Land Resources Development Centre

APPRAISAL OF THE PROPOSED DRYLAND FARMING PROJECT FOR EMBU AND MERU DISTRICTS OF KENYA

A T BARRETT

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PART I INTRODUCTION

1.1 **INTRODUCTION** The Government of Kenya, with assistance from the United Kingdom, have been implementing a Soil and Water Conservation (SWC) project in the drier areas of Embu and Meru districts. The first phase of this project is due to finish in June 1985 and proposals for a second phase, which would be wider in scope, have been prepared for submission to the Ministry of Agriculture in the Government of Kenya and the Overseas Development Administration.

The economic appraisal was undertaken on the basis of this proposal. It is possible that before it is finally submitted to the UK government for assistance there will be further alterations and amendments.

1.2 **OUTLINE OF THE PROJECT** The project area is part of the semi-arid lands of Kenya which has a fragile ecosystem and is at risk of desertification if poorly utilised. The population in the area is expanding rapidly. The basic objectives of the project are to arrest the environmental degradation in the region and to improve the social welfare of the people on a sustained basis.

The project comprises three components,

a) Soil and Water Conservation
b) Agronomy
c) Farming Economics.

It will also collaborate closely with the EMI Goat and Sheep Project and endeavour to cover most of the farming systems of the dry areas of the two districts.

Already there are clear indications of soil erosion taking place in the project area. Soil erosion is an insidious process and unless remedial action is started in the near future all of the shallow soils, which make up approximately 50% of the agricultural land, could be reduced to zero productivity within a time period of 50 years. The population is expanding rapidly and during the next twenty years it will have more than doubled. In the high potential areas on Mount Kenya the population density is already extremely high and people are beginning to move out. Given this background it is imperative that measures are started to arrest the increasing soil erosion and if possible to maintain the productivity of the soil in the longer term.

It cannot be expected that there will be any dramatic improvements in the short term in a semi-arid area. Crop yields will still be largely determined by the rainfall which varies from season to season. If conservation measures are implemented then it is hoped that in the longer term declines in average yields will be arrested and seasonal fluctuations reduced.

1.3 **OBJECTIVES** During the three years of the project several different soil conservation measures will be implemented. Their acceptance at the farm level will be closely monitored and constraints to widespread adoption, if any, identified. The initial results obtained from the first phase of the project are encouraging and many of the ideas now being implemented will be developed further. It is important that this impetus is not lost.

The project team will work with the extension service and during the dry seasons the focus of activities will be entirely on the implementation of conservation measures. Assuming that the measures are effective and the rate of uptake is as suggested in Part III then a total of 16000 hectares will be terraced, 750 hectares protected from gulley erosion and a total area of 2272 hectares put under ridged and crescent cultivation during the next 20 years. If crescents and ridges are readily adopted by farmers it is likely that this area will be far greater and these methods could easily become the normal cultivation practice in the area.

Cultivation of land using oxen is also likely to develop as more people acquire ploughs. Trials will be continued in order to develop equipment and practices which minimise soil erosion.

On-farm crop trials will be undertaken in conjunction with the extension service and the National Dryland Farming Research Station at Katumani. Improved varieties will be tried 'on-farm' in order to determine their true potential under normal farm level husbandry practices. It is expected that such a programme will result in firm recommendations which can be used by the extension service. The programme will also give valuable feedback to the research station. No attempt has been made to estimate the benefits from the trials programme.

In addition to the agricultural activities, a total of 35 sand weirs will be constructed and 5 diversion furrows will be rehabilitated. These will all be undertaken in the first three years of the project and will affect a total of 11730 people. If the population increases rapidly these structures will serve an increasing number of people.

1.4 **ECONOMIC BENEFITS** A detailed economic cost benefit analysis was not justified given the number of assumptions that were made and the quality of the data that was used. The Internal Rate of Return (IRR) for the entire project, given a twenty year life span, was estimated to be approximately 5%. Separate analyses for the water component gave an IRR of 3% and for the agricultural component, 6%. The IRR for the water component was extremely sensitive to the Shadow Wage Rate (SWR) for women during the dry season. An increase of the SWR from 50 cents per hour to Sh 1 per hour improved the IRR to 12.8%. Further survey work is required in order to accurately determine this critical value which is fundamental to the calculation of benefits of all water related projects.

Given the very low returns which result from the project, any adjustment in values which would increase the costs or reduce the benefits would rapidly reduce the IRR to a negative value.

A reduction of the stream of benefits by 50% gives an IRR of minus 3.5%.

Under normal circumstances the project would probably not be recommended. It is not, however, possible to quantify the human misery which will exist in these areas unless some action is taken now. If the project is successful its impact could have beneficial effects in similar areas both in Kenya and throughout the semi-arid lands of Africa. It should be viewed as a medium risk project with expected low returns. There is, however, the possibility of very high returns if the applied research on crops produce positive results.

The project has been written up as the second phase of an existing project and has a three year life. It is, however, expected that at the end of the second year of the project there will be a review in order to determine whether or not it should be extended into a third phase.

1.5 REPORT OUTLINE

Very little data was readily available for an appraisal of the project. Much of the time was spent in assembling data from many different sources and rejecting data which was inappropriate. In Part II of the report, many of the assumptions and information relating to the project area and the existing farming systems are outlined. In Parts III, IV and V there is a relatively detailed explanation of the activities of the project, expected rates of implementation, and benefits. Finally, in Part VI there is an economic analysis of the proposals based on the assumptions that have been made in the previous sections of the report.

PART II BACKGROUND

2.1 **THE PROJECT AREA** The whole country has been split up into agroecological zones which are used as the basis for all area development plans within the Ministry of Agriculture. These are defined in the Farm Management Handbook of Kenya, Volume II C (Ministry of Agriculture) and are delineated on the basis of climate, altitude and soils, and generally indicate areas of similar agricultural potential.

The first phase of the project, the Soil and Water Conservation project, only covered the very poor lowland areas of Embu and Meru districts which were defined as the Livestock Millet Zone or Lower Midland 5 and the Livestock Millet Zone which is part of Inland Lowland 5. The present project will also include the Marginal Cotton Zone (or Lower Midland 4) and a small intermediate zone LM4-5.

In Embu district all three zones are included in their entirety, apart from the irrigation schemes on the Tana river. In Meru, however, only those parts of LM4, LM5 and IL5 which are to the south of the Meru National Park are included. All the zones are below the 1200 metre contour and are typified by a bi-modal rainfall pattern which is low, erratic and highly variable.

Unfortunately, the Farm Management Handbook contains very little information on the zones in the project area. For most of the high potential zones there are details of farm size, labour inputs, etc.

The only information in the FM Handbook of relevance to the project area refers to the total area and the area of agricultural land in each zone. Using these figures and estimates of areas in each sublocation given in the Kenyan Population Census (Vol 1, 1979) the total project area was estimated to be approximately 3571 km^2. with a total population of just over 140000 people in 1979 (Table 1).

Table 1 Area and population of the project area.

Zone	Area (km^2)	Popul-ation	No. of house-holds	Pop. density (persons/ km^2)	Area/ house-hold (ha)	Agri-cultural area (km^2)	Estimated agricultural area per household (ha)
LM4	930	43399	8484	47	11.0	676	8.0
LM4-5	186	7369	1507	40	12.3	122	8.1
LM5	1343	55873	11462	42	1.7	1170	10.2
IL5	1112	33401	6582	30	16.9	843	12.8
Total	3571	140042	28035	39	12.7	2811	10.0

Source: The agricultural area is based on data in the Farm Management Handbook for Kenya (Vol II C).

Details of the project area in each district are given in Tables 2 and 3.

Table 2 Embu District; Area and population statistics for the project area

Zone	Area (km^2)	Popul-ation	No. of house-holds	Pop. density (persons/ km^2)	Area/ house-hold (ha)	Agri-cultural area (km^2)	Estimated agricultural area per household (ha
LM4	406	23925	4911	59	8.3	247	5.0
LM4-5	108	5660	1179	52	9.2	105	8.9
LM5	1127	44603	9391	40	12.0	976	10.4
IL5	126	3940	971	31	13.0	105	10.8
Total	1767	781128	16452	44	10.7	1433	8.7

Table 3 Meru District; Area and population statistics for the project area

Zone	Area (km^2)	Popul-ation	No. of house-holds	Pop. density (persons/ km^2)	Area/ house-hold (ha)	Agri-cultural area (km^2)	Estimated agricultural area per household (ha
LM4	524	19474	3573	37	14.7	429	12.0
LM4-5	78	1709	323	22	23.8	17	5.2
LM5	216	11270	2071	52	10.4	194	9.4
IL5	986	29461	5611	30	17.6	738	13.1
Total	1804	61914	11583	34	15.6	1377	11.9

At present the average population density in the project area is 39 persons per km^2. This ranges between 22 and 59 but there are small areas which are more densely populated.

The agricultural land area of each zone does not include the steep areas, those used for forestry and any other areas not suitable for agriculture. Available agricultural land per family varies from only 5 hectares in LM4 to 13 hectares in zone IL5. Given the fact that not all land is being utilised uniformly there is far less land available than these figures suggest in many areas. For sustained agriculture there is already pressure existing. Under more favourable conditions in central Tanzania it is recommended that each household is allocated 6 to 7 hectares of land. In addition to that area the households are able to develop valley areas for dry land rice cultivation.

2.2 **POPULATION, GROWTH AND MIGRATION** In the Meru and Embu development plans for 1984-1988 it states that there has been a movement of people from the densely populated areas around the middle slopes of Mount Kenya towards the lower slopes and the lowlands where land is more available. This assumption may not be correct as the population figures from the 1969 and 1979 population censuses indicate that the population in the lowlands within the project area has been growing at a slower rate than the rest of the district. This would imply that there has been a movement of people out of the project area between 1969 and 1979. A study undertaken by a group of students from Durham University (U.K) (private communication) also supported this viewpoint.

A more detailed analysis is required to forecast with any accuracy the projected population. Several factors will have to be considered;
Land adjudication once completed will make it more difficult for newcomers moving into the area to acquire land.
Erratic rainfall leading to crop failures make survival very difficult in some years.
Poor water supplies for drinking limit areas of settlement.
Technological improvements resulting in higher yields are more likely to apply in the high potential areas; etc.

Such an exercise is beyond the scope of the present report and for purposes of illustration it has been assumed that the population growth rate will be the same as that which has been predicted for the two districts by the Central Statistics Bureau (Population Projections for Kenya from 1980 to 2000 CSB 1979). For Embu district this is 4.18% per year and for Meru it is 3.91% per year.

Table 4 Population projections for the project area from 1979 to 2005.

District	1979	1985	1990	1995	2000	2005
Embu	78128	99887	122584	150437	184619	226568
Meru	61914	77935	94410	114368	138545	167833
Total	140042	177842	216994	264805	323264	394401

Using these projections it is estimated that by the year 2005 the population will almost have trebled compared with the 1979 estimates.

Using these projections the estimated area of agricultural land available per family in the project area wil be reduced to 3.7 ha in Embu district and 4.1 ha in Meru district by the year 2005.

The soil and water resources will therefore be under tremendous pressure and subject to increasing deterioration unless adequate measures are implemented immediately.

2.3 **THE PRESENT FARMING SYSTEMS** The present farming systems that are found in both districts are typical of the semi-arid areas. A majority of the households own mixed herds of livestock and the cropping patterns vary from year to year according to the rainfall. In zone LM4 (marginal Cotton Zone) maize and beans together with cotton are grown. In the lower areas, where the seasonal rainfall is both lower and less reliable, the major crops are millet, sorghum, greengram and cowpeas grown either singly or more commonly in mixtures. The rainfall is bi-annual and there are two distinct cropping seasons.

Alternative sources of income are limited. Beekeeping is widespread and people use the traditional log hives. Charcoal making, labouring, brewing as well as temporary movements to the towns in search of employment are other possibilities.

Unfortunately there is very little information presently available on the role that livestock play in the farming systems. In the drier areas it is likely that their contribution is very important and that this should be fully taken into account when determining appropriate improvements to the agriculture in the area. One task of the farming systems economist will be to collect additional information on livestock during the next phase.

2.3.1 **Holding Size** There is little accurate data on holding size which is available for the two zones. Several surveys have been undertaken in different parts but it is only two surveys by the SWC Project which have actually measured areas. These were undertaken in the Evurore and Marimanti catchments in Zone 5.

All the surveys indicate the variability in total holding size. This includes fallow land and possibly bush if the holding has been adjudicated. 85% of the holdings were in the 2 to 4 hectare size range with 13% less than 2 hectares (see Table 5).

Table 5 Percentage of holdings in different size ranges

Size Range (ha)	Percentage of Holdings
0.1-2.0	13
2.1-4.0	85
4.1	2

The areas cultivated were less variable and for all holdings of less than 5 hectares the average area cultivated per season was approximately 0.8 ha (see table 6).

Table 6 Average area cultivated per season for holdings of different size categories

	Area of Total Holding (ha)		
	0.1 - 2.0	2.1 - 5.0	5.0
Average area cultivated	0.8	0.8	1.5

In order to simplify the analysis it has been assumed that the average area cultivated in the project area is 0.8 hectares. It is likely that there will be differences in total holding size between zone 4 and zone 5 but given the data available it is not possible to differentiate between the two zones. Whether or not the households are using oxen will also make a difference to the area cultivated. Again there is no reliable information available. As a result of this lack of information it has been assumed that all land is hand cultivated. The soil conservation works are not dependent on whether or not the land is cultivated by hand or by oxen.

2.3.2 **Cropping Patterns** Most of the surveys that have been undertaken indicate the percentage of farmers growing different crops but again it is only the SWC surveys which have actually measured the areas of the different crops and crop mixtures. This information is unfortunately only available for zone 5 which was part of the Phase I of the project. For zone 4 there is scanty information and this was collected after several very dry seasons when the shortages of various seeds had limited the number of crops that could be grown.

Given this background the available data had been adjusted on the basis of local knowledge to derive average cropping patterns for the two zones (see table 7). These are necessarily simplified and due to the tremendous variation between farms and from one season to another on the same farms, such patterns can only approximate descriptions of the real situation.

In Zone 4 (Marginal Cotton Zone) maize is the dominant cereal crop. Cotton is grown as a pure stand and also as part of a mixture with maize. The proportion of the area under single and two crop mixtures is approximately the same.

In Zone 5, which includes LM5 and IL5, the area planted with single crops is only 7 per cent and millet and sorghum are the dominant cereals. Greengram and cowpeas are normally grown in mixtures with these cereals.

Table 7 Cropping patterns assumed in Zones LM4 and LM5

Zone 4			Zone 5		
Crop(s)	Area	% of Area	Crop(s)	Area	% of Area
Single Crops			Single Crops		
Millet	0.10	12	Millet	0.04	5
Maize	0.15	19	Maize	0.02	2
Cotton	0.07	9			
Two Crops			Two Crops		
Maize/ Cotton	0.13	16	Millet/ Cowpeas	0.27	34
Maize/ Beans	0.20	25	Three Crops		
Three Crops			Millet/ Sorghum /Green-gram	0.30	38
Sorghum/ Cowpeas/ Green-gram	0.15	19	Four Crops		
			Millet/ Sorghum /Green-gram/ Cowpeas	0.17	21
Total	0.8	100	Total	0.8	100

2.3.3 **Crop Yields** Accurate and reliable information on yield data for the crops grown in the project area was not available. Any surveys that have been undertaken only refer to a single season and do not differentiate between shallow and deeper soils. The country has now been split into agro-ecological zones and there

has been an attempt to systematically assemble data for each zone in every district throughout the country (Farm Management Handbook). Unfortunately, this source does not include any yield data for zones 4 and 5 in Embu and Meru districts. The information given for zones 4 and 5 of the neighbouring district of Kitui was not derived from survey data and was found to be highly misleading.

It was necessary therefore to utilise all the available sources of yield data in order to derive data for the economic analysis. The following sources of information were used;

1. Farm Management Handbook Vol II C: Ministry of Agriculture, Government of Kenya.
2. Potential for small-scale irrigation in Kibungu and Ruruga villages of Tharaka Division, Meru district. Results of a socio-economic survey. E. Hawkesworth, 1984. (mimeograph)
3. East Africa Crops. J.D. Ackland. Longmans 1975.
4. Thanautu Vally Irrigation Project Feasibility Study Vol VII. Appendix 15. Economic and Financial Analysis, Final report. Booker Agriculture Ltd., Binnie and Partners Consulting Engineers.
5. Embu Agricultural Research Station. Data supplied to the planning office in Embu.
6. Staff attached to the EMI Soil and Water Conservation Project.

The figures from each source were different and in order to come up with "best estimates" for the long term averages several assumptions were made.

Seasonal variation. Yields vary from season to season as a result of the rainfall; in very dry years yields will be zero. The variation will be different for each crop, with maize being more likely to have a zero yield than more drought-tolerant crops such as sorghum and millet. An analysis of rainfall data between 1972 and 1979 in Lower Embu suggested that during this period (two cropping seasons per year) sorghum would have had zero yields twice and that maize would have had a zero yield in five seasons. The yield figures given take into account this variation.

Soil depth. In the semi-arid areas the depth of soil will have an impact on yields. In poor seasons, yields of all crops will be very low, but on deeper soils, i.e. those greater than 50cms, slightly higher yields might be expected. Soil depth will also have a much greater effect on yield when soil conservation structures are installed. This is discussed in more detail later.

It was assumed that yields would normally be approximately 30% higher on deeper soils as compared with shallow soils. The area measurements of each zone resulted in the percentage distribution of soils (shallow is less than 50cms) given in Table 8.

Table 8 Distribution of shallow and deep soils in each zone

Zone	Percentage of Soils in Each Class	
	Shallow	Deep
Lower Midland 4	10	90
Lower Midland 4-5	50	50
Lower Midland 5	40	60
Inland Lowland 5	100	0

This distribution was assumed when fixing the average yields for each zone.

Crops. Yield estimates have only been given for the major crops that are included in the cost-benefit calculations. Other minor crops grown in the zones include cassava, potatoes, sugar cane, cashew nuts, bananas, various vegetables, etc.

Management. In practice, management or crop husbandry will have a major impact on yield levels, e.g. timeliness of planting, weeding, bird scaring, seed selection and availability of labour etc.

Seasonal variation. There are two cropping seasons each year which correspond to the bi-modal rainfall pattern. It has been assumed that the average yields obtained will be the same during each season.

Mixed or single crops. None of the sources of data available indicated whether the yield levels were for the crops planted as pure stands or as part of a mixture. In practice more than 50% of all crops are normally grown as part of a mixture. In order to determine total outputs of each crop the following assumptions were made.

1. If two cereals or cotton and maize, are planted together, the yield of each component will be half the yield that would be obtained when planted as a single crop.

2. Where a cereal is planted with a legume it has been assumed that the yields of each crop will be 70% of the single crop.

Number of years that the plot has been cultivated. The yields of crops planted on a plot the first year after clearing will be much higher than in subsequent years and it can be expected that initially the decline in yields will be much higher than in subsequent seasons. The yield levels used assume that the plot has been planted for more than 3 seasons.

Optimum yields. The yields that are given in the first column of Table 9 are the yields that might be expected in zone 4 in a good or optimal year i.e. when there is no water stress. These yields have then been adjusted to take into account the factors which have been discussed. The yield figures for the major crops which were given in the five year District Development Plans are given in Table 10 for comparative purposes.

Table 9 Yield Estimates for crops grown in each agro-ecological zone (kg/ha)

Crop	Optimum Yields	Zone		
		Lower Midland 4	Lower Midland 5	Inland Lowland 5
Maize	1200	780	397	260
Millet	900	670	440	290
Sorghum	1000	750	490	320
Cowpeas	460	340	225	150
Greengram	370	280	1805	120
Pigeon Peas	500	375	245	160
Cotton	700	525	370	225
Sunflower	500	375	245	160
Beans	700	525	340	225

Table 10 Yields of crops given in the district development plans (kg/ha)

Crop	District			
	Embu		Meru	
	1979	1982	1976	1982
Cotton	450	450	306	137
Sunflower	–	–	–	800
Beans	900	900	437	671
Pigeon Peas	–	–	486	600
Millet	500	500	1395	845
Sorghum	700	700	1395	845

Sources: Meru District Development Plan 1984-1988.
Embu District Development Plan 1984-1988.

2.3.4 **Crop Prices** The prices used to value crop output are the official prices recommended by the Ministry of Agriculture and the NCPB for Embu District (see Table 11). For maize and cotton the prices are based on import and export parity prices and for the other crops grown, prices are estimated according to general market conditions i.e. supply and demand in the country.

Table 11 Official crop prices

Crop	KSh per bag	kg per bag	KSh per kg
Maize	156	90	1.74
Bulrush Millet	90	90	1.12
Sorghum	115	80	1.44
Cowpeas (small)	130	90	1.44
Greengram	360	90	4.00
Beans (Mwezi moja)	280	90	3.11
Cotton	-	-	4.55

Source: Cotton price based on 90% AR and 10% BR NCPB, Embu

The local market prices collected in the project area and in Embu are given in Table 12. These are all much higher than the official prices but do reflect the effects of several successive poor seasons in the area. Two good seasons could result in the prices being substantially reduced. As the Ministry of Agriculture and the NCPB attempt to take into account longer term trends in supply and demand when fixing the official prices it was decided therefore to use the official prices rather than adjusted informal market prices.

Table 12 Informal market prices of crops

Crop	Source of Data		
	Hawkesly (KSh/kg)	Informants (KSh/kg)	Embu Market (KSh/kg)
Maize	1.11	3.88	3.00
Millet	2.5	3.33	-
Sorghum	0.77	3.55	4.00
Cowpeas	n/a	3.55	-
Greengram	2.5	4.44	7.00
Beans	2.78	-	8.00

Source: E. Hawkesly - mimeo draft. Potential for small-scale irrigation in Kibungu and Ruunga villages of Tharaka Division. Results of preliminary socio-economic survey 1984.

2.3.5 **Farm Crop Outputs and Value** The total production of each crop grown on the 'average' hand-cultivated holding in each zone was calculated using the figures already derived for areas cultivated and yield of crops grown in each zone (see tables 13 and 14). Once the total yield of each crop was estimated for a holding in each zone the total value of each crop produced was then calculated using the official prices.

Although very little is purchased officially in the zones that form the project area except for cotton it has been assumed that the official prices more closely reflect the real economic price of the crops than the informal prices. The latter are subject to variations which are largely dependant upon the rainfall in a particular season. In setting the prices the government takes into account the opportunity cost of each crop and its value on the open market. Maize and cotton, as previously mentioned, are based on import and export parity prices respectively.

Table 13 Total crop output from an average holding in one season in the Lower Midland 4 Zone

Crop	Single or Mixed	Area (ha)	Yield (kg)	Total Crop Yield (kg)
Maize	Single	0.15	117)	
Maize	Cotton	0.13	51)	277
Maize	Legume	0.20	104)	
Sorghum	Cereal/legume	0.15	56	56
Cowpeas	Cereal/legume	0.15	25	25
Greengram	Cereal/legume	0.15	21	21
Beans	Cereal	0.20	73	73
Cotton	Single	0.07	37)	
Cotton	Cereal	0.13	34)	71

Table 14 Total crop output from an 'average' holding in one season in the Lower Midland 5 and Inland Lowland 5 Zones

Crop	Single or Mixed	Area (ha)	Lower Midland 5		Inland Lowland 5	
			Yield (kg)	Total Crop Yield (kg)	Yield (kg)	Total Crop Yield (kg)
Millet	Single	0.04	16		10	
Millet	Legume	0.27	83	215	55	142
Millet	2 legumes	0.30	79		52	
Millet	Cereal/legume	0.17	37		25	
Maize		0.02	8	8	5	5
Sorghum	Cereal/legume	0.30	74	116	48	75
	Cereal/legume	0.17	42		27	
Greengram	Cereal	0.30	34	50	18	28
	Cereal/legume	0.17	16		10	
Cowpeas	Cereals	0.27	43	52	20	33
	Cereal/legume	0.17	19		13	

The total value of the crops per holding in each zone indicate the subsistence and cash income levels that might be obtained from crops in each zone in an 'average' season (see tables 15 and 16). The annual incomes will be twice the income derived in one season and range from KSh 2616 in LM4 to KSh 1394 in LM5 and KSh 872 in Zone IL5.

Table 15 Summary of total yields of crops (in kg) in one season in each zone on a cultivated area of 0.8 hectares

Crop	Zone		
	Lower Midland 4	Lower Midland 5	Inland Lowland 5
Maize	277	8	5
Sorghum	56	116	75
Millet	67	215	142
Cowpeas	25	52	33
Greengram	21	50	28
Beans	73	-	-
Cotton	71	-	-

Table 16 Value of each crop (in KSh) in each zone per season at official prices from a cultivated area of 0.8 hectares

Crop	Zone		
	Lower Midland 4	Lower Midland 5	Inland Lowland 5
Maize	482	14	9
Sorghum	81	167	108
Millet	75	241	159
Cowpeas	36	75	48
Greengram	84	200	112
Beans	227	-	-
Cotton	323	-	-
Total	1308	697	436

2.3.6 **Calorific Value of Crop Outputs** Since numerous assumptions had to be made regarding the size of holding, area cultivated, cropping patterns and yields, the total calorific value of the crops produced on an average holding were calculated (see Table 18). These were then compared with the average food requirements of a family of six people. The average requirements of a family are given in Table 17 and are approximately 11830 calories per day.

Using these figures it can be shown that even in an average year crop production in all of the zones fails to satisfy the food requirements of an average family.

Table 17 Calorific requirements per day per family of 6 people

	Calories per day
Active male	2530
Active female	1880
Youth 16-19 years	2580
Children 7-9 years	2190
Children 4-6 years	1830
Infant less than 1 year	820
	11830 Cals per day.

Total Requirements per family : 4317950 Cals per year.

Table 18 Calorific output per season per holding

CROP	Calories per 100g	LM4 Kg	LM4 Cals	LM5 Kg	LM5 Cals	IL5 Kg	IL5 Cals
Maize	359	277	994430	8	28720	5	17950
Sorghum	347	56	194320	116	402520	75	260250
Millet	341	67	228470	215	733150	142	484220
Cowpeas	338	25	84500	52	175760	33	111540
Greengram	333	21	69930	50	166500	28	93240
Beans	338	73	246740	-	-	-	-
TOTAL		-	1818390	-	1506650	-	967200

Source: FAO Nutrition Handbook.

The estimated percentage of food requirements produced on typical farms are as follows;

Zone LM4	84% of requirements
Zone LM5	70% of requirements
Zone IL5	45% of requirements

It is expected that where possible other foods when available will make up the difference e.g. livestock products, seasonal fruits, wild vegetables, purchases of food, etc. However, many families will not have access to these additional resources and are likely to be living well below the recommended levels of nutrition.

These are average figures and there will be tremendous variation in family size, yields and areas cultivated. Families also require cash and it is likely that some food crops will be sold even in an average year. In a poor year, when yields can be reduced to almost nothing, many families will be reduced to very low levels of nutrition, which can easily have an impact on the health of the family.

The present knowledge of the area suggests that the figures are representative of the real situation. This additional evidence supports the assumptions that were made regarding yields, cropping patterns, etc.

2.3.7 **Labour** There are no figures available which indicate the labour requirements of each crop. A survey undertaken by the Farm Management Economists from the National Dryland Farming Research Station NDFRS at Katumani (The Farming Systems of Semi-arid Lower Embu, Eastern Kenya, NDFRS, Katumami Feb 1983) gives the hours spent each month on the major agricultural activities by a household (Table 19). The major activity is bird scaring and takes up 50% of all the time spent on agricultural activities. Land preparation takes up only 8 to 10% of the total time.

The introduction of ridging would have a big impact on the labour use within a household. Immediately obvious benefits will be required before such a change can be expected. The indications from the trials conducted in phase one suggest that the farmers who have tried ridging will continue with the practice.

The construction of Fanya Juu terraces will be done during the dry seasons or towards the end of the cropping seasons when most of the on-going agricultural activities will be undertaken by the women and junior members of the family.

The labour profiles do indicate that there is not a dramatic lull in agricultural activities during the dry season as is often suggested. August, September, October and March have the lowest total labour inputs but these are also the months when dry planting is taking place. Care will have to be taken to ensure that the extension effort on soil conservation is focussed during the right months if the work is to be undertaken by the men.

Table 19 Average labour inputs (man hours) per household per month and year.

	J	F	M	A	M	J	J	A	S	O	N	D	Total Year	% Crop Total
Murandi														
Farm Activities														
Land Preparation	-	75	-	-	-	-	1	24	22	6	-	-	128	8.7
Planting	-	-	51	-	-	-	-	-	14	47	-	-	112	7.6
Weeding	-	-	1	127	10	2	-	-	-	6	131	21	298	20.8
Bird Scaring	170	6	-	-	168	158	28	-	-	-	-	204	734	50.1
Harvesting	44	25	-	-	2	38	51	1	1	-	-	-	162	11.1
Transporting	6	7	-	-	-	5	12	1	-	-	-	-	31	2.2
Sub total	220	113	52	127	180	203	92	26	37	59	131	225	1465	100.0
Livestock Activities	206	206	206	206	206	206	206	206	206	206	206	206	2472	
Total	426	319	258	333	386	409	298	232	243	265	337	431	3937	
Kathera														
Farm Activities														
Land Preparation	-	43	23	-	-	-	10	46	84	2	-	-	208	10.3
Planting	-	1	64	4	-	-	-	-	10	93	2	-	174	8.6
Weeding	-	-	12	151	24	3	-	-	-	10	160	53	413	20.5
Bird Scaring	188	43	-	-	140	309	111	-	-	-	21	169	981	48.6
Harvesting	2	75	2	-	-	13	72	21	-	-	-	-	185	9.2
Transporting	1	19	2	2	-	-	21	13	-	-	-	-	58	2.8
Sub total	191	181	103	155	164	327	214	80	94	105	183	222	2019	100.0
Livestock Activities	201	201	201	201	201	201	201	201	201	201	201	201	2412	
Total	392	382	304	356	365	528	415	281	295	306	384	423	4431	

Source: Rukandema, Muhammed, Jeza, The Farming Systems of Semi-arid Lower Embu, Eastern Kenya. NDFRS, Katumami, Kenya.

PART III SOIL CONSERVATION

3.1 **SOIL CONSERVATION MEASURES** At the farm level three types of soil conservation measures will be implemented. They each have different labour demands and their effectiveness will also vary.

Trash lines laid along the contour have a low labour input to construct but are of a temporary nature, are not particularly effective in conserving soil, and are easily damaged.

Stone terraces are more permanent and in areas where the soils are stoney they will be encouraged. They have a high labour input to construct and will require frequent maintenance.

The most commonly used conservation structure is the 'Fanya Juu' terrace which involves digging a shallow bench and placing the soil on the upper side. Over a period of years a bench terrace gradually develops and the average slope of the land can be reduced. Emphasis will be placed on the promotion of this type of structure and the subsequent analysis is based on the benefits accruing from the implementation of 'FJ' terraces only. This is a simplified assumption, but an attempt to quantify benefits resulting from trash lines and stone terraces, given the lack of information on their effectiveness, was not thought justified.

3.2 **CONSTRUCTION OF "FANYA JUU" TERRACES** Certain assumptions regarding the construction of FJ terraces are common to all methods of implementation.

Work on the construction of terraces will normally only be undertaken during the dry season when there are few alternative demands for labour. Most of the work will be undertaken by men, since it is physically demanding. Women will be spending more time on household activities, especially collection of water and collection and preparation of food, than during the cropping seasons. Soils can be extremely hard during the dry season and this will also affect the rate of work that can be achieved. From experience gained in Evurore catchment it is assumed that where a farmer is undertaking the work himself he will achieve approximately 6 metres per day for a FJ terrace. Where people are working in groups and social activities intervene, the rate of work is expected to be slightly less and is estimated at 4 metres per day per person. It must be stressed that these rates are expected under average conditions. Under favourable soil conditions a paid labourer working on a piece rate basis achieved almost 30 metres per day. This was under exceptional circumstances and care should be taken to ensure that such figures are not quoted as normal rates of work.

Implementation of conservation structures will be undertaken in three different ways. Firstly, work will continue on an intensive basis in selected catchments. Secondly, direct assistance will be given to social groups of people undertaking

quasi-commercial activities. Finally, support and guidance will be given to the normal extension staff working with individuals in the project area. Each method will have a different rate of implementation.

The rate of implementation will always depend on the interest shown by farmers and their awareness of the benefits of conservation measures. In the high potential areas outside the project area, soil conservation measures are now being undertaken on a wider scale by farmers. In the semi-arid areas it will take longer for a majority of the farmers to be aware of the benefits of implementing such measures, and it is not expected that there will be any dramatic results in the first few years of the programme. However, unless there is a focussed attempt to start implementation of such a programme, irreparable damage will be done and an increasing area of land will be permanently removed from the cultivation cycle. With a rapidly expanding population, pressure on land resources and limited prospects of employment outside the agricultural sector, every attempt should be made to increase the rate of implementation. This is a problem which will be addressed during the project but for purposes of the economic analysis of the project, realistic and necessarily conservative rates of implementation have been assumed.

3.2.1 **Labour Requirements** In order to estimate the labour required to protect one hectare of land with 'fanya juu' terraces, the following assumptions were made:

- slope of land is 5 per cent;
- conservation structures are installed at vertical intervals of one metre;
- at the top edge of the field a cut-off drain would be constructed

In order to protect one hectare of land a total of 600 metres of FJ terraces would need to be constructed. If the farmer or his family are undertaking the work themselves, a total of 100 man days would be required for this work i.e. 6 metres per man day. Groups would work at a slightly slower rate (4 metres per man day) and would therefore take a total of 150 man days to undertake the same work.

It is considered unlikely that a farmer would complete the work on one hectare of land during one year since most of the work will be undertaken in the dry season. For purposes of analysis it is assumed therefore that each year a farmer will protect 0.5 hectares.

3.2.2 **Catchments** Work has already been undertaken in the two catchments of Evurore and Marimanti. Initially, implementation has been slow, as staff were being trained and the techniques developed. During the course of the project another two catchments will be incorporated into the work programme.

This activity will come under the direct control of the project and will be implemented by staff employed by the project. In the first year that any activity is undertaken in a catchment, four

project staff will be involved. Two of the staff will have worked elsewhere before and two will be new. In the fourth catchment only two staff will operate from the start. It is expected that work on the third catchment will be started during the 85/86 financial year, and the fourth in the following year. After four years of working in one catchment, the staff could be transferred to another catchment.

From experience gained so far it is expected that approximately 40 hectares of land each year will be protected by FJ terraces in each catchment. The total amount of land protected by the project during its three year life span is given in Table 20.

Table 20 Area of land protected each year in the catchments (ha)

Catchment	1985/86 Year 1	1986/87 Year 2	1987/88 Year 3
Evurore	40	40	40
Marimanti	40	40	40
Number 3	40	40	40
Number 4	-	40	40
Annual Total	120	160	160
Cumulative Total	120	280	440

In years 3 and 4 this would involve the construction of 96 km of FJ terraces or approximately 12 km per staff member.

At the end of the project (after 3 years) the future of the staff undertaking this activity is uncertain. They all have the relevant qualifications to undertake certificate studies which, if completed, would enable them to be employed on a permanent basis by the GOK.

3.2.3 **Groups** In each district encouragement and support will be given, via the local chiefs, to working social groups who wish to undertake conservation measures. To date, unlike many parts of the district, there is little evidence of group activities but it is expected, with political encouragement, that this type of activity will increase. As this is a novel approach the rate of work uptake has been assumed to be slow.

In the first year only 2 groups would operate; in the second year another 4 groups, and by the third year a total of 10 groups. In each group there would be approximately 25 members who would achieve a total of 100 metres of FJ terraces each day that they worked. To protect one hectare would take a total of six group visits; during the year, if the group met on 20 occasions (during the dry season only) a total of 3.5 ha would be achieved.

The total area protected by the groups each year is given below.

	Year 1	Year 2	Year 3
A Groups (2)	7	7	7
B Groups (4)	0	14	14
C Groups (4)	0	0	14
Annual total (ha)	7	21	35

Thus by the end of the third year of the project a total of only 63 hectares of land would have been protected. It can be expected that many of the individual members of the group will undertake work on their own plots and that this will be a major spin-off. No attempt has been made to quantify the spin-off effect or to include it in the calculations.

After the 3 years of the project it is anticipated that 10 groups each year would continue to operate. Some would fold up while others would come into existence. The total area protected each year by groups would continue to be 35 hectares.

3.2.4 **Individual Farmers** As part of the normal extension programme, the implementation of soil conservation measures would become an important element of the advice being given to farmers. This would continue in the future, with or without the project. It has been assumed, however, that due to the project the extension advice would become more meaningful and that more farmers would be assisted with terracing. Tools would be provided for sale on a subsidised basis during the project. As a result of this input and assistance given to the extension workers, it has been assumed that by year 3 a total of 4 additional farmers per extension worker would complete terraces on their holdings each year. There would necessarily be a slow build-up to this number.

In the two districts it is estimated that there are a total of 170 extension workers that are operating in Zones LM4 and IL5. It can be expected therefore that an additional 650 ha of land each year would be terraced as a direct result of their efforts.

It is also speculated that there would be a spin-off effect and that other farmers would construct terraces without assistance from the extension service. They would require assistance in marking out the plots but this might be undertaken by local people with a minimum of training. The number of farmers undertaking this activity is put at an additional 160 per year from year 3 onwards.

3.2.5 **Area of Fanya Juu Terraces** As a result of these 3 types of activity the total impact of the project on the construction of Fanya Juu terraces has been estimated and the figures are given in Table 21.

Table 21 Area of Fanya Juu terraces constructed each year as a result of the project (ha)

Type of Activity	Year				
	1	2	3	4	5-20
Catchments	120	160	160	0	0
Groups	7	21	35	35	35
Extension workers	170	340	680	680	680
Individuals	0	80	160	160	160
Total	297	601	1035	875	875

The amount of work undertaken in each agroecological zone was split on an area basis; 31% in zones LM 4 and LM 4-5, 38% in LM 5 and 31% in IL5.

Table 22 Area of land terraced in each zone each year (ha)

Zone	Year				
	1	2	3	4	5-20
LM 4 (inc.LM4-5)	92	186	320	271	271
LM 5	113	229	395	493	493
IL 5	92	186	320	271	271
Total	297	601	1035	875	875

By the end of year 3 only 1933 hectares will have been terraced, but by the end of the 20th year this total will have increased to nearly 16000 hectares.

3.2.6 **Supply of Tools** A major constraint which limits implementation is the availability of suitable tools for the construction of the FJ terraces. Forked jembes (hoes), shovels, pickaxes, etc, are not generally owned by farmers and are only available at a high cost. Disposable income for the purchase of such equipment is often not available and it has been the policy of the project during the first phase, when working in the pilot catchment areas, to supply tools on a loan basis. Once the work has been completed the tools have been returned to the project. The tools are also required for maintenance and alternative arrangements will be required in the future. The sale of equipment on a subsidised basis could be introduced initially, and then gradually the subsidy removed. Hopefully by this time village shops may have recognised the demand and increased their stocks. In addition a market in secondhand equipment may have developed which would allow people with limited cash to acquire them. Undoubtedly, as with all equipment, reciprocal borrowing arrangements will develop which may be as a result of labour given. This constraint to the construction of FJ terraces must

however be recognised and appropriate methods developed so that it is overcome in the longer term on an unsubsidised basis.

3.3 **GULLEY CONTROL** Gully control is a relatively expensive operation and the measures will normally be beyond the capability of an individual farmer because of the extent and depth of the gulleys. Such measures will only be undertaken in areas which are of good potential or where there is a risk to a particular structure e.g. a building, road, etc.

The rehabilitation would include one or more of the following activities, depending on the severity of the problem:

i) live fencing of the area to allow vegetative regrowth,

ii) water retention above the gulleying by the construction of cut-off ditches,

and iii) the construction of check dams in the flow lines.

The construction of the check dams will also vary from site to site. The use of stones, gabion structures, vegetative material and the planting of trees to stabilise the sides of the gulleys are all methods that could be employed in combination or separately.

During the project, structures at 10 sites in each district will be implemented each year i.e. a total of 60 sites during the three years of the project. The work at each site will be undertaken using labour paid by the project. It is estimated that the following costs will be incurred per site;

Labour	100 man days @ Ksh18 per man day	1800
Cedar posts	50 per site @ Ksh18 each	900
Weldmesh	10 per site @ Ksh100 each	1000
	Total Ksh	3700

In the economic analysis the costs for implementing gulley control measures have been included under the item of conservation works in the project costings.

Maintenance will need to be undertaken each year and it is assumed that 10 man days per year will be sufficient.

From the fourth year onwards it is assumed that no more gulley control measures are implemented, since it is unlikely there will be funds available for such activities.

3.4 **BENEFITS FROM SOIL CONSERVATION STRUCTURES** It has to be admitted at the start that any attempt to quantify the benefits from implementing soil conservation structures is hazardous. There is no long term data available which compares yields of crops on plots with conservation measures with those without such measures over a long period of time in the semi-arid areas of Africa.

In the past, work has tended to focus on steep slopes in the high potential areas where large areas have been denuded of

vegetative cover and erosion has been dramatic. In the semi-arid areas with medium slopes, soil erosion is often an insidious process except in the steeper and incised areas where gully erosion takes place. It is however sheet erosion whereby the top soil is slowly washed away at an imperceptible rate that, in the long term, will lead to the complete destruction of large areas of land in the semi-arid areas. This process may take 30 or 40 years or even longer, but unless control measures are implemented the slow degredation of the land will continue.

It is unlikely that there will be dramatic results in the first years of any programme tackling this problem. All that can be achieved in the short term is to investigate appropriate methods of control, means of implementation, likely longer term results, and increase the awareness of farmers and officials to the longer term consequences of such issues and start the implementation of appropriate structures.

In the following sections an attempt is made to quantify the benefits that might accrue from the implementation of conservation measures. It has to be stressed that such figures are based on numerous assumptions but throughout conservative figures have been made. It is implied therefore that the benefits could be greater than those suggested.

3.4.1 **Benefits from 'Fanya Juu' Terraces** The objectives of the terraces are to reduce the soil loss to zero and to improve water retention. Without the introduction of such terraces it can be expected that top soil will be totally lost in six to ten years if the plot is continuously cultivated. After that, subsoil will gradually be eroded and bedrock will eventually be reached. The time taken for this to occur will depend on the depth of the soil. In shallow soils of less than 50 cm in depth this process could take less than 50 years.

The affect on yields as a result of terracing can be attributed to two interactive factors a) soil conservation
and b) water retention.

The effect that each factor will have on yields is difficult to isolate but in semi-arid areas water stress rather than the status of the soils is normally the critical factor determining yield levels. The problem is further complicated by the variable rainfall pattern from season to season. In a season of poor rainfall the water retention effect of the terraces on yields will be far greater than in seasons of good rainfall. This aspect has been assumed when using average yields.

For the purposes of the analysis, the following simplified assumptions have been made:

1. crop husbandry practices are constant
2. there is no soil loss including top soil once the terraces are constructed
3. nutrient loss continues normally
4. yields decline increasingly over a 5 year period at a rate of decline of 5% per season with terraces and 6% per season without terraces

5. if the plot is cultivated for 10 years then the yield differences between years 5 and 10 will be constant at 12%,
6. all crop yields decline by a similar percentage and that the effects of the terraces are the same on all crops,
7. the plot is cultivated for 6 years before fallowing.

It is realised that these assumptions are simplistic. Yields will normally fall far more rapidly in the first two seasons of cultivation than in subsequent years. Different crops will respond differently to water stress and yield responses will differ for each crop. Fallow periods are being reduced and farmers are cultivating the same plots for longer periods.

For the economic analysis it has been assumed that once a farmer has constructed terraces on part of his holding he will continue to terrace the rest of his cultivated areas. After six years it is assumed therefore that yield increases due solely to 'fanya juu' terraces will be constant at 12% per season.

3.4.2 **Benefits from Gulley Control** Where a road or a building is threatened by gulley erosion it could be assumed that the replacement cost of the asset is equal to the cost of installing the structure. It is unlikely however that more than 10 per cent of all the structures will be built for this purpose. Where agricultural land is protected the benefits will be in terms of the land which is not lost from production. Without the checks, an increasing amount of land will be lost each year, depending on the rainfall pattern. In order to quantify the loss at each site the following assumptions have been made;

In years	1 to 5	0.20 ha is lost each year
From years	6 to 10	0.5 ha is lost each year
From years	11 to 20	1 ha is lost each year

Over a period of 20 years a total of 16 ha per site could therefore be lost from production. It is assumed that half of this land will be fallow each year (similar to one season per year) and that half of the 60 structures will be in zone LM4 and half in LM5.

The total area of land saved during the project and the area effectively saved for cropping each year is given in table 23. After 20 years it is estimated that a total of 750 hectares will still be under cultivation which would otherwise have been lost.

The value of production saved per hectare is based on the average per hectare value of the crops produced in zones LM4 and LM5.

Table 23 Area of land which would have been lost from production each year due to gulley erosion (ha)

Year Structure Built	Year													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14-20
Year 1	4	4	4	4	4	10	10	10	10	10	20	20	20	20
Year 2		4	4	4	4	4	10	10	10	10	10	20	20	20
Year 3			4	4	4	4	4	10	10	10	10	10	20	20
Land lost each year (ha)	4	8	12	12	12	18	24	30	30	30	40	50	60	60
Cumulative area lost (ha)	4	12	24	36	48	66	90	120	150	180	220	270	330	750

3.4.3 **Valuation of Benefits from "Fanya Juu" Terraces** It is assumed that the benefits from "fanya juu" terraces will be derived by reducing the decline in yields from 6% per season to 5% i.e. an effective saving of 1% per season or 2% per year. On this basis and using the figures derived in table 16 on a per hectare basis, the value each year of this 'saved' production up to the seventh year has been calculated.

Table 24 Incremental value of output (in KSh) as a result of a 1% saving in yields per holding (0.8 ha) (Table 24) and per hectare in each zone in the project area

Crop	Zone		
	Lower Midland 4	Lower Midland 5	Inland Lowland 5
Maize	4.82	0.12	0.09
Sorghum	0.81	1.67	1.08
Millet	0.75	2.41	1.59
Cowpeas	0.36	0.75	0.48
Greengram	0.84	2.00	1.12
Beans	2.27	-	-
Cotton	3.23	-	-
Total per holding (KSh)	13.08	6.95	4.36
Total per hectare (KSh)	16.25	8.69	5.45

In order to value the total area terraced each year, a weighted per hectare value based on the proportion of the land terraced in each zone was calculated. The figures are given in Table 25.

Table 25 Weighted per hectare value of benefits each year for project area (KSh/ha)

Zone	Factor	Year						
		1	2	3	4	5	6	7 +
LM4	0.31	5.0	25.2	45.3	65.5	85.6	105.8	120.9
LM5	0.38	3.3	16.5	29.7	42.9	56.1	69.3	79.3
IL5	0.31	1.7	8.4	15.2	22.0	28.7	35.5	40.5
Weighted per hectare benefit		10	50	90	130	170	210.6	240.7

In each year of the project and then to the year 20 it has been assumed that an area of land will be terraced according to the projections given in table 26. In the first year that the terraces are constructed benefits will only accrue in the second season i.e. the benefits will only be equal to the 1% yield saving in the second season.

From the sixth year it is assumed that on a normal holding a farmer will have terraced more than 0.8 hectares i.e. to include fallow land so that all cropped land will be benefitting by an approximate saving in yield of 12% each year. In the longer term, if the land were not terraced, yields would eventually be reduced to zero and the net savings in yield would be much greater. Soil fertility losses would still result in a gradual decline in yields on terraced land unless improved crop and soil husbandry methods were also adopted e.g. crop stations, fallowing, use of cattle manure, burying of crop residue etc.

Table 26 Incremental benefits per hectare per year for 7 years (KSh)

Zone	Year						
	1	2	3	4	5	6	7 +
LM4	16	81	146	211	276	341	390
LM5	9	43	78	113	148	182	209
IL5	5	27	49	71	93	114	131

3.4.4 **Valuation of Benefits from Gulley Control Measures** The area each year which would have been lost from production if gulley controls such as check dams had not been implemented was estimated in section 3.3.

In order to calculate the value of the 'saved' production it was assumed that half the land would be left fallow and that the value of the crops would be equivalent to that achieved in an average year in zones LM4 and LM5 (no works are undertaken in zone IL5). Using an average figure for both zones, Sh 1253 per ha is the value of production that is saved on the area which is cropped each season. In a year, the value will be twice this.

PART IV AGRONOMIC MEASURES

4.1 **TILLAGE TRIALS** Investigatory trials to determine appropriate cultivation practices for the area will continue in the Phase II of the project. Three methods of land cultivation will be compared;

ridges
crescents
the use of digging sticks.

Ridges will be made using a heavy hand hoe and initially will be approximately 75 to 100 cm apart and 18 to 30 cm in height. Importance will be attached to ensuring that they are laid out along the contour in order to minimise runoff. At the end of each row the ridges will be tied. **Crescents** are much quicker and simpler to make. Two divots at 45° to each other are taken and the earth arranged to form a micro-dam where runoff will be caught and effective rainfall to each plant increased. They are quicker to construct but not as effective as ridges in conserving water and soil. The **digging stick** is the traditional implement for cultivation and planting. A hole is simply made in the ground and the seed is dibbled into the hole. The soil structure is not disturbed and a large area of land can be quickly planted. Once ridges are well established it is feasible that a digging stick could be used every other year.

Work will also continue on the development of appropriate ox-drawn equipment.

Preliminary data is now available on these comparative methods of land cultivation and the yields that can be obtained. Ridging is the most labour-demanding and, as with crescents, the use of a flat hoe (jembe) is required. For many farmers this will be a constraint. The comparative labour inputs for the different cultivation methods on both soft and stony soils are given in Table 27. This data is based on very few observations and should therefore be treated with caution.

Table 27 Average labour inputs for different cultivation methods (hours per hectare)

Type of cultivation	Soft Ground	Stoney Ground
Ridges	126	173
Crescents	63	93
Digging stick	30	52

Very few yield results were available but they do indicate that yields are likely to be significantly higher where ridges and crescents are used compared with flat cultivation using a digging stick.

It is also considered significant that all of the farmers who were involved in the trials are continuing to use the ridges on the same area and some are expanding the area which is ridged. Initially the labour requirements are much higher but in subsequent years 'splitting the ridges' will be far less time consuming.

The comparative advantages and disadvantages of each method of cultivation are compared in Table 28.

Table 28 Advantages and disadvantages of different cultivation practices.

	Disadvantages	Advantages
RIDGING	1. High labour input 2. May delay planting 3. Requires a heavy hoe 4. Physically demanding 5. Difficult when ground is dry and hard.	1. Reduces soil loss to zero 2. Increases moisture available to the plant 3. Allows crop residues to be buried 4. Allows animal manure to be buried 5. Increases value of land 6. Apparent higher yields 7. Can be combined with oxenisation.
CRESCENTS	1. Medium labour input 2. Top soil loss continues 3. Requires heavy hoe 4. Does not allow crop residue or manure to be buried.	1. Less labour than ridging 2. Marginal increase in moisture availability 3. Improves yield compared with digging stick 4. Reduces top soil loss 5. Expected increase in yields 6. More timely than ridges.
FLAT - DIGGING STICK	1. Does not affect soil erosion 2. Humus not returned to soil 3. Crop failure frequent 4. Further moisture retention 5. Lower yields than other methods.	1. Least labour demanding 2. Easier for dry planting 3. Minimum tillage 4. Implements readily available 5. Farmers familiar with method.

If the labour constraints are not critical and people have the cash to afford a heavy hand hoe then the advantages of ridging in the long term outweigh the disadvantages. Soil loss is minimised, moisture is retained in the soil and humus can be buried easily. It is however a new technique in the area, which has not been practised before, and as a result it is almost impossible to predict how rapidly it might be adopted.

4.1.1 **Benefits from ridges and crescents** The use of ridges and crescents is likely to have an immediate impact on the yields of the crops grown. The preliminary data available suggests that yield increases can be expected of at least 15% for ridges and 5% for crescents above the yields obtained using a digging stick.

If these tillage practices are combined with the correct use of animal manure, then further yield increases can be expected. Additional data is required during the next phase of the project. For the purpose of evaluating the benefits that might accrue from the use of ridges and crescents, it has been assumed that they would not be combined with the use of manure and that yield increases of 15% and 5% would be achieved.

Ridging and crescents will require the use of a jembe (hand hoe) and on a normal household it is assumed that one would last 2 seasons for ridges and 4 seasons for crescents. A major unknown is the rate at which these practices would be taken up by the farmers. It is significant that those who were involved with the trials have generally tended to increase their areas which are being ridged. In order to put a value on the benefits that might accrue the following take-up rate has been assumed for farmers ridging and a similar rate for those making crescents (see Table 29)

Table 29 Adoption rates for farmers making ridges and crescents

	Year					
	1	2	3	4	5	6-20
Additional no. of farmers each year	20	40	80	80	80	80
Incremental area with ridges (ha)	16	32	64	64	64	64

It is also assumed that 50% of the land ridged or cultivated with crescents will be in zone LM4 and 50% in zone LM5.

4.1.2 **Valuation of Benefits from Ridges and Crescents** The benefits which will accrue from making either crescents or ridges will be immediately apparent. It has been assumed that ridges will increase yields by 15% and crescents by 5% per season. The rate of up-take of farmers and the increase in area cultivated each year has been estimated in Table 29. Using figures previously derived for a 1% increase in yield the value of the extra production on one hectare in each zone in each year (2 seasons) was calculated. From this the economic cost of a jembe has been deducted assuming that one lasts for one year only for ridges and 2 years for crescents.

In zone LM4 the net benefits from ridging in one season are Sh 240 per hectare and in zone LM5 Sh 135 per ha. For crescents the benefits per season are Sh 80 per hectare and Sh 45 per hectare respectively. On the assumption that 50% of the uptake is in zone LM4 and 50% in zone LM5 the average net benefit per year for ridges is Sh 335 per hectare and Sh 105 per ha for crescents (economic cost of jembe has been deducted).

4.2 **ON-FARM CROP TRIALS** The project will assist the two district crop officers to conduct on-farm trials of improved crop varieties and practices. The design of the trials will be undertaken in conjunction with the Katumani Dryland Farming Research Centre. There will be regular contact with staff there and one member of the research staff will be working full time in the project area.

The trials will be undertaken by the field extension agents (IA's and JTA's) who are based in the villages. Each week during the cropping season one day will be set aside for trials under the T & V system of extension. If improved varieties suitable for the area can be determined, this could have a considerable impact. It is however impossible to forecast when and what the impact might be from this type of research and it was decided not to attempt to include any possible benefits in the economic analysis.

4.3 **BULKING-UP OF SEED** Throughout the area, and especially after a drought situation, a major problem facing the farmers is the shortage of seeds. The Kenya Seed Company tends to favour production of seed for the high potential areas, where the demand for seed is more predictable. During the first phase of the project the availability of seed for the trials was a problem and a small bulking-up programme was started of those varieties which were being tested at the farm level.

During the second phase of the project it is proposed that seed bulking will be expanded in order to meet the demand that might arise from the farmers in the area. In the first year this is not expected to be a cost covering exercise with receipts from sales only covering 50 per cent of the costs. In subsequent years receipts from sales should at least equal the costs of the exercise.

Ways of ensuring that this activity will continue will be explored during the life of the project. Possible groups or organisations who might be involved include missions, progressive farmers and government institutions.

PART V WATER CONSERVATION

5.1 **BACKGROUND** During the next phase of the project the programme of building sand weirs will continue and diversion furrows/canals will also be rehabilitated. The emphasis will be on the provision of water for domestic consumption from a reliable source during the dry season. In the low potential areas where the population density is low and relatively scattered the objective is to provide a water source within 5 kms of every homestead using low cost methods.

5.2 **SAND WEIRS** The subsurface dams or sand weirs being built by the project should have a minimum capacity of 0.5 million litres capable of serving 300 people with 10 litres of water each per day for a period of 150 days. If, as is assumed, livestock are also watered at these dams, then this will deplete the resources more rapidly and the water will only last for a shorter period.

The cost of one dam has been estimated at approximately Sh 147,000 and in order to speed up implementation during the second phase of the project, contractors will be employed. On this basis the average direct costs per person served will be Sh 490. This is less than the normal estimates used by the Ministry of Water Development for small scale schemes. The maintenance costs of a sand weir are very low and a nominal figure could be included. No costs were included in the economic analysis as most of the work should be undertaken by unskilled male labour during the dry season when the opportunity cost of labour is zero.

5.2.1 **Implementation** It is planned to build 15 sand weirs in year one and 10 in each of the second and third years.

5.2.2 **Benefits** Each dam should serve approximately 300 people and by the end of the project (3 years) a total of 35 sand weirs will have been constructed. A total of just over 10,000 people should benefit by having an improved and reliable dry season source of water available to them.

The simplest way of quantifying benefits that accrue from a sand weir is in terms of the time saved if the family normally fetches its own water. Many families now have to travel long distances (up to 12 km) for water during the dry season and it is assumed that each household will save approximately 2 hours for each 20 litre container of water. For the women there are always other activities that can usefully be done and there is therefore an opportunity cost for their time. For the analysis it has been assumed that the Shadow Wage Rate (SWR) for a women is Sh 0.50 per hour. The economic value of the time saved while collecting 20 litres of water is therefore Sh 1.

In practice it is suggested that only 50% of the water stored in a small dam will be available for domestic consumption. If the dam has a capacity of 0.5 million litres than 250,000 litres will be available at an economic value of Sh 12,500. If each person within the area served by the dam uses 10 litres per day then the dam will only have the capacity to serve 300 people for

a total of 84 days. For dams of this size it will then be necessary to restrict the watering of livestock if the dry season continues longer than normal.

5.3 **DIVERSION FURROWS** During the 1950's several furrows/canals were dug which took water from perennial rivers flowing into lower Meru. Unfortunately many of these were not aligned correctly and have silted up. It is necessary to rehabilitate these diversion furrows and during the next phase of the project five will be cleared and restored to full use again. Arrangements will also be explored to ensure that regular maintenance is undertaken and groups along each canal are made aware of their responsibilities.

The average length of a furrow to be rehabilitated will be approximately 10 kms although one which has been done during the first phase of the project was over 30 kms in length. One of the major expenses will be at the offtake from the rivers. Some of the diversion structures need repairs and others will need rebuilding due to incorrect original designs.

The average cost for rehabilitating one structure is estimated at KSh 200,000.

The main purpose of the furrows is to supply the nearby population with drinking water. They are not designed for irrigation and if large quantities of water are taken out near to the headworks then those further downstream will be deprived of supplies. It will not be possible to stop livestock from being watered from the furrows but care must be taken to ensure that they are not allowed to damage the banks.

5.3.1 **Benefits of Diversion Furrows** The benefits accruing from such a diversion furrow are similar to those from a sand weir. The people living within a reasonable distance of the furrow will have access to a reliable source of water throughout the year. Along the length of a canal (10 kms) it is expected that an area 1.5 kms on either side of the furrow will be served. Assuming that the average population density is similar to the rest of the area (41 persons per Km^2) then approximately 1230 persons or 205 families will be served. If two female members of the family were normally collecting the water and they save an hour each day, then the value of the time saved is approximately Sh 1 per day. If this saving is for 150 days of the year then the total saving for 205 families will be Sh 30,750 per furrow.

PART VI ECONOMIC ANALYSIS

6.1 **ECONOMIC COSTS** The estimated financial costs of the project for the three years of the proposed project are given in Appendix 1. These figures were adjusted in order to obtain the economic costs of the project. These costs also included the costs of technical assistance and staff and resources required to ensure that implementation continues after the initial 3 year phase.

The assumptions used for adjusting the financial costs were as follows:

i) All vehicle operating costs for both diesel and petrol driven vehicles adjusted by an Accounting Ratio (AR) of 0.65. Assumed that 20% of the resultant costs would be locally incurred.

ii) Government of Kenya staff salaries also include allowances and are net of taxes. They have been adjusted by AR's of 0.75 and 0.50 to reflect alternative employment opportunities. Travelling and subsistence allowances adjusted by an AR of 0.75.

iii) Miscellaneous costs adjusted by an AR of 0.80 to reflect sales taxes and also duties on any imported items.

iv) Housing and construction costs adjusted 0.66. This is based on AR of 0.80 for 80% of the costs and an AR of 0.50 for 20% of costs which are for labour. It is further assumed that of the building materials there is a 10% foreign exchange or imported element.

v) All imported items, consultancies and technical assistance have an AR of 1 i.e. it is suggested that the Kenyan currency is set at its correct world market value.

Whether or not to include GK staff who are not working directly with the project 100 per cent of the time depends on the assumptions that are noted. If the project is viewed as a short term research-orientated project establishing and developing extension messages for soil and water conservation resources which can be implemented for the next twenty years, then only those staff directly attached to the project need to be included in the costs. If, however, implementation is to continue at the rate suggested in the projections for the next twenty years, government staff will have to continue devoting a proportion of their time and resources towards the project. A cost element has been included for years 4 to 20 to take into account the costs of implementation during this time period. The district, division and location extension workers have been costed on a part-time basis. Junior GK extension staff based at village level have not been included in the costs as they will continue to be posted to the villages with or without the project. At the time of the year when they are supposed to be working on conservation works, alternative activities will be very limited.

All the major costs are incurred in the first three years of the project and from year 4 onwards the costs will be substantially reduced. The number of vehicles operating, equipment being used, miscellaneous costs etc have been reduced accordingly:

i) Vehicle operating costs on the basis of 1 lorry, 3 landrovers and 5 motorcycles only.

ii) Travel and accommodation only paid to GK permanent staff attached to the project.

iii) The miscellaneous costs have excluded direct works-paid staff and then been reduced by 50%.

iv) Replacement of vehicles and motorcycles on the basis of 3 landrovers, 1 lorry and 5 motorcycles every 5 years. Costs spread out over the 5 years.

v) 50 per cent of the equipment costs are replaced every 5 years.

vi) Only GK staff directly attached to project costed and then only on the basis of 30 per cent of their time.

vii) All technical assistance and consultancies discontinued after year 3.

On the basis of these assumptions the economic costs of the Kenyan government staff and for the entire project for each year are given in Tables 30 and 31 (page 43).

6.2 **BREAKDOWN OF ECONOMIC COSTS OF SOIL AND WATER CONSERVATION ACTIVITIES** In order to separately evaluate the economic benefits of the soil and water conservation activities, the costs of each set of activities were split up accordingly. Most cost items were easily allocated but for overheads it was done on a proportional basis. It was assumed that the equivalent of one TCO was permanently engaged on water conservation activities. After year 3 it has been assumed that no further water conservation structures are built and that all maintenance activities are undertaken at zero opportunity cost. This is possibly a simplistic assumption but for water structures the maintenance costs will be very low and not required during the early years.

Hand tools are required for the construction of terraces, gulley control and also for the making of ridges and crescents. Adjusted costs of hand hoes have been deducted from the benefits of terraces in order to determine the net benefits. The costs of the hand tools for gulley control along with other specific costs have been included in the overall costs. For farmers who are ridging and making crescents the cost of the hand tools has been deducted when estimating the per hectare benefits.

It has been assumed that all work on the terraces will be undertaken during the dry season when there is little alternative work for men. The opportunity cost of the labour will be zero i.e. the shadow wage rate for the time spent by

male workers constructing and maintaining terraces will be zero. Women are not involved in this work. The labour required for the construction of the gulley control measures has been included in the costs for conservation measures.

6.3 **ECONOMIC BENEFITS** The benefits accruing from the soil conservation structures can be measured either in terms of the extra output of crops or the production saved i.e. without the project land would have gone out of production. In Part III details were given of the extra production and the savings that might accrue on a per hectare basis. During the first three years of the project and then in subsequent years, specific rates of implementation have been assumed. These are given together with the benefits accruing in each year.

The value of the benefits is based on the official prices for the crops. The prices of maize and cotton are based on import and export parity prices respectively and an attempt is made to base the price of other crops on general supply and demand conditions existing in the country.

The benefits from the water conservation projects have been evaluated in terms of the time saved in the collection of water during the season. The value of this time saved is dependant on the calculation of the Shadow Wage Rate (SWR) for women. It has been argued that for men the SWR during the dry season is zero i.e. there are no alternative useful activities that they can be engaged in. However for women there are always gainful activities that they can be engaged in e.g. food gathering, cooking, washing clothes, handicrafts etc. Using the minimum rural wage rate of KSh 18 per hour and an AR of 0.2, the cost per hour for a woman's time is approximately Sh 0.5 per hour. Other benefits which might accrue from improved water conservation structures, such as reduced health hazards, can not be easily measured or quantified in economic terms.

It has been assumed that once the water structures have been installed they will be operational for the twenty year period and that benefits will accrue for the whole period. Maintenance will be required but this will again be undertaken during the dry season when there are few alternative activities.

Many of the potential benefits that might accrue from such a project are not easily quantifiable. Apart from the directly productive activities which will produce quantifiable benefits, the project can also be considered as an applied research project. All activities will be closely monitored and many of the results will be applicable in other semi-arid environments in Africa.

No attempt has been made to quantify either the benefits that could arise from the crop trials or the benefits to livestock production which could be achieved through the increased use of crop residues. The project will be very closely linked to the Goat and Sheep Project at Marimanti and there will be an integrated approach to development problems in the project area. There will also be very close links with the Dryland Farming Research Programme at Katumani Research Station.

A major unknown is the rate at which land will be degraded with a rapidly increasing population in the area during the next 20 years. Unless attempts are made immediately to arrest and improve the situation the risk of desertification will rapidly increase.

6.4 **ECONOMIC RETURNS** The net present value (NPV) and the Internal Rate of Return (IRR) for the project as a whole were calculated based on the assumptions outlined. Using a discount rate of 10%, the NPV of the total project was KSh-320,574. The IRR was 5.2% approximately (Table 35). This is a low figure but it would be unrealistic to expect high returns from such a project at the present time.

If the timespan of benefits from the project is reduced to 10 years then the IRR is -19%. An increase of the costs by a factor of 2 reduces the IRR to a negative figure (-3.6%).

Separate analyses were undertaken for the two basic components of the project. The economics of the Water Component (see table 35) were largely dependent on the benefit stream and the SWR for women in the dry season. Using the suggested value of KSh 0.5 per hour, the NPV at 10% is KSh-138,795 and the IRR is 3%. If, however, the benefits are doubled i.e. the SWR for women is increased to KSh 1 per hour, the NPV at 10% is KSh 64,839, and the IRR is 12.8%.

The returns for the agricultural component were also calculated (see Table 33). Using the normal benefit stream the NPV at 10% is KSh-181,779 and the IRR is 6.1%. If the benefits are doubled then the IRR is increased to 15.3% and the NPV at 10% is KSh 344,753.

TABLE 30

EMI SOIL AND WATER CONSERVATION PROJECT

PROJECT COSTS

	(Kenyan pounds)	YEAR																			
ITEM		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Vehicle operations	Local	4914	5044	5044	2392	2392	2392	2392	2392	2392	2392	2392	2392	2392	2392	2392	2392	2392	2392	2392	2392
	Foreign	19656	20176	20176	9568	9568	9568	9568	9568	9568	9568	9568	9568	9568	9568	9568	9568	9568	9568	9568	9568
Travel and accomodation	Local	10242	10242	10242	5092	5092	5092	5092	5092	5092	5092	5092	5092	5092	5092	5092	5092	5092	5092	5092	5092
Misc office costs	Local	15984	13824	14544	3825	3825	3825	3825	3825	3825	3825	3825	3825	3825	3825	3825	3825	3825	3825	3825	3825
Consultancies	Foreign	16000	16000	16000																	
Vehicles and cycles	Foreign	64270	8300	8300	8300	8300	8300	8300	8300	8300	8300	8300	8300	8300	8300	8300	8300	8300	8300	8300	8300
Equipment	Foreign	6840	1368	1368	1368	1368	1368	1368	1368	1368	1368	1368	1368	1368	1368	1368	1368	1368	1368	1368	1368
	Local	8536	1707	1707	1707	1707	1707	1707	1707	1707	1707	1707	1707	1707	1707	1707	1707	1707	1707	1707	1707
Buildings	Local	5280																			
Conservation works	Local	79689	63894	61846																	
	Foreign	8854	7099	6872																	
G K Staff	Local	21478	24146	24146	11254	11254	11254	11254	11254	11254	11254	11254	11254	11254	11254	11254	11254	11254	11254	11254	11254
Technical assistance	Foreign	112875	112875	112875																	
Total		374618	284675	283120	43506	43506	43506	43506	43506	43506	43506	43506	43506	43506	43506	43506	43506	43506	43506	43506	43506

TABLE 31

KENYA GOVERNMENT STAFF

DESCRIPTION	STAFF TYPE	Salary	House allowance	Gross salary	Tax rates	less NSSF	Net salary	% time project	Account ratio	Economic cost	Years employed 1	2	3	4	5-20
Project coordinator	project	2541	870	3411	387	48	2976	100	75	2232	1	1	1		
Farm systems economist	project	2541	870	3411	387	48	2976	100	75	2232	1	1	1		
District crops officers	normal	2109	720	2829	258	48	2523	30	75	568	2	2	2	2	2
Division extension offs	normal	2109	720	2829	258	48	2523	30	75	568	4	4	4	4	4
Location extension offs	normal	1341	510	1851	109	48	1694	30	75	381	7	14	14	14	14
Economics section TO	project	1341	510	1851	109	48	1694	100	75	1271	2	2	2		
SWC section TO	project	1341	510	1851	109	48	1694	100	75	1271	2	2	2		
SWC section TA	project	1002	360	1362	46	48	1268	100	50	634	2	2	2		
Drivers	project	642	270	912	0	46	866	100	50	433	7	7	7	4	4
Typists	project	652	270	922	0	46	876	100	50	438	2	2	2	1	1
Messengers	project	539	180	719	0	36	683	100	50	342	2	2	2	1	1

Costs per year	(Kenyan pounds)	YEAR 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Project coordinator	project	2232	2232	2232	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Farm systems economist	project	2232	2232	2232	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
District crops officers	normal	1135	1135	1135	1135	1135	1135	1135	1135	1135	1135	1135	1135	1135	1135	1135	1135	1135	1135	1135	1135
Division extension offs	normal	2271	2271	2271	2271	2271	2271	2271	2271	2271	2271	2271	2271	2271	2271	2271	2271	2271	2271	2271	2271
Location extension offs	normal	2648	5336	5336	5336	5336	5336	5336	5336	5336	5336	5336	5336	5336	5336	5336	5336	5336	5336	5336	5336
Economics section TO	project	2541	2541	2541	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SWC section TO	project	2541	2541	2541	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SWC section TA	project	1268	1268	1268	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Drivers	project	3031	3031	3031	1732	1732	1732	1732	1732	1732	1732	1732	1732	1732	1732	1732	1732	1732	1732	1732	1732
Typists	project	876	876	876	438	438	438	438	438	438	438	438	438	438	438	438	438	438	438	438	438
Messengers	project	683	683	683	342	342	342	342	342	342	342	342	342	342	342	342	342	342	342	342	342
	Total costs	21478	24146	24146	11254	11254	11254	11254	11254	11254	11254	11254	11254	11254	11254	11254	11254	11254	11254	11254	11254

TABLE 32

BENEFITS FROM SOIL CONSERVATION MEASURES

FANYA JUU TERRACES		YEAR																		
AREA IMPLEMENTED	hectares		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	incremental		297	601	1035	875	875	875	875	875	875	875	875	875	875	875	875	875	875	875	875	875
	cumulative		297	898	1933	2808	3683	4558	5433	6308	7183	8058	8933	9808	10683	11558	12433	13308	14183	15058	15933	16808
Value of benefits																						
year	AREA	(Kenyan pounds)																				
1	297	2970	14850	26730	38610	50787	62667	71577	71577	71577	71577	71577	71577	71577	71577	71577	71577	71577	71577	71577	71577	71577
2	601		6010	30050	54090	78130	102170	126811	144841	144841	144841	144841	144841	144841	144841	144841	144841	144841	144841	144841	144841	144841
3	1035			10350	51750	93150	134550	176985	218385	249435	249435	249435	249435	249435	249435	249435	249435	249435	249435	249435	249435	249435
4	875				8750	43750	78750	113750	149625	184625	210875	210875	210875	210875	210875	210875	210875	210875	210875	210875	210875	210875
5	875					8750	43750	78750	113750	149625	184625	210875	210875	210875	210875	210875	210875	210875	210875	210875	210875	210875
6	875						8750	43750	78750	113750	149625	184625	210875	210875	210875	210875	210875	210875	210875	210875	210875	210875
7	875							8750	43750	78750	113750	149625	184625	210875	210875	210875	210875	210875	210875	210875	210875	210875
8	875								8750	43750	78750	113750	149625	184625	210875	210875	210875	210875	210875	210875	210875	210875
9	875									8750	43750	78750	113750	149625	184625	210875	210875	210875	210875	210875	210875	210875
10	875										8750	43750	78750	113750	149625	184625	210875	210875	210875	210875	210875	210875
11	875											8750	43750	78750	113750	149625	184625	210875	210875	210875	210875	210875
12	875												8750	43750	78750	113750	149625	184625	210875	210875	210875	210875
13	875													8750	43750	78750	113750	149625	184625	210875	210875	210875
14	875														8750	43750	78750	113750	149625	184625	210875	210875
15	875															8750	43750	78750	113750	149625	184625	210875
16	875																8750	43750	78750	113750	149625	184625
17	875																	8750	43750	78750	113750	149625
18	875																		8750	43750	78750	113750
19	875																			8750	43750	78750
20	875																				8750	43750
																						8750
TOTAL (Kenya Shillings)		2970	20860	67130	153200	274567	430637	620373	829428	1045103	1255978	1466853	1677728	1888603	2099478	2310353	2521228	2732103	2942978	3153853	3364728
TOTAL (Kenya pounds)		149	1043	3357	7660	13728	21532	31019	41471	52255	62799	73343	83886	94430	104974	115518	126061	136605	147149	157693	168236
Adjusted jembe costs		594	1202	2070	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750
NET BENEFITS		-446	-159	1287	5910	11978	19782	29269	39721	50505	61049	71593	82136	92680	103224	113768	124311	134855	145399	155943	166486
GULLEY CONTROL	AREA Ha	4	12	24	36	48	66	90	120	150	180	220	270	330	390	450	510	570	630	690	750
	VALUE K Pounds	251	752	1505	2257	3010	4138	5643	7524	9405	11286	13794	16929	20691	24453	28215	31977	35739	39501	43263	47025
RIDGES	AREA Ha	16	48	112	176	240	304	368	432	496	560	624	688	752	816	880	944	1008	1072	1136	1200
	VALUE K Pounds	268	804	1876	2948	4020	5092	6164	7236	8308	9380	10452	11524	12596	13668	14740	15812	16884	17956	19028	20100
CRESCENTS	AREA Ha	16	48	112	176	240	304	368	432	496	560	624	688	752	816	880	944	1008	1072	1136	1200
	VALUE K Pounds	84	252	588	924	1260	1596	1932	2268	2604	2940	3276	3612	3948	4284	4620	4956	5292	5628	5964	6300
TOTAL BENEFITS																					
TERRACES		-446	-159	1287	5910	11978	19782	29269	39721	50505	61049	71593	82136	92680	103224	113768	124311	134855	145399	155943	166486
GULLEYS		251	752	1505	2257	3010	4138	5643	7524	9405	11286	13794	16929	20691	24453	28215	31977	35739	39501	43263	47025
RIDGES		268	804	1876	2948	4020	5092	6164	7236	8308	9380	10452	11524	12596	13668	14740	15812	16884	17956	19028	20100
CRESCENTS		84	252	588	924	1260	1596	1932	2268	2604	2940	3276	3612	3948	4284	4620	4956	5292	5628	5964	6300
VALUE OF TOTAL BENEFITS		157	1649	5255	12039	20268	30608	43008	56749	70822	84655	99115	114201	129915	145629	161343	177056	192770	208484	224198	239911

TABLE 33

AGRICULTURE COMPONENT

COSTS OF COMPONENT (Kenyan pounds)

ITEM		YEAR 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Vehicle operations	Local	2310	2371	2371	2392	2392	2392	2392	2392	2392	2392	2392	2392	2392	2392	2392	2392	2392	2392	2392	2392
	Foreign	9239	9483	9483	9568	9568	9568	9568	9568	9568	9568	9568	9568	9568	9568	9568	9568	9568	9568	9568	9568
Travel and accomodation	Local	9218	9218	9218	5092	5092	5092	5092	5092	5092	5092	5092	5092	5092	5092	5092	5092	5092	5092	5092	5092
Misc office costs	Local	14386	12226	12946	3825	3825	3825	3825	3825	3825	3825	3825	3825	3825	3825	3825	3825	3825	3825	3825	3825
Consultancies	Foreign	11000	11000	11000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vehicles and cycles	Foreign	46770	4800	4800	8300	8300	8300	8300	8300	8300	8300	8300	8300	8300	8300	8300	8300	8300	8300	8300	8300
Equipment	Foreign	6840	1368	1368	1368	1368	1368	1368	1368	1368	1368	1368	1368	1368	1368	1368	1368	1368	1368	1368	1368
	Local	8536	1707	1707	1707	1707	1707	1707	1707	1707	1707	1707	1707	1707	1707	1707	1707	1707	1707	1707	1707
Buildings	Local	5280	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conservation works	Local	9563	7668	7422	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Foreign	1063	852	825	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G K Staff	Local	18397	21065	21065	11254	11254	11254	11254	11254	11254	11254	11254	11254	11254	11254	11254	11254	11254	11254	11254	11254
Technical assistance	Foreign	75254	75254	75254	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total		217856	157012	157459	43506	43506	43506	43506	43506	43506	43506	43506	43506	43506	43506	43506	43506	43506	43506	43506	43506

BENEFITS FROM AGRICULTURE(Kenyan pounds)

	YEAR 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
TERRACES	-445	-159	1287	5910	11979	19782	29269	39722	50506	61849	71593	82137	92681	103224	113768	124312	134856	145399	155943	163862
GULLEYS	251	752	1504	2255	3007	4135	5638	7518	9398	11277	13783	16916	20674	24434	28192	31952	35710	39470	43228	46988
RIDGES	268	804	1876	2948	4020	5092	6164	7236	8308	9380	10452	11524	12596	13668	14740	15812	16884	17956	19028	20100
CRESCENTS	84	252	588	924	1260	1596	1932	2268	2604	2940	3276	3612	3984	4284	4620	4956	5292	5628	5964	6300
TOTAL	158	1649	5255	12037	20266	30605	43003	56744	70816	84646	99104	114189	129935	145610	161320	177032	192742	208453	224163	237250
NET BENEFITS																				
NORMAL	-217698	-155363	-152204	-31469	-23240	-12901	-503	13238	27310	41140	55598	70683	86429	102104	117814	133526	149236	164947	180657	193744
BENEFITS X2	-217540	-153714	-146949	-19432	-2974	17704	42560	69982	98126	125786	154702	184872	216364	247714	279134	310558	341978	373400	404820	430994

NPV NORMAL BENEFITS	AT 10%	-181779
	AT 6.1%	2756
	AT 5%	83284
NPV BENEFITS X2	AT 10%	344753
	AT 15.3%	182

TABLE 34

EMI WATER COMPONENT

COSTS OF COMPONENT

ITEM	(Kenyan pounds)	YEAR 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Vehicle operations	local	2604	2673	2673																	
	foreign	10417	10693	10693																	
Travel allowances	local	1024	1024	1024																	
Misc costs	local	1598	1598	1598																	
Consultancies	foreign	5000	5000	5000																	
Vehicles & cycles	foreign	17500	3500	3500																	
Conservation works	local	70126	56226	54424																	
	foreign	7791	6247	6047																	
G K Staff	local	3081	3081	3081																	
TCO Staff	foreign	37621	37621	37621																	
TOTAL		156762	127663	125661	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

BENEFITS

TYPE OF STRUCTURE	(Kenyan shillings)																				
SAND WEIRS		0	187500	312500	437500	437500	437500	437500	437500	437500	437500	437500	437500	437500	437500	437500	437500	437500	437500	437500	437500
DIVERSION FURROWS		0	31500	94500	157500	157500	157500	157500	157500	157500	157500	157500	157500	157500	157500	157500	157500	157500	157500	157500	157500
TOTAL		0	219000	407000	595000	595000	595000	595000	595000	595000	595000	595000	595000	595000	595000	595000	595000	595000	595000	595000	595000
TOTAL	(Kenyan pounds)	0	10950	20350	29750	29750	29750	29750	29750	29750	29750	29750	29750	29750	29750	29750	29750	29750	29750	29750	29750
NET BENEFITS		-156762	-116713	-105311	29750	29750	29750	29750	29750	29750	29750	29750	29750	29750	29750	29750	29750	29750	29750	29750	29750
BENEFITS X2		0	21900	40700	59500	59500	59500	59500	59500	59500	59500	59500	59500	59500	59500	59500	59500	59500	59500	59500	59500
NET BENEFITS		-156762	-105763	-84961	59500	59500	59500	59500	59500	59500	59500	59500	59500	59500	59500	59500	59500	59500	59500	59500	59500

NPV NORMAL BENEFITS	AT 10%	-138795
	AT 5%	-56397
	AT 3%	-130
NPV BENEFITS X2	AT 10%	64839
	AT 13%	-2953
	AT 12.84%	34

TABLE 35
TOTAL CASH FLOW

		YEAR																		
BENEFITS		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
TERRACES		-445	-159	1287	5910	11979	19782	29269	39722	50506	61049	71593	82137	92681	103224	113768	124312	134856	145399	155943	163862
GULLEYS		251	752	1504	2255	3007	4135	5638	7518	9398	11277	13783	16916	20674	24434	28192	31952	35710	39470	43228	46988
RIDGES		268	804	1876	2948	4020	5092	6164	7236	8308	9380	10452	11524	12596	13668	14740	15812	16884	17956	19028	20100
CRESCENTS		84	252	588	924	1260	1596	1932	2268	2604	2940	3276	3612	3984	4284	4620	4956	5292	5628	5964	6300
TOTAL		158	1649	5255	12037	20266	30605	43003	56744	70816	84646	99104	114189	129935	145610	161320	177032	192742	208453	224163	237250
AGRIC BENEFITS		158	1649	5255	12037	20266	30605	43003	56744	70816	84646	99104	114189	129935	145610	161320	177032	192742	208453	224163	237250
WATER BENEFITS		0	10950	20350	29750	29750	29750	29750	29750	29750	29750	29750	29750	29750	29750	29750	29750	29750	29750	29750	29750
TOTAL BENEFITS		158	12599	25605	41787	50016	60355	72753	86494	100566	114396	128854	143939	159685	175360	191070	206782	222492	238203	253913	267000
TOTAL COSTS		374618	284675	283120	43506	43506	43506	43506	43506	43506	43506	43506	43506	43506	43506	43506	43506	43506	43506	43506	43506
NET CASH FLOW		-374460	-272076	-257515	-1719	6510	16849	29247	42988	57060	70890	85348	100433	116179	131854	147564	163276	178986	194697	210407	223494
NET PRESENT VALUE	5.20%	6324																			
	10%	-320574																			

APPENDIX 1
FINANCIAL COSTS

APPENDIX 1 FINANCIAL COSTS

(For GK purposes Recurrent Staff costs (items 000 - 051) are regarded as Recurrent Expenditure and are not included in Development estimates)

Kenya F1a Kenya C (project life July 1985 - June 1988)

	Particulars		1985/86 GK	1985/86 ODA	1986/87 GK	1986/87 ODA	1987/88 GK	1987/88 ODA
000	Personal Emoluments(GK staff) 2							
	Project Co-ordinator(AO I)	(K)	2541	-	2541	-	2541	-
	Farming Systems Economist(RO I)	(K)	2541	-	2541	-	2541	-
	District Crops Officer,Embu	(J)	2109	-	2109	-	2109	-
	" " " Meru	(J)	2109	-	2109	-	2109	-
	Divisional Extension Officers(4 divisions)	(J)	8436	-	8436	-	8436	-
	Locational Extension Officers(14 Locations)	(G)	18774	-	18774	-	18774	-
	2 x TO I, Economics Section	(G)	2682	-	2682	-	2682	-
	2 x TO, Soil & Water Conservation	(G)	2682	-	2682	-	2682	-
	3 x TA, " " "	(F)	3006	-	3006	-	3006	-
	7 Drivers		4494	-	4494	-	4494	-
	2 Typists		1304	-	1304	-	1304	-
	2 Messengers		1078	-	1078	-	1078	-
010	SUBTOTAL PERSONAL EMOLUMENTS		51756	-	51756	-	51756	-
020	House Allowance							
	2 Job Group K		1740	-	1740	-	1740	-
	4 Job Group J		4320	-	4320	-	4320	-
	18 Job GROUP G		9180	-	9180	-	9180	-
	3 J6b Group F		1080	-	1080	-	1080	-
	7 Drivers		1890	-	1890	-	1890	-
	2 Typists		540	-	540	-	540	-
	2 Messengers		360	-	360	-	360	-
030	SUBTOTAL HOUSE-ALLOWANCE		19110	-	19110	-	19110	-
051	House Allowance (Aid.Staff							
	3 TCO staff		8100	-	8100	-	8100	-
051	SUBTOTAL HOUSE ALLOWANCE AID STAFF		8100	-	8100	-	8100	-

	Particulars	1985/86 GK	1985/86 ODA	1986/87 GK	1986/87 ODA	1987/88 GK	1987/88 ODA	Notes
	Transport Operation							5
	4 ICO Land-Rovers fuel	-	7400	-	7400	-	7400	
	Maintenance	-	4000	-	4000	-	4000	
	4 GK Land-Rovers fuel	7400	-	7400	-	7400	-	
	Maintenance	4000	-	4000	-	4000	-	
	Fuel cost for Gully Control	-	1300	-	1300	-	1300	
	2 GK Ferries Fuel	2000	-	3000	-	3000	-	
	Maintenance	2000	-	2000	-	2000	-	
	1 Tractor/Trailer Fuel & Maintenance	2500	-	2500	-	2500	-	
	5 Motorcycles: Fuel & Maintenace	5000	-	5000	-	5000	-	
	24 Pedal Cycles	2200	-	2200	-	2200	-	
	SUBTOTAL TRANSPORT OPERATION	25100	12700	26100	12700	26100	12700	
	Travel & Accomodation							
	3 ICO's Subsistence	2363	-	2363	-	2363	-	
	1 AGLI Warning System Research	525	-	525	-	525	-	
	1 AGLI Project Coordinator	525	-	525	-	525	-	
	2 District Crop Officers	900	-	900	-	900	-	
	7 DAs & TOs	4196	-	4196	-	4196	-	
	6 Enumerators(workspaid)	-	2700	-	2700	-	2700	6
	4 Drivers	1855	-	1855	-	1855	-	
	Lunches & B/fares field Assistants(workspaid)	-	592	-	592	-	592	
	SUBTOTAL TRAVEL & ACCOMODATION	10364	3292	10364	3292	10364	3292	
	POSTS & TELEGRAMS	300	-	300	-	300	-	
	OFFICE TELEPHONE	1200	-	1200	-	1200	-	
	ELECTRICITY & WATER CONSERVANCY	200	-	200	-	200	-	
	Purchase of Supplies							
	(a) for Crop Bulking	-	1200	-	1400	-	1600	7
	(b) for Agronomy Trials		1000	-	1000	-	1000	
	SUBTOTAL PURCHASE OF SUPPLIES	-	2200	-	2400	-	2600	
	PURCHASE OF STATIONARY	1200	-	1200	-	1600	-	
	Airphotos & Maps							
	Airphotos and Maps for Economics Section	-	2000	-	-	-	-	
	Soil Survey new catchments,(SWC)	-	1250	-	-	-	1250	
	Mapping Materials	-	1250	-	500	-	250	
	SUBTOTAL AIRPHOTOS & MAPS	-	4500	-	500	-	1500	
	TECHNICAL CONSULTANCIES	-	16000	-	16000	-	16000	8
	OFFICE RENT	-	1800	-	1800	-	1800	9
	Miscellaneous Other Charges							
	Casual Labour Seed Bulking	-	1800	-	2000	-	2000	
	Minor Office equipment stationary	-	1100	-	1000	-	800	
	Fencing materials for bulking plots	-	-	-	1000	-	500	
	Workspaid enumerators: Salaries @850/- p.m x6	-	3060	-	3060	-	3060	
	: House allowance @450/- p.m x 6	-	1620	-	1620	-	1620	
	Contigencies	-	1000	-	1000	-	1000	
	SUBTOTAL MISCELLANEOUS OTHER CHARGES	-	8580	-	9680	-	8980	

	Particulars	1985/86 GK	1985/86 ODA	1986/87 GK	1986/87 ODA	1987/88 GK	1987/88 ODA	NOTES
	Purchase of Additional Vehicles							
	1 Land-Rover Station Wagon (TC Economist)	-	9759	-	-	-	-	
	4Land-Rover Hard Tops (GK)	-	38000	-	-	-	-	
	1 5 ton lorry	-	8000	-	-	-	-	
	1 Replacement TC LandRover	-	-	-	9500	-	-	11
	SUBTOTAL PURCHASE OF VEHICLES	-	55750	-	9500	-	-	
	Purchase of Cycles and Motorcycles							
	5 post Trackers	-	5000	-	-	-	-	
	32 Pedal Cycles	-	3520	-	-	-	-	
	SUBTOTAL PURCHASE CYCLES, M/CYCLES	-	8520	-	-	-	-	
	Purchase of Plant and Equipment							12
	1 desk Top computer with Monitor & Disd Drive etc	-	2500	-	-	-	-	
	2 Programmable Calculators	-	250	-	-	-	-	
	4 Compression Spring Balances	-	200	-	-	-	-	
	2 Pine Balances	-	300	-	-	-	-	13
	17 Measuring Wheels (Agronomy, Economics)	-	935	-	-	-	-	
	Spares for measuring wheels	-	200	-	-	-	-	
	7 Prismatic Compass	-	1105	-	-	-	-	
	Measuring Tapes	-	100	-	-	-	-	
	2 manual Typewriter	-	150	-	-	-	-	
	3 sets office furniture(Local Purchase)	-	3000	-	-	-	-	
	3 Temporary Housing Units (SWC field staff)	-	2400	-	-	-	-	14
	Furniture for 1 Rest House	-	1000	-	-	-	-	
	Camping Equipment	-	1250	-	-	-	-	
	Materials for gully control	-	1920	-	1920	-	-	
	Hand Tools	-	900	-	900	-	400	
	Ox-drawn equipment	-	1000	-	800	-	-	
	Sundries	-	300	-	300	-	300	
	SUBTOTAL PURCHASE OF PLANT & EQUIPMENT	-	17510	-	3920	-	700	
	Buildings Non-Residential							15
	1 Rest House in project area	-	5000	-	-	-	-	
	SUBTOTAL NON-RES BUILDINGS	-	5000	-	-	-	-	
	Soil Conservation Works							
	(a)Construction of sandweirs(15in yr1, 10inyr2, 10 in yr 3)	-	110250	-	73500	-	73500	
		-	9750	-	19500	-	19500	
	(b) Rehabilitation Water furrows							
	(c) Soil Conservation extension and gully control:-							
	Workspaid staff	-	10500	-	10500	-	8000	
	Casual labour	-	4000	-	4000	-	3000	
	rent for 2 stores	-	500	-	500	-	500	
	Incidentals	-	220	-	220	-	220	
	(d) Soil Conservation Trials (10 sites)	-	1000	-	1000	-	1000	
	SUBTOTAL SOIL CONSERVATION WORKS	-	136220	-	109220	-	105720	
	Buildings Residential							16
	10 staff Houses GK extension staff	-	3000	-	-	-	-	
	SUBTOTAL BUILDINGS RESIDENTIAL	-	3000	-	-	-	-	
	GRAND TOTAL	117330	302072	118330	169012	118330	47572	

SUMMARY BUDGET (Kenya FYs Kenya £)

Item	Particulars	1985/86		1986/87		1987/88	
		GK	ODA	GK	ODA	GK	ODA
000	Personal Emoluments	51756	-	51756	-	51756	-
050	House Allowance	19110	-	19110	-	19110	-
051	House Allowance - Aid Staff	8100	-	8100	-	8100	-
100	Transport Operation	25100	12700	26100	12700	26100	12700
110	Travel & Accomodation	10364	3292	10364	3292	10364	3292
120	Posts & Telegrams	300	-	300	-	300	-
121	Office Telephone	1200	-	1200	-	1200	-
141	Electricity & Water Conservation	200	-	200	-	200	-
150	Purchase of Supplies	-	2200	-	2400	2600	2600
174	Purchase of Stationary	1200	-	1200	-	1200	-
175	Airphotos and Maps	-	4500	-	500	-	1500
180	Technical Consultancies	-	16000	-	16000	-	16000
182	Office Rent	-	1800	-	1800	-	1800
190	Miscellaneous Other Charges	-	8580	-	9680	-	-
210	Purchase Additional Vehicles	-	55750	-	9500	-	-
212	Purchase of Cycles & Motorcycles	-	8520	-	-	-	-
220	Purchase of Plant & Equipment	-	17510	-	3920	-	700
400	Buildings Non-Residential	-	5000	-	-	-	-
403	Soil Conservation Works	-	136220	-	103220	-	-
410	Buildings Residential	-	30000	-	-	-	-
	GRAND TOTAL	117330	302072	118330	169012	118330	47572

FINANCIAL SUMMARY

(i) ODA costs - Kenya £, Kenya FYs

	1985/86	1986/87	1987/88	TOTAL	Notes
Offshore Costs	87260	25500	16000	128760	17
Local Costs Capital	181740	113140	106420	401300	
Local Costs Recurrent	33072	30372	30872	94316	
Inflation	-	16901	32191	49092	18
TOTAL CONSTANT	302072	169012	153292	624376	
TOTAL CASH	302072	185913	185483	673468	

(ii) GK cost - Kenya £, Kenya FYs

Local Costs Capital	-	-	-	-	
Local Costs Recurrent	117330	118330	118330	353990	
Inflation	-	2610	5481	8091	19
TOTAL CONSTANT	117330	118330	118330	353990	
TOTAL CASH	117330	120940	123811	362801	

NOTES ON BUDGET TABLES & FINANCIAL SUMMARY

1. Does not include equipment already bought for EMI Soil & Water Conservation Project: now incorporated in this proposed project.

2. Under the project design, implementation by GK officers will be carried out by staff already on establishment in the project area: exept for a farming system Economist (Research Officer)who should be seconded from Katumani research station.

3. Average salary levels for relevant grades - computed from mid-point of salary scales.

4. House Allownces are for already established staff in the Province.

5. ODA would fund fuel and maintenance of vehicles provided for Technical Cooperation officers and GK would fund running costs of project vehicles given to GK by the donor. As an exception ODA would provide fuel costs for gully control exercises.

6. GK would provide subsistence costs at GK rates for established GK staff and for Technical Cooperation Officers. ODA would provide subsistence for "workspaid" temporary staff engaged expressly for emumeration in the economic surveys and for Soil Conservation work in pilot catchments.

7. Tools, Seed, Fertiliser and insecticide.
Crop Bulking would be carried out at a scale sufficient to meet the needs of the project for seed, for dissemination to farmers conducting on-farm trials. District needs for improved seed are the responsibility of the Ministry of Agriculture.

8. Technical consultancies would be supplied by the donor on the basis of 4 man months a year to allow for supplementary expertise to be made available.

9. Office rent would be payable by ODA only for the minimum extra office accomodation required for the temporary attachment of Technical Co-operation personnel.

10. See Note 6.

11. Of the existing transport facilities within the Soil & Wter Conservation Project one Land-Rover will need replacing in year 2 of the proposed project.

12. Cost provisional only. It has been suggestd that an IBM machine would be advisa so that programming and soft- were compatible with the existing systems in MALD HQ.

13. Sufficient measuring wheels and compasses will need to be available for accurate measurement of the widely dispersed on-farm trials (for yield calculation) and for farm economic survey work.

14. See note 15.

15. Overnight addomodation facilities in the project area are extremely limited and with the degree of concentrated field- work implicit in the project considerable savings on fuel etc can be made if 1 rest house is allowed for at a suitable location. such a facility already exists at Marimanti in Tharaka.

16. Presently GK extension staff are restricted in the field from living in the areas where they should work through lack of housing facilities. Donor assistance in provision of extra housing for extension staff would improve effectiveness of extension and also ensure that extension staff carry out the on-farm field trials withing the project.

17. Offshore costs calculated from Technical Consultancies, Purchase additional vehicles, cycles and motorcycles and of plant and equipment from UK-all items 220 in the detailed budget except locally made furniture, temparaty housing, hand-tools, materials for gully controll and ox-drawn machinery.

18. Inflation assumed at 10% p.a.

19. Inflation on GK costs calculated only on transprort opetation costs. No inflation assumed for GK established personnel costs.

20. Kenya £ = 20 Kenya shillings.