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AND

FARM PRACTICE INITIATIVE

WATER MAPPING AND IRRIGATION DEVELOPMENT PLAN

FOR

KABATI DIVISION IN KITUI COUNTY

Financed by

EMBASSY OF SWEDEN
Nairobi

UKaid
from the British people

Act! Building Champions for Nature
Changieni Rasili Mali

Contents

1.0 INTRODUCTION.

The irrigation development plan shall cover in detail the total area to be developed in acres and water availability to be harnessed by rain water harvesting by dams .The plan will also develop a cost estimate for the proposed projects.

1.1 AUTHORITY OF THE REPORT

This Report has been prepared in compliance with the Terms of Reference (TOR) for Consultancy Services for preparation of Irrigation development plan in Makueni, Kitui and Machakos between Joylep Enterprises Limited and Farm practice Initiatives(FPI) dated 15th August 2012).The report presents detailed designs of the project components and the cost estimates.

1.2 PROJECT BACKGROUND

1.2.1 HISTORY.

The Kitui County has three climatic zones, semi-arid arid and very arid. The characteristics of these zones are as follows:

- Semi-arid zone IV: This covers parts kitui central. Rainfall here is 250-650 mm per annum.
    - Very Arid Zone VI: This area covers Mutomo, Ikutha and Mutitu divisions which is nearly 75% of the county area. The rainfall here is between 150 and 250mm

The study area belongs to Agro ecological zone IV

Kabati division which is the study are belongs to Agro ecological zone IV and is characterized by high temperatures and for realization of food security irrigation is necessary as the area has good soils for agriculture and irrigation is necessary.

1.2.3 PROBLEMS AFFECTING THE PROJECT AREA

The area experiences a number of problems, key among them being:

- Food insecurity due to low agriculture production - a majority of households are net buyers of staple foods (maize and sorghum grains and cassava chips). Food relief is common in the area;
- High poverty levels – over 50% of the population in the project area, which is rural, is poor, with income levels below USD16 per month;
- High unemployment rate due to lack of employment opportunities in the area such as industries, large scale agriculture projects, etc;
- Low levels of education - an indication of incapacity for investment in development activities;
- Poor health –as illustrated by high morbidity due to malaria and water borne diseases and HIV;
- Lack of potable water.

The development of irrigation infrastructure in these areas would make it possible for the local communities to draw economic benefits from the water resources harnessed from the streams where the local community does not have the capacity to harness this potential. This would assist in addressing some of the above problems in the project area, in addition to contributing towards regional and national development.

1.2.4 CONSTRAINTS TO AGRICULTURE PRODUCTION IN THE AREA

Identified constraints affecting rain-fed agriculture in the area and district at large include:

- Inadequate and unreliable rainfall;
- Lack of irrigation system for crop production.
- Dependency on relief food.
- Improper and inadequate use of farm inputs hence low unit land productivity;
- Inadequate extension services;
- Inadequate and inaccessibility to credit services (limited credit services for agricultural activities);
- Inadequate farm power and mechanization;
- Insufficient and improper plant protection - pest and diseases often reduce quantity and quality of agricultural produce and include maize stalk borer, maize weevil, larger grain borer, maize streak virus, cassava brown streak disease;
- Poor farm road networks and crossing bridges, in places.

The major constraints however are:

- Inadequate and unreliable rainfall;
- Inadequate water resources;
- Lack of irrigation system for crop production.

1.2.5 Opportunities.

Despite the above outlined constraints, the project area sits on enormous opportunities which if sustainably utilized would improve the livelihoods and incomes of the inhabitants of the area and some of the opportunities include:

- Suitable land and topography for irrigation that would not require a lot of land grading, hence relatively low cost;
- Suitable soils for growing a variety of crop species;
- Unemployed human resource (unemployment is high in the area);
- Ready market for produce since the area as well as the Machakos region is deficient in food production and vegetables, among others.

Recent positive developments, among others, likely to spur and support agriculture and other development activities in the area include:

- Rural electrification – most centres are either already connected or in the process;
- Roads improvement – this has been picked with funds from the county councils, Constituency
- Development Funds and Kenya Rural Roads Development Authority;

1.3 OBJECTIVES OF THE CONSULTANCY AND SCOPE OF WORK

1.3.1 CONSULTANCY AND ITS OBJECTIVES

- The purpose of the study is first to assess the irrigation potential of the area and cost of investment in the area .The irrigation potential will be in terms of acreage.
- To identify and assess the viability of opportunities for investments in irrigated agricultural production within areas identified in the project area via delineation of irrigable area and formulation of an optimum irrigation development plan for Kabati on the basis of available natural and other resources.

1.3.2 TECHNICAL APPROACH AND METHODOLOGY

- Mobization and inception.
- Data collection, review and preliminary assessment.
- Formulation of an optimum development plan.
- Proposed sites.

1.3.3 START UP ACTIVITIES.

- Site meeting with the community and Farm practice initiative staff.
- Reconnaissance.
- Propose dam sites.

1.3.4 TOPO – SURVEY.

Topo- maps(1:50,000)-Survey of Kenya

2.0 SOCIO- ECONOMIC CONDITIONS.

2.1 POPULATION

Kitui county is inhabited by among other groups the Kamba community. The project will benefit 2000 households in the project are if implemented directly

2.2 POVERTY LEVELS.

Poverty is widespread and afflicts nearly 75% of the Kitui county population. The poverty levels for rural and urban areas are equal at (54%) and (55%) respectively. The main factors causing poverty are listed as inappropriate land tenure and pasture management, and lack of credit services, frequent droughts, underdeveloped, infrastructure and illiteracy. The income per capita is estimated at kshs 40.
Plan

2.4 EDUCATION

In Kitui, literacy levels though moderate (52% in males and 48% in females) average years of school attendance is very low (5 years) this translates to limited skills and knowledge to pursue livelihoods out of the traditional livestock sector.
At primary school level, the ratio of teacher to pupil is 1:30 while at secondary school level, the corresponding ration is 1:14.

2.5 DOMESTIC WATER SUPPLY AND SANITATION

Access to portable clean and safe water and proper sanitary facilities is of key importance to any human being. In Kitui County, about 5000 households have access to piped water and 3000 have access to potable water. The area is served by piped water from Masinga which is been conveyed to Kitui town. Average distance to watering points is 1km with average time to water points estimated at 2 hours. Pit latrines are the commonest form of sanitation facilities in the district at 70%.

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2.6 FOOD SECURITY

The cyclical droughts experienced in the County have severely hampered efforts to improve the food security situation in the County. Household crop production is currently of little significance to household food security as over 98% of cereals are imported from high potential neighbouring counties of Machakos and Thika district. At the same time, food prices sky-rocket due to high cost of transportation.

Consequently, there is continued reliance on relief food distribution and the Food for Work Programmes run by the World Food Program, Word vision and German Agro Action. The most vulnerable groups are the poor, the landless, the aged and the disabled (approximately 1,554 persons). The poor segment who rely on seasonal

casual wage labour activities are also predisposed to idiosyncratic shocks such as diseases, limiting their productivity and participation.

3.0 SOCIO-ECONOMIC ANALYSIS OF THE SCHEME AREA.

3.1 GENERAL

The Socio-economic Study was carried out with the objective of analyzing the existing socio-economic situation of the project area in regard to identifying and assessing the viability of opportunities for investments in irrigated agricultural production within the region.

The socio-economic survey was undertaken in all the potential areas for irrigation and the drainage areas to ascertain the socio-economic situation in the area including issues related to social infrastructure, economic activities carried out by the locals, land tenure system, land use, gender issues, beneficiary participation, problems faced by farmers, as well as individual experience and other social economic issues.

3.2 PURPOSE OF THE STUDY

The purpose of the study was to identify and asses the viability of opportunities for investments in irrigated agricultural production within Kauwi division in Kitui County county with a view to stabilizing food production, improving land and water resources productivity, facilitating economic empowerment of local communities and establishing a foundation for development of agribusiness. This will be achieved through the delineation of irrigable area and formulation of an optimum irrigation development plan on the basis of the available natural resources.

The consultant administered questionnaires in the project area using enumerators who were taken through training before they were sent to administer the questionnaires in various areas within the project area.

3.3 ANALYSIS

The survey was carried out using the households as the primary sampling unit. The questionnaire gathered information on the following aspects:

- Social infrastructure of the area.
- Economic activities carried out by the locals.
- Land tenure system.
- Demographic information
- Water use and sanitation
- Land use.
- Beneficiary participation
- Settlement patterns.
- Marketing.
- Gender and development .

3.4 SOCIAL INFRASTRUCTURE

Socio-Economic Activities

The main economic activity in the area is rain fed agriculture where the locals practice farming with 100% dependency on rainfall. The people also practice mixed farming. The farming practiced by the locals is usually small scale subsistence farming and livestock production.

The food crops grown include maize, beans, Irish, onions, potatoes, sorghum, millet, sweet potatoes, butternuts, and cassava. The locals trade in the crops grown in the area and hence the sources of income include trade, commerce, tourism, informal sector and employment mostly in the public sector.

3.5 DEMOGRAPHIC INFORMATION.

Demographic information captured information on sex, age, marital status level of education and area of residence. The survey was carried out in the entire scheme. The sample size of the survey was 60 respondents. Those interviewed were either household heads, or any adult found within a homestead.

Household heads

Among the respondents interviewed 70% household heads were men and 20% were women. The rest 10% were not household heads. Men headed households is common phenomenon in most Kenyan families especially in the rural areas.

Marital Status

The marital status of all respondents in the survey area was solicitated. The marital status was classified into 4 categories married, single, divorced and widowed. The survey showed that 60% of the respondents were married, 10% are widowed, 20% are single and 19% of the respondents were divorced. Some of the respondents refused to disclose their marital status and this was at 1%.

Family Size

The survey carried out on the family size indicates that most families comprise of 5 – 10 members. The 1 – 5 bracket comprised of 62% of the respondents which is the most prevalent family size, 5-10 was 28% and the remaining 12% comprised of members of the family with over 10. This is a common phenomenon in the Kenya rural families.

3.6 INFORMATION AND COMMUNICATION TECHNOLOGY AND DEVELOPMENT (ICT)

Information and Communication Technologies (ICTs) are tools that build human network, increase public awareness and provide access to information and knowledge for the use by the people. ICT consists of range of communication media and devices such as telephone, video, television, internet, computer, fax, print, radio etc. The demand for information and knowledge is increasing and that the information must be timely, relevant, easily accessible, understandable and affordable.

The telephone network in Kabati is fairly developed with over 4 networks (Safaricom, Airtel, orange Telkom). There is need to establish internet services in Kabati divisions hence the need to establish a resource centre with adequate computers and other information services. This will help in marketing products and also provide the information with economic value to the community. ICT is important health management, natural resources management, partnership, education, rural women empowerment, youth empowerment, sustainable poverty reduction, because people get to access the knowledge and information that is relevant and available.

3.7 WATER SUPPLY AND SANITATION

Access to potable clean and safe water and proper sanitary facilities is of key importance to any human being. The project area is characterized by adequate access to water from Rivers in which wells are sunk in sand. This water is usually not treated and hence poses a threat to the locals living in the scheme.

Sanitary conditions are key to any human settlement as they have direct impact on the environment and health of the inhabitants.

3.8 LEVEL OF EDUCATION

In the survey carried out, majority of the respondents had only received primary school level of education. Those at the colleges/University represented just 4% of the respondents interviewed. 19% had received education only to the secondary level, 52% which represented the highest had education to the primary level whereas 25% had not attained any level of education.

Education attainment is an important indicator of socio-economic development and the capacity of people to participate in development activities. According to the survey carried out, most households had between 1 – 3 children in primary school and all the households interviewed had 120 students in primary school level. Households with children in secondary schools were only 10 with between 1-2 children in school,

whereas those with children in colleges/University were only 2 with a maximum number of 2 of the respondent's families. See table below.

4.0 IRRIGATION AREA CHARACTERISTICS.

4.1 WATER RESOURCES

Kabati area has various sites which are suitable for harnessing flood water for irrigation purposes by construction of dams across rivers.

4.2 CLIMATE AND RAINFALL.

General climatic information (humidity, temperatures and rainfall) had been collected from the District Irrigation Officer for Kitui County.

4.3 SOILS AND LAND SUITABILITY

Irrigation and agriculture production potentials are given in terms of soil suitability according to the soil conditions within the basin. Agro-ecological zones IV and V suitable for marginal crop production and a high livestock production potential. The project area falls in AEZ IV.

5.0 EXISTING AGRICULTURE

5.1.2 CROPS

In Kitui County there are a few pockets where rain fed agriculture is practiced. The crops grown are maize, beans, bananas, tomatoes, cotton, kales, mangoes, cowpeas, cassava, onion, sweet potatoes, pawpaw, pigeon, and peas..

5.1.3 PRESENT FARMING PRACTICES.

Rain fed agricultural production is low, in the arid project area.

a) Land preparation

Land preparation is mainly carried out by manpower and to a small extent, tractor power.

b) Planting

Planting is mainly done by hand for all the crops. Most of the horticultural crops and fruit crops are first grown in the nursery after which they are transplanted to the fields.

c) Weeding

Weeding is mainly done by hand using hoes or *jembes* and there are usually two weeding sessions per growing season. First weeding is 2-3 weeks after germination and the second weeding is before flowering.

d) Application of farm inputs

Traditional cultivars, no fertilizer or chemical pests, disease and weed control. Fallow periods are used and minimum conservation measures applied.

f) Soil and water conservation

In the highland areas, soil erosion is also a major concern, especially on mountain slope of Mt. Kenya where the soils are more erodible. Soil and water conservation measures on cropland are needed in this area. Most important is a good soil cover to reduce the surface runoff and evaporation loss and to store a sufficient amount of water for rain fed crop production. In the midlands situated in the semi-arid areas, the main constraint to natural resource use is the insufficient soil moisture to support pasture and crop production. Irrigation development is largely dependent on the catchment conservation in the highlands. Maintaining good grass cover on the grazing land minimizes water loss by runoff and erosion, and as a consequence increases grazing land productivity. The main problem is how to find a catchment conservation programme and make an agreement with the upstream users to guarantee a minimum flow discharge during the dry period (Liniger, 1995). Solutions to the catchment conservation problems currently experienced by the people in the basin thus require an integrated approach.

5.1.4 LABOUR

Manual labour with hand tools are used in production. Irrigation and drainage improvements increases labour requirements in agriculture and hence enhance

employment opportunities. Labour will be sourced locally as the area has very low employment opportunities. The labour force was estimated13,942 with 6,998 being female and 6994 being male. The population working in agriculture was estimated at 6,500.

5.1.5 CROP YIELD AND PRODUCTION.

a) Crop yield

The area of arable land is 56 km^2 with that of non-arable land being 9761 ha. Main constraint is lack of enough water.

b) Total Crop production

Average farm size is 2 acres. Total acreage under food crops 1200 acres with non for cash crops. The region is not self sufficient in food production, and food is importation from neighbouring Machakos and Thika.

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5.2 AGRO-ECONOMY

5.2.1 MARKETING

Agricultural production is mainly for subsistence with little surplus produce for sale. Marketing takes place at farm levels or local market centres. Majorly marketing is done individually. In remote areas, where most people are poor and sparsely distributed there are no favorable markets. Buyers come as far as Kabati with pickup vehicles to buy the produce. The available market outlets include farm gate, nearest market, nearest big market (major towns such as Kitui town). The choice of market outlet depends on the produce, production level, farm gate prices, transport infrastructure, middle men and availability of transport.

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5.3 EXISTING AGRICULTURE SUPPORT SERVICES AND INFRASTRUCTURE

5.3.1 EXTENSION

There are inadequate extension services.

5.3.2 CREDIT

Need for credit in the project area is low since agricultural production is at subsistence level. Most crop enterprises do not attract agricultural financiers. The constraints to credit availability for infrastructural development in the project area that have been noted include:

- A lack of a common understanding of the group guarantee concept at the project area, group and household levels.
- Weak farmers' organization leading to poor marketing strategies.
- Farmers reluctant to repay the loan in hope that it would be waived.
- Low profitability attributed to low production levels and low farm-gate prices

- Lack of credit institutions within the district.

5.3.3 INPUT SUPPLY

The major farm inputs that may be of concern to farmers include certified seed (mainly maize and beans), pesticides and fertilizers. Being a semi arid area with little farming activities, the area lacks agency to supply farm inputs. Constraints to agro-input supply include:

- Very little market
- Lack of credit support to agro-input dealers to buy enough inputs and to put up sufficient facilities such as secure stockist shop;
- Inadequate training to agro-input dealers and the farmers.

5.3.4 FARM MACHINERY

Use of tractor services in Kitui County is below 5% and majority of farmers rely on oxen power for land preparation.

5.3.5 POST HARVEST FACILITIES AND PROCESSING

There are no post-harvest facilities within the project area and therefore farmers store their produce in locally assembled granaries. Processing of agricultural products and value addition in the district is limited to posho mills for maize, sorghum and millet.

6.0 ENVIRONMENTAL IMPACT ASSESSMENT

6.1 ENVIRONMENTAL, HEALTH AND SOCIO-ECONOMIC IMPACTS

The main environmental impacts from the project are associated with clearing of the vegetation at dam sites.

6.1.1 POSITIVE IMPACTS

The positive impacts include:-

- Water will be easily accessible for community, thus releasing more time to other more economically productive activities.
- In some areas conflicts arising from watering point will be alleviated by provision of watering points.
- Water provision will go a long way in alleviating poverty in the area.
- Increased yields- When irrigated, yields of conventional crops, (crops grown on both dry land and irrigated land) are commonly increased two to three folds
- Crop diversification- Irrigation makes possible production of a broader range of crops, many of which are considered specialty crops, (crops that are generally not viable under dry land agriculture). These are typically higher value crops such as maize, beans, peas and potatoes.
- Stability- Irrigated crops yields are more stable and reliable, resulting in greater income stability and food security.
- Diversity.-Irrigation fosters diversity in farm production.

6.2.2 NEGATIVE IMPACTS

Negative Impacts associated with the canal construction are:

- Loss of existing habitats in the alignment profile and embankment areas.
- Availability of water can lead to over-application in the irrigation fields leading to water lodging and development of wetlands
- Loss of flora and fauna resulting from construction of the canal.
- Increased risk of accidents during the construction phase of the project
- Various detrimental impact associated with the construction phase include noise and air pollution, soil disturbance which could result to soil erosion, spillage of chemical pollutants.
- Water quality could be affected during the construction phase.
- Conflict between the construction workers and the local people. This could occur with the causes of difference in habits and lifestyles,

incomes and encroachment of construction workers to local cultural or traditional values.

6.2 MITIGATION MEASURES

In order to prevent and mitigate the predicted impacts, an Environmental Management Plan (EMP), including measures for impact mitigation, project monitoring and strengthening management capacity is required. These measures are outlined below

- Provision of adequate sanitation in the area surrounding the furrow alignment to avert any risk of water contamination
- Conducting geological and hydrological investigation before construction in order to limit canal erosion
- Frequently organizing meetings with local people for public consultation for adequate information to the Project Affected Peoples (PAPs), so that they could prevent and control the passable adverse impacts on their living and production conditions
- Frequently conducting environmental monitoring programs to evaluate the possible changes in environmental quality and provide for the client and the contractors, sufficient information on the environmental aspects, so that the proposed measures could be applied timely to mitigate the impacts created during the construction and operation phase of the project
- In order to mitigate impacts and deterioration of living environment, suitable vegetation (grass, trees) shall be planted on the canal reserve in order to protect the bank of the furrow line
- Any borrow site out site the impoundment area should be made good to its original status upon the completion of the canal so as to avert accidents that may arise.
- Setting up a water quality-monitoring plan for assessing the change in the water quality. Regular soil sampling and analysis to ascertain continued use for irrigation. Both the water and the soils should be analysed periodically (3-5 years interval). This is because of the few changes likely to occur in both nutrient accumulation and texture, because of change of environment due to water availability. The possible intensive cultivation likely to take place in this area as well as changes in the river up-front will make some changes in the environment, which necessitates the need for periodical analysis.
- Construction of drainage lines to get rid of access water from the irrigation fields.
- Proper supervision and scheduling of construction activities will minimize risk of chemical contamination and accidents during the construction phase of the project.

7.0 WATER REQUIREMENT AND AVAILABILITY.

7.1 WATER REQUIREMENT.

7.1.1 CROPS

Farmers in Kitui County, grow several crops where crop rotation is practised with maize being the 80% of the first crop followed by a legume and some other cash crops. Maize is majorly recommended with the sole purpose of enhancing food security in the area. For various reasons, including water application regimes and pest/disease control all farmers in one row are encouraged to plant similar crops together. Crops grown by farmers include onions, tomatoes, bananas, and sugarcane and water melons. Other crops grown in the scheme include groundnuts, chillies and range of vegetables.

The cropping pattern adopted by farmers in the scheme is as follows:

- January/February – April: Onions
- March-June Maize
- July/August-December: Tomatoes/Water Melons

Though the above cropping pattern has been adopted by farmers, it is unlikely, as already is the case in similar irrigation schemes in the area, that there will be a fixed irrigation pattern on which water requirements can be based at any one time during the year.
Consequently, the Consultant has decided to use an average crop factor, Kc, of 0.9 as is common practice under such circumstances.

7.1.2 REFERENCE CROP EVAPORATION, ETO

Reference has been made to analysed and published data by T Woodhead (1968) with respect to the evapotranspiration, ETo. This has been done since there is no nearby representative weather station within the scheme area.
The ETo for the driest months of June to September has been employed. The average monthly open evaporation for these months is 225mm/month (209-241mm), thus the daily evaporation is 7.5mm/day and using a Kpan of 0.8.

ETo= Kpan x Epan
Where Kpan-evaporation pan constant

Epan-open pan evaporation (mm)

ETo=0.8 x 7.5=6mm/day

7.2 CROP WATER REQUIREMENTS. ETCROP

The crop water requirement has been determined using the following relationship:

ETcrop = Kc x ETo

ETc = crop evapotranspiration or crop water requirement for a certain period

ETo = reference evapotranspiration for same period

Kc = crop coefficient for same period.

The ETo, as mentioned above, are for the dry and sunny months of June to September (= 6 mm/day) and Kc, as mentioned above is 0.9 (average for the various crops), which gives;

ETcrop = 0.9 x 6=5.4 mm/day or 0.625l/s/ha

CROP WATER REQUIREMENT, ETCROP

The effect of the crop characteristics on crop water requirements is given by the crop coefficient (Kc) which represents the relationship between reference (ETo) and crop evapotranspiration (ETc). Values of given Kc are shown to vary with the crop, its stage of growth, growing season and the reference crop evapotranspiration in 10 days periods.

ETc is computed as follows:

$$ETc = ETo * Kc$$

ETc = crop evapotranspiration or crop water requirement for a certain period

ETo = reference evapotranspiration for same period

Kc = crop coefficient for same period

The ETo, as mentioned above, are for the dry and sunny months of June to September and January to March.

The average ETcrop was found to be 5.4mm/day or 0.625l/s/ha in the driest months.

7.3 NET IRRIGATION REQUIREMENTS (NIR)

The Net Irrigation Requirement (NIR) is determined as follows:

NIR = ETcrop – Pe

Where Pe=part of the rainfall which is effectively used by the plant. Since there is very little or nil rainfall for the months under consideration, effective rainfall has been considered as zero, which means the crop water requirement will be met 100% by irrigation then Pe=0

Therefore: NIR=ETc=5.4mm/day

7.4 GROSS IRRIGATION REQUIREMENTS (GIR)

The gross Irrigation Requirement (GIR), is determined as follows:

GIR = NIR/Irrigation efficiency

An overall irrigation efficiency of 95% has been considered for the proposed drip irrigation system, which lies within the recommended range of (90%-95%).

Therefore: GIR = 5.4/0.95 =5.7mm/day

Or GIR = 0.625/0.95 = 0.658 l/s/ha

Take 0.658 l/s/ha.

7.5 SCHEME WATER REQUIREMENTS (SWR)

The scheme water requirement has been determined considering that all the farmers will be irrigating at the same time and at a discharge of0.658 l/s/ per ha, the area to be irrigated shall be determined by detailed Engineering survey.

Using the following conversion whereby 1 acre =0.4046 ha,

8.0 PROJECT COMPONENTS AND DESIGN

8.1.1 PROJECT COMPONENTS AND DESIGN

The project comprise of the following;

- A reservoir
- Mainline
- Sub main
- Drip lines
- A pump

The design component will depend on proposed sites.

8.1.2 STABILITY OF DAM

The dam was checked against overturning and sliding.
Stability analysis against overturning:
The forces acting on the structure are

- Weight of the structure
- Hydrostatic pressure
- Uplift pressure
- Hydrostatic pressure from the tail water.

The analysis is done for a unit width of the dam, taking moment about the toe of the weir. Overturning moment should be less than resisting moment for the structure to be safe against overturning. The moment caused by the stabilizing forces is called M_s and the moment caused by overturning forces is M_o. The coefficient of stability (s) is the ratio M_s/M_o, thus

$S = M_s/M_o$
To assure stability it is necessary it is necessary that s>1 or

9.0 PROJECT COSTS.

9.1 Description of work items and Quantities

Works.

The main works considered at this stage are:

- Earthworks.
- Concrete and stone or masonry works.
- Metal works/steelwork.
- Pipeworks-Mainly Pvc and GI

Quantities

The Bill of Quantities for the various works have been derived from the designs and drawings and comprise various works as listed below:

Reservoir./Earth dam

- Site clearance
- Earthworks(cut, fill, compaction)
- Fencing.

Conveyance system.

- Earthworks (excavation and fill)
- Pipe work (Pvc and GI)
- Concrete works.

Infield system

- Sub main and drip lines.

Preliminaries and Generals

- Provision for RE requirements and related contract items.

Rates

Unit rates used for estimating the preliminary costs have been obtained from the following:

- Construction cost rates of the ministry of roads and public works (2007).
- Current construction contracts for works of similar nature.
- Prices from suppliers.

Allowances have been made for profits and overheads, labour, plant and machinery and waste margins as per ministry of public works recommendations as follows:

Preliminaries	3-5%
Profits and overheads	16%
Labour	19%
Plant and machinery, waste margins	5%

The rates used include VAT.

10.0 INVESTMENT COST FOR VARIOUS OPTIONS IN KABATI

1. Mutini earth dam and associated irrigation system (20 acres)

Table 1 Engineer's Cost Estimates

Bill no.	Description	Total cost (Kshs.)
1	Preliminaries and general items	1,000,000.00
2	Reservoir	15,250,000.00
3	Conveyance system	6,000,000.00
4	Infield system	6,000,000.00
5	Dayworks	100,000
	Subtotal	**22,350,000**
6	Contingency (10%)	2,235,000
	Grand Total	**24,585,000**

2. Desilting of Komu earth dam and associated irrigation system (50acres)

Table 2 Engineer's Cost Estimates

Bill no.	Description	Total cost (Kshs.)
1	Preliminaries and general items	1,500,000.00
2	Reservoir	20,250,000.00
3	Conveyance system	2,000,000.00
4	Infield system	8,000,000.00
5	Day works	150,000.00
	Subtotal	**31,900,000**
6	Contingency (10%)	3,900,000
	Grand Total	**35,800,000**

3. Expansion of Kimetwa earth dam and associated irrigation system (20acres)

Table 3 Engineer's Cost Estimates

Bill no.	Description	Total cost (Kshs.)
1	Preliminaries and general items	600,000.00
2	Reservoir	10,250,000.00
3	Conveyance system	2,000,000.00
4	Infield system	5,000,000.00
5	Day works	150,000.00
	Subtotal	**18,000,000**
6	Contingency (10%)	1,800,000
	Grand Total	**19,800,000**

11.0 CONSTRUCTION AND MAINTENANCE

11.1 GENERAL

Operation and maintenance is a continuous process. The main and secondary canals requires good operation and maintenance practices. This is in order to ensure that every part of the canal meets the hydraulic requirements of the irrigating community. The operation and maintenance of the physical components of the irrigation scheme: - reservoir and drip lines.

GENERAL DESCRIPTION OF THE PROJECT

The major part of the dam construction consists of earthwork.The following is the description of principal components of the scheme.

i Dam or spring
ii Distribution lines
iii Protection works.

i) The reservoir

The construction of intake works components was determined after detailed surveys and design were done. The components includes the following:-

- Mainline
- Bottom width of the dam
- Top width of the dam
- Height of the embankment
- Protection works

A master meter which needs to be placed at the intake will be placed in a lockable chamber to determine the amount of water abstracted to comply with Water Resource Management Authority (WRMA). This is because, the community will be charged for the water abstracted. In addition, it is a requirement to ensure that the down stream consumers have access to water and the basic flow of the river must also be maintained because of the fauna and flora.

PLANNING STAGE

All the concerned data including detailed drawings shall be collected. The drawings should show the location of excavation, tipping and filling. No earthwork should be started unless the land has been acquired.The area should be cleaned of all trees, bushes and other objectionable materials.

EXCAVATION STAGE

The root of the dam shall be excavated as per the drawings. Excavation may be carried out by manual labour or by excavation machines. The rocky area should be excavated by hand quarrying or using equipments like jack hammers, pneumatic drilling machines etc.

EMBANKMENT CONSTRUCTION

The dam axis shall be marked by use of pegs at intervals of 5m .

11.3 COMPACTION

The following tests are carried out while determining compaction

a) Density moisture relationship of the soil
b) Density of the soil in the field
c) Moisture content

In order to achieve the required compaction by most economic means, the following shall be used:

a) Type of compaction equipment- Smooth wheel roller or pneumatic tyred roller
b) Thickness of loose layer for compaction - 150mm.

PRECAUTIONS BORROW PITS SELECTION

While taking earth/soils from the outside borrow pits, the following precautions should be taken:-

- No borrow pit shall be dug within 50m from the toe of the dam embankment.
- Borrow pits shall normally be not more than 5m deep.

11.7 WATER MANAGEMENT.

The community should form Scheme Committee to man the project. The scheme committee will be responsible for operation of the intake works. Off-takes from the main line to the blocks and farms will be responsibility of the Block committee leaders.

The scheme committee will at the same time be expected to plan and manage water distribution within the blocks. In accomplishing this, the committee will be assisted by the blocks committee leaders who will have an intimate knowledge of the farmers' irrigation requirements in each block.

11.8 TRAINING.

The role of training farmers in irrigation water application and on farm water management practices though important but not taken up in the past, will become more critical in the future as irrigation technology and the problems associated with water scarcity become more complex in order to produce more per units of land and water consumed. To this end comprehensive training of farmers in irrigated agriculture and all those involved is of special importance.

Training of the water users in water wise use, on farm water application and management practices, waste control and minimization, training in operation and maintenance practices, and development of maintenance schedules. The training will need to be carried out after implementation of the project though sensitization should commence during project implementation.

11.9 FINANCIAL MANAGEMENT.

It is advisable to set fees for water usage in order to ensure sustainability . This fee should be set by the community after setting up of water user association. The set fees should discourage wasteful use of water but not discourage use of the water by the disadvantaged.

The objective of introducing the Irrigation Service Fee (ISF) is to obtain cost recovery especially for the operation and maintenance costs of the conveyance system and the distribution system for the various users in the project area. The Scheme Management Committee should embrace on the policy that ensures that the system should generate its own funds to keep it in good working order. This cost recovery is to occur from system water users, in a manner and timing which reflects services obtained through the system. The procedures applied should provide a strong basis to assure the willingness to pay from all users. The Scheme Management Committee should ensure that the community understands that the ISF is a payment for a service, not a tax. In this respect, ISF is clearly a first step towards resources management at the local level by the local communities through the Irrigation Water User Associations (IWUAs), companies and institutions.

The ISF concept is perhaps the key vehicle to greatly contribute in the development of the following functions a Scheme Management Committee can possibly have at the main system level:

a) Involvement in water allocation as part of determining the service at the block level and the willingness to pay for ISF.
b) System maintenance through contributions in cash (ISF) and through labour at the block level.
c) Conflict management and resolution at main system level and the prevention of farmer interference.
d) Financial management, including reconciliation on operation and maintenance costs, fee collection and accounting.

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