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MONITORING SOIL EROSION IN KIAMBU AND MURANG'A DISTRICTS, KENYA

PROGRESS REPORT
1982 - 1983

NATIONAL ENVIRONMENT SECRETARIAT
MINISTRY OF ENVIRONMENT AND
NATURAL RESOURCES
P.O. BOX 67839
NAIROBI

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IN COOPERATION WITH THE:
ENVIRONMENTAL TRAINING AND MANAGEMENT IN AFRICA (ETMA) PROJECT
OF THE
UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT,
CLARK UNIVERSITY, INTERNATIONAL DEVELOPMENT PROGRAM
AND
SOUTHEAST CONSORTIUM FOR INTERNATIONAL DEVELOPMENT

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PREFACE

In 1982 the National Environment Secretariat embarked upon a project to develop a methodology for assessing the susceptibility of different land uses to soil erosion. The methodology was to provide quantitative data to aid district planners to target their efforts in soil conservation toward the most critical areas. In many respects the methods employed were innovative - involving measurements in farmers' fields rather than formal research plots, and utilizing low-cost, locally manufactured equipment.

A pilot study of the methodology was carried out in Kiambu District during the long rains of 1982. The results were published in:

> Lewis, L.A., G. Kamau and R.C. Cheruiyot. 1983. "Land Degradation Monitoring Programme of the National Environment and Human Settlements Secretariat, Ministry of Environment and Natural Resources, Kiambu District, Kenya: The First Pilot Study". Worcester: Clark University International Development Program.

These results were then used as background to calibrate the methodology in Murang'a District during the long and short rains of 1983. In 1984 the project was expanded to include both districts with a larger number of traps, including several in a controlled experimental plot at the Katumani Dryland Agricultural Research Station.

Part I below reports the results from 1983. Part II reviews the methodology, utilizing comments from several external reviewers and internal assesments. The intention of this section is to provide sufficient documentation on the project and the methodology, such that other agencies could adapt it to their own needs. Part III is a tabulation of the Kiambu and Murang'a data for 1982 and 1983, respectively. A final report based on the 1984 data is in preparation.

The NES/ETMA soil erosion monitoring project has established several things. First, in designing and implementing any quantitative monitoring network, care must be given to a host of technical details. For the system to be respected it must be well documented from the beginning. Particularly where the methods are simplified, the rationale for the approach used must be spelled out and supported with data (if available). Second, local expertise must be involved and trained to provide continuity and initiative in adapting the design to the local (changing) situation. Third, quantitative data on soil erosion is a critical need -- sufficient accuracy can be obtained without expensive equipment. The NES/ETMA project has already provided district officials, policy makers and soil scientists with useful data for their various needs.

The authors of this progress report wish to extend their appreciation to the Government of Kenya and the ETMA project for their support (USAID contract AFR-C 1697). However the findings presented here do not represent their official views.

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Compiled By the National Environment Secretariat:
Thomas E. Downing, G. Kamau and M. Ndonye.

PART I

Progress Report on Assessing Soil Loss in Kiambu and Murang'a Districts

by

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Abstract

Soil loss was measured in Kiambu District during the long rainy season, 1982. From the data gathered during this period, the USLE was calibrated for the agro-ecologic conditions existing in the area. During 1983, soil loss measurements were collected in Murang'a District for the two growing seasons. Using the Kiambu calibrated USLE values, soil loss was estimated also for Murang'a. The significant correlation between the estimated and measured soil loss values indicates that the Universal Soil Loss Equations, as calibrated for Kiambu, gives meaningful estimates in this area of Kenya. Nevertheless, the estimation of the erosivity values at the field level as well as the assessment of the conservation practices need further refinement.

The measured soil loss values in both districts indicate that fields in annual crops, especially cotton and maize, result in the highest soil losses; perennial cash crops result in the lowest soil losses. It appears that approximately 25% of the sampled fields are undergoing land degradation solely due to excessive soil losses. This is especially true in areas of recent agricultural expansion as they generally have higher soil losses than the established farming areas, a result of even more steep marginal lands being brought under cultivation.

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INTRODUCTION

The pilot phase of the National Environment and Human Settlements Secretariat's (NEHSS) soil loss monitoring program began in July, 1981. The initial aim of the program was to develop a method for rapidly assessing soil erosion that could be used throughout Kenya. In addition, it was the intent of ETMA (Environmental Training and Management in Africa) to help train the NEHSS staff that was to work on the soil loss monitoring program. The purposes for developing the soil loss monitoring program were: to provide NEHSS with sufficient information to help it execute its mandate to monitor the state of the national environment; to provide soil erosion information to planners, district officers and operating ministries in Kenya concerned with problems associated with the soil resource; and eventually to evaluate the various interventions being used in Kenya to arrest soil loss.

Specific data for assessing land degradation are in short supply throughout Kenya. It was the goal of ETMA that by the end of 1985, the NEHSS soil monitoring program would be developed sufficiently to permit a continuous estimate of the soil resource status in those portions of the nation which required this information. During 1982 a pilot study was initiated in Kiambu District. The following year the pilot study continued in Murang'a District.

Arbitrary limits of cultivation to prevent land degradation cannot be applied unequivocally to all physical settings found in Kenya. A widely accepted guide is that slopes above 11 degrees (20%) should not be cultivated (Pereira 1982). To protect the rural and urban population downstream, the generally accepted strategy for slopes greater than 45 degrees is to maintain the existing forest cover, and to replant trees as soon as possible on lands that have been cleared. However, in Kiambu and Murang'a Districts, because of a shortage of available land and the rapidly increasing population in the rural areas, many farmers cultivate lands in excess of 11 degrees. Further, land clearing on steep lands rather than tree replanting is the normal trend in Kenya. It is the steeper slopes that are the largest remaining reservoir of non-cultivated land in the humid zones of this area. This report details the findings of the first two years of the NEHSS soil loss monitoring program. It also suggests how the data should be collected.

Given the limitations of personnel and equipment, a few important changes in the methodology used during the first two years are being introduced during the third year (1984) of data collection. First, the reliance on rainfall data gathered specifically for the soil loss monitoring needs is being phased out. Results from the second year's pilot study indicate that using the monthly rainfall data being collected by the Kenya

Meteorological Service throughout Kenya will result in better estimates of erosivity than those previously obtained with ETMA rain gauges. Second, it is crucial to integrate field personnel from other ministries, especially the Ministry of Agriculture and Livestock Development, if the soil loss monitoring is to go beyond the pilot stage. If the monitoring is to be extended to other districts, agricultural field personnel will be the key individuals gathering the soil loss data. During the third year of the pilot phase, these collaborative procedures with the Ministry of Agriculture and Livestock Development have been initiated and further strengthening of this cooperation are recommended for subsequent years.

Study Area

Kiambu and Murang'a Districts lie immediately north of Nairobi (Fig.1). Within both Kiambu (2,448 sq.km.) and Murang'a (2,476 sq.km.) are a set of diverse physical conditions including humid to semi-arid climates, flat to steep lands, and excellent to poor soils. These diverse conditions result in a wide range of agro-ecological zones that include in their spectrum agricultural lands from high to low potential (Jaetzold and Schmidt 1983). Also a diversity of farm types exist from large export oriented farms (coffee, flowers, tea) extending for hundreds of hectares in areal extent to small farms less than one hectare and largely subsistence in productivity

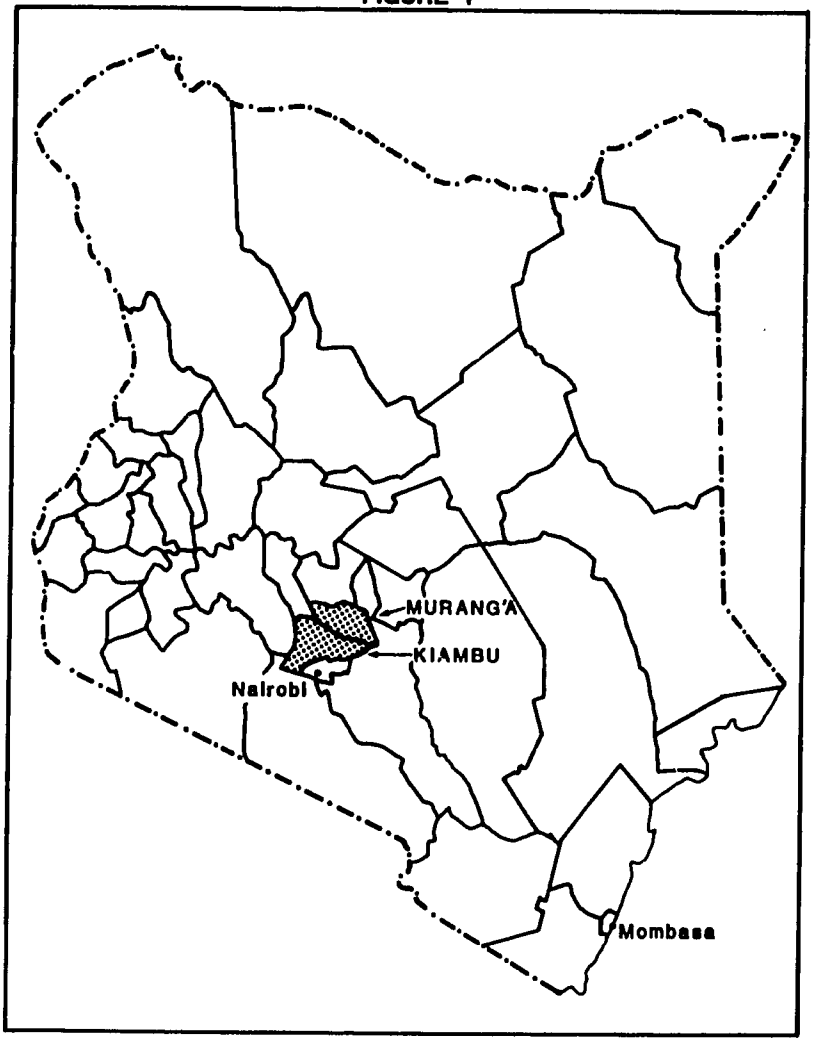
Temperatures reflect the tropical location and altitude of the land. At the Gatare Forest Station (2,590 m) the mean annual temperature is 12.3° C with an annual mean range of 9.8° C; at the Tana Power Station (1,060 m) the mean annual temperature is 22.3°C with an annual mean range of 12.6° C. Average annual precipitation in these districts roughly approximates the general elevation of the land. It reaches a maximum of 2,700 mm at 2,500 m in the northwest and decreases toward the southeast to 600 mm at 1,100 m (Fig 2). Two-peak rainfall seasons are considered the norm for the entire area. The 'long' rains begin usually in late March and decrease in frequency toward the end of May and early June. The 'short' rains occur from mid-October through December and generally are not as reliable as those in the 'long' rainy season.

Almost all of the annual and perennial crops grown in the district require a growing season longer than the length of the rainy seasons. Thus the moisture storage capacity of the soils must remain high if crop yields are to attain satisfactory levels. Selective removal of the finer soil components by erosion must be minimized to maintain the soils' high moisture storage potential.

Data Collection

Because most individuals in the Ministry of Environment and Natural Resources indicated that the highest soil erosion occurs during the long rains, field data were collected only for this

FIGURE 1



period in the first year. This was an unfortunate decision as during the short rains in 1982, important soil loss occurred. As a result, during the second year of the pilot phase, when monitoring was extended to Murang'a District, it was decided to take measurements during both rainy seasons.

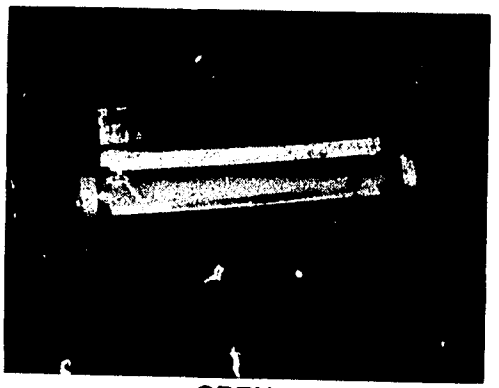
Over the two years, soil loss was measured during three periods. In Kiambu District measurements began in March, 1982 prior to the start of the long rains and ended in early July, by which time the long rains had ceased. In Murang'a, field measurements occurred from March to July, 1983 (the long rains) and from October through the middle of December,1983 (the short rains). To ensure that all of the diverse agricultural settings found in the districts were monitored, within the constraints of the sample size, field sites representative of the different conditions in the districts were identified. During the first year (Kiambu) the sites were determined both by reconnaissance and information provided by the district agricultural officers (Lewis, Kamau, and Cheruiyot 1983). During the second year (Murang'a) there was a two stage procedure that will continue to be used by NEHSS in the future. First, all of the major agro-ecological zones found in the district (Jaetzold and Schmidt 1983) were identified. Second, specific sites within each of these agro-ecological zones were then chosen using specific information provided by the district agricultural officers. By using this two stage procedure, most typical settings found within the district are monitored including: climatic conditions, soil conditions, crop types, farm sizes, topographic features, and quality of the farmers (Table 6).

Four automatic recording rain gauges (Belfort Model 5-780 300MM) were installed in the district during the period of soil loss measurements. In Kiambu they were in Gatundu, Kiambaa, Kikuyu, and Lari Divisions; in Murang'a they were in Kandara, Kangema, Kahuru, and Makuyu Divisions. In addition, data from the existing rain gauge at the Kenyan Agricultural Research Institute (KARI) in Muguga were available for the Kiambu study.

Soil traps were placed in 27 individual fields on 12 farms in Kiambu District; in Murang'a District the soil traps were placed in 26 individual fields on 15 farms (Fig. 2). The soil traps are modifications of the sedimer' trough developed by Gerlach (1967). The major modification is that PCV pipe was used instead of sheet metal in the construction of the lower portion of the trap because of ease of contruction, lower costs, and greater ruggedness (Fig. 3, Appendix I). Each trap, 50 cm wide and 110 mm in diameter, was installed at the lower limit of a field or terrace accordiag to the procedures described by Gerlach. The length of each field or terrace was determined by direct measurement; the width of the trap catchment area was assumed to be the width of the trap; and slope angles were measured along the slope segment immediately above the trap. The soil samples used to determine the erodibility value for each field were taken one meter upslope from

6'

FIGURE 3



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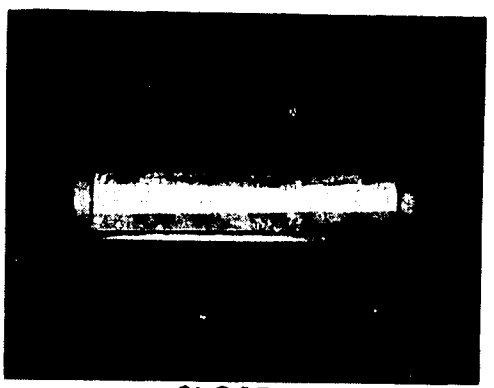

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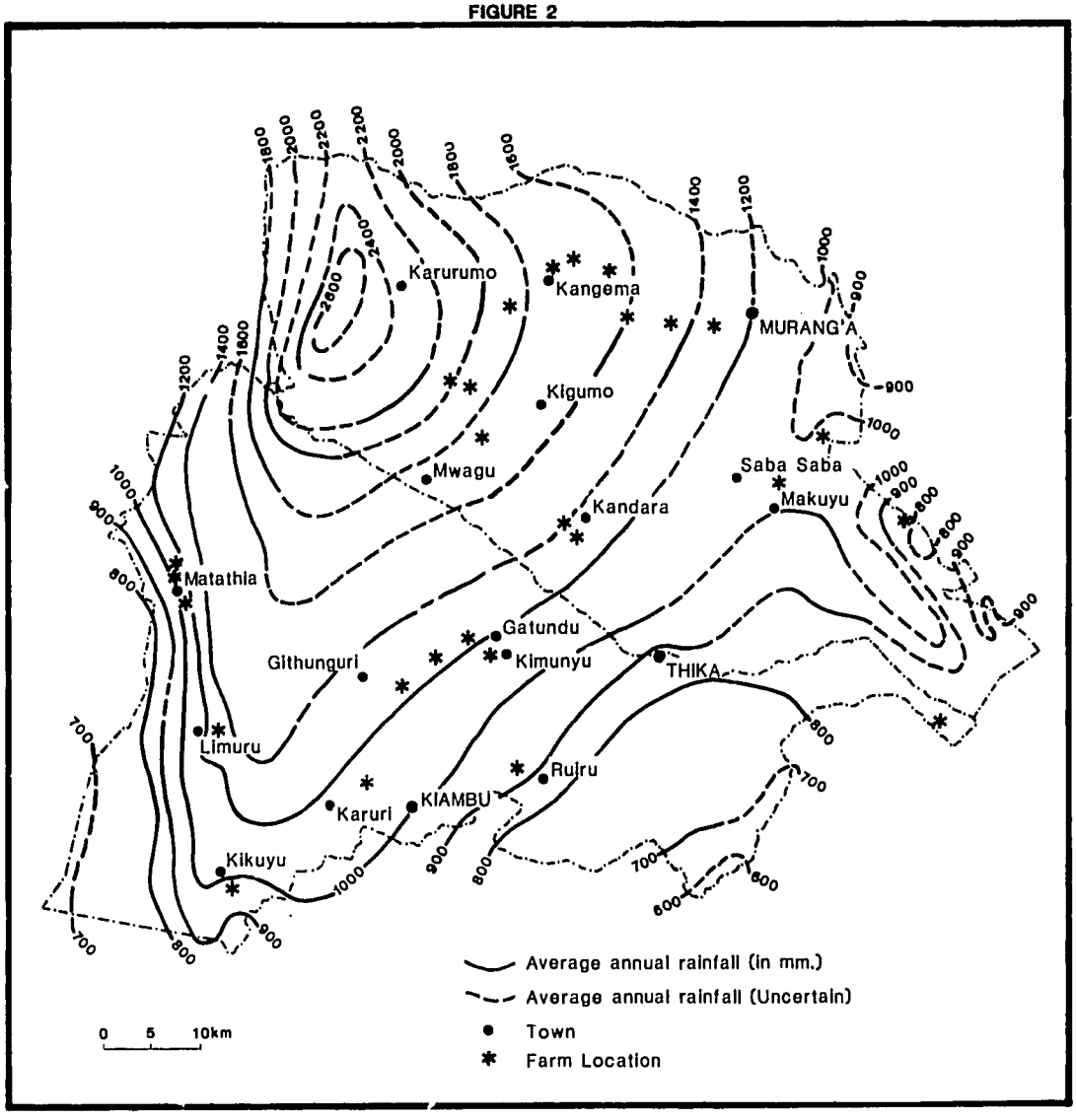
FIGURE 2


Karurumo
Kangema
MURANG'A
Kigumo
Mwagu
Saba Saba
Makuyu
Kandara
Matathia
Gatundu
Kimunyu
Githunguri
THIKA
Limuru
Ruiru
KIAMBU
Karuri
Kikuyu
Average annual rainfall (in mm.)
Average annual rainfall (Uncertain)
Town
Farm Location
0 5 10km

the soil traps at the beginning of the growing season. The soil samples were from the upper decimeter of the soil.

Assessing Soil Erosion

The Universal Soil Loss Equation (USLE) is the most comprehensive technique available for field use in estimating average cropland erosion. It is the most widely used equation for the prediction of soil loss resulting from rill and sheet erosion as well as for the evaluation of soil conservation techniques (Wischmeier and Smith 1978). The USLE is defined as:

$$A = 2.25\ RKLSCP$$

where

2.25 = conversion from English units into metric units.
A = average annual soil loss in mt/ha
R = rainfall - erosivity factor
K = soil erodibility factor
L = slope length factor
S = slope steepness factor
C = crop cover and management factor, and
P = conservation (support) practice factor.

The constraints in studying soil erosion in Kenya are similiar to those in most tropical countries. A number of earth scientists have applied the USLE throughout the world. But despite its name, the USLE is empirically derived solely from data measured in the United States. The USLE is increasingly being applied to tropical areas (El-Swaify, Dangler, and Armstrong 1982). But climate, soils, agricultural systems, land under cultivation--especially very steep land--and conservation practices differ markedly from the phenomena upon which the USLE was developed. Therefore data need to be obtained and assembled in order to permit the USLE's utility to be expanded under these different conditions. The data obtained in Kiambu and Murang'a permits some of the conditions that are found in many tropical areas to be evaluated in a format that can be used in the USLE.

For most of Africa, problems arise in applying the USLE when trying to assign values for the R, K, C, and P factors from the published standards. These problems exist largely because of fundamentally different natural and human environmental conditions on most African farms compared to North American farmlands. Because of intensity and duration differences of rain events in most tropical areas compared to middle latitude areas, often there is a need to substitute for the rainfall-erosivity factor used in

the USLE (R) with other measures such as the AI value (Lal 1976), and the E value (Elwell 1980), where:

AI = the product of the 7 1/2 minute maximum rainfall and the total rainfall, and
E = the value of mean seasonal energy.

Both of these measures require data that are not readily available in Kenya or the rest of Africa.

Because most tropical soils have an absence or low percentage of very fine sands and silt sized particles (Tricart 1972, the use of the USLE soil erodibility nomograph developed to estimate this variable would likely result in values that fall outside the ranges covered by the nomograph (El-Swaify and Dangler 1977). In consideration of human activities (C and P values) the widespread differences in many African agricultural farming systems, including both crops and management, compared to mid-latitude farming systems require a separate evaluation of the African systems. Most African farming systems have not been evaluated for the USLE. Thus, no published values exist for most cases found in Kenya. Similarly, because of differences in the crops and the lands under cultivation, the values assigned for specific conservation practices need to be assessed in the African context. This is particularly true for many of the environmental situations found in Kiambu and Murang'a Districts where cultivated lands on slopes greater than 11 degrees are common. The conservation practices required on such lands are not calibrated for the USLE in published materials, as lands this steep are rarely farmed in countries such as the United States where mechanized farming is the norm.

Because of the differences in the environmental and agricultural situations in Kenya, it was necessary to actually measure soil loss through the installation of soil traps for the various agricultural conditions that exist in the Kenyan Highlands. From these data some tentative values for the existing conditions are presented. The values derived from the Kiambu data during the first year of this project were then applied to the field sites in Murang'a to estimate soil loss. A comparison of the estimated and measured soil loss values in Murang'a confirm the validity of the Kiambu data and suggest that the values developed in Kiambu could be extended to the conditions found in other parts of Central Province.

DATA ANALYSIS

In both Kiambu and Murang'a, soil loss samples were collected on a weekly basis rather than the usual practice of data collection after each rain event. This difference in data collection was necessary because of monetary, transportation, and personnel constraints. These constraints are likely to remain or increase in the future and are therefore recommended to continue as routine data collection procedures. However, if these

constraints become less, then data should be collected after each rain event.

Estimating Rainfall Erosivity

Precipitation data for all of the locations had to be inferred from the four rain gauges which NEHSS installed (plus the KARI rain gauge for the Kiambu sites). Because of security considerations, the rain gauges could not be located directly in the fields being monitored. As the derived R-values used in the USLE in this study are based on these precipitation data, this introduces a possible error in the predicted soil loss values due to the local nature of individual rain events. However, as the rainfall values used in this study are combined for growing seasons, the measured rainfall at the four NEHSS locations are indicative of the general precipitation patterns experienced during the study periods. Originally rainfall values obtained in the field were to be used directly to derive R-values used in the USLE (Lewis, Kamau, Cheruiyot 1983). However because of the costs of the rain gauges and the need for individuals to monitor them on a daily basis, this was not a good long term strategy for NEHSS. An alternative was to compare the rainfall measured in the field to the published average annual rainfall for the district (East African Meterological Dept. 1966). This proportion was then used to weight the estimated average annual R-values derived using the method presented by Moore (1979)(Table 1). The relative success of this approach means that in the future NEHSS will not need to collect precipitation data having rainfall intensity, but will be able to use the monthly rainfall data already being collected throughout Kenya. The use of the existing rainfall network will allow the average R-values to be weighted at a more local scale than that previously permitted with the 4 NEHSS rain gauges .

It must be emphasized that the data Moore used in his study were limited to only 35 stations in all of East Africa, and only one of these was in either Kiambu or Murang'a (Nairobi-Kabete-Kiambu District). Thus the R-values used for Murang'a and Kiambu are considered only approximations of the actual erosivity. Nevertheless the soil loss estimates using these estimated R-values produced meaningful results. However this approximation of R-values for specific locations undoubtably is a cause of some of the unexplained variation between the estimated and measured soil loss values.

Estimating Relative Soil Erodibility

No published data for representative K-values (erodibility) exist for any soils found within Kiambu and Murang'a Districts. Only three K-values to date have been determined in the study area (Gachene, personal note). To estimate the K-values for the sample sites in Kiambu, seven soil samples from fields in each division were collected for mechanical analysis. Soil sizes and texture properties were classified using standard U.S. Department of Agriculture criteria. The relative K-value derived for each division was then assigned to all of the sites in that area. With the intent of improving the predictability of the USLE, in

Table 1

Estimated R-values for Kiambu and Murang'a

District	Division	Average Annual Rainfall (mm)	Estimated Average Annual R-value*	Year	Measured Rainfall/ Average Rainfall	Growing Season	Est. R-value Field Period
Kiambu	Gatundu	1250	242	1982	0.74	Long	90
	Githunguri	1250	242	1982	0.74	Long	90
	Kiambaa	1000	212	1982	0.80	Long	133
	Kikuyu	1000	212	1982	0.94	Long	100
	Lari	1300	248	1982	0.69	Long	85
	Limuru	1300	248	1982	0.69	Long	85
	Thika	800	189	1982	0.80	Long	75
Murang'a	Kindara	1300	248	1983	0.67	Long	90
						Short	75
	Kiharu	1100	224	1983	0.67	Long	80
						Short	70
	Kigumo	1600	284	1983	0.32	Long	40
						Short	50
	Makuyu	900	201	1983	0.40	Long	35
						Short	45
	Kangema	1700	296	1983	0.88	Long	140
						Short	120

*Estimated average annual R-value derived by: R=(3.96x3122)(0.03) (Moore 1979, p. 153, 155).

Murang'a soil samples were obtained at each of the 26 sites (Appendix 4). To determine the organic content of the soils, after the mechanical analysis, the soil samples were heated first to 110 degrees celcius for 6 hours to remove all residual moisture. They were then heated to 240 degrees Celcius for 24 hours to remove the organic matter. They were weighed before and after the final heating to determine the percentage of weight loss (Table 2). The K-values were then derived using the standard formula for soils that have silt fractions less than 70 percent (Wischmeier and Smith). This formula is probably invalid for many tropical areas due to the generally low concentration of silts in soils. However, because of the highland nature of the study area and the large percentage of relatively young volcanic soils in the two districts, enough silt and fine sands (0.002 to 0.1 mm) were generally present in the soils to allow the use of the formula. Only the soils in Lari Division had no measurable silt component. The derived K-values range between 0.18 to 0.38, and 0.08 to 0.31 for Kiambu and Murang'a districts respectively (Table 2). These values are in the range of K values obtained in Hawaii (Wischmeier and Smith 1978) and slightly higher than those obtained at Kabete (Gachene 1984 personal communication). The low magnitude of K-values in both districts indicate that the soils in the study area have a low susceptibility to erosion.

Estimating The Crop Cover And Conservation Practice Factors

In a preliminary analysis of the Kiambu data (Lewis, Kamau, and Cheruiyot 1983), a few basic relations between crop type and soil loss became evident. First, fields in perennial crops generally had the lowest soil losses; second, lands cultivated under maize produced the highest soil losses; and third, fields having cash crops had lower soil losses than fields in subsistenc crops. From these observations relative C-values (Table 3) were assigned for the crops based on published C-values (Wischmeier an Smith 1978) and the relative measured soil loss for the crop type in Kiambu. The identical values are used for estimating soil los in Murang'a since the farming systems in both districts are identical.

It must be emphasized that the C-values presented in this paper have been empirically derived and while they appear to be valid for Kiambu and Murang'a, more data need to be obtained before they can be applied elsewhere. The additional data being collected in 1984 in Kiambu and Murang'a will permit the C-values to be further refined in the next report. Some of the C-values presented in this paper differ greatly from the published values for similiar crops in the U.S.A. For example, tobacco's C-value is much larger in Kenya. This most likely reflects the differences in cropping practices between the commercial tobacco farmers in the U.S.A. and the small Kenyan farmers. In Kenya th spacing between the plants is larger and a large percentage of t soil is exposed to the direct impact of rain drops as ground cov is very slight. This difference in the C-values illustrates the need for extreme care when applying the USLE in countries using

Table 2

Derived K-values for field sites in Kiambu and Murang'a Districts

Site	Percent Organic	K-value	Site	Percent Organic	K-value	Site	Percent Organic	K-value
Kiambaa	6.2	0.20	Gatundu	5.3	0.27	Lari	3.5	0.25
Kikuyu	6.9	0.18	Githunguri	3.1	0.27	Limuru	5.1	0.26
			Thika	4.6	0.38			
**********								
1M.	2.6	0.24	10M.	2.6	0.10	19M.	1.6	0.10
2M.	1.6	0.12	11M.	5.4	0.19	20M.	5.8	0.08
3M.	4.1	0.12	12M.	8.0	0.08	21M.	3.6	0.08
4M.	5.3	0.08	13M.	4.0	0.08	22M.	4.3	0.08
5M.	4.4	0.08	14M.	4.2	0.08	23M.	4.3	0.08
6M.	5.0	0.08	15M.	2.1	0.10	24M.	5.4	0.08
7M.	6.6	0.08	16M.	2.6	0.10	25M.	2.3	0.10
8M.	3.7	0.08	17M.	1.7	0.10	26M.	4.9	0.08
9M.	5.3	0.08	18M.	1.0	0.31			

Note: M = Muranga. Site numbers refer to Table 6.

Table 3

Estimated C-values

Crop	Estimated C-value
Bananas	0.10
Beans	0.22
Chick Peas	0.40
Coffee	0.02
Maize	0.49
Pear and Plum Trees	0.02
Pyrethrum	0.25
Vegetables (cash)	0.22
Vegetables (subsistence)	0.35
Cotton*	0.89
Tea*	0.02
Tobacco*	0.65
Yams*	0.22

*Crops monitored in Murang'a but not Kiambu.

farming practices that differ significantly from those in the U.S.A. Published values for specific crops derived in the U.S.A. are not necessarily valid in Third World countries for identical crops due to different planting procedures.

Five categories of conservation practices have been developed for the assignment of P-values (Table 4). The types of conservation practices observed in the study area are: terracing, mulching, cut-off trenches, and grass strips. While it appears that mulching and terracing are the most effective conservation practices, the data available are insufficient to evaluate or rank the effectiveness of individual practices. The quality of the conservation practices in Kiambu and Murang'a were either adequate or of poor quality. The practice was considered of poor quality when a terrace or cut-off was in disrepair, the mulch cover was not complete and bare soil was exposed, or the grass strip was not continuous. Whenever a field had at least two conservation practices, they were always of "adequate quality." The P-values in Table 4 were derived for Kiambu and used the following year in Murang'a. While they were considered preliminary estimates, until more data are available they too appeared valid for conservation practices in central Kenya.

The Slope-Length Factors

The slope and length factors are measured in the field using standard procedures. In the computation of the USLE they are combined into a single topographic factor (LS):

where $LS = (y/72.6)^m (65.41 \sin^2 + 4.56 \sin\theta + 0.065)$;
y = slope length in feet;
θ = angle of slope; and
m = constant for slope class angles.

Because steep slopes are cultivated in the study area far in excess of what is evaluated in the normal application of the USLE, additional values are needed for the m exponent in the LS equation for steep slopes (Wischmeier and Smith, 1978). Foster, Meyer, and Onstad (1977) have already done this for steep slopes under construction. Under U.S. agricultural conditions the m exponent is always 0.5 or less. Table 5 presents the values used for Kiambu and Murang'a.

Results

Table 6 lists the properties and the measured and estimated soil losses for the field sites. The estimated soil loss values were determined using the USLE from the values presented in the previous section; they represent the expected long-run average soil loss values for the conditions found at the sites. The measured soil loss values reflect the site specific interaction of the six independent variables as they existed during the study periods.

Measured soil loss values during the long rainy season in Kiambu ranged between 1.0 to 57.4 mt/ha. In Murang'a, soil loss values ranged between 0.1 to 118.3 mt/ha in the long rainy season and 0.1 to 51.2 mt/ha during the short rainy season. In Kiambu

Table 4

Conservation factor P-values

Category	P-value	Criteria*
None	0.70	No evidence of any conservation
Poor	0.50	1 practice-poor quality
Fair	0.40	1 practice-adequate quality
Good	0.35	2 practices-adequate quality
Excellent	0.25	3 practices or more

Table 5

M exponent values for topographic (LS) factor

Slope (Degrees)	M Exponent Value
0.0 - 1.0	0.2
1.1 - 1.5	0.3
1.6 - 2.0	0.4
2.1 - 7.0	0.5
7.1 - 14.0	0.6
greater than 14.0	0.7

Table 6

Properties of field sites and soil loss values for Kiambu District

Site		Farm	Slope in Degrees	Length in Meters	Terrace Slope in Degrees	Crop(s) Cover/ Crop Second Season	Year	Soil Loss Long Season (mt/ha/season) Actual	Soil Loss Long Season (mt/ha/season) Est.	Soil Loss Short Season (mt/ha/season) Actual	Soil Loss Short Season (mt/ha/season) Est.
1K.	Kiambaa	1	3	25		Irrigated Coffee	1982	<1.0	0.0		
2K.	Kiambaa	2	18	3	2	Irrigated Cofee	1982	1.6	0.3		
3K.	Kiambaa	2	22	3	2	Irrigated Coffee	1982	1.1	0.3		
4K.	Kikuyu	3	20	7		Irrigated Cabbage	1982	3.9	1.8		
5K.	Kikuyu	3	11	10		Irrigated Cabbage	1982	1.2	0.5		
6K.	Kikuyu	3	12	5		Maize	1982	39.6	17.7		
7K.	Lari	4	45	2.5		Potatoes	1982	25.8	22.1		
8K.	Lari	4	20	4		Mixed Vegetables	1982	10.3	10.9		
9K.	Lari	5	20	18		Pyrethrum	1982	7.8	10.9		
10K.	Lari	5	15	17		Maize	1982	11.5	8.4		
11K.	Lari	6	20	6	10	Cabbage, Kale, Potatoes	1982	6.2	5.4		
12K.	Lari	6	16	6	8	Mixed Vegetables	1982	9.7	6.9		
13K.	Limuru	7	14	28		Plums	1982	1.1	0.7		
14K.	Limuru	7	11	10		Pears	1982	1.0	0.6		
15K.	Limuru	7	15	10		Pears	1982	1.5	0.8		
16K.	Githunguri	8	3	3		Tomatoes	1982	1.0	0.4		
17K.	Githunguri	8	10	4		Bananas, Beans	1982	5.3	6.6		
18K.	Githunguri	8	11	4		Coffee	1982	1.0	0.7		
19K.	Githunguri	9	4	6		Maize	1982	16.5	13.0		
20K.	Githunguri	9	6	31		New Coffee, Beans	1982	13.1	17.5		
21K.	Gatundu	10	20	4	15	Maize	1982	57.4	34.2		
22K.	Gatundu	10	20	3	15	Maize	1982	24.7	34.2		
23K.	Gatundu	11	9	3		Mixed Vegetables	1982	11.2	9.0		
24K.	Gatundu	11	12	2	1	Coffee	1982	4.1	2.2		
25K.	Thika	12	9	7	7	Beans	1982	22.9	24.1		
26K.	Thika	12	9	7	7	Beans	1982	11.4	24.1		
27K.	Thika	12	10	5	7	Chick Peas	1982	6.5	9.9		

Site		Farm	Slope in Degrees	Length in Meters	Terrace Slope in Degrees	Crop(s) Cover/ Crop Second Season	Year	Soil Loss Long Season (mt/ha/season) Actual	Soil Loss Long Season (mt/ha/season) Est.	Soil Loss Short Season (mt/ha/season) Actual	Soil Loss Short Season (mt/ha/season) Est.
1M.	Kandara	1	30	12		Tea	1983	0.1	1.3	0.1	0.6
2M.	Kandara	2	19	4		Maize	1983	56.8	18.3	9.9	8.4
3M.	Kandara	2	17	7		Maize	1983	25.5	12.5	0.4	5.8
4M.	Kandara	3	14	16		Coffee	1983	0.1	2.4	0.1	1.1
5M.	Kandara	3	16	11		Coffee	1983	1.4	3.5	0.2	1.6
6M.	Kiharu	4	7	1		Coffee	1983	3.0	0.4	0.3	0.2
7M.	Kiharu	5	23	7		Yams	1983	7.4	9.0	0.8	4.1
8M.	Kiharu	6	46	5		Maize	1983	16.3	19.3	1.5	8.7
9M.	Kiharu	7	40	5		Bananas	1983	11.3	3.8	0.5	1.7
10M.	Kangema	8	47	3		Tea	1983	1.4	0.4	0.1	0.2
11M.	Kigumo	9	46	23		Tea	1983	2.1	1.4	0.3	0.7
12M.	Kigumo	9	43	21		Tea	1983	4.2	1.0	0.1	0.5
13M.	Kigumo	10	7	1	2	Coffee	1983	0.9	0.0	0.0	0.0
14M.	Kigumo	10	30	9		Maize	1983	1.8	4.2	0.4	1.9
15M.	Kigumo	10	6	2		Maize	1983	4.4	0.6	1.4	0.3
16M.	Makuyu	11	18	1		Tobacco/Maize	1983	118.3	4.8	27.9	2.1
17M.	Makuyu	11	18	6		Cotton/Fallow	1983	32.5	10.2	3.1	4.6
18M.	Makuyu	12	13	15		Cotton/Fallow	1983	6.6	4.7	5.0	2.2
19M.	Makuyu	12	7	16		Maize	1983	2.7	4.2	0.0	2.0
20M.	Makuyu	13	6	7		Coffee	1983	0.2	2.6	0.0	1.2
21M.	Makuyu	13	9	6		Coffee	1983	23.1	4.2	0.0	1.9
22M.	Kangema	14	11	3		Coffee	1983	4.1	3.7	5.2	3.4
23M.	Kangema	14	8	6		Maize	1983	12.2	5.1	0.7	2.4
24M.	Kangema	15	20	9		Maize	1983	10.0	32.5	1.9	15.0
25M.	Kangema	15	10	10		Coffee	1983	0.1	0.6	0.3	0.3
26M.	Kangema	8	30	14		Coffee	1983	5.4	11.5	0.1	5.3

the highest soil losses were from fields planted in maize. The lowest soil loss from any field in maize was 11.5 mt/ha (site 10).

Of the nine fields having over 9 mt/ha of soil loss during the long rains in Murang'a, 5 were in maize, and one each is in tobacco, cotton, newly planted coffee, and bananas. The lowest soil loss values were generally found in fields under coffee and tea. One exception to these generalizations was site 14 which was under maize and produced a low soil loss (1.4mt/ha). No obvious difference to account for this low soil loss was detected. During the short rains two fields experienced soil losses of nine tons or greater. One of these was under maize and the other in tobacco/maize..

In both Kiambu and Murang'a a consistent pattern of high soil loss from fields under annual subsistance crops emerges. In general, maize, results in the highest soil loss while perennial cash crops have the lowest soil loss. However, when perennial cash crops are grown on very steep fields as at site 26 in Murang'a, they too result in high soil loss. Because of the size of the sample, it is difficult to evaluate the specific conservation practices under field conditions. This is especially true since most fields that were mulched utilized other practices too. However from visual observations it appears that mulching is a very important practice. Likewise as soil loss increases on steep slopes even when they are under permanent crops, it seems that terracing needs to be a prerequisite for cultivation on the steeper slopes.

While soil losses were higher during the long rains than during the short rains, significant soil loss at some of the sites took place during the October through December period. Unfortunately no measurements were made in Kiambu district during the sort rain period of 1982, which was wetter than that of 1983. But from observations during that period,it appeared that important soil loss also did occur. In order to obtain an accurate assessment of soil loss, it is necessary to take measurements during both long and short rain periods.

No assessment was made in this study of the long term effect of soil loss on soil productivity in either Kiambu or Murang'a. However, the large soil losses experienced on some of the fields during the study period indicate that land degradation is likely to be occurring throughout the area. The concept of soil tolerance is defined as the maximum level of soil erosion that will permit a high level of crop productivity to be sustained indefinitely. The highest soil tolerance documented in Africa is 12.5 mt/ha/yr in the Central African Republic (Hudson 1972). Using this conservative value for Kenya indicates that 14 out of the 53 sites in this study are undergoing declines in their productivity solely due to excessive soil losses. If the actual soil tolerance level is less than this maximum value at some of the sites, then even more locations are undergoing decline in their productivity.

The USLE as used in this study was calibrated using data gathered in Kiambu during 1982. The correlation coefficient between the estimated and measured Kiambu soil loss values was 0.85 ($n=27$; $p < 0.001$) (Fig.4). Given that the measured data were used to calibrate the USLE for the conditions found in Kiambu, a high correlation would be expected. When the Kiambu derived values were used in Murang'a, a greater scatter occurred (Table 6, Fig.5). The correlation between the Murang'a annual estimated (USLE) and the measured soil loss values was 0.53 ($n=25$; $p < 0.01$). One likely cause of the scatter is the method used in assigning R-values (erosivity factor) for the study sites. Identical R-values were given to all fields situated in the same division based on the measured rainfall at the gauge site. This procedure was valid in Kiambu as each division is relatively homogeneous. In Murang'a, it appears less valid since most of the divisions are more humid toward the northwest and become drier toward the southeast.

Even if the calibration of the USLE, as presented here, is completely valid for conditions in the Central Highlands, unless erosivity is measured at each site, some variability between the field measured soil loss and that estimated by the USLE would be expected due to the local nature of individual rain events unless erosivity is measured at each site. When combining the Kiambu and Murang'a data, the correlation is 0.68 ($n=52$; $p < 0.001$) (Fig. 6). Given the high level of significance, for most locations, the values predicted by the USLE give a good estimate of the overall soil loss conditions throughout Kiambu and Murang'a. In the future this project will use more site specific estimates of the R-values in order to improve the soil loss estimates of the USLE in Kenya. This will be accomplished by integrating the existing rainfall network data in the estimates of site R-values Additionally, with the additional data obtained.

CONCLUSIONS

The measurement of soil loss in Kiambu and Murang'a indicates that fields in annual crops experience the greatest erosion. Of the annual crops, cotton and maize result in the highest soil loss. While the generalization relative to cotton is based on only two fields, this is likely a valid conclusion since the crop provides very little ground cover. Thus considerable bare soil is exposed directly to the rain. The lowest soil loss occurs in fields having perennial cash crops. Today agricultural expansion is occurring primarily in areas of steep slopes. Vegetation cover is undergoing rapid change in these newly settled areas. The trend is from forest and woodlots to annual crops. The data in this study strongly suggest that increasing soil erosion is occurring in these areas. Even with conservation practices such as terracing, the soil loss values are generally high in these newly cultivated areas. In both 1982 and 1983 there was less than average rainfall in Kiambu and Murang'a. Yet approximately 26% of the study sites experienced soil loss values in excess of 12.5

Figure 4

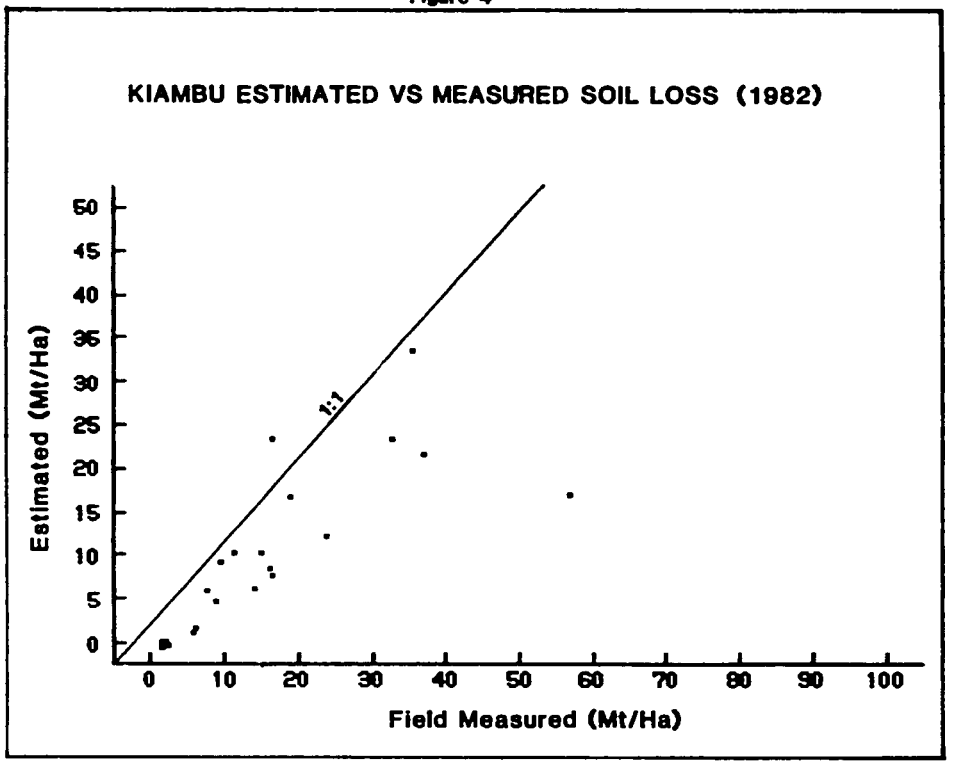

KIAMBU ESTIMATED VS MEASURED SOIL LOSS (1982)
Estimated (Mt/Ha)
50
45
40
35
30
25
20
15
10
5
0
1:1
0
10
20
30
40
50
60
70
80
90
100
Field Measured (Mt/Ha)

Figure 5

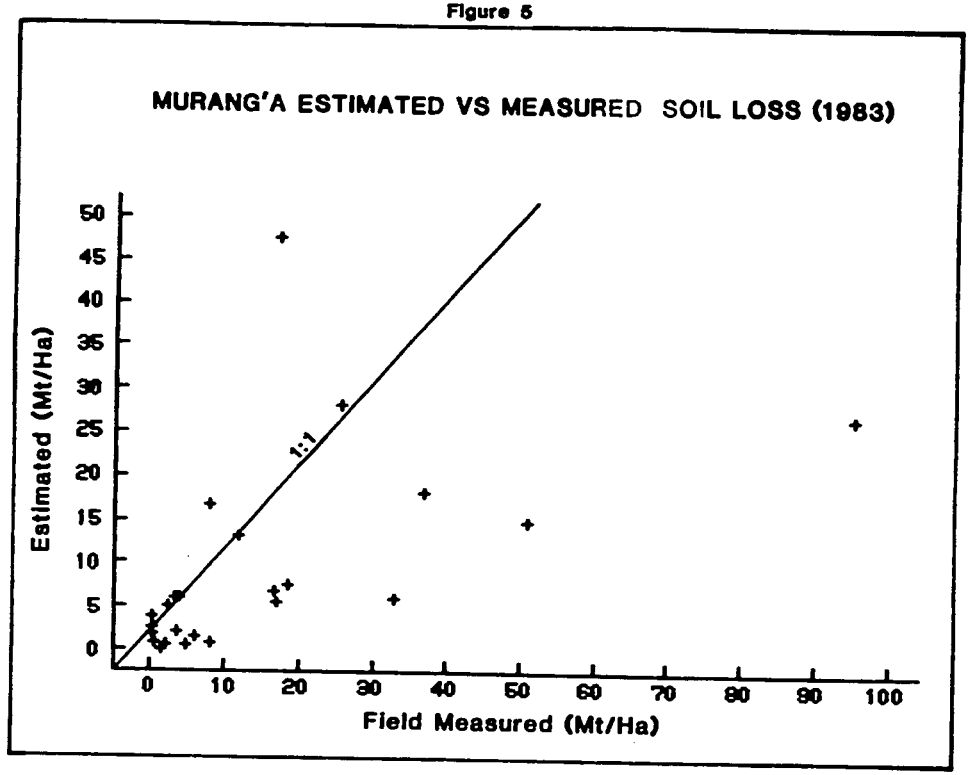
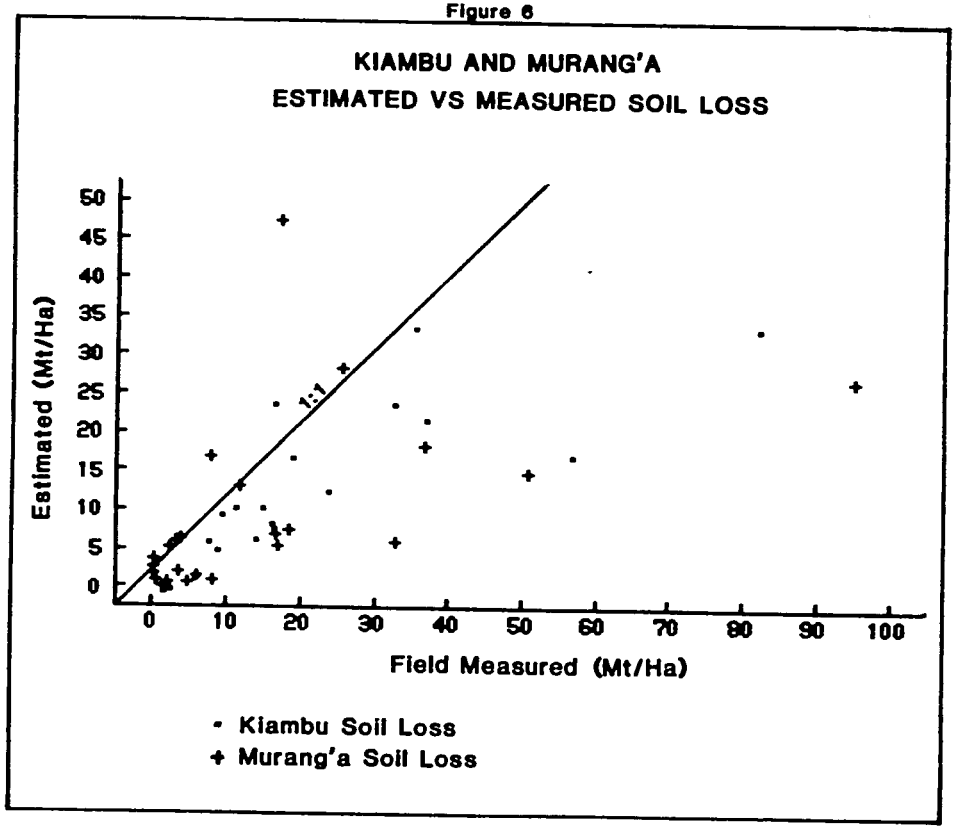

MURANG'A ESTIMATED VS MEASURED SOIL LOSS (1983)
Estimated (Mt/Ha)
50
45
40
35
30
25
20
15
10
5
0
1:1
0
10
20
30
40
50
60
70
80
90
100
Field Measured (Mt/Ha)

Figure 6


KIAMBU AND MURANG'A
ESTIMATED VS MEASURED SOIL LOSS
Estimated (Mt/Ha)
50
45
40
35
30
25
20
15
10
5
0
1:1
0
10
20
30
40
50
60
70
80
90
100
Field Measured (Mt/Ha)
• Kiambu Soil Loss
+ Murang'a Soil Loss

mt/ha/yr. It is safe to assume that erosion rates will be even higher when rainfall is average or above average. Thus significant erosion likely to affect productivity exists in this high potential agricultural area of Kenya..

The fields that experienced the lowest soil losses were sites that were heavily mulched. These were planted in cash crops, usually coffee. There exists a need to incorporate into the P- values a standard procedure for assessing quality for the conservation practices as they exist in Kenya. Also further research is needed in assessing the different conservation practices under the wide range of conditions found in the Kenyan Highlands so that the P-values presented in this paper can be expanded.

The method for assigning R-values, and the values assigned to the C and P-values as well as the m exponent need to be further tested against other soil loss measurements. The presented values when used in the USLE gave reasonable estimates of soil loss except for those sites where excessive erosion was measured. The reasons for the excessive erosion, such as at Murang'a site 16, cannot be explained from the data. This excessive soil loss might have been as a result of the field being exposed to local heavy rains which were not incorporated into the R-values. As more data become available from the field area it will be possible to determine if the USLE, as used in this study, results in estimates that approximate the long-term soil loss patterns.

POLICY IMPLICATIONS

1. Given that the correlations between the field measured and the USLE estimated soil loss values for Kiambu and Murang'a are statistically significant at the 0.95 level or higher, the USLE as calibrated, is a valid land use planning tool. The impact of proposed changes in vegetation cover on soil loss can be evaluated prior to implementation. Likewise the need for conservation practices in different areas of the districts can be assessed through the use of the USLE. As additional data are being collected in Kiambu and Murang'a during 1984-1985, it will be possible to further refine the calibration of the USLE to improve its effectiveness and precision as a land use planning tool.

2. The tentative results from the first two pilot studies indicate that widespread excessive soil loss is occurring in the newly cleared lands. The expansion of agriculture into areas that have steep slopes is particularly destructive in regard to the soil resource and increased sediment supply to the streams. This reflects the general finding that permanent vegetation cover almost always results in less soil loss than annual crops. A need exists to control the clearing of land for crops in areas of steep slopes. Also, in areas already being farmed, there is a need to immediately initiate strong conservation practices to lower the existing soil loss. If possible, the planting of trees in the area should be expanded.

3. Cash crops usually result in less soil loss than food crops. This is a result of two factors. First, most cash crops in the area are perennial. And second, the farmers seem to practice greater care in the fields having cash crops. For example, fields under cash crops are usually mulched. In addition, when cash crops are on steeper slopes, they are terraced too. These two factors indicate the importance of vegetation cover and conservation practices in controlling soil loss. Since it appears that most farmers know the importance of crop type and conservation in controlling soil loss, a need exists to increase incentives to encourage farmers to improve their farming practices.

Personnel Involved In The Collection Of The Field Data

Individuals who enabled the Kiambu investigation to be successful have already been noted (Lewis, Kamau, and Cheruiyot 1983). In Murang'a during the first rainy season the installation of the soil traps, the collection of the soil samples, and the weighing of the soil samples were undertaken by Mr. G. Kamau and Mr. P. Ndonye, both in the Natural Resources Division - NEHSS. Only Ndonye was involved in these functions during the second growing season as Kamau was on training out of the country. All farmers asked to cooperate in the project agreed, in fact the problem was not one of cooperation but in limiting the number of farmers in the project. In both Kiambu and Murang'a the farmers understand the negative economic ramifications of soil loss and are willing to assist in most projects that are trying to minimize erosion.

The following government officials also assisted during the data collection phase:

Mr. Mbaria Maina	District Commissioner, Murang'a District
Mr. R.P. Shompa	District Development Officer, Murang'a

The District Agricultural Etension Officers:

Mr. J.M. Gitau	District Agricultural Officer, Murang'a
Mr. J.K. Ngeno	District Officer, Kandara division
Mr. J.R. Mwaura	District Officer, Kangema division
Mr. C.O. Amonde	District Officer, Kiharu division
Mr. A. Mondor	District Officer, Kigumo division
Mr. D. Wilson	District Officer, Makuyu division

The Division Agricultural Extension Officers:

Mr. L.M. Waititu	Extension Officer, Makuyu division
Mr. Mburu Njuguna	Extension Officer, Kangema division
Mr. G.K. Machora	Extension Officer, Kiharu division
Mr. W.C. Tuiyoy	Extension Officer, Kigumo division
Mr. E. Kimemia	Extension Officer, Kandara division
Mr. G.K. Wakai	District Fisheries Officer, Murang'a

Mr. L. G. Ulsaker Kenya Agricultural Research Institute

The author thanks C.K.K. Gachene and A.M. Kilewe of the Kenya Agricultrual Research Institute for reading the first draft and offering many valuable suggestions.

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Appendix 1

Method of Installation of Soil Traps

1. All soil traps should be installed prior to the beginning of the rains.

2. The location characteristics are recorded at the time of installation (Appendix 3), during the growing season, and at the end of the season.

3. The location of the soil traps should be at the lower edge of the field.

4. Figure 1 illustrates the installation of the trap at a site from a cross-sectional perspective. The trap is placed

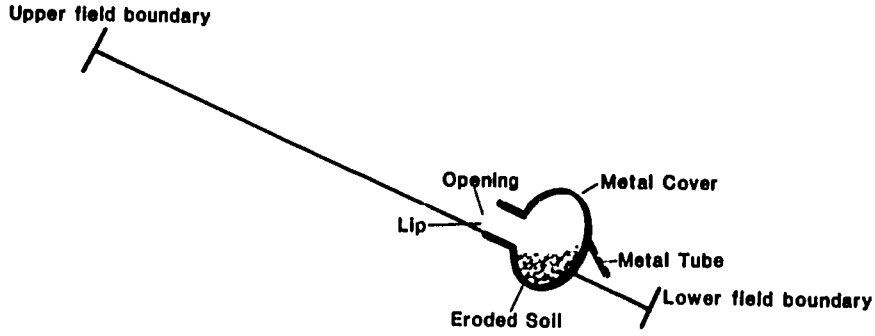

Figure 1

perpendicular to the slope. The lower lip is even with the soil. The soil is compacted under the small lower lip after installation to minimize run off going under the trap. The trap should remain in the ground once installed. Figure 2 is a front view of the trap after installation.

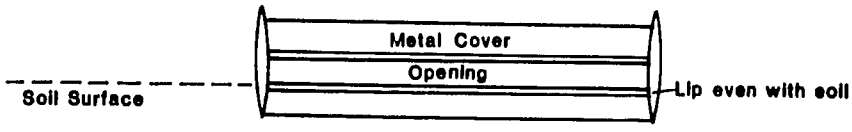

Figure 2

5. Every seven days the soil trap should be emptied. This is done without removing the soil trap from the ground. The cover is opened the soil is removed and placed in the plastic bags. The plastic bags are labeled giving date and location. The cover is closed. The trap is inspected to make sure that it is still properly installed (fig. 1). (Repeat #3). Make sure the lower lip is even with soil and no water is going under the trap.

Appendix 2

Measurement of Soil Loss

1. The collected soil samples are dried at 105°C-110°C to constant mass.

2. After drying the soil samples are weighed.

3. The data are recorded indicating date the sample was collected and amount of soil-loss (oven dry soil). Each trap has its own soil-loss data sheet shown in figure 1. Both the individuals in the field and at NEHSS have a soil loss data sheet.

Soil Loss Data Sheet

District:_____ Year_____

Division:_____ Season_____

Farm:_____ Crop(s)_____

DATE		EROSION		Weight of Soil in grams (oven dried)	Other Observations
Day	Month	Yes	No		
9	1		x		no evidence of rain during week trap moved, re-installed likely source soil not trapped
16	1	x		100	

The NEHSS individuals collect the soil at the Division or District Headquarters. They then dry and weigh the soil samples and record any other information from the collectors data sheet.

Appendix 3

1. Identification a. District	ID _____
b. Division c. Name of Farmer	ID _____
2. Land use of field	1 Cultivated 2 Pasture 3 Forest 4 Other - be precise _____
3. Time it takes to get to the soil trap, on foot, from the road.	1 less than 5 min. 2 from 5 to 10 min. 3 from 10 to 15 min. 4 more than 15 min.
4. Slope of the field Measure the angle at the soil trap using the protractor.	_____degrees
5. Locate the soil trap on the slope. Circle the appropriate code.	

6. Soil Protection				1 No conservation 2 Terraces 3 Terraces with cut-off by trench 4 Terraces, cut-off by mulching 5 Terraces, mulching 6 Mulching, cut-off 7 Mulching, cut-off 8 Cut-off 9 other - be precise _____
7. What are the two major crops on the field.	a. prime crop	b. second crop	c. How many years has the crop been in the field. (Only ans. if perennial).	
8. Do you consider the crop quality: Excellent good, average, below average, poor.				_____ _____
9. What is the distance from the trap to the upper boundary of the field. (measure in metres, if in feet please indicate this clearly).				

Circle the correct season First Rainy Season Second Rainy Season (October)

Appendix 4

Mechanical Analysis of Murang'a Soils

TRAP #	SAND %	SILT %	CLAY %	PEBBLE GM.
1M	70.73%	17.07%	12.20%	1
2M	84.85%	9.09%	6.06%	4
3M	84.00%	10.00%	6.00%	3
4M	88.89%	8.33%	2.78%	5
5M	86.96%	8.70%	4.35%	3
6M	87.50%	8.93%	3.57%	11
7M	80.33%	11.48%	8.20%	4
8M	90.20%	5.88%	3.92%	7
9M	88.24%	7.84%	3.92%	10
10M	92.11%	5.26%	2.63%	5
11M	75.00%	15.00%	10.00%	4
12M	83.02%	11.32%	5.66%	3
13M	90.20%	7.84%	1.96%	8
14M	91.43%	5.71%	2.86%	18
15M	93.88%	4.08%	2.04%	5
16M	83.33%	9.72%	6.94%	11
17M	80.70%	12.28%	7.02%	8
18M	80.68%	9.09%	10.23%	18
19M	88.06%	7.46%	4.48%	3
20M	82.61%	10.87%	6.52%	3
21M	87.93%	6.90%	5.17%	5
22M	85.71%	8.16%	6.12%	6
23M	88.00%	8.00%	4.00%	3
24M	91.18%	5.88%	2.94%	10
25M	88.46%	7.69%	3.85%	24
26M	85.37%	7.32%	7.32%	4

PART II

REVIEW OF THE NES/ETMA SOIL EROSION MONITORING METHODOLOGY

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Clark University

Maina Karaba
National Environment Secretariat

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PART II

REVIEW OF THE NES/ETMA SOIL EROSION MONITORING METHODOLOGY

INTRODUCITON

As the NES/ETMA soil erosion monitoring project began to produce results, several evaluations were conducted in order to ensure the methodology was adequately demonstrated before attempts were made to extend it to new areas or to have it adopted by other agencies. These reviews included:

November	1983	Associates in Rural Development; Dr. Ann Stroud
May	1984	University of Nairobi; Mr. D. B. Thomas
July	1984	Kenya Agricultural Research Institute; Mr. A. M. Kilewe Kenya Soil Survey; Mr. D.K.K. Gachene

This review draws upon the comments of these individuals as well as internal reviews within NES and informal discussions with other officials and soil scientists.

The purpose of this review is to note the limitations of the methodology, its suitable range of applications and suggestions for its improvement.

ORIGINAL OBJECTIVES OF THE METHODOLOGY

Soil erosion is a major problem throughout Kenya, and particularly in the highland areas of Kiambu and Murang'a. The executive order which established NES gave it the mandate to monitor trends in the environment and to formulate national policy. The ETMA project concurred with NES in identifying soil erosion, or more generally land degradation, as an area where systematic techniques in monitoring and evaluation would be useful in assisting soil conservationists to plan their activities and monitor their efforts.

The original objectives of the land degradation project were set out in 1981 as:

* to develop a methodology that is easily adopted;
* to quantify erosion;
* to identify where erosion is a major problem;
* to develop simulation techniques and to identify appropriate land use plans; and
* to help NES to suggest priorities for remedial action and appropriate strategies to use.

The resulting methodology was the first in Kenya to employ low-cost soil traps on farmers' fields in a systematic sample designed to make comparisions between the many factors affecting soil loss. A smaller effort was made to document the causes and extent of gulley erosion, but it was never carried to the level of analysis given to sheet erosion.

This review of the methodology is grouped under four categories:

Project Organization and Design
Validation of the Methodology
Technical Aspects of the Methodology
Use of the Information

PROJECT ORGANIZATION AND DESIGN

Soil erosion is the concern of many different agencies in Kenya. At the outset of a pilot project developed by a relatively small agency with little field experience, it is difficult to establish practical coordination and a consensus on methods. The project staff regularly contacted the involved agencies, made use of the laboratories and personnel at the Kenya Agricultural Research Institute, and in the last year relied upon the Ministry of Agriculture and Livestock Development extension agents to collect the soil from the traps. Nevertheless, projects of an inherent interministerial nature should make fuller use of existing committees and channels to elicit cooperation and to establish formal liasons.

NES originally planned to commit five officers to the project, but was plagued by rapid staff turnover and the lack of senior personnel (at or above the MSc level) trained in soil science. As a result, the project tended to rely very heavily on the U.S. expatriat staff. The project design should have included more thorough training of qualified staff (in degree courses) and greater involvement of local experts, in the university and research organizations, who could have provided a local continuity

which was often lacking. More attention should have been given to how to create the local capability to carry out the analyses, including provision of computing facilities and programmes and seminars in the details of the analysis.

The project methodology had as a prime objective the analysis of the relative causes of soil erosion, in particular, the correlation of land uses to quantitative measures of soil loss from agricultural fields. While project objectives may be changed, the methodology was never designed to measure absolute soil loss. The traps were too small to collect soil from the most erodable areas (bare ground on steep slopes) and the total run-off was not collected, leading to an unknown loss of fine materials. Traps were not designed to measure the extremes of soil erosion, and the cost and limited staff and facilities for soil analysis were further constaints. Thus project results provide limited insight into total erosion in the district, or the likely erosion into a reservor.

The sampling strategy in the early stages was deficient. Traps wre located over the entire district(s) with the justification of involving agricultural officers in each division. Yet little effort was made to use the traps as educational tools (see below). Little attention was paid to soil type or erodability. The traps could have been placed in similar fields under different soil conservation practises to test each's effectiveness. Many of the traps were located near automatic recording rain gauges provided by the ETMA project. However there were only four such gauges, which for security reasons could not be located on farmers' fields. Little attempt was made to use the Meteorological Department's existing network of rainfall observers. There were too few traps to include in each slope/crop/conservation category. Thus the 1982-83 results are based on comparisons between a relatively small sample of fields. The number of traps was doubled in 1984, but the sampling strategy was not notably improved. Originally the project did not envision long-term (more than one season) monitoring. Thus traps were moved each season, which means there is not now a long time series of data in each micro-site.

VALIDATION AND RELIABILITY

For the purposes of developing a pilot methodology, greater attention should have been paid to establishing the validity and reliability of the traps employed. Validation could have been easily accomplished by placing the simple field traps alongside more elaborate monitoring systems which collect all the soil lost and run-off. This was done in 1984 at the Katumani Research Station, but other places could have been tried. Reliability is a measurement of how well any one trap reflects the performance of another one in a similar location. Experiments with two or three traps in the same field would have provided data on this point.

Again this has been done in 1984, although hampered by the lack of rain in the first part of the year.

TECHNICAL ASPECTS

There were a number of lessons learned about the technical aspects of the methodology. The traps should be carefully placed in a field:

- perpendicular to the fall line in a catchment area,
- away from paths, trees or other channels of run-off,
- below a clear field boundary which prevents soil loss and run-off from other fields i.e. cut-off drain, wide grass strip, etc.

In addition to crop type, the amount of ground cover should be monitored, as it is more directly related to soil erosion. Cultivation practises (weeding, ploughing, thinning, mulching) should be recorded as they can drastically affect the soil erodability and effective rainfall erosivity.

The soil caught in a trap must be removed before the next storm, or at frequent enough intervals so the trap rarely overflows. The use of farmers and extension workers has proved fairly reliable, but adequate incentive and monitoring is essential. Where project staff must collect the soil, provision of transport and per diem every week is essential, and always a problem.

The automatic recording rain guages should have been used more in a validation exercise. They provide too much data and are too expensive for routine monitoring. As mentioned above, greater use could have been made the existing network of daily rainfall observers.

USE OF INFORMATION

The only products of the project so far have been technical reports. These have been fairly widely circulated, but can only be properly understood by knowledgeable experts. Several proposals have been made to further the use of the traps as educational devices, including walking workshops where farmers see the fields and traps and are shown how much soil was lost from each trap. To be adequate for such purposes the traps would have to be placed fairly close together and such that all the extraneous variables are controlled. A similar workshop for soil

scientists and policy-makers would also be useful. This was achieved in several instances on an informal basis.

A review of the traps in 1985 revealed high interest in the project among the chiefs and farmers in Murang'a and Kiambu. They repeatedly asked when the results would be available and requested NES to compile them in an understandable format. One woman insisted that the data from the trap on her shamba be sent to the local agricultural technical assistant so that she could implement the recommendation as soon as possible. Already she had noted the amount of soil being collected by "her" trap and had dug several cut-off drains to check the run-off which was "robbing her of her soil," as she put it.

Replication of the methodology requires that all the data, methods and analyses are clearly documented and available. Local scientists and staff should be purposely trained in all aspects of the methodology in the event they are called upon to provide advise to other organizations, or wish to use the data and results in their own research.

CONCLUSION

The NES and ETMA staff involved in developing this soil erosion monitoring methodology have learned a great deal from the effort. As it stands at present the methodology has been improved to the point where it could be intelligently used by others. These comments are offered to avoid some of the pitfalls experienced on this project. The results of the monitoring project have already been useful. It is our hope others will take up the methodology and adapt it to their own circumstances.

PART III

SOIL EROSION DATA FOR 1982 - 1983

KIAMBU 1982 SITE CHARACTERISTICS

KIAMBU 1982 SOIL EROSION IN GRAMS

MURANG'A 1983 SITE CHARACTERISTICS

MURANG'A 1983 SOIL EROSION IN GRAMS

SURVEY OF GULLIES IN MURANG'A, 1983

Compiled by the National Environment Secretariat

KIAMBU 1982 SITE CHARACTERISTICS

SITE	DIVISION	CROP	SLOPE	LENTH	C	K	R
1	KIAMBAA	IRR.COFF	3	25.0	0.02	0.20	212
2	KIAMBAA	IRR.COFF	6	3.0	0.02	0.20	212
3	KIAMBAA	IRR.COFF	7	3.0	0.02	0.20	212
4	KIKUYU	IRR.CABB	20	7.0	0.22	0.18	212
5	KIKUYU	IRR.CABB	11	10.0	0.22	0.18	212
6	KIKUYU	MAIZE	12	5.0	0.49	0.18	212
7	LARI	POTATOES	45	2.5	0.35	0.25	248
8	LARI	MX.VEGE.	20	4.0	0.35	0.25	248
9	LARI	PYRETHRU	20	18.0	0.25	0.25	248
10	LARI	MAIZE	15	17.0	0.49	0.25	248
11	LARI	MX.VEGE.	20	6.0	0.35	0.25	248
12	LARI	MX.VEGE.	16	6.0	0.35	0.25	248
13	LIMURU	PLUMS	14	28.0	0.02	0.26	248
14	LIMURU	PEARS,GR	11	10.0	0.02	0.26	248
15	LIMURU	PEARS	15	10.0	0.02	0.26	248
16	GITHUNGURI	TOMATOES	3	3.0	0,22	0.27	242
17	GITHUNGURI	BANA,BEA	10	4.0	0.10	0.27	242
18	GITHUNGURI	COFFEE	11	4.0	0.02	0.27	242
19	GITHUNGURI	MAIZE	4	6.0	0.49	0.27	242
20	GITHUNGURI	COFF.BEA	6	31.0	0.35	0.27	242
21	GATUNDU	MAIZE	16	4.0	0.49	0.27	242
22	GATUNDU	MAIZE	16	3.0	0.49	0.27	242
23	GATUNDU	MX.VEGES	9	3.0	0.35	0.27	242
24	GATUNDU	COFFEE	4	2.0	0.02	0.27	242
25	THIKA	BEANS	8	7.0	0.35	0.38	189
26	THIKA	BEANS	8	7.0	0.35	0.38	189
27	THIKA	CH.PEAS	8	5.0	0.40	0.38	189

KIAMBU 1982 SOIL EROSION DATA IN GRAMS

SITE	DAY	MON.	YEAR	SOIL
1	26	4	82	0.00
1	12	5	82	0.00
1	18	5	82	0.00
1	28	5	82	0.00
1	4	6	82	0.00
1	10	6	82	0.00
1	16	6	82	0.00
1	24	6	82	0.00
2	26	4	82	20.20
2	12	5	82	0.00
2	18	5	82	0.00
2	28	5	82	0.00
2	3	6	82	0.00
2	9	6	82	0.00
2	15	6	82	0.00
2	23	6	82	0.00
3	26	4	82	0.00
3	12	5	82	0.00
3	18	5	82	0.00
3	28	5	82	0.00
3	3	6	82	0.00
3	9	6	82	0.00
3	15	6	82	0.00
3	23	6	82	0.00
4	27	4	82	51.00
4	5	5	82	48.03
4	18	5	82	112.22
4	27	5	82	168.16
4	3	6	82	0.00
4	9	6	82	0.00
4	15	6	82	0.00
4	23	6	82	0.00
5	27	4	82	29.10
5	5	5	82	21.45
5	27	5	82	7.42
5	3	6	82	0.00
5	9	6	82	0.00
5	15	6	82	0.00
5	23	6	82	0.00
5	18	5	82	16.25
6	27	4	82	2724.74
6	5	5	82	614.29
6	18	5	82	39.08
6	3	6	82	0.00
6	9	6	82	0.00
6	15	6	82	0.00
6	23	6	82	0.00
6	27	5	82	512.99
7	28	4	82	38.90
7	5	5	82	58.71

KIAMBU 1982 SOIL EROSION DATA IN GRAMS

SITE	DAY	MON.	YEAR	SOIL
7	18	5	82	31.76
7	27	5	82	21.24
7	3	6	82	0.00
7	9	6	82	0.00
7	15	6	82	0.00
7	23	6	82	0.00
8	28	4	82	35.77
8	5	5	82	73.09
8	18	5	82	23.14
8	27	5	82	0.00
8	3	6	82	0.00
8	9	6	82	0.00
8	15	6	82	0.00
8	23	6	82	0.00
9	28	4	82	0.00
9	5	5	82	0.00
9	18	5	82	0.00
9	27	5	82	18.80
9	3	6	82	0.00
9	9	6	82	0.00
9	15	6	82	0.00
9	23	6	82	0.00
10	28	4	82	34.72
10	5	5	82	216.08
10	18	5	82	201.59
10	27	5	82	154.84
10	3	6	82	0.00
10	9	6	82	0.00
10	15	6	82	0.00
10	23	6	82	0.00
11	28	4	82	33.60
11	5	5	82	0.00
11	18	5	82	28.65
11	27	5	82	0.00
11	3	6	82	0.00
11	9	6	82	0.00
11	15	6	82	0.00
11	23	6	82	0.00
12	28	4	82	38.80
12	5	5	82	34.53
12	18	5	82	95.13
12	27	5	82	12.31
12	3	6	82	0.00
12	9	6	82	0.00
12	15	6	82	0.00
12	23	6	82	0.00
13	28	4	82	16.62
13	11	5	82	23.57
13	18	5	82	11.70
13	27	5	82	0.00

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KIAMBU 1982 SOIL EROSION DATA IN GRAMS

SITE	DAY	MON.	YEAR	SOIL
13	3	6	82	0.00
13	9	6	82	0.00
13	15	6	82	0.00
13	23	6	82	0.00
14	28	4	82	1.62
14	11	5	82	0.00
14	18	5	82	0.00
14	27	5	82	0.00
14	3	6	82	0.00
14	9	6	82	0.00
14	15	6	82	0.00
14	23	6	82	0.00
15	28	4	82	30.93
15	11	5	82	21.40
15	18	5	82	22.23
15	27	5	82	0.00
15	3	6	82	0.00
15	9	6	82	0.00
15	15	6	82	0.00
15	23	6	82	0.00
16	28	4	82	0.00
16	12	5	82	0.00
16	19	5	82	0.00
16	28	5	82	4.31
16	4	6	82	0.00
16	10	6	82	0.00
16	16	6	82	0.00
16	24	6	82	0.00
17	28	4	82	16.06
17	12	5	82	0.00
17	19	5	82	15.38
17	28	5	82	10.87
17	4	6	82	0.00
17	10	6	82	0.00
17	16	6	82	0.00
17	24	6	82	0.00
18	28	4	82	0.00
18	12	5	82	0.00
18	19	5	82	0.00
18	28	5	82	0.00
18	4	6	82	0.00
18	10	6	82	0.00
18	16	6	82	0.00
18	24	6	82	0.00
19	28	4	82	532.84
19	12	5	82	76.22
19	19	5	82	0.00
19	28	5	82	54.10
19	4	6	82	0.00
19	10	6	82	0.00

KIAMBU 1982 SOIL EROSION DATA IN GRAMS

SITE	DAY	MON.	YEAR	SOIL
26	28	4	82	47.46
26	12	5	82	0.00
26	19	5	82	0.00
26	28	5	82	0.00
26	4	6	82	0.00
26	10	6	82	0.00
26	16	6	82	0.00
26	24	6	82	0.00
27	28	4	82	77.70
27	12	5	82	0.00
27	19	5	82	0.00
27	28	5	82	0.00
27	4	6	82	0.00
27	10	6	82	0.00
27	16	6	82	0.00
27	24	6	82	0.00

KIAMBU 1982 SOIL EROSION DATA IN GRAMS

SITE	DAY	MON.	YEAR	SOIL
19	16	6	82	0.00
19	24	6	82	0.00
20	28	4	82	630.59
20	12	5	82	312.69
20	19	5	82	0.00
20	28	5	82	112.33
20	4	6	82	0.00
20	10	6	82	0.00
20	16	6	82	0.00
20	24	6	82	0.00
21	28	4	82	1315.82
21	12	5	82	2651.63
21	19	5	82	45.01
21	28	5	82	1174.30
21	4	6	82	0.00
21	10	6	82	0.00
21	16	6	82	0.00
21	24	6	82	0.00
22	28	4	82	744.90
22	12	5	82	2943.78
22	19	5	82	163.72
22	28	5	82	0.00
22	4	6	82	0.00
22	10	6	82	0.00
22	16	6	82	0.00
22	24	6	82	0.00
23	28	4	82	59.79
23	12	5	82	1023.72
23	19	5	82	2250.43
23	28	5	82	88.79
23	4	6	82	0.00
23	10	6	82	0.00
23	16	6	82	0.00
23	24	6	82	0.00
24	28	4	82	0.00
24	12	5	82	0.00
24	19	5	82	0.00
24	28	5	82	414.45
24	4	6	82	0.00
24	10	6	82	0.00
24	16	6	82	0.00
24	24	6	82	0.00
25	28	4	82	224.95
25	12	5	82	0.00
25	19	5	82	0.00
25	28	5	82	0.00
25	4	6	82	0.00
25	10	6	82	0.00
25	16	6	82	0.00
25	24	6	82	0.00

SITE CHARACTERISTICS,

MURANG'A 1983

Trap #	Crop Name	Crop Number	Conservation Name	Conservation Number	Slope Degree	K-value	Percent Organic	Actual Soiloss	Simulated Soiloss
1	TEA	6	NONE	5	30	0.24	2.6	0.11	1.3
2	MAIZE	3	POOR	4	19	0.35	1.6	56.76	18.3
3	MAIZE	3	NONE	5	17	0.12	4.1	25.49	12.5
4	COFFEE	4	POOR	4	14	0.08	5.3	0.13	2.4
5	COFFEE	4	NONE	5	16	0.08	4.4	1.40	3.5
6	COFFEE	4	GOOD	2	7	0.10	5.0	2.97	0.4
7	YAMS	4	NONE	5	23	0.08	6.6	7.38	9.0
8	MAIZE	3	NONE	5	46	0.08	3.7	16.31	19.3
9	BANANAS	4	FAIR	3	40	0.08	5.3	11.26	3.8
10	TEA	5	FAIR	3	47	0.10	2.6	1.40	0.4
11	TEA	6	NONE	5	46	0.19	5.4	2.10	1.4
12	TEA	6	NONE	5	43	0.08	8.0	4.15	1.0
13	COFFEE	6	GOOD	2	7	0.08	4.0	0.91	0.0
14	MAIZE	3	FAIR	3	30	0.08	4.2	1.75	4.2
15	MAIZE	3	FAIR	3	6	0.10	2.1	4.43	0.6
16	TOBACCO	2	POOR	4	18	0.27	2.6	118.26	4.8
17	COTTON	4	POOR	4	18	0.10	1.7	32.48	10.2
18	COTTON	6	POOR	4	13	0.31	1.0	6.56	4.7
19	MAIZE	3	NONE	5	7	0.10	1.6	2.67	4.2
20	COFFEE	4	NONE	5	6	0.08	5.8	0.16	2.6
21	COFFEE	3	NONE	5	9	0.10	3.6	23.11	4.2
22	COFFEE	3	FAIR	3	11	0.08	4.3	4.07	3.7
23	MAIZE	3	FAIR	3	8	0.08	4.3	12.22	5.1
24	MAIZE	3	POOR	4	20	0.08	5.4	9.98	32.5
25	COFFEE	6	GOOD	2	10	0.10	2.3	0.07	0.3
26	COFFEE	4	POOR	4	30	0.08	4.9	5.43	11.5

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METERS	SLOPE DEGREES	CROP TYPE	CONS. TYPE	EROSITI-VITY	K-VALUE	R-VALUE
12.2	30.0	6	5	0.72	0.10	35.0
4.2	19.0	3	4	0.72	0.25	35.0
7.2	17.0	3	5	0.72	0.15	35.0
15.6	14.0	4	4	0.72	0.08	35.0
11.2	16.0	4	5	0.72	0.08	35.0
0.7	7.0	4	2	0.71	0.08	60.0
7.4	23.0	4	5	0.71	0.08	60.0
4.9	16.0	3	5	0.71	0.08	60.0
4.6	40.0	4	3	0.71	0.08	60.0
2.8	47.0	6	3	0.71	0.10	60.0
23.3	46.0	6	5	0.63	0.10	33.0
21.3	43.0	6	5	0.63	0.08	33.0
0.9	7.0	6	2	0.63	0.08	33.0
9.4	30.0	3	3	0.63	0.08	33.0
1.7	6.0	3	3	0.63	0.10	33.0
0.7	18.0	3	4	0.63 3	0.30	16.0
6.2	18.0	3	4	0.67	0.20	32.0
15.0	13.0	3	4	0.67	0.10	18.0
16.0	7.0	3	5	0.67	0.10	32.0
75.1	6.0	4	5	0.67	0.08	32.0
6.2	9.0	4	5	0.67	0.08	32.0
2.6	11.1	3	3	0.64	0.08	120.0
5.8	8.0	3	3	0.64	0.08	120.0
9.2	20.0	3	5	0.64	0.08	120.0
10.4	10.0	6	2	0.64	0.10	120.0
13.9	30.0	4	4	0.64	0.08	120.0

MURANG'A 1983

WEEK #	TRAP #	AREA M^2	SLOPE	CROP	RAIN MM	SOIL GRAMS	TOTAL
1	1	6.1	30	1	14	0.00	
2	1	6.1	30	1	18	14.20	
4	1	6.1	30	1	147	18.42	
5	1	6.1	30	1	14	20.25	
6	1	6.1	30	1	4	0.00	
7	1	6.1	30	1	21	13.32	
8	1	6.1	30	1	8	0.00	66.19
1	2	2.1	19	2	14	259.12	
2	2	2.1	19	2	18	2555.91	
4	2	2.1	19	2	147	2662.21	
5	2	2.1	19	2	14	3396.10	
6	2	2.1	19	2	4	0.00	
7	2	2.1	19	2	21	3046.74	
8	2	2.1	19	2	8	0.00	11920.10
1	3	3.6	17	2	14	89.80	
2	3	3.6	17	2	18	270.52	
4	3	3.6	17	2	147	3529.01	
5	3	3.6	17	2	14	3295.73	
6	3	3.6	17	2	4	0.00	
7	3	3.6	17	2	21	1990.00	
8	3	3.6	17	2	8	0.00	9175.06
1	4	7.8	14	3	14	31.75	
2	4	7.8	14	3	18	0.00	
4	4	7.8	14	3	147	20.96	
5	4	7.8	14	3	14	23.68	
6	4	7.8	14	3	4	0.00	
7	4	7.8	14	3	21	27.95	
8	4	7.8	14	3	8	0.00	104.34
1	5	5.6	16	3	14	27.06	
2	5	5.6	16	3	18	204.63	
4	5	5.6	16	3	147	231.21	
5	5	5.6	16	3	14	124.87	
6	5	5.6	16	3	4	0.00	
7	5	5.6	16	3	21	202.46	
8	5	5.6	16	3	8	0.00	790.23
1	6	0.4	7	3	20	0.00	
2	6	0.4	7	3	90	0.00	
4	6	0.4	7	3	55	79.53	
5	6	0.4	7	3	33	0.00	
6	6	0.4	7	3	13	0.00	
7	6	0.4	7	3	78	39.32	
8	6	0.4	7	3	2	0.00	118.85
1	7	3.7	23	4	20	0.00	
2	7	3.7	23	4	90	272.59	
4	7	3.7	23	4	55	1651.21	
5	7	3.7	23	4	33	732.61	
6	7	3.7	23	4	13	0.00	
7	7	3.7	23	4	78	75.78	
8	7	3.7	23	4	2	0.00	2732.19
1	8	2.5	46	2	20	578.23	
2	8	2.5	46	2	90	305.80	
4	8	2.5	46	2	55	1547.14	
5	8	2.5	46	2	33	1301.02	
6	8	2.5	46	2	13	0.00	

7	8	2.5	46	2	78	344.81	
8	8	2.5	46	2	2	0.00	4077.00
1	9	2.3	40	5	20	0.00	
2	9	2.3	40	5	90	826.19	
4	9	2.3	40	5	55	702.24	
5	9	2.3	40	5	33	650.72	
6	9	2.3	40	5	13	0.00	
7	9	2.3	40	5	78	411.61	
8	9	2.3	40	5	2	0.00	2590.76
1	10	1.4	47	1	20	0.00	
2	10	1.4	47	1	90	69.93	
4	10	1.4	47	1	55	77.79	
5	10	1.4	47	1	33	28.00	
6	10	1.4	47	1	13	0.00	
7	10	1.4	47	1	78	19.69	
8	10	1.4	47	1	2	0.00	195.41
1	11	11.7	46	1		0.00	
2	11	11.7	46	1		1097.83	
4	11	11.7	46	1		1010.34	
5	11	11.7	46	1		292.89	
	11	11.7	46	1		0.00	
7	11	11.7	46	1		43.02	
8	11	11.7	46	1		0.00	2444.08
1	12	10.7	43	1		62.58	
2	12	10.7	43	1		1237.27	
4	12	10.7	43	1		2221.18	
5	12	10.7	43	1		767.18	
6	12	10.7	43	1		. 0.00	
7	12	10.7	43	1		154.06	
8	12	10.7	43	1		0.00	4442.27
1	13	0.5	7	3		0.00	
2	13	0.5	7	3		13.22	
4	13	0.5	7	3		0.00	
5	13	0.5	7	3		0.00	
6	13	0.5	7	3		0.00	
	13	0.5	7	3		32.36	
8	13	0.5	7	3		0.00	45.68
1	14	4.7	30	2		247.23	
2	14	4.7	30	2		41.10	
4	14	4.7	30	2		319.44	
5	14	4.7	30	2		92.38	
6	14	4.7	30	2		0.00	
7	14	4.7	30	2		122.09	
8	14	4.7	30	2		0.00	821.74
1	15	0.9	6	2		59.60	
2	15	0.9	6	2		19.57	
4	15	0.9	6	2		159.46	
5	15	0.9	6	2		116.33	
6	15	0.9	6	2		0.00	
7	15	0.9	6	2		43.58	
8	15	0.9	6	2		0.00	398.54
1	16	0.4	18	6	0	118.78	
2	16	0.4	18	6	30	1317.00	
4	16	0.4	18	6	5	3198.64	
5	16	0.4	18	6	0	95.84	

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6	16	0.4	18	6	0	0.00	
7	16	0.4	18	6	22	0.00	
8	16	0.4	18	6	0	0.00	4730.26
1	17	3.1	18	7	0	51.65	
2	17	3.1	18	7	30	4378.62	
4	17	3.1	18	7	5	5565.63	
5	17	3.1	18	7	0	72.26	
6	17	3.1	18	7	0	0.00	
7	17	3.1	18	7	22	0.00	
8	17	3.1	18	7	0	0.00	10068.20
1	18	7.5	13	7	0	193.92	
2	18	7.5	13	7	30	111.66	
4	18	7.5	13	7	5	4246.00	
5	18	7.5	13	7	0	367.79	
6	18	7.5	13	7	0	0.00	
7	18	7.5	13	7	22	0.00	
8	18	7.5	13	7	0	0.00	4919.37
1	19	8.0	7	2	0	33.08	
2	19	8.0	7	2	30	1903.70	
4	19	8.0	7	2	5	200.72	
5	19	8.0	7	2	0	0.00	
6	19	8.0	7	2	0	0.00	
7	19	8.0	7	2	22	0.00	
8	19	8.0	7	2	0	0.00	2137.50
1	20	37.5	6	3	0	47.42	
2	20	37.5	6	3	30	92.53	
4	20	37.5	6	3	5	461.18	
5	20	37.5	6	3	0	0.00	
6	20	37.5	6	3	0	0.00	
7	20	37.5	6	3	22	0.00	
8	20	37.5	6	3	0	0.00	601.13
1	21	3.1	9	3	0	87.29	
2	21	3.1	9	3	30	3448.57	
4	21	3.1	9	3	5	3469.93	
5	21	3.1	9	3	0	81.27	
6	21	3.1	9	3	0	0.00	
7	21	3.1	9	3	22	76.93	
8	21	3.1	9	3	0	0.00	7163.99
1	22	1.3	11	3	0	0.00	
2	22	1.3	11	3	148	96.85	
4	22	1.3	11	3	52	322.34	
5	22	3.1	11	3	49	59.03	
6	22	3.1	11	3	10	0.00	
7	22	3.1	11	3	65	51.18	
8	22	3.1	11	3	5	0.00	529.40
1	23	2.9	8	2	0	0.00	
2	23	2.9	8	2	148	836.07	
4	23	2.9	8	2	52	2232.29	
5	23	2.9	8	2	49	170.03	
6	23	2.9	8	2	10	0.00	
7	23	2.9	8	2	65	305.53	
8	23	2.9	8	2	5	0.00	3543.92
1	24	4.6	20	2	0	0.00	
2	24	4.6	20	2	148	121.42	
4	24	4.6	20	2	52	1860.33	

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5	24	4.6	20	2	49	2412.63	
6	24	4.6	20	2	10	0.00	
7	24	4.6	20	2	65	198.33	
8	24	4.6	20	2	5	0.00	4592.71
1	25	5.2	10	3	0	0.00	
2	25	5.2	10	3	148	0.00	
4	25	5.2	10	3	52	37.00	
5	25	5.2	10	3	49	0.00	
6	25	5.2	10	3	10	0.00	
7	25	5.2	10	3	65	0.00	
8	25	5.2	10	3	5	0.00	37.00
1	26	7.0	30	3	0	0.00	
2	26	7.0	30	3	148	591.19	
4	26	7.0	30	3	52	2455.03	
5	26	7.0	30	3	49	0.00	
6	26	7.0	30	3	10	0.00	
7	26	7.0	30	3	65	753.91	
8	26	7.0	30	3	5	0.00	3800.13

CROP NUMBER :	CROP NUMBER
1	TEA
2	MAIZE
3	COFFEE
4	YAMS
5	BANANA
6	TOBACCO
7	COTTON

WEEK NUMBER :	WEEK DATE
1	13/4/83
2	22/4/83
3	27/4/83
4	4/5/83
5	13/5/83
6	22/5/83
7	27/5/83
8	2/6/83

AREA NAME	TRAP NUMBER
KANDARA	1 : 5
KIHARU	6 : 10
KIGUMO	11 : 15
MAKUYU	16 : 21
KANGEMA	22 : 26

SURVEY OF GULLIES IN MURANG'A 1983

LARGE GULLIES IN KANDARA DIVISION

MURUKA LOCATION NAME	LENGTH (M)	WIDTH (M)	DEPTH (M)
KARUMU	24	2.1	2.3
MARUKA	30	2.5	3.0
NGANEA	26	2.5	2.1
KWENDO	25	2.1	2.2
KAIMUHU	22	3.0	2.1
GATITU	34	2.1	2.1
GATUMBU	22	2.3	2.2.
KIBEREKE	100	7.0	2.0
KING'ARA	70	10.5	8.0
KIANJOGU	70	6.0	2.2
RUCHU LOCATION			
MUNGARIA	100	2.5	4.0
ITHIRU LOCATION			
KIRITI	30	2.4	8.0
KIGUARU	40	2.0	3.0
MIIRI THUKU	88	3.0	2.5
IHIGA-INI	70	3.0	2.0
KIRUNGURU	110	3.0	4.0
UNJIRU-INI	70	3.0	3.7
MAKINDI VALLEY	50	2.0	2.5
KIRUNGURU SCHOOL	75	2.5	3.0
NJOGU-INI	70	2.5	2.5
GITOBORO SOCIETY	80	2.0	2.5
GATHANGA LOCATION			
MBURU NGUGI	60	6.0	10

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GATANGA DOCATION	LENGTH (M)	WIDTH (M)	DEPTH (M)
MUGO GATUMBI	40	4.0	4.0
GUTIA GITHINJI	20	3.0	2.0
GATANGA SCHOOL	60	2.0	2.0
KABA NDUTI	20	4.0	2.0
GAKURARI FACTORY	20	3.0	2.0
NDUNGU KAGORI	80	5.0	4.0
MBUGUA KANJIRI	75	2.0	3.0
WANYOIKE MAGU	50	2.0	2.0
THUKU KINGARA	65	2.0	3.0
THUKU MUHIA	60	3.0	2.0
SIMON MWARUA	200	4.0	5.0
NGUGI WACHICHI	150	4.0	3.0
NDURURI WAITHAKA	150	3.0	2.0
KININA MBUCHIRI	100	3.0	3.0
RICHARD NGUGI	150	3.0	4.0
MWANGI KARANJA	80	12.0	6.0
MWANGI MUTHA	25	3.0	6.0
NJOROGE KINGANGI	56	8.0	5.0
KAMANDE KIARII	60	2.0	2.0
MACHARIA KAGECHA	40	2.0	2.0
EZEDKIEL GACHIHI	70	4.0	3.0
K[illegible]IA KINUTHIA	150	5.0	2.0
NJOROGE KIHURIA	150	5.0	3.0
KIBUNYU PLOT	40	5.0	2.0
SHADRACK NGUGI	30	3.0	2.0
GITUAMBA SCHOOL	50	5.0	5.0
KIAWAIHIGA	80	3.0	2.0
IRIA TOTO	150	2.0	2.0
GICHII	200	2.0	3.0

GATANGA LOCATION	LENGTH (M)	WIDTH (M)	DEPTH (M)
NDUNGU MWIRU	50	2.0	3.0
GAICHANJIRU LOCATION			
KAGUMOINI	160	11.0	3.5
KARITI/GITHIGE	80	4.0	5.0
GITHUNGURI/NDIKWE	180	10.0	8.0
GITHIGI PRIMARY SCHOOL	85	4.0	5.0
KAMAE	95	6.0	7.0
KAGUMOINI/KARIGUINI	140	4.0	5.0
GITURA/NJORORO	180	70	3.0

MAJOR GULLIES IN KIHARU DIVISION

MUGOIRI LOCATION NAME	DEPTH (m)	WIDTH (m)	LENGTH (m)	CAUSE
Munyutha Gathiru	7	8	1500	road run off
Kiria-Ruoro	8	12	1000	"
Yamugwe	4.5	3	1000	"
Ndutumi Stanley	3	4	2500	"
Gikoyo Mwaura	4	3	1000	"
Mitarakwa Factory	3	4	1000	"
Gatundu Dip	3	3	900	"
Kiamakara	4	3	200	"
MURARANDIA LOCATION				
John Kanoru	2.5	5	120	"
Maina Mbogo	5	4	200	"
GIKINDU LOCATION				
Kiangatia	4	10	300	"
Karii Nambirwa	4	5	200	"
Mirira	3	6	300	"
Gakanga	4	3	300	"
Thanju	3	4	500	"
Kiamuti Hills	4	5	300	"
GATURI LOCATION				
Kamutuhia	3	3	400	"
Kandigini	3	4	300	"
Gathaini	3	3	200	"
Murio Wanda	2	4	500	"
Gachirago	3	3	400	"
Gatihi Giethaga	2.5	4	300	"
Kambogo	3	3	100	"
MBIRI LOCATION				
Kahatia-Mukungai	3	4	500	"
Giatia	3	5	400	"
Kiawanjugu	3	3	300	"
Kirene-Gaitega	2.5	4	200	"

LARGE GULLIES IN KANGEMA DIVISION

SIZE OF GULLY

GITUGI LOCATION NAME	DEPTH (m)	BREADTH (m)	LENGTH (m)	FEEDER CATCH MENT	REMARKS
MIHUTI	5	7	140	Culvet	affecting 10 farms
NGUTU	3	6	120	Plots	8 farms
THUITA	3	4	500	Culvert	10 farms
KAMAKAMBI	5	6	150	Road	8 farms
IHARA	4	4	300	Road	4 farms
KIRU LOCATION					
KARIKO	2.5	3	800	Road	8 farms
MURI-INI	3	3	400	Road	10 farms
KANJAMA	2.5	2	200	Road	3 farms
WARUGARA	3	2.5	1000	Road	18 farms
KIONGO-INI	3	3	400	Ridge	6 farms
KANYENYA-INI LOC.					
KIBUTHA	2.5	3	150	Road	
GITUGU	3	5	180	Stream	
CATANGARA	2	2	120	Road	
WANJIKU KIMANI	5	4.5	120	Road	
KIRITI LOCATION					
MWANGI WAKABA	3.5	1.5	30	Culvert	
TITUS LIVAI	2.5	1.5	25	Culvert	
IYEGO LOCATION					
MWANGI MUTHIORA	3	2.5	115	Road	
GAKIRA	3	3	279	Market	
SIMON WANJOHI	2	2.5	115	Road	
KARURI BOYO	7.2	6	230.6	Road	
GITHUNGURI	3	2	60	Road	
MBUTHIA KARIUKI	5	3	300	Village	
ESPHAN GITHUA	2.5	2	35	Road	

MAJOR GULLIES IN MAKUYU DIVISION

LOCATION	NUMBER	(m) LENGTH	(m) WIDTH	(m) DEPTH	CAUSE	COST OF CURE IN K£
MUNGETHO	1	15m	5m	5m	Natural flow	1,000
MIHANGO	1	10	4	2	Rainfall wash	600
RETIRE	1	20	4	3	"	1,000
GITHOMES	1	12	2	2	"	600
KAMA-INI	1	25	8	6	"	1,200
GITUNE	1	18	7	7	"	1,200
KAMOITI	1	15	5	5	"	1,000
MAMBITI	1	265	3	2	"	20,000
MITOMBIRI	3	15,20, 30	1.5, 1.5, 1	0.5,1 0.8	"	14,250
KAKUZI HILLS	1	150	2.5	2	"	8,000
GAICHANJIRU	1	100	2	2	"	5,000
MITHINI	1	150	2	2	"	7,000
MUTITHI	1	200	3.5	2.5	"	5,000
ITHANGA	3	-	-	-	"	21,000