Changing landscapes and livelihoods on the southern slopes of Mt. Kilimanjaro, Tanzania

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Abstract

This case study on the traditional Chagga homegarden system on the slopes of Mt. Kilimanjaro and the adjacent plains in northern Tanzania was undertaken as part of a project 'Socio-ecologic dynamics of land use change on East-African highlands'. To map and analyse changes in the landscape an aerial photo interpretation was conducted covering approximately the Kirua Vunjo Division, a transect of 152 sq km from the forest reserve edge to the plains. The study looked at land use in 1961, 1982 and 2000. Earlier changes were traced from an extensive literature review. Results of the photo interpretation were further processed in a fragmentation analysis. The results show the expansion of cultivation to more marginal land down the slope, the disappearance and extreme fragmentation of natural bush land and appearance and expansion of settlements. The homegarden area has experienced some specific internal change, but has not expanded down the slope. In the 1960s there was still space for small open fields and patches of grazing lands in the homegarden area. In 1980s the area has more closed canopy. Since then the

area has become patched again, as due to population growth new homesteads have been built on subdivided farms and more food is produced on the higher slopes. Severe population pressure and the ensuing land use intensification have caused changes in the environment reflecting back to farmers' livelihoods. In addition, low coffee price in the world market has rendered the traditional Chagga coffee-banana system unprofitable. As land scarcity now hinders expansion of agriculture, common land for free resources is scarce, and prices of coffee in the world market continue being low, farmers are trying to find options for more intensified and diversified production. Off-farm activities have become increasingly crucial.

Key words: homegardens, Chagga, land use, highlands

Introduction

Kilimanjaro area with the highest (5895 m) mountain in Africa is one of the most densely populated areas in Tanzania. With the old Chagga homegarden system covering the upper southern slopes of the mountain, it has been one of the most productive agricultural areas in the country. Today the area is, however, facing several challenges that affect people's livelihoods. Due to subdivision of farms between the sons of the family, farms have become very small. Global climate change affecting the glaciers of the mountain (Hastenrath & Greischar 1997), change of indigenous vegetation to exotic species, and cultivation of the immediate riverbanks has contributed to the drying up of rivers (Fernandes et al. 1984; Aminu-Kano et al. 1992; Kisanga 1997 & 1998; Zongolo et al. 2000b; Rasmussen & Parvez 2002; Soini 2002a & 2002b). Further, low coffee prices in the world market have rendered the traditional coffee-banana farming system unprofitable.

The case study on changing landscapes and livelihoods on the southern slopes of Kilimanjaro, Tanzania (3.16-3.28º S latitude and 37.25-37.32º E longitude) was undertaken as part of a project 'Socio-ecologic dynamics of land use change on East-African highlands'. The study area (Figure 1) for the land use change analysis covers approximately an administrative area of Kirua Vunjo Division. This area represents the parts of the slopes of the mountain with only small-scale farming and no big farm estates in between. It coversrs an area of 152 km^2 from the lowlands at about 800 m altitude up to about 1700 m altitude. Interviews were conducted in the neighbouring Kilema and Marangu divisions as well.

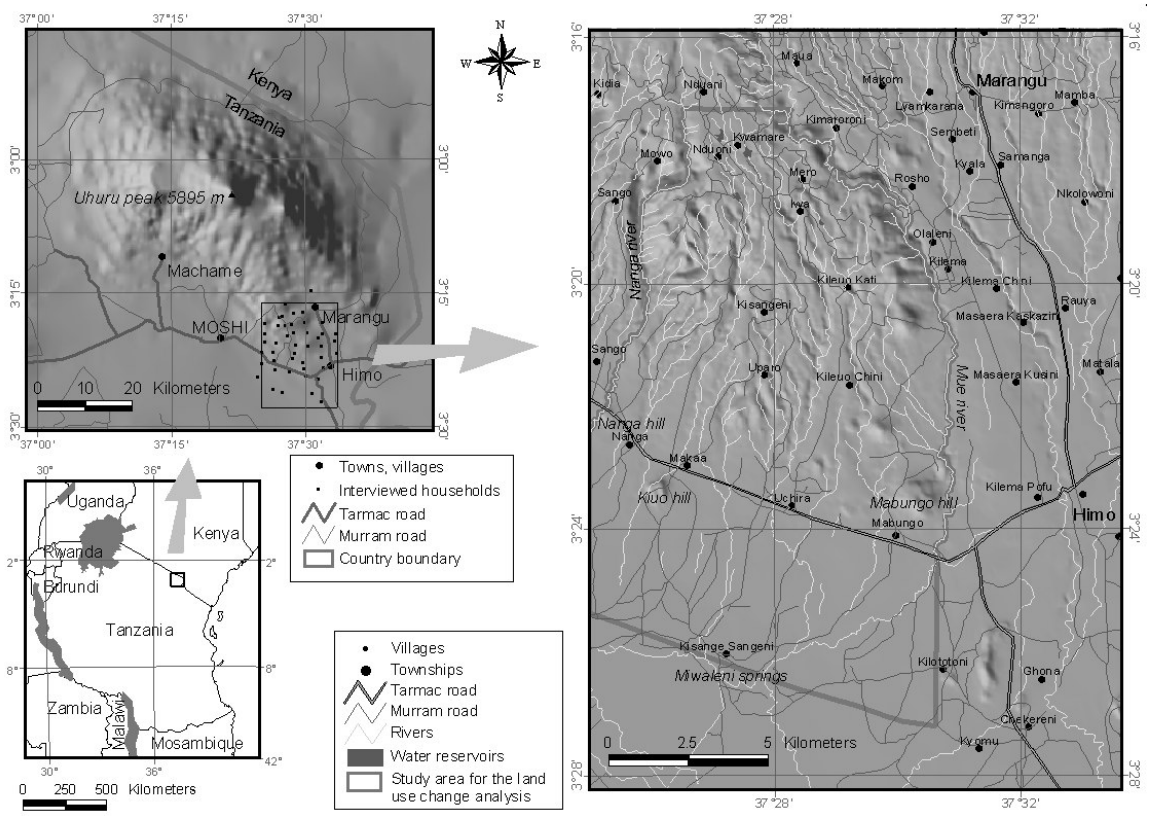

Figure 1. The study area on the southern slopes of Mt. Kilimanjaro, east of Moshi town.

Three distinct agro-ecological zones can be identified in the area; 1.) A lowlands zone of extensive livestock farming, 2.) A midlands maize-bean

belt and 3.) A homegarden area (Coffee-banana belt, highlands). Lowlands extend up to about 900 m, midlands up to 1200 m and homegarden area to about 1800 m above sea level. Annual rainfall varies according to the altitude, being 400-900 mm in the lowlands, 1000-1200 mm in the midlands and 1200-2000 in the homegarden area. The montane forest covered by the Kilimanjaro forest reserve and the National Park above the homegarden zone receives in excess of 2000 mm rain per year. (Zongolo et al. 2000b).

To map and analyse changes of land use patterns, an aerial photo interpretation of land use change was conducted. The results of the interpretation were further processed by a landscape fragmentation analysis . To study the changing farm production and management of the Chagga homegardens and the lowland fields on the adjacent plains, forty-five homesteads were interviewed. The survey was based on DFID sustainable livelihoods framework (Department for International Development, 1999). Extensive literature review was conducted to put the survey into historical perspective. All data presented in this paper, unless otherwise cited, is based on Soini 2002a and 2002b.

Methods

Aerial photo interpretation

Black and white aerial photographs from 1961 (1:40 000), 1982 (1:60 000) and 2000 (1:40 000- 60 000) were used in the analysis. The older two sets were purchased from the Survey of Tanzania, images from the year 2000 from Photomap International. The aerial photos were scanned and georeferenced, warped (lower slopes) or orthorectified (upper slopes), and mosaiced. Classification was done visually.

Anderson's (1982) natural vegetation classes in the Kilimanjaro area

were used as a base in selecting land use categories for the interpretation of the aerial photos. As it was not possible to distinguish between all the different classes on the aerial photos, some classes were combined (Table 1 and 2). The categories of natural vegetation used in the classification of the aerial photos were Riverine Forest, Forest and Bush land. All Anderson's categories of Wooded grasslands, Bushed grasslands and Bushlands were put under one category, Bush land. The four categories of man-made land cover types used in the aerial photo interpretation are Fields, Settlements, Homegardens and Degraded areas. Fields are mainly cultivated fields but may also include very small patches of grazing land and fallows. Settlements are the villages along the main road as well as the missions on the upper slopes. Homegardens cover practically all the upper slopes. Degraded areas are areas with high reflectance in the aerial photos, are overused and have sparse vegetation cover most of the year.

After completing the interpretation, a ground-truthing was done for the year 2000 land cover map. A total of 56 points were selected with 32 points placed symmetrically at 2 km intervals and the rest of the points placed in areas which were difficult to interpret. All 56 points were found to be within the correct land use category though minor corrections were made to update the boundary lines. Distinguishing between the selected broad categories was shown to be easily accomplished using the 2000 dataset. As the interpretation of all the three sets of images was done by the same interpreter, the reliability of interpretation is approximately the same for the two older image sets. To improve the accuracy on the heavily shady areas in the Nanga river valley in the year 1982 aerial photos, interpretation was enhanced through ancillary

Table 1. Natural vegetation classes used in the aerial photo interpretation with natural vegetation classification by Anderson 1982.

Land use class	Anderson's vegetation classes	Sub-types of major classes (Anderson 1982)	Occurs in
Bushland	Wooded grasslands	Medium height *Hyparrhenia-Panicum/ Combretum-Acacia* wooded grassland. Also: *Acacia tortilis* and *A. mellifera*.	Lower slopes bordering the road, below 1200 m
		Tall *Hyparrhenia-Panicum/ Croton – Combretum – Rauvolfia* wooded grassland (replaced by maize, beans, millet and banana). Also: *Acacia tortilis* and *A. polyacantha*.	Upper parts of the plains
		Medium height *Hyparrhenia – Cynodon / Acacia tortilis* seasonally waterlogged wooded grassland. Also: *Acacia polyocantha, A. seyal, A. mellifera* and *A. stulmannii*.	Seasonal water courses
	Bushed grassland	Medium height *Aristida – Heterropogon / Acacia-Combretum* bushed grassland (mainly grazed, some maize, beans, millet and sorghum).	Lower slopes and plains
		Medium height *Hyparrhenia – Heteropogon / Combretum – Acacia* bushed grassland (rarely cultivated, grazed mainly)	Volcanic ash and scoria cones in the drier areas
	Bushlands	*Acacia / Commiphora bushland* (rarely cultivated, overgrazed)	Steep eroded slopes
Forest	Forests	*Albizzia / Rauvolfia* medium altitude forest (now mostly coffee and bananas, in addition small areas of pastures). Also: *Croton macrostachys, Newtonia buhananii, Macaranga kilimandcharica, Fauria saligna, Olea welwitchii, Ficus capensis* and *Teclea viridis.*	Altitudes 1100-1700 m
Riverine forest	Riverine forest	Lowland riverine forest. The most common species *Cordyla africana* and lianas.	Along the rivers in the lowlands

Table 2. Man made land use classes used in the aerial photo interpretation.

Land use class	Characteristics of man made land use classes	Occurs in
Fields	Mainly maize and bean fields. Also sunflower, millet and groundnuts occur. In the highlands may include small grass fallow patches and other openings in the homegarden area.	Big open fields in the lowlands, small patches in the highlands.
Settlements	Villages and missions.	Villages on the main road, missions on the upper slopes.
Homegardens	Chagga homegardens with coffee and banana integrated with multipurpose trees	Altitudes 1200-1800m
Degraded areas	Very poor vegetation cover, bare soil.	Close to Miwaleni springs in the far southern end of the study area.

interviews of local people.

To quantify changes in pattern, a fragmentation analysis was done using Fragstats Arc software. Forests, Riverine forest and Settlements were left out from thestudy as the land use changes were either very small or not structural in nature. The indices calculated were: Class area (ha), Number of patches, Largest patch index indicating the percentage of the land use class covered by the largest patch, Mean patch size (ha), Total core area (ha) of all the patches with a 50m buffer along the borders and Mean core area per patch (ha).

Sustainable livelihood study framework (DFID)

"Livelihood comprises the capabilities, assets, both material and social resources, and activities required for means of living…" (Carney 1998).

In addition to collecting basic information on human, social, natural, physical and financial capital the interviews focussed on farm management and production, and coping strategies during sudden shocks and long term trends.

45 households were interviewed between March and May 2001. Adjusted Grid Sampling with 1 by 1 km sample areas was used to select the

households. One household, the second house on the left after entering the square was selected until about two thirds of the households were interviewed. After that, selection was adjusted in order to have five old (above 50), five middle aged (36-50) and five young families (up to 35 years) from each zone. This was done selecting the closest household representing the desired age group. This method of stratified random sampling gives the advantage of using analysis methods based on the assumption of independent observations, yet representing households and livelihoods of a variety of people at different stages of life.

The farming system

The Chagga farming system is an old traditional agroforestry system. It consists of a highland coffee-banana farm with multiple other food crops intercropped, and a lowland maize, millet and bean field. Part of the upper and middle slopes are covered by irrigation channels. Very few channels reach all the way down to the plains. The family typically resides on the highland homegarden and daily trips are made at least during cultivation time to attend a lowland plot. Livestock in the highlands is kept under stall-feeding. Trees are used to provide shade for coffee, as live fences, for fodder and mulch, for bee forage, for anti-pest properties and for timber and firewood. (Fernandes et al. 1984).

Over the years sons who have not inherited homegarden land from their fathers have shifted down the slope (Maro, 1974). These midland and lowland farmers mainly grow maize and beans. The main cropping in the lower and middle belt is done during the long rains from March to August. A second crop can be grown during the short rains if irrigation is available (Zongolo et al. 2000a).

Families are typically relatively large (6.5 persons). The whole family takes part in farm activities. A casual labourer can be hired to help especially in weeding and harvesting. On top of farm activities, 55% of fathers have off-farm jobs, either casual or permanent and 15% of mothers work outside their home to supplement farm income.

Highland farms are considered owned by the Chagga society though they are used by individual farm families. Fields in the lowlands are all individually owned and can be sold and bought without it becoming a clan issue. Many families also rent plots in the lowlands (Maro 1974). About half of the farmers have plots in different agroecological zones. The average number of plots per family is 2.5. The size of one plot is typically about 0.6 ha. Plots can be many kilometers apart.

Early changes

Landscapes on the slopes of Mt. Kilimanjaro started to change when the first immigrants started to move to the area at least five or six hundred years ago, possibly much earlier (Odner 1971; Maro 1974). They began to transform the original forest into an agroforestry system. Useful trees were kept while less useful species gradually disappeared (Fernandes et al. 1984).

Contacts with outsiders, like the early trading caravans, brought changes. The introduction of the banana crop is believed to have occurred during the 16th century (Koponen 1988). Maize, cassava and sweet potatoes came from the Portuguese traders and sugar cane from Asia via the Arab traders (Krapf 1860; Moore & Puritt 1977). Significant land use changes started to occur in the late 19th century with the arrival of missionaries and early colonialists. When the railway arrived in Moshi in 1912, the area was suddenly opened up to large scale European colonisation. It was especially the

grazing lands that were proclaimed vacant and taken over by the Europeans (Mtei 1974; Masseliere de la 1999). Introduction of coffee by the Catholic mission on the slopes of Mt. Kilimanjaro in 1893 led to major modifications of the Chagga farming system (Wallace 1968; Mtei 1974). The rangelands in the uplands were converted to coffee, necessitating stall-feeding of the cattle. Stall-feeding cut milk production as the traditional Zebu cattle are less suitable for stall-feeding. Later on, especially in the 1950s with the relatively good income from coffee, farmers started to purchase improved cattle (Aminu-Kano et al. 1992). Grazing areas and sweet potato fields were taken under homegarden cultivation. Millet and beans production in the uplands declined due to the expanding coffee production. Formerly both were intercropped with bananas, with pulses being used to regenerate the soil after the millet crop (Zalla 1982).Also *Dracaena* groves, areas set apart for burials and sacrifices, were converted to homegardens. Since the 1950's there has been no unused land on the higher slopes suitable for homegardens. (Maro 1974; Fernandes et al. 1984). Due to expanding coffee production food cropping moved down the slope to the lowland. Since 1960s there has not been space for new plots close enough to the mountain for farmers to travel daily from their highland farm (Maro 1974).

Population density figures show a dramatic growth of population. In the 1920s population density was 26 people per square kilometre. No land below the road was cultivated. In 1948 an average density was 50/km^2, with some areas already about and over 200/km^2. These high-density areas had 23-36 % of their land under large-scale plantations (Swynnerton 1949). Resettlement under the Ujamaa Villagization Programme, which peaked between 1973 and 1975 was not common in the area and did not have any implications on land use and ownership (Aminu-Kano et al. 1992; Mlambiti 1985). Population doubled again between 1948 and 1967 (Fosbrooke 1955; Henin & Egero 1972; Maro 1974; Mlambiti 1985).

Changing landscapes, 1969, 1982 and 2000

The land use change analysis studying the time period from 1961 to 2000 (Table 3, Figure 2) indicates a marked decrease of Bush land in the lower areas. In the early 1960s bush land covered 40% of the whole study area. By 2000 there was only 7% of bush land left, mainly on the steep slopes of small volcanic cones. Most of the Bush land has been replaced by cultivated fields.

Despite of the population densities of 650 persons/km^2 on the higher slopes (Zongolo et al. 2000b), the homegardens themselves have not extended downwards. The system reached its lower limit much earlier.

The extent of the forest areas on the upper boundary of the study area has stayed approximately the same over the study period. This area belongs to the "Half-mile zone" which is part of the Kilimanjaro forest reserve. Local people are allowed to collect fallen branches for firewood and fodder for livestock from the area. Even if the forest edge has stayed approximately in the same place in the study area, a recent aerial survey reveals illegal logging, burning of forest, charcoal production, establishment of villages, grazing and cultivation, landslides and quarries in the protected forest reserve (Lambrechts et al. 2002).

There is a slight decrease in riverine forest, which mostly happened between 1961 and 1982. Lowland riverine forest cover very narrow areas along the rivers. These areas are increasingly exploited for firewood and timber.

Table 3. Land use change from 1961 to 2000 in the study area.

	Year 1961		Year 1982		Year 2000	
LANDUSE	**Km^2**	**%**	**Km^2**	**%**	**Km^2**	**%**
Bush land	60.88	40.0	16.94	11.1	10.91	7.2
Forest	1.69	1.1	1.46	1.0	1.27	0.8
Degraded areas	0.33	0.2	0.12	0.1	0.40	0.3
Field	62.88	41.3	98.12	64.4	102.48	67.3
Homegardens	23.05	15.1	32.24	21.2	29.45	19.3
Riverine forest	3.28	2.2	2.33	1.5	2.34	1.5
Settlements	0.16	0.1	1.11	0.7	3.64	2.4
Cloud					1.81	1.2
	152.27	**100.0**	**152.32**	**100.0**	**152.30**	**100.0**

Many new villages have mushroomed along the road in the study area. Kiuo Hill has a new settlement on its northern side, just south of the main road. This is a major volcanic brick-cutting site. Settlements cover 24 times the area today compared to 1961, though they still cover a mere 2.4% of the total area. Population density in the lowlands is over 200 at present (Zongolo et al. 2000b).

Some clear changes have happened in the landscape patterns of the area. In 1961 the homegarden area had many small open patches of grazing lands and fields of sweet potato, millet and maize (302 patches of on average of 7.2 ha) (Table 4). In 1982 the homegarden zone is more uniformly covered by homegardens. In 2000 the homegarden area has become more patched again. In 2000 the open space in between of homegardens is practically all cultivated fields. There is no more open grazing land or unused land on the upper slopes, even the steepest slopes are cultivated. Also, the homegarden area in 2000 has a more broken tree canopy in the aerial photos compared to the 1961 and 1982 homegardens. This can be partly caused by the fact that the 1982 photos were taken earlier in the dry season when the trees are more lush

while the 2000 images were taken at the end of the dry season. Many old people in the area claim that there are fewer trees in an average homegarden than before. Also Kisanga's (1998) study on the effects of replacing indigenous species with exotic ones states that despite some advantages, the introduced tree species have not replaced the total land cover that the natural vegetation covered.

Over the years fields have expanded to occupy larger uniform patches. In 2000 more than half of the total field area (64 %) was covered by one largest patch of field (Largest patch index). In 1961 the corresponding figure was 10.5 %. Due to expanding cultivation bush land has become extremely fragmented with mean patch size of 35 ha in 2000 while the mean patch size in 1961 was still 119.4 ha. A 50 m buffer was drawn along bush land area borders and the core area inside the buffer was calculated. The core bush land area has decreased from 4238.6 ha in 1961 to a mere 680.1 ha in 2000. (Due to the tiny fragments of Bush land in the middle of big areas of lowland fields in the 1982 image, Mean core area per patch has dropped from 83 ha in 1961 to 21.9 ha in 2000 having been down at 13.7 ha in 1982.) The significant fragmentation of the bush land areas affects bush land bird species and other species dependent on the type of vegetation (e.g. Helzer & Jelinski 1999; Zanette & Tremont 2000; Johnson & Igl 2001). There is already an indication that some of the smaller and more isolated patches of bush land are not viable habitats for typical bush land bird species of the region. There are several bird species in the area that inhabit only bush lands and are not spread to the adjacent fields. Field areas though have biggest numbers of both species and individuals (Soini 2002c).

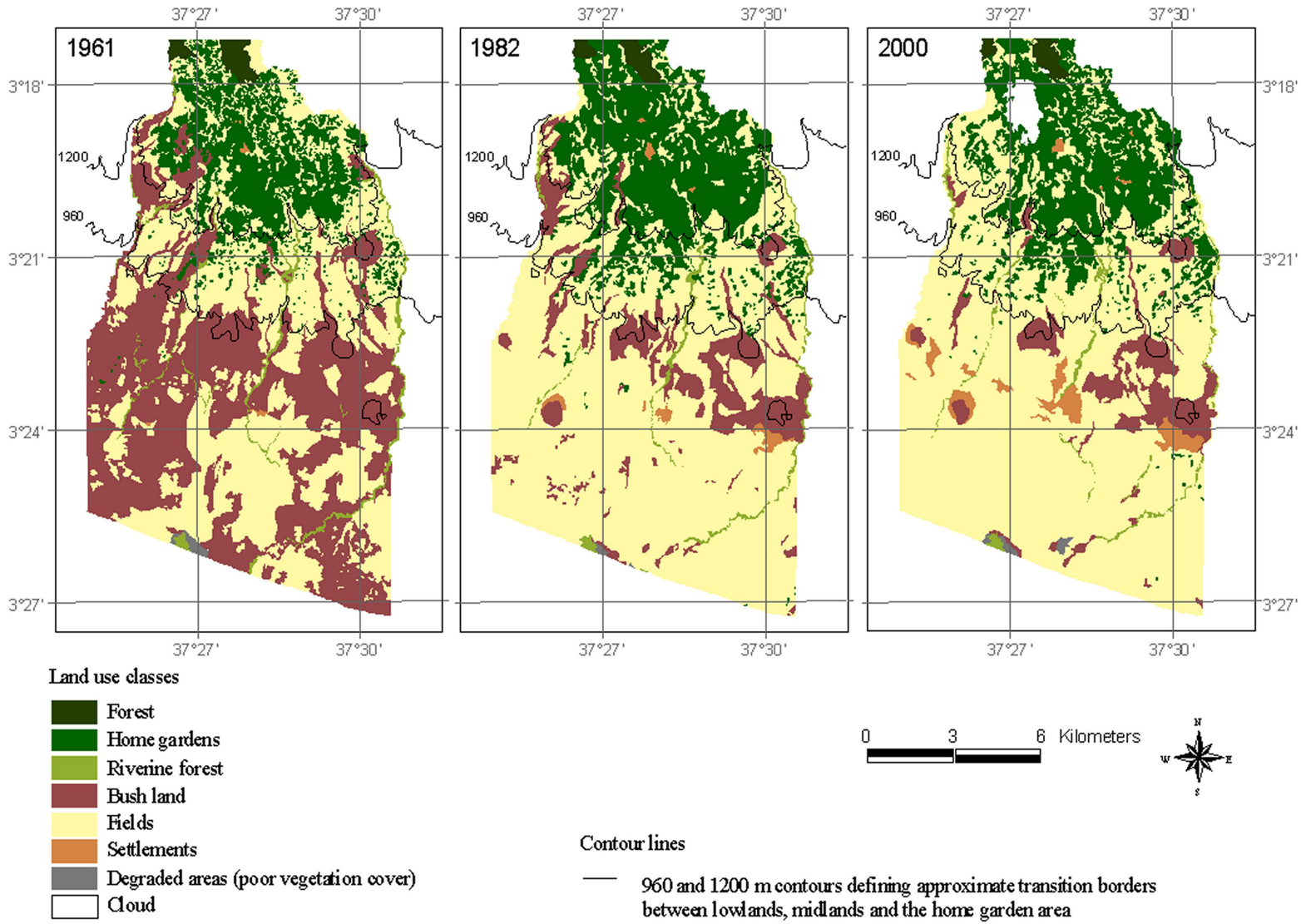

Figure2. Thematic maps of land use change produced from the aerial photo interpretation.

Table 4. Landscape fragmentation indices.

Year	Land use category	Class area (ha)	Number of patches	Largest patch index	Mean patch size (ha)	Total core area (ha)	Mean core area per patch (ha)
1961	Home-gardens	2174.9	302	11.3	7.2	922.6	3.1
	Fields	6238.5	264	10.5	23.6	3585.3	13.6
	Bush land	6087.9	51	19.4	119.4	4238.6	83.1
1982	Home-gardens	3065.3	112	17.7	27.4	1750.3	15.6
	Fields	9790.6	86	59.9	113.8	7514.5	87.4
	Bush land	1693.3	67	4.0	25.3	917.4	13.7
2000	Home-gardens	2945.3	157	15.5	18.8	1486.7	9.5
	Fields	10225.4	139	64.05	73.6	7920.5	57.0
	Bush land	1112.3	31	4.4	35.9	680.1	21.9

Adapting to changes

As response to decreasing plot size, farmers are trying to diversify their production. Typical new crop introductions in the lowlands are groundnuts, sunflower and vegetables. Vegetables like tomatoes, green peppers, chillies and onions seem a very lucrative option, but lack of marketing channels often leads into extremely low prices, and due to oversupply in the local markets, part of the harvest is spoiled. There are also farmers in the lowlands who have

needed to discard growing crops like rice or onions due to drying up or redirection of an irrigation channel. Especially the lowland and midland farmers are suffering of decreasing water supply or complete drying up of furrows.

Most of the people (70%) live on inherited land, the average size of an inherited plot being 0.56 hectares. However, some had inherited only about 0.1 ha. Most of these extremely small farms were found in the lowlands. These often belong to young or old farmers who have never inherited a homegarden. When the rains fail they are entirely dependent on casual labour opportunities. They have often not inherited animals either, and they lack the capital to purchase any. Credit is generally not available for local farmers in the area.

Farmers with proper off-farm activities are better off. A young carpenter interviewed had bought six plots on top of the one inherited and was currently saving money in order to further expand his farm. The land purchases were made during droughts when other farmers needed to sell their land as a last resort. Buying land seems to have increased a lot as one third of the farmers had bought land at some point of their lives. In the seventies (Maro 1974) only eleven percent of the farmers had a lowland field and six percent had a homegarden by direct purchase.

For a long time coffee was the major cash earner in the highlands and the base of the Chagga economy, but with the decline of coffee prices on the world market since 1960s and the rise of production costs, farmers have started to devote their attention to other activities. The number of banana plants has increased on farms as a result of substitution of coffee. Other activities substituting coffee include sale of other farm products, milk, beans and vegetables (Aminu-Kano et al. 1992). All of these suffer from lack of big enough markets. Though coffee yields are highly variable due to pattern of

alternate bearing and management, there is still a clear pattern of declined production observable from different studies. According to an agricultural production survey in the agricultural year 1975/76 (Mlambiti 1984) coffee production was still 924 kg/ha. Fernandes et al. (1984) reported coffee yields of the 1980s as 412 kg/ha. Yields declined steadily down to 186 kg/ha in 1990 (Aminu-Kano et al. 1992).The present study indicates production figures of about 270 kg/ha, which is slightly better than ten years ago but still far from the potential.

Farmers claim that farm extension was more available and inputs cheaper during the period of socialism in Tanzania (1967-1983). Even if information on best practices is not easily available, farmers are investigating new technologies and trying them out. A new farming method mentioned often by the farmers is spacing, i.e. planting maize and beans in rows. Almost half of the farmers interviewed practise this technique. Contour bunds, *fanya juu* ("make up") and *fanya chini* ("make down") structures have been adopted by some farmers as, 'a new practice', though in general, contours were introduced already by the colonial government. Other improvements mentioned by few farmers are spacing of coffee and banana in the highlands and planting banana into big holes continuously filled with compost. Some have been able to change banana varieties, but very few have started to use improved maize seed varieties or to start using fertilisers. Still one third of plots are cultivated without using any fertilisers at all, organic or inorganic.

Changing existing tree species to more valuable or fast growing is typical in the highlands. The most common species are *Grevillea robusta* and *Persea americana.* Farmers had also planted other species like *Albizia ssp*., *Citrus cinensis, Azadirachta indica, Cassia siamea, Mangifera indica, Cordia holstii, Prunus persica* and *Annona squamosa*. In the process of changing the location of trees on farm from the centre of the farm to the borders in order to have more space for food crops, farmers might get rid of less valuable species

and plant more high value trees instead.

The trend of decreasing livestock numbers is not a new phenomenon, but has started since the colonial times when money started to play a more important role and old traditions began to lose their importance (Fernandes et al. 1984). Today the main reason for decreasing livestock numbers is lack of space and lack of enough fodder. However, the value of livestock production may not have changed as dramatically when better breeds and higher quality feeds are used today. 26% of all cattle in the interviewed households were grade cattle or cross-breeds of local and grade cattle. The percentage of improved cattle in the highlands was 58%.

As land is scarce even the most marginal land is taken under cultivation. This happens despite of bylaws. In many places riverbanks have been cleared to water's edge (Kisanga 1998) and riverine vegetation is in danger of disappearing altogether. Also uncultivable bush land on top of hills is in danger. This is due to firewood collection and brick cutting for volcanic bricks for building. As resources on common land are getting scarce, farmers need to devote more efforts in being more self sufficient in firewood and fodder production and growing their own timber and medicinal trees. But when the space is limited food crops will still be considered more important.

Conclusion

There is no doubt that the areas on the southern slopes of Mt. Kilimanjaro and the adjacent plains require increased efforts to maintain and improve their agricultural productivity. The farming system has not been able to efficiently adapt to local and global changes. Despite all the environmental changes and the fact that the cash crop on which the whole system was built on in the 1930s has lost its value, the farming system is trying to function as before, with only

little adaptations made. Growing expectations are forcing the younger generation to look for better and more productive ways to earn their living. The area has already partly become a suburban from where people commute daily to off-farm work. But as education and/or off-farm jobs are not, and will not be, a realistic option for all of the farmers, many remain as full-time farmers. There is a clear and urgent need for technical research and experimentation on the suitable intensification and diversification options and a need of understanding marketing channels for these options in order to provide these farmers and organizations working with them with sound technical advice on the alternative development pathways.

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