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MAKUENI DISTRICT PROFILE: TREE MANAGEMENT, 1989-1998

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Preface

Drylands Research Working Papers present, in preliminary form, research results of studies carried out in association with collaborating researchers and institutions.

This working paper is part of a study which aims to relate long-term environmental change, population growth and technological change, and to identify the policies and institutions which are conducive to sustainable development. The study builds upon an earlier project carried out by the Overseas Development Institute (ODI) in Machakos District, Kenya, whose preliminary results were published in a series of *ODI Working Papers* in 1990-91. This led to a book (Mary Tiffen, Michael Mortimore and Francis Gichuki, *More people, less erosion: environmental recovery in Kenya*, John Wiley, 1994), which was a synthesis and interpretation of the physical and social development path in Machakos. The book generated a set of hypotheses and policy recommendations which required testing in other African dryland environments. Using compatible methodologies, four linked studies are now being carried out in:

Kenya	Makueni District	
Senegal	Diourbel Region	
Niger	Maradi Department	(in association with ODI)
Nigeria	Kano Region	(in association with ODI)

For each of these study areas, there will be a series of working papers and a synthesis, which will be reviewed at country workshops. An overall synthesis will be discussed at an international workshop in London in 2000.

The Kenya series updates the previous study of Machakos District (which included the new Makueni District) and examines this more arid area in greater depth. The Research Leader for these studies is Michael Mortimore. The Leader of the Kenya Team is Francis Gichuki of the University of Nairobi. Michael Mortimore, Mary Tiffen or Francis Gichuki may be contacted at the following addresses.

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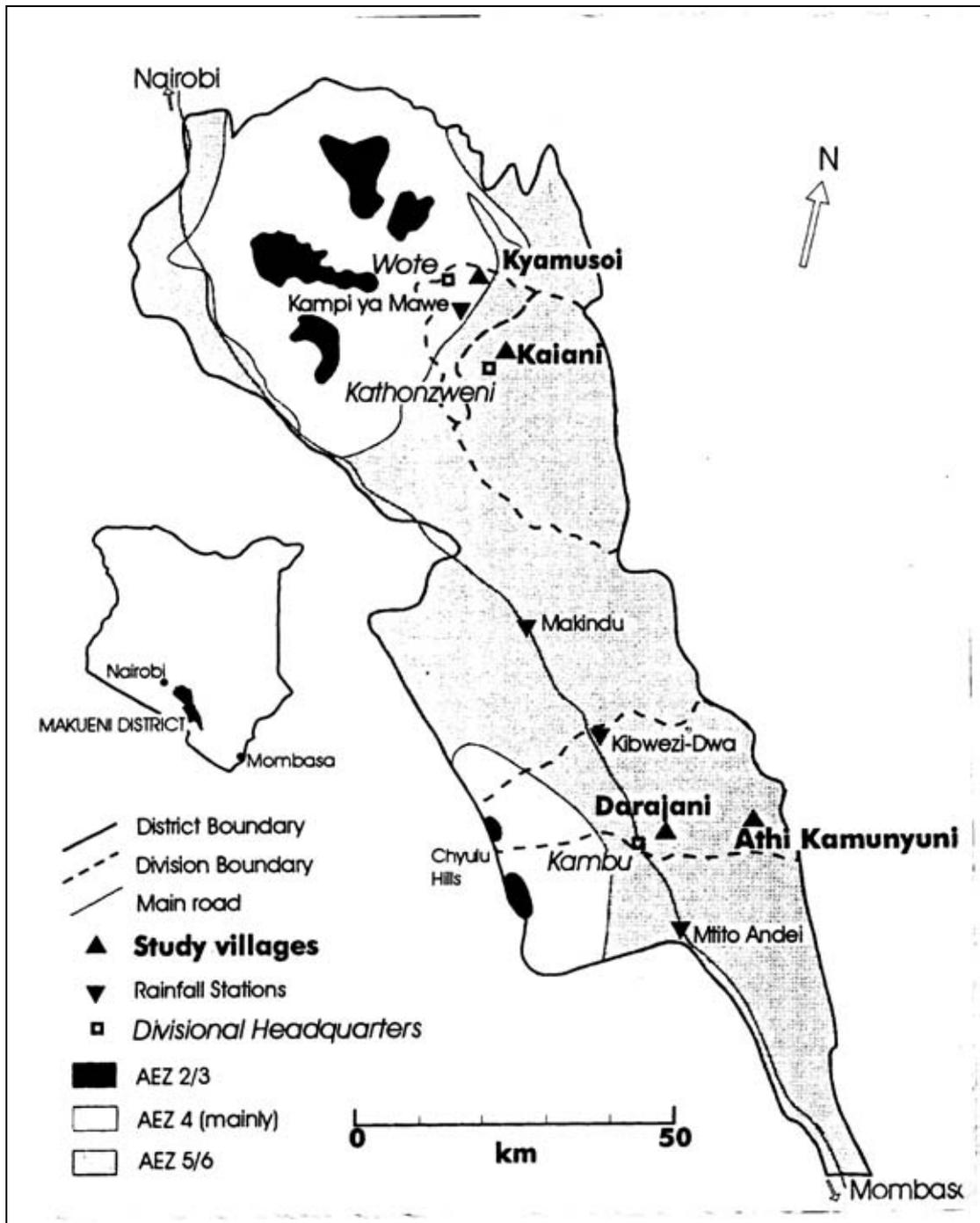
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Preface map



Abstract

This paper reviews the efforts made by households in Makueni District, Kenya to manage trees in crop and grazing lands over the past ten years, drawing on survey data from four villages in Wote and Kibwezi Divisions. It also reviews the impact of external initiatives in tree seedling production and promotion over the same period, and the government management of gazetted forests. The survey found that investments by farmers in tree management have taken place during the past five to 15 years, and that there has been a gradual and long-term shift from cutting down trees to conserving and planting them. Key constraints to tree production include low seedling survival due to drought (combined with irrigation water shortages), termites and livestock damage, households' poor access to markets for tree products and a lack of suitable drought tolerant varieties. The main policies that have influenced investments in tree management are reviewed. The paper highlights a recent policy change that is shifting some of the control of the forestry sector from the government to private and community organisations. This study shows that deforestation is going on alongside afforestation, and that farmers' investments in tree planting and management of trees on grazing lands are an indication that farmers value and invest in trees, even in low rainfall areas.

Résumé

L'objet de ce rapport est d'examiner les efforts effectués par les familles d'agriculteurs du district de Makueni au Kenya, au cours des dix dernières années, pour développer l'exploitation des arbres dans les terres de culture et de pâturages. Il se base sur les résultats d'une étude qui a été effectuée dans quatre villages des divisions de Wote et de Kibwezi. Ce rapport analyse également l'impact, durant la même période, des initiatives externes pour encourager et augmenter la production de plants de pépinière, ainsi que l'exploitation par les services du gouvernement des forêts du patrimoine.

D'après les résultats de cette étude, les agriculteurs plantent des arbres sur leurs terres de culture et de pâturages pour différentes raisons, notamment : pour se procurer de l'ombre, améliorer le microclimat, pour leurs vertus médicinales, pour accroître la fertilité du sol, pour s'approvisionner en bois, pour nourrir le bétail, et enfin pour stabiliser les sols sensibles à l'érosion. Les effets négatifs sont, entre autre: le fait que ces arbres s'approprient des éléments nutritifs, de la lumière et de l'eau au détriment des plantes cultivées, qu'ils favorisent la prolifération de parasites, et qu'ils constituent un obstacle lors de l'utilisation de certaines machines agricoles.

Cette étude révèle que les agriculteurs ont investi de l'argent pour l'exploitation des arbres au cours des cinq à quinze dernières années, et qu'ils ont suivi une évolution progressive et à long terme, passant d'une politique de déboisement vers une politique de conservation et de reboisement. Les contraintes majeures pesant sur la production sont: le faible taux de survie des plants de pépinière à cause de la sécheresse (et du manque d'irrigation), les ravages causés par les termites et le bétail, les difficultés que rencontrent les familles pour avoir accès aux marchés spécialisés dans les produits du bois, le fait qu'il n'y ait pas de variétés appropriées arrivant à supporter la sécheresse.

Aucune pénurie de bois de chauffage n'a été remarquée dans le district, que cela soit dans les fermes ou dans les marchés spécialisés dans les produits du bois. Cependant, après examen, il a été constaté que les mesures concernant la production du charbon de bois semblent être inadéquates, surtout si l'on considère l'impact de cette production sur les forêts du patrimoine. Celles-ci subissent actuellement une pression considérable car il y a une demande accrue de charbon de bois et de bois dur à sculpter.

Les mesures principales qui ont influencé les investissements au niveau de l'exploitation des arbres sont : celles concernant l'occupation des terres et le foncier, le développement des régions arides et semi-arides, les mesures concernant l'exploitation forestière et l'énergie. Ces dernières sont réévalués régulièrement, et le cadre légal et institutionnel dans lequel des ressources naturelles telles que les arbres et les forêts sont exploitées au Kenya est clairement défini. Ce rapport souligne un changement récent de politique de la part du gouvernement et qui consiste à céder une partie du contrôle qu'il exerce sur le secteur forestier à des organisations communautaires ou privées. La figure 1 illustre la réduction progressive depuis 1993 des effectifs du service du district chargé de l'entretien et l'exploitation des forêts.

La figure 2 établit l'emplacement des hautes futaies et des taillis dans les forêts du patrimoine du district. Les principaux problèmes qui existent au niveau de l'exploitation forestière sont: la protection des zones de captage d'eau et la préservation de la biodiversité, particulièrement dans la forêt de Kibwezi. Les interventions, notamment celles des ONG, se sont concentrées récemment sur l'agroforesterie et la foresterie au niveau des communautés. Les principaux projets d'agroforesterie entrepris dans cette région sont énumérés dans le tableau 2; des informations concernant la production des plants de pépinière sont données dans les figures 3 et 4.

Cette étude montre que la reforestation va de pair avec la déforestation. Lorsque les familles d'agriculteurs s'installent sur les terres, elles déboisent afin de dégager un espace pour la construction des bâtiments de la ferme, et pour établir des terres de cultures et d'élevage, pour s'approvisionner en matériaux de construction et pour générer des capitaux (en vendant du charbon de bois et du bois de chauffage) de manière à financer les frais d'installation. La déforestation qui a lieu est néanmoins très sélective; elle épargne les jeunes arbres ayant le plus de valeur commerciale pour une exploitation future, ainsi que quelques vieux arbres pour se procurer de l'ombre ou pour délimiter des territoires. Dans les régions où il y a une forte demande pour le charbon de bois, la déforestation continue parfois jusqu'à ce que tous les arbres disponibles aient été coupés. Mais en général, la déforestation qui a lieu lorsque les fermiers s'installent, est progressive et son objectif est uniquement de répondre aux besoins en bois des familles et de dégager des terres d'année en année pour accroître les surfaces cultivées et les pâturages. Pendant que ces activités ont lieu, un reboisement s'opère car les agriculteurs plantent des arbres fruitiers sur les terres cultivées ou dans les vergers, ainsi que des arbres pour marquer la limite des terrains et établissent des parcelles boisées dans certains endroits endommagés. Les agriculteurs qui plantent des arbres sont conscients de leurs effets négatifs. Le fait que les cultivateurs investissent au niveau de la plantation et de l'exploitation des arbres dans les terres de pâturage révèle qu'ils accordent une certaine valeur aux arbres et qu'ils n'hésitent pas à investir dans ce domaine, même dans les régions où les précipitations sont faibles, à condition que la loi foncière les y incite.

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About the author

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Acronyms

ASAL:	Arid and semi-arid lands
AEZ:	Agro-ecological zone
DFDP:	District Forestry Development Programme
GoK:	Government of Kenya
JICA:	Japan International Co-operation Agency
Ksh:	Kenya shilling (70 Ksh \cong 1 United States Dollar Apr 2000)
MAP:	Makueni Agricultural Programme
MENR:	Ministry of Environment and Natural Resources
MoE:	Ministry of Energy

INTRODUCTION

1.1 Background

Natural vegetation climaxes have disappeared in most semi-arid areas and remain only in a few isolated pockets. Most of what we see today is the result of man's intervention through burning, grazing, clearing for agriculture and tsetse fly control, and through planting trees. Farmers are investing in tree resources management not to avert a fuel wood deficit but to increase their incomes. Most household fuelwood needs are met through trimming, pollarding, lopping and coppicing of trees and shrubs in cropland, grazing land, along roadsides and river banks and in woodlots and government forests, though Emerton (1996) noted that tree products tend to be marginal in their contribution to farm income. Motivations for, and types of, tree planting vary from household to household depending on the biophysical characteristics of the area, gender, wealth and the perceived contributions to farm income, which are mainly through sales of fruits, timber, poles, fuelwood and charcoal.

Natural vegetation in the semi-arid areas of Makueni District varies from grassland to woodland. Over the years, the vegetation resources have been modified by biotic and fire factors to produce the distribution of vegetation types we see today. The composition of tree and shrub vegetation in the semi-arid areas as influenced by human and natural factors is documented by Hussain *et al.* (1982), Makin and Pratt (1984), Farah (1991) and Mortimore (1992). These studies show that there has not been indiscriminate felling of trees to clear the land for cultivation. Farmers have undertaken selective bush clearing, leaving trees that are of value. Appendix I presents some indigenous trees and their uses to the community.

1.2 Objectives

The overall objective of the tree management component of the study is to construct a profile of tree management for the semi-arid areas of Makueni District. It specifically addresses the issues of tree management in cropland, grazing land and gazetted forest. This is achieved by:

1. documenting farmers' investments in tree management; and
2. documenting external interventions that have complemented farmers' initiatives.

1.3 Methodology

The study was carried out in the semi-arid areas of Makueni District. The study focused on four study areas, namely: Kyamusoi village in the marginal cotton zone (LM 4), Kaiyani and Darajani villages in the sorghum/millet/livestock zone (LM 5) and Athi Kamunyuni village in the livestock zone (IL 6) (see Preface map). The characteristics of these study sites are summarised in Table 1.

For each study area a group interview consisting of 6-12 farmers was conducted to gather information required to document soil conservation initiatives in the study area. Twelve respondents for each village were selected at random from a list of all village

households for detailed interviews. Specific tree management issues were addressed through:

1. analysis of secondary data on tree management in semi-arid areas;
2. group and individual interviews to trace changes in tree management and dominant causal factors;
3. farm level observations, interviews and measurements to quantify investments in tree management; and
4. district level interviews with subject matter specialists.

Table 1: Characteristics of study sites

	Kyamusoi	Kaiani	Darajani	Athi
AEZ*	LM 4	LM 5	LM 5	IL 6
<i>Time of settlement</i>	<i>1950s</i>	<i>1960s</i>	<i>1960s</i>	<i>1970s</i>
Mode of settlement	Government supported settlement	Spontaneous settlement	Spontaneous settlement under govt guidance	Spontaneous settlement
Predominant land use	Cultivation cattle	Cultivation cattle	Cultivation beef cattle	Cultivation goats
Access to market	Good	Good	Good	Poor
Administrative division	Wote	Kathonzweni	Kibwezi	Kibwezi

*Lower midland (LM) zones extend over an elevation of 800 to 1300 m in Eastern Kenya and have an annual mean temperature of 21-24°C, with a minimum temperature greater than 14°C. LM4 is a marginal cotton zone with an annual average rainfall 40-50 percent of potential evaporation. The climatic conditions are fair to poor for cotton and maize, fair for pigeon peas and good for sisal. LM5 is a lower midland livestock-millet zone with an annual average rainfall 25-40 percent of potential evaporation. The climatic conditions are fair to poor for millet, cowpeas and sisal. The natural pasture can support low density grazing. IL6 is an inner lowland ranching zone not suitable for rainfed crops and with natural pasture that can support low to very low grazing density (Jaetzold and Schmidt, 1982).

2 FARMERS' INVESTMENT IN TREE MANAGEMENT

2.1 Trees in cropland

Farmers maintain scattered, naturally regenerating trees for:

- shade and micro-climatic improvement;
- improved water efficiency (in semi-arid areas only 30-40 percent of the rainfall is used by crops. Trees utilise water that percolates below the crop root zone and

- rainwater that falls during the non-cropping season. However proper tree management, i.e. the right tree, proper spacing, etc., is required to reap the benefits);
- medicinal value (the neem tree, for example, is believed capable of curing at least forty diseases);
 - soil fertility enhancement (soil fertility is enhanced under the tree by falling leaves and pods, and by animal droppings as they browse the tree or rest under the shade);
 - livestock feed; and
 - stabilisation of erodible soils.

However there are also negative effects, including:

- excessive shade (or competition with crops for light)
- competition for nutrients;
- competition for moisture;
- harbouring of pests (insects, birds)¹; and
- obstruction of mechanised family operations.

Tree management activities include clearing the land, planting tree seedlings, watering the seedlings for at least three months, protecting the young tree from livestock that may browse it and fertility enhancement, pest and disease control in the case of fruit trees.

Trees planted in cropland are mainly fruit trees, live fences, mulberry and neem trees. The main fruit trees grown in the area are mangoes and pawpaws, mainly due to their drought tolerance. Banana, citrus fruit, orange and guava trees are grown in areas with improved soil water regimes, either through runoff concentration, or in large planting pits. Approximately 40 percent of the respondents have established some euphorbia tree fences. Most of them are in Kyamusoi, Kaiani and Darajani. Twenty percent of the respondents living near Darajani railway station have planted mulberry trees as part of a women's group project aimed at increasing their income by producing and selling silk. The project did not take off, mainly owing to the poor performance of the mulberry trees during establishment years. A farmer in Kyamusoi planted 10 neem trees in 1980. Tree planting patterns range from scattered trees to well-maintained orchards.

All the farmers have planted fruit trees and the number per holding ranges from trees in the small farms in Darajani, to over 200 trees in the more commercially oriented Kaiani area. The main problem expressed by the respondents is the low seedling survival rate. This is due to water stress, termite damage or browsing by livestock. The most remarkable experiences in fruit tree production encountered in the survey are summarised in Appendix II.

The general observations are:

- Fruit tree establishment is constrained by water scarcity, and acceptable survival rates are only achieved where supplementary irrigation or water harvesting are practised.

¹ Mortimore (1992) reported that when land is cleared for cultivation dominant acacias (except *A. tortilis*) are removed and volunteer seedlings controlled because they are thorny and harbour crop pests. *Terminalia brownii* are generally preserved.

- Most of the farmers produce fruits for home consumption and few have surplus production which they sell.
- Fruit tree varieties planted in these area are the same as those planted in wetter areas, and hence there is a need for breeding more drought tolerant species.
- The farmers have acquired tree-grafting techniques to improve the performance of fruit trees.
- Investments in tree management have taken place over the last five to fifteen years. Investment in fruit trees is a form of intensification and comes after the farmers have settled.
- There is a gradual and long-term shift from cutting down trees to conserving and planting them, as was observed in the wetter parts of Machakos District (Tiffen *et al.*, 1994).
- There is a significant swing in the profitability of tree produce (fruit especially), which includes its value for domestic consumption, and which offsets the risk and the costs.

2.2 Trees in grazing land

Trees in grazing land are mainly used as a source of firewood, construction timber, shade, browse and human and livestock medicine. Emerton (1999) reported that in Kibwezi Division, over 68 percent of the households use trees in natural woodlands for fodder, fuel and construction, 24 percent use the trees for brick making, 18 percent for bee-keeping and less than four percent use them for medicine and cash. The common human ailments cured by traditional medicine obtained from medicinal trees are worm infestation, stomach ache, diarrhoea, coughing, small pox and malaria.² Most respondents reported that they had at least two trees of medicinal value on their grazing land. Euphorbia is the tree most commonly planted to reinforce the farm boundaries and for partitioning grazing land.

The trees on grazing land are managed by selectively cutting them, leaving those trees with a high value such as *Acacia* species (for browse) and *Terminalia brownii* (for termite-resistant hardwood for construction of houses, ox-yokes, and handles for farm tools). Bush clearing is gradual, and is dictated by the need for additional cropland or improved grazing land. The gradual approach is adopted in an effort to conserve the trees for future supplies of wood products. This is particularly so on farms in remote areas, and where there are no suitable trees (by size and species) for charcoal production. The most suitable tree for charcoal making are *Acacia mellifera*, *Acacia tortilis*, *Acacia etbaica* and *Terminalia brownii*.

There are no signs of a wood fuel crisis under current levels of wood product utilisation either on farms or in available markets for wood products. The main sources of firewood are trimming, pollarding and lopping of trees in cropland and grazing land, and, for over 80 percent of the respondents who have large farms, collecting dead branches. In Darajani, approximately 30 percent of the respondents have very small farms with no trees for fuelwood (Gichuki, 2000). These farmers get their fuelwood

² Inhabitants of Kathulumbi Location reported that traditional herbs are used to treat diseases (neem tree treats coughs and malaria; sodom's apple treats diarrhoea; and the *muuku* tree treats coughs and yellow fever (MAP, 1998).

from trimming, pollarding and lopping of trees growing on road and railway line reserve areas and from collecting dead branches from their neighbours who offer access rights to their woodlands.

3 EXTERNAL INTERVENTION

3.1 Policies influencing tree management

The main policies that have influenced investments in tree management are settlement (Gichuki, 2000a), land tenure (Gichuki, 2000a), Arid and Semi-Arid Lands (ASAL) development (Gichuki, 2000b), energy, and forest policies. These policies have had a direct or indirect influence on tree management.

Forest policy: Forest policy in Kenya has evolved from the management of industrial forests to the inclusion of community and non-gazetted tree resources. The government has endeavoured to create an enabling environment for the sustainable use and management of tree resources. A new forestry policy was drafted by the Ministry of Environment and Natural Resources in 1994, but is still to be officially adopted. The stated objectives of this policy are to increase forest and tree cover and the availability of forest products, alleviate poverty by providing employment and income through forest and tree resources, and contribute to rural development by promoting equity and participation of local communities in forest and tree resources management (Kenya, MENR, 1994).

This focus is in direct contrast to the preceding policy. It puts less emphasis on government control of the forestry sector, and expands the scope for the involvement of other government, non-government, private and community organisations in forest management (Kenya, MENR, 1994 and Emerton, 1996). The changes in policy statements that have contributed to better tree management include a shift in focus from industrial plantation in gazetted forests to farm forestry, a shift from tree seedling production to the facilitation of communities to produce tree seedlings (in 1992), and tree protection legislation.

Energy policy: The main forms of energy used in Makueni District are woodfuels, petroleum fuels and electricity. The energy policy is outlined in the National Energy Policy and Investment Plan (MoE, 1992). The general objective of the energy policy is to achieve optimal use of energy by influencing consumption and supply patterns through supply and demand management strategies. Supply management strategies aim at influencing the availability of energy sources and fuel substitution. Demand management strategies include pricing and energy conservation. In Makueni, energy policy has therefore contributed to tree management initiatives through the promotion of forestry programmes to meet household woodfuel needs and by reducing demand through the promotion of energy-efficient cooking stoves.

3.2 Legal framework

Forest and tree resources are subject to the Forests Act of 1942 and the Forestry Policy of 1968. This legislation vested monopoly control of gazetted forest reserves in the

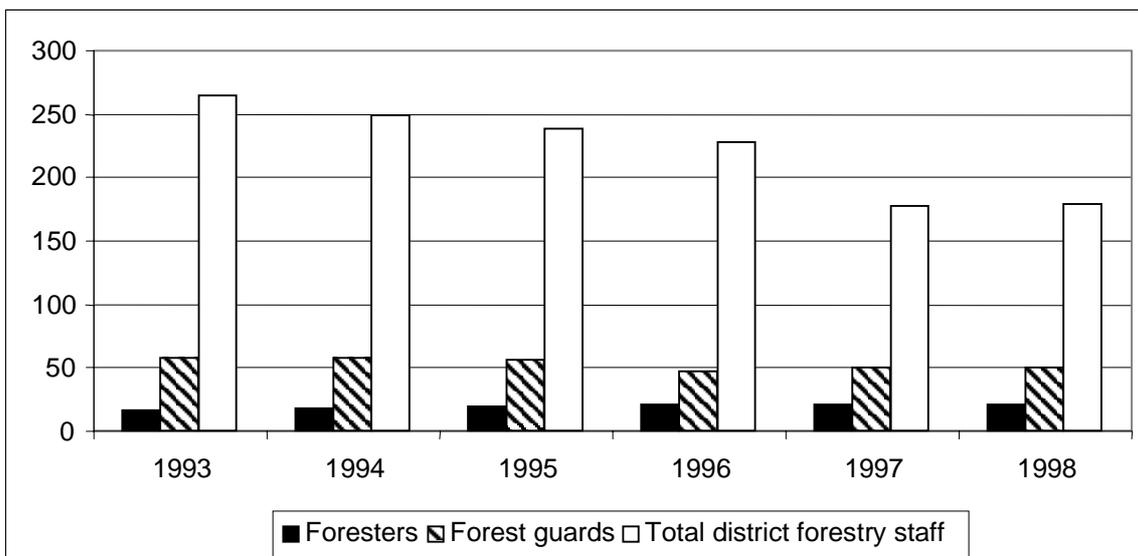
Forest Department. Emerton (1996) reported that rules originally made under the provisions of the Forests Act of 1942 permitted communities living adjacent to forest to use the reserves without license or fee, by virtue of customary practice. New rules have progressively narrowed these extractive activities over the last decades. Many forest uses were discontinued under a series of bans and directives starting in the mid-to late 1980s:

- A presidential directive of 1983 banned the felling of live indigenous trees on gazetted forest lands.
- Forest grazing was prohibited under a presidential ban made in 1986 and enacted through the Local Authority Act.
- All exports of unworked indigenous timber were stopped in 1988 under departmental instruction.
- A government announcement in 1995 stated that all sales of hardwoods would soon be declared illegal.

3.3 Institutional framework

The District Forest Office was set up in 1993, after the splitting of Machakos District into Machakos and Makueni Districts. Professional staff strength has not increased with the creation of new administrative divisions, while support staff strength has been decreasing partly due to the ‘Golden Handshake retirement plan’ (see Figure 1). Foresters are deployed at the district headquarters, in divisions and are in charge of gazetted forests. Forest guards are charged with the responsibility of protecting gazetted forests from illegal harvests. The number of forest guards has not changed much, due to the importance placed on the protection of the gazetted forest resources.

Figure 1: District Forest Office staff



Source: District Forest Office, 1999.

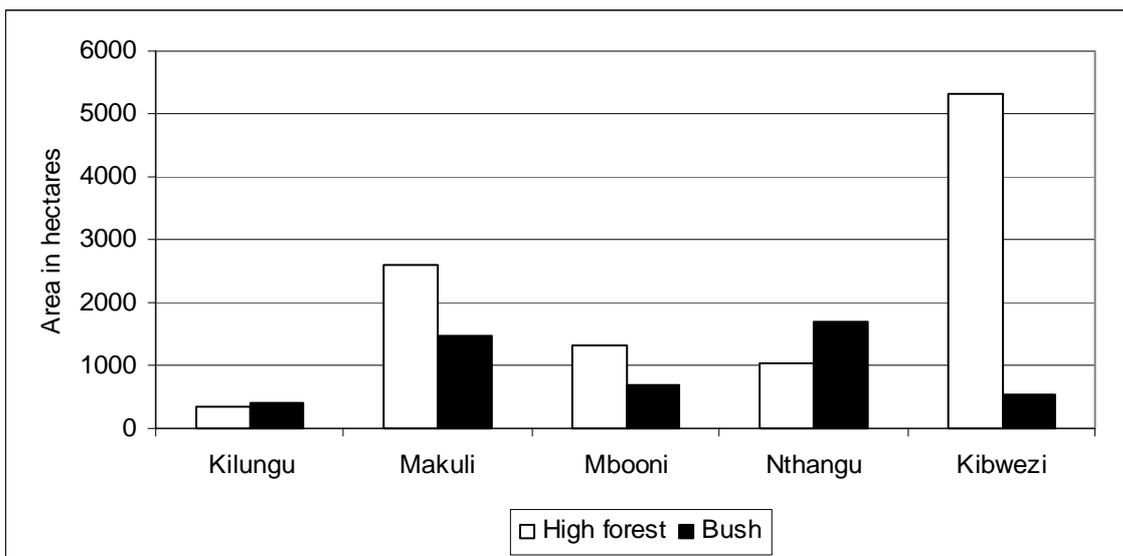
3.4 Programmes and projects

Management of gazetted forest

The forest areas requiring protection were gazetted in 1960. In Makueni the gazetted forest areas are on trust land and consist of small dispersed forests on the hill tops, ranging in area from 13.8 to 1,653 ha. Kibwezi forest is a contiguous forest on government land. There are five gazetted forest areas (Nthangu, Mbooni, Makuli, and Kilungu Kibwezi), all but the last in the hilly areas of north Makueni.³ The total gazetted forest area covers 15,340 ha, out of which 10,587 ha are in high forest and the remainder in bush (see Figure 2). These forests produce an estimated 2,650 m³ of timber and 18,916 running metres of fuelwood per year (Kenya, MLRRWD, 1997). Forestry earns the district an estimated Ksh 45,710 (US\$ 4,500) per year.

The main management issues are the protection of the catchment areas and of biodiversity, particularly in Kibwezi Forest. Local communities are allowed to extract fuelwood up to a maximum of 20 kg of wood per person per day and to collect grass for thatching. Grazing in the gazetted forests is illegal and takes place mainly during the dry seasons where there are no alternative grazing resources.

Figure 2: Area under (high) forest and bush in gazetted forests



Source: District Forest Office, 1998.

Gazetted forests are experiencing enormous pressure as the demand for charcoal and hardwood for carving increases. Carving is a local craft serving the tourist industry. Charcoal production, particularly along the Nairobi-Mombasa Highway, is perceived officially to be taking place in an unsustainable manner. A survey of charcoal sales along the Kiboko-Kambu stretch of Nairobi-Mombasa highway in 1998 showed that wood for charcoal production is coming from game reserves, forest reserves and private

³ The location of these reserves are shown in Mortimore (1992) Appendix map.

farms (see Appendix III). The District Forestry Development Programme (DFDP) is concerned with sustainable tree resources management.

Agroforestry promotion projects

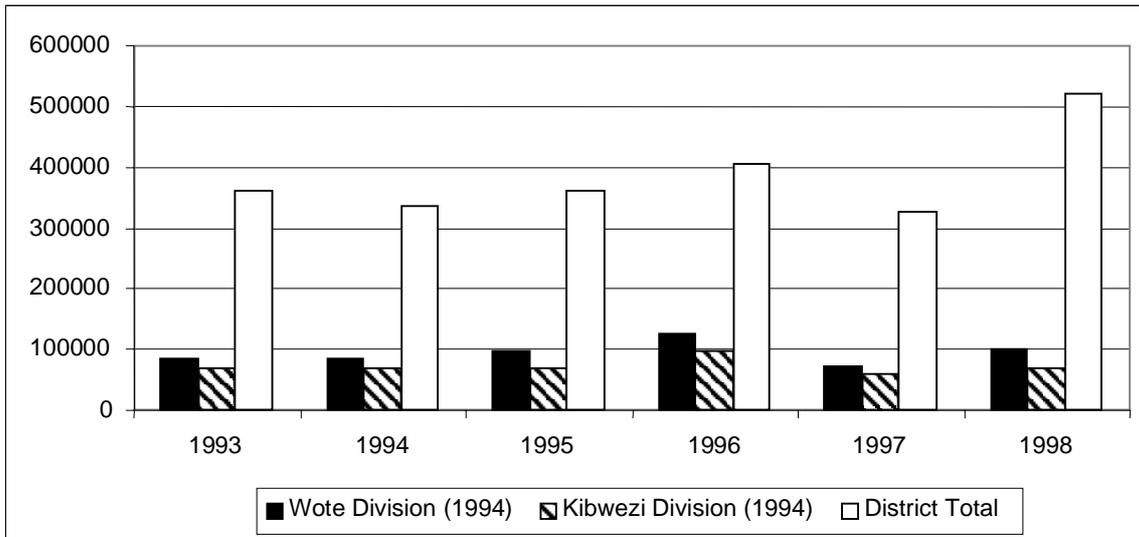
Community agroforestry activities aim to produce tree products from non-forest sources. By supporting on-farm wood and non-wood production, it is assumed that levels of forest use will decrease as these goods and services become cheaply and easily accessible outside the forest areas. The district forest office has implemented several projects aimed at promoting community forestry in the semi-arid area (see Table 2). The World Food Programme funded a project implemented by the Ministry of Environment Natural Resources (Forestry Department) in Makueni. Since the commencement of the project in 1994, the project has assisted over 34 self-help groups in tree establishment. The Makueni Agricultural Programme (MAP) has supported agroforestry since 1997, through setting up group nurseries, hill afforestation and farmer training. The DFDP has facilitated the establishment of 13 tree species in trial plots in agro-ecological zones (AEZ) 5 and 6. The main objectives of this programme are to prepare a district forestry master plan and promote incomes from farm forestry among the poor.

Table 2: Agroforestry activities in AEZ 5&6

Project	Period	Remarks
Government of Kenya	1972-	Community forestry activities in AEZ 5&6.
World Food Programme	1994-	Community forestry activities. Eight groups in Kibwezi and Wote Divisions assisted.
Japan International Co-operation Agency	1994-	Training farmers involved in community forestry activities.
Makueni Agricultural Programme	1997-	Assisted 20 self help groups involved in community forestry activities.
ARIDSAK	1998-	Undertaking on-farm agroforestry research in Kibwezi and Kathonzweni Divisions
District Forestry Development Programme	1998-	Set up 11 demonstration plots in community forestry in AEZs 5&6.

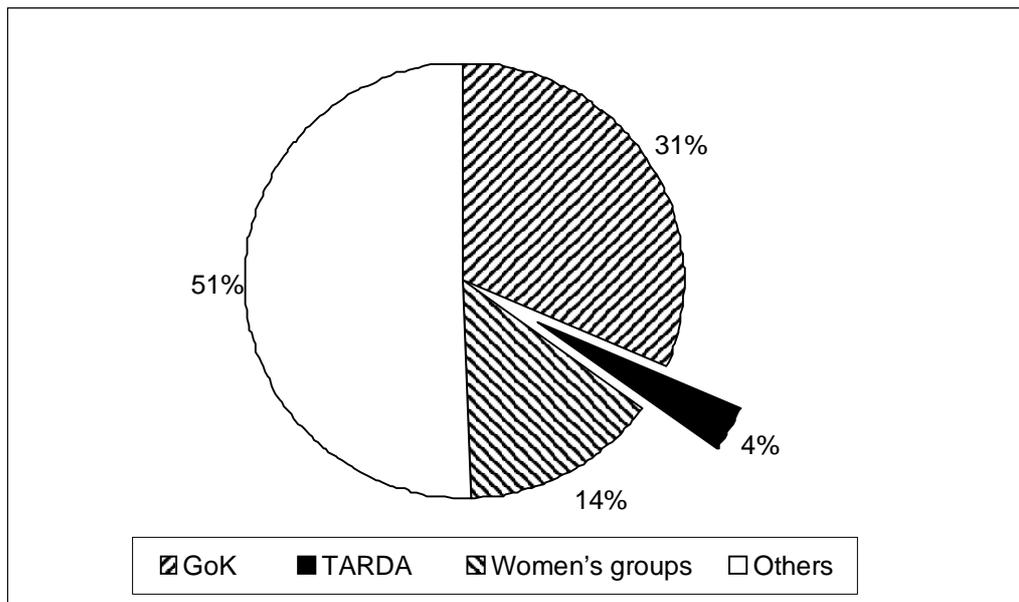
According to the District Forest Office, 564,280, 435,766 and 2,309,952 tree seedlings were produced between 1993 and 1998 in Wote Division, Kibwezi Division and the whole district respectively. Of the tree seedlings produced, 43 percent were for the semi-arid zone, indicating a high commitment to reforestation, despite low survival rates. The annual production and the sources of the seedlings are presented in Figure 3 and 4. Women's groups, community and private tree nurseries produced 65 percent of the tree seedlings in 1997.

Figure 3: Annual tree seedling production



Source: District Forest Office, 1998.

Figure 4: Sources of tree seedlings in 1997



Source: District Forest Office, 1998.

CONCLUSIONS

Farmers' attitudes: Farmers are eager to plant and protect trees. Preferred species include fruit trees, live fences, mulberry and neem. All interviewed farmers have planted fruit trees. Among fruit trees, mango and pawpaw are preferred on account of their drought tolerance. Planting pits are used to improve soil water availability. Fruit supplement other food sources or are sold. Reasons for establishing or protecting trees on farms include: shade, medicine, soil fertility enhancement, and as a source of fodder.

Constraints on tree performance include low seedling survival due to drought, termites, and livestock damage. Constraints on profitability include water shortage, poor access to markets, and poor adaptation to the environment. Other constraints include pest habitats, competition with crops for soil moisture and nutrients, obstruction of mechanised operations.

Investments in tree planting increased during the past 15 years, are a form of intensification, and take place after farmers have settled. Management of trees in grazing land involves the gradual clearing of bush to conserve individuals for future use. There is no evidence of a woodfuel shortage under current levels of tree utilisation. Firewood sources are trimmings, lopping, pollarding and deadwood. Those without trees use roadside harvesting or deadwood or collect from neighbours' farms by agreement.

Investments in fruit-tree planting have taken place under high climatic risk, necessitating in some places the use of planting pits and/or supplemental irrigation during early establishment. Farmers are willing to make long-term investments in tree planting, even though the future may be uncertain.

External versus farmers' contribution: External intervention has mainly contributed in raising awareness and in complementing farmers' efforts in tree seedlings production. The farmers have invested heavily in tree planting even under high climatic risk.

Trees on grazing land: Selective conservation, protection and harvesting of trees on grazing land represents a significant transition in land use; and the sustainability of wood fuel production also, though presumably not always at the level of every individual holding.

Policy has shifted from control of the forestry sector towards enabling sustainable use through private and community organisations. Forestry policy has promoted on-farm tree planting and protection. Interventions have focussed recently on agroforestry and community forestry.

Gazetted forests earn the district authority income from timber and fuel but biodiversity protection is a major management issue. Charcoal production is inadequately regulated, fails to contribute to re-forestation, and present levels may be unsustainable.

Deforestation and afforestation: The study shows that deforestation is going on alongside afforestation. During the settlement period deforestation takes place to create room for homesteads, cultivation and grazing, to provide building materials and to generate cash (through sale for charcoal and firewood) in order to finance initial settlement. The deforestation that takes place is, however, selective, leaving young, high-value trees for future use and also some older trees for shade or boundary markers. In areas where there is a high demand for charcoal, deforestation may continue until all available trees are cut. More usually, deforestation following initial settlement is gradual, aimed at meeting household wood product needs and clearing more land year by year for cultivation and improved grazing. As this takes place, re-forestation takes place in planting fruit trees in the cropland or orchards, boundary trees and woodlots in degraded patches. People are planting trees in full knowledge of the negative aspects of

tree planting. Farmers' investments in tree planting and management of trees in the grazing land are an indication that farmers value and invest in trees, even in low rainfall areas, so long as land tenure conditions are conducive. The scenario projected by several writers, that of deforestation linked to population growth in marginal lands, needs to be reconstructed.

ANNEX I

Illustrations of the uses of indigenous trees

Acacia tortilis (umbrella thorn tree) is a spiny acacia usually 4-8 m high, with a flat-topped and umbrella-like canopy. It is among the most drought-resistant acacias in Kenya and grows in AEZ 4-7. *A. tortilis* has multiple values. It is used as a source of livestock feed and provides high quality charcoal⁴ and shade. Its fresh, ripe pods and gum are sometimes eaten during periods of famine. A boiled infusion of bark is used as a treatment for diarrhoea and stomach ache (Hussain *et al.*, 1982; Kaiani informant, 1998; and Maundu *et al.*, 1999).

Terminalia Brownii is an indigenous tree that regenerates well even after burning. A good tree for charcoal production, its termite resistant timber is also used for construction of houses, ox-yokes and farm and household tools (Mortimore, 1992 and Mugo, 1999). Its availability in these dry areas has decreased due to utilisation without adequate protection of volunteer seedlings.

Adansonia digitata (boabab tree) is a grotesque-looking deciduous tree with a disproportionately large, soft, fibrous trunk. The fruit contains a dry, cream-coloured pulp that is eaten raw or used to make juice. The seeds are roasted like groundnuts. The leaves are also used as vegetables. Its bark is used for medicinal value or as fibre for ropes and baskets (Maundu *et al.*, 1999). The use is, however, limited to drought years only (Athi Kamunyuni informant, 1999).

Kigelia pinnata (sausage tree) is usually 5-8 m tall. It produces 30-40 cm long sausage-like fruit. The fruit is widely used for fermenting traditional beer. *Syzygium guineense* (waterberry tree) grows around Kibwezi area and produces edible sweet fruits that can also be used to make a drink. Its timber is hard, durable, easy to work and is generally used to make beehives (Maundu *et al.*, 1999; and Darajani informant, 1998).

⁴ Due to its high quality wood most of the trees in the area are young. Farah (1991) reported that 87 percent of *A. tortilis* trees sampled had a height of less than 2 m in Ngwata area, while at Kathonzweni, 81percent were less than 4 m in height.

ANNEX II

Farmers' experiences in tree planting

- Maingi Kuttita is a farmer in Kyamusoi. He established a citrus orchard (2000 m²) in 1986. He planted 50 seedlings in November and watered them on a weekly basis for the first three dry months (January, February and March) applying approximately 20 litres per week per tree. He lost 30 percent of the seedlings in the first month and another 20 percent over the next two months. He applies manure regularly and pesticide occasionally. He sells approximately 800 Ksh worth of citrus fruits per tree per year.
- Mutinda Ndunda is a farmer in Kyamusoi. He has established an orchard with eight mango, 21 orange, two guava, two avocado, 12 banana and 10 pawpaw trees over the last eight years. He was fortunate to have established his seedlings during good rainfall years. Most of the fruit trees were planted in holes 1x1 m wide and 0.5 m deep. He has acquired tree grafting skills and has successfully applied them on orange and mango fruit trees. His main expense is in manuring. The fruits are mainly for domestic use and he sells approximately 5,000 Ksh worth of fruits per year.
- Anna Ngui is a farmer in Kaiani village. She has an orchard of about 6000 m² with approximately 100 pawpaw and 120 mango trees. Most of the seedlings were provided by the Catholic Church through womanise groups. She is fortunate to have a small earth dam, where she gets water for supplemental irrigation when the trees are experiencing water stress. In 1982 she planted orange trees. These did not prove to be a profitable investment due to the high incidences of disease, the high cost of pesticides, fluctuating prices and unreliable markets.
- Poor performance by fruit trees in Athi Kamunyuni is illustrated by experiences of three farmers. Joni Mutheka planted 30 pawpaw seedlings over the last three years. There are 15 surviving trees, most of them water stressed and only three in fruit in 1999. Mule Kavivya invested in constructing 40 planting pits for mangoes and pawpaws. He has planted mangoes and pawpaws over the last four rainy seasons but has no surviving trees due to water stress. Beatrice Mwanzia Nthongo planted 20 pawpaws in 1997 but only one tree has survived.

ANNEX III

Charcoal sales along Nairobi-Mombasa highway in November, 1998

Observation point	Place of origin	No. bags	Price Ksh*	M ³ of wood extracted	Destination (% of bags)		
					Nairobi	Mombasa	Machakos
Kiboko	Chyulu, Masongaleni	2770	180	2,327	86.5		13.5
Mbui Nzau	Forest reserve, Chyulu conservation area, Kaunguni farmers	6720	110	5,645	100		
Kibwezi	Kikumbulyu, Masongaleni, Mwatini, Kalungu, Kalamba	1862	148	1,564	23	48	29
Machinery	Chyulu, Masongaleni	855	170	718	100		
Kambu	Chyulu, Masongaleni	3387	90	2,845	47	45	8

Source: District Forest Office, 1999.

* Average in Ksh

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