Land use change patterns and livelihood dynamics on the slopes of Mt. Kilimanjaro, Tanzania

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Abstract

This study is about changes in land use and interactions of land use change and livelihoods in the Chagga farming system on the slopes of Mt. Kilimanjaro, Tanzania. An aerial photo interpretation and fragmentation analysis of the years 1961, 1982 and 2000 was conducted covering approximately the Kirua Vunjo Division, a transect of 152 sq km from the forest reserve edge to the plains. Earlier changes were traced from literature review. The results show the expansion of cultivation to more marginal land down the slope, the disappearance and extreme fragmentation of bush land and appearance and expansion of settlements. The home garden area has experienced some specific internal change, but has not expanded down the slope. In the 1960s there were small open fields and patches of grazing lands amongst home gardens. In the 1980s the area was more uniformly covered by homegardens. Since then it has become patchy again as new homesteads have been built on subdivided farms and more food is produced on the higher slopes. Population pressure and the ensuing expansion of agriculture to more marginal land, intensification of the homegarden system, together with climate changes affecting the water supplies, have caused changes in farmers' livelihoods. As land scarcity now hinders expansion of agriculture, farm size has seriously decreased, common resources have become scarce, and prices of coffee in the world market remain low, farmers are trying to intensify and diversify their farm production. Local initiative is leading to change, but the locally conceived alternatives are too few and lack integrated approaches of technical agricultural research, economic analysis, and policy studies and reforms. Non-agricultural activities and paid employment are becoming increasingly important. However, due to considerable entry barriers to remunerable off-farm jobs, not all households enjoy equal access to attractive non-farm opportunities. The future welfare of the area will depend on increasing the marketable knowledge and skills of the population that will enable it to become integrated in the economy of the region and the country.

Key words
Home gardens, Chagga, land use, diversification, occupational multiplicity, landscape

1. Introduction

The southern slopes of Mt. Kilimanjaro in northern Tanzania are one of the most densely populated areas in the country, with densities comparable to urban population densities (Moore, 1986). The Chagga farming system, with homegardens covering the upper southern slopes of the mountain and open fields on the lower slopes and the adjacent plains, has evolved over more than five centuries (Odner, 1971; Maro, 1974), and it has often been described as a model sustainable land use system. Over the centuries, as Moore (1986) states, their climate, their soil, their water have favoured the Chagga. Important old caravan routes passed through the area and drew the Chagga into long-distance trade. Later, a profitable cash crop favoured them and enabled them to develop faster than other areas in Tanzania. Income from coffee was used for improving farming practices and water supply; establishing schools, dispensaries and courts, building roads and enhancing other public works; and for investments in personal and household commodities (Moore, 1986).

Now this farming system is facing several challenges that affect local livelihoods. Decreasing farm size due to population pressure and land scarcity is limiting the viability of the system. Farms have simply become too small to sustain a family under the present management. Continuing low coffee prices mean the traditional coffee-banana system is unprofitable. Further, global climate change has had an impact in the area with the disappearance of 75% of glaciers on the mountain since 1912 (Hastenrath and Greischar, 1997), which has affected the water supplies in the rivers and irrigation channels. Change of indigenous vegetation to exotic species in the home garden area, and cultivation of the immediate riverbanks is also believed to have contributed to the drying up of rivers and springs (Anderson, 1982; Fernandes et al., 1984; D.R. Kisanga, 1998, pers.comm.).

Such development is not strange to Africa, and agricultural change in areas with poor farmers is often associated with land degradation (e.g. Stoorvogel and Smaling, 1990; Cleaver and Schreiber, 1994; Sanchez et al., 1997; Henao and Baanante, 1999; Nair et al., 1999) and landscape fragmentation (e.g. Nagendra et al., 2004) affecting the viability of agro-ecosystems. However, the relationship between agricultural intensification and environment is complex (Lee et al., 2001) and poor farmers apply multiple strategies of expansion, intensification and diversification to cope with change. The increasing occupational multiplicity of rural populations is perhaps one of the most important of these strategies (Reardon et al., 1998; Bryceson, 1999).

How are the Chagga adjusting their livelihood strategies to cope with these local and global changes challenging them? How are the changing livelihood strategies reflected in the landscapes and how are these landscape changes feeding back to the livelihoods of the Chagga? Can the Chagga system survive as an agricultural system or are we - in the context of general occupational diversification of rural Africa (Bryceson, 1999; Bryceson, 2000) - saying farewell to the farms on Mt. Kilimanjaro?

2. The study site

The study area is a transect from lowlands to highland (3.16-3.28º S latitude and 37.25-37.32º E longitude) (Figure 1). For the land use change analysis it covers approximately the administrative area of Kirua Vunjo Division, with some interviews conducted in the neighbouring Kilema and Marangu divisions as well. The lower boundary was drawn 5 km south of the main tarmac road at about 800m.a.s.l. The upper end of the transect was the forest boundary at about 1800m.a.s.l. The area is 152 km^2. It was chosen to represent the parts of the slopes used for small-scale farming with no large estates. Thus the vertical interaction between the higher slopes, the lower slopes and the plains has not been disrupted by blocks of land not belonging to the farming system, and changes in small-scale farming have been the main causes of land use change.

Figure1

Three distinct agro-ecological zones can be identified in the transect: 1) a lowlands zone (<900 m.a.s.l.) of extensive livestock farming, 2) a midlands (900 m.a.s.l. – 1200 m.a.s.l.) maize-bean belt and 3) a highland (1200 m.a.s.l. to 1800 m.a.s.l.) home garden area, the Coffee-banana belt. Annual mean rainfall is 400-900 mm in the lowlands, 1000-1200 mm in the midlands and 1200-2000 mm in the home garden area.

The Chagga farming system consists of a highland coffee-banana farm (Coffea arabica, Musa spp.) intercropped with many other food crops, and a lowland maize (Zea mays), millet (Eleusine coracana) and bean (Phaseolus vulgaris) field. Parts of the upper and middle slopes are served by irrigation channels. Very few channels reach down to the plains. Livestock in the highlands is stall-fed. The family resides on the highland home garden and makes daily trips to the lowland plot, at least during cultivation time. Highland farms are considered owned by the Chagga society. They are used and inherited by individual farm families (Moore, 1986), but cannot be freely bought and sold by them. Over the years, sons who have not inherited home garden land from their fathers have settled on the lower slopes or the adjacent plains (Maro, 1974). These midland and lowland farmers mainly grow maize and beans. Livestock in the lowlands is grazed freely. Fields in the lowlands are individually owned and can be sold and bought. Many families also rent plots in the lowlands. About half of the farmers have plots in different agro ecological zones. The average number of plots per family is 2.5, and the size of one plot is typically about 0.6 ha.

3. Methods

This study was undertaken as part of a project investigating social and ecological implications of land use change and the impacts of population pressure, socio-economic and regional historical factors on landscape patterns. Kilimanjaro was one of the three sites selected for the study. The study consists of two parts, a land use change analysis of Kirua Vunjo area using aerial photographs, and a livelihood survey of 45 farmers in approximately the same area.

3.1. 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 assembled into mosaics. Classification was done visually.

Anderson's (1982) natural vegetation classes were used in selecting land use categories. As it was not possible to distinguish between all of Anderson's 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 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. Degraded areas have high reflectance in the aerial photos and have sparse vegetation cover most of the year.

Tables 1 and 2

Ground-truthing was done for the year 2000 land use map. A total of 56 points were selected with 32 points placed symmetrically at 2 km intervals and 24 points placed in areas which were difficult to interpret. The interpretation accuracy of larger land use classes is more thoroughly checked than that of the small land use classes. All 56 points were found to be within the correct land use category though corrections were made to update the boundary lines. 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 shaded areas in the Nanga river valley in the year 1982 aerial photos, interpretation was enhanced through ancillary interviews of local people.

To quantify changes in pattern, a fragmentation analysis was done using Fragstats Arc software (Innovativegis, 2004). Forests, riverine forest and settlements were left out from the study 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).

3.2. Livelihood study

A questionnaire organised according to the DFID (2001) sustainable livelihood framework was used. Carswell (1997) defined livelihood as "comprising the capabilities, assets, both material and social resources, and activities required for means of living. A livelihood is sustainable if it can cope with, and recover from, stresses and shocks, maintain or enhance its capabilities and assets and provide net benefits to other

livelihoods locally and more widely, both now and in the future, without undermining the natural resource base". The sustainable livelihood framework by the Department for International Development (Carney, 1998; DFID, 2001) is a useful operationalisation of the livelihood concept which captures the complexities of the interrelationships of livelihood assets (human, social, natural, financial and physical capital), strategies to use these assets in order to come up with desired livelihood outcomes (for example more income, increased well-being, reduced vulnerability, sustainable use of resources) in the context of external influences such as policies, institutions, laws, culture and individual preferences and priorities. Strategies may never be articulated, but they nevertheless influence people's choices of which activities to combine, which outcomes to pursue, and which assets to invest in.

Information was collected on the different livelihood assets: human (family structure, education, occupation, links to outside the farm sources of income), social (collective action, access to knowledge), natural (land, livestock, trees and crops grown, access to common resources), financial capital (markets, off-farm jobs), and physical capital (access to markets, technologies). Temporal change was emphasized. For this, information on the reason and time of introduction and abandoning activities, crops, trees, livestock and technologies was collected. Perceived problems with crops, livestock, trees, off-farm activities, and other spheres of life were documented. To measure priorities and values, farmers were asked: 1) which on-farm or off-farm activity they would prefer to improve their livelihoods given that they had all the money and the ability to realise their dream; or 2) what they would purchase for the farm or their household to improve their life. Only data on coping strategies and adaptation to change are presented in this paper.

Forty-five 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 by selecting the closest household representing the desired age group.

4. Results and Discussion

4.1. Early changes

Landscapes on the slopes of Mt. Kilimanjaro started to change when the first immigrants moved 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, such as the early trading caravans, brought changes. The

introduction of the banana crop is believed to have occurred during the 16th century (Koponen, 1988), and maize, cassava (Manihot esculenta) sweet potatoes (Ipomoea batatas) and sugar cane (Saccharum officinarum) were brought to the area by traders (Krapf, 1860; Moore and 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. Grazing lands were proclaimed vacant and taken over by Europeans (de la Masseliere, 1999). Large scale adoption of coffee growing by the Chagga in the 1930's led to major modifications of the farming system (Maro, 1974; 1975). The rangelands in the uplands were converted to coffee, necessitating stall-feeding of 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 converted to homegardens. Millet and bean 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 late 1950's there has been no unused land suitable for homegardens on the higher slopes. (Maro, 1974; Fernandes et al., 1984). Due to expanding coffee production food cropping moved down the slope to the lowland. But since 1960s there has not been space for new lowland plots close enough to the mountain for highland 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 persons km^{-2}. No land below the road was cultivated. In 1948 the average density was 50 persons km^{-2}, with some areas already over 200 persons km^{-2}. These high-density areas had 23-36 % of their land under large-scale plantations (Swynnerton, 1949; Maro, 1974). Population doubled again between 1948 and 1967 (Mlambiti, 1985). Resettlement under the Ujamaa Villagization Programme, which peaked between 1973 and 1975, was not common in the area and did not have any implications for land use and ownership (Mlambiti, 1985).

4.2. Changing landscapes, 1961, 1982 and 2000

The land use change analysis of the period from 1961 to 2000 (Table 3, Figure2) 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. Fields have expanded to occupy larger uniform patches. In 2000 64% of the field area was in a single continuous patch of fields (largest patch index). In 1961 the corresponding figure was 10.5 %. 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 large 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 13.7 ha in 1982. Many of the smallest 1982 patches had disappeared by 2000, and do not contribute to the mean core area now. Fragmentation of these bush lands may have significant affects on bush land bird species and other species dependent on the type of vegetation (e.g. Helzer and Jelinski, 1999; Winter and Faaborg, 1999; Cornelius et al., 2000; Zanette and Tremont, 2000; Johnson and Igl, 2001; Beier et al., 2002; Herkert et al., 2003; Kurosawa and Askins, 2003). The overall decrease and fragmentation of bush lands has also significantly reduced the area earlier used for grazing and firewood collection. This has lead to more intensive and destructive use of the remaining bush lands.

Table 3, Figure 2

Despite population densities of 650 persons km^{-2} on the higher slopes (Moshi Rural District Council, pers.comm.), home gardens have not extended downwards since 1961. The system reached its lower limit much earlier. However, some clear changes have happened in the landscape patterns of the area. In 1961 the home garden area had many small open patches of grazing lands and fields of sweet potato, millet and maize (302 patches of average area 7.2 ha) (Table 4). In 1982 the zone was more uniformly covered by homegardens. In 2000 the home garden area has become patchy again. In 2000 the open spaces amongst homegardens are nearly all cultivated fields. There is no open grazing land or unused land on the upper slopes, with even the steepest slopes cultivated. The homegardens in 2000 have a more broken tree canopy in the aerial photos compared to 1961 and 1982. This may be partly due to the 1982 photos being 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. However, many old people in the area claim that there are now fewer trees in a typical home garden than before.

Table 4

The extent of the forest areas at 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 livestock fodder from the zone. Even if the forest edge has stayed approximately in the same place in the study area, a recent aerial survey revealed 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). In 2000 part of the forest area in the study area consists of planted Eucalyptus spp.

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

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 persons km^{-2} at present (Moshi Rural District Council, pers.comm.) with a very uneven distribution. Most of the lowland population lives in the settlement areas leaving the agricultural field area very sparsely populated.

4.3. Adapting to changes

Table 5 is a summary of problems listed by the farmers as the most difficult to cope with. Even if farmers are unable to combat some of the most serious problems listed (e.g. drought and availability of water), the study revealed some typically used coping strategies as a response to change.

Table 5

Two of the biggest problems, lack of capital for farm inputs and lack of knowledge of best practices in the absence of an efficient extension service, are connected to the land problem. As a response to decreasing plot size, farmers need to intensify and diversify their farm production. Typical new crop introductions in the lowlands are groundnuts (Arachis hypogeoa), sunflower (Helianthus annuus) and vegetables. Vegetables like tomatoes (Lycopersicon esculentum), green peppers (Capsicum annuum), chillies (Capsicum spp.) and onions (Allium cepa) seem to be profitable, but lack of marketing channels often leads to extremely low prices, and due to oversupply in the local markets and no further processing, part of the harvest is spoiled. 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 and trying new technologies. A new farming method mentioned by 44% of the farmers is spacing, i.e. planting maize and beans in rows. Contour bunds have been adopted by 18% of the farmers as 'a new practice', though contour structures were introduced already by the colonial government, and 42% of the farmers have contour bunds on one or two of their plots. Other improvements mentioned by only few farmers are spacing of coffee and banana in the highlands and planting banana into big holes continuously filled with compost. Few have been able to change banana varieties, to use improved maize seed varieties or to start using fertilisers. One third of plots are still cultivated without using any fertilisers at all, organic or inorganic.

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 the 1960s and the rise of production costs, farmers have started to diversify. Though coffee yields are highly variable due to patterns of alternate bearing and management, there is still a clear pattern of declining production observable from different studies (Mlambiti, 1985; Fernandes et al., 1984; Soini, in press). The number of banana plants has increased on farms to replace coffee (Aminu-Kano, et al., 1992). Other activities substituting coffee include sale of milk, beans, vegetables and other farm products. All of these suffer from lack of sufficiently large markets.

Changing existing tree species to more valuable or fast growing species is typical in the highlands. The most common species are Grevillea robusta and Persea americana.

Farmers had also planted other species like Albizia spp., Citrus cinensis, Azadirachta indica, Cassia siamea, Mangifera indica, Cordia holstii, Prunus persica and Annona squamosa (Soini, in press). 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.

Changing local livestock breeds into improved dairy breeds has been a common trend. However, 29% of the households – mainly in the lowlands - still have Zebu cows. Twenty-four percent of the households do not have cows at all. Eighty-three percent of the households which do not own cows are in the lowlands or middle slopes, while 88% of the households having improved or mixed breed cows are in the highlands or midlands.

Nine percent of the interviewees had not inherited or been allocated any land and half of them had not been able to buy land but were renting or borrowing it. Of those having inherited land 47% had inherited less than 0.4 ha, and 21% inherited only about 0.1 ha, which can hardly be called a farm. Most of these extremely small 'farms' are found in the lowlands. These often belong to young or old farmers who have never inherited a home garden and due to lack of capital they are unable to purchase more land. The only option for them is to rent a field. When the rains fail they are entirely dependent on casual labour opportunities, which is considered a good supplement to farm production, but it is difficult to survive on exclusively. During prolonged droughts it is also hard to find work due to oversupply of labourers, and the pay drops even lower than usual. During droughts any casual opportunities are acceptable and some lowland farmers said they may need to walk long distances in search of work. Obviously these extremely difficult situations do not leave much room for household income planning. As the farmers have often not inherited animals, and they lack the capital to purchase any, the only investment they can afford is to buy poultry. As credit is generally not available for farmers in the area they are unable to diversify for risk management, and they perceive their situation as very insecure. They reported some people to have died of hunger during the last drought in 2000 when both the short and long rains failed. The sustainable livelihood framework assumes that one needs to have some assets in order to have successful strategies that lead to desired livelihood outcomes. How much, and in what combinations, no-one has yet been able to determine. But these lowland farmers with small plots definitely do not have enough.

One should assume that farmers with multiple assets and - as a consequence - multiple strategies, including a proper off-farm activity, have a better chance of acquiring more well-being and more income, being more empowered, more healthy and less vulnerable (Ellis, 1998; Pretty et al., 2003). Even though difficult to quantify in this study, personality differences also have a role to play. A young carpenter interviewed had bought six plots on top of the inherited lowland plot of 0.3 ha and was currently saving money in order to further expand his farm. The land purchases were made during droughts when some farmers needed to sell their land as a last resort. In his case, diversification to a successful off-farm activity enabled him to accumulate wealth at the expense of those with fewer options to rely on, the most vulnerable people. This clearly leads to rural wealth differentiation. In the study area 55% of fathers have paid jobs,

either casual or permanent, either agricultural on other farmers' fields or non-agricultural, and 15% of mothers work outside their home to supplement farm income (Soini, in press). Fifty-six percent of all households receive income from off-farm jobs. There is, however, large variation on how continuous or remunerable these jobs are. Forty percent of the jobs are casual jobs or self-employment such as keeping a tiny kiosk or brewing. The majority (87%) of the 'proper' jobs belong to highland or midland farmers while lowland and midland farmers hold the majority of casual jobs. Forty percent of the fathers had gone through some formal vocational training (excluding agricultural training) varying from a one-month course up to a diploma, but only 11% of the mothers had obtained any vocational training.

4.4. Expansion, intensification and unequal opportunities in diversification

Despite decreasing land resources per farm, diminishing shared natural resources and the fact that the cash crop on which the whole system was built in the 1930s has lost its value, the Chagga homegarden system is trying to function with only small adaptations being made. The land use change analysis of the past forty years showed a major expansion of agriculture to the lowlands. This expansion has created a new and distinct group of farmers who have settled in the dry lowlands previously considered by the Chagga as unsuitable for permanent settlement due to inadequate rains and malaria. Due to the marginality of their farming land this group of farmers is potentially the most vulnerable group in the area. However, population pressure has not only resulted in expansion but also in agricultural intensification and diversification, following a typical Boserupian development (Boserup, 1965).

As the income derived from small-scale farming is often not sufficient, rural livelihoods have become increasingly multi-occupational. This follows patterns seen elsewhere in Africa where diversification happens in two ways: adding further agricultural enterprises or adding a non-farm activity to farming. Even though there are differences between regions, non-farm earnings account for roughly 40% of farm household income in rural Africa, typically more so than in other World regions (Livingstone, 1991; Haggblade et al., 1989; Reardon, 1997; Reardon et al., 1998; Bryceson, 1999). Specialisation, seen in farm development in other parts of the World, is not a common strategy in African peasant farming.

Among the Chagga, both highland and lowland farmers are looking for new diversification opportunities and are willing to engage in ad hoc activities depending on their livelihood capital. There is clearly plenty of initiative locally, but the locally conceived alternatives are too few and lack integrated approaches of technical agricultural research, economic analysis, and policy studies and reforms. But the shift from agriculture to non-agriculture earning is already happening and is going to be more significant in the future. More than half of the household heads are dependent on paid jobs. However, the study showed large variation in the types of jobs and spatial variation in how they are distributed and not all households enjoy equal access to attractive non-farm opportunities. More highland farmers have more attractive off-farm jobs while lowland farmers more often occupy casual jobs. For the poorest, diversification typically means highly diversified portfolios but low marginal returns, or desperation-led

diversification (Barrett, 1997; Reardon et al., 2000; Little et al., 2001). Reardon et al. (2000) have predicted that in the medium run, it is probable that the inequality in accessing off-farm opportunities will lead to an increasingly skewed distribution of land and other assets in rural Africa. There is already some evidence of this (e.g. Francis and Hoddinott, 1993; Andre´ and Platteau, 1998; Barrett et al., 2001). In Tanzania studies have shown a growing incidence and awareness of poverty differentials not only between rural and urban areas, but also between and within villages (World Bank, 1993; Cooksey, 1994; Mung'ong'o, 1995; Narayan, 1997). In addition there can be psychological and moral dimensions to the process (Tellegen, 1997; Mung'ong'o, 1995; Bryceson, 1999; 2000).

An increasing number of young people in the future will not inherit any land in the Chagga system. At the same time growing expectations are forcing the younger generation to look for better ways to earn their living. The area has already partly become sub-urban, and people commute daily to work in the nearby villages and Moshi town. Out-migration of the younger generation to find jobs elsewhere in the country has relieved what would otherwise have been even greater pressure on land, but it has left behind another problem of an ageing population, which is less capable of tending the land. In addition to out-migration and working in the villages or Moshi town, many farmers are multi-occupational with a non-agricultural job based on the farm. This trend will gradually make the area more urban with multiple services being made available in the previously purely agricultural countryside.

5. Conclusion

As a whole the challenges and opportunities that the region face today are not exceptional in the context of a general African rural economic, cultural and environmental transformation. Any development activity in the area would need to address the two major problems of African peasant agriculture's inability to perform in the present global and national market, and the need for skills training to prepare farmers, especially children and youth, for the inevitable occupational change. Integrated approaches and better planning are also needed to make the future agricultural and off-farm activities complement each other. Interventions should explicitly target the marginalized subpopulations as stimulus to the non-farm sector benefits, by default, those already possessing the assets necessary to take advantage of emerging market opportunities.

There is no doubt that the southern slopes of Mt. Kilimanjaro and the adjacent plains require increased efforts to maintain and improve its agricultural productivity in an ecologically sustainable way. Several concrete agricultural options for both the highlands and the lowlands have been suggested by Soini (in press). But the future welfare of the area will crucially depend on how the rural human potential can be provided with marketable skills that will enable the rural dwellers to become integrated into the economy of their region and the whole country. Planning is also required to guide the future development of the semi-urban landscapes on the slopes of Kilimanjaro, and multidisciplinary approaches are needed in guiding the re-creation of

the landscapes without undermining the natural resource base.

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Table 1. Natural vegetation classes used as a basis in the aerial photo interpretation of Kirua Vunjo on the southern slopes of Kilimanjaro, Tanzania, 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, with 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 of Kirua Vunjo on the slopes of Mt. Kilimanjaro, Tanzania.

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 home garden 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.

Table 3. Land use change in 1961, 1982 and 2000 in the study area of Kirua Vunjo on Mt. Kilimanjaro, Tanzania.

	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**

Table 4. Landscape fragmentation indices as calculated by Fragstats Arc software of the aerial photo interpretation of the study area of Kirua Vunjo on Mt. Kilimanjaro, Tanzania, in 1961, 1982 and 2000.

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

Table 5. Problems perceived by farmers and the percentage of farmers mentioning the specific problem.

Problem category	Problem mentioned	% of farmers mentioning the problem
Crops	Lack of capital to buy pesticides, fertilisers, good seeds, land, or rent more land (at least one of these)	60.0
	Pests	55.6
	Decreasing rainfall or droughts	37.8
	Lack of labour, especially for weeding or picking coffee	20.0
	Lack of preservatives or place for storage	4.4
	Moles eat roots	2.2
	Low coffee price	2.2
	Extension services not available[1]	68.9
Livestock	Diseases	46.7
	Medicines are expensive	24.4
	Not enough fodder (no money to buy fodder or concentrates, not allowed to graze along the rivers)	17.8
	Veterinary services not available[1]	15.6
Off-farm activities	Lack of capital to start or to expand or to maintain a business or an occupation	17.8
	Not enough customers to buy or give assignments	11.1
	Irregular prices and random taxation	6.7
	Lack of tap water for the business, lack of good road leading to the tarmac, not being paid, limited time to take care of the business	8.9
Tree growing	Drought kills seedlings	20.0
	Seedlings are not available	15.6
	Termites and pests kill seedlings	8.9
	No time and labour to plant	4.4
	No enough land to plant more, no knowledge of valuable exotics, seedlings expensive	6.7

[1] Availability of extension and veterinary services was not originally listed by the farmers amongst their problems, but came up when the farmers were asked about access to farm inputs and knowledge.

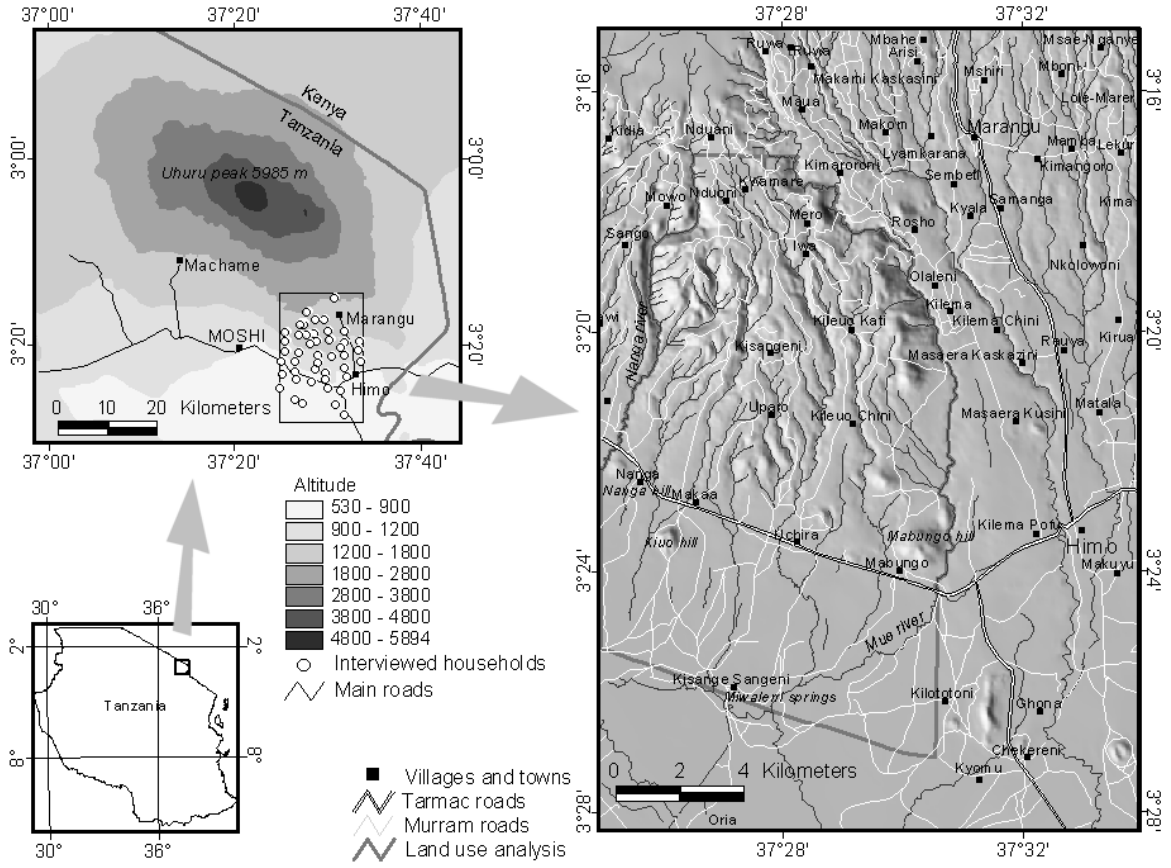

Figure 1. The study area on the southern slopes of Mt. Kilimanjaro, Tanzania.

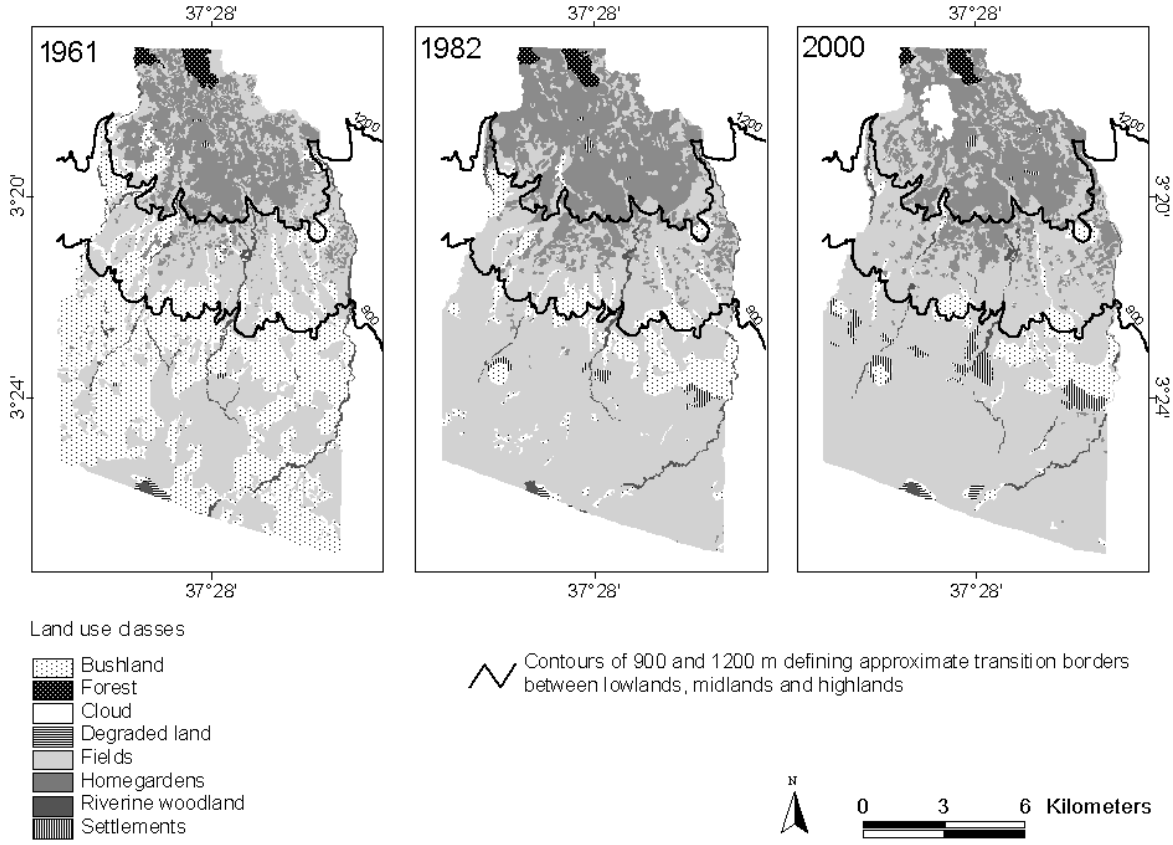

Figure 2. Thematic maps of land use change in 1961, 1982 and 2000 produced from the aerial photo interpretation of Kirua Vunjo on Mt. Kilimanjaro, Tanzania.