

Chapter 10

Adaptations to Climate Change and Variability Among Smallholder Farmers in Tanzania

Stephen Justice Nindi and David Gongwe Mhando

Abstract Tanzania is not an exception to the situation where climate change and variability (CC&V) are emerging threats to development, with adverse impacts on environment, human health, natural resources and physical infrastructure. CC&V has been one of the major limiting factors in agriculture production, resulting in food insecurity and low household incomes possibly due to over-dependence on rain-fed agriculture by the majority of people living in rural areas of Tanzania. Thus, understanding adaptation to CC&V impacts among rural communities is of paramount importance for effective interventions on adaptation strategies. Checklist questions were used to collect information on various adaptation strategies to CC&V impacts carried out by farmer groups in two villages of the Matengo. Spectacular adaptation strategies found in both villages were working in farmer groups for activities such as agroforestry, dairy cattle keeping, running of hydro-mills, beekeeping, and fish farming. Most of these activities ensured both livelihood diversification and landscape conservation under a changing environment. Unique to these farmer groups were their spontaneous expansions, largely owing to farmers' own inventiveness. This study, however, was only preliminary, hence calls for in-depth and longitudinal studies that could allow panel data collection and enable strategic intervention to the problems of CC&V.

Keywords Sub-Saharan Africa · Matengo highlands · Rural communities · Climate change and variability · Adaptation · Livelihood diversification · Landscape conservation · Smallholder farmers

S. J. Nindi (✉) · D. G. Mhando
Centre for Sustainable Rural Development,
Sokoine University of Agriculture (SCSRD),
P. O. Box 3035 Chuo Kikuu, Morogoro, Tanzania
e-mail: nindistephen@yahoo.com; snindi@suanet.ac.tz

Introduction

The impacts of climate change and variability (CC&V) have been the highest priority on the agenda in modern times. The impact of climate change especially to millions of poor households mostly residing in Africa is horrifying. To be precise, Africa, especially south of the Sahara, is one of the most vulnerable regions in the world to the impacts of climate change. Previous assessments (IPCC 2007) concluded that the region is particularly vulnerable to the impacts of climate change because of factors such as widespread poverty, recurrent droughts, inequitable land distribution and over-dependence on rain-fed agriculture. Nindi and Itani (2008) assert that the problems of CC&V are expected to escalate among many subsistence farmers in rural Africa where information flow systems are pathetic and technological changes are slow.

According to IFPRI (2009), agriculture and climate change are inextricably linked. Agriculture is part of the climate change problem, contributing about 13.5% of annual greenhouse gas (GHG) emissions (with forestry contributing an additional 19%), compared to 13.1% from transportation. Agriculture is, however, also part of the solution, offering promising opportunities for mitigating GHG emissions through carbon sequestration, soil and land use management, and biomass production. Climate change threatens agricultural production through higher and more variable temperatures, changes in precipitation patterns, and increased occurrences of extreme events such as droughts and floods. Thus, if agriculture is not included, or not well included, in the international climate change negotiations, resulting climate change policies could threaten poor farming communities and smallholders in many developing countries. The policies could also impede the ability of smallholders to partake in new economic opportunities that might arise from the negotiations.

Devereux and Maxwell (2001) reported that countries in East Africa, for instance, are already among the most food insecure in the world and CC&V will aggravate failing harvests. Having realized the gravity of CC&V, various conventions, protocols, policies, acts, frameworks, guidelines and programmes have been established and ratified and numerous studies conducted from global to local levels trying to understand the devastating impacts of climate change and take on board specific and transboundary initiatives to adapt and mitigate these impacts (EPMS and CEEEST 2006).

Tanzania is not exceptional to this situation where CC&V is rapidly emerging as one of the most serious problems affecting many sectors and is considered to be one of the leading threats to sustainable development with adverse impacts on environment, human health, food security, economic activities, natural resources and physical infrastructure (IPCC 2007). Indeed, given the over-dependence on rain-fed agriculture by the majority of people living in rural areas of Tanzania, CC&V has been one of the major limiting factors in agriculture production thus resulting in natural resource vulnerability, food insecurity and low household incomes. The impacts of CC&V are manifested by floods, droughts, erratic rains

and natural events. United Republic of Tanzania (URT 2005) revealed that famine resulting from either floods or drought has become increasingly common since the mid-1990s and is undermining food security. CC&V is likely to intensify drought and increase the potential vulnerability of the communities to future climate change (Hillel and Rosenzweig 1989), where crop production and livestock keeping are critically important to food security and rural livelihoods.

Certainly, the impacts of and adaptations to CC&V vary with geographical zones and households due to the varying distribution of opportunities in Tanzania, and households throughout the country are engaged in different and often multiple adaptation strategies (Liwenga 2003). Thus, understanding adaptations to CC&V impacts is of paramount importance so as to devise effective interventions that ensure both livelihood improvements and landscape conservation, which is also important to carbon sequestration under climate change. Thus, this study assessed climate change adaptations in two villages that have distinct climatic characteristics of Tanzania based on farmer groups' activities.

Materials and Methods

The study was conducted in the Matengo highlands, located in Mbinga district, Ruvuma region which is located in the southwestern part of the URT. The district lies between longitudes 34° 24'E and 35° 28'E and latitudes 10° 15'S and 11° 34'S. Two villages, namely Kindimba and Kitanda, located 22 km apart from each other were purposely selected for this study. Kindimba village was selected because it is one of the oldest villages in the Matengo highlands and is located in the Mountain Area sub-ecological zone (about 2,000 m above sea level (masl)), while Kitanda was relatively a new village in the Rolling Hills North sub-ecological zone of the Matengo highlands (located between 900 and 1,500 masl) and inhabited by immigrants mainly from Mountain Area. Both villages have been severely affected by land degradation partly associated with CC&V and have interacted with other development partners in conducting activities that aim at landscape conservation and livelihood transformation.

Subsistence rain-fed agriculture is the mainstay of the Matengo farmers' economy in both villages. Farmers in the study villages largely cultivate coffee, tobacco and wheat as cash crops, whereas maize, beans and recently cassava serve as food-cum-cash crops. Except for coffee, which is planted on flat or bench terraces, other crops are planted on Matengo pits (ngolo). They keep a limited number of livestock, mainly cattle, goat, pigs and chicken. Their main system of livestock-keeping is either through tethering or free range and seldom have they conducted zero or indoor grazing.

This study used a cross-sectional design in which two sample villages were studied. Combinations of methods were used in order to elicit relevant information. Since adaptations at village level in these two villages largely followed activities by farmer groups, five farmer groups from each village were selected for

interviews using simple random sampling approach. First, all farmer groups available in the village were listed (20 and 12 farmer groups in Kitanda and Kindimba, respectively), and then a simple random sampling was carried out to select five groups from each village. Two interviews, one in each village, were held with farmer group representatives. Each farmer group was represented by five members: the Chairperson, Secretary, Treasurer and two ordinary members making a total of 25 members per each interview in each village. Besides this, two focused group discussions (FGDs), one in each village, were conducted with the secretariat of farmer groups' umbrellas. Ten members of farmer groups' umbrellas from each village were involved in FGDs. Two sets of checklist questions were respectively used to collect information from farmer group representatives as well as for FGDs. Satellite image analysis for the periods of 1984, 1989, 1991, 1994 and 2000 were analysed for vegetation cover change detection for both villages and their results presented in tables to see if all adaptations are in line with sustainable resource management. Field observation and informal discussions were also part of the research process at all times. Information gathered from farmer groups' interviews, FGD, observations and informal interviews were subjected to content analysis.

Results and Discussions

Five farmer groups from each village (Kindimba and Kitanda) were involved in this study, as indicated in Table 1. During discussions with members of farmer groups, they noted various indicators of CC&V in their respective localities. These include severe drought of the early 1970s, recurrent droughts, El Niño rains of 1997–1998, change of rainfall season (onset and offset, durations, increasing dry spells), crop failures, increasing temperatures, outbreak of unusual pests and diseases such as maize leaf rust in the 1990s, increasing incidences of malaria, and declining soil fertility that forced replacement of maize with cassava. However, they mentioned failure of crops as another indicator of CC&V but they also linked it to other changing socioeconomic factors such as globalization of the market systems, which has taken place since the mid-1980s.

Their adaptation strategies to these CC&V include working in farmer groups, rural–rural migration and adoption of improved cooking stoves, intensive valley bottom cultivation and changes in eating habits. Other adaptations included intensifying agroforestry activities, beekeeping, fish farming, and adoption of new coffee clones, cultivating drought resistant crops such as cassava and engagement in non-farm activities. Most of these activities ensured both livelihood diversification and landscape conservation, which is also important in carbon sequestration. Indeed, farmers in these villages do adapt to climate change at household level but the most striking feature was their organization and working in farmer groups in the wake of adapting to CC&V. Unique to these two villages was that both farmer groups and farmer activities have registered spontaneous vertical and

Table 1 Farmer groups involved in interviews during survey

Villages	Farmer groups	Membership			Year established	Main activities
		M	F	Total		
Kitanda	Ujamaa	8	7	15	2002	1, 2, 3, 4, 5
	Familia	8	7	15	2003	1, 2, 3, 4
	Vumilia	7	5	12	2003	1, 2, 3, 4
	Ushindi	0	20	20	2004	5 ^a
	Mundeki	6	2	8	2004	1, 2, 3, 5
Kindimba	Jiokoe	6	9	15	2003	1, 2, 3, 4
	Ondoa Umaskini	15	4	19	2003	1, 2, 3
	Women SACCOS	0	5	5	2005	5 ^a
	Amani	9	12	21	2004	1, 2, 3, 4, 5
	Jikwamue	11	13	24	2004	3,4,5
	Total		70 (45.5)	84 (54.5)	154 (100)	

Numbers in parentheses are percentages

^a Women Farmer Group whose activity was diary cattle keeping only

1 Fish farming, 2 tree planting, 3 beekeeping, 4 crop farming, 5 others (Chicken and pig husbandry, pasture production, manure and local brewing)

horizontal expansions, largely owing to farmers' own inventiveness. In subsequent sections, we will discuss the evolution of farmer groups and their activities aiming at adapting to CC&V.

Evolution and Dynamics of Farmer Groups in the Study Areas

With respect to interviews with farmer groups' representatives and FGD with the Group Union, effective farmer group formation in the study villages can be traced back to 2002 when one farmer group (Ujamaa) was formed in Kitanda village with the founding objectives of landscape conservation and livelihood diversification through fish farming, after observing a devastating decline in rural productivity due to changing environment. Development of farmer groups in the study villages received an impetus from the presence of the SCSRD Project (Centre for Sustainable Rural Development of Sokoine University of Agriculture), whose activities involved chanting out with farmers on possible methodology that can enable realization of sustainable rural development. The Project was implemented from 1999 to 2004 under collaboration of Sokoine University of Agriculture (SUA), Japan Cooperation Agency (JICA), Mbinga District Council and farmers in the Kindimba and Kitanda villages. Farmer groups involved in this study, their memberships, year of establishment and their subsequent activities are presented in Table 1.

Table 2 Number of farmer groups in Kindimba and Kitanda villages during and after SCSRD Project period

Villages	2002–2004 During Project period	2004–2005 Additional farmer groups after the Project period	Total number of groups	Main activities
Kitanda	12	8	20	Fish farming ^a , beekeeping, tree planting, pasture, crop cultivation, poultry keeping, pig and dairy cattle keeping, hydro-mill machine, vegetables farming
Kindimba	8	4	12	Fish farming ^a , beekeeping, tree planting, hydro-mill machine, local brewing

^a Main founding activity

The subsequent parts present how farmers from these two villages continuously implemented activities spontaneously by themselves even after the end of the SCSRD Project. Inside these two villages, we can observe not only quantitative progress (increasing of the number of farmer groups), but also qualitative progress (diversifying and diffusing their activities within their communities and outside their villages) that is in line with adaptations to the changing environment.

Adapting to changing climate, farmer groups have enacted activities that have shown both qualitative and quantitative progress. Table 2 shows that in terms of qualitative and quantitative progress, farmer groups had increased in number and diversified their activities. For instance, farmer groups in Kitanda village have increased from one group in 2002 to 12 groups by SCSRD project termination in 2004 and to 20 groups in 2005 one year after the SCSRD project ended. A similar trend was also observed in Kindimba village. Their activities have diversified from original fish farming to pig farming, dairy cattle and beekeeping, tree planting and local brewing. While implementing these activities, farmer groups have always been involved in tree and fodder planting and refraining from setting bush fires and, on other occasions, villagers were restricted to cultivating near river courses so as to ensure natural vegetation restoration and hence landscape conservation, which is also important in adapting to changing environment.

It was further learnt during interviews that farmer group activities in the study area seem to have been diffusing throughout and even outside their communities. Group activities have been permeating from a few leading villagers, e.g. “relatively educated and/or the governing class/status”, to “ordinary villagers”. Certainly, this progress of spontaneous diversifying and diffusing of activities are essential for sustainable resource management because these activities of diversification and diffusion reflect villagers’ ingenuity. Tamura (2006) described such quantitative and qualitative processes as “vertical expansion”, implying that the expansion takes a hierarchical family or clan model wherein the founding group is viewed as a fore parent and subsequent groups are viewed as its descendants. However, on the basis of out-scaling of the group formation that went along with

the expansion of farmer group activities in a ripple-like pattern to both the neighbouring and distant villages, the process is also worthy of the phrase “horizontal expansion”. Some group leaders from Kindimba and Kitanda have been advising and assisting new groups from other villages at their own initiatives. The vertical and horizontal expansion processes are currently working closely together in the Matengo highlands, owing to originality from Kindimba and Kitanda villages. It is through these processes that farmers from distant villages are working together to improve their natural environment and livelihoods in the effort to adapt to climate change and variability.

Vertical Progress of Farmer Groups

Various vertical progresses were registered by farmer groups in the study villages. It was observed during the discussions with farmer groups’ representatives and FGDs that robust vertical expansion of farmer groups occurred after a three-day farmers’ exchange visit that took place in January 2004. About 150 farmers from both Kindimba and Kitanda villages were involved in this exchange visit (SCSRD 2004). On the first day of the exchange visit, Kindimba farmers visited Kitanda village, while on the second day, Kitanda farmers visited Kindimba village, and the third day involved discussions by participants from both villages. Group formation, group activities and management were the central matters under discussion. Demonstrations of farmer group activities depicting relationships between fish farming, tree planting and beekeeping as an integrated practical model for landscape conservation and livelihood improvement by already established groups attracted many participants.

Interviews with farmer group representatives revealed that after the exchange visits in 2004, many villagers requested the senior group leaders to include them in their groups. However, the group leaders declined the request because they were afraid the groups would become too big to manage. Instead, the consulted group leaders advised these villagers to form their own groups and promised to offer them managerial assistance and fish fingerlings for free. Such “free” assistance is not uncommon among the Matengo who have been practising reciprocal labour, “ngokela”, for many years. There were some cases where some members from the old groups shifted to the new groups. Ten and seven farmer groups with diversified activities were respectively formed in Kitanda and Kindimba villages after the exchange visits of 2004, which is typical of what Tamura (2006) classified as vertical progress.

FGDs and interviews with farmer group leaders and representatives revealed another vertical development, in that all farmer groups in each village have established a closer connection to each other and formed a farmer groups’ umbrella, which in Kitanda village is referred to as Groups Union and in Kindimba is known as Sengu Committee. Sengu is a traditional place where men used to assemble in the evening and discussed various issues to their lives including

marriage and work plans for the purpose of improving lives in the family. The farmer groups' umbrella conducts monthly meetings, which involve the participation of all farmer group leaders, village government authorities, the agricultural extension officer and religious leaders, forming the so-called tripartite relationship (local people, religious leaders and government agents) in local resource management. They exchange their experiences and discuss challenges and ways forward. When necessary, the leaders of the umbrella visit a group in need of attention to discuss and advise on their challenges. The umbrella also managed the farmers' exchange visits inside the village. In Kindimba village, the umbrella (Sengu Committee) also manages the day-to-day running of the village hydro-mill project, including bookkeeping and accounts of the hydro-mill project.

A characteristic feature for all farmer groups both in Kindimba and Kitanda villages was the fish farming. Thus, fish farming has become a symbol of group activities for nearly all groups. Certainly, the impact of fish farming as a catalyst of formation of farmer groups and mushrooming of group activities came as a serendipitous event rather than a planned one. Some reasons can be attributed to this phenomenon. The growth of the fish is very rapid and thus the group output is seen within a short time. The making of fishponds also goes hand in hand with tree planting or keeping the micro-catchment vegetation intact to enable sustainable water flow to the ponds. The conserved micro-catchment can be used for other human-environmentally friendly purposes such as beekeeping and sustainable harvesting of mushrooms, medicinal plants and construction materials. Additionally, digging of fish ponds is perceived as not being so difficult by the Matengo people, who are used to labour-intensive traditional cultivation methods known as ngolo (a kind of ploughing to make four-tiered ridge farms by digging steep slopes). Matengo people have been using this type of cultivation method for more than 100 years (MWARP 1998) and they are applying similar hard-working spirit and energy to digging fishponds. The hard-working virtue of the Matengo is referred to by SCSRD (2004) as the "potential of indigenesness" to sustainable resource management.

Fingerling distribution to new groups also played a significant role in farmer groups' vertical expansion. It must be noted that the first fingerling installation in Kitanda village was done in November 2002 by one farmer group (Ujamaa) in one fishpond. Ujamaa group distributed 360 fingerlings to its seven group members by 2005. After two years, six members of this group managed to distribute about 4,300 fingerlings to emerging groups and individuals within and outside the village in Kindimba, Lipumba, Mtama and Kikolo villages. It was encouraging noting during discussion that one member of Ujamaa group, Mr Kevin Ndimbo, for instance, who initially received only 19 fingerlings, managed to distribute about 1,500 to other groups and individuals. As a result of active fingerling distribution, there were 210 ponds in Kitanda village and 75 fishponds in Kindimba village by the end of 2005. However, in Kindimba village, the first fingerling installation took place in July 2003.

Next to fish farming, social forestry activities were another fundamental activity that overlapped in many farmer groups from older to new groups. While several

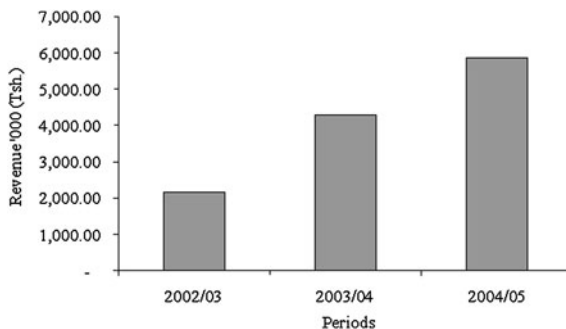
Table 3 Some of the indigenous tree species planted in Kindimba and Kitanda villages by 2005

Local names	Botanical names	Major uses
Mdhambarau pori	<i>Syzygium guineense</i>	Conservation of water sources
Muwawa	<i>Khaya anotheca</i>	Conservation of water sources
Msindano	<i>Pinus patula</i>	Timber, landscape conservation
Mwanga	<i>Pericopsis angolensis</i>	Timber, fuelwood supply, agroforestry
Mtela wa mbamba	<i>Rauvolfia caffra</i>	Medicinal, timber
Mzombo	<i>Brachystegia spiciformis</i>	Fuelwood, building poles
Mtumbati	<i>Pterocarpus angolensis</i>	Medicinal, agroforestry, timber
Mdonga	<i>Strychnos cocculoides</i>	Fruits, fuelwood, building poles
Mnyenda	<i>Bridellia micrantha</i>	Conservation of water sources
Mkaranga mti	<i>Macadamia spp</i>	Alternative cash crop to coffee
Mtanga	<i>Albizia schimperiana</i>	Soil fertility conservation and shade in coffee plantation

farmer groups received tree seeds and seedlings from the District Office and SCSRD, some groups collected indigenous tree seeds and/or seedlings from Miombo woodland forests and sowed or transplanted them to rehabilitate the degraded landscape. The total number of trees planted by farmer groups in Kindimba and Kitanda villages by 2005 was 10,500 and 3,500, respectively. Farmers regard the increase or diversification of farmer groups and activities (vertical and horizontal expansion) as a strategy of strengthening the vigour of their groups. The tendency of farmer group activities to directly integrate tree planting activities and micro-catchment vegetation preservation is vital not only for landscape conservation but also adaptive mechanisms to changing environment. Table 3 shows some of the tree species planted in Kindimba and Kitanda villages by farmer groups.

Indigenous knowledge is an important tool employed in the process of restoring the degraded landscape cover in the study area. Various micro-climates have different kinds of appropriate vegetations that revitalize their ecological potentials. Since local people have existed for a long time with the natural environment around them, they possess an indigenous knowledge resource on trees, which used to grow around catchments before land cover was degraded. This knowledge was very useful during the identification of the right tree species for conservation of water sources and degraded landscapes. Tree seedlings were distributed not only for planting within village water sources, mountain tops and open spaces, but also within and around river sources.

Fig. 1 Revenues (Tanzanian shillings) accrued from hydro-mill project at Kindimba village



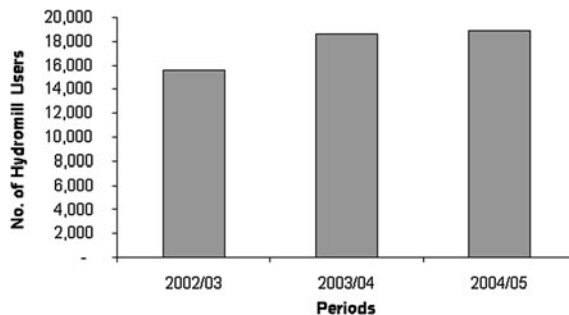
Step Towards an Economic Stage

Farmer activities not only realized landscape conservation but they were also involved in income generation activities and accessed financial institutions, which is referred to as an economic stage to improve livelihoods. In Kindimba village, the farmer group umbrella (Sengu Committee) pointed out the success achieved by the village hydro-mill project, which is run collaboratively by all groups under the leadership of the umbrella group. Figure 1 shows revenues accrued from hydro-mill project in respective years and Fig. 2 presents the number of hydro-mill users, including those from neighbouring villages. It was learnt during informal discussion with district leaders that the Kindimba village hydro-mill project was the biggest sole project (in terms of number of users and revenues) manned by villagers themselves in the district.

The Sengu Committee elaborated an efficient system of record keeping of hydro-mill revenues against customers' attendance registry. The Committee has also opened a bank account for the project as an important step towards an economic stage. Revenues from this project were being used to articulate other development activities in the village such as providing financial support to the ongoing electrification project in the village and purchase of tree seeds and/or seedlings for landscape conservation. Expenses for the servicing of the hydro-mill machine are also borne by part of the revenues from the same machine. The milling charges are far cheaper compared to a diesel-propelled milling machine and the served income is used by households to cover other domestic needs, as reported by SCSRD (2004) and Tamura (2006), which is important to livelihood improvement.

Besides collaborative (whole village) economic transformation, some farmer groups such as Ushindi and Ujamaa in Kitanda village had also opened bank accounts, with the aim of acquiring bank loans for both the group and individual members as an important step towards an economic stage. Normally, after opening the group's bank account, the group members make weekly deposits which later can act as collateral. When each group member's deposits reach 5,000 Tanzanian shillings (Tsh.) (~US\$4), each member can get a maximum loan of Tsh. 50,000 (~US\$40) from the bank. This is a new type of the rural micro-finance

Fig. 2 Number of hydro-mill users at Kindimba village



arrangement and the villagers can access loans without any other collateral because their deposits in the group account guarantee them. For many years, financial institutions have been reluctant to give loans to poor people especially when collateral is missing (Barger 1989; Albee 1994). However, this new invention can permit many poor rural dwellers access to financial services and hence improve their livelihoods. For instance, Ushindi group in Kitanda has capitalized on the available loan system at the Savings and Credit Cooperative Society (SACCOs) and have used the loan to acquire a dairy cow. Farmer group savings from the selling of fingerlings, fish, vegetables and honey were other examples of economic diversification managed by farmer groups.

Horizontal Expansion of Farmer Group Activities

Discussion with farmer groups and FGDs noted that vertical expansion of farmer groups (in number and activities) in Kindimba and Kitanda villages also influenced the spontaneous formation of farmer groups even outside these two villages. By the same token, tree seeds and/or seedlings and fish fingerling distribution were extended up to the neighbouring and distant villages. Some of the outside villages were rather further than “neighbouring”. For example, it took about a 7 h walk for Lipumba villagers to bring fingerlings from Kitanda to their village. Through such a process, horizontal expansion of farmer groups was realized, as discussed in subsequent sections.

Notably, villagers have been implementing these expansions mainly spontaneously. Neighbouring villagers and groups who wanted to get fingerlings, tree seedlings and advice received support from older groups mainly for free. On some isolated occasions, new groups had to buy fingerlings and seedlings from established groups. In October 2004, Vumilia group from neighbouring Lipumba village purchased 200 fingerlings from Ujamaa group. Vumilia group had other activities such as farming, beekeeping, tree planting and pig farming, but they wanted to diversify to fish farming as well. In this way, Ujamaa group increased group income and expanded fish farming activities to others. This was one of the

ways to realize horizontal expansion of farmer groups' activities, which was a way of adapting to the changing environment.

The second type of horizontal expansion was observed through expansion of new groups and their activities to both neighbouring and distant villages under the assistance of older groups in Kindimba and Kitanda villages. For instance, Furaha group in the neighbouring Masimeli village (20–25 km away from Kitanda) was established in April 2005 with assistance from Ujamaa group of Kitanda village. It was in 2003 when one villager from Masimeli village (the present group leader), heard about fish farming in Kitanda. He visited the Ujamaa group leader in March 2005 and received some advice on how to form and manage a farmer group and how to start activities including fish farming. On returning to his village, he convinced his relatives, friends and neighbours to form a group, which is now known as Furaha. Their first activity was to establish a fishpond and purchase 250 fingerlings from *Ujamaa* group. Since Furaha group had no skills to start their activities they received “brotherly” advice from Ujamaa and other groups from Kitanda village. By the time of this survey, Furaha group was also conducting other activities such as crop, poultry and pig farming, and beekeeping and had established a tree nursery. All these activities were supported by the advice from Ujamaa group in terms of both skills and philosophy. The intention of Ujamaa group to help Furaha group was that the latter would be a keystone in Masimeli village and extend its activities within and outside the villages as well, hence ensuring livelihood improvement and conservation of degraded landscape due to changing climate.

The third horizontal expansion was to individuals who wanted to start fish farming or to add new or good fish pedigree to their existing ponds. Commonly, in Kindimba and Kitanda villages, individual farmers and households were also involved in making their own fishponds and some travelled long distances (40–50 km) near Lake Nyasa (or Malawi) to purchase “good” fish breeds or pedigree. Ujamaa group and other old groups always extended their advice and support to such individual household activities. Focus group and key informants' discussions contended that fish farming ensured food security, income to the households and conservation of village landscape.

So far, various farmer group adaptive activities to CC&V have been discussed. It is very important for farmers to initiate their own activities to adapt to a new environment and for outsiders to respect farmers' ways of doing things. Outsiders can act as “messengers” of farmers, carrying their opinion to upper radars where farmers cannot easily access. Most of these activities reflect the great potential to forest catchment conservation and livelihood transformation. Conservation of catchment environment serves to reduce the fluctuation in water levels and prevent soil erosion, and provides daily livelihood materials such as timber and medicine, and food materials such as honey, fruits and mushrooms (Nsenga et al. 2004). In addition, the hydro-mill machine project, fish cultivation, planting of useful tree species and promoting beekeeping are intended to serve as management approaches to these catchment forests. Intriguing to note is that these adaptive activities, even the advanced ones such as the hydro-mill project, have been initiated and

Table 4 Land cover changes (%) in Kitanda village extracted from satellite image analysis

Periods	Tree cover	Burnt area	Grass cover
1984	≥ 80	≤ 5	≤ 15
1989	≤ 70	≥ 5	≥ 25
1991	≤ 50	–	≥ 55
1994	≤ 40	≤ 5	≥ 55
2000	≤ 20	≥ 10	≥ 70

Table 5 Land cover changes (%) in Kindimba village extracted from satellite image analysis

Periods	Tree cover	Burnt area	Grass cover
1984	≤ 30	–	≥ 75
1989	≤ 40	–	≥ 60
1991	≤ 40	–	≥ 60
1994	≤ 45	≤ 5	≥ 55
2000	≤ 35	–	≥ 60

managed by the villagers themselves, although support from other development partners cannot be ruled out. In addition, the expansion processes have been supervised by the villagers themselves. This is a very important aspect in sustainable resource management and rural development in general, especially under the changing environment influenced by CC&V.

Impacts of Climate Change Adaptations on Land Cover Degradation

Sometimes adaptations or coping strategies can lead to severe repercussions on the landscape. The extent and trends of vegetation cover degradation were extracted from satellite imagery from the 1984, 1989, 1991, 1994 and 2000 periods and are presented in Tables 4 and 5, and Figs. 3 and 4, respectively. Values from Table 4 extracted from Fig. 1 show that land area covered by trees dropped from over 80% in 1984 to less than 20% in 2000 in Kitanda village. In contrast, in the same village, the grass-covered areas increased from less than 12% in 1984 to more than 70% in 2000, indicating unprecedented conversion of tree cover to grassland, largely due to expansion of cultivation activities in these Rolling Hills due to decline in soil fertility in the Mountain Area.

Analysis of satellite images of Kindimba village (Mountain Area) presented in Table 5 show that tree cover seems to have stabilized for a long time, though at low level. Equilibrium had been reached through long-time habitation largely due to agroforestry practice in coffee farms and the establishment of eucalyptus woodland. Table 5 and Fig. 4 indicate that from 1994 tree cover showed slight downscale changes and the decline was associated to conversion of a few remaining fallows and woodland to crop fields and valley bottom cultivation after

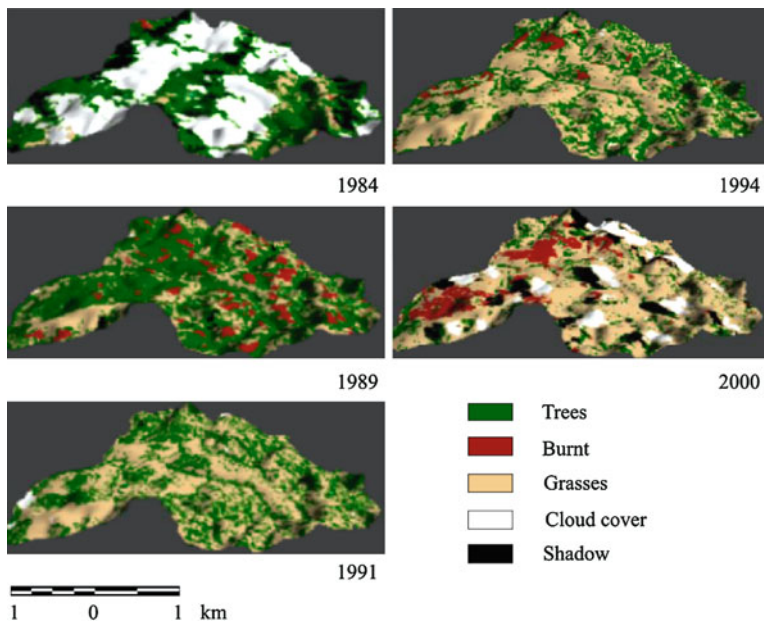


Fig. 3 Satellite images showing trends of land cover change in Kitanda village

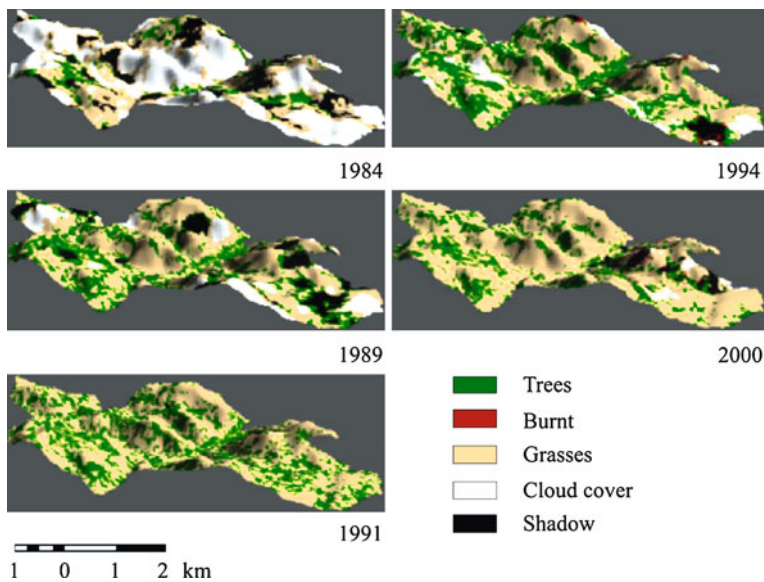


Fig. 4 Satellite images showing trends of land cover change in Kindimba village

Table 6 Percentage factors affecting tree cover in Kitanda village

Factors	Percentage
Opening of new farms	58.0
Fuelwood demand	21.0
Lumbering	12.5
Others	8.5
Total	100

changing climate and economic crisis in Matengo highlands since the 1990s. Lack of ample agricultural land for expansion within the Mountain Area could have contributed to low vegetation change within the sub-agroecological zone.

Reading from Table 4 and Fig. 3, one can conclude that land use in the Rolling Hills of the Matengo highlands has changed significantly, especially since the 1980s. Apart from changing climate, Nindi (2004, 2007) and Mhando (2005) also relates this situation to the economic destabilization faced by the Matengo farmers since the mid-1980s, especially after the introduction of trade liberalization of the coffee market, which led to the collapse of the Mbinga Cooperative Union (MBICU). They further reported that the collapse of the MBICU negatively impacted the ability of the Matengo farmers to access chemical fertilizers, which supported crop production in their discrete mountain farm plots. Interviews with farmer group representatives, FGDs and informal interviews confirmed that coffee economy (the major cash economy) has supported the Matengo and their agricultural systems for many years. At most of the times, MBICU ensured them with markets and a reliable input supply chain to farm level, hence stable farm production not only for coffee but also other food crops. Inputs bought from coffee money at several times supported production of food crops in their small highlands farm plots. With the biting of CC&V coupled with economic destabilization, farmers from Mountain Area had to invade adjacent frontiers in the Rolling Hills, and Kitanda village was not spared this invasion. Mhando (2005) contends that tumbling of the coffee production and its marketing systems from the 1980s led to the vast and abrupt creation of new farms on virgin land in adjacent frontiers in the Rolling Hills, where the use of agro-chemicals was not necessary.

FGD and informal discussions during the survey also confirmed that recent unprecedented deforestation of the Rolling Hills was largely due to the influx of Matengo immigrants from the Mountain Area after the collapse of the coffee economy, declined land productivity and invasion of new maize leaf rust disease in 1990s. Nindi (2004) revealed that in the new land, farmers from Mountain Area largely conduct extensive agricultural practices of slash-and-burn. He further pointed out that the practice of a slash-and-burn cultivation system on such steep and rugged slopes coupled with intense and erratic rains certainly provoked not only vegetation cleansing but also intensive soil erosion and sediment runoff to river valleys. Revelations from Kjekshus (1977), Pratt and Gwynne (1978), Pomeroy and Service (1986), and Itani (1998) show that soil erosion from uncoordinated agricultural practices is a serious problem in mountainous areas that experience frequent heavy rains. In such environments, the removal of vegetation

can easily erode surface soil if the land is cultivated, erosion becomes more serious and the land may become barren within several years.

Indeed, prior to the mid-1980s, the Matengo had adaptive mechanisms to the changing environment of migration into frontiers, especially when the population was against the carrying capacity in the Mountain Area. Normally, after 3–4 generations, a Matengo extended family would allow some of the family members to migrate to “new land” and open up farms, and live their permanently, initially practising slash-and-burn agriculture and later resorting to their permanent intensive indigenous ngolo cultivation system (MWARP 1998; Nindi 2004). In the new land, they also followed their traditional land holding practice known as “ntambo” [a mountain ridge sandwiched between two river valleys owned and utilized in sustainable manner by extended family (Itani 1998)]. When the coffee economy was good, ntambo was normally bought from money saved from cash sales (MWARP 1998; Nindi 2004, 2007). Thus, the Matengo managed their natural landscape largely through the cash saved from coffee sales. The recent abrupt migration of the Matengo farmers from the Mountain Area to the frontiers did not follow this normal ntambo land holding system. The land tenure shifted from permanent ntambo land holding to the hiring of farm plots to be utilized for a few seasons only, and hence lacked the indigenous sense of resource ownership. Thus, both the abrupt invasion of Rolling Hills’ frontiers and the changing land-holding system posed severe repercussions to vegetation cover and the livelihood of the people in the Matengo highlands.

It was learnt during FGDs that cutting down trees to open up new farms in the Rolling Hills contributed to forest degradation by 58%, as shown in Table 6. It was further noted that new farms in the Rolling Hills were opened up not only by the inhabitants of the Rolling Hills and immigrants from Mountain Area alone but also the urban-based farmer inhabitants from Mbinga Township. District officials lamented that fast population growth at Mbinga Township coupled with low food supply chain from adjacent rural areas also contributed to debilitating vegetation cover in the Rolling Hills. For instance, by 1978, the population of Mbinga Township was only 7,308 but reached 25,416 in 2002 (Mbinga District Council 1997; National Bureau of Statistics, 2003) and most of them (86%) were immigrants (Mbinga District Council 1997). Unfortunately, most of these immigrants and original inhabitants demanded land for cultivation as well as forest goods and services mostly from the adjacent Rolling Hills. This abrupt population increase in Mbinga town was partly due to an increased number of petty traders and artisan-mining activities that had concentrated in the district since the late 1980s. Economic liberalization also allowed free trading, a circumstance that brought a number of petty traders of second-hand clothing (“mitumba”), shops, kiosk, and restaurants in Mbinga Township, all demanding goods and services from the adjacent rural landscape.

According to Mbinga District Council (1997), about 64% of Mbinga town dwellers were farmer-based inhabitants and utilized farms and obtained their fuel wood and timber demand from the same Rolling Hills, consequently affecting tree cover in the area. Cool climate and lack of power supply complicated the situation

further, as more fuel wood was needed for heating as well. Such an abrupt influx of immigrants in the non-electrified town of Mbinga possibly influenced deforestation in the woodland further. It could therefore be surmised from above that environmental degradation in the Matengo highlands is also a result of interplay of urban–rural relationships rather than an exclusive rural–rural based problem.

It was also revealed during FDs that most tree species ruined for lumbering were Muwawa (*Khaya anthotheca*), Mchai (*Harungana madagascariensis*), Mpuga (*Erythrophleum africanum*) Mgwina, (*Breanardia africana*) and Muwanga (*Pericopsis angolensis*). Tree species most affected by fuelwood demand include Mbuni (*Parinari curatellifolia*), Mnyonyo (*Syzygium cordatum*), Muwanga (*Pericopsis angolensis*), Mzombo (*Brachystegia spiciformis*) and Mteteleka (*Faurea speciosa*). One elder also commented that due to intense deforestation in the Rolling Hills, people now even make charcoal out of mango trees (*Mangifera indica*), previously not meant for that purpose.

It can be summarized that tree cover degradation under the influence of CC&V and trade liberalization has recently been very severe in the Rolling Hills area of Kitanda village than in the mountain area village Kindimba. The most influential factor in the fast deterioration of tree cover in the Rolling Hills could therefore be agreed as the tendency of opening up new food crop farms especially by mountain immigrants as well as Mbinga town dwellers who attend such farms on a temporal basis. This could be ascertained by the increased percentage of grass cover, which also represents food crop farms. However, the tendency of agroforestry cover in coffee farms would in future conserve the environment in the Matengo highlands, as was seen in the case of Kindimba village.

Conclusions

Undeniably, climate change and its impacts are very obvious and very serious, especially among poor farm families mostly residing in rural areas of Tanzania and the vulnerability to a rural production system cannot be tied to a single causality, but rather an interplay of factors and sometimes CC&V has only intensified the vulnerability of the changing rural landscape. In response to changing climate, the villagers have been developing and deepening their adaptation activities related to landscape conservation and livelihood diversification, both quantitatively and qualitatively, as a means of adapting to their changing environment. And in most cases, they have been doing these activities by themselves. Certainly, all areas and communities have their own peculiarities and identities, with sustainable adaptation strategies depending on their sense of value and behaviour or culture. Thus, we must find the possibility for sustainable adaptations within their sense of value/behaviour or culture, which reflect their potential of indigenoussness.

The impact of integrated farmer group activities is an eye-opener to new adaptation to landscape degradation influenced by CC&V and other socio-economic factors. Thus, the effect of farmer group activities to adapt to changing

environmental issues has revealed the new perspective of integrated resource management in the area. Through vertical and horizontal progress, many people and villages will be integrated into the natural resource management, which is the basis of their adaptation to changing climate. With such micro-catchment conservation strategies, larger areas can be conserved through integrating more farmer groups in a wider area. Integrated resource management also provides added value to the resource, hence ensuring its sustainability; e.g. tree planting and beekeeping can lead to careful management of tree and forest resources. With such committed spirits, time and financial resources, the Matengo highlands will without doubt be rehabilitated, improving livelihoods under changing climate conditions and other socioeconomic factors.

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