remittance), which should be treated equally with on-farm income earning activities.

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with similar sets of income-earning activities by employing a cluster analysis (Everitt and Dunn, 2001). This approach helps us treat heterogeneous households in different ways in terms of understanding the strategies they are pursuing, which will in turn inform more targeted interventions aimed at enhancing returns to these different livelihood strategies (Solano *et al*., 2001; Kristjanson *et al*., 2002; Rischkowsky *et al*., 2006).

Secondly we examined the socio-economic characteristics of households in each cluster by comparing means of the variables representing household characteristics (age and education levels of the household head, participation in farmers groups, distance from the homestead to a training centre, family size), land size, number of livestock and number of off-farm income activities that serve as proxies for household's human and financial capital asset endowments. Thirdly, we used logistic regression to determine if and how these different livelihood diversification strategies and physical land characteristics influence the soil management measures being implemented.

3 RESULTS

3.1 Dominant Livelihood Diversification Strategies

Cluster analysis was performed using variables representing the percentage contribution to total income coming from crops (drought-resistant, staple, fruits, commercial), livestock (traditional, exotic), off-farm sources (regular, casual, remittance) and land rent. Five clusters or dominant livelihood diversification strategies were identified (Table 1).

Cluster [1] can be described as 'specialisation in casual off-farm activities'. Sixty-one or 34% of the households belong to this cluster. On average, their annual gross income is KSh 36 957[5] (KSh 3000 or roughly U.S.$43 per month). Over three quarters (78%) of their total gross income comes from casual off-farm earnings (KSh 26 589 or KSh 2200/month), 8% from traditional livestock and 5–6% from staple crop and fruits. Their main sources of off-farm income are charcoal burning (KSh 200/bag, 10–12 bags per month) and casual labour (KSh 100/day).

Cluster [2] can be characterised as 'specialisation in traditional livestock'. Twenty-one or 12% of the households fall in this cluster. On average, their annual gross income is KSh 47 625 (KSh 4000/month or U.S. $57 per month). They derive 73% of their total gross income from traditional livestock (KSh 31 687 or KSh 2640/month), 9% from casual off-farm sources and 8% from staple crops. They are considered traditional subsistence pastoralists.

Cluster [3] is made up of households with a 'combination of staple crops and traditional livestock'. Eleven per cent of households (20) belong to this cluster. On average, their annual gross income is KSh 81 500 (KSh 6800/month or U.S. $97 per month). They derive 59% of their total gross income from staple crops, 16% from traditional livestock and 11% from casual off-farm income.

Cluster [4] can be defined as the 'integration of fruits and exotic animals'. Thirty-four households (19%) fall in this cluster. On average, their annual gross income is KSh 96 213 (KSh 8000/month or U.S. $114 per month). They derive 32% of their income from fruits, while 14% comes from exotic animals and 12% from remittances. One of the reasons why the households in this cluster tend to adopt more new varieties, that is horticulture and

[5]US$ 1 was equivalent to KSh 70.

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Table 1. Clusters of livelihoods diversification strategies

	[1] specialisation in casual off-farm income	[2] specialisation in traditional livestock	[3] staple crop and traditional livestock	[4] integration of fruits and exotic animals	[5] specialisation in regular off-farm income
No.(%) of households	61(34%)	21(12%)	20(11%)	34(19%)	41(23%)
Main components					
Crop	Staple	Staple	Staple+++	Fruits+++	Exotic and Fruits
Livestock	Traditional	Traditional+++	Traditional	Exotic	Both animals
Off-farm	Casual+++	Casual	Casual	Remittance	Regular+++
Each component's contribution to total income (%)					
Drought-resistant crop	0.01	0.01	0.03	0.02	0
Staple food crop	**0.06**	**0.08**	**0.59**	0.05	**0.06**
Fruits	0.05	0	0.02	**0.32**	**0.06**
Commercial crop	0	0	0	0.04	0.02
Traditional livestock	**0.08**	**0.73**	**0.16**	0.09	**0.08**
Exotic livestock	0.01	0	0	**0.14**	**0.07**
Regular off-farm income	0	0.02	0.01	0.08	**0.72**
Casual off-farm income	**0.78**	**0.09**	**0.11**	0.10	0
Remittance	0	0.06	0.07	**0.12**	0
Land rental	0.01	0.01	0.01	0.04	0
Mean annual income (KSh/year)					
Crop income	6579[a]	5481[a]	49 237[c]	44 424[c]	27 337[b]
Livestock income	3668[a]	31 687[c]	13 703[a,b]	28 037[b,c]	21 456[b,c]
Off-farm income	26 589[a]	10 400[a]	17 690[a]	22 361[a]	115 295[b]
Land rental income	121	57	870	1391	244
Total gross income	36 957[a]	47 625[a,b]	81 500[b,c]	96 213[c]	163 666[d]

Notes: +++ and the bold values indicate the subgroup of livelihood activities which contribute most to total income.
Superscripts a, b, c, d indicate subsets of clusters which are statistically significantly different from other subsets at the 5% level. A subset with a superscript a has the smallest value and the one with a superscript d has the largest value. Some clusters may overlap over a few subsets.

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exotic animals, could be that they are more exposed to information and knowledge from family members working elsewhere. Horticulture and exotic animals could also be managed in more integrated ways in the sense that farmers are more likely to use manure from improved breeds of animals kept on their homestead plots for growing crops than from traditional animals extensively grazed on communal lands (Iiyama, 2006b; Iiyama *et al*., 2007).

Cluster [5] represents 'specialisation in regular off-farm income'. Forty-one households (23%) fall in this cluster. On average, their annual gross income is KSh 163 666 (KSh 13 500/month or U.S. $190 per month), far higher than the other clusters. They derive 72% of their income from regular off-farm earnings (KSh 115 295 or KSh 9600/month), 7–8% from traditional and exotic animals and 6% from staple crops and fruits. They do not earn casual off-farm income or receive remittances. Employment opportunities in the study area are scarce, and the households belonging to this cluster are among the few who have a household member that is regularly employed or running their own business. Occupations include teaching, brick-making, operating small shops/kiosks, livestock trading, working for NGOs and employment as policemen or security guards.

3.2 Characteristics of Households in Each of the Clusters

In this section, we identify socio-economic characteristics and the human and financial capital asset endowments of households in the different livelihood diversification clusters. The means of the key variables are shown in Table 2. The table also contains analysis of variance (ANOVA) results, *F*-test results showing whether means are statistically significantly different across the clusters and Duncan's Multiple Range Test results showing if the means are statistically significantly different between subsets of the clusters. The results show that, except for total land access,[6] all the other variables are significantly different across the clusters, with most statistically significant at the 1% level.

Among the variables describing household characteristics, household heads of Cluster [5] (regular off-farm income) are the youngest (35 years old), followed by those of [1] (casual off-farm income), while those of [2] (traditional animals) are the oldest (61 years old). With respect to education levels, household heads belonging to Cluster [5] attended school for more years on average (11 years), followed by those of [1] (6 years), [4], [3] and [2], in decreasing order.

Households in Cluster [4] (integration of fruits and exotic animals) were more likely to participate in farmers' groups (47% of the households were group members for an average of 5 years), followed by those in Cluster [5] (regular off-farm income). In contrast, households in the other clusters rarely joined farmers groups.

With respect to location, homesteads of the households in Clusters [5] and [4] were found to be located nearer to a local training centre (18 and 23 min in walking distance respectively) than those of [1] and [2] (32 and 50 min). Clusters [4] and [5] are also characterised by larger households (four adult equivalents (AEs) each[7]) than Clusters [1] and [3].

For other variables, households in Cluster [3] (staple crop and traditional animals) used more arable land (5 acres) followed by those in [4] (fruits and exotic animals) and [5] (regular off-farm), while those of [1] (casual off-farm) and [2] (traditional animals) use less

[6]They include the land acquired through inheritance, purchase, as a gift, and through rental contracts.
[7]A person over 15 is equivalent to 1 AE, 0.65 AE for over 5–14 and 0.24 AE for under 4.

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Table 2. Characteristics of the clusters

	[1] specialisation in casual off-farm income	[2] specialisation in traditional livestock	[3] staple crop and traditional livestock	[4] integration of fruits and exotic animals	[5] specialisation in regular off-farm income	Total	*F*-value[†]
No.(%) of households	61(34%)	21(12%)	20(11%)	34(19%)	41(23%)	177	
Household characteristics							
Age of the head	45.23[b]	61.10[c]	49.55[b]	53.09[bc]	35.46[a]	46.85	11.07***
Gender of the head (male = 1, female = 0)	0.74[ab]	0.71[a]	0.80[ab]	0.68[a]	0.95[b]	0.78	2.66**
Education years of the head	5.52[b]	2.67[a]	4.55[ab]	5.18[b]	10.88[c]	6.25	21.77***
Participation in farmers group (yes = 1, no = 0)	0.08[a]	0.14[a]	0.20[a]	0.47[b]	0.46[b]	0.27	8.14***
Participation in farmers group (years)	0.61[a]	2.33[ab]	2.20[ab]	4.94[c]	3.54[bc]	2.50	5.06***
Distance to a training centre (minutes)	32.38[b]	49.90[c]	21.25[a]	23.09[ab]	17.90[a]	28.06	8.69***
Family labour (AE)	2.95[ab]	3.34[ab]	2.77[a]	3.80[b]	3.64[ab]	3.30	2.19*
Land use and access							
Total land access (acres)	3.69	6.59	9.56	8.80	11.79	7.55	1.38
Total acres used (acres)	1.12[a]	1.34[a]	4.79[c]	3.23[b]	2.47[ab]	2.28	8.45***
Livestock							
Total number of livestock (TLU)	1.63[a]	13.11[c]	6.82[b]	5.44[b]	5.25[b]	5.15	12.10***
Number of exotic animals (TLU)	0.02[a]	0[a]	0.10[a]	2.41[c]	1.44[b]	0.814	14.94***
Number of traditional animals (TLU)	1.59[a]	13.11[c]	6.72[b]	3.05[a]	3.79[ab]	4.33	13.74***
Access to off-farm income							
Regular off-farm (yes = 1, no = 0)	0[a]	0.05[a]	0.05[a]	0.29[b]	1.00[c]	0.30	135.17***
Casual off-farm (yes = 1, no = 0)	1.00[c]	0.33[b]	0.40[b]	0.38[b]	0[a]	0.50	65.75***
Remittance (yes = 1, no = 0)	0[a]	0.24[b]	0.40[c]	0.26[bc]	0[a]	0.12	11.40***

Notes: The superscripts a, b and c indicate subsets of clusters which are statistically significantly different from other subsets at the 5% level.
A subset with a superscript a has the smallest value and the subset with a superscript d has the largest value, while some clusters may overlap over a few subsets.
[†]***Statistically significant at the 1% level.
[a]**Statistically significant at the 5% level.
*Statistically significant at the 10% level.

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land, indicating little engagement in crop production. Households of Cluster [2] own more animals,[8] all of which are traditional breeds, while those of [4] and [5] have more exotic animals in their livestock portfolios. All of the households in Cluster [5] only have access to regular off-farm income activities, while all the households in Cluster [1] only have access to casual off-farm income activities.

3.3 Implications of Livelihood Diversification Strategies for Soil Management

We are interested to see if different livelihood diversification strategies correspond to the use of different soil management techniques, as different crop and animal activities (subsistence or commercial) can be managed with differing degrees of intensification (i.e. input usage), and we are not sure whether engagement in off-farm activities will promote or constrain investment in improvements in soil management. We used a binary logistic regression to test the relationship between terracing and mulching (our dependent variables, yes or no) and our clusters. For explanatory variables, we included four dummy variables to represent the clusters: [1] specialisation in casual off-farm, [2] specialisation in traditional livestock, [4] fruit–exotic animal integration, [5] specialisation in regular off-farm. We excluded [3] (staple crops livelihood pattern) as the control case because this cluster was moderate in terms of the level of specialisation and contained the least number of households.[9] Because the clusters are highly correlated with human and financial capital asset endowments, as was seen in Subsection 3.2, we are able to interpret the effects of human and financial capital asset endowments on soil management through the clusters. The variables representing shares of land by location as proxies for physical characteristics of farmland (slopes and soil types) were also included. Shares of land by location summed up to one. To estimate the parameters, we excluded the share of land in the lower valley, because it is relatively flat and measures such as terracing are less likely to be implemented there. The results are presented in Table 3.

We found that Clusters [4] and [5] are highly associated with terracing and moderately associated with mulching, while Clusters [1] and [2] are not. In other words, households engaged in integration of horticulture and exotic animals, or those that have regular off-farm income activities are more likely to undertake soil management measures than those dependent on low-return livelihood activities. The share of land farmed in the upper valley is strongly related to terracing and weakly related to mulching, while the share of land in the highlands has a slightly positive effect on terracing. Most of the land found in the upper valleys and highlands are moderately sloped, so terracing is very effective. However, little terracing or mulching is occurring in plots located along the escarpment, where it is the most needed, and this may relate to the predominance of subsistence crops.

4 DISCUSSION AND CONCLUSIONS

In this research, we identified the main livelihood diversification strategies being pursued in our study area, based upon the relative contributions to overall income coming from

[8]The total livestock unit (TLU) is calculated as follows: a bull is equivalent to 1.29 TLU, cow 1 TLU, calf 0.7 TLU, sheep and goat 0.11 TLU (Kristjanson *et al*. 2002).

[9]If a socio-economic category is indicated by the use of five dummy variables, one approach to solve the equations for the estimation of the parameters is to arbitrarily set one of the parameters to zero (in this case, cluster [3]). Whatever the type of constraint introduced, it does enable one to obtain unique estimates for the other parameters (in this case, clusters [1], [2], [4], [5]) (Everitt and Dunn, 2001).

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Table 3. Logistic regressions on soil management

	Terracing		Mulching	
% of households undertaking	57%		28%	
Explanatory variables	Coefficient	Odds ratio	Coefficient	Odds ratio
Cluster [1]: casual off-farm	0.644	1.904	0.482	1.620
Cluster [2]: traditional animals	−1.244	0.288	−0.255	0.775
Cluster [4]: fruits and exotic animals	1.383	3.988**	1.485	4.415*
Cluster [5]: regular off-farm	1.955	7.067***	1.736	5.677**
% land in upper valley (near homestead)	1.992	7.327***	1.276	3.581*
% land in escarpment (steep)	0.904	2.469	1.442	4.230
% land in highlands (moderate slope, cold)	2.068	7.911*	1.067	2.906
Constant	−1.866	0.155***	−2.854	0.058***
−2 log likelihood	196.96		187.86	
Prediction rate	72.3		74.0	

Notes:
***Statistically significant at the 1% level.
**Statistically significant at the 5% level.
*Statistically significant at the 10% level.

cropping, livestock and off-farm activities. We found five main livelihood diversification strategies with a wide variation in income levels. The highest gross incomes (roughly $190/month) were earned by households with a member earning a steady income from regular off-farm employment or a formal business. Next were households that were diversified into higher return agricultural activities that included fruits and dairy animals, earning on average $114/month. These were followed by households largely dependent on staple crops, earning $97/month, pastoral households with traditional livestock breeds ($57/month) and households obtaining most of their income from less steady, casual off-farm sources ($43/month). This last, poorest category, also contained the largest percentage of households (34%).

More than half of the surveyed households (57%) fall into the two clusters that are heavily dependent on off-farm income-generating activities, that is Cluster [1] or Cluster [5]. This result supports a trend reported by other authors who found that income inequality between households within many rural African communities has deepened, and is attributable largely to differences in non-agricultural activities and earnings. They suggest that substantial mobility barriers to high-return niches exist within the rural off-farm economy (Reardon, 1997; Ellis, 2000; Barrett *et al*., 2001; Bryceson, 2002; Ellis and Freeman, 2005). In our study area, while many households depend on off-farm activities, organised off-farm labour markets do not exist. Relatively high-paying and reliable formal employment opportunities are limited to a few civil servants, teaching or development agency positions. Many rely on more risky and less remunerative self-employment options. Others enter forests and cut and burn trees to make charcoal whenever in need of cash. Similar findings are reported by Freeman and Ellis (2005) from a case study in southwestern Kenya, where poorer households are engaged in strategies with low-return off-farm activities such as collecting firewood while well-off households are diversified into high-return off-farm activities such as salaried employment. Lack of skills and knowledge and significant barriers to entry for limited high-return opportunities tend to leave the poor with less diversified income portfolios and lower, more variable earnings.

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These livelihood diversification strategies in turn affect decisions by households regarding adoption and implementation of soil management measures. While Morera and Gladwin (2006) found in their studies of Honduras hillside communities that off-farm income activities actually discouraged households from undertaking soil conservation measures, our result was mixed, as we differentiated off-farm income activities into high and low-return categories. We found that households engaged in integration of horticulture and exotic animals, or those that have regular off-farm income activities, are more likely to invest in soil management measures than those dependent on low-return livelihood activities.

They can afford to invest cash in such practices and have also diversified into more commercially oriented crop and livestock activities that require more inputs and management. In contrast, we found that poorer, less diversified households are heavily dependent on utilising trees from forests (Cluster [1]) and grazing their animals on communal lands (Cluster [2]), while typically earning very little from crops or livestock. Low-return combinations of activities and little diversification mean households stay trapped in poverty, and these households are not investing in improved, or even sustainable, soil management practices.

Our findings reveal that human capital asset endowments (knowledge and skills) of households are major factors differentiating the livelihood strategies they pursue, and how successfully they pursue them, from both an income and soil management perspective. We also see that households involved in regular off-farm income activities are more likely to employ soil management measures. Regular off-farm income activities help to provide capital and to mitigate risks when adopting market-oriented on-farm activities, as households can cope with risks inherent in commercial agriculture better than when they depend only on farm activities (Evans and Ngau, 1991). In turn, high-return on-farm activities provide households with incentives to invest in maintaining soil fertility and structure.

How best this knowledge can be translated into action that sustainably alleviates poverty is the next question and not an easy one. A better understanding of what livelihood strategies mixed crop–livestock and pastoral households are pursuing is needed at both national and local levels, however, this knowledge does not guarantee better informed decision making. Our finding regarding the importance of education for the adoption of relatively high-return livelihood strategies, and in turn the correlation of high-return portfolios with investment in improved soil management practices supports the recommendation made by Barrett and others (Barrett *et al*., 2001; Ellis and Freeman, 2005) that national development policies and strategies need to be multi-sectoral, and encompass education and farm as well as off-farm activities.

Given that our households with extremely low-return, undiversified portfolios were found to be more dependent on the use of natural resources while much less likely to pursue sustainable soil management practices, we suggest that interventions and policies aimed at improving the diversity and profitability of livelihood portfolios of the poor, which improves their ability to make such investments, are needed. Strengthening collective efforts aimed at natural resource management, rather than a focus on restricting access to communal natural resources is another policy direction that community members and leaders indicated they would support. In the past, the customary age-set system was used to ensure coordination among community members in the management of common resources, but these days the system is less binding due to communication gaps between the educated and the less/uneducated. In this study we were not able to measure differences in

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access to social institutions and kinship networks across Rokocho households. However, discussions with household members and community leaders revealed that the most vulnerable households are increasingly losing access to social capital assets. Skewed access to social capital assets in turn negatively affects governance of common resources. Community leaders voice concerns that socio-economic differentiation may in the future alienate the poor from the benefits arising from social capital and feel that bringing people together to negotiate and agree upon access rules and enforcement will be more effective than approaches aimed only at restricting access to communal resources.

The methodology used in this study was found to be as effective at delineating and understanding drivers of different livelihood strategies and links to soil management practices as more complicated, time and data-intensive approaches taken by, for example Tittonell *et al*. (2005). Tittonell *et al*. (2005) first attempted to categorise households solely based on resource endowments (land, labour, livestock), but as this resulted in poor categorisation, they added other variables, such as production orientation (self-consumption vs. market oriented), main constraints faced (capital, land or labour), position in farm cycle (age of the head, size of household) and main source of income. The five farm types they derived were in fact very similar to our five clusters and they also found that the wealthier farm types invested more in natural resource management practices. This suggests that categorising households based on the proportion of income coming from various crop, livestock and non-farm activities is a relatively simple but effective approach for investigating livelihood strategies and implications for sustainable management of the environment.

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