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THE CHAGGA HOMEGARDENS: a multistoried agroforestry cropping system on Mt. Kilimanjaro (Northern Tanzania)

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PLANT SPECIES IN THE KILIMANJARO AGROFORESTRY SYSTEM

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The Chagga homegardens: a multistoried agroforestry cropping system on Mt. Kilimanjaro (Northern Tanzania)

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Abstract. The homegardens are characterised by an intensive integration of numerous multipurpose trees and shrubs with food crops and animals, simultaneously on the same unit of land.

The Chagga are skilled farmers with an intimate knowledge of the crops and their ecological requirements. They have a good idea of functions/uses of the plant species on their farms. The large species diversity provides both subsistence and cash crops. It enables the farmer to keep his management options open and provides insurance against drought, pest and economic risks.

1. Introduction

The Chagga are Bantu speakers descended from immigrants of various tribes who migrated into the once forested foothills of Mt. Kilimanjaro. Then began the process of transforming the native forest. Trees that provided fodder, fuel and fruits were retained while the less useful species were eliminated and replaced with new tree and crop species. This process is still continuing on Mt. Meru – a neighbouring mountain.

Mt. Kilimanjaro is one of the most densely populated areas in Tanzania. This is due largely to the ecological and economic success of the Chagga cropping system. The homegardens enable the farmer to obtain a sustained production with a minimum of external inputs and thus represent a good model of landuse for extrapolation to other areas with similar ecological and socio-economic characteristics.

Although the Chagga homegardens are often cited as an example of model landuse [1, 7], the system has not been described in any detail. This paper identifies the major components, describes their interactions and management aspects and presents an evaluation of the system's ecological stability, productivity and sustainability.

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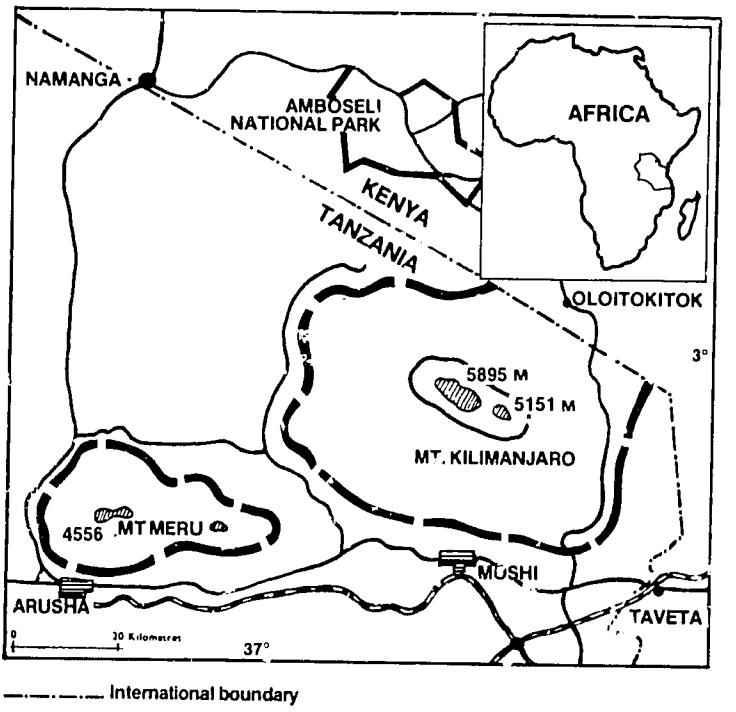

Figure 1. Location of Mt. Kilimanjaro in northern Tanzania.

2. General description of the area

2.1 Geographic location

The Chagga homegardens are found on Mt. Kilimanjaro in northern Tanzania (2.9–3.3 °S, 37.0 –37.5 °E) (Figure 1). The bulk of the mountain covers about 3100 km^2 and the highest peak is 5895 m above sea level. The area above the 1900 m contour is a designated forest reserve and national park.

2.2 Biophysical environment

2.2.1 Climate. Mt. Kilimanjaro region has a bimodal rainfall pattern; 'short rains' from October to December and 'long rains' from March to May. The average annual rainfall ranges from 1000 to 1700 mm with marked variation depending on elevation, exposure and aspect. Thus, Kilimanjaro gets more rainfall on its southeastern and eastern flanks (where the Chagga homegardens are) than on its northern and western sides which are sheltered from the wet southeast winds.

2.2.2 Soils. There are four major groups (FAO/UNESCO Soil Map of the World -- Sheet VI-3):

(1) Humic nitosols and associated Humic andosols
(2) Chromic cambisols and associated Eutric cambisols
(3) Orchric andosols and associated chromic cambisols and vitric andosols
(4) Mollic andosols and associated Eutric nitosols

In general, these volcanic soils are fertile with a high base saturation and cation exchange capacity. A major limitation is the step slopes which prevent mechanization and require substantial erosion control work. Other limitations include stoniness or a shallow petrocalcic horizon.

2.2.3 Vegetation. Climax vegetation is montane rainforest. The forest varies in composition and structure along altitudinal and rainfall gradients. On the wetter southeastern slopes, there is a zone of *Ocotea usambarensis* and *Podocarpus usambarensis*. This occurs at an altitude of 1900 to 2400 m.a.s.l. and a rainfall of 1500 to 1800 mm. The drier end of *Ocotea* forest sometimes grades into a forest with much *Cassipourea malosana* associated with *Myrica salicifolia*. At lower altitudes what little remains of the forest is characterised by the following species: *Newtonia buchananii, Macaranga kilimandscharica* and *Parinari excelsa*. At around 1200 m.a.s.l. and 1300 mm rainfall, species include *Albizia* spp., *Bombax schumanianum, Chlorophora excelsa, Diospyros mespiliformis, Khaya nyasica, Newtonia paucijuga* and *Terminalia kilimandscharica*. In contrast, the drier northwestern slopes (1000 to 2800 m) have *Juniperus procera* as the dominant species in association with *Olea africana* and *Olea welwitschii* and sometimes in pure stands.

2.3 Landuse systems

2.3.1 Agriculture. The southeastern and eastern slopes are characterised by intensive smallholder production of both subsistence and cash crops. Individual homesteads are densely scattered and food crops are grown under the canopies of banana and coffee. In addition, there are state owned coffee estates and farms. The drier northern and western slopes are used mainly for extensive grazing by the Masai.

2.3.2 Forestry. Major plantation species are *Cupressus lusitanica* and *Pinus patula* of which there are about 3000 ha in the west and 3500 ha in north-eastern Kilimanjaro. The Forestry Department carries out various silvicultural operations in natural forests to encourage natural regeneration or root suckers of *Ocotea usambarensis, Podocarpus gracilior, Podocarpus milanjianus* and *Juniperus procera.*

2.3.3 Agroforestry. The intensive cropping system of the Chagga involves integration of several multipurpose trees and shrubs with food and cash crops and livestock simultaneously on the same unit of land. Within this cropping system several agroforestry practices can be identified. These include the use of multipurpose trees/shrubs:

- to provide shade for coffee
- as live fences
- for fodder and mulch production
- for bee forage
- with anti-pest properties.

A typical homegarden scene is depicted in Figure 2.

Figure 2. Chagga homegarden showing large trees e.g. *Cordia abyssinica*, *Albizia* spp. and *Grevillea robusta* in the uppermost storey. Next are the banana and coffee canopies and here the lowest layer is comprised of fodder herbs and grasses. (Photo: I.C.M. Fernandes)

3. Structure of the system

The Chagga homegardens ('vihamba') cover about 1200 km^2 (120,000 ha) on the south and east slopes of Mt. Kilimanjaro. Recent estimates indicate that the south slopes have a population density of 500 km^{-2} and an annual population growth rate of at least 3%. Marketing facilities are fair with Moshi town (Figure 1) being the nearest major market and a good road linking Moshi with Arusha, Tanga and Dar es Salaam.

The homegardens are located mainly between 900–1900 m above sea level. In addition, each family has another plot ('kishamba') 10 to 16 km away in the drier plains below the southern and eastern slopes. The kishamba has only very few trees and is used mainly for growing annual crops.

3.1 Components of the homegarden

3.1.1 Crops

3.1.1.1 Food crops. Banana (*Musa* spp.), beans (*Phaseolus vulgaris*), cabbage (*Brassica oleracea*), cow pea (*Vigna unguiculata*), maize (*Zea mays*), onion (*Allium cepa*), potato (*Solanum tuberosum*), sweet potato (*Ipomoea batatas*), taro (*Colocassia* spp. and *Xanthosoma* spp.), tomato (*Lycopersicon esculentum*), yam (*Dioscorea* spp.)

3.1.1.2 Cash crops. Coffee (*Coffea arabica*), cardamom (*Elettaria cardamomum*). Surplus bananas and other food crops are also sold. Women are responsible for marketing the surplus bananas, vegetables and milk and they keep the proceeds. Men get the money from coffee, poultry and egg sales.

There are at least 15 different types of banana grown on the homegardens. These include cultivars for food, brewing and fodder. In addition to the fruit, the leaves and pseudostems are also used for fodder while the stem sheaths and dried leaves are used as mulch for coffee bushes. Although a little maize is grown in some homegardens, the bulk of the crop is grown intercropped with beans on the lowland kishamba. Finger millet (*Eleusine coracana*), an important crop used for brewing and making a porridge, is also grown in the lowlands.

3.1.2 Trees and shrubs. Chagga farmers deliberately retain and manage numerous species of trees and shrubs on homegardens. Table 1 provides an indication of the species diversity and their uses. The men are responsible for lopping the fuel and fodder trees while the women harvest the fodder grasses and herbs.

3.1.3 Animals. Cattle are kept for milk, while goats and pigs are kept for meat for sale and/or for home consumption. Recently, some farmers have started keeping improved cattle. The more popular breeds are Fresian, Jersey, Ayrshire and crosses involving these and local breeds. Each farmer has an average of 3 cows, 2 goats and 6 chickens [6]. In some cases a pig is also kept. Livestock are stall-fed with fodder from trees/shrubs, banana plants and grasses grown on the homestead. Supplementary fodder is harvested from the kishamba in the plains or bought at 20 Tshs* a headload (30–50 kg).

3.2 Arrangement/Interaction of components

The spatial arrangement of components is irregular and appears very haphazard with the trees/shrubs and food crops intimately mixed. Vertically, however, several relatively distinct zones can be distinguished. A schematic presentation of the canopy structure is presented in Figure 3. In terms of canopy depth, the lowest zone (0–1 m) consists of food crops like taro, beans, and fodder herbs and grasses. Included in this zone is the regeneration of the overstorey trees/shrubs. The next zone (1–2.5 m) comprises mainly coffee with a few young trees/shrubs and medicinal plants. Next is the banana canopy (2.5–5 m) with some fruit and fodder trees. Above the 'banana' layer, vertical zonation is less distinct with a diffuse zone (5–20 m) of the preferred fuel and fodder species and another zone (15–30 m+) of the valuable timber trees and other fodder and fuelwood species. There is considerable overlap of the stories with continuous recruitment to the various zones.

*1 US$ = 12.45 Tanzanian shillings (January 1984).

Table 1. Woody species commonly found in the Chagga homegardens and their functions and uses

Species	Functions/Uses
Albizia schimperiana	fuelwood, building material.
Bridelia micrantha	building poles, fodder, roots used medicinally.
Caesalpinia decapetala	live fence.
Calpurnia aurea	coffee shade, poles, tool handles, leaf decoction as anti-helminthic for cattle.
Carica papaya	fruit, mosquito repellent.
Cassia didmyobotrya	medicinal uses, poisonous to cattle.
Cedrela mexicana	fuelwood, timber.
Chlorophora excelsa	Valuable timber.
Citrus spp.	fruit.
Commiphora spp.	fodder, anti-insect properties, live support for yams, fencing material.
Cordia abyssinica	coffee shade, fuelwood, building material, beehive construction.
Croton macrostachys	coffee shade, fuelwood, fodder, anti-insect properties.
Datura arborea	bee forage, anti *Armilaria mellea*, anti-nematodes.
Diospyros mespiliformis	valuable timber.
Dracena usambarensis	live fence, boundary marker.
Dracena afromontana	live fence, boundary marker.
Ethretia spp.	poles, tool handles, anti-biotic properties.
Eriobotrya japonica	fruit, building material, hedge tree.
Ficus spp.	fodder, charcoal.
Gardenia spp.	utensils, anti-insect properties.
Grevillea robusta	coffee shade, fuelwood, building material.
Iboza multiflora	live fence, leaves fed to cattle as anti-helminthic, roots have anti-Bilharzia properties.
Markhamia platycalyx	termite proof building poles, fuelwood.
Morus alba	fodder, fuelwood, reinforce live fence of *Caesalpinia decapetala*.
Newtonia buchananii	fuelwood.
Olea welwitschii	valuable timber, fodder.
Persea spp.	fruit.
Psidium guajava	fruit, fuelwood.
Rauwolfia caffra	fuelwood, bark for brewing, anti-pest properties, used as store for maize cobs which ar hung in its branches.
Rauwolfia inebrians	coffee shade, fuelwood.
Ricinus communis	seed oil used medicinally, seeds in bait as rodent poison.
Syzigium africanum	fuelwood, fruit.
Tectona grandis	valuable timber.
Trema guineensis	fodder, anti-insect properties, used medicinally.
Trichilia emetica	fuelwood, root decoction as anti-helminthic.
Uvaria spp.	fuelwood.
Vangueria tomentosa	fruit, roots as snake bite remedy and anti-helminthic.

Table 1 (Cont.)

Species	Functions/Uses
Other useful plant species maintained in homegardens	
Aloe volkensis	antibiotic properties, grave marking.
Cynodon dactylon	fodder grass.
Pennisetum purpureum	fodder grass.
Senecio kilimandscharica	medicinal use especially against kidney ailments.
Setaria sphacelata	fodder grass.
Vetiveria zizanoides	grass planted along contours for soil erosion control, roof thatch.

Over 100 crop and other plant species that appear in the Chagga homegardens have been listed in a separate publication [5]

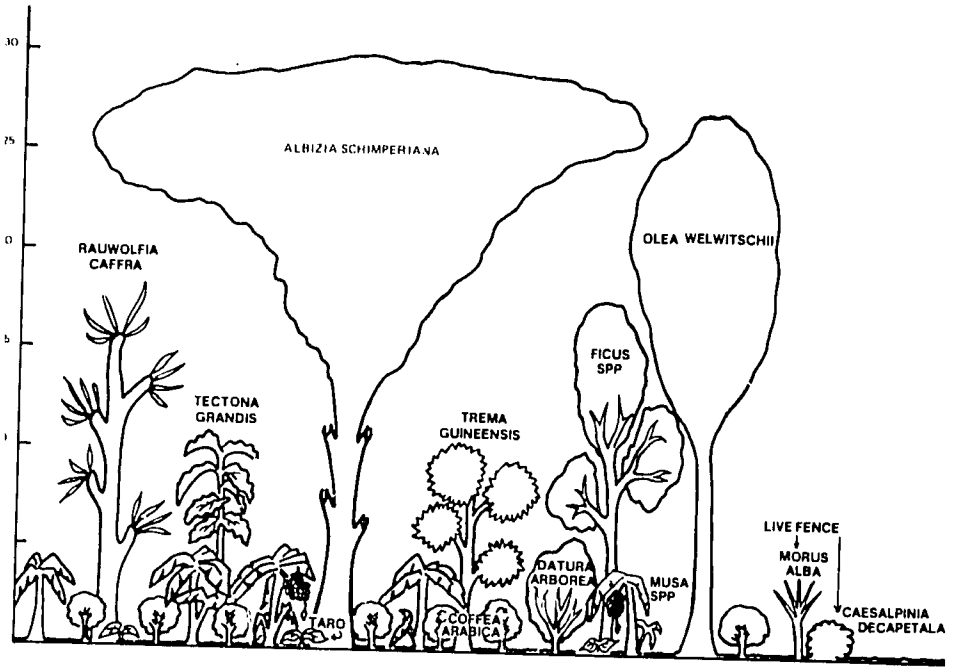

Figure 3. Typical vertical zonation in a Chagga homegarden.

The intimate arrangement of components results in the interactions between components occurring both in time and space. The nature of interactions varies and can be

- direct, e.g. fodder trees/shrubs and livestock; tree/shrubs and bees; cattle manure and crops, tree/shrubs.
- cyclic, e.g. crop residues and cattle.
- competitive, e.g. bananas and coffee; tree/shrubs and crops.

No data is available to indicate the magnitude of the direct or cyclic

interactions. Trials conducted at the Coffee Research Station, Lyamungu and over a part of the main coffee area on Mt. Kilimanjaro showed that bananas interplanted in either young or mature, lightly shaded or unshaded *Coffea arabica* significantly reduced coffee yields [8]. Other trials elsewhere showed that provided farmyard manure was applied to the banana clumps, the yield of bananas planted at 960 stools per ha was not greatly affected by the presence or absence of interplanted coffee. Reduction of the density of bananas interplanted in coffee from 960 to 480 stools per ha resulted in a lower total banana production, which was partially offset by the higher rate of fruiting and larger bunches from the wider spaced plants [2]. This is significant since it is bananas and not coffee that is the primary crop in the Chagga cropping system.

3.3 Management aspects

The Chagga have an intimate knowledge of the various crops and plants and their ecological requirements. Management techniques applied today have been continuously refined and tested over the ages and handed down from one generation to the next. Thus, when the farmers think the time is right, they carry out various operations such as opening up the canopy to ensure better fruiting of the coffee, spacing out the banana stools and manuring the different crops. They maintain plant species (e.g. *Datura arborea, Rauwolfia caffra*) that repel or eradicate various pests and know the best fodder trees/shrubs and when and how to lop them.

Each homegarden has a network of irrigation/drainage furrows distributed over its area and linked to other homegarderns in the vicinity. The farmer is thus able to tap and utilise run off from the forest reserve and other homegardens on the slopes above.

The number of banana clumps and coffee bushes on a homegarden varies not only with altitude and aspect but also with the management capabilities and preferences of the owner. In general, the range of banana clumps per homegarden varies from 200 to 800 (330 to 1200 ha^{-1}) and coffee 300 to 1000 (500 to 1400 ha^{-1}). There are in addition, an average of 39 other trees/shrubs retained and managed on the homegarden. Shade tolerant crops e.g. taro, yams and beans are intercropped between the coffee and bananas (Figure 4, bottom) while the more light demanding species are grown in a section of the homegarden over which the canopy has been thinned to minimise shade.

Coffee extension services provide advice on prunning and spraying against coffee berry disease and leaf rust. Most of the coffee trees have a single stem, while each banana clump is maintained with 3 to 5 pseudostems of different ages so as to facilitate a continuous banana harvest.

Most Chagga farmers either plant or encourage any natural regeneration of valuable timber species (see Table 1). These young trees in the understorey experience considerable shade and this encourages straight stems with few

Figure 4. (top) Valuable timber trees are found on most Chagga homegardens. Teak trees (to the left and centre of picture) are seen growing up through the banana canopy (bottom) Taro together with young coffee and banana plants in the lowest storey. Note the hoe used for tillage. (Photos: I.C.M. Fernandes).

branches. When appropriate, the overhead canopy is thinned to allow the tree to grow into the upper stories. Figure 4 shows teak trees growing up through the banana canopy. The trees are allowed to grow to a size approaching 0.6 to 1 m^3 i.e. a rotation of 60 to 80 years. A large tree (about 1 m^3) of *Olea welwitschii* can fetch a price of 10 000 Tshs. If such a tree is to be felled

during the lifetime of the present owner, then he in turn plants one so that the next owner will also inherit a valuable tree.

It is important to note that although the great majority of homegardens are intensively cultivated and well managed, one also encounters some that are neglected, overgrown and sometimes abandoned.

4. System functioning

4.1 Resource utilisation

4.1.1 Land. The average size of a homegarden is 0.68 ha with a range of 0.2 to 1.2 ha. Traditionally, the land was divided only between the sons but nowadays daughters can also inherit the homegarden or part of it. Land tenure is based on a strongly held traditional belief that there is a close 'spiritual' link between one's ancestors and the soil [1]. Thus, once a member of the immediate family is buried in the homegarden, tenure is assured for the current owner and his descendants and such a homegarden may even be abandoned for several years without the danger of someone else assuming ownership. This is in contrast to the lowland kishamba (allocated by the state and whose size is proportional to family size) where tenure is on an annual and usufructuary basis. If this land is not used for one or two years it may be claimed by another person.

4.1.2 Labour. An average household size of 9.9 people provides a workforce of four family members. In the homegardens, planting, tending and harvesting of bananas, taro and yams occurs throughout the year. Coffee harvesting usually starts in August and continues till January. The peak labour period is between January and March [3]. This is because coffee harvesting coincides with land preparation and planting of crops both in the homegardens and on the lowland kishamba. In contrast, April to June is a low labour period and preceeds the harvesting of maize, beans and finger millet from the lowlands. In the homegardens all operations are performed by human labour, whereas in the lowland, ploughing may be done by tractor.

4.1.3 Capital. Each farmer has an average of 560 Tshs worth of farm implements (axes, hoes and pangas). Only a few farmers own a tractor. These are leased to others for ploughing the lowland kishamba.

4.2 Inputs

Seeds are mostly obtained from previous crops although it is possible to buy seed from the Tanzania Farmers' Association. Dung from the stall-fed livestock and other household wastes are spread around the banana clumps and coffee bushes. Chemical fertilisers are generally not used. The Kilimanjaro Uremi Cooperation (KUC), a cooperative concerned with the production and marketing of coffee, supplies pesticides free of charge for use against coffee

berry disease and leaf rust. In addition, the Chagga use a variety of plant species with anti-pest properties (see Table 1). Credit facilities are offered by the KUC and the Tanzania Rural Development Bank (TRDB). The TRDB also offers soft loans for dairy cattle and pig production.

4.3 Production

An average homegarden of 0.68 ha produces about 125 kg of beans (184 kg ha^{-1}), 280 kg of parchment coffee (412 kg ha^{-1}) and 275 bunches of bananas (404 ha^{-1}) annually. In August 1983, Coffee fetched 16.85 Tshs kg^{-1} while the average price of a bunch of bananas was 30 Tshs. The maize harvest from the lowland plot averages 360 kg per year. Almost all the coffee produced is sold, although the poorer quality beans obtained towards the end of the harvest are retained for home consumption. No production data is available for taro, yams cardamom and onions. Local sources indicate that crop failure involving coffee and/or maize and beans occurs once every 3 or 4 years. However, total failure involving in addition, bananas, other fruits, root crops and livestock has never occurred. Each farmer keeps between 3–5 traditional bee-hives. It is conservatively estimated that each hive produces at least 5 kg of honey per year. Milk production by traditional breeds under stall feeding conditions is low (1–4 l per day), whereas improved cattle produce between 8–16 l per day. Pigs are fattened up and sold within a period of 6–12 months.

It is difficult to estimate the quantity of fodder produced in the homegarden, but most of the Chagga farmers are almost self sufficient in fodder production for their livestock. As outlined in 3.1.3. supplementary fodder is bought if needed.

Fuelwood production in homegardens is estimated to be between 1–2 m^3 yr^{-1} (1.5–3 m^3 ha^{-1} yr^{-1}). If we assume a minimum consumption of 1 m^3 per adult per year, then each family requires between 4–6 m^3 yr^{-1}. Thus a homegarden supplies $\frac{1}{4}$ to $\frac{1}{3}$ of the fuelwood requirements. The rest is obtained from the forest reserve or from the kishamba where *Acacia* spp. and *Combretum* spp. are retained.

5. System dynamics

5.1 Growth of system

There is no more land (outside the forest reserve) on Mt. Kilimanjaro that is suitable for the Chagga homegardens. Thus expansion in terms of increased area occupied by the cropping system is no longer possible on Mt. Kilimanjaro. Instead, existing homegardens are reaching the limit of intensive use at the present level of management. They are also becoming increasingly fragmented due to sub-division. This land scarcity has led to the migration of some Chagga to Mt. Meru (70 km southwest of Mt. Kilimanjaro), an area that

has ecological conditions similar to those on Mt. Kilimanjaro. Local sources indicate that there has been some inter-marriage between the Chagga and Meru (the indigenous tribe on Mt. Meru) and this has probably been an important factor in enabling the Meru (who were formerly pastoralists), to successfully adopt the complex Chagga homegarden system within a period of about 50 years.

5.2 Sustainability

Although the Chagga cropping system has been stable over at least a century, it is only recently that the system as a whole has come under pressure due to rapid population growth, diminishing land resources and change in dietary habits (maize replacing bananas as the staple food). Migration of youngsters to urban areas leads not only to labour shortages, but also disrupts the traditional transmission, from one generation to the next, of the knowledge and experience required for the successful management and perpetuation of the complex multicropping system. In recent years, coffee prices declined markedly on international markets and this combined with the labour intensive nature of the crop, resulted in some Chagga farmers threatening to remove the coffee bushes from their homegardens. Despite these pressures, however, the system still appears to be working well with the majority of farmers. Nevertheless, if the system is to remain sustainable, then its productivity will have to be increased to cater for the rapidly increasing population.

6. Evaluation

6.1 Merits

(1) The continuous ground cover and high degree of nutrient cycling are the major factors that permit the Chagga homegardens to remain sustainable on the erosion-prone slopes of Mt. Kilimanjaro.

(2) Coffee produced by the Chagga contributes significantly towards Tanzania's foreign exchange earnings. Over 52% of Tanzania's export coffee comes from Kilimanjaro and in 1982 this represented an earning of US$ 65 million.

(3) The various crop species and varieties in the homegarden represent years of natural selection for survival and farmer selection for better production and quality. These species have a good resistance to prevalent pests, compete well with weeds and have a generally high level of genetic variability. The Chagga homegardens thus represent a valuable gene pool for use in any breeding programmes to improve crop varieties for multistorey cropping systems.

In addition, the advantages attributed to intimate multispecies, multistorey associations are many. They include soil conservation, nutrient cycling and nutrient efficiency, microclimate enhancement (4) and other benefits such as labour efficiency, risk minimisation and continuous production.

6.2 Weaknesses/Constraints

(1) Although the Chagga homegardens are a stable landuse system, their productivity is relatively low. In order to meet the demand for food of a rapidly growing population, the productivity of the homegardens must be increased. The problem lies in the need to increase productivity while retaining the stability of the present system.

(2) With the present trend of young people migrating to urban areas, it is mostly the older people left to manage the homegardens. Extension workers may thus find it more difficult to introduce innovations.

(3) Present extension workers focus on individual crops/components. The absence of an integrated approach and subsequent lack of awareness of the possible interactions of the various components and their repurcussions can result in problems for the farmer and loss of faith in the extension service.

6.3 Potential

On Mt. Kilimanjaro, the homegarden's potential as a productive and sustainable system can be enhanced by

(1) Replacing the less productive trees/shrubs with fast growing nitrogen fixing species e.g. *Leucaena leucocephala, Calliandra calothyrsus, Gliricidia sepium* and *Lespedeza bicolor*. These would provide increased fuel, fodder and green manure on the homegarden and would reduce the time spent in travelling long distances to gather supplementary fuel and fodder.

(2) Improving animal husbandary so as to achieve, for example, a lactation period of around 300 days per year.

(3) Improved apiculture e.g. the use of top bar hives, better bee strains, improved harvesting and honey extraction methods.

(4) Introducing new crop varieties using the gene pool developed by natural and farmer selection not only in Tanzania, but also from homegardens in other parts of the world.

(5) Using fertilizers. Credit facilities could be provided by the Tanzania Rural Development Bank. Purchasing, storage and distribution of the fertiliser could be carried out by the Tanzania Farmers' Association or the Kilimanjaro Uremi Cooperation.

6.4 Extrapolability

Despite the need for intimate knowledge of the components and a high level of management capability, the Chagga homegardens can be extrapolated to upland areas (e.g. Kenyan highlands, S.W. Ethiopia, S.W. Rwanda) where ecological conditions are similar and farmers practise less intensive multistorey cropping. Preferences for local species/varieties can be catered for by appropriate substitution or introduction. A demand for maize cultivation in such homegardens could be accomodated by growing the maize between rows of trees. Shade effects could be minimised by an east-west orientation of

the rows. Ground cover can be maintained by intercropping the maize with beans or cow peas.

6.4 Research needs

Information is required on the following possibilities that could be used to improve the overall productivity of the homegardens.

(1) Optimal spatial and temporal arrangements of the various components.

(2) Optimal crop associations. This includes component crops/varieties differing in morphology, maturity period, shade tolerance, rooting depth and photoperiod sensitivity.

(3) Since chemical pest control is no real alternative in small holder cropping systems, information is required on crop/species combinations with a greater potential to reduce pests, diseases and weeds. The effectiveness of the plant species with anti-pest properties that are already used by the Chagga could be investigated as a first step.

(4) Better soil management techniques e.g. green manure, mulches and the most appropriate time of application.

(5) Appropriate fertiliser prescriptions for the intimate multispecies associations present in the Chagga homegardens.

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References

1. von Clemm M (1963) Agricultural productivity and sentiment on Kilimanjaro. Econ Bot 18:99–121
2. Mitchell HW (1963) Results on a coffee and banana interplanting trial in Bukoba. In: Tanganyika Coffee Board Research Report, 1963
3. M'lambiti (1982) Agricultural sector analysis for Kilimanjaro region: a basis for decision making and planning. Unpublished PhD thesis, Univ of Dar es Salaam
4. Nair PKR (1984) Soil Productivity Aspects of Agroforestry. Science and Practice of Agroforestry 1. ICRAF, Nairobi
5. O'ktingati A, Maghembe J, Fernandes ECM, Weaver GH (1984) An inventory of plant species in the Kilimanjaro agroforestry system. Agroforestry Systems (in press)
6. O'ktingati A, Mongi H (1983) Agroforestry and the small farmer. A case study of Kilema and Kirua Vunjo in Kilimanjaro (unpublished)
7. Openshaw K, Morris J (1979) The socio-economics of agroforestry. In: Chandler T, Spurgeon D (eds) International Co-operation in Agroforestry. Proceedings of an international conference, pp 327–351, ICRAF, Nairobi
8. Robinson JBD (1961) The influence of interplanted bananas on Arabica coffee yields. In: Annual Research Report, 1961, Coffee Research Station, Lyamungu

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Plant species in the Kilimanjaro agroforestry system

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Abstract. An inventory of plant species was conducted on farms, farm boundaries and homesteads in the Kilimanjaro agroforestry system. The survey covered 30 farms in 6 villages in Hai District on the slopes of Mount Kilimanjaro, Tanzania. Over 100 plant species spread over 40 families were identified and their uses obtained through interviews with farmers. The species identified include 53 tree species, 29 food crop species, 21 non-woody plants of economic value and 8 weed species. The food crops, trees and other economically useful plants are carefully chosen by the local farmers and intimately intercropped on the same unit of land. In most cases, the plants had two or more uses of which food, fuelwood, medicine, poles, timber and fodder were the most important.

1. Introduction

In most of the tropics, selected tree species always form a component of the multiple cropping systems in farms and in rangelands. These multi-cropping systems (agroforestry systems) have been the subject of recent discussion among agronomists, foresters and animal husbandry specialists [3, 5, 9, 11], and a few such agroforestry systems have been described in detail [8, 16].

A recent study on the Chagga homegardens in northern Tanzania brought out the salient operational aspects and functional characteristics of that traditional agroforestry system [4]. As a follow-up, an inventory of plant species was undertaken in 30 farms and their surrrounding in the Chagga area on the slopes of Mount Kilimanjaro, and this paper summarizes its results.

2. The study area

Mount Kilimanjaro is in Tanzania at 2.9–3.3° S latitude and 37–37.5° E longitude. Its peaks is the highest mountain in Africa, rising to 5895 m.a.s.l. The study was conducted on the southern slope of the mountain in Hai Mashariki Division. The area surveyed rises from 800 to 2500 m.a.s.l.

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The slopes of Mount Kilimanjaro have a mild climate with mean annual temperatures of 22 °C at 800 to 1000 m.a.s.l. and 18 °C at 2000 m.a.s.l. The annual total rainfall ranges from 800 mm at lower altitudes to over 2000 mm at 2500 m.a.s.l. The rainfall is bi-modal falling between October and June with a dry spell in January and February. Soil types in the area have already been listed [4]. The population density on the slopes of Mount Kilimanjaro is 190 people/km^2 with an annual growth rate of 3.7% [15]. Land is highly fragmented giving an average family farm size of 0.6 ha. This has led to a highly intensive mixed farming system with multiple cropping as its mainstay [10].

3. Method of study

An inventory of plant species was conducted on farms, farm boundaries and around homesteads in 30 subjectively selected farms. Five farms were selected from each of the following villages, Mwasi Kusini, Mwasi Kaskazini, Kushimundu, Mruwia, Kyaseni and Materuni in the study area, as shown in Figure 1.

Plant species were identified by us. Herbarium samples are kept at the National Forestry Herbarium, Tanzania Forestry Research Institute, Lushoto. Data on the local names and uses of the plant species were obtained through interviews with farmers.

4. Results and discussion

Plant species identified and their economic importance are presented in Table 1. A total of 111 plants species spread over 42 families were identified. They include 53 tree species, 29 food crop species, 21 economically useful non-woody plant species and 8 weed species. Except for the weeds, the other plant species are carefully interplanted on the same unit of land to form a very dense multistorey ecosystem as described in the system description [4]. Most of the plant species are maintained in the farm for two or more uses. For the trees, the main uses were fuelwood (90% of the tree species), medicines for humans and livestock (30% of the tree species), poles (25% of the tree species), shade (24% of the tree species), timber production (23% of all the tree species), fodder production (10% of all the tree species), other uses (19% of all tree species). Nearly all the non-woody plant species and climbers are grown for fodder or medicinal purposes.

The use of nearly all the trees to provide fuelwood is a reflection of the importance of this resource for the day-to-day life of rural communities in the tropics [2].

Nearly 30 food crop species are used in the multicropping system on the same unit of land. In one of the surveyed farms (2 ha in size), more than 15 food crop species were planted. This phenomenon is very different from the

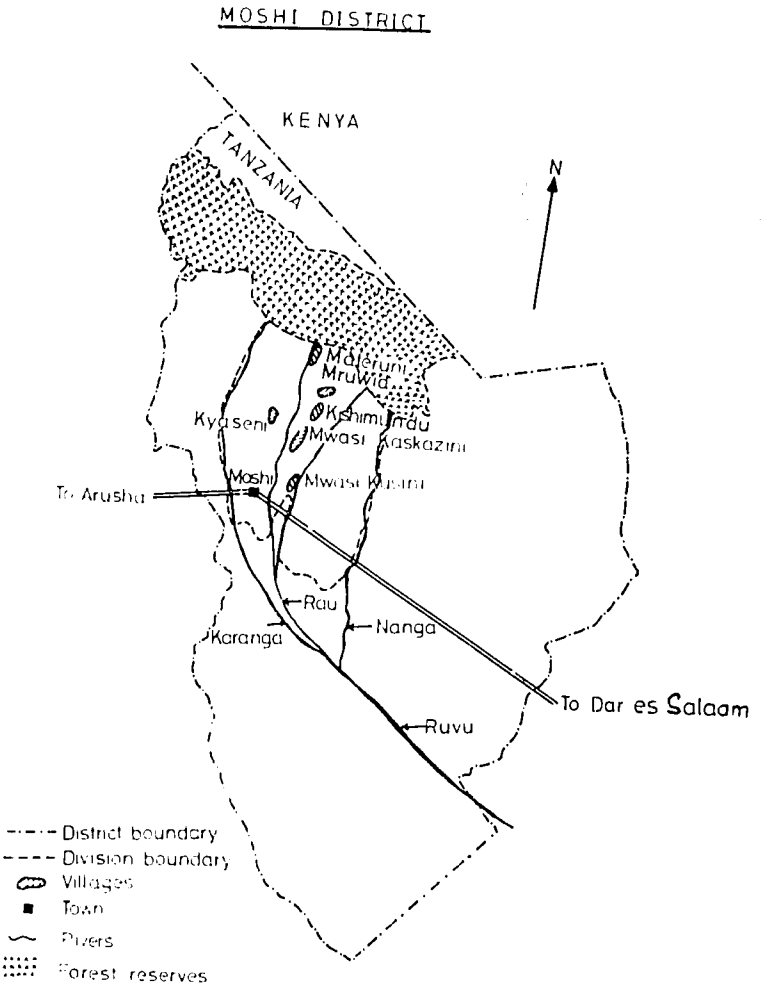

Figure 1. Location of villages sampled for this study.

conventional two-crop intercropping that is often reported in the literature (for example, 1, 7, 12, 14), and provides the farmer with the insurance for basic necessities that is so crucial under poor economics and the vagaries of climate.

This inventory brings out for the first time the totality of plant species used in the multicropping as practised at the farm level in the region. Most of these species are under-exploited and their role and importance in the rural communities little understood by outsiders. Undoubtedly, one of the opportunities in agroforestry lies in exploiting the vast potential of such species, large numbers and forms of which can be found to exist in the various localized agroforestry systems around the world [6, 13].

Table 1. Plant species in the Kilimanjaro agroforestry system, Northern Tanzania

Family name	Botanical name	Common nane	Vernacular name	Uses	Remarks
Alangiaceae	*Alangium chinense*		Mringonu	Fuelwood, fodder and shade	fast-growing tree to 25 m
Amaranthaceae	*Achyranthes aspera*		Kisoka	Fodder, medicinal	shade tolerant shrub
	Amaranthus dubius		Shaana	Vegetable	
Anacardiaceae	*Anacardium occidentale*	cashew	Mkorosho	edible fruit and seed, fuelwood	tree to 12 m
	Mangifera indica	mango	Mwembe	edible fruit, fuelwood	tree to 20 m
	Sorindeia madagascariensis		Mngwera	shade, fuelwood & edible fruits	tree 10–15 m
Annonaceae	*Annona muricata*		Mstafeli	edible fruits, fuelwood	tree 5–8 m
	Uvaria sp.		Mrisirisi	timber and fuelwood	woody climbers, shrub or small tree
Apocynaceae	*Rauwolfia caffra*		Msesewe	timber, fuelwood, catalyst for brewing, medicinal	tree 12–20 m
	Tabernaemontana usambarensis		Mracha	fuelwood, medicinal	
Araceae	*Colocasia esculenta*	taro	Maduma	edible roots	
Araliaceae	*Cussonia holstii*		Mnengere	fodder	tree to 8 m high
Balsaminaceae	*Impatiens kilimanjari*		Sunguala	weed, ornamental	
Bignoniaceae	*Jacaranda acutifolia*		not available	shade, fuelwood, ornamental	tree to 12 m
	Kigelia africana	sausage tree	Imomo	fuelwood, years and sponges from fruits	tree to 6–15 m
	Markhamia Platycalyx		Mtarawanda	timber, fuelwood, poles	tree to 22 m
Boraginaceae	*Cordia abyssinica*		Mringaringa	timber, shade, fuelwood, fodder	tree to 20 m
	Ehretia cymosa		Mnemvu	poles, medicinal	
Bromeliaceae	*Ananas comosus*	pineapple	Mnanasi	edible fruits	
Burseraceae	*Commiphora zimmermannii*		Mfifina	fodder	tree 10–20 m
Caricaceae	*Carica papaya*	pawpaw	Mpaipai	edible fruits	
Commelinaceae	*Commelina latifolia*		Torontoro	fodder	rambling herb

Compositae	*Ageratum conyzoides*		Mafuna	fodder	shrubs
	Conyza sumatrensis		Inanzie	weed	
	Galinsoga parviflora		Shimakamaka	vegetable	
	Helichrysum spp.		–	weed	herbs/shrubs
	Senecio spp.		Ifuifui	medicinal	
	Vernonia subuligera		Iduhuduhu	medicinal, weed	shrub or small tree to 6 m
Convolvulaceae	*Ipomoea batatas*	sweet potato	Shisowia	edible roots, vegetable	
Cruciferae	*Brassica oleracea*	cabbage	Kabichi	vegetable	
Cucurbitaceae	*Telfairia pedata*		Makungu	fat from seed	climber with stems to 30 m long
Dioscoreaceae	*Dioscorea alata*	yam	Ngao, Shia	edible tubers	
	D. bulbifera	yam	Nduu	edible tubers	
Ebenaceae	*Diosy pros mespiliformis*		Msindesinde	timber, fuelwood	tree to 20 m
	Euclea divinorum		Mkinyanyi	fuelwood, red dye from bark	shrub or small tree
Erinaceae	*Agauria salicifolia*		Not available	fuelwood	tree 12–15 m
Euphorbiaceae	*Bridelia micrantha*		Mmarie	fuelwood, poles, withies, fodder	tree to 15 m
	Croton macrostachyus		Mfurufuru	shade, fuelwood & goat fodder	tree to 15 m
	Jatropha curcas		Mchimbakaburu	boundary and grave marking	tree to 6 m
	Manihot esculenta	cassava	Muhogo	edible root, vegetable	shrub to 4.5 m
	Maragaritaria discoidea		Mshamana	fuelwood, poles, fodder	
	Ricinus communis	castor oil tree	Mbarika	purgative oil, medicinal	short lived shrub to 6 m
	Synadenium volkensii		Mracha	for making graves and boundaries, poisonous sap	tree with fresh branches
	Tragia brevipes	stinging nettle	Kimangima Shiwawo Kilachia		

Table 1. (continued)

Family name	Botanical name	Common name	Vernacular name	Uses	Remarks
Gramineae	*Eleusine coracana*	finger millet	Mbege	grains are used in the preparation of local brew (mbege) and making porridge	
	E. indica.				
	E. africana	fowl-foot grass	Kikwale	pasture grass	
	Panicum monticola		Mlaa	pasture grass	
	Saccharum officinarum	sugar cane	Miwa, Mauwa	edible stem	
	Tripsacum laxum	Guatemala grass		fodder	
	Vetiveria zizanioides	vetiver	Khuskhus grass (manzao)	thatching, anti-erosion	
	Zea mays	maize	mahindi, meemba	staple food	
Labiatae	*Geniosporum rotundifolium*		Isuwambewa	weed	
	Hoslundia opposita		Tarambe	hedges, fodder	
	Iboza riparia		Mombo, Ombo	medicines for stomach ache & fever	
	Ocimum suave		Ikachi	medicine for stomach ache	
Lauraceae	*Persea americana*	avocado	Mparachichi	edible fruits, shade, fuelwood	
Leguminosae (Caesalpinioideae)	*Caesalpinia decapetala*	mauritius thorn	King'utuo	boundary marking, hedges	thorny shrub
	Cassia didymobotrya		Iwinu	purgative, antihelminthic leaves	shrub to 6 m
	C. floribunda		Ototo	weed	
Leguminosae (Mimosoideae)	*Albizia Schimperiana*		Mruka	fuelwood, shade	tree 20–30 m
	A. petersiana		Muula	poles, fuelwood, shade	tree to 12 m
	Newtonia buchan[illegible]		Mkufi	timb[illegible]shade, fuelwood	

Leguminosae (Papilionoideae)	*Calpurnia aurea*		Mletangawo	poles, fuelwood, antihelminthic, insecticide	
	Erythrina abyssinica		Mriri	shade, fuelwood	
	Phaseolus vulgaris	beans	Maharagwe	food	
	Pisum sativum	peas	Njegere	vegetable	
	Tephrosia aequilata		Urutupa	fuelwood, poisonus seed	
	Vigna unguiculata	cowpea	Kunde, Soko	food	
Liliaceae (Alloideae)	*Allium cepa*	onion	Vitunguu	spice	
Liliaceae (Asphodeloideae)	*Aloe volkensii*		Sale la njofu, Iratune	grave marking, sap medicine for wounds	
Liliaceae (Dracaenoideae)	*Dracaena afromontana*		Masale	fence, boundary marking and grave marks	
Malvaceae	*Sida acuta*		Mlenda	fodder	
Meliaceae	*Trichilia emetica*		Mbomu	timber, fuelwood, poles, shade	
	Turraea robusta		Mokyanyama	fuelwood	
Melianthaceae	*Bersama abyssinica*		Mchakuru	timber, shade and fuelwood	
Menispermaceae	*Stephania abyssinica*		not available	weed, climber	
Moraceae	*Artocarpus heterophyllus*	Jack fruit	Mfenesi	edible fruits, fuelwood	tree 10 -20 m
	Chlorophora excelsa			timber	tree to 35 m+
	Ficus exasperata	fig	Msasa	shade, fuelwood	tree to 20 m
	F. natalensis		Mfumu	shade, ritual tree	tree 18–20 m
	F. vallis-choudae		Mkuu	shade, fuelwood	tree 18–20 m
	Morus alba	mulberry	Ipala, Wero, Iwero	boundary marking, hedges, edible fruits	tree to 15 m
Musaceae	*Musa nana*	banana/	Kiguruwe	edible fruits, fodder	
	M. paradisiaca	Plantain	Mshare	fodder	

Table 1. (continued)

Family name	Botanical name	Common name	Vernacular name	Uses	Remarks
Myrtaceae	*Eucalyptus camaldulensis*		Mkaratusi	fuelwood, poles, crushed leaves relieve colds	
	E. citriodora		Mkaratusi	fuelwood, poles, crushed leaves relieve colds	
	E. grandis		Mkaratusi	fuelwood, poles, crushed leaves relieve colds	
	E. robusta		Mkaratusi	fuelwood, poles, crushed leaves relieve colds	
	E. saligna		Mkaratusi	fuelwood, poles, crushed leaves relieve colds	
	Myrica salicifolia		Mkaratusi	fuelwood, medicinal	
	Psidium guajava	guava	Mpera	edible fuits, fuelwood	tree to 8 m
Oleaceae	*Olea capensis*		Mwisi, Mmasi Loliondo, Mchio	fuelwood, edible fruits timber, fuelwood, poles, withies	tree to 25 tree 20–30 m
Passifloraceae	*Passiflora edulis*	Jack fruit	Isapiku	edible fruits	climber
Proteaceae	*Grevillea robusta*	Australian silky oak	Mkawilia	timber, shade, fuelwood	tree to 30 m
Rosaceae	*Eriobotrya japonica*	loquat	Sambia?	edible	
	Rubus steudneri		Mstafeli	edible fruits, fuelwood	tree to 7.5 m
Rubiaceae	*Coffea arabica*	coffee	Mawero Mkahawa	hedge, edible fruits coffee, fuelwood	shrubs
	Pentas lanceolata		not available	weed, ornamental	
	Vangueria madagascariensis		Ndawiro, Ndoro	fuelwood, edible fruits	tree to 10 m
Rutaceae	*Citrus limon*	lemon	Mlimau, Ndimu	edible fruits, fuelwood	
	C. sinensis	sweet orange	Mchungwa, Ichungwa	edible fruits, fuelwood	

Solanaceae	*Capsicum annum*	red pepper	Mpilipili	spices	
	C. frutescens	bird chillies	Ngogwe	edible fruits	
	Datura arborea		not available	boundary marking	tree to 7 m
	Lycopersicon esculentum	tomato	Mnyanya	edible fruits	
	Nicotiana tabacum	tobacco	Mbatu	snuff and tobacco	
	Solanum incanum		Ndu	medicine for stomach ache and anti-snake bites	shrub 1–2 m
	S. nigrum		Nafu	vegetable	
Ulmaceae	*Trema orientalis*		Mrisio	fodder, fuelwood	fast-growing tree to 15 m
Verbenaceae	*Lantana camara*		Singarere	hedge, grave marking, weed	shrub 1–2.5 m

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References

1. Andrews DJ (1974) Response of sorghum varieties to intercropping. Expl Agric 10:57–63
2. Arnold JEM and Jongma J (1978) Fuelwood and charcoal in developing countries. Unasylva 29:2–9
3. Chandler T and Spurgeon D (eds) (1979) International Cooperation in Agroforestry. Nairobi. 469 p
4. Fernandes ECM, O'Kting'ati and Maghembe JA (1984) The Chagga homegardens: A multistoried agroforestry cropping system on Mt. Kilimanjaro, Northern Tanzania. Agroforestry Systems (in press)
5. Hoekstra D and Kuguru FM (eds) (1983) Agroforestry Systems for Small-Scale Farmers: Proceedings of a Workshop. ICRAF/BAT Nairobi. 283 p
6. ICRAF (1983) A global inventory of agroforestry systems: a project announcement. Agroforestry Systems 1:269–273
7. Keswani CL and Ndunguru BJ (1982) Intercropping. Proceedings of the second symposium on intercropping in semi-arid areas. IDRC – 186e. Ottawa. 168 p
8. Mann HS and Saxena SK (1980) Khejri (Prosopis cineraria) in the Indian Desert. Central Arid Zone Research Institute, Jodhpur. 77 p
9. McDonald LH (ed) (1982) Agroforestry in the African Humid Tropics. United Nations University, Tokyo. 163 p
10. Mlambiti EM, Eldelsten P and Colyer D (1982) Economic analysis of the traditional farming systems of the Kilimanjaro Region, Tanzania. IAF Publication. West Virginia Agricultural and Forestry Experiment Station, Morgantown, West Virginia. 57 p
11. Mongi HO and Huxley PA (eds) (1979) Soils Research in Agroforestry: Proceedings of an Expert Consultation. ICRAF, Nairobi. 584 p
12. Monyo JH, Ker ADR and Campbell M (eds) (1976) Intercropping in Semi-Arid Areas. Proceedings of a Symposium. IDRC, Ottawa. 76 p
13. Nair PKR (1983) Tree integration on farmlands for sustained productivity of smallholdings. In: Lockeretz W (ed) Environmentally Sound Agriculture, pp. 333–350. Praeger Pub., New York.
14. Rao MR and Wiley RW (1980) Evaluation of yield stability in intercropping. Studies on sorghum/pigeon pea. Expl. Agric. 16:105–116
15. Tanzania Bureau of Statistics (1979) Population Census of 1978. TBS Dar es Salaam.
16. Wiersum KF 1982. Tree gardening and taungya on Java: Examples of agroforestry techniques in the humid tropics. Agroforestry Systems 1:53–70.