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Social perception of soil conservation benefits in Kondoa eroded area of Tanzania

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Abstract

A soil conservation project was implemented in Tanzania for over 30 years. This study applied a socio-economic approach to examine and analyse the benefits of soil conservation in the Kondoa eroded area of Tanzania by conducting a household survey of 240 households. The study findings show that 89% and 70% of respondents consider soil conservation activities have increased vegetation and soil fertility, respectively. Decreased soil erosion was perceived by 68% of respondents, increased firewood by 98%, increased fodder by 50%, high crop yields by 56%, and food sufficiency by 68%. These are the outcomes of conservation tillage, integrated farming and use of organic fertilizers, controlled stall feeding, agroforestry, construction of cut off drains, contour bunds and contour ridges cultivation, which are the main land use practices in the area. Access to extension services, household sizes, long term land ownership, crop incomes and awareness of soil conservation project were found to determine the level of participation in soil conservation. Major challenges are the lack of sustainability of those activities because of a recent policy decision to withdraw conservation investment. Despite the challenge, this study concluded that past government efforts on soil conservation activities initiated since the early 1970s through decentralization, institutional collaboration, socioeconomic support to farmers and continuous local community participation in restoring the degraded ecosystem of Kondoa have contributed to ensure environmental and socio-economic sustainability in the area.

Keywords: Kondoa eroded area; Environmental and livelihood sustainability; Social perceptions; Soil conservation

1. Introduction

Land degradation is a major development problem in most countries despite considerable investment in rehabilitation. It is estimated that 25% of global land is degraded and that affects 1.5 billion people worldwide (Von Braun, Gerber, Mirzabaev, & Nkonya, 2012). In Africa, land degradation affects 46% of the total land area (World Meteorological Organization, 2005). Over many decades, countries and international agencies have been striving to support better land use husbandry to halt land degradation and improve peoples' livelihoods. In Tanzania, more land is vulnerable to soil erosion

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because of unsustainable farming, wildfire, overgrazing and a high proportion of arid, semi-arid and dry sub-humid areas which occupy 61% of the country (United Republic of Tanzania, 1999). Among the areas which are highly affected by land degradation in Tanzania is the Kondoa eroded area (KEA) in the Kondoa District. Severe soil erosion in KEA, particularly in and around the Irangi hills, caused the Kondoa District to enact by-laws in 1968 which prohibited activities, like grazing, cultivation in some areas, cutting of trees and digging water channels without permission. In 1973 the large-scale Hifadhi Ardhi Dodoma (HADO translated as the Dodoma Region Soil Conservation) project was established in the area.

The Project established tree nurseries, planted trees and grasses, established demonstration woodlots, communal bee keeping and used agricultural machinery and human labour to construct cut-off drains, contour bunds and reclaimed land from gullies (Nshubemuki & Mugasha, 1985). It also enforced measures, such as complete expulsion and banning of livestock keeping during 1979–1989 with a view to ensure quick vegetation recovery (Mungo'ng'o 1995). However, small scale zero-grazing had to be re-introduced in 1989 for socio-economic development purpose. Review of HADO showed that the project had a fumbled start under the initial top down approach with physical erosion control measures, tree planting and forced destocking strategies, which caused low adoption of soil conservation measures (Mung'ong'o, 1995; Dejene, Shishira, Yanda, & Johnsen, 1997; Catterson & Lindahl, 1999; Ogle, 2001). However, modification of strategies by employing a community participatory approach and increased project benefits to the local community resulted in more community support for soil conservation activities (Catterson & Lindahl, 1999; Ogle, 2001).

Increased community participation in soil conservation in KEA was achieved through decentralization of tree planting and socio-economic support, like free provision of cattle under stall feeding, materials and education support, and awareness raising (Catterson & Lindahl, 1999). Despite the limitations of HADO the Project succeeded in rehabilitation of the degraded ecosystem of the area and an improvement of livelihoods (Holtland, 2007). Some of the previously reported achievements in KEA included vegetation successions and improvement in child nutrition from increased milk availability and meat from cattle (Ogle, 2001), reduction of gullies, expansion of cropland into restored former degraded areas and increased agricultural productivity (Kangalawe, Christiansson, & Ostbergy, 2008). Conflicts between HADO and local communities have also decreased due to increased forest products and firewood (Holtland, 2007). Similar type of achievements have been reported in numerous West African countries where land degradation controls involving multiple objectives of nature conservation with a wide range of social investments have also contributed to long-term environmental and socio-economic benefits, like soil erosion control, improvised soil fertility, pastures, natural forests, tree planting and fire prevention (Pagiola, 1999).

The operation of HADO activities has been dormant following donor withdrawal in 1996. Currently adoption of measures are the results of policy reforms, which ensures provision of social and economic policies support by extension services, favourable crop marketing and prices for crops, land tenure security, provision of subsidized cattle for stall feeding. Studies have also shown that in many countries, there have been government policy reforms intended to provide favourable crop prices and trade liberalization to ensure increased participation of farmers in controlling land degradation (Pagiola, 1999). Other factors for continuous adoption of measures in KEA include conservation technologies (Kangalawe et al., 2008) since the universal perception of farmers on existence of land degradation problems in KEA also increased adoption of soil conservation measures.

In Tanzania, studies which addressed adoption of soil conservation measures are scanty. There are also limited case studies and literature on the benefits of soil conservation in the Country. Previous findings showed that the education and local institutional developments are the determinants of participation in soil conservation (Tenge 2005 cited in De Graaff et al., 2008). Boyd et al. (2000) identified extension support, policy on decentralization of tree planting and trade liberalization as the determinants of adoption of soil conservation. Kangalawe et al. (2008) examined land use and adopted farming strategies by farmers to mitigate land degradation problems in KEA. Studies examining the extent of people's participation and benefits of soil conservation in the study area are very rare. Understanding whether soil conservation increased agricultural productivity, enhanced soil fertility, food security and farmers' income provides a powerful rationale for their promotion (Kassie, Holden, Köhlin, & Bluffstone, 2008). This study aimed to: i) examine social perceptions of farmers on participation in soil conservation activities and its benefits; and ii) identify the social and economic determinants of soil conservation.

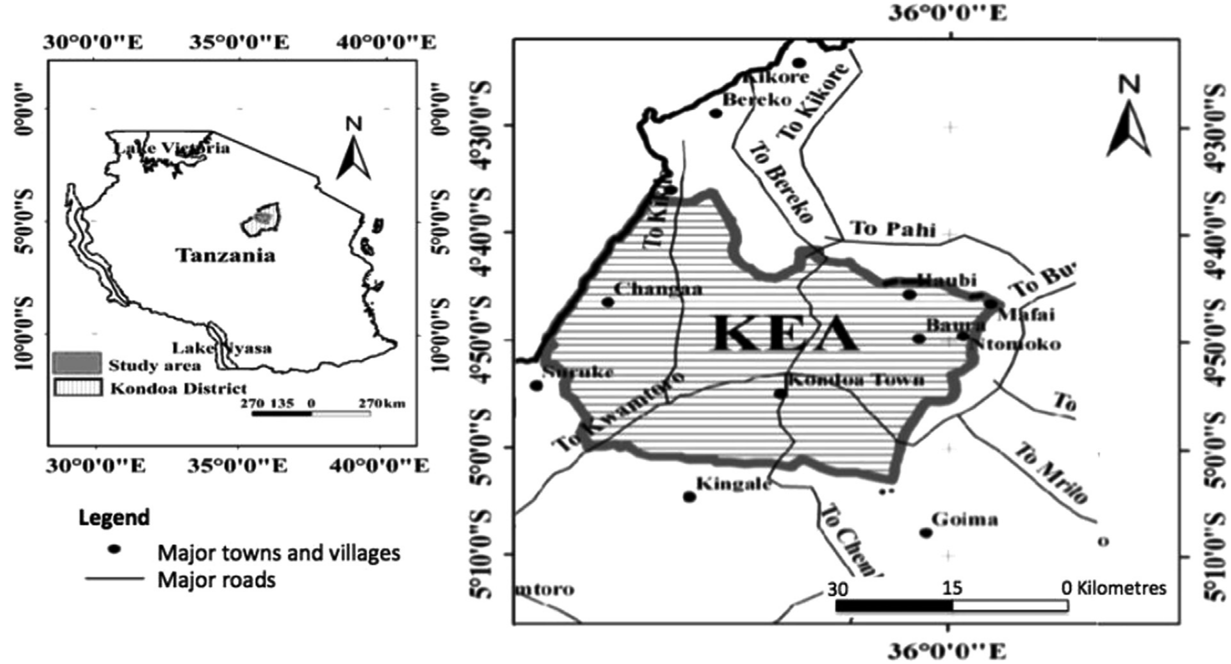

Fig. 1. Location map of the study area.

2. Materials and methods

2.1. Study area

The study area is located in the Kondoa District in Tanzania (4°40′–5°00′ South latitude and 35°40′–36°00′ East longitude) (Fig. 1). The District has an altitudinal range between 1620 and 2000 m above sea level and has a semi-arid to sub-humid climate. Annual Rainfall ranges from 600 to 1500 mm while temperature ranges from 16°C to 29 °C, with evapotranspiration reaching 1500 mm per year (Dejene et al., 1997). Major vegetations are grasslands, woodland savanna, shrub savanna, short trees with patches of closed forest in the Mafia highlands (Backéus, Rulangaranga, & Skoglund, 1994). The major soil types in the area are *Chromic Luvisols, Ferralic Cambisols, Haplic Phaeozems* and *Lithic Leptosols* (United Republic of Tanzania, 1984).

2.2. Field survey and sampling method

Fieldwork was conducted in the Kondoa District from August to October 2010 for data collection. Field work involved a combination of household level questionnaire survey, key informant interview, and direct observation. Key informant interview with village elders, the village executive officer (VEO), HADO and Kondoa District Council officers were conducted to obtain information on implemented soil conservation measures, supporting policies, achievements and challenges. A total of 240 households (10% sample size of households in the study area) were interviewed by administering a structured questionnaire survey. For selecting sample households, a cluster sampling method, which divides each village into clusters of lower, middle and high elevation, was used at the first stage. From each cluster, systematic sampling was used to pick every 10th household for interview. Villages selected for household interview were Baura, Haubi, Mafia and Ntomoko, which represent different conservation intensity, varying soil erosion severity and different land use cover conditions as observed during transect walks. Data collected included household condition, (age, education, family sizes, land holding, types of land use practices, perception of soil erosion, participation in soil conservation, types of applied soil conservation measures and their effectiveness) and perceived benefits of soil conservation, such as change of vegetation cover, rate of soil erosion, soil fertility, and socio economic benefits (availability of manure, fodder, fuelwood, level of crop yields, income from

Table 1
Variables used in multiple regression analysis.

Name of variable	Values labels	Weight	Measurement level
Dependent variable			
Y=rate of participation	Do not know	0.25	
	Decreasing	0.50	
	No changes	0.75	Continuous
	Increasing	1	
Predictor variable			
X_1=Access to extension services	Yes	1	Dummy
	No	0	
X_2=Membership in local institution	Yes	1	Dummy
	No	0	
X_3=Crop income per year (Tanzanian shillings)		Amount	Continuous
X_4=Awareness of HADO Project	Yes	1	Dummy
	No	0	
X_5=Access to market for sales of livestock	Yes	1	Dummy
	No	0	
X_6= Time length of land occupation		Number of years	Continuous
X_7=Household size	1–5	1	
	6–10	2	Discrete
	> 10	3	
X_8=Age of respondent		Number of years	Continuous

Note: US$ 1–1.5888 Tshs (2010).

sale of crops, forest products and livestock and food security). Data on past conditions were collected by asking recall questions.

2.3. Data analysis

The household questionnaire data were analysed using SPSS. It involved calculating simple statistics, such as frequencies and cross tabulation to examine socio-economic characteristics of local communities, participation in soil conservation and its benefits. The multiple linear regression technique was employed to examine the association of socio-economic variables, such as access to extension, crop income per year, awareness of HADO, household sizes and time length of land occupation with level of participation in soil conservation. Ranking technique was used to identify the most effective soil conservation measures using the following equation:

$$I = \sum_{i=1}^{N} Xi.Wi/N$$

where, I=Index of perceived effectiveness of soil conservation measures; Xi=individual conservation measure, Wi=respective weight for effect (very low effective=0.25; low=0.5; high=0.75 and very high=1); and N=total number of responses. Hypotheses testing for identification of some of the benefits of soil conservation were made using the Chi square (χ^2) test of significance of relationship between household food balance with condition of soil erosion and soil fertility, and tree planting as related to construction poles and fuelwood sources.

2.4. Social economic determinants of soil conservation

Multiple linear regression was used to analyse the socio-economic determinants of participation in soil conservation. In Table 1, the variables used as the social economic determinants included: access to extension services (X_1), and membership in local institution (X_2), which tends to provide education for farmers to participate in soil conservation. Sufficient crop income (X_3) tends to increase investment on adoption of soil conservation measures among farmers (Kessler, 2007). Awareness of HADO (X_4), i.e. education and awareness of conservation technologies

Table 2
Socio-economic characteristics of Respondents and Households.

Characteristics	% Households	Characteristics	% Households
Age of respondent (years)		Land ownership	
< 20	1.7	Owned	86.3
20–29	10	Rented-in	4.2
30–39	23.3	Parent's land	7.9
40–49	26.7	Owned and Rent-in	0.8
> 50	38.3	Open land	0.8
		Economic activities (number)	
		1	6.3
Education level of respondent		2	50.4
Adult education	1.7	3	21.3
Illiterate	17.9	4	13.8
Primary	88.3	5	7.9
Secondary	1.7	6–10	0.4
Tertiary	0.4		
Sex of respondents		Household size	
Male	59.6	1–5	47.5
Female	40.4	6–10	50.4
		> 10	2.1

Note: primary education (Grade I–VII); Secondary (VIII–XII).

impacted through the presence of soil conservation projects may contribute to increased investment by farmers on conservation activities (De Graaff et al., 2008). Other factors include access to market for sales of livestock (X_5), time length of land occupation (X_6) whereby those having long-term occupation of land are more likely to have soil erosion control measures in place, such as overgrown trees planted on farmlands. Household size (X_7) determines the capability of the household to engage in soil and water conservation because with increased household size there is a possibility to increase the supply of labour, which is an important determinant of participation in soil conservation (Jones, 2002).

3. Results and discussion

3.1. Socio-economic characteristics of households

The household level socio-economic characteristics are presented in Table 2. Most respondents were above 40 years old who could provide sufficient information on soil conservation. Some 59.6% of interviewed households head were male and 40.4% were female. The level of education in the area is very low. Some 88% respondents have only primary education. Some 18% of respondents were even illiterate and < 2% have only adult education. There is also a marked high population pressure in the area, as half of the households have 6–10 members, followed by those with 1–5 members. Very few households have over 10 members. Most households have two active members, usually husband and wife, one-fifth have three active members, and very few have four or five active members. The greatest proportion of households (86%) owns their farm land and use despite high population pressure in the area. Some 88.3% of respondents were original inhabitants in their villages, 11.7% migrated from nearby villages and districts. Farming ranked high among major economic activities involving 90.4% of respondents. Only 5% of households keep livestock as their main activity, whereas 59% keep livestock as a secondary activity.

Table 3
Regression summary for factors influencing participation in soil conservation.

Unstandardized coefficients			Standardized coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	0.355	0.102		3.465	0.01
Household size	0.372	0.134	0.182	2.774	0.01
Crop income per year	1.051E-7	0.000	0.089	1.357	0.05
Access to extension services	0.123	0.038	0.219	3.256	0.01
Time length on land occupation	−0.020	0.019	−0.072	−1.063	0.05
Awareness on HADO	0.087	0.070	0.082	1.249	0.05

3.2. Social perception of farmers on status of land degradation

Diminishing prime land is a worldwide phenomenon, as only about 11% of global land surfaces are considered prime land suitable for crop production (World Meteorological Organization, 2005). Efforts to control soil erosion in KEA over the past four decades have been able to only minimize the extent of land degradation problems. Farmers are still affected by various forms of land degradation, such as soil erosion, soil compaction, lack of sufficient vegetation cover and low soil fertility. Of the surveyed households, 23.8% said they have fertile soils while a large majority (41.3%) perceived their farmlands are affected by land degradation, soil erosion in particular. Some 4.2% perceived both soil erosion and soil fertility decline, and 5% perceived soil fertility decline alone in their farmlands. Only 24.2% said their lands are not eroded.

3.3. Participation in soil conservation

Some 45% of respondents participated in adopting the soil conservation measures during 1973–1985, <1% in planning, and 41% did not participate at all. Some 2.1% were even unaware of the programme. Low adoption in the initial stage of the project is attributed to non-participatory conservation strategies, particularly inappropriate top down strategies, similar to the experience in Ethiopia as reported by Bewket (2007). Lack of participation resulted in a very low success of the HADO Project until 1989 (Dejene et al., 1997). Low success of soil conservation activities was also an inherent feature of the newly independent government in Tanzania, which found it difficult to enforce colonial adopted soil conservation measures as it denounced during the independence struggles of the 1960s (Mung'ong'o, 1995). Boyd et al. (2000) also reported that until the mid-1980s there was low success of soil conservation activities in Tanzania due to early political factors and policies, like abolition of chieftainship administration and agricultural price control. It is only after the mid 1980s, decentralization of tree planting, environmental education, social economic supports, such as subsidized stall feeding cattle, equipment supplies for soil conservation and free tree seedlings contributed to increased participation in soil conservation and this improved livelihoods and environmental sustainability in KEA (Catterson & Lindahl, 1999; Boyd et al., 2000). It was during that period (1986–1996) when more resources were directed towards socio-economic support for soil conservation, most respondents (53.8%) participated in implementation of soil conservation measures, and an additional 15.8% were involved in both planning and implementation. Yet 23.8% respondents did not participate.

Despite the defunct HADO Project in 1997, still 82.5% of the respondents mentioned that they participated in soil conservation during 1997–2010, and only 13.8% did not participate. Some 38% of households have increased their frequency of participation in soil conservation activities since then, 26% have decreased, and 22% have the same level of frequency in participation. Currently, increased adoption of soil conservation measures is the outcome of sectoral policies in agriculture, forest and livestock that emphasized socio-economic support to farmers by increased extension services, community awareness and education, and increased livelihood support, such as subsidized cost of cattle under zero grazing or stall feeding conditions. The increased participation in soil conservation in the area showed that farmers are determined to overcome problems of soil erosion and improve productivity, as also portrayed by land rehabilitation in the highly populated area of Machakos in Kenya (Tiffen et al. 1994 cited in Kiome & Stocking, 1995)

3.4. Factors of participation in soil conservation

3.4.1. Socio-economic determinants of soil conservation

The changes in biophysical soil erosion and their impacts can best be validated by supporting evidence from their social causation (Warren, Batterbury, & Henny, 2001). A bivariate correlation analysis found five out of eight variables significantly correlated with the dependent variable, i.e. participation in soil conservation. A multiple linear regression technique, which determines the association between correlated socio-economic variables and level of participation in soil conservation found that five independent variables (namely household size, annual income from crops, access to extension services, length of time of land occupation, and awareness of HADO) were the significant factors influencing participation in soil conservation (Table 3). The model was significant overall, however the obtained coefficient of determination (R^2) of 0.122 indicates a slight association between predictor variables and level of participation in soil conservation. As shown in the model, higher household size has an association with increased rate of participation in soil conservation, this may be attributed partly to increasing labour supplies, which provide capacity for farmers to adopt soil conservation (Jones, 2002). The variable crop income per year also has an association with rate of participation in soil conservation and this is supported by the argument that the agriculture and livestock should generate income for the farmers to be able to implement conservation measures (Kessler, 2007). Low crop prices before trade liberalization of the mid-1980s reduced incentives for soil conservation in Tanzania (Crees, 2000). However, trade liberalization and the national agricultural policy of 1997, which facilitates crop marketing, has contributed to improvement of farmers' income and increased conservation incentives. For example, every Sunday crop markets, which gather farmers for trade in the core area of KEA at Haubi village, help increased farmers income and part of which invested back in soil conservation through purchases of manure to improve soil fertility.

The variable extension service also has a significant positive correlation with level of participation in soil conservation in the area. Despite the district Council and the HADO Project with a limited number of extension officers, most respondents (59.2%) still acknowledged receiving extension service support. Unlike KEA in central Tanzania where extension support facilitates soil conservation, Boyd et al. (2000) found that limited access to extension was a key constraint to soil water conservation in northern Tanzania and in the Katakwi District of Uganda. In KEA, farmers received more extension during HADO and under the 1997 agricultural policy as both emphasized provision of extension services. The Tanzanian Government agricultural policy of 1997 was successful in achieving its objectives, which focuses on provision of extension services to small farmers, especially through District Agriculture Development Plans, as this aims at improving agricultural productivity to raise income and improve household level food security, improve the quality and quantity of livestock products through appropriate extension services, including on farm visit training.

Awareness of the HADO Project also has a significant association with increased level of participation in soil conservation. Findings from this study showed that the overwhelming majority of respondents (93%) were aware of HADO soil conservation activities and only 7% of respondents were not. High awareness of HADO is attributed to government policy on education and the awareness programme stipulated and implemented under the second HADO master plan (1986–1996). The master plan stipulated that "*The education and extension programme proposed in the HADO second master plan could have the greatest spin off benefits in making the people aware of the gravity of land degradation problems and in making them participate fully and accept the sacrifices involved*" (United Republic of Tanzania, 1984). Such political statements in turn play an important role for land users to recognize their vital roles in ensuring sustainable land management. The HADO training programme also ensured that district agriculture, livestock and forest officers received training in conservation technologies and communication skills, which helped to improve their capacity to deliver soil conservation knowledge to the local communities throughout Kondoa District.

3.4.2. Perception of famers on the effectiveness of conservation measures

Adoption of soil conservation is influenced by knowledge of conservation measures and perception of the effectiveness of measures to control soil erosion and improve productivity. In the study area, contour cultivation ranked as the most effective conservation measure followed by grass cover, stall feeding, cut off drains, tree planting,

Table 4
Effectiveness of soil conservation measures.

Conservation measures	Effectiveness of measures				Sum of Index	Rank
	Not effective (0.25)	Low (0.5)	High (0.75)	Very high (1.0)		
Contour ridges ($n=88$)	0	0	16	72	0.955	I
Cover grasses ($n=58$)	0	2	22	34	0.888	II
Stall feeding ($n=118$)	0	7	53	58	0.858	III
Cut off drains ($n=108$)	0	18	27	63	0.854	IV
Tree planting ($n=84$)	0	7	42	35	0.833	V
Destocking ($n=53$)	2	14	16	21	0.764	VI
Grass strip ($n=22$)	1	1	17	3	0.750	VII
Mulching ($n=3$)	0	1	1	1	0.750	VIII

N=number of multiple responses.

destocking, grass strips and mulching (Table 4). The relative high rank of grass cover matched with the result of land cover classification, which shows an increase of grassland vegetation, especially along gullies and sand fans. Contour ridges also ranked high because it is the traditional method of cultivation widely used in Tanzania. Stall-feeding is a requirement for every household in KEA, and this leads to the confinement of the livestock owned by households on their farms resulting in farmers planting more grass for fodder in their farms. This serves to protect gullies and sand fans from soil erosion.

3.5. Land management practices for soil conservation

In this study, three broad categories of land management practices have been identified as contributing factors to increased participation in soil conservation in KEA.

3.5.1. Conservation tillage

Traditionally, cultivation in KEA involved slash and burn with over 20 years of fallow by planting crops on land without tillage (Christiansson, Mbegu, & Yrgard, 1993). Increased population has caused a reduction in length of the fallow period and with the HADO strategy promoting land for cultivation along with policy formulation banning free grazing, made slash and burn cultivation economically and environmentally unviable. This study found that increasing numbers of people are practicing permanent cultivation, as only 2% of the respondents practice shifting cultivation. Permanent agriculture in the form of minimum tillage is practiced by 44.2% of respondents, no-tillage by 21.3%, contour ridges by 20%, contour ridges and minimum tillage by 4%, and deep tillage by 9% of respondents. In KEA, no-tillage and minimum tillage farms are protected from soil erosion by constructing cut off drains in the upslope and trees are planted on the margins of farms. Unsustainable management of physical erosion control structures, such as lack of adequate maintenance and protection of cut off drains, has been serious in the area as these structures constructed with donor funds and with the cessation of fund (Jones, 2002).

3.5.2. Increased use of organic fertilizer

Most farmers (76%) in Kondoa District use organic fertilizers comprised of plant and animal residues. Some 3% households use chemical fertilizers and compost along with practicing crop rotation, whereas 18% do not practice any fertilization. Most farmers believe industrial fertilizers cause further worsening of land degradation. Farmers in Ntomoko and Mafai villages use *in-situ* green manure and compost buried in the ridges to increase yield of sweet potatoes and maize. These villages are leaders in construction of contour ridges with 72.2% farmers following such practice in Ntomoko and 27.5% in Mafai compared to only 10% in Haubi village. The objective of using contour ridges is to control soil erosion and increase crop yield. Like in other parts of the world, farmers have been reported to address economic viability before environmental sustainability (Warren et al., 2001). In Haubi village, for example, biophysical and social constraints, such as land shortages and overpopulation, made farmers reject widespread contour ridges as they feel it reduced cropping space resulting in reduced crop yield. The situation in Haubi village corresponds with the findings of Jones (2002) in highlands of

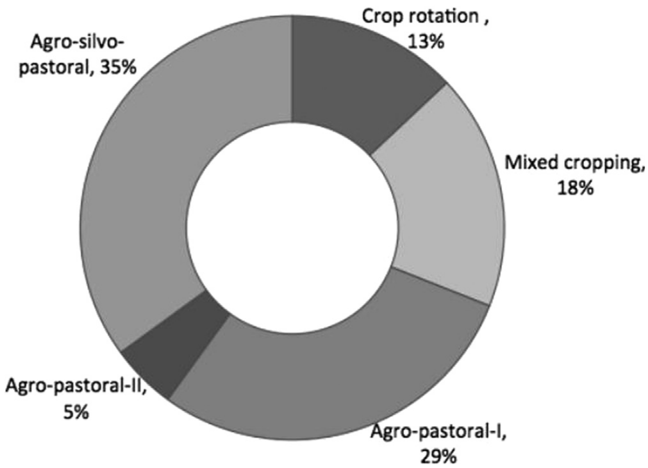

Fig. 2. Farming practices by respondents.

Tanzania and Thailand, which showed that whenever land is a limiting factor, any soil conservation measures which may deprive farmers of cropping area are unlikely to be implemented.

3.5.3. Integrated farming and agricultural diversification

In most tropical countries crop diversification and sustainable farming were widely practiced by traditional farmers before contact with the outside world (Mung'ong'o, 1995). Such sustainable farming practices included the long fallow in shifting cultivation practiced in several areas, including the Kondoa district (Östberg & Sleger, 2010) and sustainable fallow land management in South East Asia (Burgers, Ketterings, & Garrity, 2005). Later, intensified cultivation was favoured over integrated farming. The intensification has increased agricultural output considerably, although there are ever increasing issues of social and environmental sustainability in developing countries. This is partly because of severe land degradation and a low capacity to obtain external inputs in traditional cultivation in most tropical countries (World Meteorological Organization, 2005). Therefore, social and economic hardship and negative effects of monoculture cultivation and over-grazing forced most farmers and national governments in the tropics to return to agricultural diversification (Michon & de Foresta, 1999). In KEA, increased land degradation associated with overpopulation, overgrazing and unsustainable cultivation caused social and economic hardship. Thus, several political decisions were made about the area, including resettlement and forced destocking. However, the best option in the long run was to introduce integrated farming involving agroforestry practices and small scale zero grazing. Farmers have adapted to the transformation of agriculture and livestock keeping by abandoning the destructive intensification form of crops and livestock keeping in favor of small manageable herds and crop diversification.

The leading forms of integrated farming practiced in KEA is agro-silvo-pastoral as practised by 34% of households followed by Agropastoral-I by 29%, mixed cropping (pigeon peas and maize) by 18%, crop rotation (sweet potatoes-maize) by 13%, and Agropastoral-II by 5% (Fig. 2). Agropastoral-I includes animal integrated with seasonal and perennial crops, and livestock are stall fed throughout the year, Agropastoral-II includes seasonal crops and animals, but the land is used for pasture after crops are harvested. Major crops grown in the mixed farming included maize by 99% of respondents, pigeon peas by 67%, millet by 41%, sunflower by 30%, beans by 30%, sweet potatoes by 25%, ground nuts by 6%, and cassava by 5%. Maize, sweet potatoes and pigeon peas are preferred by most farmers because they are major food crops and are easily marketed. Maize is mixed with millet to mitigate moisture constraints during drought, as millet is drought resistant and can survive, but also the association of the two crops contributed to increased maize yields. In northeast Thailand, intercropping maize with green manure, such as pigeon peas, contributed to improved soil quality and a significant increase in yield (Cho, 2003).

In terms of agroforestry practices, only 47% of respondents planted trees in the area. Key informants in Ntomoko village stated that most farmers did not plant trees on their farms in the fear of being evicted from their farms by the Forest Department after afforestation. In Haubi village, farmers also stated that shortage of cropping land prevented them from planting more trees, a common phenomenon in most parts of the world, whereby the social and economic dilemma between allocating more land and capital to conservation or to increase crop production for socio-economic development usually constrained adoption of soil conservation measures (Duff et al., 1990). However, past efforts by the Swedish International Development Cooperation Agency (SIDA) and HADOs' Agroforestry Programme provided lessons for agroforestry practices and its benefits, which resulted in increasing numbers of farmers requesting more government support for tree seedlings for planting on their farms.

The most favored trees species included *Gravillea robusta* planted by 42% of respondents. Other planted trees species included, eucalyptus, acacia, orchards and elephant grass. Elephant grass is widely used for stabilization of gullies and also as animal feed. In terms of livestock keeping, 68% of respondents own grazing animals. The socio-economic characteristics of local people in KEA is dominated by agro-pastoral activities and hence most people started to practice zero-grazing immediately when livestock keeping was re-introduced in 1989. Hence, cows, goats, sheep and donkeys formed important components on the farm. The decision made in 1979 to declare KEA as a non-livestock zone had to be reversed after 10 years to allow controlled or zero grazing in the area due to the importance of livestock components in agro-silvo-pastoral ecosystems and the contribution of grazing animals in the social development of land users. Some 31% of households adhere to the limit of a maximum of four cows allowed to be kept by a household under the Kondoa District environmental by-law of 2009 (Kondoa District Council, 2009), whereas 32% do not have cattle, 26% own 5–10 cattle, 5% own 11–20 and another 5% own 21–40 cattle. The tradition of local communities, which considers livestock as essential components of local socio-economic development, contributed to increased return of illegal grazing animals in the areas after withdrawal of HADO Project activities.

3.6. Social perception of the benefits of soil conservation

3.6.1. Improvement in vegetation cover

Most (88.7%) respondents perceived increased vegetation as explained by vegetation recovery, increased tree populations, grass cover, agroforestry and secondary forests regeneration while 11.3% respondents did not perceive any change in vegetation biomass. Most farmers acknowledged an increased vegetation cover justified the political decision of 1979 destocking and HADO Project for afforestation and agriculture transformation by replacement of overgrazing and over-cultivation with conservation form of agriculture. However, studies showed increasing destruction of vegetation cover in KEA. A decline of timber forest species has occurred in the area due to commercial harvest of woods. A lack of protection of natural vegetation from activities, like overgrazing, has caused woodland decline since 1995 (Dallu, 2002).

Recent deforestation may be attributed to political factors, which encouraged soil conservation through establishment of HADO for sustainable management of agriculture, forestry and rangeland in KEA. Deforestation has been driving land degradation due to a government political decision to withdraw support to HADO soil conservation activities. The withdrawal of government investment of soil conservation in KEA has occurred without building local institutional capacity to take over management responsibilities and ensure sustainability. There are cases of dealing with such situations, for example in India, poor management of the cardamom forest by the central government was addressed by Joint Forest Management (JFM) between the Government and the local people by sharing forest products between each party (Gebremedhin, 2004; Burgers et al., 2005). The forest policy of 1998 in Tanzania provisioned the participatory forest management (PFM) approach which could be a way forward to rescue forest and woodlands from complete depletion in KEA.

3.6.2. Reduction of soil erosion and enhancement of soil fertility

This study found that decreased rates of soil erosion was confirmed by 68% of respondents, however 32% indicated that soil erosion has not decreased. Similarly, 70% of respondents perceived that soil fertility has improved. Main indicators of increased soil fertility described by farmers included high yields, healthy vegetation, increased soil organic matter contents and soil depth. This implies that soil conservation initiatives have contributed significantly in improving soil fertility and reducing soil erosion and, in turn, has improved crop productivity and livelihoods.

3.6.3. Improvement of livelihoods

The study results revealed that 50% of respondents obtained fuelwood from domestic sources, like farmlands, village woodlands, and collecting deadwood in the HADO plantation forest, whereas 48% get firewood from the wilderness in the vicinity (Fig. 3). Some 98% of households thus get fuelwood from their own farms and homesteads. The existing benefits in KEA owe much to the efforts in tree planting in the HADO Project. There is a significant relationship between tree planting and fuelwood sources ($\chi^2 = 104.53$, $p < 0.001$, df=5), indicating that an increased tree planting also increases fuelwood. In sub-Saharan Africa, women walk very long distances to obtain firewood, but in KEA the problem is minimized to some extent because they collect fuelwood from village woodlots, farm lands and nearby wilderness. There is also a significant relationship between tree planting and source of construction poles ($\chi^2 = 78.176$, $p < 0.001$, df=8) indicating that an increased tree planting also influences increased availability of construction poles. Field observations in Haubi villages showed that there is widespread harvesting of *Gravillea robusta* trees for timber processing and transportation for sales in Kondoa town. It was also observed that very limited efforts have been put in to replacing the harvested trees by planting additional trees because most tree nurseries are not active since withdrawal of HADO.

Most households use fodder from their own farms while a few get fodder from their farms and off-farm sources. Only a small proportion of households completely collect fodder for livestock from off-farm or wilderness. Some people have moved their livestock to the lower steppe of Irangi hills for free grazing (Fig. 3). The HADO Project attempted to integrate stall-fed livestock and crops in the same field and by leaving patches of natural regenerated vegetation to grow as fodder banks. This has contributed to increased availability of animal feeding from within the agricultural lands and surrounding areas. Support to local communities in planting fodder in KEA begun to emerge in the 1990s following the establishment of a stall-feeding heifer cattle project by the Swedish Agency for Research Cooperation with Developing Countries (SAREC). Records from the HADO Office in Kondoa shows that by 1993, only three years after reintroducing stall feeding cattle, over 40 ha of fodder multiplication plots were established (Mbegu, 1993). The social implication of destocking and later small scale zero grazing was the realization of more social benefits, like improved education due to releasing the work burden of children who now attend schools rather than herding grazing animals in distant pastures. The area now has a high literacy rate (82%) compared to the national average of 72.5% (United Republic of Tanzania, 2009).

3.6.4. Productivity and food security

The average farm size in the study area is 0.81 ha and average household size constitutes of five members. Most respondents (56%) perceived that crop yield has increased due to improved soil fertility in their farms. Maize yield per ha was 1.48 t and per capita maize production was 120 kg, which is above the Tanzanian national per capita average of 112 kg. The number of people having a relatively surplus maize production are also high because only 28% of respondents obtained 0.5–1.48 t per ha, while 49% of respondents obtained 1.97–2.96 t, 22% obtained 3.45–4.94 t per ha.

The majority of households (68%) have sufficient food balance throughout the year. Some 17, 5 and 10% of households have food sufficiency for 9, 6, and < 6 months, respectively. It was observed that there is significant association between household food balance and reduction of soil erosion rate ($\chi^2 = 13.96$, $P < 0.01$, df=3). Household food balance and soil fertility increase were also found to have a significant association ($\chi^2 = 38.19$, $P = 0.01$, df=3). Increase of food production and income are also attributed to a growing number of livestock keepers over time. For example in 1989 only 13% of people owned livestock in KEA (Mung'ong'o, 1995) compared to 68% in 2010, however increased livestock numbers could have negative consequences to environmental degradation if the livestock population is not managed.

3.6.5. Income and wealth gap

In terms of income, findings show that average per capita income in KEA villages is ~145,669 and 195,000 Tanzanian Shillings (Tshs) from agriculture and livestock sales, respectively[1]. Both of these income levels are higher than the district average of 130,000 Tshs (Kondoa District Council, 2010). Social networking has also been developed by farmers in an attempt to mitigate destocking, whereby households with larger herds tend to distribute their animals to friends and relatives outside KEA (Mung'ong'o, 1995). It is because the distribution of animals helps to distribute benefits of livestock, such as ox-plough, milk and meat for improvement of child nutrition, as well as an increase of manure and income in a wider spatial area of the Irangi hills with much benefit going to women who manage milk processing and sales.

[1] 1 USD=1,588 Tanzanian shillings (Tshs) in 2010.

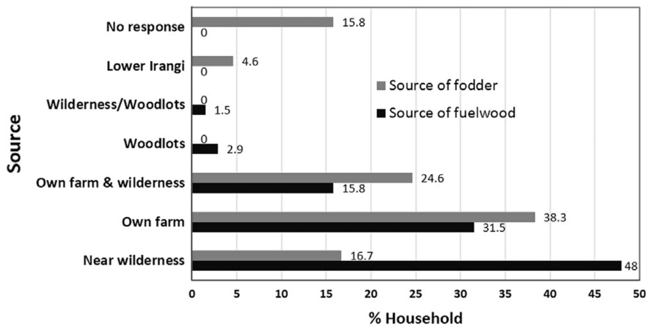

Fig. 3. Sources of fuelwood and fodder.

4. Conclusions

This study demonstrated that government interventions and local peoples' participations are essential in controlling soil erosion. Increased participation in soil conservation in KEA is associated with increased access to extension services, household sizes, and awareness of the HADO soil conservation project, long-term land ownership and crop income. Past government efforts and continuing community participation in soil conservation through conservation tillage, integrated farming and use of organic fertilizers, agroforestry, construction of cut-off drains, contour bunds, contour ridge cultivation and controlled stall feeding have contributed to ensuring environmental and socio-economic sustainability. Farmers perceived that soil conservation practices have reduced soil erosion and increased vegetation density, soil fertility, crop yield and income. It has also increased access to livelihood needs, such as wood products, fodder, and food security and in turn has contributed to improvement of nutrition and education, increased social networking and reduced women workload.

It is, however, also evident that some policies, such as withdrawal of conservation investment by the central government, without building local capacity to take over management responsibility, have resulted in overgrazing, over-cultivation and uncontrolled commercial logging. This has undermined the past successes and now is negatively impacting the environment and livelihood sustainability. Despite that, it can be concluded that soil conservation activities including agriculture transformation in favour of agroforestry and crop diversification have contributed to improvement of land cover and ensuring environmental and socio-economic sustainability in the area. The breakdown of centralized conservation activities can be addressed by enhancing local community based participatory approaches (Michon & de Foresta, 1999) and this requires efforts to enhance the socio-economic factors that determine increased participation in soil conservation, such as extension services, education and awareness, and participatory forest management.

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