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Environmental Degradation, Local Perceptions and Implications on Land Management in the Irangi Hills, Central Tanzania

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Abstract

This paper presents findings from a study conducted in three villages in the Irangi Hills in central Tanzania between 1994 and 1996 to examine land degradation, local perceptions and the diversity of approaches that local communities use in land resource management, including soil conservation. Both participatory assessments using PRA, and quantitative methods including household interviews and soil analysis were employed to obtain qualitative and quantitative information pertaining to the biophysical and socio-economic factors influencing management of land resources. The findings from the study indicate that the local people are aware of land degradation processes that are explained using various indicators. Despite the reported awareness of land degradation, little or no deliberate efforts were taken by the local community to rescue the land from severe degradation before conservation activities were started by HADO project in the early 1970s. This was due to limited technical know-how, labour constraints, interference of conservation structures with farm operations, and social-political environments associated with negative attitudes to conservation inflicted during the colonial period. The limiting factors to local participation in soil conservation initiatives would be successfully corrected through proper farmer-education that inculcates the culture of conservation among communities. Thus, to enhance sustainable resource management necessary steps should be taken to incorporate the diversity of the attitudes and socio-political environments among rural communities.

Introduction

One of the issues gaining importance in land/soil management is the implication of different local environmental perceptions on resource management. In southern Africa, where many researchers are engaged in land management and conservation issues, a few have included the aspect of perception and its influence on resource management by different groups of a society (Hackel, 1990; Hunter et al. 1990; Whyte 1977). In Lesotho, for example, understanding of the causal links of soil erosion over time was enhanced by interviewing local people about their perception of the past and present situation (Showers & Malahleha, 1992). On the basis

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of experiences from Lesotho, Rydgren (1993) discusses the importance of acknowledging the socio-economic environment of the different decision making groups involved. In Botswana, this aspect has been included in the study of environmental change and degradation (Dahlberg, 1996). Understanding the local people's perceptions on environmental issues is thus a prerequisite in making successful resource management strategies. This is aimed at ensuring that studies on resource management become more practical, accurate, and more useful.

Local people's perception on environmental issues can be looked upon in three perspectives. First, people will perceive soil degradation on the basis of their socio-economic interests. In this case farmers will be more aware and concerned about environmental changes and damages that affect agricultural productivity such as soil erosion. Secondly, once local people understand that their physical environment is deteriorating they will attempt to control some of their activities leading to degradation (Nsiah-Gyabaah, 1994). They will then be willing to support land management programmes if they are aware that their actions are harmful to others and the environment (Herberlein, 1972).

The third perspective from attitude survey shows that a big majority of farmers are concerned about soil and/or land degradation as a general community problem, disregarding the fact that their own holdings are likely to be also at risk (Pitt & Yapp, 1992). Under such circumstances, no actions are taken although the people hold positive attitudes towards conservation. However, it is believed that when landowners themselves have been involved in fact-finding on their own land, they become instrumental in implementing planned courses of action. Thus, basing on the local people's perceptions and knowledge, it is possible to develop methods which can allow the people themselves to provide part of the solution to environmental problems (Critchley, 1991; Nsiah-Gyabaah, 1994; Toulmin & Chambers, 1990).

This article is based on a study undertaken in the Irangi Hills between 1994 and 1995 to examine farmers' perceptions and awareness on environmental degradation. It also examines the mechanisms that are taken by the local communities to address land resource management issues, including various approaches used in soil conservation. A consideration is also put on how such approaches help to improve agricultural productivity and local livelihoods in general. It further examines the diversity of factors limiting effective involvement of farmers in land/soil conservation initiatives.

The Study Area

The Irangi Hills are located in Kondoa District in the severely eroded area named as the Kondoa Eroded Area (KEA). Kondoa District is located in the northern part of Dodoma Region at latitudes 4°10'–5°44' South and longitudes 34°54'–36°28' East. The land area of the District is approximately 13,210km² (Nshubemuki & Mugasha, 1986; Mbegu, 1988), out of which the KEA covers 1256km². Irangi Hills forms a largest part of KEA (Mbegu 1988). The villages studied are located northeast of Kondoa Town (see Figure 1). The altitude of the Irangi Hills ranges from 1200 to 2000m above sea level.

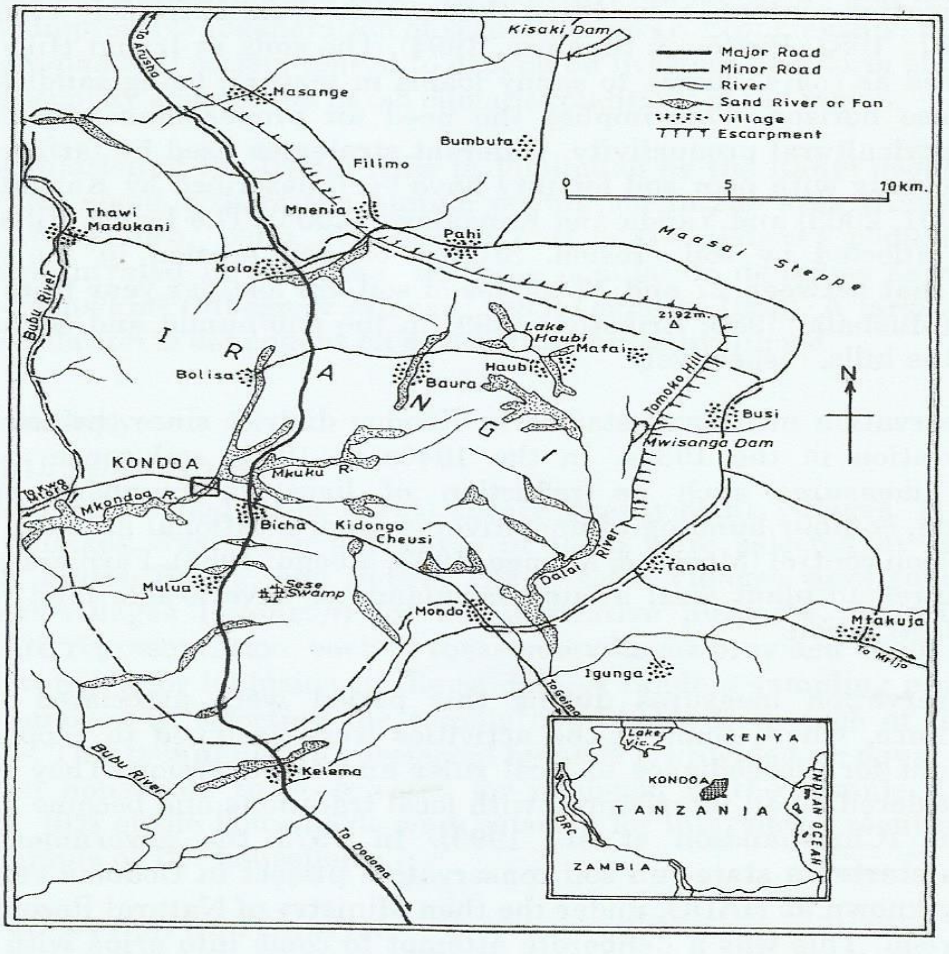

Figure 1: ***Map of Irangi Hills showing the Kondoa Eroded Area and the surveyed villages of Mafai, Baura and Bolisa***

The climate of Kondoa District is semiarid, characterised by an average annual rainfall of between 600 and 800mm, with a long-term average of 640mm (Mbegu, 1988). However, in some parts of the Irangi Hills up to 900mm of rain have been recorded (Ngana, 1990). The rainfall pattern in this area is highly variable, and most of the precipitation occurs in short duration storms. The district is characterised by high evapotranspiration rates that double the amount of precipitation (Christianson, 1981).

The majority of soils in the semiarid areas of central Tanzania originate from granitic, gneissic, and schistic parent material. These soils are of low fertility, base-exchange capacity, bulk density and water-retention capacity (Tosi et al., 1982; Payton et al., 1992). These soils also have low organic matter content, a condition that makes them extremely erodible (Tosi et al., 1982; Payton & Shishira, 1994). The soils in Irangi Hills are generalised as coarse loamy to sandy loams in texture, being sandiest in the surface horizon. This implies the need for proper management to sustain agricultural productivity. Different strategies used by farmers in KEA in coping with poor soil fertility have been described by Kangalawe (1995, 2001, 2003) and Yanda and Kangalawe (2004). The Irangi Hills are severely affected by soil erosion. Studies on soil erosion in the area indicate that between 27 and 37 tonnes of soil are lost per year from one hectare (Mushala, 1986; Eriksson, 1999) in the sub-humid and semiarid parts of the hills, respectively.

Soil conservation initiatives started in Kondoa district since the colonial administration in the 1930s. In the 1940s to 1950s soil conservation involved measures such as reduction of livestock numbers, ridge cultivation, contour bunding of uncultivated land, rotational grazing, and gully erosion control (Mbegu & Mlenge, 1983; Mbegu, 1988). Farmers were also required to plant sisal around farmlands to save arable land from further destruction.

Soil conservation measures during this period were associated with colonial force, where some of the activities were assigned to people as punishment for disobedience to local ruler and tax aversion. They were thus considered as an interference with local traditions and became quite unpopular (Christiansson et al., 1993). In 1973 the government of Tanzania started a state-run soil conservation project in Dodoma region, popularly known as HADO, under the then Ministry of Natural Resources and Tourism. This was a deliberate attempt to come into grips with the menace of soil erosion and degradation in the region (Mbegu, 1988; Östberg, 1986). Three kinds of approaches were undertaken to enhance soil conservation, including mechanical, biological, and administrative measures (Christiansson et al., 1993). *Mechanical measures* involved barriers such as terraces and earth banks across the slopes, which were built to slow down surface runoff. *Biological measures* involved earth binding with plantations of different kinds, such as grass strips across the slope, planting grass in sandy rivers and in bottom of gullies, rotation of crops, and the spread of residue on the fields. *Administrative measures* encompassed tree planting demonstration plots, organising grazing and farming techniques such that the land is protected as much as possible. These measures were complemented by evacuation of all domestic animals in 1979 (Mbegu, 1988). Expulsion of livestock from the Irangi Hills in 1979 as part of soil conservation approaches instituted in the KEA has resulted in ecological transformation from the heavily browsed shrub and scattered trees to impressive regeneration of vegetation cover. Economically, however, this agro-pastoral society ceased to depend on livestock as a form of capital, or as a security against the harsh climatic conditions of the region.

The population of the Irangi Hills is dominated by the Rangi people, who constitute about 85% of the human population in the area (Kangalawe, 1995; Mung'ong'o, 1995). The largest part of the district's population is also concentrated in this area, reaching population densities as high as 100 persons/km^2 (Mbegu & Mlenge, 1983; Östberg, 1986). A large part of this population is dependent on agriculture for its livelihood.

Methodology

Sampling procedure

The Kondoa Eroded Area (KEA) covers twenty-eight villages. A list of these villages was made and three of them were selected at random: namely Mafai, Baura, and Bolisa. The selected villages were subdivided into sub-villages (*vitongoji*) for administrative purposes. To allow for adequate representation, each of these sub-villages provided about 10% of its households for inclusion in the sample. A random sampling procedure was employed in selecting the sample households from each of the sub-villages. This technique was preferred because it provided an equal chance for each household to be selected for inclusion in the sample. In each village, 10% of the households were selected for interviews, resulting in a total sample of 147 households.

Data collection and analysis

Household interview was the major means used to collect both qualitative and quantitative information. A standard questionnaire was used. The questionnaire survey was complemented by informal surveys that involved discussions with key informants, including village leaders, extension workers, district agricultural officials, and HADO staff. These informal surveys were conducted to get some general remarks on soil degradation and agricultural performance in the area. These surveys also provided a means and direction in crosschecking the responses from formal interviews.

The surveys were complemented by field observations in farmers' fields. Field visits involved observations of various land degradation features and agricultural practices. Field observations included also sampling soils from selected transects for subsequent laboratory analysis of soil nutrients. The data was analysed using statistical measures of central tendency (means), measures of dispersion (range), frequency distribution (percentages), and correlation analyses as described by Johnson and Bhattaracharyya (1992) and Ryan et al. (1992). The frequency distribution data was cross-tabulated into contingency tables.

Results and Discussion

Farmers' Perceptions on Soil Degradation

Most people in the Irangi Hills seem to be aware that soil degradation is taking place in their farms, as well as other surrounding areas (Kangalawe, 1995, 2001; Mung'ong'o, 2004). This is based on their perception and interpretation of various indicators that reveal soil degradation conditions of their land. To determine the level of awareness of soil degradation three exploratory questions were asked. First was, did the local people perceive soil degradation as a problem in their village and farms? Second, what criteria are used by the local people to determine the quality of soil/land in general? Thirdly, did they associate soil degradation with cropping or livestock management systems of the area?

Local Peoples' Perception of Soil Degradation

Responding to the first question on the perception of soil degradation, 58% considered soil degradation as being a serious problem in their vicinities. The remaining 42% did not consider it to be an important problem. This diversity in the level of perceptions may be influenced by differences in socio-economic characteristics inherent among the local people. Those who perceived soil degradation as a problem mentioned declining soil fertility, soil erosion and runoff, sandy soils and sedimentation, and the generally low fertility status of the Kondoa soils as key indicators of soil degradation in their villages. Table 1 presents the proportions of responses on indicators to farmers' awareness of soil degradation processes. The presence of these indicators shows that rural people are aware of their environment and its related problems, and particularly so with those which affect farm productivity, and/or those that resulted into more visible landscape changes such as soil erosion.

Table 1: Farmers' awareness of soil degradation processes (%)

Problem category	Mafai (n = 22)	Baura (n = 19)	Bolisa (n = 44)
Declining soil fertility	68.2	42.1	43.2
Soil erosion and runoff	22.7	57.9	52.3
Low inherent fertility	27.3	42.1	11.4
Sandy soils and sedimentation	9.1	15.8	13.6

Source: Kangalawe (1995).

Declining soil Fertility

The major process perceived as an indicator of soil degradation in the studied villages was declining soil fertility. More than 50% of farmers attributed such decline to continuous cultivation without resting the fields, whereas about 20% ascribed it to inadequate application of manure and/or fertilisers. Both aspects were perceived to have caused continuous extraction of the soil nutrients reserve without sufficient replenishment, thereby leading to the gradual decline of soil fertility. One explanation to continuous cultivation is the increasing land shortage that has led to intensified crop cultivation and short or no fallow periods.

A large part of the land in the studied villages has been severely degraded by soil erosion, or protected under the regional soil conservation programme, HADO. Studies conducted in a neighbouring villages and in other parts of the Irangi Hills also revealed that most plots are cultivated every season without fallow, and are thus subject to a significant loss in soil fertility (Mohamed, 1996; Kangalawe, 2001). To manage the soil fertility smallholder farmers in the area use two main approaches. First, they adapt to traditional low-input methods such as intercropping, use of farmyard manure, crop residue management, and agroforestry (Barr, 1994; Kangalawe, 1995, 2001; Kangalawe et al., 1999). The second approach has been expanding their crop fields to new areas that appear to have better opportunities outside the Irangi Hills, and in various parts of the Hills with stabilising sandfans and small wetlands, locally known as *mbuga* areas (Kangalawe et al., 1999; Kangalawe, 2001). The latter were traditionally used for dry season grazing of livestock. With the expulsion of livestock from KEA, such *mbugas* emerged as new areas for agricultural expansion (Kangalawe et al., 1999; Kangalawe, 2003).

Low Inherent Soil Fertility

The influence of the processes discussed above is further exalted by the inherently low soil fertility in the area. Farmers are also aware of this fact. The perception of this indicator was echoed more in Baura (42%), probably because its landscape has been stripped more by erosion compared to the other two studied villages. The local perception agrees with the general assessment of soil fertility in Kondoa District that soils in the area are of low fertility (Tosi et al., 1982; Mbegu, 1988; Christiansson et al., 1993; Mowo et al., 1993; Payton & Shishira, 1994; Shishira & Payton, 1996; Dejene et al., 1997; Kangalawe, 2001, 2003). Results from laboratory analyses for nutrients (Table 2) further confirm the low levels of soil nutrients in soils of the three villages studied. These results also indicate that Mafai soils had more advantage in terms of nitrogen content than both Baura and Bolisa. These soils had about four times as much total nitrogen as Baura and Bolisa, whereas Baura had soils richer in available phosphorus than the other two villages. The variations in nutrient contents may be attributed to, among other factors, the severity of soil degradation that characterises the studied villages and management practices of the farms.

Table 2: Some characteristics of soils from the study area (measured at 0-20 cm depth)

Soil characteristic	Mafai	Baura	Bolisa
pH (H_2O)	4.80	5.20	5.40
Total Nitrogen (%)	0.29	0.07	0.08
Available P (ppm)	4.20	7.20	3.20
CEC me/100g	17.12	3.84	13.89
Exchangeable K (me/100g)	0.61	0.61	0.52
Exchangeable Ca (me/100g)	4.39	1.83	2.74
Exchangeable Mg (me/100g)	1.61	0.40	1.20
Exchangeable Na (me/100g)	1.86	0.92	0.80
Organic carbon (%)	2.62	0.31	0.54
Particle size			
% Sand	54.83	80.27	69.20
% Silt	14.57	10.60	17.63
% Clay	30.60	9.13	13.17

Source: Kangalawe (1995)

In literature, the low intrinsic soil fertility has been attributed to climatic and parental material factors. The dry climatic condition of the study area limits high productivity of organic matter. Subsequently, this results in poor surface cover and low incorporation of organic matter into the soil as binding agent and for fertility enhancement (Smith and Elliott, 1990; Kangalawe, 2001). As regards parent material, soils in this area are reported to have formed from Gneiss, rocks that are considered to be generally poor in plant nutrients (Tosi et al., 1982).

Soil erosion and runoff

Soil erosion and surface runoff featured as felt problems and indicators of soil degradation to about 40% of farmers. On village basis, awareness of soil erosion as a soil degrading process featured more prominently among Baura and Bolisa respondents, accounting for 58% and 52% of the interviewed households respectively (see Table 1). Visual observation of the landscape in these villages affirms the local people's response. Both Baura and Bolisa have landscapes dissected by more pronounced gullies (see Figure 2) compared to Mafai village, a fact that makes their inhabitants well aware of the extent of soil degradation, particularly through soil erosion (Kangalawe, 1995).

Figure 2: ***Gully erosion in Baura village.*** (This is a common feature of the landscape in the studied villages and in many other villages in the Kondoa Eroded Area. Photo by R.Y.M. Kangalawe, August 1998)

Informal discussions during fieldwork indicated that historically the two villages had large numbers of livestock prior to destocking in 1979 that rendered many places devoid of vegetation because of overgrazing. Such situation exposed the land surface to agents of soil erosion, such as runoff water. The extensive gullies seen today in these and several other villages in the Irangi Hills are said to have formed along former cattle tracks aligned down the slope (cf. Payton et al., 1992). Although the badlands that cover about 25% of the Irangi Hills have decreased by about 10% between 1960 and 1992, they seem to be relatively unaffected by the conservation efforts undertaken in the area (Eriksson et al., 2003).

Soil texture and sedimentation

Soil texture was perceived as a problem by only a few farmers (see Table 1). According to these farmers the soils are of light (sandy) texture, locally known as *udongo mwepesi,* with very low moisture-holding capacity. This response was obtained from farmers whose fields laid in stabilising sandfans that have soils with very low organic matter levels, and hence low moisture holding capacity and poor fertility status. Such soil characteristics are also common in other parts of the Irangi Hills, such as Haubi and Mulua (Payton et al., 1992; Payton & Shishira, 1994; Kangalawe, 2001; 2003). Sedimentation was reported to take place in depositional foot slopes and valley bottoms where the eroded materials from hill slopes accumulate. One would expect this indicator to be mentioned by most respondents. However, since farmers have had their settlements and fields in that kind of environment for generations they have the feeling that such soils and/or sedimentation features are a common feature of their landscape. The effect of the sedimentation of the materials eroded upslope is immense. In many places sedimentation of sandy materials buried the former fertile clayey topsoil (Payton & Shishira, 1994; Kangalawe, 2001).

Assessing land and soil quality

Perception on soil degradation is based on certain values that the local people use to describe the qualities of the land they are working with in their farming systems. Consequently, farmers' resource management strategies are based upon their observations, values and experiences with local resources. These factors help them interpret changes on indicators of soil/land degradation and make decisions about specific actions (Kangalawe, 1995; 2000; 2001; 2003). In this study, farmers were asked to explain the various traditional ways they used to evaluate the quality of the land and the soils they are cultivating. Three categories of responses were provided, namely crop vigour and crop yields, presence of indicator-plant species, and density of vegetation under fallow (Kangalawe, 1995).

Crop Vigour and Yield

Crop or plant vigour is one of the criteria used by farmers to determine soil/land quality. A healthy and vigorous crop growth, reflected by a good crop stand in the field, is used as an important indicator that the soil is fertile enough, if moisture and other factors are not limiting (Kangalawe, 1995). Under such circumstances, even if anything happens with the weather such that final yields are not good enough, the farmer would have an assessment criterion ready in hand. A stunted crop with less vigorous growth in the field when other factors such as moisture are considered not limiting is locally perceived to indicate a high probability that soils on which the crop is growing is of low quality, mainly due to poor soil fertility.

Crop yield was another criterion commonly reported to indicate the quality of a given piece of land. Majority of farmers (95%) considered crop yields as the best measure to comprehend land/soil quality. It was noted that low or declining crop productivity could be a clear indicator of declining soil fertility, and hence soil degradation. The use of this indicator by the local farmers in evaluating land/soil quality is also appreciated by experts in land degradation. This view compares well with studies conducted in several other places as reported by Kikula (1989) from a study in southern Mufindi district, Dejene et al. (1997) and Kangalawe (2001) in some villages of Kondoa District, and Nsiah-Gyabaah (1994) in West Africa. It is generally agreed by these studies that crop output decline is a proxy indicator of soil degradation in farmlands, both in traditional and modern contexts of soil degradation. It is particularly important because it affects people directly in terms of food availability and security (cf. Liwenga, 2003).

However, this factor alone is not sufficient to establish that degradation is taking place since cropping conditions vary considerably between years and between individual farmers. The influence of other factors such as crop pests and diseases and climate variability may influence crop yields, particularly with drought incidences (cf. Kangalawe, 2000; Kangalawe et al., 2007). In the Irangi Hills more than 50% of the farmers indicated also that low crop yields could be due to low and/or erratic rainfall. This aspect needs to be investigated further to establish detailed linkages between climatic patterns and crop yield trends in the area. Nevertheless crop yields are an important indicator of proximate soil conditions if other factors are not constraining.

One of the causes of low crop yields in the study area is declining soil fertility attributable to, among other factors, rampant soil erosion. However, despite the prevalence of severe erosion in this area, not all farmers could associate it to poor crop performance, although many of them live in locations where there are evident signs of severe erosion (Kangalawe, 1995; 2001). This suggests that there is little awareness among the local people of the effects of soil erosion on crop productivity. Thus, increasing the awareness among the people in the area would not only enhance understanding of their landscape, but also facilitate their undertaking of the various land management actions at the local level.

Indicator-species and Density of Vegetation under Fallow

Presence of indicator-species of vegetation is another indicator of soil/land quality used by farmers in the study area (Kangalawe, 1995). However, farmers practice continuous cultivation and almost no fallow periods due to land shortage. This indicator is thus not as significant as the other two mentioned above. Where it qualifies its use, a dense vegetation cover under fallow is indicative of a fertile soil, often associated with high productivity of organic matter. Subsequently, this may result in higher levels of nutrients recycling as the organic matter decomposes. Similarly, soil physical properties such as structure and moisture characteristics are improved through the good binding and moisture retention capacity of organic matter (cf. Scott, 1994; Yanda, 1995; Rockström, 1997), making the soil more suitable for a following crop. Conversely, stunted or total absence of vegetation signifies poor soil fertility or soils undergoing degradation. The use of indicator-species in the determination of land quality is commonly used in the Kondoa Eroded Area. Several plant species have been identified by farmers to be associated with soils of low fertility. Table 3 presents some of the locally identified plant species and their scientific names.

Table 3: Locally identified plant species used as indicators of low soil fertility in the Irangi Hills

Local Name (Rangi)	Scientific Name
Chilori	NI
Idumbasi	*Ocimum basilicum*
Ijenganieche	*Mellines repreis*
Inyerya	*Dipcadi longifolium*
Irenda	NI
Kilimilasengo	*Indigofera cuniata*
Kinyafunyafu	*Melinis repens*
Kinyasanga	NI
Kivumba	*Digitaria spp*
Mabangi bangi	*Tagetes minuta*
Mbigiri	*Oxygonum stuhlmannii*
Njolai or Lukalanga	*Spermacose senensis*
Thathauri	NI
Tutukuru,	NI

NI = Not identified.

Source: Kangalawe (1995); Dejene et al. (1997).

In another account, Mwalyosi (1997) pointed out that tree species such as *Brachystegia microphylla* are associated with hill slopes that are subjected to erosion, giving rise to shallow soils with topsoils being mainly coarse loamy and often with bare rock. He noted also that tree species such as *Brachystegia spiciformis* and *Parinari curatellifolia* can be used as indicators of the extent of soil erosion. While *Brachystegia spiciformis* is found mainly in deeply eroded red soils, *Parinari curatellifolia* is found in Albic Arenosols. In many cases additional criteria such as soil colour are used as indicators of the potential of the soil, where dark soils are considered by farmers to be the most fertile (Kanté & Defoer, 1994). In the

Kondoa case, the dark *mbuga* soils are the ones considered to be the most fertile (Payton & Shishira, 1994; Kangalawe et al., 1999; Kangalawe, 2000; 2001; 2003).

Association between Farming Systems and Soil Degradation

Different crop and livestock management systems have different influence to soil degradation. The perception of the people on the relationship between these systems and soil degradation may be variable, both spatially and temporally. The diversity in the relationships may be attributed to the variability in the extent and causes of soil degradation, as well as to the variable socio-economic status among the local people.

In this study farmers were asked whether there was any association between soil degradation, cropping, and/or livestock systems. Sixty-five percent of the respondents acknowledged the existence of such relationship, while the remaining 35% could not express any direct relationships. Table 4 shows the relationships that were cited as being the contribution of the farming practises to the observed soil degradation. More than half of the respondents associated soil degradation to continuous cropping, while 23% considered the lack and/or inadequate manure application to be responsible for the diminishing soil quality.

Table 4: Perceived relationships between cropping/livestock management systems and soil degradation in the Irangi Hills (%)

Relationship category	Mafai (n=28)	Baura (n=26)	Bolisa (n=42)	Total Responses (n=96)
Continuous cropping	57.1	30.7	61.9	52.1
Lack or inadequate availability of manure	10.7	53.8	11.9	22.9
Overgrazing in the past decades	14.3	11.5	11.9	12.5
Cultivation on steep slopes	14.3	4.0	4.8	7.3
Lack of on-farm conservation measures	3.6	0	9.5	5.2

Source: Kangalawe (1995)

Overgrazing was pointed out to be one of the degradation processes by 12.5% of farmers. The low figure is explained by the fact that the Rangi community, which is traditionally agro-pastoralist, having big herds of livestock is just part of the culture; and thus locally overgrazing is rarely seen as a major problem. A similar explanation regarding perceptions on overgrazing has been reported recently among communities in the Sukumaland (Kangalawe et al., 2007). Other associations presented in Table 4 did not feature as important concerns among farmers, but because of their role in soil degradation they are worth some attention.

Many communities in Kondoa district acknowledge the significance of continuous cultivation without manure or fertiliser application on soil quality. The overuse of the soil in continuous tillage without fertiliser supplementation, coupled by grazing on plant residues, weeds, and crop stubble, has deprived the soils of both nutrients and organic matter (cf. Kangalawe, 1995; 2001). However, despite this felt need to rest the fields in order to regain natural fertility, the problem of land shortage that prevails in the surveyed villages makes fulfilment of this soil fertility management approach only a wishful thinking. Overgrazing had similar effects on the soils of steep slopes and on shallow and stony soils, where continuous cultivation has not been practised (Tosi et al., 1982). Lack of on-farm conservation measures, especially before HADO started its activities, significantly contributed to the degradation features witnessed in the present days (cf. Payton & Shishira, 1994; Mung'ong'o, 1995; Eriksson, 1998; Kangalawe, 2001).

Farmers Involvement in Resource Management

Farmers' Participation in Soil Conservation

During the 20th century the pressure on land has practically increased all over the country as a result of population growth. This has, in many instances, resulted in unsustainable cultivation techniques including shortened fallow periods (Mohamed, 1989; 1996) that consequently impoverish the soil. Enhanced long-term productivity and sustainability of land resource thus require sound soil conservation measures in farming systems that enhance maintenance and/or improvement of soil and land quality in general.

In many instances, environmental degradation has provoked a variety of responses and adaptation mechanisms by local communities. This study made an enquiry on whether farmers had undertaken any deliberate efforts to protect their land holdings from soil degradation. A majority of farmers (95%) indicated to have used one or more conservation techniques in their farms as a means of adjusting and adapting to soil degradation. On a village basis, the responses to this inquiry were 97%, 93% and 95%, for Baura, Bolisa, and Mafai villages respectively. The various soil conservation approaches mentioned by the interviewed farmers are presented in Table 5. The first two categories of steps appeared to be the most prominent conservation strategies adopted by majority of farmers who were practising conservation, accounting for 97% of farmers in Mafai, 85% in Baura, and 81% in Bolisa village. The generally sloping terrain in Mafai village partly explains the reported increase in the use of contour ridges, trees, sisal and grass planting to protect the soil from erosion.

Table 5: Soil conservation measures undertaken by respondent farmers (in %)

Measures taken	Mafai (n = 35)	Baura (n = 34)	Bolisa (n = 70)	Total Response (N = 139)
1. Contour ridges, tree, sisal, grass planting, manure application and incorporate residue	80.0	55.9	68.5	68.4
2. Contour ridges and tree planting	17.1	29.4	12.9	18.0
3. Tree planting only	0	5.9	12.9	7.9
4. Stall-feeding	2.9	5.9	4.3	4.3
5. Crop rotation	0	2.9	1.4	1.4

Source: Kangalawe (1995)

A majority of farmers have planted trees as one of the soil conservation practices advocated by HADO. Table 6 presents a list of tree species that are planted in the study area, and associated uses. As shown in Table 6, it appears that *Grevillea robusta* is the most preferred species, as indicated by the large percentage of respondent households planting this tree species.

Table 6: Tree species planted in the study area, ranked according to preferences and percent of respondent farmers that have planted them

Name	Scientific name	Purpose[1]	Mafai (n = 31)	Baura (n = 31)	Bolisa (n = 67)	Total (N = 129)
Silk oak	*Grevillea robusta*	Ct, Fw, Fi	87.1	90.3	95.5	92.2
Guava	*Psidium guajava*	Fr	51.6	51.6	49.3	50.4
Pawpaw	*Carica papaya*	Fr	29.0	29.0	76.1	47.3
Orange	*Citrus sinensis*	Fr	25.8	0	26.9	20.2
Lemon	*Citrus limon*	Fr	19.4	22.6	17.9	19.4
Mango	*Mangifera indica*	Fr, Sh	0	16.1	14.9	11.6
Eucalyptus	*Eucalyptus sp.*	Fw, Ct	35.5	3.2	1.5	9.3
Pomegranate	*Punicum granatum*	Fr	3.2	3.2	11.9	7.8
Leucaena	*Leucaena leucocephala*	Fd, Fi	3.2	3.2	1.5	2.3
Cypress	*Cuppressus sp.*	Fi, Ct	3.2	3.2	0	1.6
Iron wood	*Senna siamea*	Ct, Fw	0	3.2	1.5	1.6

[1]Note: Ct = construction material/timber, Fr = fruits, Fd = fodder, Fi = soil fertility improvement, Fw = fuelwood, Sh = shade.

Source: Kangalawe (1995)

Although an important step towards averting soil degradation caused by uncontrolled grazing, some of the measures reported in Table 5, such as stall-feeding, were not mentioned by many people as being deliberately practised for environmental concerns regardless of the relatively large number of farmers using this livestock keeping system. The low response to this attribute may be explained by the attitude of most people in the area that they should be allowed to bring back the evicted animals under free grazing system following the apparent vegetation recovery in most of the KEA (Kangalawe, 1995; Östberg, 1995). Already, there are obvious signs of unauthorised free grazing in several places of the KEA (Kangalawe, 2001). Since no thorough studies have been carried out regarding carrying capacity in this rather delicate ecological setting, allowing extensive grazing will quickly ruin the conservation efforts that have been achieved through the HADO project.

As for crop rotation, the low response was mainly attributed to the small farm holdings that necessitate continuous cultivation of same fields. The farms are too small and cannot support long rotation cycles. The high population in the area is reported to have caused significant land shortage (Mohamed, 1996), with subsequent land fragmentation. The Irangi Hills consist of the largest part of the population of Kondoa District, and is characterised by high growth rates (Madulu, 1996). The limited supplies of manure and the high fertiliser prices are responsible for the low response to their use as adaptive mechanisms in fighting against soil degradation at farm level (Kangalawe, 1995).

Findings from this study are in agreement with studies elsewhere that farmers often attempt to adjust to environmental degradation by using various measures and strategies (Cummingham & Jenkins, 1981; Nsiah-Gyabaah, 1994). The measures taken may be different depending on the natural environment and cultural backgrounds of the area concerned. According to Nsiah-Gyabaah (1994), farmers' adjustment to their environment can generally be effective when they are able to predict the changes (e.g. in soils and weather). Under such a situation, they may be able to successfully use available technology and local expertise to maximise the benefits of both soils and weather. Local adaptive strategies range from indifference to inertia, and to active interest and firm commitment to soil conservation and environmental protection in general (Cummingham & Jenkins, 1982). However, where changes have been unpredictable, farmers have played a subservient role and have been very much at the mercy of soil and weather elements (Nsiah-Gyabaah, 1994).

Limiting Factors to Local People's Participation in Soil Conservation Practices

It has been established in the preceding sections that the local people in the Irangi Hills are aware of soil degradation. However, despite the existence of awareness of soil and environmental degradation in general, little or no deliberate efforts were undertaken by the local community to rescue the land from severe degradation. This was particularly so before

HADO started its conservation activities in the early 1970s. This is indicated by the small proportion (18%) of respondents who reported to have practised on-farm conservation for periods longer than the duration when the state-run soil conservation project in the Dodoma Region (HADO) has been in operation (see Figure 3).

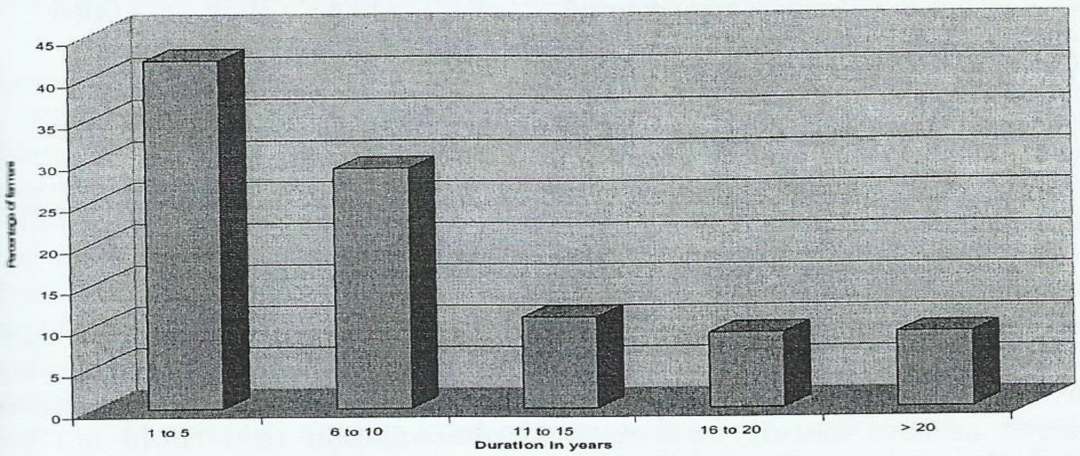

Figure 3. ***Duration of farmer involvement in soil conservation***
Source: Kangalawe (1995)

The remaining 82% reported to have adopted conservation practices during the HADO period. As shown in Figure 3, majority of these have actually started practising soil conservation measures only ten years before this study was conducted. This section, therefore, discusses the various factors that were reported to constrain the involvement of local people in conservation activities carried out in the study area.

The concerns about conservation in Africa and other parts of the world are not new. They have been in place since the colonial times. In Tanzania and other British territories, for example, soil conservation became a major issue since the 1930s (Kauzeni et al., 1987; Critchley, 1991) when a number of conservation programmes started. However, the need for conservation is much greater now than it was in the past decades. Population has increased and more land has to be put under cultivation, while fields cannot be rested from cropping to recover their natural fertility as used to be in the past. In several occasions, however, soil conservation has not received the expected involvement of local communities. Table 7 summarises the reasons that have influenced local people's attitudes towards land/soil conservation efforts in the Irangi Hills.

Table 7: Limiting factors to farmer participation in soil conservation practices as perceived by farmers in the study area (%)

Constraint	Mafai (n=37)	Baura (n=35)	Bolisa (n=75)	Total Response (N=147)
1. Soil erosion considered to be not a serious problem - just a natural process	78.4	54.3	52.0	59.2
2. Limited technical know-how and potential benefits	8.1	14.3	21.3	16.3
3. Interference of conservation structures with farm operations	2.7	8.6	6.7	6.1
4. Labour constraints	2.7	8.6	13.3	9.5
5. Influence of socio-political environment *(e.g.* Negative attitude inflicted by colonial rule)	8.1	14.3	6.7	8.8

Source: Kangalawe (1995)

A Problem Underestimated

One of the reasons put forward was the tendency to underestimate the seriousness of the soil erosion problems by many people in the area, as shown by about 60% of all respondents. This group of respondents considered erosion merely as a natural phenomenon that could not be curtailed by human efforts. The lack of perception of soil degradation problems by some people may be associated with what Hardin (1968) called *the tragedy of the commons*. Under a situation where there is no elaborate tenure system individual farmers may not be concerned on degradation as their own problem, but consider it a general community problem, without regarding their holdings being also at risk. Such attitudes may result in no action being taken against degradation even when there are no clear hindrances. The implication of the foregoing is that effective conservation is likely to be achieved when land tenure systems are properly articulated (Kangalawe, 1995; 2001). Recent experiences from studies in Kishapu and Kahama Districts in Shinyanga Region, and in Nyarugusu area in Geita District, Mwanza region, indicate that people practice soil and water conservation mainly in their own lands/farms (Kangalawe et al., 2007). Similar observations are reported in some parts of Mwanza and Mara regions, where the Lake Victoria Environmental Management Project has pilot sites on integrated soil and water conservation (Mang'ombe et al., 2004; Ngazi et al., 2004). This perspective is likely to have influenced reactions to the earlier conservation measures imposed by the colonial administration in the district, which were far from total success.

Apart from the underestimation and inarticulate tenure system, it is also evident that the Rangi people themselves are traditionally not

The influence of socio-political environment
Experiences from the Kondoa Irangi Hills and elsewhere in East Africa indicate that resource management is closely influenced by the prevailing socio-political environment (Mung'ong'o et al., 2004). Kangalawe (1995, 2001) reported that some people in the Irangi Hills were of the opinion that the low adoption of soil conservation measures was based on negative attitudes that were inculcated among people during the colonial era, when such activities were basically coercive. During the colonial period soil conservation was seen as a form of oppression (Kauzeni et al., 1987; Mung'ong'o, 1995). In Kenya, for example, soil conservation was made compulsory under colonial administration, and forced labour was used for community conservation programmes (Critchley, 1991). Although some of the soil conservation techniques employed were effective (e.g., in Machakos district), the coercive methods used were very unpopular (Kauzeni et al., 1987; Critchley, 1991; Christiansson et al., 1993), resulting into some local communities withholding their own conservation initiatives. This was also experienced in the Irangi Hills and among other communities in Kondoa District (Mung'ong'o, 1995).

In the Kondoa case, the opposition to conservation during the 1940s was closely linked to the fact that there was widespread discontent within the Rangi community with the way the colonial government appointed local leaders. Thus a more explicit political course became linked to soil conservation policies (Mung'ong'o, 1995). Consequently, it was no longer possible to enforce communal turnout during the nationalist struggle in the late 1950s, and most conservation work came to a halt (Berry & Townshend, 1973; Mung'ong'o, 1995). The Kondoa chief of the time came to side with the Rangi underground opposition against regulations on land-use. It is not surprising then that even independent governments found it difficult to reverse the previous nationalist attitudes and support conservation measures (Critchley, 1991; Kauzeni et al., 1987). Land degradation was thus left to continue. These experiences reflect the need for local community participation in developing and implementing resource management strategies, which has been lacking in many development initiatives.

Conclusions

This paper has examined how perceptions and knowledge act as barriers to land management. It has been realised that farmers in the Irangi Hills are aware of soil degradation and its various processes, with levels of perception varying between villages and among respondents. Different indicators have been used to ascertain the reported perceptions of the local people on environmental degradation. Declining soil fertility and soil erosion, demonstrated by existence of spectacular gullies and extensive depositional sand fans, have been found to contribute significantly to the perception of soil degradation problems.

Awareness of environmental degradation was also reflected by the various criteria that the local people use in assessing the potentials and constraints that farmlands and the landscape in general are facing. Low crop productivity has been identified as one of the important constraints; attributed mainly to declining soil fertility, unreliable rainfall, and to a lesser extent, soil erosion. The latter suggests that there is a limited farmers' awareness of the effect of soil erosion on crop productivity. However, farmers seem to be quite aware of the association between cropping and/or livestock management systems and soil degradation. What is probably needed is motivation and elaborate extension services on the various techniques that may contribute to sustainable farm production, such as on-farm erosion control, agroforestry practices, and proper residue management. This is particularly important in a situation where continuous cultivation has become the norm because of increasing land shortage. Thus the various adaptations that farmers are already exposed to with regard to improving agricultural productivity in the erosion-stricken farmlands need to be promoted and developed further.

Limiting factors to local participation in soil conservation initiatives would probably be successfully corrected through proper farmer education that inculcates the culture of conservation among communities. It is important, therefore, that steps are taken to incorporate the diversity of the intricate attitudes and socio-political environments among rural communities. It is recommended that further comparative studies be conducted so as to come up with sound strategies that will motivate the local people to participate more in environmental issues and address sustainable resource management.

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