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IMPACT OF INDIGENOUS-BASED INTERVENTIONS ON LAND CONSERVATION: A CASE STUDY OF A SOIL CONSERVATION AND AGROFORESTRY PROJECT, ARUMERU DISTRICT, TANZANIA

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ABSTRACT

Land degradation has been identified as a serious problem in Tanzania since the 1920s. Among the factors normally cited as contributing to land degradation are deforestation, overgrazing and inappropriate farming practices. Several attempts by the government to arrest the problem have been based on top-down approaches. Indigenous-based interventions are among the alternative practices adopted by the Soil Conservation and Agroforestry Project in Arumeru District, Tanzania. The main objective of this study was to assess the impact of the indigenous-based interventions on land conservation. More specifically the study intended to assess farmers' perception of land degradation, the adoption rate of indigenous-based interventions, the impact of those interventions, and lastly the sustainability of those interventions. Data for the study were collected through Participatory Rural Appraisal (PRA) techniques and a questionnaire survey. The Statistical Package for Social Sciences (SPSS®) was used to analyse quantitative data and Content and Structural-Functional Analyses were used for qualitative data. The study found that the rate of land degradation was perceived by respondents to be rather severe. The study also revealed that indigenous-based interventions, which require minimal labour and capital, have been highly adopted by many farmers while labour/capital intensive ones have been taken up by fewer farmers. In general, indigenous-based interventions appear to have eased farm operations and contributed towards increased crop yield, improved soil fertility and increased income. Success in some of the indigenous interventions warrants their wider promotion beyond the project area. Copyright © 2005 John Wiley & Sons, Ltd.

KEY WORDS: land degradation; land/soil conservation; indigenous-based interventions; sustainable agriculture; Tanzania

INTRODUCTION

In Tanzania, soil erosion and general land degradation has been identified as a serious problem since the 1920s (Kauzeni *et al.*, 1987). Soil erosion in Tanzania is mainly water induced and results from rainwater runoff on fragile lands, especially steep slopes, overgrazed lands and other lands degraded by various factors such as deforestation and over-cultivation (Liwenga, 1995). The degraded area is estimated to cover between 33 per cent and 45 per cent of the total land area of the country (URT, 1991). Figure 1 shows the state of land degradation in Tanzania. The processes of land degradation vary and are not easily detected and measured. However, both central and local governments recognize land degradation as a major issue for the country. A number of factors contribute to land degradation in Tanzania, some being more important in one area than in others. Other factors cited as causes of land degradation in the Country, include inappropriate cultivation techniques (i.e. farming practices on fragile lands without conservation measures), the growing population with unmatched provision of appropriate technology, inadequate land tenure (e.g. land ownership uncertainty, which prevails in the country, discourages long-term investment), and overstocking (MTNRE, 1994). External forces including international terms of trade

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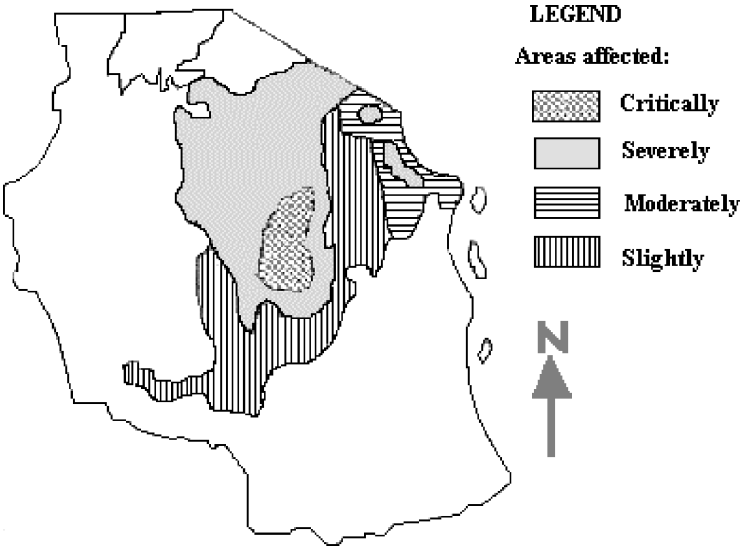

Figure 1. The state of land degradation in Tanzania. (*Source* = URT, 1991.)

have worked against the Tanzanian farmers leading to the lowering of prices for the farm products and the increasing of prices for farm inputs.

Long before independence in 1961, the problem of land degradation was well known in Tanzania. As a result, various soil conservation programmes were established on a trial basis to combat the problem. Demonstration plots, conservation orders and directives (e.g. destocking of livestock and controlled fires) were first introduced by the colonial government. Most of these interventions were concentrated in mountainous areas where land degradation was most apparent. These areas include Kilimanjaro, Uluguru, Usambara, Pare and Meru Mountains. The local authorities of these areas were charged with administering the orders. Meanwhile experiments were carried out at agricultural research stations to quantify soil and water losses. These experiments were expected to provide insights for conservation activities (FAO, 1986).

Partly as an outcome of these early initiatives, but also due to the escalating problem of land degradation, several integrated conservation schemes were established in different parts of the Country including Sukumaland, Kondoa-Irangi and Masailand. Later after independence, they were followed by such programmes as Hifadhi Ardhi Dodoma (HADO) in Dodoma Region, Soil Erosion Control and Agroforestry Programme (SECAP) in Lushoto District Tanga Region, Hifadhi Ardhi Shinyanga (HASHI) in Shinyanga Region, Hifadhi Mazingira (HIMA) in Iringa Region and the Kigoma-Ujiji Soil Erosion Control Programme in Kigoma Region.

The nature of the land degradation problems, successes and failures of the above mentioned schemes and programmes have been the focus of many studies (Kikula *et al.*, 1990). Information has also been accumulating from many other parts of Tanzania, where land-use planners, foresters, agriculturists, and social scientists have endeavoured to analyse the processes of land degradation in terms of cause–effect relationships and possible solutions (Per, 1999). Some of these analyses have rightly taken the interdisciplinary approach, given that land degradation processes, including their causes, effects and possible solutions, cut across different sectors and disciplines. Other analyses, however, have taken narrower approaches and, inevitably, their perspectives have been limited in scope. In general, with time large volumes of literature have accumulated on land degradation and related subjects (Kikula *et al.*, 1990).

In spite of many programs on land conservation, land degradation is still a big problem in Tanzania. Plausible reasons include the top-down approach, concentrating more on mechanical measures in preventing erosion and run-off, and ignoring the contribution of indigenous knowledge in addressing the problems. Land degradation is of much concern as it strikes at one of the basic elements of survival of humankind, which is the productivity of land

(Kikula *et al.*, 1990). Soil erosion as a major form of environmental degradation in the tropics is a major constraint to agricultural production (Beets, 1990). Due to the vastness and the physical diversity of Tanzania, there is no single solution to environmental degradation and the dwindling of the land resource base. This entails combinations of different practices in conserving the land.

Among the areas that are threatened by land degradation in Tanzania is sea-level Region, specifically Arumeru District. About 2 per cent (58 km^2) of the district is severely eroded (Per, 1999). According to SCAPA (1997) the major causes of soil erosion and land degradation are high population density in high potential areas forcing farmers to open up fragile lands for farming, poor farm management, overstocking and overgrazing in the low potential areas. Other factors include deforestation and poor forest management resulting in a lack of woodfuel and timber, low levels of awareness regarding land and environmental degradation within the farming community and among governmental and political leaders. Lastly, there are inadequate appropriate facilities and skills within the extension system to solve the problem of the soil erosion as well as encroachment and cultivation in the water sources and riverbanks. In the final analysis, these processes lower the potential capacity of the Country to produce food due to over exploitation of land and other resources (Liwenga, 1995).

In the effort to combat land degradation, which is a serious problem in Arumeru District, a land conservation project, known as the 'Soil Conservation and Agroforestry Project in sea-level' (SCAPA), was established in 1989 with assistance from the Swedish International Development Agency (SIDA). The programme was designed to rehabilitate eroded areas, specifically Mukulati and King'ori Divisions (Mawenya, 1994). The main objective of the study reported here was to assess the impact of indigenous-based interventions on land conservation in Arumeru District. Indigenous-based interventions are those interventions that take indigenous knowledge and practices as their entry point. Specifically, the study intended to assess the perception of land degradation by farmers, the adoption of indigenous-based interventions, the impact of indigenous-based interventions and the sustainability of such interventions. The results from this study will contribute to prescribing indigenous-based interventions that may promote effective land conservation in Arumeru District and in other parts of Tanzania.

STUDY AREA AND METHODOLOGY

Study Area

Arumeru District is located between longitudes 35° 37′ and 35° 47′ East and latitudes 3° 17′ to 3° 27′ South. It borders Simanjiro District to the east, Hai District to the northwest, Kiteto District to the south, and Monduli District to the north. The District has six divisions, 32 wards and 133 villages. The study was carried out in four villages, namely: Olchorovus; Oldonyosapuk; Ekenywa; and Manyire (Figure 2).

Arumeru District has three agro-ecological zones namely: the high-potential areas; the medium-potential areas; and the low-potential areas. The term 'high-potential' is used to distinguish areas that, depending on characteristics of rainfall pattern, temperature and soil fertility, can be used for intensive agricultural production. The term 'highland' (normally a physically identified area recognized by altitude) is also commonly used to describe these fertile high-potential mountainous areas. High-potential areas are densely populated with volcanic ash (nitrosol soils) moderately developed and bimodal rainfall ranging between 1000 and 1500 mm per annum. The areas have high altitudes at 1500 m, or more, above sea-level (a.s.l.) on the eastern slopes of Mount Meru and are densely populated due to relatively fertile soils and higher levels of precipitation. Crops grown are mainly coffee, banana, fruits (avocado, citrus, pawpaw, etc.). Animals kept are mainly exotic and mixed breeds of dairy cattle, which are stall-fed because people living in these areas tend to concentrate on small family farms of about 0·8 ha (on average) and produce just enough food for consumption with a very limited surplus for sale.

The term 'medium-potential areas' refers to land resources with physical limitations for intensive small-scale farming, compared to the high-potential areas. Crops grown are maize intercropped with beans, coffee, and banana with a semi-extensive livestock system. Livestock are mainly free-grazed and few are stall-fed. Precipitation in this zone is slightly lower than that found in high-potential areas and ranges from 800 to 1000 mm per annum. Altitude ranges from 900 to 1500 m a.s.l. Soils in these areas are browner, less leached and slightly more fertile than soils in the low-potential areas.

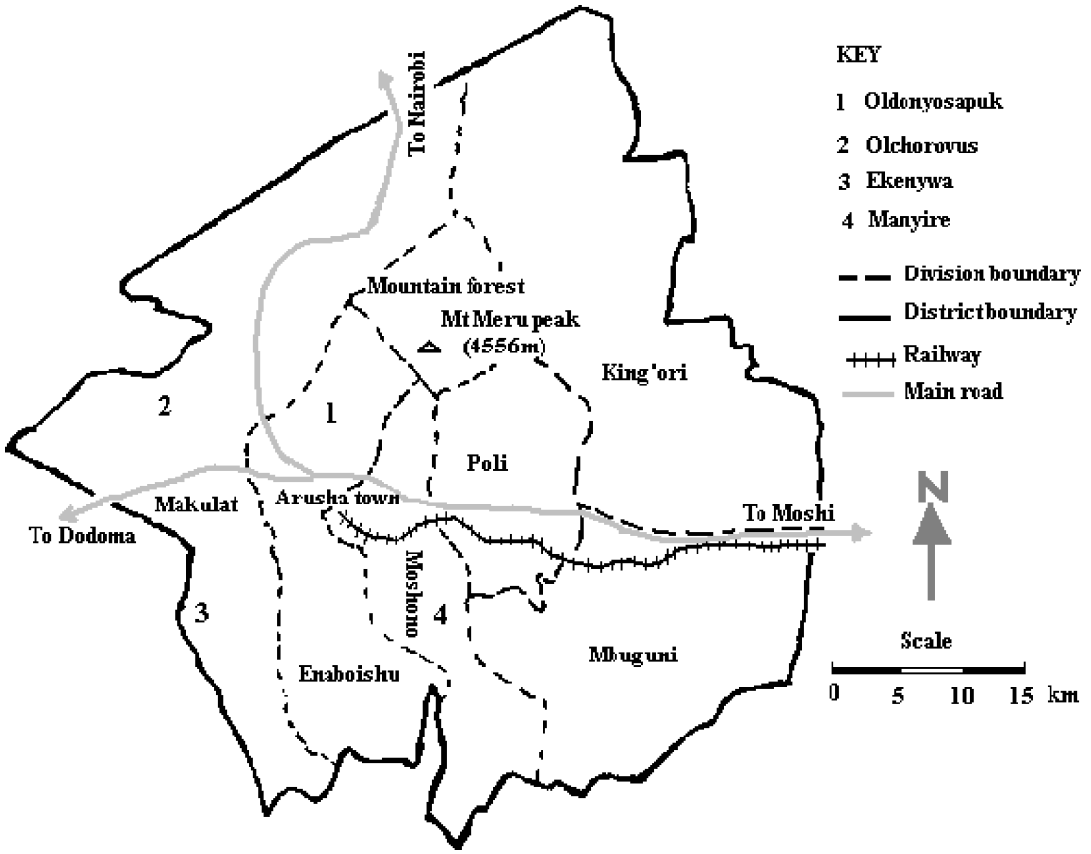

Figure 2. A map of Arumeru District (Tanzania) showing the study villages. (*Source* = Land Use Planning and Soil Conservation Unit, Arusha Region, Tanzania.)

The 'low-potential areas', also commonly referred to as 'lowlands', consist mainly of plains surrounding the mountains with altitudes of 900 m a.s.l. or less. These lowland areas are relatively dry, compared to the high- and medium-potential areas. The amount of rainfall is less than 800 mm per annum. It is normally erratic and bimodal (Nkonya *et al.*, 1991). The soil is volcanic ash, more developed than in high- and medium-potential areas (Cunard *et al.*, 1985). Maize is intercropped with beans. Wheat and barley are grown in western areas. Livestock rearing is quite extensive and concentrates mainly in raising local cattle breeds (zebu), with very few improved dairy cattle. Goats, sheep, donkeys and chicken are also kept. Soil erosion is quite pronounced due to the vulnerability of the volcanic soils and rolling topography (Cunard *et al.*, 1985).

Both natural and planted forests surround the steep slopes of Mount Meru. The southern sides of the steep slopes of Mount Meru have a well-developed montane forest belt, while the northern sides are mainly agricultural land or planted forests. In general, more than half of the district is cultivated and the rest is forest, bush and open grasslands.

According to the 2002 census, the total population of Arumeru District was 516 814 (253 143 males and 263 671 females). The population growth rate between 1988 and 2002 was estimated to be about 3·5 per cent per annum (URT, 2003). The dominant tribes are Wameru and Waarusha (Laizer, 2000).

Methodology

The study was carried out in two phases. Phase one involved carrying out reconnaissance survey and Participatory Rural Appraisal (PRA) in order to become acquainted with the study area. During phase two, a survey with

questionnaires was carried out to pursue major issues identified during phase one. Structured questionnaires, with both open-ended and close-ended questions, were used to collect information about issues such as land holdings, indigenous-based interventions, farm size, and tree planting. Pre-testing of the questionnaire was done during PRA exercises to check the reliability and validity of the questions.

The sampling unit of the study was the household, which was defined as a group of people who eat from a common pot, share a dwelling house and may cultivate the same land and recognize the authority of one person, the household head. Four villages out of the forty-one where land conservation measures are being instituted (i.e. 10 per cent) were randomly selected; two from the low-potential area, one in the high-potential zone and the last in the medium-potential zone of the district. Furthermore, in each selected village 5 per cent of households were randomly selected from village registers. In total, 84 households out of 1680 households in the sampled villages were interviewed. Respondents were household heads.

Other tools used during data collection included discussion with key informants using checklists of issues of interest and participant observation. Participant observation consisted in directly observing practices in the village, trying to learn how and why things were done the way they were done (Martin, 1995). The participant observation method was primarily used to tie together the more discrete elements of data gathered by other methods.

Data Analysis

Data collected by PRA techniques in phase one were analysed with the help of the communities. Data collected in phase two were analysed by both quantitative and qualitative methods. The Statistical Package for Social Sciences (SPSS®) was the main tool used to analyse the quantitative data. Cross tabulation, and logistic regression analyses were employed to process and present the data.

Content and structural—functional analysis techniques were used to analyse qualitative data and information. The components of the verbal discussions held with key informants were analysed in detail with the help of the content analysis method. In this way the recorded dialogue with respondents was broken down into the smallest meaningful units of information or themes and tendencies.

RESULTS AND DISCUSSION

Historical Background of Land Degradation in Arumeru District

The problem of land degradation in Arumeru District started in the highlands of Mount Meru and then extended to the lowland areas of the District. The study revealed that about 70 per cent of the respondents perceived the rate of land degradation as being rather severe. This realization has come after the local communities in the study area had faced shortages of arable land, pasture and water for quite sometime (Per, 1999). The perception of respondents as to the level of land degradation in historical perspectives is shown in Table I.

The historical time with regard to land degradation in the district can be divided into three periods, namely: (1) the colonial era; (2) the independence era; and (3) the present era. The colonial era represents the time before Tanganyika (Tanzania mainland) got its independence. As early as the 1930s the British Colonial Authorities

Table I. Distribution of respondents by their perception on the level of land degradation in historical perspectives, Arumeru District, Tanzania

Perception	Olchorovus		Oldonyosapuk		Ekenywa		Manyire		Total	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
Severe	20	23·8	11	13·1	18	21·4	10	11·9	59	70·2
Slightly severe	1	1·2	10	11·9	3	3·6	11	13·1	25	29·8
Total	21	25·0	21	25·0	21	25·0	21	25·0	84	100·0

Source: Survey results, 2001.

recognized soil erosion to be a problem and therefore imposed restrictions on cultivation above 500 m a.s.l. on Mount Meru to protect the forest areas, and introduced the construction of terraces on sloping farm lands (Spear, 1997). The colonial authority's main efforts to reduce problems of soil erosion and increase farm production were, however, concentrated to large-scale farming at lower altitudes around the mountain. The small-scale farmers perceived such conservation practices as unsuitable for the diversified small-scale farming systems practised on the mountain. Terracing as advocated by the colonial authorities was therefore rarely implemented among the small-scale farmers living further up on the mountain slopes (Per, 1999).

Issues of utilization and conservation of land resources at the time of independence were delicate issues in the Arumeru District and often observed with scepticism by the local population. The suspicion that the local population displayed towards the authorities meant that the Tanzanian administration held a low priority on issues of land use in these fertile coffee producing areas around Mount Meru (Japhet and Seaton, 1967). Instead, issues of land use and soil conservation largely focused on the surrounding lowland areas. Generally speaking, efforts to preserve land resources in Arumeru District, as well as in other parts of Tanzania, were often not as successful as predicted (Spear, 1997). One reason for this situation was related to the farmers scepticism of soil conservation activities imposed by the colonial government, coupled with a technical 'top-down' oriented approach that involved either limited or non-existent involvement by the local population. One such example can be seen in the lowlands around the Kisongo area located on the undulating lowlands South of Mount Meru in the Arumeru District. In the 1970s, in order to reduce the problems of soil erosion in this area, extension staff implemented schemes for constructing terraces and planting trees using machinery. The participation of the local population in the process was almost non-existent. The interest in or concern for terracing the land by the local community was therefore quite limited. Consequently, constructed terraces were not maintained, and animals grazed the planted trees. Within a short period, most of the constructed terraces were destroyed and the planted trees killed. Today, only traces of these terraces can be found in the area (Per, 1999). During the present period, starting from the mid-1980s, the sea-level Regional administration has stressed that problems of land degradation are not only a problem in the lowland areas of the region, but also in the highlands of Mount Meru. Signs of erosion and degradation of land resources had also become a problem in the fertile highland areas due to population pressure, which had forced small-scale farmers to clear environmentally fragile areas for cultivation. In turn, these farming practices tended to activate degradation process and erode the land resources. According to Massao (1993), it is estimated that over 500 hectares of forest on the slopes of Mount Meru were cut or burnt in 1990, which indicates the severity of the forest depletion. As noted by Ahlback (1988) this is regarded as a major problem since the natural and planted forests on Mount Meru serve an extremely important function regarding soil protection and water-flow regulation from the mountainous areas.

Furthermore, apart from the intensive crop production on the upper slopes of the mountain, the Arumeru District contains large herds of livestock mostly concentrated in the low-potential areas surrounding Mount Meru. According to the available livestock statistics and the study by Semu *et al.* (1992), Arumeru District has an overstocking rate exceeding 70 per cent. Overgrazing, arising from overstocking and poor management of grazing lands, thereby causing severe erosion in the lowland areas of the District.

Adoption Rate of Indigenous-based Interventions

Most of the farmers in the study area had experienced land degradation. This raised the question as to what interventions they normally applied in order to conserve the land against degradation. Their responses are summarized in Table II. The key indigenous-based interventions mentioned included intercropping, ploughing in crop residues, tree planting and application of farmyard manure.

Tree planting

Table II shows that the majority of respondents (90·5 per cent) adopted tree planting. Trees are planted around farm boundaries, homesteads, and in woodlots. The common sources of seedlings in the study area were SCAPA (76·2 per cent of all seedlings) and individual nurseries (10·7 per cent of all seedlings). The free of charge availability of seedlings from SCAPA could explain why many people have engaged themselves to tree planting.

Table II. Adoption rate of indigenous-based interventions, Arumeru District, Tanzania

Interventions	Adopters	Non-adopters	Total	Ranking with reference to adoption
Contour making	45·2	54·8	100·0	4
Intercropping	85·7	14·3	100·0	2
Tree planting	90·5	9·5	100·0	1
Ploughing-in crop residues	69·0	31·0	100·0	3
Application of farmyard manure	36·9	63·1	100·0	5

Source: Survey results, 2001.

Trees are the major long-term crops grown by the villagers, and they are grown for many reasons including woodfuel, timber, fruits, poles, fodder and soil-erosion control. Tree/shrub species mostly preferred in the study villages include: *Leucaena leucocephala*, *Leucaena diversifolia*, *Sesbania sesban* and *Calliandra calothyrus*. Other tree species include *Markhamia lutea*, *Eucalyptus* species, *Grevillea robusta* and *Senna siamea.* Fruit trees include *Carica papaya*, *Mangifera indica*, *Psidium guajava*, *Citrus limon* and *Citrus sinensis.* Other tree species that are used in the study area are *Acacia* and *Casuarina* species.

Intercropping

Findings from Table II suggest that intercropping was the second most used farming practice in the study villages (86 per cent). Chatterjee *et al.* (1989) also reported that intercropping provides economic benefits to the farmer against falling prices of one commodity and minimizing the risk of crop failure.

Ploughing-in crop residues

The plausible explanation for the relatively low adoption of ploughing-in crop residues as compared to tree planting and intercropping as shown in Table II could be that data for this study were collected during the dry season, the critical time for livestock feeds, hence it was possible that crop residues were fed to livestock.

Contour making

Results from Table II show that contour making had a low rate of adoption by farmers (45·2 per cent) compared to tree planting, intercropping and ploughing-in crop residues. Holden *et al.* (1996) argue that smallholder farmers, who are in most cases resource poor, tend to avoid the risks associated with the adoption of new technologies. According to Hudson (1987), the slow rate of adoption of what appear to be a satisfactory new method or the poor adoption of new conservation techniques such as contour making is the inability of the subsistence farmers to take risks. Farmers will not adopt technologies without economic incentives (Pawlick, 1989). This means that new technologies such as contour making must have some advantages over the existing ones.

Application of farmyard manure

The application of farmyard manure had the lowest rate of adoption by farmers in the study area (Table II). People who depend on livestock as a source of income are many in the study area and therefore one would expect increased use of farmyard manure on their farms. However, Table III shows that the application of farmyard manure was not closely associated with respondents' economic activity.

This result is contrary to that of Davies *et al.* (1982) who reported that the use of farmyard manure increases with the ownership of livestock. The unexpected relationship between use of manure and livestock ownership was explained by Gabriel (1998), who discovered that one of the major reasons for under-utilization of animal manure for crop production was a lack of technical know-how by most farmers. To a large extent this is due to the lack of scientific facts involved in advising farmers on such aspects of fertilization as application rates, storage techniques and appropriate manure-application methods.

Table III. Distribution of respondents by source of income, Arumeru District, Tanzania

Activity	Olchorovus		Oldonyosapuk		Ekenywa		Manyire		Total	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
Business	—	—	—	—	1	1·2	7	3·6	4	4·7
Crop/livestock	6	7·1	—	—	2	2·4	7	8·3	15	17·9
Crop/livestock/trees	9	13·1	21	25	9	13	7	8·3	50	59·5
Crop/livestock/business	4	4·8	—	—	7	8·4	5	4·8	15	17·9
Total	21	25·0	21	25	21	25·0	21	25·0	84	100·0

Source: Survey results, 2001.

Table IV. Impact of indigenous-based interventions as perceived by the local people, Arumeru District, Tanzania

Impact	*n*	%
Improved crop yield	47	55·9
Improved soil conservation	51	60·7
Increased income	49	58·3

Source: Survey results, 2001.

Impact of Indigenous-based Interventions

Impacts of the indigenous-based interventions as perceived by local people

The impact of the indigenous-based interventions was estimated by requesting the respondents to single out the main positive impacts that have originated from the SCAPA Project. Their responses are summarized in Table IV. Overall, the interventions are said to have eased-up farm operations and contributed towards increased crop yields, improved soil conservation and increased income.

Kashuliza and Saria (1995) reported improved crop yield and improved soil conservation through practices introduced by the Farming System Research (FSR) Project. Project interventions produce environmental and social impacts, which can be positive or negative. It is an accepted fact in the literature that these impacts are difficult to identify and quantify despite the numerous attempts to address the problem (Hufschmidt *et al.*, 1983; Dixon and Hufschmidt, 1986; Sodebaum, 1990). Therefore, this study advocates a clear verbal description of the environmental and social impact associated with the project interventions as a guide to decision makers.

Impact of the key indigenous based interventions on key crops

(1) *Intercropping*. Table V shows that half of the respondents (50 per cent) had intercropped maize and beans whereas only 14·3 per cent of the respondents reported growing crops in pure stands. Beans are normally grown under an intercropping system, and the practice of intercropping is very common in areas with land shortage due to dense human populations (Mkenda, 1997). This indicates that the probability of yield performance of maize was higher on farms with much intercropping. This result is contrary to Ndakidemi *et al*. (1996), who argued that planting maize in association with beans had no significant effect on maize yield.

The regression analysis revealed that the correlation coefficient associated with intercropping was positive and significant at the 0·05 level for yield performance of maize (Table VI). None of remaining variables were significant (Table VI).

The significance of intercropping in the study villages is in line with findings by Gilley *et al.* (1999) who showed that intercropped crops can influence the microclimate and yield potential for adjacent crops. These authors also pointed out that a well-managed intercropping system could result in profitability and a greater soil and water conservation potential than most monocropping systems.

Table V. Cropping systems in the study villages, Arumeru District, Tanzania

Activity	Olchorovus		Oldonyosapuk		Ekenywa		Manyire		Total	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
Maize	1	1·2	2	2·4	1	1·2	—	—	4	4·8
Beans	—	—	—	—	—	—	—	—	—	—
Maize + beans*	10	11·9	9	10·7	11	13·1	12	14·3	42	50·0
Maize, beans + trees	8	9·5	7	8·3	5	7·1	9	10·7	30	35·7
Irish potato	—	—	3	3·6	—	—	—	—	3	3·6
Wheat	2	2·4	—	—	3	3·6	—	—	5	5·9
Total	21	25·0	21	25·0	21	25·0	21	25·0	84	100·0

Source: Survey results, 2001.
*The common species of beans intercropped with maize is *Phaseolus vulgaris* (common bean) with a number of varieties.

Table VI. Key interventions affecting yield performance of maize and beans in the study villages, Arumeru District, Tanzania

Independent variable	Yield performance of maize	Yield performance of beans
Intercropping	1·250 (4·280)*	1·176 (0·329) *ns*
Ploughing-in crop residues	−1·369 (0·319) *ns*	1·216 (1·554) *ns*
Tree planting	0·230 (0·870) *ns*	0·120 (2·200) *ns*

Key: *Significant at 0·05 level (95 per cent confidence).
ns, non-significant.
Figures in brackets are wild statistics.
Source: Survey results, 2001.

(2) *Ploughing-in of crop residues*. Table II shows that 69 per cent of the respondents had adopted ploughing-in of crop residues on their farms. However, under a logistic regression model (Table VI) the results were not significant. These results are contrary to those of Muchlig-Versen *et al.* (1997) who showed that leaving crop residues in the field is a way of increasing yield and replenishing soil nutrients levels. Lamers and Bruentrup (1996) who studied the use of crop residues in West Africa, found that the highest gross margin returns to land resulted from mulching with crop residues. A plausible explanation for this interesting observation was given by FAO (1990) and Van Schoubroeck (1991), who pointed out the fact that adoption of new technologies does not always produce the desired effects.

(3) *Tree planting*. Although about 90 per cent of the respondents were reported to adopt tree planting (Table II), this had no significant effect on the yield performance of crops (Table VI). A plausible explanation could be that there is a reduction of output from food crops where trees compete for arable land and/or depress crop yields through shade and root competition (Nair, 1989). Another plausible explanation could be the incompatibility of trees and agricultural crops due to allelopathic effects, either of trees on crops or vice versa (Lulandala, 1994). Furthermore, it can be argued that the presence of tree vegetation on the land management unit may attract pests and diseases that can in turn cause problems to the associated crops (Lulandala, 1994). The study by Kerkhof (1990) showed that trees compete with adjacent crops for light and soil nutrients.

Impact of minor interventions on key crops

(1) *Contour making*. Contour making had a relatively low rate of adoption (Table II) and had no impact on the yield of maize and beans. Bernstein and Ferguson (1992), pointed out that in order to have an impact, projects must have developed and released technologies that have been adopted by a large proportion of producers/consumers, and the adopted technologies must have resulted in an improvement that can be measured/quantified.

(2) *Application of farmyard manure*. The application of farmyard manure had the lowest rate of adoption (Table II) and thus had no significant impact on crop production. This could be explained by the fact that farmers in the study area applied very little manure due to the lack of a means of transport. Similar results were also reported by Kimbi *et al.* (1992), who noted that very little animal manure was being utilized for crop production in most parts of the country. Kyomo and Chagula (1983) argued that most of the studies on utilization of animal manure for crop production in Tanzania had largely focused on crop yield responses of various field crops with very little effort being made to relate such responses to the availability of nutrients. Efficient utilization of animal manure requires a thorough understanding of the relationship between crop responses and the availability of nutrients in the soil following animal manure application.

Sustainability of Indigenous-based Interventions

Awareness of land husbandry and land conservation

The results of the survey show that 100 per cent of the respondents were aware of land husbandry and environmental conservation. Awareness of the people about the project helped SCAPA to achieve its objectives. Many farmers adopted the interventions that the SCAPA project disseminated. The level of awareness has increased tremendously among the farming communities. According to Sharma (1992), designing strategies around specific social actors, and constructing or strengthening groups, requires at least two key elements: (1) awareness of the project activities; and (2) tangible economic incentives and benefits to the social actors.

The study showed that a greater proportion of the respondents (79·8 per cent) indicated that there was close collaboration and trust between project officials and the villagers. This is in line with what Kerkhof (1990) pointed out concerning the Village Afforestation Programme in Kondoa District, Dodoma Region, which was successful in its initial phases because of the collaboration and trust developed between the programme officials and the farmers. Reynolds and De Leeuw (1988) reported that the long-term sustainability of a farming system depends upon awareness and acceptance by the farming community.

Presence of by-laws enforcing land conservation practices

The study villages were found to have laid down by-laws that restricted villagers from undertaking activities that destroy the environment. These by-laws restrict villagers on four important issues: (1) free grazing of livestock in the crop fields; (2) cultivating and grazing on conserved areas; (3) cutting trees haphazardly; and (4) starting up unauthorized fires. Table VII shows that 83·3 per cent of the respondents were aware of the existence of these by-laws, but awareness of the by-laws varied between villages and only 52·3 per cent of the respondents reported that the by-laws were effective.

Individuals who are accused of destroying the environment are normally sent to the Village Office where, if convicted, they are fined. The maximum fine is ten thousand shillings (Tshs 10 000). Out of this, two thousand

Table VII. Respondents' awareness of the by-laws and their effectiveness, Arumeru District, Tanzania

Villages	Olchorovus		Oldonyosapuk		Ekenywa		Manyire		Total	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
Awareness										
Yes	14	17·9	19	25	15	17·9	19	22·6	70	83·3
No	6	7·1	—	—	6	7·1	2	2·4	14	16·7
Total	21	25·0	21	25·0	21	25·0	21	25·0	84	100·0
Effectiveness										
Effective	4	4·8	21	25	8	9·5	11	13·1	44	52·3
Ineffective	17	20·2	—	—	13	15·5	10	11·9	40	47·7
Total	21	25·0	21	25·0	21	25·0	21	25·0	84	100·0

Source: Survey results, 2001.

shillings (Tshs 2000) go to the Village Government fund, three thousand shillings (Tshs 3000) remain with the Environment Committee, four thousand shillings (Tshs 4000) are given to the person whose farm was destroyed and the remaining one thousand shillings (Tshs 1000) are given to the person who apprehends the culprit as a motivation for a job well done (Tshs 1000 = US$1).

Informal discussion with some villagers revealed that there were problems of 'inconsistency' in the administration of the fines paid by the convicted individuals. Inconsistency involved the culprits not paying the fines or paying less than what was specified due to a fear of jeopardizing the good relationship that existed among the villagess. Kelly (1982), reported that there was inconsistency in administering local institutions to meet the needs of individuals and the community because of economic instability, change in the structure of the family, and village and tribal organizations.

The use of local resources for land conservation

The study revealed that the majority of the respondents (84·5 per cent) used the locally available resources for preparing and conserving their land. The locally available resources for conserving the land include maize straw, beans stoves, grass mulch and locally available seed varieties. This implies that they do not depend entirely on donor assistance to get the resources for implementing conservation activities. Thus, the ability of the farmers' economy to sustain further development from their own resources is very substantial. This agrees with what was reported by UNESCO (1995), that the productivity of assistance over short periods could be measured by the increase in output resulting from the fuller use of domestic resources.

The locally available resources for managing the land include hand hoes, sickles, brachetes, and the use of oxen. Most of the agronomic activities such as weeding and sowing were done by hand-hoe (Figure 3). This was also reported by Portch and Jesse (1980), Blustain (1982) and Rogers (1983), who state that simple, inexpensive landscape management methods may be more appropriate and effective in sustaining productivity. According to FAO (1986) the development initiative must be suitable for the conditions in the localities served.

Integration of crops, livestock and trees

The fact that about 60 per cent of the respondents (Table III) had integrated crops, livestock and trees on the same field is an important aspect of sustainability. Mphuru (1991) proposed a similar view that, in developing research priorities, integration of crops, livestock and trees should be considered. This system ensures high soil protection against agents of erosion and gives a high degree of nutrient recycling, thus enabling the production system to

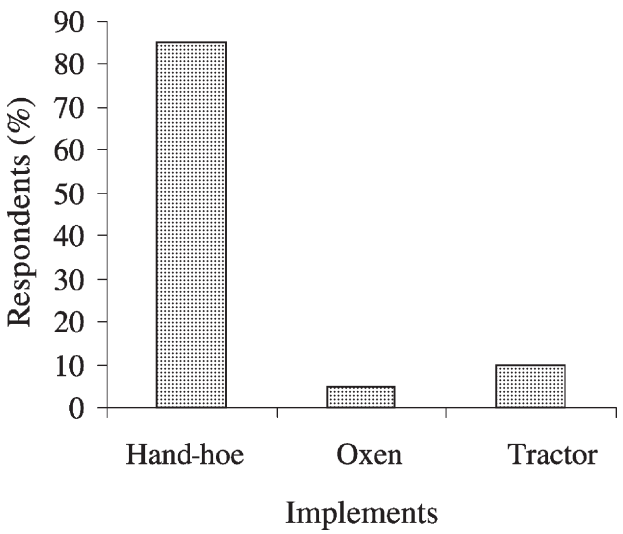

Figure 3. Distribution of respondents by use of agricultural implements, Arumeru District, Tanzania.

remain sustainable for a long time. Reynolds and De Leeuw (1988) also reported that integration has the potential to raise sustainable yields of crops and livestock.

Capacity building of staff, paraprofessionals and farmers

The study showed that 71·4 per cent of the respondents have been provided with basic training on soil and water management. Hence the majority of the farmers have skills for and knowledge of conserving the environment with minimal support from extension staff. Furthermore, the presence of Village Soil Conservation Committees (VSCC) was observed in the survey villages. The major reasons for having these committees was to ensure active participation of farmers in planning, implementation and sustaining programme achievements (SCAPA, 1997).

The study also revealed that about 73 per cent of the respondents use the handbook *Guidelines for Soil Conservation and Agroforestry* [*Mwongozo wa Hifadhi ya Ardhi na Kilimo Mseto*] Scapa (1996). This is very important as far as farmers' learning ability is concerned. Lugeye (1994) reported that the use of extension training manuals is very important in building the capacity of the farmer. The use of paraprofessionals was also noted to be one of the most outstanding and peculiar approaches used by SCAPA Project. Paraprofessionals are important in training large numbers of farmers in the Arumeru District, which could not be done by the regular extension services.

The use of farmers (paraprofessionals) to teach other farmers was noted to be one of the best approaches to ensure sustainability because they are most familiar with their own environment, therefore their advice and comments are easily accepted by the local people. A similar observation was made by Turuka (2000), i.e. that paraprofessionals are instrumental in training farmers and that this is one of the mechanisms for ensuring sustainability. SCAPA (1997) indicated that a total of 683 extension staff, 300 ward and village leaders and 10 878 farmers had already been provided with basic training on soil and water management between 1989 and 1997.

Major Constraints in Implementing Indigenous-based Interventions

Cost of inputs

The study revealed that 89·3 per cent of the respondents faced the problem of expensive and unavailable inputs. Most of the respondents had no purchasing power to buy inputs such as improved seeds, inorganic fertilizer or pesticides. This is maybe the reason why most farmers are engaged in indigenous-based interventions.

Byerlee and Heisey (1992) argued that farmers may be aware of the benefits associated with the adoption of technologies (e.g. improved seeds), however, if the technologies are not easily available at a price they can afford, the farmers will not adopt the technology. The farmers may need to be convinced that the benefits would far outweigh the costs involved. One of the methods used to create a more favourable farmers' response to modernizing agriculture is to subsidize the cost of inputs, thereby giving the farmer a better net return for his produce (BOT, 1979). However, it is unfortunate that the Tanzanian Government has currently removed subsidies that could help farmers to reduce the cost of production.

Absence of credits

About 82·1 per cent of the respondents mentioned inaccessibility to credit. This result suggests that the use of inputs in the survey areas was very limited due to inaccessibility to credit, low levels of income and low levels of investment. Similar results were reported by Massao (1993), who staked that small farmers in the vast majority of developing countries are caught in a vicious circle of low level of income, low investment in improved technology, and low level of agricultural productivity. Inaccessibility to credit is perhaps one of the most critical factors that impedes peasant agricultural production.

Drought

About 46·4 per cent of the respondents faced the problem of drought. It was mainly farmers in Olchorovus and Ekenywa villages who mentioned this problem. These areas are relatively dry compared to the other two Villages (Oldonyosapuk and Manyire). Nkonya *et al.* (1991) reported that drought remains the most important technical problem in these areas. Only about 3·6 per cent of respondents mentioned experiencing no problem of cost, absence of credits and drought in implementing indigenous-based interventions.

CONCLUSION AND RECOMMENDATIONS

Conclusion

This study examined the impact of indigenous-based interventions on land conservation in Arumeru District, where they were used to restore soil fertility and prevent land degradation due to deforestation, overgrazing and inappropriate farming practices. The results showed that the rate of land degradation was perceived by farmers to be rather severe. The study also revealed that interventions, which require minimal labour and capital, have been highly adopted by many farmers while labour/capital intensive ones have been taken up by few farmers. In general, indigenous-based interventions have been shown to ease-up farm operations and contribute towards increased crop yield, improved soil fertility and increased income. Success in some of the interventions warrants their wider promotion beyond the Project area.

Factors thought to influence sustainability of interventions were reported to include awareness of land husbandry and land conservation, presence of by-laws enforcing land conservation, use of local resources for land conservation, integration of crops–livestock–trees, and capacity building of staff, paraprofessionals and farmers. The major constraints facing the farmers in the study area include the high costs of inputs, absence of credit, and drought.

Recommendations

Considering the above findings, the following recommendations are pertinent:

- Farmers have multiple objectives that are interlinked and therefore there should be a study by an interdisciplinary team on their needs and priorities. Results of such a study could be used to produce development plans that incorporate land conservation as an important aspect of development in the study area.
- The study revealed that SCAPA has contributed positively towards land conservation in the area through indigenous-based interventions. Indigenous-based interventions ease-up farm operations and contribute towards increased crop yield and improved land conservation. Farmers in neighbouring districts should be encouraged to adopt indigenous-based interventions through visiting SCAPA.
- In order to find lasting solutions to the problem of land degradation in the country, an examination of the causes of misuse of land is essential. The causes of land misuse range from inappropriate land tenure systems to lack of farm inputs. Solutions may mean changing the agricultural policy. The agricultural policy should be reviewed, especially the aspect of cost of inputs and absence of credits. The cost of inputs should be subsidized so as to give the farmer a better net return for his/her produce. The policy should also allow the farmers to have access to credit to enable them make high level income and hence high investment in agricultural productivity.
- In order to reduce pressure in densely populated areas such as Arumeru District, the Tanzanian Government should consider reallocating farmers to new lands where the population is sparser.

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REFERENCES

Ahlback AJ. 1988. Forestry for development in Tanzania. *Working Paper No. 71*. Swedish University of Agricultural Science: Uppsala.

Beets WC. 1990. *Raising and Sustaining Productivity of Small Holder Farming Systems in the Tropics: A Handbook of Sustainable Agriculture Development*. AgBe Publishing: Alkmaar.

Bernstein RH, Ferguson A. 1992. Assessing the impact of research in the bean/cowpea CRSP. *B/C CRSP Socio-Economics Working Paper No. 92-1*. Document prepared for the Technical Committee meeting of the Bean/Cowpea CRSP; 1–13.

Blustain H. 1982. Social issues in technology choice: soil conservation in Jamaica. *Journal of Soil and Water Conservation* **37**(6): 323–325.

BOT. 1979. *Credit for the Development of Agriculture in Tanzania*. Bank of Tanzania: Dares Salaam.

Byerlee D, Heisey P. 1992. Strategies for technical change in small-farm agriculture, with particular reference to sub-Saharan Africa. In *Proceedings of a Workshop*, Russel NC, Dosswell CR, (eds). 23–25 August 1992. VI; 21–47. Workshop title: *Policy Options for Agricultural Development in Sub-Saharan Africa.*

Chatterjee BN, Maiti S, Mandal BK. 1989. *Cropping System (Theory and Practice)*. (2nd edn). Oxford & IBH Publishing Co: New Delhi.

Cunard AC, Tang CY, Nyassi P, Mushi L, Masomo SMS, Mamkwe JA, Swai IE, Nahum S. 1985. *Results of the Diagnostic Survey in Arumeru District*. Interim Report. Unpublished Report.

Davies DB, Eagle DJ, Fimmey JB. 1982. *Soil Management*. Farming Press: Ipswich.

Dixon JA, Hufschmidt MM. 1986. *Economic Valuation Techniques for the Environment: A Case Study Workbook*. Johns Hopkins University Press: London, Baltimore.

FAO. 1986. *The Conservation and Rehabilitation of African Lands: Towards Sustainable Agriculture*. ARC/90/4. FAO: Rome.

FAO. 1990. *Production Year Book 1990*, Vol. 44. FAO: Rome.

Gabriel BLM. 1998. *Utilisation and Management of Animal Manure for Crop Production: The Case of Morogoro Urban and Kilosa Districts*. BSc (Agric.) Special Project. Sokoine University of Agriculture: Mororogo, Tanzania.

Gilley JE, Kramer LA, Cruse RM, Hill A. 1999. Sediment movement within a strip intercropping system. *Journal of Soil and Water Conservation* **52**: 443–446.

Holden ST, Shiferaw B, Wik M. 1996. Poverty credit constraints and time preference of relevance for environmental policy. *Discussion Paper No. D-26/1996*. Department of Agricultural Economics and Social Sciences, Agricultural University of Norway:

Hudson NM. 1987. Soil and water conservation in semiarid areas. Soil Resources, Management and Conservation Services, FAO Land and Water Development Division. *FAO Soils Bulletin No. 57.* Rome.

Hufschmidt MM, Janes DE, Meister AD, Bower BT, Dixon JA. 1983. *Environment, Natural Systems and Development: An Economic Valuation Guide to Project Analysis*. Johns Hopkins University Press: Baltimore, MD.

Japhet K, Seaton E. 1967. *The Meru Land Case*. East African Publishing House: Nairobi.

Kashuliza AK, Saria SI. 1995. Impact assessment of Morogoro District farming system research (FSR) project: preliminary findings. In *Meeting Farmers' Needs Through Agricultural Research*, Mattee AZ, Sibuga PK, Semoka JMR, Tusnoda M (eds). Proceedings of the 1st FOA Annual Research Conference, held at the Institute of Continuing Education, SUA, Morogoro 28–30 August 1995; 387–395.

Kauzeni AS, Kukula IS, Shishira EK. 1987. Development of soil conservation in Tanzania. In *History of Soil Conservation in the SADCC Region*. Research Report No. 8. SADCC Soil and Water Conservation and Land Utilisation Programmes Coordinating Unit: Maseru, Lesotho.

Kelly HW. 1982. Keeping the land alive: soil erosion, its causes and cures. *FAO Soil Bulletin* **50**: 27–30.

Kerkhof P. 1990. *Agroforestry in Africa: A Survey of Project Experience*. Panos: London.

Kikula IS, Mung'ong'o CG, Jengo RD. 1990. *Perspectives of Land Degradation and Conservation in Tanzania: An Annotated Bibliography.* Institute of Resource Assessment, University of Dar es Salaam/Regional Soil Conservation Unit, Swedish International Development Authority: Nairobi.

Kimbi GG, Rutachokozibwa V, Mollel NM, Simalenga TE, Ngeti MS, Biswalo PL. 1992. *Identification of SUA-TU linkage Project Needs Assessment: A Preliminary Survey.* Report Submitted to SUA-TU Linkage Project. Institute of Continuing Education, Sokoine University of Agriculture. Morogoro, Tanzania.

Kyomo ML, Chagula A. 1983. Role of livestock in organic farming. In *Proceedings of Workshop on Resources Efficient Farming Methods for Tanzania*, Morogoro, 16–20 May 1983; 42–46.

Laizer PM. 2000. *Environmental Conservation in Tanzania*. Arusha: Tanzania.

Lamers JPA, Bruentrup M. 1996. Comparative advantage of single and multi-purpose uses of millet stoves in Niger. *Agricultural Systems* **50**: 273–285.

Liwenga ET. 1995. *The Impact of Land Conservation Measures on Household Food Security in Kondoa Eroded Area*. Centre for International Environment and Development Studies NORAGRIC, Norwegion University of Agriculture: Åre.

Lugeye SC. 1994. The role of farmers' indigenous knowledge in natural resource management. In *Proceedings of the 1st SUA Convocation Workshop*, held in Morogoro, 26–27 July 1994; 166–177.

Lulandala LLL. 1994. *Agroforesty Course Program*. Department of Forest Biology, Sokoine University of Agriculture: Morogoro, Tanzania.

Martin, GJ. 1995. *Ethnobotany. A method manual*. WWF International/UNESCO/Royal Botanic Gardens, Kew UK; Chapman & Hall: London.

Massao JFK. 1993. *Soil Conservation on the Slopes of Mount Meru: Strategies Developed on the Basis of SCUAF Model Prediction*. University of Wales Bangor: Bangor.

Mawenya LAJ. 1994. *Soil Conservation and Agroforesty in Tanzania: A Survey of Nine Regions and Proposals for Training of Staff*. RSCU/SIDA: Nairobi.

Mkenda VF. 1997. *A Farm-level Impact Assessment Study of the Tanzania Bean Research Project Technologies: The Case of Morogoro and Kilosa District, Tanzania*. MSc Dissertation, Sokoine University of Agriculture: Morogoro, Tanzania.

Mphuru AN. 1991. Sustainable livestock production system in Tanzania. In *Proceedings of TSAP Vol. 18*, held 24–26 September 1991, Arusha International Conference Centre. Arusha, Tanzaniaa.

MTNRE. 1994. *Tanzania National Environment Action Plan: A First Step*. Ministry of Tourism and Natural Resources: Dar es Salaam.

Muchlig-Versen B, Buerkrt A, Bationo A, Marschener H. 1997. *Crop residue, and phosphorous management in millet-based cropping systems on sandy soils of the sahel*. In *Soil Fertility Management in West African Land Use Systems*, Renard G, Neef A, Becker K, Von Oppen M (eds). Magraf Verlag: Wekersheim; 31–40.

Nair PKR. 1989. Agroforestry defined. In *Agroforestry Systems in the Tropics*, Nair PKR (ed.). Kluwer Academic Publishers: Dordrecht.

Ndakidemi PA, Mmbaga MET, Edge OT. 1996. The effect of planting patterns of maize on bean yield when sown in association. In Msumali GP, Mabagala RB (eds). *Bean Research* **9**: 85–94.

Nkonya E, Schroeder T, Norman D. 1991. Factors affecting adoption of improved maize seed and fertilizer in Northern Tanzania. *Journal of Agricultural Economics* **48**: 1–12.

Pawlick T. 1989. Does agroforestry pay? *Agroforestry Today* (July–Sept.), **1**(3): 6–10.

Per A. 1999. *Livelihood Strategies and Land Degradation: Perceptions Among Small Scale Farmers in Ngiresi Village, Tanzania*. University of Göteborg, Series B, no. 96.: Göteborg.

Portch S, Jesse LH. 1980. A conservation program for Ecuador. *Journal of Soil and Water Conservation* **35**: 243–244.

Reynolds L, De Leeuw, PN. 1988. Integration of crops, trees and livestock in dryland farming for developing countries. In *Proceedings of the International Conference on Dryland Farming: Challenges in Dryland Agriculture: A Global Overview*, held in Amarillo/Bushland, TX, 15–19 August, 1988; 873–875.

Rogers EM. 1983. *Diffusion of Innovations* (3rd edn.). Collier Macmillan: London.

SCAPA. 1996. *Guidelines for soil Conservation and Agroforestry (Mwongozo wa Hifadhi ya Ardhi na Kilimo Mseto).* RUS/SIDA: Nairobi.

SCAPA. 1997. *Programme Action Plan 1997–98*. Soil Conservation and Agroforestry Project in Arusha: Arusha, Tanzania.

Semu E, Bergman G, Skoglund E. 1992. *Evaluation of Soil Conservation and Agroforestry Project, SCAPA in Tanzania*. RSCU/SIDA: Nairobi.

Sharma NP. 1992. *Managing the World Forests: Looking for Balance Between Conservation and Development*. Kendal/Hunt: Dubuque, IA.

Sodebaum P. 1990. *Economics in Relation to Environment Agriculture and Rural Development: A Non-Traditional Approach to Project Evaluation.* Swedish University of Agricultural Sciences: Uppsala.

Spear T. 1997. *Mountain Farmers*. James Curry: Oxford; 34–67.

Turuka FM. 2000. HIMA impact study: methodology for Agricultural Research Impact Assessment. In *Proceedings of a Workshop Under the Project 'Food Security and Household Income for Small Holder Farmers in Tanzania: Applied Research with Emphasis on Women'*, held at TANESCO Training Centre, Morogoro, Tanzania, 5–12 December 2000; 34–35.

UNESCO. 1995. *International Review of Education* **41**(6): 460–478.

URT. 1991. *Population and Development in Tanzania: Population Planning Unit*. Planning Commission of the President, United Republic of Tanzania: Dar es Salaam.

URT. 2003. The 2002 Population and Housing Census. General Report. Tanzania National Website http://www.Tanzania.go.tz/census/tables.htm. [Accessed 13 April 2004].

Van Schoubroeck, FHJ. 1991. *Managing Pests and Pesticide in Small Scale Agriculture*. CON/CTA/TIOL: Amsterdam.

