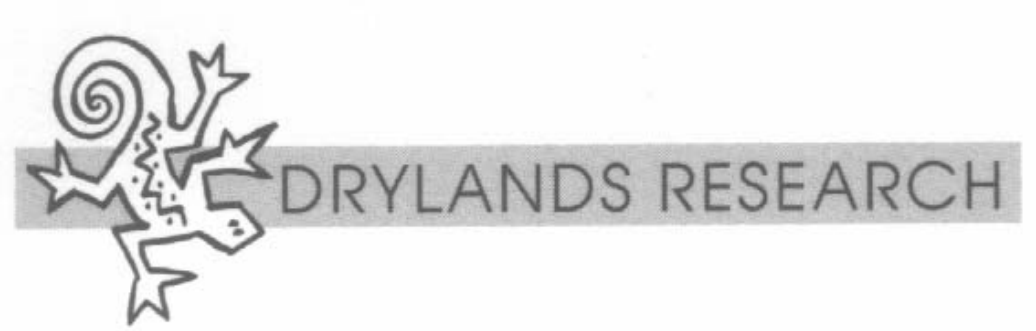


# Drylands Research Working Paper 4

# MAKUENI DISTRICT PROFILE: SOIL MANAGEMENT AND CONSERVATION, 1989-1998

**F.N. Gichuki**

**2000**

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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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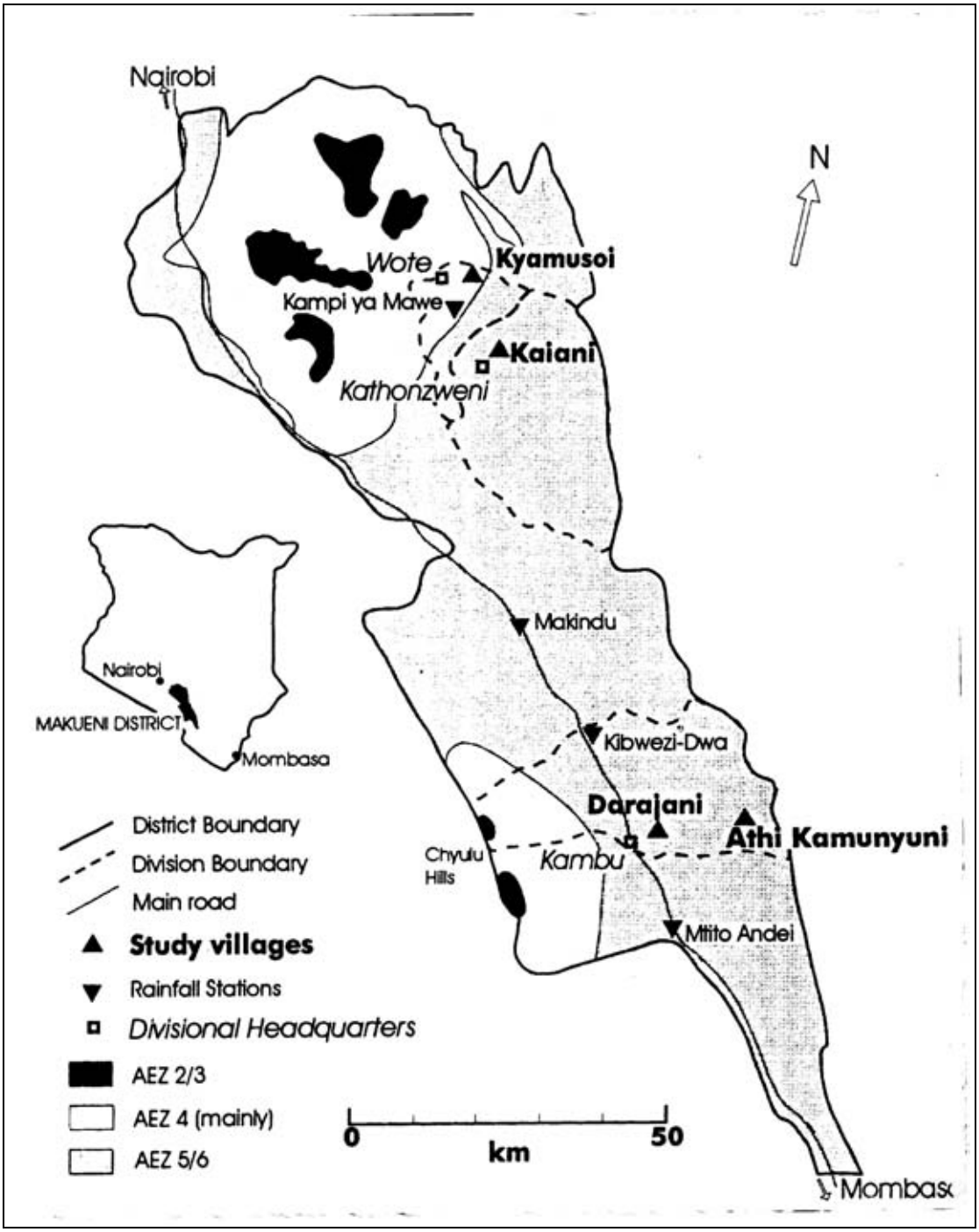
## Preface map


Nairobi
N
Wote
Kyamusoi
Kampi ya Mawe
Kaiani
Kathonzweni
Makindu
Nairobi
MAKUENI DISTRICT
Mombasa
Kibwezi-Dwa
Darajani
Athi Kamunyuni
Chyulu Hills
Kambu
Mtito Andei
District Boundary
Division Boundary
Main road
Study villages
Rainfall Stations
Divisional Headquarters
AEZ 2/3
AEZ 4 (mainly)
AEZ 5/6
0
km
50
Mombasa

## Abstract

This paper explores the investments in soil conservation made by farmers in Makueni District, Kenya over the period 1950-1998 and the policy and institutional framework under which the investments were made. An assessment of the scale and impact of these measures is also presented, and the Government's support for this work is described. In general very few signs of erosion were observed, so the area is considered to have low erosion status. Measures to conserve soil and water include the use of crop residues in trashlines, contour ridging, grass strips, *fanya juu* terraces and cut-off drains. Crop residue management and tillage are the main practices used to facilitate *in situ* moisture conservation, and most survey respondents practise contour ridging. Physical soil conservation measures are used to complement cultural practices that conserve rainwater *in situ* by trapping and preventing further runoff. A key constraint to the expansion of soil and water conservation measures by households is the shortage of hired and family labour.

Generally grazing land has received very little investment because there farmers perceive a low return. In Makueni District farmers have been able to make long-term investments in soil conservation partly because their land tenure was secure. Due to rising fertiliser prices, farmers are now relying more on soil conservation as way of reducing the loss of plant nutrients. Forest and water policies have provided additional impetus for soil and water conservation through the initiatives in farm forestry and watershed conservation. Training and extension in soil and water conservation has been a major external input into soil management initiatives by the farmers.

## Résumé

L'objet de ce rapport est d'examiner les investissements fournis par les agriculteurs du district de Makueni au Kenya, en ce qui concerne la conservation des sols, au cours des années 1950-1998, ainsi que le cadre politique et institutionnel dans lequel ces investissements ont été effectués. Il y a aussi une évaluation de l'impact et l'étendue des mesures prises et une analyse de l'assistance du gouvernement dans ce domaine.

De manière générale, très peu de signes d'érosion ont été observés dans cette région qui est donc est considérée comme étant à faible risque (tableau 2). Cela est dû à l'abondance des pluies la saison passée (Mars - Mai 1998) qui a donné lieu à la densité de la couverture végétale, à la faible pente des sols, (Tableau 3) et parce que des techniques de conservation des sols ont été utilisées dans pratiquement toutes les fermes. Dans la quasi totalité de celles qui ont été examinées, il a été établi que des mesures pour la conservation des sols et de l'eau (CSE) ont été prises, et que de nouveaux travaux étaient en cours au moment où cette étude avait été effectuée. Néanmoins, le niveau des investissements fournis pour la conservation des sols ainsi que l'efficacité des méthodes utilisées pour la CSE variaient de manière considérable.

Des différences ont été notées dans la productivité des terrains cultivés dans tous les villages étudiés sauf un. D'après les agriculteurs, elles sont dues aux différents types de sol, à l'érosion, aux pertes de sols et/ou l'accumulation dues au ruissellement et à l'application sélective d'engrais ou de fumier (tableau 4). Dans de nombreuses régions, les exploitants ont remarqué qu'un long laps de temps s'écoulait entre le début des

travaux entrepris pour la conservation des sols et l'amélioration effective de leur fertilité.

Les techniques utilisées pour la CSE sont, entre autre, l'utilisation de résidus végétaux provenant des cultures pour former des lignes de déchets, le billonage en courbes de niveau, les bandes de graminées, la construction de terrasses *fanya juu* et de fossés d'évacuation. L'utilisation de résidus végétaux provenant des cultures et le labourage des sols sont les principales méthodes employées pour favoriser la conservation de l'humidité *in situ* (tableau 5), et la plupart des agriculteurs interrogés dans le cadre de cette étude réalisent des billons en courbes de niveau (tableau 7). Des techniques de conservation des sols sont utilisées en complément des pratiques culturales permettant de conserver l'eau de pluie *in situ*. Elles consistent à canaliser et à empêcher le ruissellement, et celle qui est utilisée le plus est la construction de terrasses *fanya juu* (tableau 8). Un des facteurs qui limite le plus l'adoption de méthodes de CSE par les familles d'agriculteurs est le manque de main- d'œuvre disponible (membres de la famille ou ouvriers agricoles).

Le laps de temps entre l'implantation initiale des agriculteurs et la construction de structures permettant la conservation des sols varie de un an à dix ans, selon leur perception de la gravité des phénomènes érosifs et de l'importance de la conservation des sols, ainsi que les capacités d'investissement des familles dans ce domaine. Dans les villages que nous avons étudié, l'amélioration de la CSE, se font de manière progressive, et dans certains endroits étaient facilités par le soutien des services officiels (principalement le projet d'assistance de MIDP) ou par des projets mis en oeuvre par des ONG (tableau 11). La figure 1 montre les variations au niveau des investissements pour la construction de terrasses *fanya juu* et de fossés d'évacuation (qui sont utilisés pour diriger les eaux des routes vers un endroit où elles peuvent être utiles), et le tableau 16 indique les investissements moyens par hectare. En général les agriculteurs ont très peu investi au niveau des pâturages car ils estiment que ce sont des terres qui rapportent peu par rapport à la somme investie.

La figure 2 montre quelles sont les sommes allouées par le gouvernement pour la CSE. Les exploitants ont pu faire des investissements à long terme dans la conservation des sols, car on leur a accordé la propriété permanente de leur terre. La libéralisation de la production d 'engrais chimiques a entraîné une hausse du prix des engrais, et ceux ci sont devenus trop chers, surtout pour les agriculteurs des zones semi-arides du district de Makueni, par conséquent l 'utilisation d 'engrais a diminué dans cette région. Les agriculteurs emploient donc actuellement davantage des techniques de conservation des sols pour atténuer leur perte en élément nutritifs. Certaines mesures concernant les eaux et les forêts ont favorisé encore plus la CSE, surtout les initiatives qui ont été prises dans le domaine de l 'exploitation forestière et de la conservation des bassins hydrographiques. Les résultats obtenus par les agriculteurs du district au niveau de la CSE sont présentés dans le tableau 19. La formation et le soutien dont ont bénéficié les exploitants en ce qui concerne les techniques de CSE a été un facteur externe très important pour stimuler leurs initiatives au niveau de l 'exploitation des sols (figure 3).

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Many people have contributed to this work by providing data, help, advice and direction. I am indebted particularly to the farmers who took time off their busy schedule to participate in the study by sharing their experiences and allowing me to interfere with there privacy by sometimes asking very personal questions and taking measurements in their fields. I am equally grateful to the district staff, particularly Mr. S. Njoroge, the District Soil Conservation Officer, who assisted me in accessing their data rich files and sharing their experiences and ideas. Thanks also goes to the University of Nairobi for giving me time off to undertake this study.

**About the author**

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**List of acronyms and abbreviations**

| | |
|---|---|
| AEZ: | Agro-ecological zone |
| ALDEV: | African Land Development Programme |
| ASAL: | Arid and semi-arid lands |
| MAP: | Makueni Agricultural Project |
| MIDP: | Machakos Integrated Development Programme |
| NSWCP: | National Soil and Water Conservation Programme |
| PPCSCA: | Permanent Presidential Commission on Soil Conservation and Afforestation |

# 1 INTRODUCTION

## 1.1 Background

Land is a major input in agricultural production. When land suffers from soil degradation, it loses its productivity. Soil degradation is the decline in the productive capacity of the soil as a result of soil erosion and changes in hydrological, biological, chemical and physical properties (Douglas, 1994). It can result from inappropriate land use and poor land management. Investments in soil management can therefore be justified on the basis of sustaining and/or improving land productivity. Soils in semi-arid areas are generally fragile and of low inherent producing capacity. The objectives of soil management are to maximise the limited water supply, control weeds, maximise plant nutrient supply, minimise insect pests and diseases, minimise erosion, and maintain or improve soil fertility and soil physical conditions (Henderson, 1979). Investment in soil management is constrained by labour, time, money, equipment, technological know-how, land use, crop prices and markets. Soil management investment is influenced by the nature and extent of soil degradation, type of investment, time frame for the investment, level of investment (earthwork moved per ha, or per household), finance (family versus hired labour, on-farm versus off-farm source of investment, investment in relationship to land use and value of the crop, opportunity cost of labour, cost-benefit analysis) and timing (dry season - ground too hard, labour availability, etc.). The study focuses on water erosion as it is the main form of soil erosion in the area.

## 1.2 Objectives

This paper explores the investments in soil conservation made by farmers over the period 1950-1998 and the policy, legal and institutional framework under which the investments were made. The overall objective is to construct a profile of soil conservation for the semi-arid areas of Makueni District. This is achieved by:

1. reviewing literature on soil erosion and conservation;
2. analysing farmers' investments in soil conservation; and
3. documenting external interventions that have complemented farmers' initiatives.

## 1.3 Methodology

The study was carried out in the semi-arid areas of Makueni District. It focused on Kyamusoi village in agro-ecological zone (AEZ) 4, Kaiani and Darajani villages in AEZ 5 and Athi Kamunyuni village in AEZ 6 (see Preface map). The characteristics of these study areas are summarised in Table 1.

For each study area a group interview consisting of 6-12 farmers was conducted to gather information on soil conservation initiatives. Twelve respondents for each village were selected at random for interviews on private conservation investments. Specific issues were addressed through:

1. analysis of secondary data on soil and water conservation activities;

2. group and individual interviews to trace timing of soil conservation investments and dominant causal factors;
3. farm level observations, interviews and measurements to quantify soil conservation investments; and
4. district level interviews with subject matter specialists.

The erosion status was assessed by literature review and by observing signs of erosion such as rilling and gullying on crop and grazing land, and along footpaths and roads.

**Table 1: Characteristics of study sites**

| | Kyamusoi | Kaiani | Darajani | Athi |
|---|---|---|---|---|
| AEZ* | LM 4 | LM 5 | LM 5 | IL 6 |
| *Time of settlement* | *1950s* | *1960s* | *1960s* | *1970s* |
| 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$^{o}$C, with a minimum temperature greater than 14$^{o}$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 THE STATUS OF SOIL EROSION

Erosion by water is a function of the erosivity of the rainfall and erodibility of the soil. Erosivity of the rainfall is influenced by amount and intensity and rain drop size, drop size distribution and terminal velocity of the rain drops. Erodibility of the soil is influenced by soil physical characteristics; land management factors which influence ground slope and slope length; conservation management practices; and crop management factors (Hudson, 1995).

## 2.1 Literature review

Soil erosion in these areas was recognised as early as the 1940s during planning for the Makueni settlement. Several researchers have documented soil loss in semi-arid areas of Makueni District and other similar areas under different land uses and management (Thomas *et al.*, 1981; Thomas, 1991; Gachimbi, 1993; Muya, 1990; and Tiffen *et al.*, 1994). The erosion rates range widely, depending on the land use and management. The rate of soil loss in semi-arid areas of Makueni was estimated as <200 and 200-500 tons per square kilometre per year (t $km^{-2}$ $yr.^{-1}$) for terraced fields and grazing land respectively (Reid, 1982).

Thomas (1991) reported that rills on cropland were running from the upper to the lower parts of the steeply sloping cultivated land in Kathonzweni and Ngwata in 1990. He noted that soil erosion continues to be a serious problem, particularly under steep sloping, degraded grazing lands and along footpaths or cattle tracks. In some cases cultivation had been abandoned as a result of declining soil productivity, where erosion was severe and soils were shallow and with low nutrient status. This was reported to have happened over a period of 20-30 years of cultivation with no adequate soil conservation.

## 2.2 Erosion observations and impacts

Erosion observations were made for the present study in cropland, grazing land and along footpaths and roads. For each farm, erosion status was classified as very low if there were only minor rills in crop land, low if there were minor rills in cropland and rills on bare patches in the grazing land and medium if there were major rills in the cropland and rills on bare patches in the grazing land. In general very few erosion signs were observed so the area is considered to have low erosion status (Table 2). This is mainly attributed to the good rains and ground cover of the previous rainy season (March-May, 1998), low ground slopes, (see Table 3) and the existence of soil conservation measures on virtually all farms. Minor rilling was observed in all farms. Major rilling was observed in one farm in Kyamusoi and one in Kaiani.

**Table 2: Extent of erosion signs (percent of fields)**

| | Kyamusoi | Kaiani | Darajani | Athi | Total sample |
|---|---|---|---|---|---|
| Very low (rill in crop land) | 88 | 88 | 100 | 100 | 94 |
| Low (rill in cropland and bare patches in grazing land | 12 | 12 | 0 | 0 | 6 |
| Total | 100 | 100 | 100 | 100 | 100 |

Source: Field surveys, 1998-99.

**Table 3: Slope of cultivated land (percent) and average**

| Slope | Kyamusoi | Kaiani | Darajani | Athi | Total sample |
|---|---|---|---|---|---|
| 2-4 | 11 | 25 | 33 | 80 | 38 |
| 5-7 | 78 | 63 | 67 | 20 | 56 |
| 8-10 | 11 | 13 | 0 | 0 | 5 |
| Total | 100 | 100 | 100 | 100 | 100 |
| Average slope | 6.0 | 5.8 | 4.6 | 3.7 | 5.0 |

Source: Field surveys, 1998-99.

Soil loss from cropland, grazing land, foot paths and cattle tracks and roadsides was observed in the form of soil deposits above terrace embankments, in depressions in the fields and along footpaths. The respondents in Kyamusoi and Kaiani reported dam siltation and attributed it mainly to soil loss along roads, foot paths and animal tracks. Other off-site impacts of runoff and soil loss were the bad state of roads where runoff accumulates, and poor dam and river water quality.

Differences in the productivity of cropland were noted. Farmers attributed these differences to soil type, erosion, runoff loss and/or accumulation and selective application of manure or fertiliser (Table 4). They were attributed to the differences in investments in soil conservation. In Athi Kamunyuni there were no reported differences, mainly owing to the short period of crop production.

**Table 4: Reasons for different levels of productivity of cropland (percent of respondents)**

| | Kyamusoi | Kaiani | Darajani | Athi |
|---|---|---|---|---|
| Soil type | 50 | 22 | 0 | 0 |
| Erosion | 0 | 0 | 38 | 0 |
| Runoff accumulation | 25 | 33 | 30 | 0 |
| Selective application of manure/fertiliser | 25 | 45 | 32 | 0 |

Source: Field surveys, 1998-99.

## 3 FARMERS' INVESTMENTS IN SOIL CONSERVATION

### 3.1 Preferences for soil and water conservation practices

All the farms visited had soil and water conservation measures in place. This indicates that all farmers are aware of the need for soil conservation. The level of investment in soil conservation and the effectiveness of the soil and water conservation practices are, however, highly variable. The main conservation practices used are *fanya juu* terraces, cut-off drains, grass strips, trash lines and conservation tillage. *Fanya juu* terraces and cut-off drains are widely used even in areas with gentle ground slopes (see

Table 3), mainly due to their role in trapping runoff. This is in contrast to areas with higher rainfall and steeper slopes, where the main contribution of these structures is to conserve soil (see Gichuki, 1991).

*In situ moisture conservation*

Crop residue management and tillage are the main practices used to facilitate *in situ* moisture conservation. The percentage of crop land covered by crop residues before ploughing was assessed through interviews and field observations. In Darajani, most of the crop residue is used as livestock feed, mainly due to the lack of alternative grazing resources. Small farm sizes for most of the respondents were noted (Gichuki, 2000a). The percentage of the crop residue grazed depends on the quantity available, grazing pressure and length of grazing period. Some of the residue decomposes naturally or is eaten by termites. Burning of the remaining crop residues is undertaken just before ploughing, due to the perceived tillage difficulties in areas with high plant residue cover. Crop residues piled into trash lines were observed on 51 percent of the farms visited. The farmers reported that there was an unusually high amount of crop residue, due to the heavy rains in the 1997/98 agricultural year.

**Table 5: Crop residue management (percent of fields)**

| | Kyamusoi | Kaiani | Darajani | Athi | Total sample |
|---|---|---|---|---|---|
| None | 0 | 0 | 42 | 0 | 4 |
| Crop residue burnt | 43 | 25 | 25 | 50 | 35 |
| Crop residue piled into a trash line | 57 | 75 | 33 | 50 | 51 |
| Total | 100 | 100 | 100 | 100 | 100 |

Source: Field surveys, 1998-99.

Ground cover was observed to be quite high, particularly for the months of October and November, which are normally preceded by a long dry season (June-September). Forty-three percent of all the fields surveyed had at least 10 percent ground cover (Table 6). Low ground cover in the Darajani area was attributed to small farm sizes (less than 0.4 ha) and the use of crop residues for livestock grazing and as a source of firewood (especially pigeon peas stalks).

**Table 6: Ground cover conditions (percent of fields)**

| | Kyamusoi | Kaiani | Darajani | Athi Kamunyuni | Total sample |
|---|---|---|---|---|---|
| <10 | 43 | 38 | 84 | 50 | 57 |
| 10-30 | 57 | 38 | 8 | 40 | 32 |
| >30 | 0 | 24 | 8 | 10 | 11 |
| Total | 100 | 100 | 100 | 100 | 100 |

Source: Field surveys, 1998-99.

Tillage practices observed in the study areas are contour ridging and hand hoe-digging (Table 7). Contour ridging creates a furrow that increases the opportunity for trapping runoff and enhancing infiltration along the crop row. Most of the respondents in all the areas practise contour ridging. Cultivation up and down the slope was observed in one field.

**Table 7: Tillage method (percent of fields)**

| | Kyamusoi | Kaiani | Darajani | Athi Kamunyuni | Total |
|---|---|---|---|---|---|
| Tractor or ox-plough contour ridging | 100 | 100 | 50 | 90 | 78 |
| Hand hoeing | 0 | 0 | 50 | 10 | 22 |
| Total | 100 | 100 | 100 | 100 | 100 |

Source: Field surveys, 1998-99.

*Trapping runoff and soil*

Physical soil conservation measures are used to complement cultural practices that conserve rainwater *in situ*, by trapping and preventing further runoff. In this category, the most prevalent soil and water conservation measure is *fanya juu* terracing (Table 8). Even resource-poor farmers in Athi Kamunyuni consider *fanya juu* terraces as the most effective soil conservation measured on slopes less than 10 percent, despite the high labour requirement. *Fanya juu* terraces are considered to be superior because their water conserving characteristics permit farmers to get a better performance from fruit trees, fodder and food crops grown in areas where runoff accumulates. In the drier areas of Athi Kamunyuni, cut-off drains are considered to be effective in trapping runoff from up-slope catchments. Grass strips are a common soil conservation measure in Kaiani (Table 9), partly due to the demand for livestock feed (Fall, 2000).

**Table 8: Conservation technology ranking (percent of farmers)**

| | Kyamusoi | Kaiani | Darajani | Athi Kamunyuni |
|---|---|---|---|---|
| *1st rank* | | | | |
| *Fanya juu* | 100 | 88 | 30 | 80 |
| Cut-off drain | 0 | 0 | 50 | 20 |
| Grass strip | 0 | 12 | 10 | 0 |
| Trashline | 0 | 0 | 10 | 0 |
| Total | 100 | 100 | 100 | 100 |
| *2nd rank* | | | | |
| *Fanya juu* | 0 | 12 | 50 | 0 |
| Cut-off drain | 88 | 0 | 50 | 100 |
| Grass strip | 12 | 88 | 0 | 0 |
| Total | 100 | 100 | 100 | 100 |

Source: Field surveys, 1998-99.

The areas protected by different conservation measures were assessed by pacing the length and width of the fields. *Fanya juu* terraces protect the largest land area. Farmers reported that most of the *fanya juu* terraces are of the standard size (60 cm wide and 60 cm deep at the time of excavation).

**Table 9: Land protected by different conservation measures (percent of fields)**

| Soil conservation measure | Kyamusoi | Kaiani | Darajani | Athi Kamunyuni |
|---|---|---|---|---|
| Cut-off drain | 10 | 16 | 10 | 17 |
| *Fanya juu* | 65 | 48 | 50 | 47 |
| Grass strip | 25 | 36 | 28 | 0 |
| Trash line | 0 | 0 | 12 | 36 |
| Total | 100 | 100 | 100 | 100 |

Source: Field surveys, 1998-99.

### 3.2 Timing of farmers' investment in soil and water conservation

The timing of farmers' investments in soil and water conservation is presented in terms of when it started, the period of major expansion and the reasons for expansion. This was assessed using questionnaires and group discussions.

Table 10 shows that soil conservation started at different times in the different study areas, farms and fields. Soil and water conservation efforts in Makueni began at the time of the Makueni Settlement Scheme, when farmers were assisted in the construction of terraces on the fields opened up for cultivation. Therefore, Kyamusoi area has the longest history of soil conservation among the four study areas. Farmers reported that they were still maintaining the original terraces and had undertaken new conservation works between 1970 and 1985. Conservation work started later in Darajani and Athi Kamunyuni, partly due to the later settlement. The lag time between initial settlement and construction of soil conservation structures varies from one to 10 years, depending on the perceived soil erosion hazard, farmer's awareness of the importance of soil conservation and ability to invest in soil conservation.

**Table 10: Time of commencement of soil conservation works (percent of fields)**

| Period | Kyamusoi | Kaiani | Darajani | Athi Kamunyuni | Total |
|---|---|---|---|---|---|
| 1950s | 57 | 0 | 0 | 0 | 12 |
| 1960s | 14 | 25 | 0 | 0 | 9 |
| 1970s | 29 | 63 | 18 | 0 | 26 |
| 1980s | 0 | 0 | 27 | 12 | 12 |
| 1990s | 0 | 12 | 55 | 88 | 41 |
| Total | 100 | 100 | 100 | 100 | 100 |

Source: Field surveys, 1998-99.

Improvements to, and expansion of soil and water conservation measures were undertaken gradually, and in some places received additional impetus from Government (mainly MIDP project support) or NGO projects (Table 11). In Kaiani, Darajani and Athi areas, improvements and expansion took place between 1979 and 1993. The main reasons given for the expansion of soil and water conservation works were on-farm labour availability, government assistance and group efforts (Table 12). On-farm labour availability was considered to be the main factor in Kyamusoi, Kaiani and Darajani.

**Table 11: Time of soil conservation expansion**

| | Kyamusoi | Kaiani | Darajani | Athi Kamunyuni | Total |
|---|---|---|---|---|---|
| Gradually over time | 72 | 0 | 0 | 0 | 18 |
| 1963-1978 | 14 | 12 | 0 | 0 | 6 |
| 1979-1993 | 14 | 88 | 36 | 13 | 38 |
| No expansion | 0 | 0 | 64 | 87 | 38 |
| Total | 100 | 100 | 100 | 100 | 100 |

Source: Field surveys, 1998-99.

**Table 12: Reasons for expansion of soil conservation (percentage of farmers expanding)**

| | Kyamusoi | Kaiani | Darajani | Athi Kamunyuni |
|---|---|---|---|---|
| Labour availability | 71 | 74 | 100 | 100 |
| Government assistance | 15 | 13 | 0 | 0 |
| *Mwethya* group assistance | 14 | 13 | 0 | 0 |
| Total | 100 | 100 | 100 | 100 |

Source: Field surveys, 1998-99.

Most of the respondents indicated that maintenance of conservation measures is not done on a regular basis but rather as a response to major breakages (Table 13). Some respondents in Kyamusoi reported that they undertake regular maintenance during crop weeding and tillage operations.

**Table 13: Maintenance of soil conservation structures (percentage of farmers with structures)**

| | Kyamusoi | Kaiani | Darajani | Athi Kamunyuni | Total |
|---|---|---|---|---|---|
| Not done | 17 | 100 | 100 | 100 | 84 |
| Done after a break | 83 | 0 | 0 | 0 | 16 |
| Total | 100 | 100 | 100 | 100 | 100 |

Source: Field surveys, 1998-99.

Farmers reported that they notice soil fertility decline at different times, depending on the inherent soil fertility and cultivation history (Table 14). At Athi Kamunyuni, the farmers still attribute their yield variability to weather fluctuations and believe that the inherent soil fertility has not been depleted. In Kyamusoi, soil fertility decline was detected in 1960s, and a few farmers started applying manure. Inorganic fertiliser application started in the 1980s but is practised by only a few people, due to the high cost and climatic risk (Mbuvi, 2000).

**Table 14: Timing for soil fertility improvements (percent of farmers)**

| Decade | Kyamusoi | Kaiani | Darajani | Athi Kamunyuni |
|---|---|---|---|---|
| 1970s | 12 | 25 | 17 | 0 |
| 1980s | 88 | 25 | 33 | 0 |
| 1990s | 0 | 50 | 50 | 0 |
| Total | 100 | 100 | 100 | 0 |

Source: Field surveys, 1998-99.

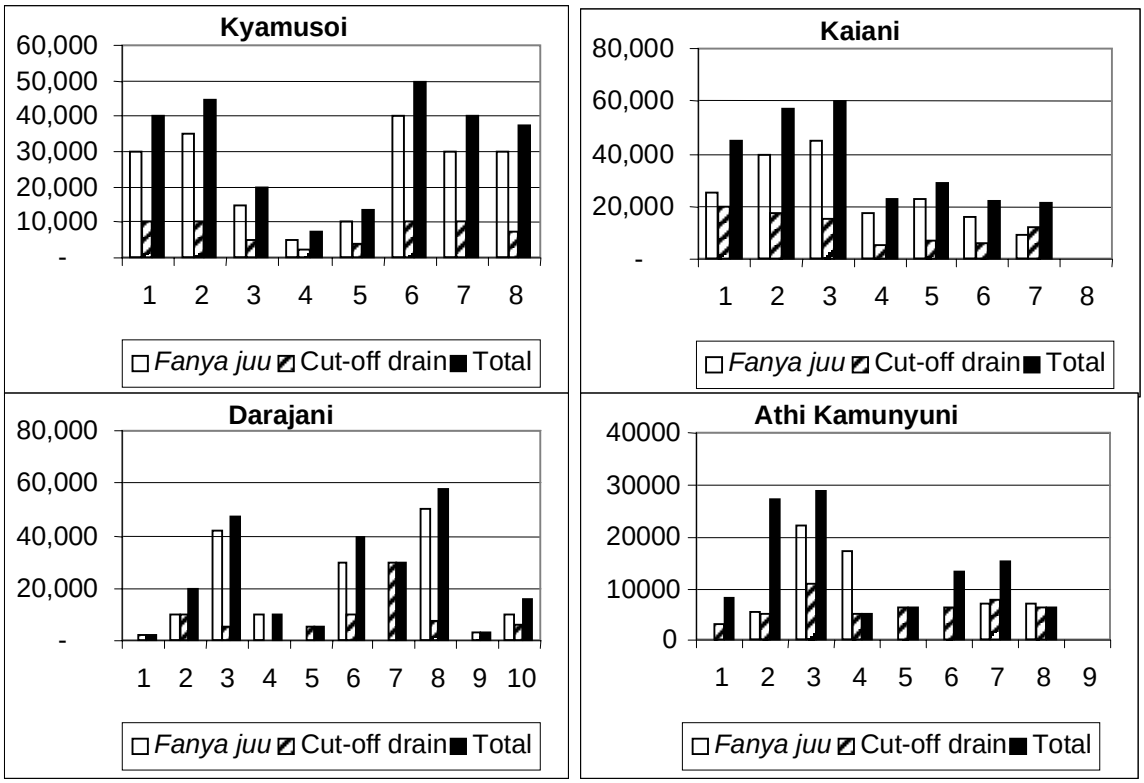
### 3.3 Labour and financial inputs

Investments in soil conservation include (1) investments in gaining the knowledge and expertise required to undertake soil conservation, (2) planning and establishment of conservation measures, and (3) repair and maintenance of conservation structures. Gaining knowledge and expertise in soil and water conservation has taken place through formal and informal learning and experimentation. Investment costs include the cost of establishing conservation measures (planting fodder grasses, hedge barriers, digging cut-off drains, terraces and/or retention ditches). The cost of making terraces made by hand depends on the method of construction, the slope of the land, the type and size of terrace, the spacing of terraces and ease or difficulty of digging. Maintenance costs consist mainly of repairing terrace embankments. In areas with a land scarcity, farmers may consider the lower production resulting from not using land occupied by conservation measures as a conservation cost.

*Investments in cropland: physical structures*

Investments in cut-off drains and *fanya juu* terraces were computed using the earthwork excavated, the average daily excavation volume and wage rate for 1998. The average excavation volume per day is 3 $m^3$. One man-day would construct an 8 m terrace (0.6 m wide and 0.6 m deep trench) per day (Thomas, 1997). The earthwork excavated was estimated on the basis of length, depth and width measurements made during the field survey. The variation in investment in *fanya juu* terraces and cut-off drains is presented in Figure 1. The investments in *fanya juu* terraces and cut-off drains are highest in Kaiani, due to larger farm sizes and length of structures per ha (Table 15). The investment has been undertaken over a long period of time, and in most cases using family labour. The labour input is estimated to vary from 93 to 245 man-days per household and between 31 and 58 man-days per hectare. The average investment per ha is presented in Table 16.

**Figure 1: Investments in *fanya juu* and cut-off drain**




Source: Field surveys, 1998-99.

**Table 15: Average total investments in terracing per farm (per household)**

| | Investment in Ksh | | Total | |
|---|---|---|---|---|
| *Study site* | *Fanya juu* | *Cut-off drain* | *Ksh* | *Man-days* |
| Kyamusoi | 24,375 | 7,344 | 31,719 | 211 |
| Kaiani | 25,000 | 11,714 | 36,714 | 245 |
| Darajani | 15,200 | 7,950 | 23,150 | 154 |
| Athi Kamunyuni | 7,563 | 6,323 | 13,885 | 93 |

Source: Field surveys, 1998-99.

**Table 16: Average *fanya juu* and cut-off drain investment (per hectare)**

| Study area | Ksh per hectare | Man days per hectare |
|---|---|---|
| Kyamusoi | 5,116 | 34 |
| Kaiani | 4,667 | 31 |
| Darajani | 8,663 | 58 |
| Athi Kamunyuni | 5,599 | 37 |

Source: Field surveys, 1998-99.

*Investments in grass strips*

In Kyamusoi, Kaiani and Darajani farmers planted *Makarikari* grass (*Panicum makarikariensis*) for terrace bank protection. Investment in grass strips for soil and water conservation is highest in Kaiani, where all the farms visited have grass strips ranging from 200-800 $m^2$. In Kyamusoi and Darajani only 25 percent of the farms visited have grass strips, with considerable fodder value. In Athi Kamunyuni, no grass strips were observed, mainly due to the dry conditions and the fact that there is no shortage of grazing resources.

**Table 17: Amount of grazing land per household (percent of household)**

| Ha per landholding | Kyamusoi | Kaiani | Darajani | Athi Kamunyuni | Total |
|---|---|---|---|---|---|
| < 0.8 | 29 | 0 | 66 | 0 | 24 |
| 1.2-4 | 14 | 14 | 17 | 30 | 19 |
| 4-8 | 14 | 29 | 0 | 20 | 16 |
| 8-12 | 43 | 43 | 17 | 0 | 25 |
| 12-16 | 0 | 14 | 0 | 40 | 13 |
| >16 | 0 | 0 | 0 | 10 | 3 |

Source: Field surveys, 1998-99.

*Grazing land improvements*

Grazing land ranges from 0.8-14 ha in Kyamusoi and Kaiani, to 0-10 ha in Darajani, and 2-24 hectares in Athi Kamunyuni (Table 17). The main form of grazing land improvement is bush clearing (Table 18). Natural grasses and forbs are the main grazing resources. In general the grazing land has received very little investment. No special effort is made to control erosion as the land is left to regenerate naturally. Only severely degraded areas are rehabilitated. This is attributed to the perceived low return on investment in grazing land.

**Table 18: Area of cleared grazing land (percent of households)**

| Hectares | Kyamusoi | Kaiani | Darajani | Athi Kamunyuni | Total |
|---|---|---|---|---|---|
| None | 29 | 38 | 55 | 88 | 52 |
| <0.8 | 0 | 12 | 0 | 0 | 3 |
| 0.8-4 | 57 | 50 | 36 | 12 | 39 |
| 4-8 | 14 | 0 | 9 | 0 | 6 |

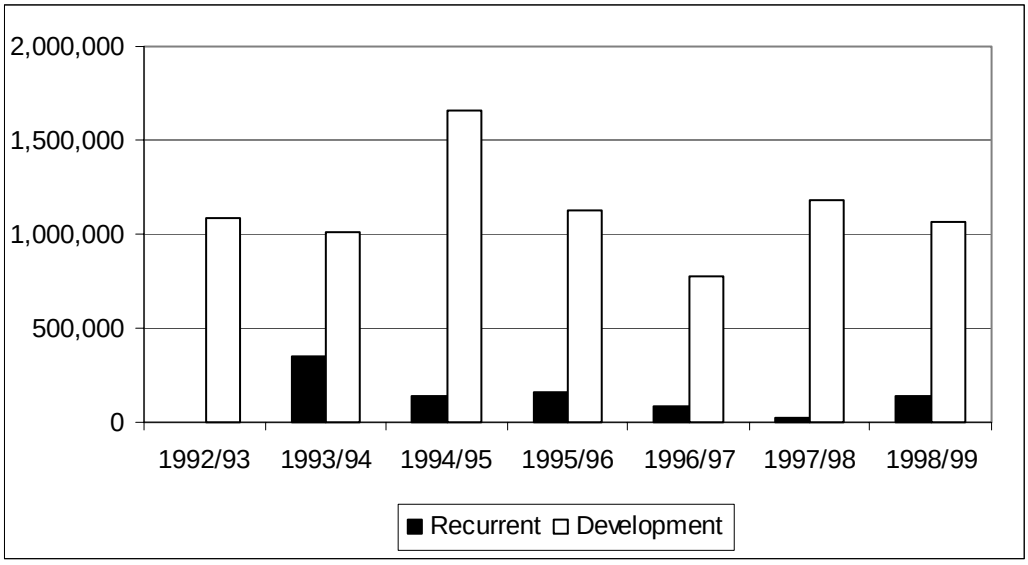
Source: Field surveys, 1998-99.

# 4 EXTERNAL INTERVENTIONS

## 4.1 Institutional framework

A soil conservation unit of the Ministry of Agriculture was established in the 1930s to address the soil erosion and land degradation problems facing the country (Gichuki, 1991). The unit has grown into the Soil and Water Conservation Branch. The District Soil and Water Conservation Office implements activities of the branch. It is charged with the responsibility of promoting soil and water conservation activities.

**Figure 2: Government expenditure (Ksh) in soil and water conservation**




Source: District Soil and Water Conservation Office data, 1999

Makueni District was split from Machakos District in 1992 and set up its own district soil and water conservation team. It grew from four divisional staff in 1992 to a current staff level of 29, distributed in all but four of the 16 divisions. Staffing priority is given to the semi-arid areas. Allocations for recurrent and capital development budgets have fluctuated from year to year (see Figure 2). About 60 percent of the funds were used in AEZ 5 and 6. The recurrent budget (estimated at Ksh 1.8 million/yr., excluding salaries) has been decreasing since 1993. The development budget, mainly financed by the donor funded National Soil and Water Conservation Programme, has fluctuated around one million shillings per year. Programme activities covers only nine out of the 16 divisions, due to lack of staff and/or transport (District informant, 1998).

The main achievements of the district soil and water conservation can be grouped into three categories: training, provision of tools, and conservation.

## 4.2 Policies influencing soil conservation

The main policies that have had a direct or indirect influence on investments in soil conservation are settlement, land tenure, soil erosion control, fertiliser, ASAL development, water and forest policies.

*Settlement*

Government policies that led to both planned and spontaneous settlement in the semi-arid areas of Makueni District contributed to the reduction of soil degradation by relieving human and livestock population pressure on the settled land. The Makueni settlement model recognised the importance of appropriate land use, soil and water conservation and better farming practices (Gichuki, 2000a). The explicit inclusion of soil and water conservation extension messages and enforcement of the rules laid the foundation for the soil and water conservation initiatives that followed. The success of the Makueni settlement and reduced government crackdown on illegal squatter settlement lead to spontaneous settlement in even more marginal areas of Kibwezi and Mtito Andei.

*Land tenure*

Improvements started in the late 1940s when the Makueni settlement scheme was being planned (Gichuki, 1991; 2000a). Farmers were able to make long-term investments in soil conservation because of the granting of secure tenure. Title deeds however, are not necessary for investment in areas where traditional rights are respected. In Makueni, the perceived rights to use the land in the foreseeable future are good enough.

*Soil erosion control*

Soil erosion control has been a concern of the Government since the 1930s when soil degradation reached alarming levels (Tiffen *et al*., 1994). Soil erosion control has been attempted through different strategies (Gichuki, 1991). The main ones include: (a) the setting up of a soil conservation section in the Ministry of Agriculture in 1938; (b) direct investment in public land reconditioning programme and soil conservation; (c) the passage and enforcement of soil conservation legislation (the Agricultural Act of 1965); (d) capacity building; (e) development of appropriate approaches and technologies for soil conservation; and (f) empowerment of communities to undertake soil conservation activities (Gichuki, 1991).

*Fertiliser*

Liberalisation of the fertiliser industry resulted in unaffordable fertiliser prices, particularly for farmers in semi-arid areas of Makueni (Mbogo, 2000). Fertiliser use in the semi-arid areas has declined and farmers are relying more on soil conservation as way of reducing the loss of plant nutrients (District informant, 1999).

*Development of arid and semi-arid lands*

The Government's development plans for 1974/78 and 1979/83 set out policies for the development of semi-arid areas. The Machakos Integrated Development Programme (MIDP) (1978-88) was conceived and implemented as a strategy to promote integrated development and agricultural intensification and diversification in the semi-arid area. Soil conservation was a major component of this programme.

*Forest and water policies*

Forest and water policies have provided additional impetus for soil and water conservation through the initiatives in farm forestry and watershed conservation (Gichuki 2000a; 2000b).

## 4.3 Rules and regulations

Soil conservation and land use rules and regulations are intended to promote the protection and proper utilisation of the land resources. At the time of the Makueni settlement these rules included soil management. Their effectiveness declined in the run-up to independence. Growing concerns over land degradation after independence were provoked mainly by the encroachment of cultivation on steep sloping land (>35 percent), the cultivation of land without adequate soil conservation measures, and encroachment of riverbanks. This concern led to the enactment of land use rules which promote soil and water conservation (Kenya, MoA, 1965). Other legislation intending to promote the sustainable use of land, water and tree resources can be found in the Forest Act, the Water Act, the Chiefs' Act and many Presidential directives. The Permanent Presidential Commission on Soil Conservation and Afforestation (PPCSCA) was established in 1981 to:

1. review legislation on soil conservation, afforestation, and flood control and to advise on its adequacy and effectiveness;
2. advise on areas which should be declared 'Protected Catchment Areas' and to recommend the measures to be taken to regulate the management of such protected areas; and to
3. continually evaluate the performance of government agencies charged with the responsibility of implementing soil conservation, afforestation and flood control programmes, and to advise on the adequacy of the Government's machinery for organising such programmes (Anyieni, 1982).

A regulation and enforcement approach has had limited impact on soil conservation, due to inadequate enforcement of laws and low fines that do not serve as an effective deterrent. Agricultural extension officers who are expected to enforce the Agricultural Act sometimes find it difficult, and hence prefer to concentrate on educating and persuading the farmers to manage the land well, rather than prosecuting them.

## 4.4 Role of development programmes

*The programmes*

Several development programmes have been implemented in an effort to combat soil degradation problems. The most notable ones are the African Land Development (ALDEV) programme, the Machakos Integrated Development Programme (MIDP), the National Soil and Water Conservation Programme (NSWCP) and Makueni Agricultural Programme (MAP).

The ALDEV was implemented between 1946 and 1955. This programme promoted soil and water conservation and better farming practices, assisting settlers in the Makueni Settlement with the initial investment and guaranteeing security of tenure. This

programme used a combination of approaches: (a) direct government investment in rehabilitation of denuded lands; (b) regulation and enforcement; and (c) farmer training.

The NSWCP has sustained the momentum for soil and water conservation through the following innovative strategies:

1. Involvement of farmers in identifying priorities, analysing problems and devising solutions
2. Encouraging group work and strengthening local institutions (traditional groups)
3. Recognising the role of women and ensuring their active participation in decision-making
4. Encouraging co-operation between government and non-government organisations
5. Promoting interdisciplinary approaches to research and extension
6. Building on local knowledge, experience and expertise
7. Promoting adoptable technologies
8. Using catchment and individual farm approaches
9. Monitoring and evaluating at farm, catchment, division, district and national levels (Thomas, 1997)

Rural development programmes, the MIDP (1979-1988) and MAP (1995 to the present) recognise the role of soil resources in supporting rural development.

*Soil conservation achievements*

District soil and water conservation achievements by farmers are presented in Table 19. Over 12,000 farmers were assisted in laying soil conservation measures and 2,328 km of terracing constructed over seven years period. Approximately 66 percent of these achievements and financial expenditures were in the semi-arid areas of the former Wote and Kibwezi Divisions.

**Table 19: Soil conservation achievements***

| Year | 1992/93 | 1993/94 | 1994/95 | 1995/96 | 1996/97 | 1997/98 | 1998/99 | Total |
|---|---|---|---|---|---|---|---|---|
| Catchments | 8 | 8 | 13 | 14 | 21 | 18 | 17 | 99 |
| Farms planned | 1,252 | 748 | 1,210 | 870 | 2,405 | 3,900 | 2,245 | 12,630 |
| Hectares | 2,045 | 1,503 | 2,245 | 2,465 | 3,771 | 6,660 | 4,420 | 23,109 |
| Terracing (km) | 295 | 324 | 497 | 387 | 458 | 367 | - | 2,328 |

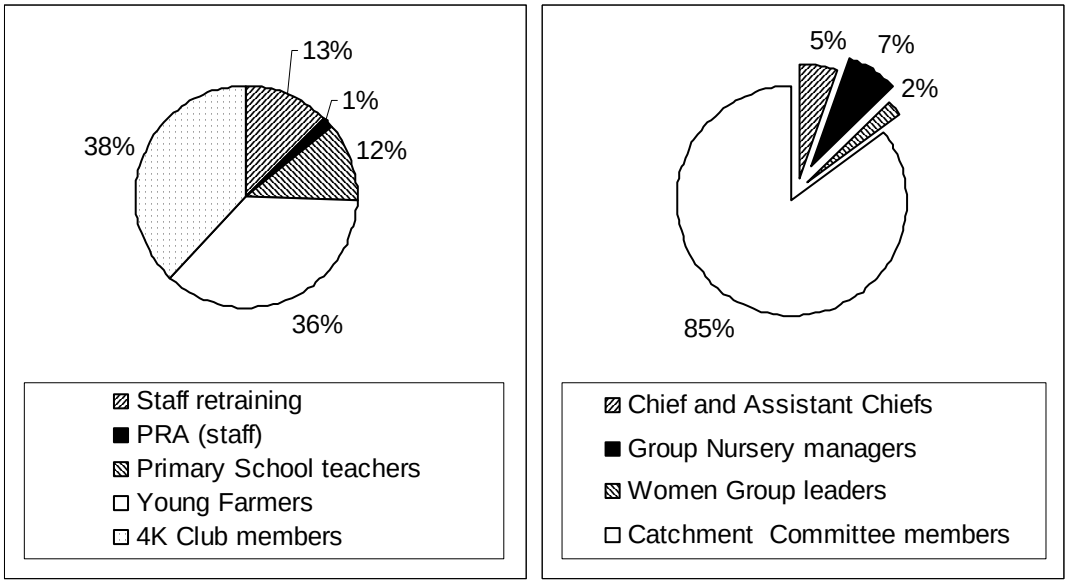
Source: Soil conservation office data, 1999.
*Approximately 55 percent of the achievements are from AEZ 5 and 6 in all years.

*Research, training and extension achievements*

Information on which to base soil management decisions is a prerequisite for sustainable soil management. Experimental work was started at Kampi Ya Mawe in the 1950s to investigate methods of maintaining and improving soil productivity, crop husbandry and pasture management under low rainfall conditions (District informant, 1998). Research carried out here and in Katumani Research Station have contributed to

improved understanding of the soil suitability for dryland farming and the performance of different soil conservation practices.

**Figure 3: Distribution of training achievements**




Source: District Soil Conservation Office, Makueni.

Training and extension in soil and water conservation has been a major external input into soil management initiatives by the farmers. Training started in the 1940s in an effort to build local capacity to planning, implement and supervise soil and water conservation activities. Training and extension activities have benefited from donor funded programmes such as the MIDP, NSCWP and MAP. The training achievements over the last seven years are an indicator of the importance of training and extension in soil and water conservation. Training achievements are subdivided into three categories: staff and the youth training; local leaders; and informal training activities (Table 19 and Figure 3).

*Incentives offered by the programmes*

Incentives are sometimes used as a strategy for promoting soil and water conservation activities. The main incentives provided are food-for-work and the provision of tools. The first strategy is applied in drought years in areas where families are suffering from famine. This is mainly done by NGOs. Provision of soil conservation tools has been a national strategy implemented through the NSWCP, and started in the study area in 1980, under the MIDP. This strategy was withdrawn by the NSWCP in 1997 to reduce dependency. *Jembes* and shovels accounted for the largest number of tools (see Table 20), as they are the main tools used in the construction of cut-off drains and *fanya juu* terraces.

In a cost sharing strategy adopted by MAP for soil conservation, the project contributes technical support and the cost of the initial tools, while the community contributes labour and tools for subsequent work (Kenya, MAP, 1997).

**Table 20: Distribution of tools**

| | Tools issued* | | | | | |
|---|---|---|---|---|---|---|
| *Type* | 1992/93 | 1993/94 | 1994/95 | 1995/96 | 1996/97 | Total |
| Plain *jembes* | 500 | 400 | 190 | 175 | 287 | 1552 |
| Fork *jembes* | 500 | 400 | 190 | 175 | 287 | 1552 |
| Shovels | 500 | 400 | 190 | 175 | 287 | 1552 |
| Local *jembes* | 1,000 | 0 | 0 | 0 | 0 | 1000 |
| *Pangas* | 50 | 30 | 26 | 19 | 49 | 174 |
| Crow bars | 10 | 13 | 26 | 19 | 28 | 96 |
| Axes | 10 | 13 | 26 | 19 | 28 | 96 |
| Mattock | 20 | 13 | 26 | 19 | 28 | 106 |
| Sledge Hammer | 5 | 13 | 26 | 19 | 28 | 91 |

Source: District soil conservation data, 1999.
*Approximately 60 percent of the tools were distributed in AEZ 5 and 6.

## CONCLUSIONS

1. The semi-arid areas of Makueni have not experienced the level of soil degradation reported in Machakos District in the 1930s, owing in part to the gentler slopes and prompt investments in conservation before minor rills developed into gullies. While there are still signs of erosion and patches of highly degraded soils, erosion rates have been reduced to low levels. Soil conservation is practised in all farms, though not in all fields of the farm, and with different levels of effectiveness. This is attributed to high levels of awareness of the importance of investing in soil conservation.

2. Estimates of soil loss in various parts of Machakos and Makueni Districts, usually based on plot measurements, are high and variable. High soil losses occur on land with steep slopes, low ground cover and inadequate soil conservation measures. Soil loss continues to be a problem in grazing land, due to the low level of returns on investments and along roads, foot paths and cattle tracks, as the land affected is considered to be public land. The main negative impacts are siltation of dams and the poor condition of roads during the rainy seasons. Addressing these off-site impacts of soil and runoff loss may require incentives which have been successful in protecting dam catchment areas. The opportunities for reducing this soil loss problem by trapping and utilising runoff along roadsides, footpaths and cattle tracks have not been tapped.

3. In good rainy seasons the crop produces sufficient residue for livestock feed and for use in soil conservation. Crop residues are piled into trashlines on a quarter to a half of all farms. During periods of prolonged drought all the crop residues are used as livestock feed, leaving the soil bare and susceptible to erosion when the rains begin (hence the need for soil conservation structures even in fields with a gentle ground slope).

4. From a quarter to a half of all farmers use contour ridging to control runoff and infiltration. *Fanya juu* terraces and cut-off drains are the most popular technologies, even in areas where slopes are gentle (<5 degrees). There is a 1-10 year lag between initial settlement and construction of soil conservation structures, depending on the perceived soil erosion hazard, farmers' awareness of the impacts and ability to invest in soil conservation. Expansion of conservation was mainly influenced by the availability of labour. Cumulative investments in terraces and drains are in the following ranges: 93-245 man-days/household; 31-58 man-days/ha; and 4,667-8,663 Ksh/ha (estimated using 1998 wage rates). Investments in *fanya juu* terraces and cut-off drains are as a result of the long-term effectiveness of these technologies, which have performed well under extreme weather conditions (both too wet and too dry) experienced in the semi-arid areas.

5. Soil conservation investments on grazing land are low due to perceived low returns. Degraded grazing lands are generally left to recover naturally, particularly where alternative grazing resources can be found. The area of cleared bushland and of improved pasture (planted fodder grasses) increases with the age of settlement/density of population and a shift to more intensive livestock production.

6. High investment in soil conservation reflects individual and community awareness of the negative impacts of soil and runoff loss: reduction of soil fertility, agricultural production, and land value and increased rehabilitation costs, and the positive effects of their investments. As a result of the increasing cost of inorganic fertiliser, farmers are relying more on crop residue management and the reduction of plant nutrient loss (by reducing soil loss). Although the returns on investments are not attained in a short period, the immediate improvements in land productivity, particularly upstream and downstream of the conservation structure, are appealing.

7. The role of communal work in soil conservation is lower in the semi-arid areas than was reported in the high potential areas of Machakos (Tiffen *et al.*, 1994). This is partly attributed to the larger farms and longer distances between homesteads, a shift to the use of hired labour, more social differentiation, and differences in the nature and extent of help required.

8. The lag time between settlement and investment in soil conservation is decreasing, due to the realisation of the benefits accruing to adjacent areas from runoff concentration along *fanya juu* and cut-off drains. Farmers who immigrated from areas where soil conservation is widely used brought with them the conservation tradition. The farmers are responding to crop water stress and getting encouraging results.

9. Government has invested in soil conservation activities in national programmes and with support from external agencies. The main contribution of the Government has been in human resource and institutional capacity building. Donor support has provided the financial resources necessary to mobilise individuals and communities and to adapt different approaches for a more effective soil conservation programme.

10. Legal and regulatory approaches have had a minimal effect, due to the community attitudes towards coercion and the lack of an effective enforcement and deterrent mechanism.

11. Land tenure influences the farmers' time horizons in making long-term investment decisions.

12. There was inadequate data to assess the scale and positive impact of external interventions. There is however a general consensus that the external interventions, particularly those aimed at influencing the farmers' behaviour, have contributed to keeping soil conservation issues high in the farmers' priority list through persuasion rather than coercion, and by providing technical assistance and incentives. Farmers and external interventions are therefore complementary, and when properly synchronised can result in high levels of adoption.

13. Increasing awareness of the importance of soil conservation and provision of technical support and incentives have played a key role in promoting farmer investments in soil conservation. In the future, investments in soil conservation will be based more on increases in productivity and profitability of the farming systems as government and donor interventions decrease. Future soil conservation interventions will have to be components of an integrated intervention package, aimed at increasing productivity and profitability of farming systems.

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