Republic of Kenya **AFDB**

MALF **African Development Bank**

ENVIRONMENTAL SOCIAL IMPACT ASSESSMENT STUDY

FOR KILIMANI GALANA BUTTRESS DAM, KILIMANI LOCATION

BURAT WARD

ISIOLO COUNTY.

October, 2017

CERTIFICATION

FOR AND ON BEHALF OF DROUGHT RESILIENCE SUSTAINABLE LIVELIHOOD PROJECT

P.O BOX 30028-001000,

NAIROBI, KENYA

This Environmental and Social Impact Assessment report was prepared in accordance with the Environmental Management and Coordination Act (EMCA) 1999 (Amended 2015) and the Environmental Impact Assessment and Audit Regulations 2003 for submission to the National Environmental Management Authority (NEMA). We, the undersigned, confirm that the contents of this report are a true representation of the Environmental and Social situation ESIA for the proposed, Kilimani Galana Buttress Dam, Kilimani Location, Burat Ward of Isiolo County.

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ACKNOWLEDGEMENT

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We appreciate the co-operation and contributions of all the stakeholders consulted during this ESIA study, without whose support this study would not have been successful. Further, we wish to acknowledge the Desk officer, Mr Ngare, Chief Officer (Aden Jaldesa), County Irrigation officer, County Agricultural Engineer, Frontline Agricultural Extension Officers and the Local leadership of Isiolo central division for their logistical and technical support that led to the success of this study. Finally, we recognize the support from the Department of Provincial Administration Isiolo, the Commandant KDF School of Infantry Isiolo, the CEO Lewa conservancy and KWS for their support during the field visits.

ABBREVIATIONS.

ASAL-	Arid and semi- arid lands
Asl-	Above sea level
DRSLP-	Drought Resilience & Sustainable livelihood Project.
EA-	Environnemental Audit
ESIA-	Environment and Social Impact Assessment
EMCA-	Environmental Management and Coordination Act
EMP-	Environnemental Management Plan
ER	Environnemental Report
IFAD-	international Fund for Agricultural Development
KFS	Kenya Forest Service
KWS	Kenya Wildlife Service
LM_1, LM_2, LM_3, -	agro-ecological zones Lower Midlands 1, 2, 3
LR No.	Land Registration number
MALF-	Ministry of Agriculture, Livestock and Fisheries
MTAP	Medium Term Asal Programme
MOH-	Medical Officer for Health
NEMA-	National Environmental and Management Authority
NEC-	National Environmental Council
NPEP	National Poverty Eradication Plan
Q-	Flow rate for water
PPE-	Personal Protective Equipment
PRSP	Poverty Reduction Strategy Plan
PCM	Project Management Committee
WUA	Water Users’ association
WRMA	Water Resources Management Authority
WRUA-	Water Resource Users’ Association
WSTF-	Water Service Trust Fund

EXECUTIVE SUMMARY

This is the report of an Environmental Social Impact Assessment study for the Proposed Kilimani Galana Buttress Dam in Burat Ward, Isiolo central sub-county, Isiolo County financed by Drought Resilience and Sustainable Livelihoods in the Horn of Africa Program (DRSLP).

Background on DRSLP

Drought Resilience and Sustainable Livelihoods in the Horn of Africa (DRSLP) - Kenya Project, is a project under the Ministry of Agriculture, Livestock and Fisheries (MALF). The project covers six arid and semi-arid counties namely Baringo, Isiolo, Marsabit, Samburu, Turkana and West Pokot. The project is funded through a loan between the Kenya Government and African Development Bank (AfDB).

The need for this project emanated from the necessity to adapt and build resilience to the damage occasioned by droughts experienced by the population of the poor and vulnerable communities in the arid and semi-arid lands (ASALs) who needed support to bounce back and resume normal economic and social activities. The livestock sub-sector sustained a key share of the damage followed by the agriculture sub-sector. In rural areas, individual family water systems sustained partial damage due to the lowering of the groundwater table and rural inhabitants were forced to collect water from far away sources.

DRSLP Project Goal & Objectives

The overall sector goal of the programme is to contribute to poverty reduction, food security and accelerated sustainable economic growth in the Horn of Africa (HOA) through enhanced rural incomes. The project's goal is to enhance drought resilience and improve livelihoods of the communities in the arid and semi-arid lands of Kenya. The key objectives of the project were to: -

1: Increase the number of people and livestock accessing water for domestic and Irrigation.

2: Improve quality and availability of pasture

3: Develop and improve rural feeder roads

4: Improve access to animal health services

5: Increase the number of personnel capable of handling pastoral livestock production systems

6: Increase the percentage of community members with improved capacity to adapt to drought effects

Kilimani Galana Irrigation Scheme

It is on this background that the DRSLP identified Kilimani Galana Irrigation scheme as one of the projects for rehabilitation and expansion of irrigation infrastructure which is ongoing. During the irrigation scheme ESIA public participation and stakeholder's workshop, it came out clearly that for the project to sustainable in achieving its objectives, it was necessary for the proposed irrigation scheme to have an additional buttress dam for water harvesting and storage to prevent potential water use conflicts. The proposal to design and construct a water dam was adopted by DRSLP.

The proposed Butress Dam is expected to provide irrigation water to Kilimani Galana irrigation scheme which is under construction. Water will conveyed under gravity through a 13 km pipeline from the proposed site. The purpose of the project is to support the Kilimani irrigation scheme and thus enhance living standards of the people of Kilimani and Burat Ward in general, by providing supplemental water for agricultural purposes, create employment and reduce poverty within the framework of Kenya's Poverty Reduction Strategy Paper (PRSP). Thus the project's development objective will be to enhance food security and promote sustainable livelihoods.

The proposed project site is in Kilimani Location and is on a relatively gentle terrain at the foot of Samburu Ranges. The location of the site is suitable for a runoff harvesting structures with the slopes of the Hills acting as a catchment for the Buttress Dam.

Project cost

The proposed buttress dam will be implemented on contract basis at an estimated of Kshs 159 million

Objectives of the ESIA study

The objectives of the ESIA study were to:

- Identify the anticipated environmental and social impacts of the project and the scale of the impacts;
- Propose mitigation measures to be taken during and after the implementation of the project; and
- Develop a comprehensive environmental and social management plan with mechanisms for monitoring and evaluating the compliance and environmental performance which shall include the cost of mitigation measures and the time frame of implementing the measures.

Methodology

The methodology of this study included: mobilization and planning; desk review of documents; field data collection; project data synthesis; public consultation and participation for a. A number of stakeholders from both the government offices and the community were consulted for their inputs to the study through community consultative meetings, focus group discussions, key informant interviews and completion of qualitative questionnaire. The applied field methodologies for data collection included: qualitative questionnaires, focus group discussions, key informant interviews and random field visits to the project area.

Policy and legal framework

The existing institutional and legal frameworks that are related to the project include the EMCA 1999 (Revised 2015), Water Act 2012 and the Crops Act, 2013.

Environmental and social impacts

Findings from the study included a possibility of both localized positive and negative environmental and social impacts of the project. The key potential positive impacts were:

- Employment creation
- Food security and income benefits
- Drought mitigation and enhanced environmental sustainability
- Creation of employment opportunities and increased income through horticultural farming. Besides,
- Improved access to water for livestock, domestic consumption and irrigation.

- Reduction in the time employed for fetching portable water thereby redirecting it to productive engagements elsewhere
- Reduction in distance covered by livestock in search of water.
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The key potential negative impacts were:

- Accelerated land degradation
- Water resource conflicts
- Safety and health issues
- Aesthetics and dam safety issues down stream

Conclusions and recommendation

It is of view of experts that by implementing the proposed Kilimani Butress dam, the reservations raised by the stakeholders issues against the construction Kilimani –Galana irrigation scheme will have adequately been addressed. Mitigation measures for any possible negative impacts have been suggested and if implemented according to the ESMP, the project would strengthen sustainability of irrigation activities for the beneficiaries. The project was accepted as a priority by all stakeholders consulted who also fully supported immediate implementation as along as the river abstractions would not be interfered with.

The recommendations made with respect to the proposed Irrigation Project include:

(1) A complete audit be undertaken and submitted to NEMA a year after commissioning to ensure that all the proposed mitigation measures have been complied with;

(2) Construction works in the proposed Project be carried out in accordance with approved designs, regulations, policies and laws;

(3) An action plan for the catchment protection and conservation be developed and implemented in line with the requirements of the Water Act, 2002 and the Environmental Management and Coordination Act of 1999 and any other applicable laws. This action plan should involve key stakeholders, WRUA, IWUA, lead organizations including the Water Resources Management Authority and National Environment Management Authority;

(4) Contractor and the staff from MALF are required to strictly adhere to the provided ESMP including the continuous evaluation and adaptation of this plan during the course of project construction and operation phases.

(5)The dam should be regularly inspected for signs of deterioration, such as cracks, gullies, damage by rodents or insects, seepage, and damage to structures, especially the spillway.

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1 INTRODUCTION

1.1 BACKGROUND ON KILIMANI IRRIGATION PROJECT

The proposed Kilimani-Game irrigation project is located about 8km from Isiolo town and is found in Isiolo central Division, of Isiolo County. The project is located in arid area with low, unreliable and poorly distributed rainfall. Reliable crop yield is not guaranteed under rain fed agriculture and this has resulted in food insecurity, low employment, low living standards and poor household incomes. Thus, the overall purpose of the project is to promote irrigation farming.

The Kilimani–Game Galana irrigation scheme was started in 1985 by a group of about 300 farmers with the support of Ministry of Agriculture which had helped in laying about 3km of water pipeline. In 1997 El-nino rains destroyed the irrigation infrastructure completely stalling the project. The project was thereafter rehabilitated in 1999 with support from ILO (International Livestock Organization) with the building of intake and pipeline repair and farming resumed. Again in 2002 the project stalled after community conflict erupted and the infrastructure completely vandalized until to date. The project was identified for rehabilitation and expansion in 2013 with support from DRSLP. In 2016 ESIA experts in consultation with communities and other stakeholders recommended inclusion of a Buttress Dam for water storage and provision in the design of the project before commencement of irrigation project construction. The dam would ensure storage and release of water for use without disturbing the normal river flow. DRSLP adopted the recommendations and included a 103, 000 m^3 dam in the design project.

The current membership is at 461 farmers who are divided into five blocks and registered under Kilimani Game water users association. The beneficiary farms are individually operated in what is considered as community land with an approximated area of 250 acres (100Ha) with the proposed intake at Nthirini community. Downstream are three other irrigation schemes and individual farms which utilize water from the Lewa River. The neighbors are Akore Akadeli, Bunesi Dima, Kakili irrigation schemes, Kenya Defense forces SOI barracks and Lewa conservancy.

1.2 Background Information and Project Justification

The proposed Buttress Dam is going to be constructed in Kilimani Galana village, Kilimani location, Burat ward of Isiolo County along river Lewa. Three irrigation schemes have intakes at different points along the river leading to reduced river volumes during the dry seasons which limits irrigated agricultural activities .Water shortages during those seasons have often resulted community to water resource conflicts and an additional irrigation scheme without provision for water storage facility will be disastrous. The area has good valleys for dam construction, receives good amount of rainfall hence the proposed Dam will collect and store the flood water for the irrigation purposes of the proposed Kilimani Game Galana irrigation scheme which is under construction. The water abstraction from the dam will not to interfere the normal flow of the river in addition it likely to be enhanced to the advantage of downstream users

1.3 ESIA Terms of Reference

The ESIA is a comprehensive evaluation which is usually conducted before the approval and implementation of development activities listed in Schedule II of EMCA Cap 387 which could have adverse impacts on both the natural and social environment. The ESIA is expected to predict specific project areas that are likely to affect the environment and society negatively and also prescribe appropriate mitigation strategies in order to alleviate or at the least to minimize the level of disturbance. The ESIA especially through the prescribed Environmental Social Management Plan (ESMP) usually recommends the activities which require regular monitoring through audits.

A team of Lead of experts within MALFwas tasked to carry out the ESIA study of the proposed Kilimani Butress dam. The ESIA study report would inform the National Environment Management Authority (NEMA) in their decision making on matters related with the issuance of an NEMA ESIA license to the project as stipulated by EMCA Cap 387.

1.3.1 Specific objectives of the ESIA

1) Identify the anticipated environmental and social impacts of the project and the scale of the impacts;
2) Identify and analyze alternatives to the proposed project;
3) Propose mitigation measures to be taken during and after the implementation of the project; and
4) Develop a comprehensive environmental and social management plan with mechanisms for monitoring and evaluating the compliance and environmental performance which shall include the cost of mitigation measures and the time frame of implementing the measures.

1.3.2 Kilimani Buttress Dam TOR

1) To detail the project activities including bio-pyhsical and social background, inputs, outputs, benefits and involved parties.
2) To use information on the ground so as to adequately identify the potentially negative environmental and social effects that will arise as a result of the project's implementation.
3) Based on a suitable scale, identify significant negative environmental and social impacts and propose feasible mitigation measures.
4) To devise an environmental and social management and monitoring plans articulating the negative identified impacts with possible dates for carrying out future environmental and social audits.
5) To formulate implementation framework for the proposed mitigation measures clearly indicating responsible persons, the required resources and to provide the necessary implementation schedule and specify financial implications

1.3.3 Purpose of ESIA report

The ESIA is needed to evaluate the environmental and socioeconomic impacts of Project-related activities during the construction and operation of the proposed dam by Ministry of agriculture along river Lewa in Isiolo County. As a requirement under the Environmental Management and Coordination Act (EMCA, Cap 387), the proposed project requires an ESIA report because it belongs to the activities listed in Schedule II. The ESIA process ensures mitigation measures are integrated in the project design to ensure project sustainability. This ESIA report is part of the ESIA implementation framework in Kenya and is expected to assist NEMA in decision making concerning the project.

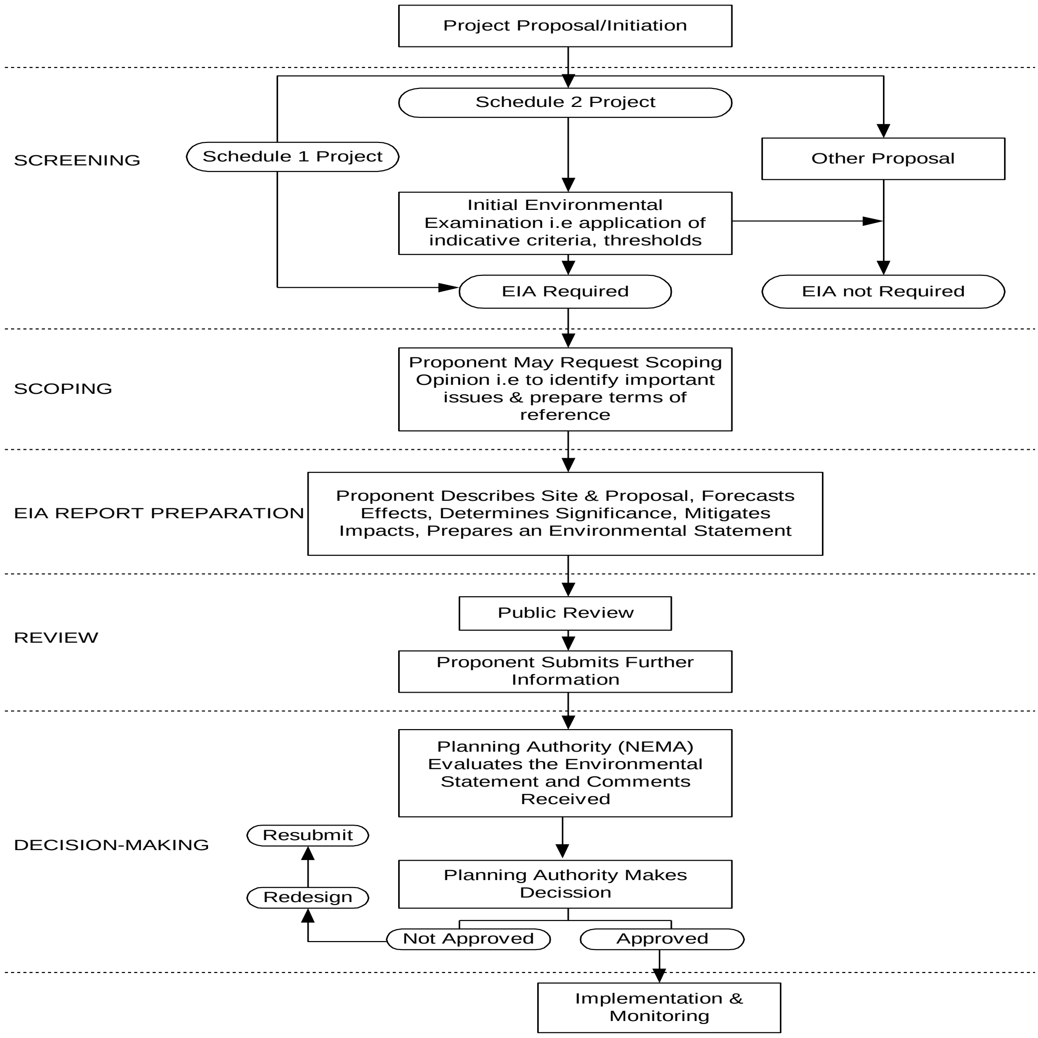

Figure 1: Proposed methodology for the ESIA study.

1.4 ESIA Methodology

In carrying out the impact assessment, the following strategies were adopted by the study team.

1.4.1 Identifying study area

The study team with other relevant implementing partners visited the proposed dam area had a transect walk. The team had site discussions on the main dam components, made site observations and identified several trees of cultural importance which will be destroyed

1.4.2 Data gathering

Data about the project was gathered through desk top and field studies. The engineering designs, hydrological studies and geotechnical and geophysical studies formed the primary sources of the study. The studies had been carried out during the process of project development and design.

1.4.3 Desk top study

Review of relevant environmental laws and standard guidelines in governing the implementation of the project was done through desktop studies. In addition, more project documents were studied and relevant information studied.

1.4.4 Field study

Several studies were carried out by qualified experts and reports discussed shared with the ESIA study team. The studies were meant to inform the study team and design engineers about the general suitability of the site for dam construction and predict various risk scenarios of the project. The studies include;

I. Geological & geophysical investigations report
II. Hydrological assessment report
III. Water quality analysis

1.4.5 Stakeholder engagement

Public Participation and Stakeholder Engagement are integral parts of the ESIA process. Stakeholder engagement can be described as the systematic effort to understand and involve stakeholders and their concerns in the environmental and social assessment and in the decision-making processes. The stakeholder and public engagement plan (SEP) was based on the following:

(a) Resource users' scope

Public consultation was conducted within the project areas. More emphasis was put on the people who directly or indirectly depended on Lewa River for water more importantly to irrigation and the immediate neighbors

b) Technical scope

The technical scope for the stakeholder consultation was based on public views and concerns on all the key areas of potential environmental and social impact, namely a) physical environment, b) biological environment, c) social-cultural environment, d) economic issues, e) political issues, f) institutional issues, g) regional implications, and h) any other issues

c) Preliminary stakeholder mapping

A from the recognizance visit by the study team a preliminary stakeholder mapping was undertaken. The mapping identified the following stakeholder profiles for the project components who were formally invited for the public meeting:

- Kakili irrigation water users
- Buness Bima irrigation water users
- Lewa conservancy
- Action AID
- Yana kore irrigation water users
- WRMA Isiolo
- Kenya Forest service
- Kenya Wildlife service
- County Commissioner of the project area
- Area chiefs
- Water resource Management Authority
- National Environment Management Authority

- Water Resource Users Association
- Kenya Defence Forces (SOI)
- ENNDA Isiolo
- Kamp Sheik
- Drought Management Authority

- questionnaires

2 PROJECT AREA AND ENVIRONMENTAL BASELINE

2.1 Location

The proposed Kilimani Butress Dam is located about 15km South of Isiolo Town. The Dam site lies in Kilimani Village, Kilimani Sub-location, Burat Location, Isiolo Central Sub-County, Isiolo County. The axis of the proposed dam is across a perennial stream called Lewa, a tributary of Ewaso Nyiro River (Figure 1).

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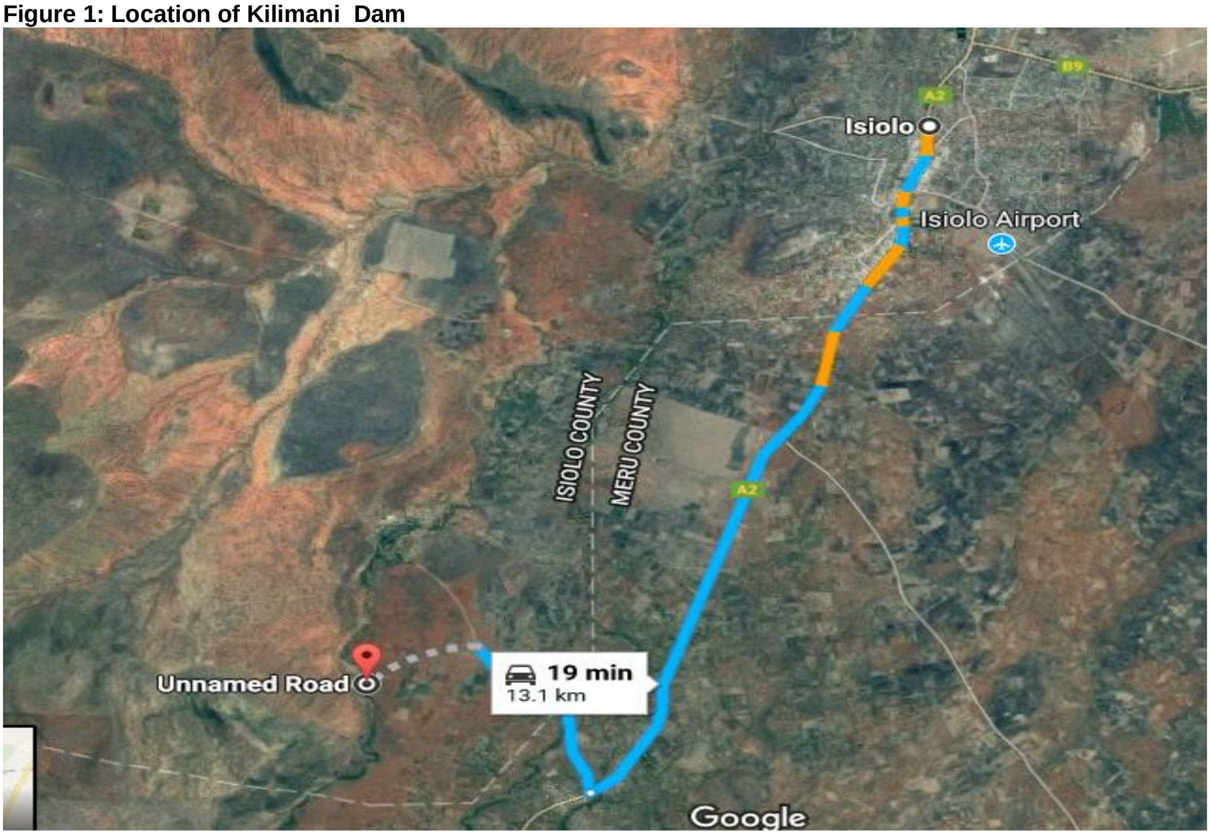
The Dam Site can be located on SK No. 108/1-Isiolo scale 1:50,000 at:-

Region	37N
Longitude	0336228E UTM
Latitude	00331348N UTM
Altitude	1295M

Figure 1: Location of Kilimani Dam



2.2 Climate

The agro-climatic zonation of the area falls into three agro-climatic zones (Herlocker et al. 1993; Sombroek et al. 1982), semi-arid (occupying 5% of the area), arid (30%) and very arid (65%). The climate in the towns of Isiolo and Kinna is semi-arid and the median annual rainfall is in the range of 400-600 mm (Figure 2). The arid region stretches from Ol Donyiro region to Archers Post and Garbatulla areas, where the annual rainfall ranges from 300-350 mm.

The very arid zones cover Merti and Sericho divisions, where the annual rainfall is between 150-250 mm (Figure 3). Isiolo suffers high rainfall intensities with poor temporal and spatial distribution, resulting in flash floods. Under these conditions, rain-fed agriculture is unsustainable (Jaetzold and Schmidt, 1983).

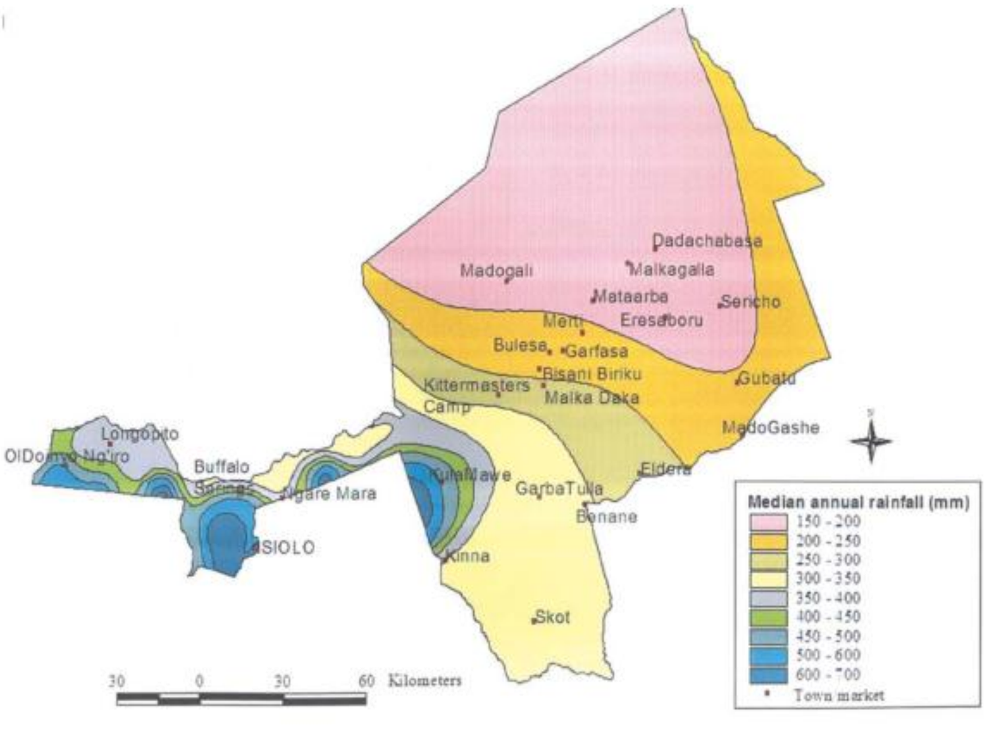


Figure 2: Rainfall Distribution in Isiolo County

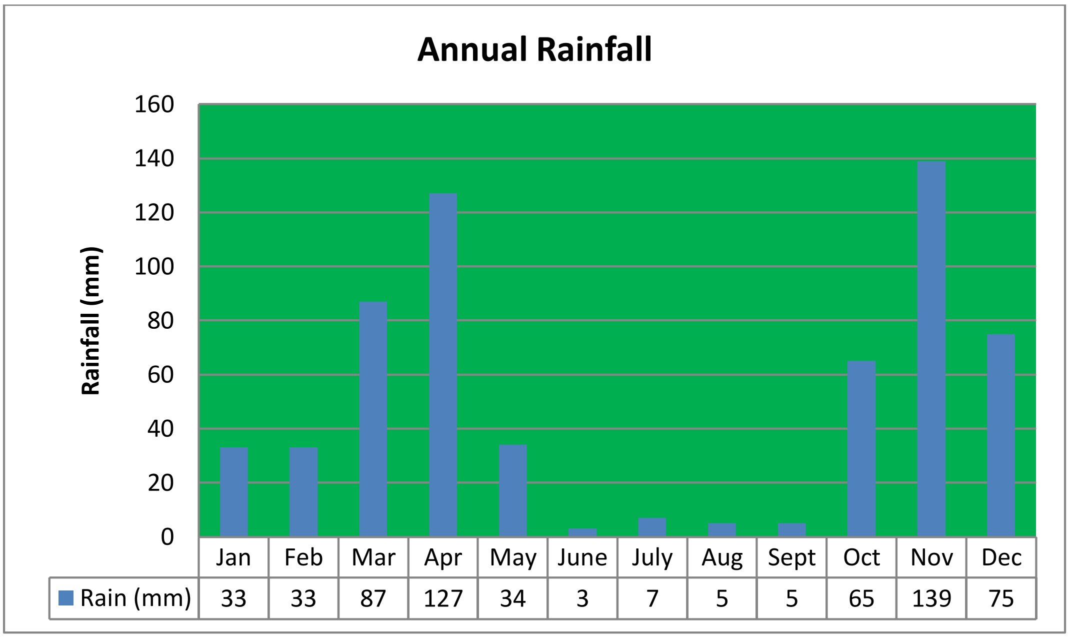


Figure 3: Annual rainfall in isiolo

2.3 Temperatures

High temperatures are recorded in the county throughout the year, with variations in some places due to differences in altitude (Table 1). The mean annual temperature in the county is 29^0C. The county records more than nine hours of sunshine per day and hence has a huge potential for harvesting and utilization of solar energy. Strong winds blow across the county throughout the year peaking in the months of July and August.

Table 1 : Temperature variations

January	15.6	30.7	57	173	8.8	22.3	5.21
February	16.2	32.2	52	173	9.1	23.5	5.72
March	17.5	31.6	54	216	8.3	22.5	5.85
April	17.7	30	64	216	7.9	21.3	5.16

May	17.7	29.8	62	285	8.6	21.2	5.43
June	16.8	29.5	59	328	8.8	20.7	5.64
July	16.2	28.8	58	354	8.2	20.1	5.64
August	16.5	29.3	56	354	8.1	21	5.96
September	16.8	30.7	53	328	8.8	22.9	6.49
October	17.5	30.8	54	242	7.9	21.6	5.81
November	16.5	28.5	66	156	7.1	19.8	4.43
December	15.5	29	67	156	7.8	20.4	4.45
Average	16.7	30.1	58	248	8.3	21.4	5.48

2.4 Vegetation Cover

All ground below 1500m asl supports a poor thorn scrub , mainly species of acacia with succulents and larger trees only along water courses. Above 1500m and with increasing rainfall, patches of indigenous forest still remain. These are interspersed with rolling grassy plains, which have resulted from forest clearing though some may have been original. In forested areas, soil cover is thick, however in the lower areas, soil is thin or absent due to poor vegetation cover due to aridity and overgrazing. Soil erosion on the lower areas has been accelerated by this state of affairs.

The project area lies about 1300m asl and is largely covered by indigenous thorn scrub and a host of other flora. Dessert palms are common along the river courses and where water tables are relatively shallow. The following vegetation species were identified;

- *Ficus Sycamoras*
- *Balanites Aegyptica*
- *Acacia tortlitis*

- *Acacia Senegal*
- *Acacia mellifacus*
- *Cammphora Africana*
- *SALVADWA persica*

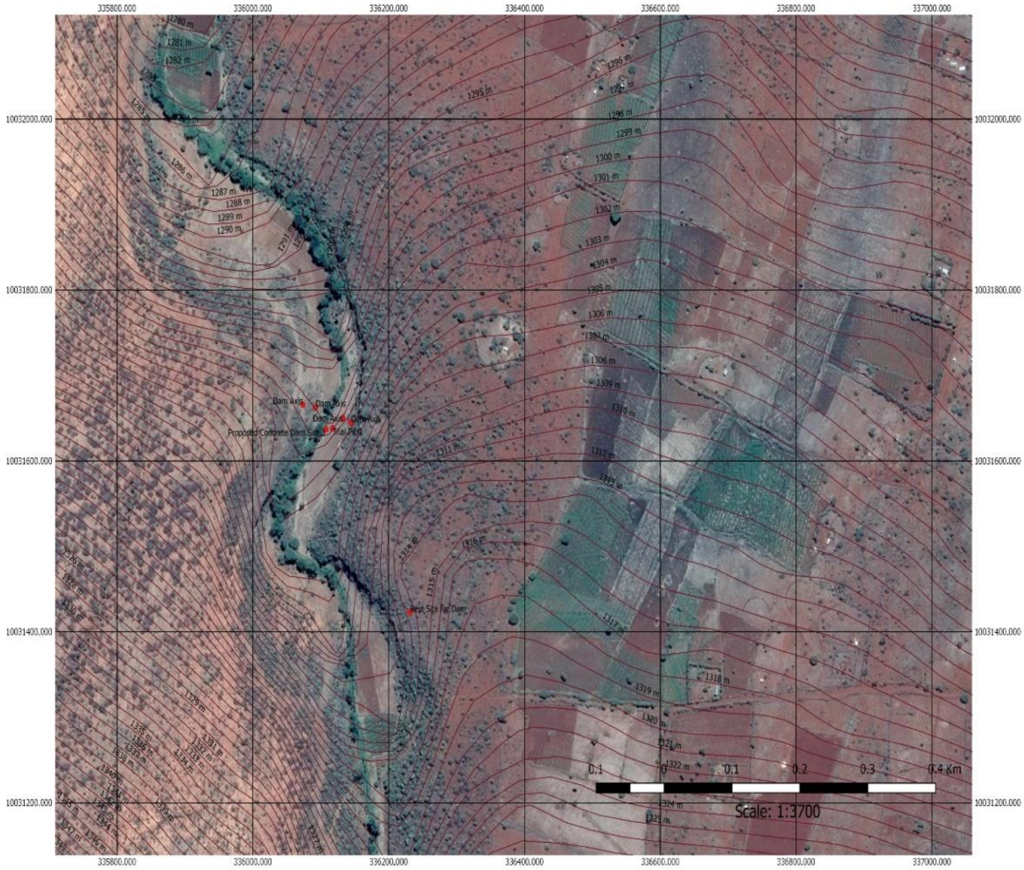
2.5 Topography

Most of the area of Isiolo County is flat low lying featureless plain especially in the lower Ewaso Ng'iro Basin resulting from weathering and sedimentation. The plains rise gradually from an altitude of about 200m above sea level at Lorian Swamp (Habaswein) in the northern part of the District to about 300m above sea level at Merti Plateau. To the north of the Ewaso Ng'iro River, plateau lavas form low but clear escarpments above the surrounding plains.

The Western part of the District is an extensive poorly developed plain land, associated particularly with the basin of the Ewaso Ng'iro River which roughly corresponds with the end tertiary erosion. This plain lying at about 1,000m has leveled extensive tracts of quite diverse metamorphic rocks. The Pleistocene basalt flows originating from the northern slopes of Mount Kenya and the Nyambene Hills have covered large areas of this surface, surrounding isolated inselbergs such as Shaba Dogo.

The dam area lies in the sloppy region of the County. The land is relatively sloppy with slopes at about 6.67%. This is indicative of the rapid stage of Lewa river starting at 1314 masl at check dam to 1295 masl at dam axis and therefore a protection check dam should be constructed upstream of the dam. Figure 4 below depicts the general land topography

Figure 2: Google map for Topography of Kilimani Dam Site and Environs



2.6 Geology of the Investigated Area

The dam axis is located along a narrow section of the   Lewa River valley. The cross section along the designed dam axis shows an assymetrical U-shaped profile.

Geology around and on the proposed intake weir is dominated by:-

(i) Pleistocene Lower Nyambene basalts which occupy east of Lewa River

(ii) Basement System of rocks comprising quartz-feldspar gneisses and schists covered with red sandy soils to the west of Lewa River.

(iii) Geology of the right bank

The right bank of the study area is comprised of the Lower Nyambene basalt overlying a rock suite of the Basement System of rocks at depth.   At outcrop level, on the proposed dam axis on the right bank, an almost vertical cliff of basalt rock was observed as shown on Figure 7.

Figure 3:- Basalt cliff on the right bank of Lewa river around the dam axis. The rock exhibits moderate jointing.

(iv) Geology of the left bank

Rock exposures on the left bank are similar to those on the right bank in composition except for a thick bouldery accumulation probably overlying jointed basalts at depth. The formation comprises of rock breccia of various sizes admixed with soils. This brecciation may be related to mass movement due to wetting. **Figure 10** shows rock exposures on the left bank over the dam axis. The boundary with Basement rocks is further to the west.

Figure 4 Blocky basalt formation on the right bank. The rock fragments are admixed with sandy soils.

(v) Geology of the channel

The Lewa channel is in-filled with a thick layer of alluvium and colluviums. These are presumed to overlie basalts at depth. The deposit is presumed to comprise of crudely stratified mixture of sands, silts, clays , cobbles and bouldery float blocks of basaltic composition.

2.7 Analysis of structural elements of the study area

(i) Faults

There is evidence on the ground that Lewa channel is structurally controlled by faults that define the direction of the river channel. Two vertical cliffs characteristic of faulting event were observed on either bank around the dam site. Figure 16 shows the faultlines as mapped from Google maps.

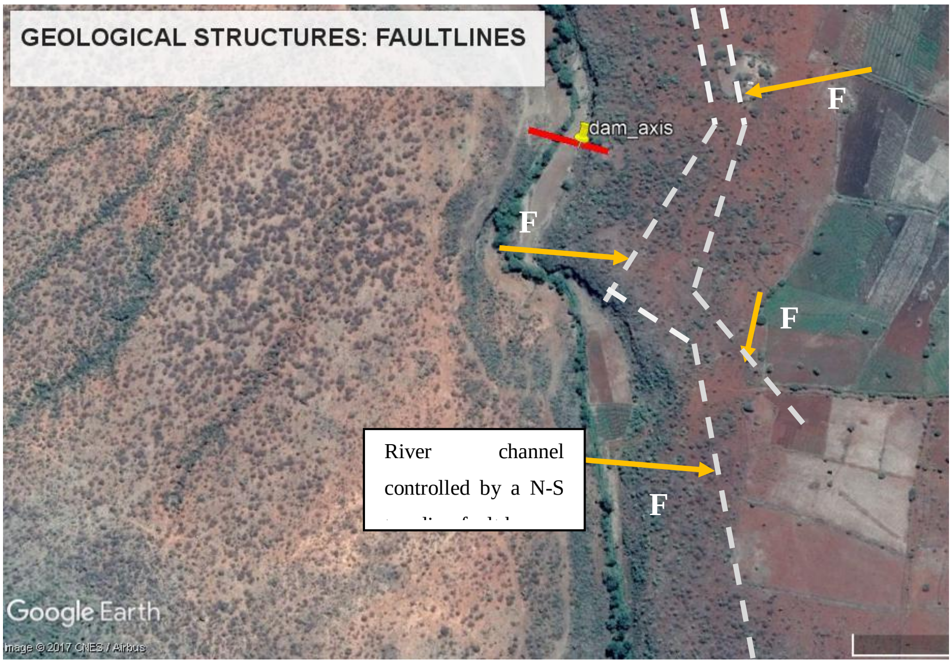


Figure 5- Geological structure around the proposed dam

It is deduced that both banks define the up-throw sides with a central sunken graben block like a miniature rift valley along which Lewa has curved its channel. Consequently the sunken block has been covered by both alluvial and colluvial sediments. Basalt blocks transported from upstream fall-blocks are embedded in the alluvium.

(ii) Joints

Rocks exposed over the dam axis and reservoir area have significant jointing which does not have any specific orientations. The joints are deduced to be shrinkage joints upon cooling of lava.

Figure 6:- Jointed basalt rock on the left bank. White arrows show he joint

NB: These joints may allow seepage losses from the dam and hence require to be sealed if identified.

2.8 Hydrogeology

Two aquifer systems are recognized for the area, viz. regional aquifer systems allowing continuous groundwater flow over large areas, and localized aquifer systems with isolated groundwater pockets the surroundings.

(i) Regional aquifer systems

These are composed of Tertiary marine sedimentary and volcanic rocks. The first aquifer system comprises pervious sedimentary rocks i.e sands , gravels, pebbles, sandstones and basalts. These rocks cover the Basement rocks in a large part of eastern Isiolo. They are sporadically overlain by volcanic rocks.

The second category of aquifer system consists of fissured and weathered volcanic rocks with interbedded sediments (paleosols, lucustrine deposits, and pyroclastics) between lava flows. These rocks overlie in the central western part of Isiolo County.

The regional aquifer system is an important recharge source for the Ewaso Nyiro river.

(ii) Local aquifer systems

This system is made up of fissured and weathered Basement and sedimentary deposits. The fissured Basements form pockets of isolated groundwater bodies. These pockets are scattered all over the Basement areas and also occur at the interface of the Basements and the overlying sedimentary or volcanic rocks.

Local sedimentary deposits comprise fluviatile deposits, lucustrine deposits and deposits of other origins. Groundwater in these deposits is isolated from that in other aquifer systems by impervious layers of clay or rock. Important system exists in flood plain deposits of Ewaso Nyiro and limestones in Garba Tula.

2.9 Ecological Zone, Land availability and Livelihood

Isiolo County is one of the counties in the lower eastern region of Kenya. It borders Marsabit County to the North, Samburu and Laikipia Counties to the West, Garissa County to the South East, Wajir County to the North East, Tana River and Kitui Counties to the south and Meru and Tharaka Nithi Counties to the south West. The county covers an area of approximately 25,700 km^2

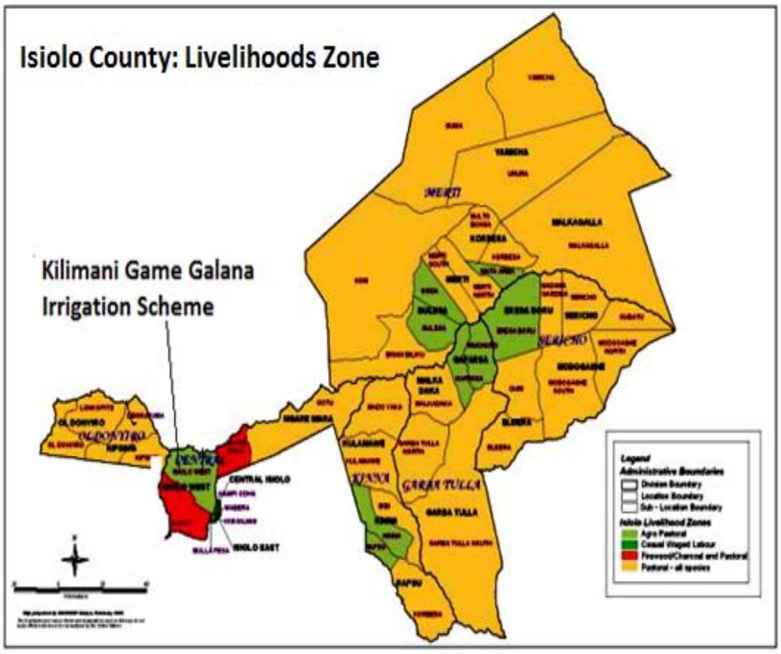
The analysis shows that the county has 3 distinct agro-ecological zones as follows:

1. Lower Midland (LH 3-5)- 1,275 km2

2. Lower midlands (LM 6-7)-7,710 km2

3 Intermediate Lowlands (IL) -16.705km

Map 1;Livelihood Zones of Isiolo County



(1) Soils cover on study area

(i) Banks

On both bank along the proposed dam axis, the country rock is exposed and is either bare or has a shallow cover of sandy stony soils. Beyond the bank and away from the river channel the soils are more developed.

(ii) Lewa river channel

The Lewa river channel is filled with a thick alluvial deposit, being thickest in the middle and thinning out towards the banks where the country rock is exposed. The alluvial deposits are an admixture of sands, silts and volcanic rock fragments. Stratification of the deposits was observed reflecting depositional episodes during floods. This is exemplified in figure 5.

2.10 Water chemical and biological composition

Water was tested for chemical composition and the results are presented in Table 2 below. The chemical attributes showed that the water was suitable for irrigation.

Table 2: Results of chemical analysis for Lewa river sub-catchments

		results
Parameter	**Unit**	**Lewa**
pH	pH Scale	7.85
Colour	mgPt/l	100
Turbidity	N.T.U	145.9
Electrical Conductivity (EC) (25^0 C)	µS/cm	319
Iron	mg/l	0.73
Manganese	mg/l	<0.01
Calcium	mg/l	18.4
Magnesium	mg/l	14.1
Sodium	mg/l	22
Potassium	mg/l	5.9
Total Hardness	Mg of $CaCO_3$/l	104
Total Alkalinity	Mg of $CaCO_3$/l	128
Chloride	mg/l	19
Fluoride	mg/l	0.38
Nitrate	mgN/l	<0.01
Nitrite	mgN/l	<0.01
Sulphate	mg/l	<0.3
Free Carbon Dioxide	mg/l	12
Total Dissolved Solids	mg/l	197.78
SAR (Computed in milli-equivalents) NB: $SAR = \frac{Na}{\sqrt{\frac{(Ca+Mg)}{2}}}$	No unit	0.94

2.10.1 Sodium absorption ratio

Salts in the water can build up through evaporative concentration and damage both plants and the soil. Sodium can affect plants and soils in three ways: by destroying soil structure, by poisoning sodium sensitive plants when absorbed by either their roots or leaves, and by causing calcium and/or potassium deficiencies to occur if the soil or irrigation water is high in sodium.

The sodium adsorption ratio (SAR) was measured and used to predict the sodium hazard (Table 3). The water from the Lewa river had SAR below 6 and therefore suitable for irrigation.

Table 3

Hazard levels for SAR

SAR	Hazard
<10	Safe to irrigate with no structural deterioration but salt-sensitive plants may be affected depending on EC/TDS
10-18	Hazard on fine textured soils with a high cation exchange capacity. Suitable on coarse textured soils with good drainage.
18-26	Hazard on most soils. Need to manage with amendments and drainage (i.e. leaching)
>26	Not suitable for irrigation

2.10.2 Bacteriological results

From the bacteriological results, River Lewa had Ecoli level of 1203/100ml as compared to Isiolo River and its tributaries with 308/100ml. The river water therefore requires some pre-treatment in the event that it may be used for human consumption

2.10.3 Flow duration analysis

The mean flow duration foe Lewa river was 31,964 m^3/day (Table 5)

Table 4

Flow duration		**Lewa** m^3/day
Mean daily flow		31,964
95 percentile (Q95)		*2,060*
80 percentile (Q80)		*8,897*
75 percentile (Q75)		11,121
50 percentile (Q50)		*20,842*
25 percentile (Q25)		47,864
10 percentile (Q10)		67,058
5 percentile (Q5)		74,967

2.11 Administrative and Political Units

2.11.1 Administrative subdivision (Sub-Counties, Wards, locations)

The County has three sub-counties, ten wards, 22 locations and 43 sub locations (Table 6).

Table 6: Administrative units for Isiolo County

Subcounty	area	Ward
Isiolo	3,269	wabera,bulla pesa oldonyiro, ngaremera ,burat
Merti	12,612	Chari,cherab
garbatula	9,819	Kina ,Garbatulla

Table 5 ;Demographic Features

2.11.2 Wildlife(lewa conservancy)

Lewa Wildlife Conservancy is neighboring the project area and the area forms part the migration corridor for the elephants. The Lewa Wildlife Conservancy works as a model and a catalyst for the conservation of wildlife and its habitat. It does this through the protection and management of species, the initiation and support of community conservation and development programmes, and the education of neighboring areas in the value of wildlife.

Currently, the Conservancy holds more than 11% of the global wild population of the endangered Grevy's zebra, over 11 percent of Kenya's critically endangered black rhino and over 14 percent of Kenya's white rhino, an abundance of the 'Big Five' as well as 70 other large mammal species native to east Africa and a multitude of birdlife. A fence to protect the wildlife runs around the perimeter with the exception of four "wildlife gaps" that allow for the migratory movements of elephant herds and other wildlife from the arid areas to Lewa's north, all the way to the forests of Mt Kenya

2.12 Population Size and Composition

The county's population stood at 143,294 as per the 2009 Population Census comprising of 73,694 males and 69,600 females. The population was projected to rise to 159,797 by the end of 2012 and 191,627 by 2017. The population consists largely of Cushites communities (Oromo-speaking Boran and Sakuye) and Turkana, Samburu, Meru, Somali and other immigrant communities from other parts of the country. The planned massive capital investments under development of the LAPSSET Corridor including International Airport, Resort City, and oil storage facilities are expected to boost rapid population growth in the county.

2.13 Infrastructure

2.13.1 Road and Rail Network, Airports and Airstrips

The county has a road network of 975.5 km, out of which only 34 km are bituminised. Gravel All the earth surface roads are impassable during the wet season. The project area is accessible by all-weather murram road off the Isoilo - Marsabit road just outside Isiolo town

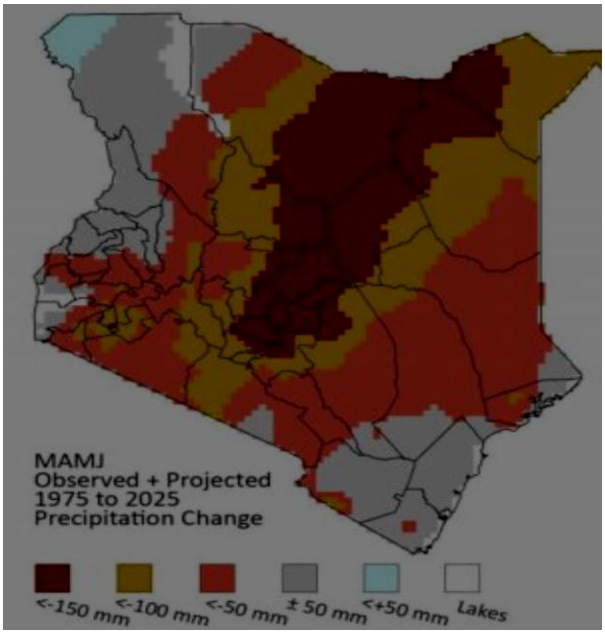
The County has 5 Airstrips. Isiolo Airstrip is in the process of being upgraded into an international Airport as envisaged in the Kenya Vision 2030.

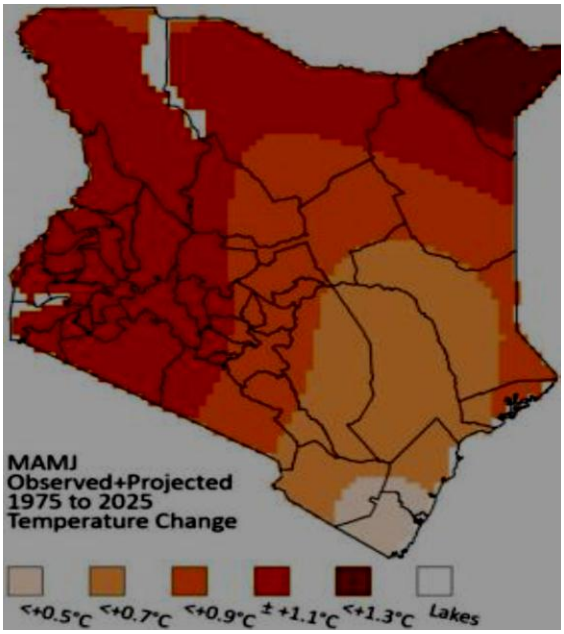
2.13.2 Water Resources and Quality

Three big perennial rivers namely Ewaso Ngiro, Isiolo, and Bisanadi flow through the county. Rivers Ewaso Ngiro has its catchment area from the Aberdare and drains into the Lorian Swamp. The Isiolo River originates from Mt. Kenya and drains into Ewaso Ngiro River. Bisanadi river drains into River Tana. Most irrigation schemes are found along these rivers. Where the site conditions are suitable, floodwater harvesting facilities for communities in the county can be be constructed and by excavating shallow pans or ponds.

2.14 Climate change scenario analysis

According to the National Climate Change Response Strategy (NCCRS) in Kenya, the evidence of climate change in the country is unmistakable (GoK, 2010). Evidence of temperature rise is common throughout the country and rainfall has become more irregular, unpredictable and torrential. **Figure 4-3** shows the projected temperature and rainfall change levels for country including isiolo County. The NCCRS (2009) predicts that the more torrential rainfalls accompanied by floods could affect dams thereby leading downstream flood hazards. However, the near-time scenario of upto 2025 predicts a 0.9 C rise in temperature and a 150mm reduction in mean annual rainfall (USAID/USGS, 2010) as shown below .The long-term scenario indicates a slight increase in precipitation by upto 20mm per annum





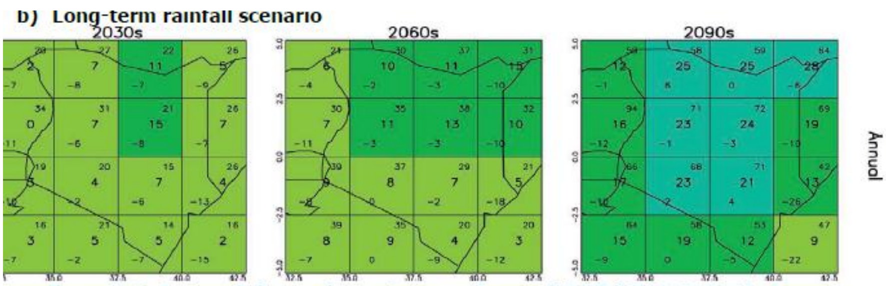


Figure 4- 3: Projected climate change in Kenya Source: (USAID/USGS, 2010, Mc Sweeney, et al. (2010)

3 PROJECT DESCRIPTION

3.1 Location of Project Area

The proposed project is sited in a natural occurring gorge along river Lewa on the edge of Kenya defense forces school of infantry fence . The river is perennial with as shown on the image below

Figure 7 ;Position of proposed site

3.2 Water demand

Table 7: Summary of Projected Water demand in m^3/day

Estimating Water Demand of Kilimani Village, Kilimani Sub-Location, Burrat Location			
Item	**Population**	**Consumption (Litres/Day)**	**Total (m^3/ Day)**
1. People			
People	800	20	16
Kilimani Primary School	200	5	1

2. Livestock’s			
Camels	20	15	0.3
Cattle	1,000	15	150
Sheep’s/Goats	10,000	3.5	35
Donkeys	0	15	0.00
3. Irrigation			
Allow for Irrigation	500		
Total			**239**
Current Sources			
Kilimani Buttress Dam			103,275
Total Daily Deficit			142,275
Catchment yield			255,000
Estimating Water Storage Required for the Reservoir			
Total Storage Required			255,000
Average Storage Required			**255,000**
Estimated Loss (25%)			63,750
Estimated Seepage Loss (10%)			25,500
Required Storage			344,250
A Dam of Capacity 344,250m^3 is required			
Source: Water for Small Dams-A Handbook for farmers, Technicians and others on site investigations, designs, cost estimates, construction and maintenance of small earth dams by Erik Nissen Petersen for Danish International Development Assistance (Danida) dated 2006 page 8 to 10			

3.3 Sedimentation

The dam is expected to be filled by sediments in a period of about 34 years as evidenced by table 4-2.

4.2: Estimation of Sedimentation of proposed Kilimani Dam

Sedimentation analysis for Dam Site S1							
Categorization							
Catchment can be categorized as Heavy with Sediment Yield of				1,500	$m^3/km^2/Year$		
Catchment Area	**Annual sediment Catchment Yield**						
Km^2	**$m^3/Year$**						
4	6,000						
Hence the Dam can be filled with Sediment within a period of (103,275*2)/6000 = 34							Years
ence Dam Lifespan is estimated at about 34 years at estimated capacity of 103,275m^3							

3.4 Normal flow

Lewa stream normal flow is 0.0078m^3/s and the flow will always be maintained the project will be only allowed to abstract flood water stored in the dam.

3.5 Project concept

The project concept was developed through participatory approaches with technical support from Government professionals .The proposed project will enhance the sustainability of irrigation activities and contribute to enhancing water availability to stakeholders during dry periods

3.6 Project Cost

The project will have a total investment cost of Ksh. 159 Million Kenya shillings

3.7 Design of Kilimani Buttress dam

The design concept and criteria for Kilimani Buttres dam was developed in accordance with the general guidelines and standards used in the design of irrigation and water supply projects in Kenya and are in line with international standards for best practice. Safety concerns and appropriate materials selection during construction given priority and utmost care.

3.7.1 Design Concept

It is proposed that the project be slightly over 100,000 cubic meters of volume and throwback of about 1km long will be purely concrete type. It will have spillway, intake works which are detailed in the design report. The parameters of the dam are summarized as,

A Buttress concrete structure is proposed and the main parameters of the proposed dam are as follows;

Height above river bed	9.5 m
Length of dam crest	91m
Crest width	1.5m
Upstream slope	Vertical
Downstream slope	0.7H: 1V
Concrete Volume	60,361m^3
Reservoir Capacity	103,275m^3

3.7.2 Dam Height

The height of any dam above the lowest level in the river channel is determined from

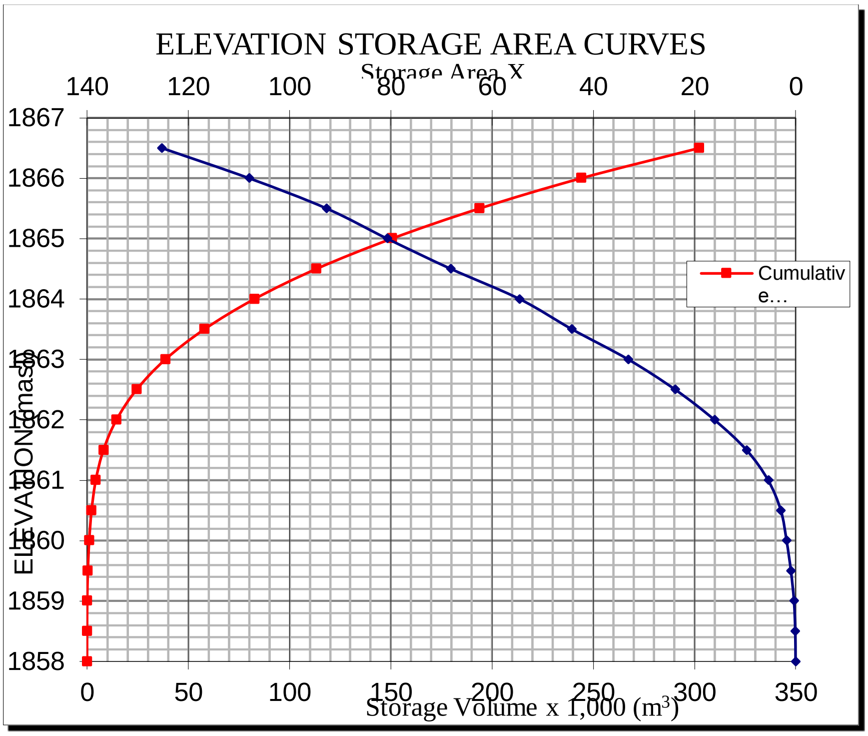
- The gross storage (live storage + dead storage) capacity of the dam,
- The space required to pass maximum design flood over the spillway (called flood surcharge),
- The wave height generated from extreme winds,
- The wave run-up over the upstream sloping face due to wind gusts and
- The free board.

A 8.0 m high dam (reservoir capacity **103,275 m^3**) was adopted in order to meet the storage requirements for the water project.

Table 6: **Reservoir Characteristics**

Elevation (m)	Dam Height (m)	Dam crest (m)	Flooded Area (m^2)	Storage Volume (m^3)	Cumulative Storage Volume (m^3)
1,858.0	0.0	0.0	0.000	0.00	0.00
1,858.5	0.5	10.8	54.260	13.57	13.57
1,859.0	1.0	24.7	306.354	90.15	103.72
1,859.5	1.5	35.7	913.523	304.97	408.69
1,860.0	2.0	44.2	1,769.018	670.64	1,079.32
1,860.5	2.5	67.9	2,901.578	1,167.65	2,246.97
1,861.0	3.0	108.3	5,416.285	2,079.47	4,326.44
1,861.5	3.5	159.8	9,686.609	3,775.72	8,102.16
1,862.0	4.0	217.8	16,038.729	6,431.33	14,533.50
1,862.5	4.5	253.9	23,777.750	9,954.12	24,487.62
1,863.0	5.0	286.1	33,066.296	14,211.01	38,698.63
1,863.5	5.5	326.4	44,196.253	19,315.64	58,014.26
1,864.0	6.0	362.5	54,544.570	24,685.21	82,699.47
1,864.5	6.5	397.8	68,157.232	30,675.45	113,374.92
1,865.0	7.0	427.4	80,725.553	37,220.70	150,595.62
1,865.5	7.5	460.6	92,699.877	43,356.36	193,951.97
1,866.0	**8.0**	**492.7**	**108,011.988**	**50,177.97**	**244,129.94**
1,866.5	8.5	523.5	125,259.963	58,317.99	302,447.93

Figure 3.8: Reservoir Characteristics



3.8 DIVERSION WORKS

A temporary diversion which consists of an upstream open channel, a waterway through the dam body and a downstream open channel will be during construction work to divert river flow.

Since the dam will constructed by concrete on which the water is allowed to overflow, the temporary diversion should have a capacity equal to a 5-year return flood. In this study, the design discharge of temporary diversion is determined to be 7.12 m^3/sec. Stop-logs will be installed at upstream portal of waterway after construction of the gravity concrete dam.

3.9 INTAKE STRUCTURE

3.9.1 Basic design concept

The intake structure of drop-inlet type is constructed at the inlet of the diversion tunnel. Steel conduit is employed as the intake pipe to deliver water of the design discharge with pressure flow. A trash rack is to be provided at the inlet to prevent floating logs and debris intrusion.

3.9.2 Type of conduit

There are two (2) types of steel conduit, i.e., exposed type and embedded type, and they are classified as follows:

- Exposed type
  - Free support
    - Saddle support
      - Plate support
      - Concrete support
      - Concrete saddle
      - Steel saddle
    - Ring support
      - Rocker support
      - Roller support
      - Slide support
      - Pin support
      - Concrete saddle
      - Steel saddle
  - Fixed support (Anchor block)
- Embedded type
  - Backfilled with concrete
  - Backfilled with earth

The embedded type backfilled with concrete is employed for the design of the steel conduit for the intake pipe.

Materials	Cement, sand, water steel /iron bars, murram, ballast, water proofing materials, timber, steel pipes, and binding wires. iron sheets ,formwork materials ,logs
Major tools and equipment and vehicles	Concrete mixers, vibrators, delivery vehicles ,excavators, tippers, saws ,wheel barrows, drilling machines among other equipment ,generators ,tipers ,

3.10 Project Construction Phase

3.10.1 Inputs for the construction

The construction works will require the following materials and equipment during construction,

3.10.2 Construction activities

Construction of the dam will be done in a dry area this means a cofferdam will need to constructed and means of delivery to the main channel will done temporarly. Then excavation works will involve mechanized and labour intensive methods in order to benefit from a mix of involving the beneficiary community and reaping from economies of scale.

3.10.3 Waste generation during construction

Waste likely to be generated during the project construction includes the following:

- ⇒ Spoiled and used construction materials;
- ⇒ Earthworks
- ⇒ Cut trees ,shrubs and metal remnants `;
- ⇒ Solid waste (paper, plastics, metal cans, wood, metal, dry paint and stone chippings);
- ⇒ Liquid waste (wet paint, wastewater, glue, solvents and other chemicals);
- ⇒ Used oil waste products (e.g. lubricants and filters) from construction machinery;
- ⇒ Waste mortar and concrete; and
- ⇒ Sanitary waste
- ⇒ waste from packing materials
- ⇒ disturbed stones
- ⇒ waste from the camp site

3.11 Project Operation Phase

3.11.1 Inputs during operation

The project operation will require the following:

⇒ Labour for seasonal de silting at the intake structures;
⇒ Repair works during the operation time (fence ,structure and pipes)
⇒ Protection against drowning of animals and human beings
⇒ Monitoring to check safety of the dam

3.11.2 Waste from operation phase

- Silt
- Tree logs from the upstream
- Solid material from the flood

3.12 Project operation, maintenance and water management

Rehabilitation or expansion process will involve institutional, organizational and technological changes. The objective will be to improve water delivery to farmers . Improvements in water delivery operation and maintenance will be a critical first step in the process.

Project operation and maintenance involves all activities concerned with proper water abstraction from source, conveyance,. The operation and management activities are carried out to ensure that water abstraction is scheduled properly

The WUA will be fully responsible for operation and maintenance of the system with technical advice from the WRMA or any other collaborator. The goal is to optimize participation in ways which contribute to improving the performance of water management. Costs incurred will be met from water charges and contribution from members

The involvement of the WUA will have the following advantages:

- The O & M costs will be reduced because most activities will be performed by WUA members;
- Internal capacity building;

- Opportunity to participate in decision on operation and maintenance function;
- Will enhance group cohesion and contribute to strengthening of the WUA

The O&M activities consist of:

- schedules and water allocation ,
- Maintainace of water structures
- System maintenance.

The operation and maintenance procedures and schedules will be prepared with the assistance of water engineers or consultants whenever need arises.

SWOT Analysis of Kilimani –Butress Dam Project

The SWOT analysis identifies the internal factors (strengths and weaknesses) and the external factors (opportunities and threats) are shown in the table below.

Table 7:SWOT analysis of Kilimani Buttress Project, isiolo county Kenya.

A. Strengths
• Availability of DRSLP- ADB funding. • Training skills and technologies. • Sustainability through WUAs. • Local capacity building (i.e.WUAs and farmers). • Hygiene and environmental sanitation training and knowledge. • Employment creation. • Community organization and participation. • Institutional sustainability of project activities. • Logical frame approach. • Economic benefits of project activities. • Unity of farmers. • Government support. • Presence of high number of NGOs supporting development activities • Increased participation by women and girls • Access to water • Ecological enhancement • Suitable site and materials on site
B. Weaknesses

- Inadequate local capacity to manage project activities
- Inadequate skills and staff for project monitoring
- Inadequate experiences in concrete dam construction
- Shortcomings in project design and implementation
- Nil community contribution to water supply.
- Inadequate funding.
- Inadequate operation and maintenance expertise (i.e. IWUAs).
- Low labor productivity due the Somali culture.
- Non-involvement of community in project planning (budgetary processes).
- Short project implementation period.
- Lack of commitment of some farmers.
- Inadequate communication and co-ordination of activities (Committees/farmers/Management)
- Community conflicts and land disputes
- Droughts /flooding
- Illiteracy levels
- Community related conflicts
- Complexity of concrete dam construction

C. Opportunities

- Donor and community support.
- Collaboration and networking among institutions.
- Participatory planning & monitoring at scheme and management levels
- Support of local leadership (opinion leaders &Administrative leaders.
- Adoption of new agricultural technologies.
- Enforcement of by-laws by IWUAs and scheme committees.
- Community mobilization on water management and environmental conservation.
- Awareness creation (HIV/AIDs, Environmental Conservation, Health services, Sanitation, IPM, Personal Hygiene).
- Many NGOs doing development work
- Lappset project
- Other government funding programmes
- Unemployed youth

D. Threats

- Increase wildlife human conflict
- Water resource use conflicts
- Political interference
- HIV/AIDs
- Financial constraints

- Poor management of water resources
- Illiteracy and ignorance
- Influx of people/encroachment
- Increased insecurity/crime
- Corruption
- Climate change
- Lack of spare parts
- Lack of skilled labor
- tribal conflicts
- resistance from neighbors
- high stakeholder expectation

4 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

The prime purpose of this section is to provide the proponent with quick reference to the critical legal and policy provisions that relate to the proposed project. Environmental Management and Coordination Act (EMCA, 1999) is the principle law of environmental management. This framework law guarantees every Kenyan the right to a clean and healthy environment.

One of the greatest challenges facing Kenya today is achieving sustainable development without interfering with the environment. This has necessitated the establishment of legislative and policy frameworks to guide and monitor the implementation of development projects to ensure environmental sustainability. There are several policies and legislations which have been put in place to address environmental and development issues and there are those relevant to the proposed development. These have have been summarized and analyzed as below

	National policies
2	1.The Constitution of Kenya 2. Sessional Paper No. 10 of 2014 on the National Environment Policy 3. National Water Policy (2012 Draft) 4. Draft National Wildlife Conservation and Management Policy, 2017 5. Draft National Forest Policy 2015 6. National Policy for Disaster Management, 2009 7. National Policy on Occupational Safety and Health, 2012 8. National HIV and AIDS Policy, 2009 9. National Gender and Development Policy, 2000 (GoK, 2000) 10. Sessional Paper No. 10 of 2012 on Kenya Vision 2030
2	1.Environmental Management and Coordination Act (EMCA) Cap 387 2. Water Act, No. 43 of 2016

	3. Forest Conservation & management Act No. 34, of 2016 4. Wildlife (Conservation and Management) Act Cap 376 of 1976, 2009 5. Physical Planning Bill 2015 6. Public Health Act, Cap 242 (GoK, 1986) 7. Employment Act, No. 11 of 2007 8. Occupational Safety and Health Act 2007 9. Work Injuries Benefits Act (WIBA), No. 13 of 2007 10. HIV and AIDS Prevention and Control Act No. 14 of 2016 11. National Construction Authority Act, No. 41 of 2011

	Policy	Relevant environmental obligations	Relevancy /linkages with PROJECT
1	The Constitution of Kenya (GoK 2010c)	Article 42 – Supporting public involvement in ensuring the rights to a clean and healthy environment. Article 43 – Supporting public involvement in ensuring the need for every person to have access to clean and safe water in adequate quantities, Article 69 - Environment and natural resources (1) (d) Encouraging public participation in the management, protection and conservation of the environment (f) Supporting environmental impact assessment, environmental audit and monitoring of the environment (g) Eliminating processes and activities that are likely to endanger the environment; and Article 66 – Regulating use of any land or any interest or right over any land, in the interest of public health or public planning Article 185: 22 - Protection of the environment and natural resources with a view to establishing a durable and sustainable system of development	• the project was identified and proposed by stakeholders through public consultation and further consultations on project implementation are on going • mitigation plans to ensure sustainability environmental of the project have proposed for implementation • project will support to access to water
2	Sessional Paper No. 10 of 2014 on the National Environment Policy (GoK, 2014	• Adopting measures, incentives and disincentives to promote the re-use, recycling and reclamation of re-usable packaging material and combat pollution of the environment • Promoting application of sound environmental management tools, in particular; ESIA, environmental audits, environmental management systems, risk assessment/management and environmental reporting • Working with private sector, NGOs and CBOs to enhance corporate social responsibility and accountability	• Stakeholders from the private sector are involved project identification • Wastes will be minimized by encouraging re-use during project implementation

3	National Water Policy (2012) (GoK, 2012f)	a) Increased per capita water availability above the international benchmark of 1000 m³ by 2030 f) Water pollution control 5.4: Public participation in water resources management	• The dam ensures general availability of water for the beneficiaries dry seasons • The proponent to ensure that the normal river flow will be maintained. • The Kilimani Dam Project implementation will ensure that water pollution will not occur at any site during construction and operational phases • Stakeholder engagement will be undertaken for project period
4	National Policy on Occupational Safety and Health, 2012	• Affirmative action for addressing workplace gender biases in occupational safety and health • Develop and implement workplace code of practice on HIV and AIDS at work • Develop guidelines for provision of facilities for persons with disabilities and other special needs in workplaces • Prevention of environmental pollution	• The proponent will ensure that the contractor employs community members without discrimination • The proponent will ensure that contractor gives safety of the public the attention it required • The proponent will ensure that the dam Project will ensure that no environmental pollution occurs during construction and operation • The proponent that strict adherence to design specifications to guarantee dam safety
5	Draft National Wildlife Conservation and Management Policy, 2017	• Wildlife Security • Strengthening wildlife security in conservation areas Putting in place mechanisms to identify, control and eradicate invasive alien species in wildlife conservation areas	• Fencing will be done for the project to ensure wild animals are protected during project operation and scaring of wild animals

6	Draft National Forest Policy 2015	• Promotes Conservation of forest reserve	• The Kilimani dam project does not encourage on any forest whoever planting of trees in project site will be encouraged
7	National Policy for Disaster Management, 2009 (GoK, 2009e	• Promoting the mainstreaming of disaster management and climate change into development planning and management for sustainability • Providing for well-structured participation of society in disaster management by integrating traditional coping strategies into the DM systems • Other policy goals: • Supporting climate change disaster risk reduction initiatives	• The proponent will ensure all safety guidelines on dam construction and operation are strictly adhered to in accordance to the international standards
8	National Gender and Development Policy, 2000	• Considering the needs and aspirations of all Kenyan men, women, boys and girls across economic, social and cultural lines • Ensuring the empowerment of women	• The projects supports activities normally done by women and proponent will ensure gender issues are addressed by ensuring 30% representation
9	Sessional Paper No. 10 of 2012 on Kenya Vision 2030	• Institutional capacity in environmental protection	• The proponent has environmental desk within the project which does capacity building on environmental matters and activities
10	National HIV Policy (GoK, 1997	Ensuring that new development projects especially in the rural areas encourage preventive and responsible behaviour both for the workers involved in such projects and also the local people within which projects are taking place as a goal towards curtailing the spread of the disease	The proponent will ensure that the contarctor will develop and implement workplace code of practice on HIV and AIDS during construction and operation
	Legal framework	Environmental obligations	Linkages with proposed dam

1	Environmental Management and Coordination Act (EMCA) Cap 387	Section 42 – Protection of rivers and wetlands Section 44 – Protection of forests Section 50 – Conservation of biodiversity Specific integration obligations • Water Quality Regulations, 2006 (Legal Notice No. 121) • Waste Management Regulations, 2006 (Legal Notice No.121) • Air Quality, Regulations, 2008 • Controlled Substances Regulations, 2007 (Legal Notice No.73 of 2007) • Fossil Fuel Emission Control Regulations (2006) • Conservation of Biodiversity Regulations 2006 • Wetlands, River Banks, Lake Shores and Sea Shore Management Regulation, 2009 • Environmental (Conservation of biological diversity and resources, and access to genetic resources and benefits sharing) Regulations	• The Kilimani dam project does not encourage on any forest whoever planting of trees in project site will be encouraged The dam ensures general availability of water for the beneficiaries dry seasons • The proponent to ensure that the normal river flow will be maintained. • The Kilimani Dam Project implementation will ensure that water pollution will not occur at any site during construction and operational phases • Stakeholder engagement will be undertaken for project period • Fencing will be done for the project to ensure wild animals are protected during project operation and scaring of wild animals • Proponent will ensure mitigation measures as suggested in the EMP are implemented • Tree planting will be encouraged around the project to replace any trees which will been cut • The proponent will ensure that the NWCPC Bosto Dam Project adheres and complies with all relevant regulations associated with EMCA Cap 387
2	Water Act, No. 43 0f 2016	• 40(4): An application for a permit shall be the subject of public consultation and, where applicable, of ESIA in accordance with the requirements of the Environmental Management and Co-ordination Act, Cap 387 • WRMA Rules (2007) require that the environmental reserve below a dam should be sufficient to meet human and ecological demands downstream. The Third Schedule of the WRM Rules (2007) sets out the fines and penalties for offences committed against the Rules	• The proponent will ensure t Project complies with the EMP in the ESIA report . • The beneficaiies will apply for water abstraction permit and will be required to adhere to the allowed levels.

3	Public Health Act, Cap 242 (GoK, 1986)	Article 129: Protection of public water supplies	• The project will be fenced for protection during construction and operation.
4	Employment Act, No. 11 of 2007	• The Employment Act declare and define the fundamental rights of employees, to provide basic conditions of employment of employees, to regulate employment of children and to provide for matters connected with the foregoing. The Act declares that: - Priority will be given to the local community in terms of employment opportunities • 29. Maternity leave **-** A female employee is entitled to three months maternity leave with full pay	The provisions of the Act shall apply especially with regard to the employment of local people in isiolo where applicable
5	Occupational Safety and Health Act 2007	Maintain a safe working environment: • Provision of suitable personal protective equipment and clothing • Machinery safety, chemical safety and electrical safety Part IX - Chemical safety • (4) Safe collection, recycling and disposal of chemical wastes, obsolete chemicals to avoid the risks to safety, health of employees and to the environment	The contractor will be required to adhere to the act requirements
6	Work Injuries Benefits Act (WIBA), No. 13 of 2007	Compensation for temporary total or partial disablement 30. Compensation for permanent disablement 38. Compensation in respect of scheduled and unscheduled diseases 45. First Aid (1) The employer shall provide and maintain such appliances and services for the rendering of first aid to his employees in case of any accident 46. Transportation of injured worker to a hospital	The provisions of the Act shall apply during the construction and operation of the project and the contractor will have to strictly adhere to the act
7	National Construction	Registration of civil construction works as specified in Section 5 and the 3rd Schedule of the Act	The provisions of the Act shall apply during the construction of the project .The contractor will have to be registered to been engaged by the proponent

	Authority Act, No		
8	HIV and AIDS Prevention and Control Act No. 14 of 2016	3.(a): Public awareness about the causes, modes of transmission, consequences, means of prevention and control of HIV and AIDS (iii) Outlawing discrimination in all its forms and subtleties against persons with or persons perceived or suspected of having HIV and AIDS 13. Prohibition against compulsory HIV/AIDS testing	The provisions of the Act shall apply during the construction and operation of the Dam Project
9	Physical Planning Bill 2015	Proper landuse zoning	The access roads, WTP and water distribution network shall comply with relevant physical
10	Forest Conservation & management Act No. 34, of 2016	Protection of forests Other legal obligations • Prevention of forest fires • Initiating payments for ecosystem services (PES) initiatives for carbon sequestration and other environmental services	The project does not encroach on any forest
11	Wildlife (Conservation and Management) Act Cap 376 of 1976, 2009	68:(4): Preventing development in a national conservation areas without approved management plans Section 30 of part VI: Prevention of adverse effects on the environment	The proponent will ensure that environmental pollution is avoided and that the animals migrating near the project site will not be killed and at all times KWS to be informed in case of incidents.

6.3.2 National Institutional Framework

1. Institutions under EMCA, 1999

The Government established the following institutions to implement the EMCA 1999.

a) <u>National Environmental Council (NEC)</u>

The National Environmental Council (NEC) is responsible for policy formulation and directions for the purposes of the Act. The NEC also sets national goals and objectives and determines policies and priorities for the protection of the environment.

b) <u>National Environmental Management Authority (NEMA)</u>

The responsibility of the National Environmental Management Authority (NEMA) is to exercise general supervision and co-ordination over all matters relating to the environment and to be the principal instrument of government in the implementation of all policies relating to the environment.

In addition to NEMA, the Act provides for the establishment and enforcement of environmental quality standards to be set by a technical committee of NEMA known as the Standards and Enforcement Review Committee.

c) <u>County Environmental Committees)</u>

The county and subcounty Environmental Committees also contribute to decentralised environmental management and enable the participation of local communities. These environmental committees consist of the following:

- ⇒ Representatives from all the ministries;
- ⇒ Representatives from local authorities within the province/district;
- ⇒ Two farmers / pastoral representatives;
- ⇒ Two representatives from NGOs involved in environmental management in the province/district;
- ⇒ A representative of each regional development authority in the province/district.

d) <u>Public Complaints Committee (PCC)</u>

The Act also established a Public Complaints Committee, which provides the administrative mechanism for addressing environmental harm. The committee has the mandate to investigate complaints relating to environmental damage and degradation. Its members include representatives from the Law Society of Kenya, NGOs and the business community.

e) <u>Standards and Enforcement Committee (S&EC)</u>

Part VIII of the Act deals with environmental quality standards. It establishes a Standards and Enforcement Review Committee (SERC) whose functions include the establishment of standards for all environmental media.

Standards have been established as regulations to the Act as presented above. Standards for the following are still scheduled for release:

- ⇒ Air quality;
- ⇒ Chemicals;
- ⇒ Land use;
- ⇒ Economic instruments.

2. Institutions under Water Sector Reforms

The key institutions provided for in the water sector reforms are: The Water Resources Management Authority (WRMA); Seven Water Services Boards (WSBs); The Water Services Trust Fund (WSTF); The Water Services Regulatory Board (WASREB); and The Water Appeals Board WAB).

The Act gave the Ministry of Water and Irrigation the responsibility to set up and oversee various autonomous institutions that provide a harmonized and streamlined management of water resources, supply sewerage services and integrated water resources management. These duties were previously undertaken by line departments in the Ministry, and one of the institutions established is the Water Resources Management Authority (WRMA).

The MoWI operates mostly through the Water Act 2002 to operationalize water resources management through two departments –Water and Irrigation. The Department of Water is responsible for the provision of water resources and water services strategies through various institutions provided for under the Act. The

Department of Irrigation was moved from MoA to MoWI and the governing Act is the Irrigation Act (Cap 347).

The MoWI has also created institutions for water resources management and the provision of water services that would resolve water conflicts and challenges due to growing population, catchment degradation, invasive weeds, groundwater depletion, water pollution and resource use conflicts. The organizations under this structure include Water Resources Management Authority (WRMA) and associated Catchment Area Advisory Committees (CAACs) and Water Resource User Associations (WRUAs); Water Services Regulatory Board and associated Water Services Boards (WSBs) and Water Service Providers (WSPs); Water Services Trust Fund (WSTF); and Water Appeal Board.

Water Resources Management Authority (WRMA)

The Water Resources Management Authority (WRMA) is of particular relevance to the project. Its mandate covers some sectoral issues which are applicable to environmental management, such as use of water resources, human settlement and administration of activities in the scheme.

Part III of the Water Act 2002 defines the powers and functions of WRMA which include:

- ⇒ Developing principles, guidelines and procedures for the allocation of water resources;
- ⇒ Monitoring the national water resources management strategy;
- ⇒ Receiving and determining applications for permits for water use;
- ⇒ Monitoring and enforcing conditions attached to permits for water use;
- ⇒ Regulating and protecting water resources quality from adverse impacts;
- ⇒ Managing and protecting water catchments.

WRMA may prosecute any offences arising under the Water Act and also provides the basis for the following:

- ⇒ Formulation of a National Water Resources Management Strategy;
- ⇒ Classification of water resources and resource quality objectives;

⇒ Determination of water reserves;

⇒ Designation of catchment areas;

⇒ Formulation of a catchment management strategy;

⇒ Declaration of protected catchment areas national monitoring of and information on water resource management;

⇒ Definition of state schemes and community projects.

3 Key Institutional Organs

In summary, the key institutional organs of relevance to the proposed Kilimani Game Galana Irrigation Project are presented in Tab

Table 8; Institutional Organs of relevance to the proposed dam project

Institution	Parent Ministry	Responsibility
Department of Cooperatives	Ministry industrialization and enterprise development	Regulation of cooperative societies
Directorate of Occupational Health	Ministry of Labour ,social security and services	Approval of construction plans and activities
Public Health Department	Ministry of health	Inspection of the project
NEMA	Ministry of Environment and natural Resources	Approval of ESIA Project Report
Water Catchment Boards	Ministry of Water and Irrigation	Catchment conservation and issuance of water permits
WRMA	Ministry of Water and Irrigation	Approval of water abstraction
NCA	Ministry of transport and infrastructure	Construction project registration
Physical planning	Ministry of transport and infrastructure	County development plans approval

6.4 International Conventions and Treaties

Kenya has ratified or acceded to numerous international treaties and conventions. Those that have implications on Kilimani Game Galana Irrigation Project are described below:

6.4.1 Cartagena Protocol on Biosafety, 1999

A complimentary to the Convention on Biological Diversity, this protocol has the objective of creating a balance between the benefits that accrue from biotechnology while still safeguarding the environment and human health from the potential harmful effects that biotechnology may pose. The Provisions of the protocol are captured in the EMCA which should be abided by the proposed project.

6.4.2 United Nations Convention to Combat Desertification, 1994

Addresses the problem of the degradation of land by desertification and the impact of drought, particularly in arid, semi-arid and dry semi-humid areas. This convention is domesticated in EMCA 1999 via Section 46 where District Environment Committees are required to identify areas that require re-forestation or afforestation as well as to mobilise the locals to carry out these activities. The project area in the zone climatic can be affected if the county Environment Committee decides as such.

6.4.3 Convention on Biological Diversity (CBD), 1993

The CBD adopts a broad approach to conservation. It requires Parties to the Convention to adopt national strategies, plans and programmes for, the conservation of biological diversity, and to integrate the conservation and sustainable use of biological diversity into relevant sectoral and cross-sectoral plans, programmes and policies. The proposed project is expected to conserve biodiversity, especially the rare and endangered species in the project area and its environs in compliance with the Environmental Management and Co-ordination (Conservation of Biological Diversity) Regulations, 2006.

6.4.4 United Nations Framework Convention on Climate Change, 1992

Sets an ultimate objective of stabilizing greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic (human-induced) interference with the climate system. Development projects in Kenya such as the proposed Kilimani Game Galana Irrigation Project are expected to take climate change considerations into account, to the extent possible, in their relevant social, economic and environmental policies and actions.

5 PUBLIC CONSULTATION

5.1 Background to public consultation in ESIA

Timely, well-planned and implemented public involvement and consultation is a vital component of a successful ESIA study. The Kenya government has enshrined the need for human societies' involvement in project development in the Constitution. This has been set out in the 2010 Constitution, *EMCA Act, 1999* and *Environmental (Impact and Audit) Regulations, 2003*. Community consultation and participation ensures that communities and stakeholders are part and parcel of the proposed developments and in so doing assures the sustainable use of resources. It has also demonstrated successfully that projects that go through this process will acquire high level of acceptance, identify possible conflicts areas early, and accrue benefits to a wider section of the society.

Public consultations form a useful component for gathering, understanding and establishing likely impacts of projects determining community and individual preferences and selecting alternatives. Furthermore, through public participation, it is possible to enhance project designs, ensure sustainability of the projects. The proposed project has incorporated public consultations in order to understand the local impacts, needs and thoughts and eventually incorporate them into the final designs and operations of the project.

5.2 Aims and objectives of public consultation

The aims and objectives of public involvement and consultation include:

- ⇒ Allowing the public to express its view on the scope and content of an ESIA(and the proposed development action);
- ⇒ Obtaining local and traditional knowledge (corrective and creative) before decision-making;
- ⇒ Allowing more sensitive consideration of alternatives, mitigation measures and trade-offs;
- ⇒ Ensuring that important impacts are not overlooked and benefits are maximized;
- ⇒ Reducing conflict through the early identification of contentious issues;

⇒ Influencing project design in a positive manner (thereby creating a sense of ownership of the proposal);

⇒ Improving transparency and accountability of decision-making; and increasing public confidence in the ESIA process.

Experience indicates that public involvement and consultation provides a wide range of such benefits for all participants in ESIA/SEAs. Many benefits are concrete, such as improvements to project design ,identifying early conflict resolution mechanisms. Other benefits are intangible and incidental and flow from taking part in the process. For example, as participants see their ideas are helping to improve proposals, they gain confidence and self-esteem.

5.3 Methodology

Public consultation for the Environmental and Social Impact Assessment Study for the proposed Kilimani Butres dam was conducted through impromptu visits, public meetings, workshop, and oral interviews with key informants, focus group discussions and administration of structured questionnaires. The questionnaires administered to the stakeholders were on three topical issues:

a) Environmental and technical issues
b) Socio-economic aspects
c) Gender and socio-cultural issues

At the onset of the ESIA study, a meeting was held in with the project implementation team there after the team attended an impromptu site visit with stakeholders , a stakeholder workshop was held in Isiolo town at Agricultural training center attended by the ESIA consulting team, representatives from the government agencies with a stake in the project, project beneficiaries, representatives from downstream water users, neighboring conservancies ,Kenya Defence forces ,interested parties and the local leadership. The meeting was meant to discuss the project information in terms of its implementation, anticipated benefits, predicted impacts and their mitigations, project alternatives and further comments.

5.4 Summary of the stakeholder's comments

The comments from the stakeholders during public meetings on the proposed project are summarized below

5.4.1 Positive impacts of the proposed Kilimani Buttress Dam, Kilimani-location

- support the Kilimani Galana irrigation project, Providing water for livestock fodder production and tree nurseries for generating income
- Providing water for livestock from nearby villages saves time and reduces erosion caused by cattle being tracked for water.
- Providing domestic water in extremely dry season thus reducing water conflicts in the area
- Reduction of energy wasted by animals through trekking for long distances in search of drinking water
- Water can be used for making bricks and construction works for income generation.
- Saving peoples' time by reduced walking distances to fetch water.
- Reduced impact of floods by storing initial floodwaters thus lessening erosion.
- Increasing the value of land near an earth dam, because of all the above benefits and promotion of development
- Employment creation and skill development in the area
- Market for local materials
- Reducing poverty levels through the income generating activities

5.4.2 Negative Impacts during Buttress Dam Construction Phase

Negative impacts	Mitigation measures
Closure of elephant routes/corridor – human wildlife conflict	• Provide community scouts during construction. • Provide safe passage of elephants outside dam site. • The normal flow of water in the stream should not be interrupted for wildlife and other users.
Dust produced from trucks may interrupt KDF training Vision and workers health.	• Wet the dam site and road during construction works to minimize dust. • Provide dust masks for workers during constructions. • Put speed limits for trucks.

	• Murrum the road to the dam
Sound pollution	• Awareness creation in times of blasts if any. • Machines should meet required sound standards. • Minimize truck movements at night.
Water for construction may reduce stream water level for other users	• Contractor to use supplementary water for constructions. • Harvest rain water for constructions • Practice Properly scheduled Water rationing..
Deforestation activity during site and road clearance	• Plant indigenous trees in the camp. • Involve forestry department for guidance in the re-afforestation programe. • Selective cutting of trees, preserve indigenous species
Interference with cultural sacred sites and trees. (Azapan area)	• Get blessings of elders • Make sacrifices
Up scaling of crime among workers	• Seek assistance from office of Administration. • Theft- Vetting of workers during recruitment • Balancing of workers on ethnicity • Contractors to use unskilled labour where possible
Erosion of moral values and diseases out breaks	• Awareness creation of diseases among workers. • Use of protective devices • Provision of dispensers at camp toilets. • Cultural awareness induction
Conflict and mistrusts among workers	• Dialog between community, chiefs contractors and project officers
Water shortage in KDF camp	• Enlighten KDF engineers during construction works to ensure constant flow of the stream to the camp • Meet with KDF environmental experts to discuss way forward within 2 weeks.
Likely Dam breakages/ leakages in dam wall or base/	• Choice of experienced and qualified contractors. • Proper design and BQ to set standards of strong dams • Construction to be carried out according specification. • Construction to be checked and supervised on daily bases by qualified engineers.
Encroachment in the dams catchment area	• Chiefs to stop encroachment in the riverine and catchment area. • Facilitate Barazas to inform community on protected sites • Dam to be properly fenced
Destruction of ecosystem	• Debris to be dumped in recommended sites. • Ensure protection of flora and fauna
Unsafe working conditions	• Contractor to ensure safe working conditions for workers • Provide training on safe conditions for using safety gears provided

	• Proper fencing of work site. • Vet workers on health standards before recruitment. • Transparency between contractors and stake holders
High expectations by workers	• Transparency between contractors and workers. • Standard labor payment to be applied
Introduction of new land use	• Ensure all community members are well sensitized

5.4.3 Negative impacts expected from the operation of the Kilimani Buttress Dam

Negative impacts	Mitigation measures
Waterborne diseases- vector build up e.g. mosquitoes, bilharzias	• Field hygiene- proper disposal of containers, poly bags/tubes. • Main Dam to be protected from mosquito build up eg use of tilapia fish. • Improved sanitation and personal hygiene. • Water treatment before use • Closed conveyance systems
Siltation of Dams	• Put series of sedimentation pits in conveyance line
Introduction of alien species	• Screening species for undesirable characteristics e.g. allelopathy • Ensure introduction of environmentally friendly tree species
Water lose through seepage through dam cracks and fitstures or base	• Ensure proper construction according to specification. • Dam construction on strong hard base
Lose of flora and fauna in dam sites	• Ensure safe environment for flora and fauna
Crocodile invasion in dam	• Avoid swimming in the dam • Proper fencing to deter human and wildlife into the dam • Provide water points outside the dam
Land degradation	• Control encroachment in the dam catchment
Increased competition for irrigation water	• Put proper by-laws on water usage. • Maintain natural water flow • Control of new developments in the area
Human wildlife conflict	• Scaring of wildlife from the farms • Introduce crop insurance cover. • Apply for crop compensation
Increased water pollution incidences	• Enhance field hygiene through construction of pit latrines • Put in place series of silt traps along the conveyance system to avoid Dam siltation • Use water coagulants to reduce suspended matter • Ensure periodic Dam de-silting
Increased generation of agricultural wastes	• Educate community on pollution control

	• Practice safe and effective use organic wastes e.g. composting • Proper disposal of wastes

All stakeholders believed the project was good and would generally lead to improvement of livelihoods and promote water availability to the community however there was a feeling that there was need to manage high expectations from neighbouring communities in that the overall responsibility of abstraction and payment water bills would be under Kilimani water users association and it was prudent to follow laws when implementing the project

Captured voices

Major May Kirwa (The KDF representative) "*We support the project and will require it to succeed and every participant should be given opportunity to express his/her thoughts. We request to have that be a meeting between the contractors, the project officers and engineers and the KDF environmental experts to iron out fears that might arise within the next 2 weeks"*

Mr. Kisela (The WRMA representative) "water *is natural resource whose responsibility is invested in the government of that particular site. The WRMA being the authority gives an Applicant for the water a license use and manage according to the applicant's requirement and there is a cost involved which the applicant has to pay. This is to say that the applicant who paid has the right for use and management of the water according to his requirement therefore this is to say that other down stream users have to cooperate and the schemes by-laws have to be followed*."

Mr. Filla (Buress Dima Farmer) "*there is high expectations from the project from even non targeted beneficiaries especially those where the pipeline passes and should be honestly told what they expect to avoid future conflicts as we know water will always be scarce and that does not mean we are opposing the project in anyway. I fully support it even if I know I wont necessary benefit"*


Photo 1: one of design engineers explaining to stakeholders on the design



Photo 2 member giving their views

KENYA DEFENCE FORCES CONCERNS

The project office held further consultations on 20/11/2017 with the KDF School of infantry regarding the dam project in the view addressing some of the concerns raised about the project.

At the meeting the project coordinator gave a brief of the project and the meeting was a result of communication form NEMA requiring further consultations and conflict resolution with KDF

The brigade commander acknowledged having written to NEMA about the project and that they wanted to know the impacts of the project especially the flow of the river.

The project engineer briefed about the dam design and reiterated that

- ⇒ The dam will harvest and store **flood flows** of River Lewa which will be utilized for irrigation purposes and the normal flow of the river will not be interfered with;
- ⇒ once the dam will be in place, the normal flow was likely to be enhanced to the advantage of downstream users;
- ⇒ During Construction phase of the Kilimani Buttress Dam, KDF will be involved to ensure compliance with mitigation measure as detailed in the Environmental Management Plan (EMP);
- ⇒ The Water Resources Authority (WRA) shall monitor the flows to ensure compliance with the abstraction levels along River Lewa

The lead expert confirmed to have captured issues presented by KDF representatives during previous meetings on the projects (irrigation and dam). A draft report was shared with brigade commander with invitation for further comments extended.

1. Later other copies of project documents were shared with commander, they included
2. Draft Environmental and Social Impact Assessment (ESIA) report
3. Hydrological Survey report
4. Kilimani Buttress Dam Design report
5. Kilimani Game Galana Irrigation Scheme Design report
6. Geological and Geophysical investigation report

photo 3 showing conflict resolution meeting with KDF inset Project team and brigade commander of SOI Isiolo

6 ENVIRONMENTAL AND SOCIAL IMPACTS

This Chapter identifies and discusses both positive and negative impacts associated with the proposed Kilimani concrete Buttress dam Project. The anticipated impacts are discussed in three phases namely: construction, operation and de-commissioning phases. Impacts associated with the construction phase are short term while the impacts associated with the operation are long term.

6.1 Project sitting (Resettlement action plan)

The proposed project is sited in a community land which is not settled at the moment with the nearest settlement being approximately 2 kilometers downstream where the school of infantry under the Kenya defence forces have their camp. There will be no need to resettle anybody though some KDF activities may affected during construction and may need some rescheduling .The KDF normally does the shooting exercises nearby and this will have to be relocated during project construction to avoid accidental injury of workers using the route.

6.2 Project impacts during construction phase

6.2.1 Positive impacts

6.2.1.1 Creation of employment

During the construction of the proposed project there will be employment opportunities for both professionals and unskilled workers. Several workers including casual laborers, plumbers and engineers are expected to work on during the construction period. Semi-skilled, unskilled laborers and formal employees are expected to obtain gainful employment during the period of construction..

The creation of employment opportunities is beneficial both from the economic and social point of view. Economically, it means abundant unskilled labor will be used in doing manual work for example clearing the sit. This positive social change in the social behavior will be one of the anticipated transformational indicators in the project area.

6.2.1.2 Injection of money into the local economy

A large sum of the project money shall be released into the local economy due to the construction activities. This money will be inform of payments for skilled and unskilled labour; Purchases of construction materials; and payments for local provisions including fuel, foods and accommodation.

6.2.1.3 Creation of market for construction materials

The project will require materials, some of which will be sourced locally within the project area. Some of this include sand and hardcore for the construction of the intake weir. Local suppliers of will be given first priority in supply of construction materials.

6.2.2 Negative impacts and mitigations measures

6.2.2.1 Interference with existing infrastructure

Negative Impact

The proposed project could result into the interruption of existing infrastructure such as access roads to watering points from the river, grazing lands. These services are critical and have implications with spillover effects on the social and economic performance.

Mitigation Measures

- ⇒ DRSLP should request for permission neighbors mainly KDF , break in accessing the project site .
- ⇒ During construction works, the farmers and other property owners neighboring the proposed should be formerly engaged by the Project Contractor;
- ⇒ DRSLP should allow provision of designing and construction animal watering points away from the construction site to minimize disturbances

6.2.2.2 Noise pollution

Negative Impacts

Construction of the proposed Kilimani dam Project will most likely result in noise emissions as a result of the machines that will be used (excavation equipment e.t.c) and construction vehicles delivering materials to site. Noise could impact negatively on the workers during the construction phase. Noise can also be a nuisance to the local community and KDF camp if construction works begin too early in the day and continues into the night.

Noise levels from construction activities exceeding 60 Db(A) at the construction camp site have a negative impacts to the environment.

Mitigation Measures

The contractor should employ the following noise-suppression techniques in order to minimize the impact of temporary construction noise at the Project site.

- ⇒ The Project Contractor to use the best available practices on-site to minimize occupational noise levels;
- ⇒ The Project Contractor to regularly inspect all construction equipment to ensure they are maintained in good working condition;
- ⇒ The Project Contractor to provide ear muffs for those working with noise producing equipment; and
- ⇒ Combine noisy operations so that they occur at the same time.

6.2.2.3 Dam safety concerns

Negative impact

Concrete dam construction requires skilled people and utmost care to taken during construction. One simple mistake in material selection, non-adherence to minimum specifications or poor design can lead to dam failure which can be often being a disaster.

Mitigation measures

- ⇒ Strict supervision of construction activities by qualified staff and if possible in collaboration with KDF Personnel
- ⇒ ensuring substandard material are not used and materials are used in strict conformation with set standards

⇒ DRSLP to ensure that material testing to be done in the presence of appointed qualified personnel.

⇒ DRSLP to ensure that the resident Engineer is permanently on site during the construction period and should not be engaged in other activities

⇒ The project contractor to ensure that high skilled technicians /fundis of integrity are involved in concrete works and are provided with the right tools of trade.

6.2.2.4 Dust emissions

Negative Impact

Dust will be emitted during excavation and related earthworks. Air borne particulate matter pollution is likely to occur during the route clearance, excavation and during the transport of construction materials. This is likely to affect site workers and the residents, in extreme situations leading to respiratory problems.

Mitigation Measures

The following measures can help mitigate dust generation and damage likely to arise during the construction phase:

⇒ Public Health Office to ensure that strict measures are applied in the handling of construction materials such as cement, lime, concrete additives, etc.;

⇒ The Project Contractor to ensure that excavation, handling and transportation of erodible materials shall be avoided under high wind conditions or when a visible dust plume is present;

⇒ The Project Contractor to minimize the number of motorized vehicles in use;

⇒ The Project Contractor to wet all active construction areas as and when necessary to eliminate dusty conditions on site; and

The Project Contractor to ensure that vehicle speeds are limited to a maximum of 30 km/h.

6.2.2.5 Workers accidents and hazards

Negative Impacts

Construction workers are likely to have injuries and hazards as the construction works unavoidably expose workers to occupational health and safety risks. The workers are also likely to be exposed to risk of accidents and injuries resulting from accidental falls, injuries from hand tools and construction equipment.

Mitigation Measures

- ⇒ DRSLP will be required to commit the contractor to Site Occupational Health and Safety rules and regulations as stipulated in the OHSA, 2007;
- ⇒ The Project Contractor will be required to provide appropriate personal protective equipment and a safe and healthy environment for construction workers;

There should be a crisis management team to administer First Aid to injured persons;

The Project Contractor should test and approve equipment before use; and

The Project Contractor should train workers on how to use various PPE and safe use of machines

6.2.2.6 Generation of solid wastes

Negative Impacts

Solid wastes generated during construction include papers used for packing, plastics, cuttings and trimmings off materials among others. Dumping around the site will interfere with the aesthetic status and has a direct effect on the surrounding community. Disposal of the same solid wastes off-site could also be a social inconvenience if done in the wrong places. The off-site effects could be pest breeding, pollution of physical environment including water resource, invasion of scavengers and informal recycling by communities.

Mitigation Measures

- ⇒ The Project Contractor to comply with NEMA's Waste Management Regulations of 2006;
- ⇒ DRSLP should identify designated garbage storage areas during construction and the contractor should be responsible for handling and disposal of all construction related wastes;

⇒ DRSLP and contractor to ensure that waste disposal by burning should not be permitted and workers should be sensitised on proper handling and disposal of waste;

⇒ Debris from cut trees and bush should be instead used to put a fence /a barrier along the farm edges ;and

⇒ The Project Contractor should as much as possible put to good and acceptable use any materials damaged or rejected for use on site.

⇒ Mixing of concrete should be done away along the flood water pathway

6.2.2.7 Depletion of flora and fauna

Negative Impacts

The proposed project will involve clearing of vegetation sited along the gorge .From the field visits, the areas selected have concentrated and shrubby vegetation cover. Large trees are available at the affected sites.

Mitigation measures

⇒ The Project Contractor shall ensure strict control of construction vehicles so that they operate only within the area to be disturbed by access routes and other works;

⇒ DRSLP shall ensure proper demarcation of the Project area to be affected by construction works; and

⇒ The Project Contractor to minimize creation of new access routes as much as possible.

⇒ DRSLP to establish tree nurseries in area and encourage planting of indigenous trees along the banks of the dam to replace any which will have been destroyed

6.2.2.8 Occupational health and safety concerns

Negative Impacts

Labor camps including workers' living and eating areas; grounds where equipment will be stored and serviced; and where construction materials will be stockpiled is likely to bring a temporary influx of migrant workers. This may stimulate business in the project area and also propagate the spread of STDs including the deadly HIV/AIDS. There could also be cases of unwanted pregnancies as the migrant workers interact and get into relationships with the local people.

Local services such as medical, water supplies sanitation and waste disposal can be over stretched by the sudden increase in population. Improper sanitation arrangements at the camps can cause contamination of groundwater and pose a major health hazard, and outbreaks of diseases such as diarrhea, cholera and typhoid.

Mitigation measures

- ⇒ Public Health Office to control disease causing vectors and avail health care services on site;
- ⇒ The Project Contractor to provide clean drinking water and pit latrines on site;
- ⇒ The Public Health Office should sensitize the migrant workers on risky sexual behavior;
- ⇒ The Project Contractor in collaboration with the Public Health Office should have VCT services on site and encourage workers to be tested; and
- ⇒ The Public Health Office should provide condoms and other protective devices on site.
- ⇒ Provision shall be made for employee facilities including shelter, toilets and washing facilities.
- ⇒ Toilet facilities supplied by the contractor for the workers shall occur at a minimum ratio of 1 toilet per 30 workers (preferred 1:15).
- ⇒ The exact location of the toilets shall be approved by the Public Health Department prior to establishment.
- ⇒ Sanitation facilities shall be located within 100m from any point of work, but not closer than 50m to any water body.
- ⇒ All temporary/portable toilets shall be secured to the ground to prevent them toppling due to wind or any other cause.
- ⇒ The contractor shall ensure that the entrances to toilets are adequately screened from public view.
- ⇒ Only approved portable toilets should be used.
- ⇒ These facilities shall be maintained in a hygienic state and serviced regularly.
- ⇒ Toilet paper shall be provided

⇒ The contractor shall ensure that no spillage occurs when the toilets are cleaned or emptied and that the contents are removed from site to an approved disposal site.

⇒ Discharge of waste from toilets into the environment and burying of waste is strictly prohibited.

⇒ Wash areas shall be placed and constructed in such a manner so as to ensure that the surrounding areas, which include groundwater, are not polluted.

6.2.2.9 Cultural site destruction

Some the areas which will be affected happen to cultural sites for the local community .it was reported there was an area which used to be a circumcision site for the community and will need some cleansing before construction begins

Area chief in collaboration with the project contractor to lead cleansing exercise of the affected areas before construction begins

6.2.2.10 Interference with wildlife migration corridor

Negative impact

The chosen site happens to be in the path of migration route of elephants and if not checked the animals can cause damage to any barrier along the transport corridors.

Mitigation measure

- KWS to monitor and control wildlife movement in the project area.
- Project contractor to report any incidences of interruption by wild animals

Table 9: Summary of potential negative impacts and their mitigation measures during construction phase of the project

Potential negative impacts	Mitigation measures
Interference with existing infrastructure	• DRSLP should request for permission neighbors mainly KDF , break in accessing the project site . • During construction works, the farmers and other property owners neighboring the proposed should be formerly engaged by the Project Contractor; • DRSLP should allow provision of designing and construction animal watering points away from the construction site to minimize disturbances
Dam safety	• Strict supervision of construction activities by qualified staff and if possible in collaboration with KDF Personnel • ensuring substandard material are not used and materials are used in strict conformation with set standards • DRSLP to ensure that material testing to be done in the presence of appointed qualified personnel. • DRSLP to ensure that the resident Engineer is permanently on site during the construction period and should not be engaged in other activities • The project contractor to ensure that high skilled technicians /fundis of integrity are involved in concrete works and are provided with the right tools of trade.
Workers accidents and hazards during construction	• DRSLP will be required to commit the contractor to Site Occupational Health and Safety rules and regulations as stipulated in the OHSA, 2007;

	• The Project Contractor will be required to provide appropriate personal protective equipment and a safe and healthy environment for construction workers; There should be a crisis management team to administer First Aid to injured persons; • The Project Contractor should test and approve equipment before use; and • The Project Contractor should train workers on how to use various PPE and safe use of machines
Generation of solid wastes	• The Project Contractor to comply with NEMA's Waste Management Regulations of 2006; • DRSLP should identify designated garbage storage areas during construction and the contractor should be responsible for handling and disposal of all construction related wastes; • DRSLP and contractor to ensure that waste disposal by burning should not be permitted and workers should be sensitised on proper handling and disposal of waste; • Debris from cut trees and bush should be instead used to put a fence /a barrier along the farm edges ;and • The Project Contractor should as much as possible put to good and acceptable use any materials damaged or rejected for use on site. • Mixing of concrete should be done away along the flood water pathway
Depletion of flora and fauna	• The Project Contractor shall ensure strict control of construction vehicles so that they operate only within the area to be disturbed by access routes and other works;

	• DRSLP shall ensure proper demarcation of the Project area to be affected by construction works; and • The Project Contractor to minimize creation of new access routes as much as possible. • DRSLP to establish tree nurseries in area and encourage planting of indigenous trees along the banks of the dam to replace any which will have been destroyed
Noise pollution	• The Project Contractor to use the best available practices on-site to minimize occupational noise levels; • The Project Contractor to regularly inspect all construction equipment to ensure they are maintained in good working condition; • The Project Contractor to provide ear muffs for those working with noise producing equipment; and • Combine noisy operations so that they occur at the same time
Occupational health and safety concerns	• Public Health Office to control disease causing vectors and avail health care services on site; • The Project Contractor to provide clean drinking water and pit latrines on site; • The Public Health Office should sensitize the migrant workers on risky sexual behavior; • The Project Contractor in collaboration with the Public Health Office should have VCT services on site and encourage workers to be tested; and • The Public Health Office should provide condoms and other protective devices on site.

Dust emissions	• Public Health Office to ensure that strict measures are applied in the handling of construction materials such as cement, lime, concrete additives, etc.; • The Project Contractor to ensure that excavation, handling and transportation of erodible materials shall be avoided under high wind conditions or when a visible dust plume is present; • The Project Contractor to minimize the number of motorized vehicles in use; • The Project Contractor to wet all active construction areas as and when necessary to eliminate dusty conditions on site; and • The Project Contractor to ensure that vehicle speeds are limited to a maximum of 30 km/h.
Interference with wildlife migration corridor	• KWS to monitor and control wildlife movement in the project area. • Project contractor to report any incidences of interruption by wild animals
Cultural site destruction	Area chief in collaboration with the project contractor to lead cleansing exercise of the affected areas before construction begins

6.3 Project impacts during operation phase

6.3.1 Positive impacts

6.3.1.1 Contribution to flora, fauna and micro-climate

The supply of irrigation water to the farms in the project area will motivate the farmers to grow crops, fodder crops for the animals and trees. Through this, it is envisaged that the number of flora and fauna species will increase. This means that micro climate within the project area will be enhanced. This will immensely contributed to the property value, land value and aesthetic value of Isiolo area while ensuring that the environment remains healthy and productive.

6.3.1.2 Creation of employment

During operational phase, there will be employment opportunities especially for those who will be employed to manage, maintain irrigation water supply system. A number of youths within the project area will be employed in the farms to undertake such activities as cultivation, weeding, harvesting among others. This will improve their living standards and by engaging them will also change their social behavior.

6.3.1.3 Creation of wealth

The proposed irrigation project will ultimately provide revenues to the beneficiaries and expand the wealth base for the nation as a whole. It will pump both liquefied and tied up wealth hence making the nation gain. It will also go a long way in uplifting Isiolo County and its neighborhood as a whole. Once the people will be empowered in the project area, some will invest and develop the nearby Isiolo, the District Headquarters.

6.3.1.4 Improved food security

Crop production in the project relies on other small irrigation schemes and the community often relies on relief and buying from neighbouring town. This has led to the rampant cases of food shortage in the households during droughts when there animals die and there is nothing to trade with. The expansion of irrigated agriculture through the proposed project will increase crop production and thus alleviate the food shortage problem in the households. Surplus produce could be sold and earn households much needed incomes.

6.3.1.5 Improved well-being of women and children

At the household level, women and children bear the burden of fetching water. Other than the time spent in getting water from long distances, these practices has far reaching consequences on their health and wellbeing.

Irrigation water accessibility near the homestead and if treated well would translate to time saving by the women. Time saved thus would be invested in other engagements that could bring financial benefits to the family. Children also bear the brunt of water borne diseases while women are tied down to provide nursing care to the sick family members. With proximity of water and treatment at household level : all these negative impacts will be reversed in the project area.

6.3.2 Negative impacts and their mitigations measures

6.3.2.1 Depletion of river water downstream

The proposed irrigation is projected to use substantial high volumes of water during operation. These will definitely to affect river flow regimes especially during drought situations even though the proposed dam is meant to caution against this. If not checked the river can be affected during

Mitigation measures

- WRMA to control abstraction of water of the licensed water user through strict adherence of permitted levels.
- DRSLP to encourage the irrigation water to adopt water efficient technologies.

6.3.2.2 Increase in waterborne diseases

Negative Impacts

Once dam is complete water easily accessible by the community at the periphery and most households will use the same as drinking water and for domestic use without any treatment. This would increase the chances of contracting waterborne diseases such as typhoid and cholera. The reservoir will also form breeding ground of mosquitoes which will be responsible for the spread of malaria. This will lead to ill health problems among the residents and even increase the chances of child mortality rates in severe cases.

Mitigation Measures

⇒ The Public Health Office should create awareness on waterborne diseases, water pollution and waste disposal should be adequately addressed;

⇒ The Public Health Office should train community members on household water treatment; and

⇒ Public health office to create awareness on mosquito control in houses

⇒ DRLSP to introduce fish to the dam to with the intention of them eating mosquito larvae.

6.3.2.3 Water use conflicts

Negative Impacts

The surrounding communities have high expectations as result of the construction of the dam even if they are not necessarily targeted .This scenario is likely to cause conflicts especially with farms where the water pipe line will pass and farmers do not benefit in anyway.

Secondly, if a scenario happens where water in the dam will be not enough and water flows are severely affected water conflicts between the dam users and downstream water users are likely to raise.

Mitigation Measures

- DRSLP to install water meters at the intake and water distribution points in order to control water usage and ensure that water tariffs are settled; and
- WRMA to strictly enforce the Water Act 2002 through issuance of water permit and empower WRUA and IWUA to control irrigation water usage and resolve water use conflicts among all water users
- DRSLP to install common community water points among the non- beneficiaries as CSR service along the pipelines
- DRSLP to share and create about project information among community members.

6.3.2.4 Increased human wild life conflicts

The project area is in close proximity to conservancies with wild animals. The river is a source of water for the animals by building a dam the will increase surface area where wild animals will want to take water from and this likely to experience wild life conflicts.

Mitigation measures

- DRSLP to ensure watering points are erected near transport corridor
- KWS to monitor and control of wildlife

6.3.2.5 Dam Siltation

Negative

The project area is prone to soil erosion due to over grazing upstream and siltation of dam reservoirs will shorten the lifetime of Buttress Dam unless proper soil conservation is implemented in the catchment.

Mitigation

⇒ DRSLP to ensure that check dam and soil erosion conservation measures are constructed upstream.

⇒ DRSLP to encourage tree planting along the banks

6.3.2.6 Drowning Risks

Once in operation the proposed dam will certainly pose risks of drowning especially to the animals and children who may have been used to the new development who may risk to bathe of try to swim

⇒ The project to ensure that fencing around the dam is done

⇒ Senior members of community to create awareness of the new development

Table 10: Summary of potential negative impacts and their mitigation measures during operation phase

Potential negative impacts	Mitigation measures
Depletion of river water downstream (water shortages**)**	• Minimum Normal flow of the river should not interfered with at all the times • WRMA to control abstraction of water of the licensed water user through strict adherence of permitted levels. • DRSLP to encourage project beneficiaries to adopt water efficient technologies • DRSLP to construct supplementary water pans for the project beneficiaries to provide extra water harvesting and storage facilities
Increase in water borne diseases	• The Public Health Office should create awareness on waterborne diseases, water pollution and waste disposal should be adequately addressed; • The Public Health Office should train community members on household water treatment; and • Public health office to create awareness on mosquito control in houses • DRLSP to introduce fish to the dam to with the intention of them eating mosquito larvae.
Water use conflicts	• DRSLP to install water meters at the intake and water distribution points in order to control water usage and ensure that water tariffs are settled; and • WRMA to strictly enforce the Water Act 2002 through issuance of water permit and empower WRUA and IWUA to control irrigation water usage and resolve water use conflicts among all water users

	• DRSLP to install common community water points among the non- beneficiaries as CSR service along the pipelines • DRSLP to share and create about project information among community members
Human –wildlife conflicts	• DRSLP to ensure watering points are erected near transport corridor • KWS to monitor and control of wildlife
Soil and water pollution	• The DRSLP should promote Integrated Pest Management (IPM) practices that incorporate crop management control techniques, biological control and restricted use of biocides; and • The IWUA in collaboration with the local extension workers should train farmers on fertiliser and biocides application rates to be used for various crops and on safe use of these chemicals.
Dam siltation and soil erosion	• DRSLP to ensure that check dam and soil erosion conservation measures are constructed upstream. • DRSLP to encourage tree planting along the banks RS • DRSLP to plant grass in disturbed areas during construction
Drowning risks	• The project to ensure that fencing around the dam is done • Senior members of community to create awareness of the new development

6.4 Project impacts during decommissioning

Negative impacts

During decommissioning of the project, the under listed negative impacts are expected:

⇒ Loss of livelihood due to sudden closure of irrigation activities is considered a significant impact;

⇒ Soil erosion will occur as a result of opening up previously firm ground to remove canal

⇒ Visual impacts are anticipated as a result of removing previously constructed canal and demolition of the intake weir, watering points and other concrete installations;

⇒ Generation of waste material comprising concrete rubble, steel and disused pipes and fittings;

⇒ Risk of accidents and down stream flooding

Mitigation Measures

⇒ Soil conservation works should be maintained until the site stabilizes;

⇒ Propose alternative livelihood activities;

⇒ Waste from decommissioning of the canal and concrete structures should be carted away and disposed off in a manner that is acceptable by NEMA;

⇒ Fence off all unsafe and potentially dangerous areas.

6.5 Summary of impacts and rating

This section rates the potential impacts with the aim of;

- To provide a basis for prioritization of impacts to be dealt with;
- To provide a method of assessing the effectiveness of proposed mitigation measures; and
- To provide a scale which shows the level of impact both before and after a proposed mitigation measure has been applied.
-

Table 11:S howing impact ratings

Phase	Nature of impact	Nature of impact			
		Negative		positive	
		Major	Minor	Major	minor
Project site	Resettlement and compensation		Non		
Construction phase	Creation of employment			Major	

	Market for local materials				minor
	Injection of material to local economy			Major	
	Noise and dust pollution	Major			
	Interference with existing infrastructure				
	Workers safety and hazards	major			
	Occupational health concerns				
	Depletion of flora and fauna		minor		
	Solid waste generation	Major			
	Wildlife corridor interference		minor		
	Cultural site destruction		Minor		
Operation phase	Dam safety concerns	Major			
	Water depletion down stream due to over abstraction	Major			
	Wildlife conflicts		Minor		
	Water use conflicts	major			
	Dam siltation	Major			
	Water borne diseases		Minor		
	Improved well being of women and children			Major	
	Improved food security			Major	
	Wealth creation and employment			Major	
	Contribution to Micro climate			Major	
Decommissioning phase	Visual impacts		Minor		
	Soil erosion and flooding risks	Major			
	Loose of livelihood	major			
	Solid waste generation	Major			

7 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN (ESMP)

7.1 Background

The purpose of the Environmental and Social Management Plan (ESMP) for the proposed Kilimani Buttress dam Project is to provide mitigation measures for the significant negative environmental impacts. The objectives of the ESMP are:

To clearly show how the project will manage the negative impacts while enhancing the positive ones to ensure a project that is economically, socially and environmentally sustainable.

- ⇒ To provide evidence of practical and achievable plans for the management of the proposed project.
- ⇒ To provide the Proponent and the relevant Lead Agencies with a framework to confirm compliance with relevant laws and regulations.

To provide community with evidence of the management of the project in an environmentally and socially acceptable manner.

Conversely, environmental monitoring provides feedback about the actual environmental impacts of a project. Monitoring results help judge the success of mitigation measures in protecting the environment. They are also used to ensure compliance with environmental standards, and to facilitate any needed project design or operational changes. Monitoring is a proven way to ensure effective implementation of mitigation measures. By tracking a project's actual impacts, monitoring reduces the environmental risks associated with that project, and allows for project modifications to be made where required.

The Environmental and Social Management Plan for the proposed Kilimani buttress dam Project is as shown in

Table 12: Environmental and Social Management Plan (ESMP)

Environmental/ Social Impact	**Mitigation Measures**	Responsibility for Mitigation	Monitoring Means	Frequency of Monitoring	Estimated Cost (Kshs)
PROJECT CONSTRUCTION PHASE					
Workers accidents and hazards DRSLP during construction	• will be required to commit the contractor to Site Occupational Health and Safety rules and regulations as stipulated in the OHSA, 2007; • The Project Contractor will be required to provide appropriate personal protective equipment and a safe and healthy environment for construction workers; • There should be a crisis management team to administer First Aid to injured persons; • The Project Contractor should test and approve equipment before use; and	Public Health Officer Project Engineer Crisis Management Team Project manager Project Contractor Environmentalist	– Inspect all workers to ensure that they have their PPE on. – Frequency of incidents/accidents and fatalities	Daily	200,000

	• The Project Contractor should train workers on how to use various PPE and safe use of machines				
Interference with existing infrastructure	• DRSLP should request for permission neighbors mainly KDF , break in accessing the project site • During construction works, the farmers and other property owners neighboring the proposed should be formerly engaged by the Project Contractor; • DRSLP should allow provision of designing and construction animal watering points away from the construction site to minimize disturbances	Project manager Project Contractor Environmentalist	-frequency of complaints or concerns	Daily	100,000

Generation of solid wastes	• The Project Contractor to comply with NEMA's Waste Management Regulations of 2006; • DRSLP should identify designated garbage storage areas during construction and the contractor should be responsible for handling and disposal of all construction related wastes; • DRSLP and contractor to ensure that waste disposal by burning should not be permitted and workers should be sensitised on proper handling and disposal of waste; • Debris from cut trees and bush should be instead used to put a fence /a barrier along the farm edges ;and • The Project Contractor should as much as possible put to good and acceptable use any materials damaged or rejected for use on site. • Mixing of concrete should be done away along the flood water pathway •	Project Supervisors Project Contractor Environmentalist	The following waste streams should be measured and reported. – Waste generation – Waste reuse – Waste recycling – Waste disposal	Monthly	250,000
Depletion of flora and fauna	• The Project Contractor shall ensure strict control of construction vehicles so that they operate only within the area to be disturbed by access routes and other works; • DRSLP shall ensure proper demarcation of the Project area to be affected by construction works; and	Project Contractor Environmentalist Project Supervisors Project Engineer KFS	– Rate of depletion of vegetation adjacent to the construction site will be undertaken during and after construction. – Changes in natural vegetation	Monthly	400,000

	• The Project Contractor to minimize creation of new access routes as much as possible. • DRSLP to establish tree nurseries in area and encourage planting of indigenous trees along the banks of the dam to replace any which will have been destroyed				
Noise pollution	• The Project Contractor to use the best available practices on-site to minimize occupational noise levels; • The Project Contractor to regularly inspect all construction equipment to ensure they are maintained in good working condition; • The Project Contractor to provide ear muffs for those working with noise producing equipment; and • Combine noisy operations so that they occur at the same time	Project Contractor Public Health Officer Environmentalist County Environmental Officer.	– Use noise meter to measure noise levels in decibels .	Daily	30,000
Occupational health and safety concerns	• Public Health Office to control disease causing vectors and avail health care services on site; • The Project Contractor to provide clean drinking water and pit latrines on site;	Project Contractor Public Health Officer Environmentalist	– Routine inspection – The demand for protective devices. – Uptake of VCT by project workers and the local people.	Weekly	200,000

	• The Public Health Office should sensitize the migrant workers on risky sexual behavior; • The Project Contractor in collaboration with the Public Health Office should have VCT services on site and encourage workers to be tested; and • The Public Health Office should provide condoms and other protective devices on site.		– Reported incidences of STDs among workers and local people.		
Dust emissions	• Public Health Office to ensure that strict measures are applied in the handling of construction materials such as cement, lime, concrete additives, etc.; • The Project Contractor to ensure that excavation, handling and transportation of erodible materials shall be avoided under high wind conditions or when a visible dust plume is present; • The Project Contractor to minimize the number of motorized vehicles in use; • The Project Contractor to wet all active construction areas as and when necessary to eliminate dusty conditions on site; and	Project Contractor Public Health Officer Environmentalist District Environmental Officer.	– Visual inspections will be undertaken to check for evidence of excessive dust generation	Daily	500,000

	• The Project Contractor to ensure that vehicle speeds are limited to a maximum of 30 km/h. •				
Interference with wildlife migration corridor	• KWS to monitor and control wildlife movement in the project area. • Project contractor to report any incidences of interruption by wild animals	Project contractor KWS Environmentalist	– Reports of sittings /incidents	Daily	20,000
Dam safety	• Strict supervision of construction activities by qualified staff and if possible in collaboration with KDF Personnel • ensuring substandard material are not used and materials are used in strict conformation with set standards • DRSLP to ensure that material testing to be done in the presence of appointed qualified personnel. • DRSLP to ensure that the resident Engineer is permanently on site during the construction period and should not be engaged in other activities	Project engineer KDF Dam committee	– Inspections	Daily	Project cost

	• The project contractor to ensure that high skilled technicians /fundis of integrity are involved in concrete works and are provided with the right tools of trade.				
Cultural site destruction	Area chief in collaboration with the project contractor to lead cleansing exercise of the affected areas before construction begins	Area chief Project contractor Environmentalist	– Compliance	Once	10,000
PROJECT OPERATION PHASE					
Downstream water depletion (water shortages	• Minimum Normal flow of the river should not interfered with at all the times • WRMA to control abstraction of water of the licensed water user through strict adherence of permitted levels. • DRSLP to encourage project beneficiaries to adopt water efficient technologies • DRSLP to construct supplementary water pans for the project beneficiaries to provide extra water harvesting and storage facilities	WRMA Project engineer IWUA Project coordinator Project funders (ADB ,GOK)	Approved designs Budgeted funds Improved designs	Continuous – Planning phase	Part of project cost

Increase in water borne diseases	• The Public Health Office should create awareness on waterborne diseases, water pollution and waste disposal should be adequately addressed; • The Public Health Office should train community members on household water treatment; and • Public health office to create awareness on mosquito control in houses • DRLSP to introduce fish to the dam to with the intention of them eating mosquito larvae	Public Health Officer Environmentalist District Environmental Officer.	- Frequency of occurrence of waterborne diseases - Health status of local people	Weekly	50,000
Human –wildlife conflicts	• DRSLP to ensure watering points are erected near transport corridor • KWS to monitor and control of wildlife	Project KWS Project Engineer	– Reported cases of distraction farm produce – Wild animal attacks – Losses of farm produce	Daily	150,000
Dam siltation and soil erosion	• DRSLP to ensure that check dam and soil erosion conservation measures are constructed upstream. • DRSLP to encourage tree planting along the banks RS	IWUA WRMA Local Extension Workers	- Water quality measurements. - Physical and chemical properties	Monthly	Part of project cost

	• DRSLP to plant grass in disturbed areas during construction • Visual inspection of dam condition	KFS Dam committee	of soil in irrigated area		
Drowning risks	• The project to ensure that fencing around the dam is done • Senior members of community to create awareness of the new development	WRUA CHIEF	- Incident record	Daily	Project cost

Environmental and Social Impact	**Mitigation Measures**	Responsibility for Mitigation	Monitoring Means	Frequency of Monitoring	Estimated Cost (Kshs)
PROJECT DECOMMISSIONING PHASE					
Sudden closure of dam a nd irrigation activities due to an exit strategy	• MoA to prepare project beneficiaries for a transition strategy when de-commissioning and water sources	IWUA Project Engineer Environmentalist	- Increase in poverty and decrease in household income levels	Monthly	100,000
Soil erosion	• Plant grass and other native vegetation along soil filled trenches. • Maintain soil conservation works until the site stabilizes.	MoA IWUA Project Contractor Project Engineer M&E Specialist	- Erosion/sedimentation rates in the project area and downstream of river Ena	Monthly	1,000,000
Visual impacts	• Carry out landscaping works to rehabilitate the open trenches.	MoA IWUA Project Contractor	- Visual inspection	Weekly	1,000,000

		Project Engineer M&E Specialist			
Generation of waste material	• Safe disposal of waste materials such as concrete rubble, steel and disused fittings..	MoA IWUA Project Contractor Project Engineer M&E Specialist	- Measurement of waste streams generated and disposed.	Daily	500,000
Risk of accidents and hazards	• Secure all unsafe and potentially dangerous areas • Fence off all unsafe and potentially dangerous areas.	MoA IWUA Project Contractor Project Engineer M&E Specialist	– Inspect all workers to ensure that they have their PPE on. – Frequency of incidents/accidents and fatalities	Daily	300,000

7.2 Community participation and dam management

It is important to involve the whole in dam development especially in location, design, construction and maintenance as it ensures;

- Common ownership of the water source in the end ensuring operation and maintenance properly in addition to ensuring the sharing of communal benefits fairly
- Likely to support by community members any future calls to assist in repair or maintenance work, such as removal of sediment from the reservoir.
- Ensures general support even from non-beneficiaries especially neighbors who not targeted by the project
- potential issues or obstacles can be identified from the outset and appropriate action taken thus averting future fallout
- That there is equal representation in decision making by all community members.

7.3 Safety and management

The dam should be regularly inspected for signs of deterioration, such as cracks, gullies, damage by rodents or insects, seepage, and damage to structures, especially the spillway.

8 ANALYSIS OF PROJECT ALTERNATIVES

8.1 The 'no project' alternative

The selection of the "No project "alternative would mean the discontinuation of the proposed propped dam project. The "No project" alternative is likely to have the greatest loss of the anticipated socio-economic benefits that include opportunity for employment, water security, improved living standards and general wellbeing of the local people throughout the construction and operation phases of this project. It would mean the irrigation scheme it is meant to serve would not maximally reap the benefits anticipated in addition may strain more the water resources which lead to further exacerbating of water conflicts in the project areas. In addition, this option will undermine Kenya's Vision 2030 on irrigation intensification and expansion that is aimed at increasing agricultural productivity.

The implementation of the proposed project and as outlined in this ESIA document has good support based on the outcomes of the consultation with various stakeholders and the project beneficiaries. The project has been designed to meet the national policies and legal statutes on water projects. The design will boost water availability in general and if the targeted beneficiaries adopt water efficient methodologies they are likely to benefit a lot and contribute economically furthermore it is anticipated that the dam will contribute to the development of microclimate thus improving ecological conditions.

8.2 Alternative dam construction technologies

There various types which are suitable for the proposed project and can be explored if it determined that the chosen concrete buttress dam faces challenges in implementation in one way or other . The alternative include:

8.2.1 Embankment Dams

Embankment Dams are made from compacted earth, and have two main types, rock-fill and earth

-fill Dams. Embankment Dams rely on their weight to hold back the force of water, like the gravity Buttress Dam made from concrete.

8.2.1.1 Rock-fill Buttress Dam

Rock-fill Dams are embankments of compacted free-draining granular earth with an impervious zone. The earth utilized often contains a large percentage of large particles hence the term *rock-fill*. The impervious zone may be on the upstream face and made of masonry, concrete, plastic membrane, steel sheet piles, timber or other material. The impervious zone may also be within the embankment in which case it is referred to as a *core*. In the instances where clay is utilized as the impervious material the Dam is referred to as a *composite* Dam. To prevent internal erosion of clay into the rock fill due to seepage forces, the core is separated using a filter. Filters are specifically graded soil designed to prevent the migration of fine grain soil particles. When suitable material is at hand, transportation is minimized leading to cost savings during construction. Rock-fill Dams are resistant to damage from earthquakes. However, inadequate quality control during construction can lead to poor compaction and sand in the embankment which can lead to liquefaction of the rock-fill during an earthquake. Liquefaction potential can be reduced by keeping susceptible material from being saturated, and by providing adequate compaction during construction.

8.2.1.2 Earth Dams or Buttress Dams

Earth dams, also called earthen, rolled-earth or earth fill dams, are constructed as a simple embankment of well compacted earth. A *homogeneous* rolled-earth dam is entirely constructed of one type of materials but may contain a drain layer to collect *seep* water. A *zoned-earth* dam has distinct parts or *zones* of dissimilar materials, typically a locally plentiful *shell* with a watertight clay core. Modern zoned-earth embankments employ filter and drain zones to collect and remove seep water and preserve the integrity of the downstream shell zone. An outdated method of zoned dam construction utilized a hydraulic fill to produce a watertight core. *Rolled-earth* dam may also employ a watertight facing or core in the manner of a rock-fill dam. An interesting type of temporary earth dam occasionally used in high latitudes is the *frozen-core* dam, in which a coolant is circulated through pipes inside the dam to maintain a watertight region of permafrost within it.

Because earthen dam can be constructed from materials found on-site or nearby, they can be very cost-effective in regions where the cost of producing or bringing in concrete would be prohibitive.

8.2.2 Asphalt-concrete core

A third type of embankment dam is built with asphalt concrete core. The majority of such water dam is built with rock and/or gravel as the main fill materials. Almost 100 dams of this design have now been built worldwide since the first such dam was completed in 1962. All asphalt-concrete core dams built so far have an excellent performance record. The type of asphalt used is a visco elastic-plastic materials that can adjust to the movements and deformations imposed on the embankment as a whole, and to settlements in the foundation. The flexible properties of the asphalt make such dams especially suited in earthquake regions.

8.3 Extraction of water from the reservoir

A gravity outlet can be constructed, using a screened inlet on the bed of the reservoir, and a pipe in a trench below the Buttress Dam. Problems can arise with seepage through poorly compacted materials beside the pipe (reduced by placing seepage collars along the pipe to increase the perimeter by at least 25 per cent), and difficulty repairing a damaged pipe. Alternatively, water can be extracted by lifting or pumping.

• A sump (well reservoir) in natural ground at the side of the reservoir, supplied by gravity from a screened inlet and pipe through the bed and side of the reservoir;

• A bank-mounted motorized or human-powered pump; or • a floating intake.

8.4 Spillway alternatives

A spillway is required to protect the dam from overtopping, for example during high flows. It passes surplus water downstream safely, preventing both the failure of the dam, and damage downstream.

Surplus water flows over a spillway crest at the top water level, and into an open channel around the side of the dam, discharging safely into the stream below the dam. It may be made from reinforced concrete, but a cheaper solution is a grassed spillway with a: vegetated earth channel

_ protected crest at reservoir top-water level

_ Maximum velocity 2.5m/s

A grassed spillway requires regular inspection and maintenance, so that erosion can be repairs red and a good grass cover is maintained. It is often used together with a trickle-pipe spillway so that small inflows into a full reservoir flow through the trickle pipe, and do not erode the grass spillway.

8.5 Alternative site

The option of alternative site explored and it was technically found that the current location offered the best bet and the community fully supported it and offered to perform traditional rituals to cleanse it as some affected areas used to be circumcision /rite of passage areas

8.6 Alternative supportive donors

Stakeholders identified KDF as possible collaborative partner especially on technical matters.

9 : CONCLUSIONS AND RECOMMENDATIONS

11.1 Conclusions

This ESIA Project Report presents the findings of the assessment which include an Environmental and Social Management Plan (ESMP) and fulfils the requirements of EMCA. A comprehensive Environmental and Social Impact Assessment study of the project showed that it is technically and environmentally feasible and limited adverse environmental and social impacts during the construction, operation and decommissioning phases. Some of these impacts can be avoided while others will have minimal effects if the potential impacts were to be mitigated properly. It was broadly accepted important by all the stakeholders' consulted and thus will be implemented smoothly if all procedures are properly followed

The "No-project" alternative will be catastrophic. The community has already been mobilized and funds set aside for its implementation and has high expectations from the project. From an environmental point of view if the project is not implemented the ecological advantages and environmental contributions expected to be gained from the project will be lost.

11.2 Recommendations

It is of view of experts that by implementing the proposed Kilimani Butress dam will have adequately addressed earlier stakeholder concerns regarding the construction Kilimani –Galana irrigation scheme. Mitigation measures for any possible negative impacts have been suggested and if implemented according to plan the project would strengthen sustainability of irrigation activities for the beneficiaries .The project was accepted as a priority by all stakeholders consulted and was fully supported immediate implementation

The recommendations made with respect to the proposed Irrigation Project include:

(1) A complete audit be undertaken and submitted to NEMA a year after commissioning to ensure that all the proposed mitigation measures have been complied with;

(2) Construction works in the proposed Project will be carried out in accordance with approved designs, regulations, policies and laws;

(3) An action plan for the catchment protection and conservation be developed and implemented in line with the requirements of the Water Act, 2002 and the Environmental

Management and Coordination Act of 1999 and any other applicable laws. This action plan should involve key stakeholders, WRUA, IWUA, lead organizations including the Water Resources Management Authority and National Environment Management Authority;

(4) Contractor and the staff from DRSLP are required to strictly adhere to the provided ESMP including the continuous evaluation and adaptation of this plan during the course of project construction and operation phases.

(5)The dam should be regularly inspected for signs of deterioration, such as cracks, gullies, damage by seepage, and damage to structures, especially the spillway.

(6) The normal flow of the Lewa river should minimally interfered with harvested and stored **flood flows** of River Lewa should utilized for irrigation purposes

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11 APPENDICES

11.1.1 Stakeholder Invitation letter

Republic Of Kenya

AfDB

Ministry of Agriculture

African Development Bank

Drought Resilience and Sustainable Livelihoods Program,

Ministry of Agriculture, Livestock and Fisheries,

P. O Box 30028-001,

Nairobi.

11th Sept, 2017.

Dear Stakeholder,

Re: Public Consultation for the Development of Kilimani Game-Galana butress dam.

The Drought Resilience and Sustainable Livelihoods Program (DRSLP) Project is a National Government project funded by the Africa Development Bank (ADB) covering six arid and semi-arid counties namely Baringo, Isiolo, Marsabit, Samburu, Turkana and West Pokot. The overall goal of the project is to address the damages and losses sustained by the poor and vulnerable communities of the arid and semi-arid lands (ASALs), during the 2008-2011 drought in order to restore a sense of normalcy and resumption of economic and social activities.

The Kilimani Game Galana irrigation scheme stakeholders through public consultation exercise held in January 2016 recommended the incorporation of dam design along Lewa river as way of strengthening the Kilimani irrigation project and cautioning against any adverse effects of water over abstraction. The project adopted the recommendations and agreed to fund dam development. The designs have completed and preparations are being made for the construction to commence.

Based on the Environmental Impact Assessment and Audit Regulations under 2nd Schedule of the Environmental Management and Coordination Act 1999, For such projects, the proponent is required to carry out an Environmental Impact Assessment (ESIA) study and submit a report to the National Management Authority (NEMA) to seek authorization for continuation of the project.

The DRSLP has initiated an ESIA study for the dam project and a key requirement for this exercise is the holding of public consultations with all stakeholders (members of the immediate community, interested and affected parties) to collect and assess their views regarding the feasibility of the proposed project.

Your institution has been identified as one of the key stakeholders for the proposed irrigation project and you are requested to send a representative to attend a **consultative meeting** for all the **stakeholders** to be held on 10/10 2017at the **Isiolo Agricultural Training Centre** from **9:00 am**. For confirmation of attendance and any further details, contact **Mr. Ngare** (**Mobile no. 07**).

Yours faithfully

JOSPHAT OMARI

Lead Expert

Environmental Impact Assessment Team

Drought Resilience and Sustainable Livelihoods Program

11.1.2 Correspondence with KDF

REPUBLIC OF KENYA

MINISTRY OF AGRICULTURE, LIVESTOCK AND FISHERIES

STATE DEPARTMENT OF AGRICULTURE

DROUGHT RESILIENCE AND SUSTAINABLE LIVELIHOODS PROGRAMME (DRSLP) – ADB

Telegraphic Address NAIROBI
Hill Plaza Building
Telephone: 0204933000
9th Floor
Fax: (020)2244337
P.O. Box 30028-00100
NAIROBI

When replying Please Quote

Ref: No. MALF/DRSLP/8/4/VOL.I/20

Date 20th November, 2017

The Brigade Commander,

Kenya Defence Forces,

School of Infantry

Isiolo

ENVIRONMENTAL AND SOCIAL IMPACT ASSESSEMENT (ESIA) FOR PROPOSED KILIMANI GAME GALANA IRRIGATION SCHEME AND KILIMANI BUTTRESS DAM ISIOLO COUNTY

The Ministry of Agriculture, Livestock and Fisheries, State Department of Agriculture through **Drought Resilience and Sustainable Livelihoods Programme (DRSLP) in conjunction with the County Government of Isiolo carried** out a feasibility study and established the viability of the two projects.

The programme commissioned the design of Kilimani Game Galana Irrigation Scheme and it was established that for the scheme to be sustainable, a dam needed to be constructed across Lewa River to supply water for irrigation scheme. This decision was corroborated by the hydrological study.

In this regard, the programme further commissioned the design of the Kilimani Buttress dam which is aimed at storing the flood flow and supply the water needed for irrigation at Kilimani Game Galana Irrigation Scheme. During the ESIA exercise for the Kilimani Game Galena irrigation scheme and Kilimani Buttress dam, your institution was represented and concerns captured. The purpose of this communication is to assure your institution that;

The dam will harvest and store **flood flows** of River Lewa which will be utilized for irrigation purposes and the normal flow of the river will not be interfered with;

Additionally, once the dam is in place, the normal flow is likely to be enhanced to the advantage of downstream users;

During Construction phase of the Kilimani Buttress Dam, your institution will be involved to ensure compliance with mitigation measure as detailed in the Environmental Management Plan (EMP);

The Water Resources Authority (WRA) shall monitor the flows to ensure compliance with the abstraction levels along River Lewa.

Kindly find attached the following reports for your perusal, further necessary comments and feedback to facilitate NEMA certification namely;

Draft Environmental and Social Impact Assessment (ESIA) report

Hydrological Survey report

Kilimani Buttress Dam Design report

Kilimani Game Galana Irrigation Scheme Design report

Geological and Geophysical investigation report

Mrs Esther Wambua

PROJECT COORDINATOR

11.1.3 Stakeholders minutes

Minutes of ESIA Public participation of Kilimani Buttress Dam meeting on 10/102017 held in ATC Isiolo

Attendance

Names	Organization/Designation	Station

Original attendance list attached

Introduction

The lead facilitator Mr. Omari welcomed the participants and thanked them for being punctual and honoring the invitation for the public participation and requested the meeting to be opened with a word of prayer. The meeting was opened by word of prayer by Mr. John Ekai and after wards the facilitator opened a session with introduction as follows:-

Minute 1; self-introduction

Every member present did self-introduction by mentioning full names, occupation, the organization which was represented and rank within the organization.

Agenda

Self-introduction

Introductory speech by Lead experts

Brief from scheme chairperson

Discussions on positive and negative impacts from proposed project during;-

Construction phase

Operation phase

Decommissioning phase

Mitigation of negative impacts during construction, operation and decommissioning phases.

Fears and concerns of the proposed project.

AOB

Minute 2; introductory speech by lead experts

Later the facilitator introduced what brought all together being ESIA of Kilimani Buttress Dam located about 15 Kilometers from Isiolo Town and meant to serve Kilimani Game Galana Irrigation project. He informed the participants that the Dam is actually a brain child and recommendation of the same stake holders during the ESIA for the said Irrigation scheme. He said Environmental Impact Assessment (ESIA) is a study process used to predict the environmental consequences for a development project. It addresses environmental problems, land use conflicts and constraints of natural resource management that may cause disruptive effects on projects performance or sustainability. The aim is to improve project design, implementation and also to evaluate the suitability of the project for the selected environment in order to minimize the occurrence of adverse environmental impacts through appropriate mitigation measures.

EMCA Act, 1999 and *Environmental (Impact and Audit) Regulations, 2003*. Community consultation and participation ensures that communities and stakeholders are part and parcel of the proposed developments and in so doing assures the sustainable use of resources. It has also demonstrated successfully that projects that go through this process will acquire high level of acceptance, identify possible conflicts areas early, and accrue benefits to a wider section of the society. The Kenya government has enshrined the need for human societies' involvement in project development in the Constitution. This has been set out in the 2010 Constitution.

An explanation of the ESIA Process was clarified and the steps which the developers had taken to ensure that stakeholders were consulted though the participants felt that process started a bit late as opposed the progress which had been made on the proposed development of Kilimani buttress dam

With the above introduction to the session the lead expert welcomed the scheme chairman to give a brief of the project.

Minute 3; introductory speech by chair person

The chairman briefed the participants on the water resource survey carried out along the lewa river in order to help the kilimani game galena scheme water supply and the recommendations of the stakeholders during the irrigation scheme's ESIA to put up a Dam for the scheme. He informed the participants that dam is located 13 km from the scheme in a gorge along the lewa stream and 2km upstream from KDF SOI Camp, being the nearest neighbor. He added that several other sites has been

Identified but this was found to be the best for the project, thus urged the stakeholders to participate fully in this important exercise.

At this point Mr. Banticha asked the resident engineer to give in a technical input on the site selected.

Minute 4. Technical brief by the Resident Engineer

The Engineer told the participants that Dam site has a catchment of 4km2, soil tests have been done and found that strong base is 3m deep. The dam is 8m high above ground level, with spillways and other provisions. He added that it is meant to harness flood waters during times of plenty for times of need and will not interfere with the normal running of the stream. The scheme water requirement has been done and the dam designed for 10,000cm3 (100 Million liters) and will have about 1km draw back and will be fenced.

Having finished with brief the lead facility welcomed the second lead expert Mr. Manyara to lead the session on the discussion of the projects impacts and urged the stake holders to participate fully and openly.

Minute 5. 1. Positive and Negative impacts during construction phase

Mr. Manyara guided the participants in identifying the likely positive and negative impacts as a result of implementation of the proposed project .The participants contributed as follows:-

Positive Impacts to the Environment

Employment creation e.g. engineers, contractors skilled and unskilled labor employed

Peace building and cohesion improved as a result of open dialogue during construction.

Reduced crime rate as a result of job created.

Increased revenue through licensing e.g. WRA and from small business which crop up.

Improved infrastructure – road to the Dam site opening.

Improved environment

Increased hope for future public participation

Strengthening partnership among stake holders in the location

Skill development

Building ownership and sense of responsibility.

Awareness creation- Knowledge on intended dam to be constructed is beneficial

Water provision for wildlife

Eye opener for future development

Provision of feeder roads during construction

Negative Impacts to the Environment

Elephant corridor will be interrupted hampering free movement wildlife.

Increased human wildlife conflict

Dusts produced during construction may affect soldier's health and vision during training.

Stream flow to KDF camp may be affected and human and wildlife inhabitants may be compromised.

Sound /Noise pollution as a result of trucks movement and heavy machineries.

Water level downstream may reduce creating water shortage for other users.

Deforestation of dam site and route to dam.

Increased soil erosion

Crime within labor camp and reduced moral values

Conflicts and mistrusts may occur impacts

Disturbance of ecosystem

Possible environmental degradation

Encroachment of land around the dam

Perception of eviction from the dam catchment.

Occupational health hazard of workers

Very high expectation during construct

social conflict eg removal of traditional sacred sites/trees

minute 5:2Mitigation of negative impacts

having gone through the positive and negative impacts the facilitator thanked for the active participation and requested them to give all possible mitigation measures for all the negative impacts during construction phase of the proposed project which they mentioned and the session went as follows:-

Negative impacts	Mitigation measures
Closure of elephant routes/corridor – human wildlife conflict	Provide community scouts during construction. Provide safe passage of elephants outside dam site. The normal flow of water in the stream should not be interrupted for wildlife and other users.

Dust produced from trucks may interrupt KDF training Vision and workers health.	Wet the dam site and road during construction works to minimize dust. Provide dust masks for workers during constructions. Put speed limits for trucks. Murrum the road to the dam
Sound pollution	Awareness creation in times of blasts if any. Machines should meet required sound standards. Minimize truck movements at night.
Water for construction may reduce stream water level for other users	Contractor to use supplementary water for constructions. Harvest rain water for constructions Practice Properly scheduled Water rationing..
Deforestation activity during site and road clearance	Plant indigenous trees in the camp. Involve forestry department for guidance in the re-afforestation programe. Selective cutting of trees, preserve indigenous species
Interference with cultural sacred sites and trees. (Azapan area)	Get blessings of elders Make sacrifices
Up scaling of crime among workers	Seek assistance from office of Administration. Theft- Vetting of workers during recruitment Balancing of workers on ethnicity Contractors to use unskilled labour where possible
Erosion of moral values and diseases out breaks	Awareness creation of diseases among workers. Use of protective devices Provision of dispensers at camp toilets. Cultural awareness induction
Conflict and mistrusts among workers	Dialoge between community, chiefs contractors and project officers

Water shortage in KDF camp	Enlighten KDF engineers during construction works to ensure constant flow of the stream to the camp Meet with KDF environmental experts to discuss way forward within 2 weeks.
Likely Dam breakages/ leakages in dam wall or base/	Choice of experienced and qualified contractors. Proper design and BQ to set standards of strong dams Construction to be carried out according specification. Construction to be checked and supervised on daily bases by qualified engineers.
Encroachment in the dams catchment area	Chiefs to stop encroachment in the riverine and catchment area. Facilitate Barazas to inform community on protected sites Dam to be properly fenced
Destruction of ecosystem	Debris to be dumped in recommended sites. Ensure protection of flora and fauna
Unsafe working conditions	Contractor to ensure safe working conditions for workers Provide training on safe conditions for using safety gears provided Proper fencing of work site. Vet workers on health standards before recruitment. Transparency between contractors and stake holders
High expectations by workers	Transparency between contractors and workers. Standard labor payment to be applied
Introduction of new land use	Ensure all community members are well sensitized

Minute 6; 1 OPERATION PHASE

After completion of the construction phase the facilitator Mr. Manyara briefed the participants on operation phase which is as crucial to the environment as the construction

Negative impacts	Mitigation measures
Waterborne diseases- vector build up e.g. mosquitoes, bilharzias	Field hygiene- proper disposal of containers, poly bags/tubes. Main Dam to be protected from mosquito build up eg use of tilapia fish. Improved sanitation and personal hygiene. Water treatment before use Closed conveyance systems
Siltation of Dams	Put series of sedimentation pits in conveyance line
Introduction of alien species	Screening species for undesirable characteristics e.g. allelopathy Ensure introduction of environmentally friendly tree species
Water lose through seepage through dam cracks and fitstures or base	Ensure proper construction according to specification. Dam construction on strong hard base
Lose of flora and fauna in dam sites	Ensure safe environment for flora and fauna
Crocodile invasion in dam	Avoid swimming in the dam Proper fencing to deter human and wildlife into the dam Provide water points outside the dam
Land degradation	Control encroachment in the dam catchment
Increased competition for irrigation water	Put proper by-laws on water usage. Maintain natural water flow Control of new developments in the area
Human wildlife conflict	Scaring of wildlife from the farms Introduce crop insurance cover. Apply for crop compensation
Increased water pollution incidences	Enhance field hygiene through construction of pit latrines

phase. This is the actual damming of water in the reserve and use in the farms and other outlets. The impacts identified are as follows;_

	Put in place series of silt traps along the conveyance system to avoid Dam siltation Use water coagulants to reduce suspended matter Ensure periodic Dam de-silting
Increased generation of agricultural wastes	Educate community on pollution control Practice safe and effective use organic wastes e.g. composting Proper disposal of wastes

Positive impacts

Improved microclimate in the catchment area.

Increased income and revenue

Increase land Value per acre.

Improved water availability in the area thus water sufficiency

Reduced conflict over water resource

Increased population growth

Improved partnership among various stake holders.

Improved production technologies.

Sufficient water for wildlife therefore reduced human wildlife conflict over water.

Minute 6. 2 Negative impacts in operation phase and their mitigation measures

Here the facilitator asked the participants to list negative impacts and their mitigation measures concurrently.

Minute 7:1 DECOMMISSIONING PHASE

After completion of the operation phase the facilitator Mr. Manyara briefed the participants on this phase which is the last phase in the Assessment program. This is the actual removal of the project if deemed not necessary and the solution is to demolish the structures and return the site to near normal.

Positive impacts

Improved road network upstream

Negative impacts

Very expensive exercise

Accidents may occur

Requires damping site for debris

Loss of biodiversity

Destruction of flora and fauna.

Minute 8 ; REACTIONS

The lead expert thanked the stake holders for the very successful deliberation on the likely impacts discussion and asked them to further deliberate on issues which may come as a result of the proposed project being implemented.

Reaction: 1 High public expectation.

The WRA representative Mr. David Kisela pointed out that there might be high expectations as result of the proposed project but one should consider water might not be enough as result of climate change. It might fell to rain for some period there should be considered during planning. Pointed out that proper management should be put in place to man the dam as well as the irrigation scheme.

Lewa stream is under Isiolo water resource users association therefore the committee should liaise with for good management.

Reaction: 2 Support to proposed project

The KDF representative Mr May Kirwa said that they supported the project and will require it to succeed and said every participant should be given opportunity to express his/her thoughts. He requested that there should be a meeting between the contractors, the project officers and engineers and the KDF environmental experts to iron out fears that might arise within the next 2 weeks.

Reaction : 3 Water management

Mr Filla a farmer from Buless Dima inquired on the competency of the management to ensure all the beneficiaries of the area benefit in one way or the other. He said the Kilimani water users association should in cooperate representatives from downstream users for proper management. The chairman said that the down users are fully in cooperated and there are 3 water points provided in the design between the dam and targeted irrigation scheme. Mr Gichiri of Burat said people downstream are expressing strong interest in the project therefore should at least benefit from the project. He said the community should be sensitized more and informed of future benefits.

Reaction: 4 Water regulations

The WRMA representative Mr. Kisela informed the stake holders that water is natural resource whose responsibility is invested in the government of that particular site. The WRMA being the authority gives an Applicant for the water a license use and manage according to the applicant’s requirement and there is a cost involved which the applicant has to pay. This is to say that the applicant who paid has the right for use and management of the water according to his requirement therefore this is to say that other downstream users have to cooperate and the schemes by-laws have to be followed.

Reaction : 5 Alternative site

One member Mr. John Ekai inquired why the dam was not put on other site and the Secretary informed him several sites have been considered during preliminary feasibility studies and the chosen site found to be the best of all.

Having no other business the lead expert Mr. Omari Invited Assistant county commissioner Mr. Hussein Abdurrahman to give a closing speech.

The commissioner told the participants that the office is quite aware of the proposed project which is meant to assist the farmers of kilimani Game Galana irrigation scheme. He thanked the ministry of Agriculture coming in to assist the farmers when they required the most assistant. He said that resources are always limited and one should use it carefully and wisely when opportunity arises. He also thanked the participants for their presence and active participation. He said it the administrations responsibility to welcome all development projects after carefully vetting and weighing its importance to the community at large. If the benefits outweigh the losses then put corrective or mitigation measures and approve the project. That is why we are gathered on that day. The assistant commissioner also asked the stake holders to enhance and propagate peace in the county during this times of election petition.

With those few remarks he requested for a copy of the report once ready a declared the meeting closed.

The meeting ended at 3.43 Pm with a word of prayer

Signed ……………………

Banticha A Jaldesa

Taking minutes

Signed

Chairman

Confirmed by

11.1.4 Design report

MINISTRY OF AGRICULTURE, LIVESTOCK AND FISHERIES

DROUGHT RESILIENCE AND SUSTAINABLE LIVELIHOOD PROGRAMME

KILIMANI GAME GALANA BUTTRESS DAM

IDENTIFICATION AND DETAILED DESIGN REPORT

BURRAT LOCATION
ISIOLO CENTRAL SUB-COUNTY
ISIOLO COUNTY
17th November 2016

PREPARED BY MINISTRY OF AGRICULTURE,LIVESTOCK AND FISHERIES, STATE DEPARTMENT OF AGRICULTURE	DRSLP SURVEY AND DESIGN TEAM P.O BOX 30028-00100 NAIROBI

PROJECT SUMMARY SHEET

KILIMANI GAME GALANA BUTRESS DAM

A1. LOCATION

Sub-Location	Kilimani
Location	Burrat
Sub-County	Isiolo Central
County	Isiolo
Source	Lewa River
Drainage Basin	Ewaso Ng'iro North
Purpose	Irrigation
Survey of Kenya Map SK	108/1:-Isiolo (1:50,000)

Location	Region	Longitude	Latitude	Altitude
	37N	336228mE	31348mN	1295m

A2. CATCHMENT

Area	$4km^2$
Average slope	6.67%
Maximum probable flood (PMF)	$16.75m^3/s$

A3. RESERVOIR

Design Capacity	103,275 m3

Submerged area at NWL	11,000M^2 (1.1Hectares)
CONCRETE	
Type	Butress Dam
Height	8.0m
Crest Length	91.00m
Crest Width	0.84 m
Upstream Slope	Standing with apron
Downstream Slope	Slanting at 1V:0.70H with stilling basin
Gross Freeboard	1.5m

A5. WATER

WATER DEMAND (M^3/DAY)	213m^3/day (Year 2016)
DRY SPELL ASSUMED	7 Months
YIELD (M^3/day)	213m^3/day
Deficit	0m^3/day
Satisfaction % (Supply/Demand)	100
Evaporation (M^3)/7months	57,176m^3 (1797mm per year)

A6.:INVESTMENT REQUIRED

INVESTMENT (KSHS)	246,057,250
CAPACITY BUILDING	Zero
ESTIMATED LIFESPAN	34 Years

PHASING RECOMMENDED No.

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List of Abbreviations

B.S	British Standard
CH	Chainage
DBE	Design Basis Earthquake
FWL	Full Water Level
g	Gravitational acceleration
OF	Over Flow Block
NOF	Non-over Flow Block
K	Hydraulic Conductivity
Kshs	Kenya shillings
Ltd	Limited
M.O.R.P.W	Ministry of Roads and Public Works
MCE	Maximum Credible Earthquake
MOWI	Ministry of Water and Irrigation
No.	Number
NWL	Normal Water Level
O&M	Operation and Maintenance
PMF	Probable Maximum Flood
Q1000	Return Period One Thousand Years
R	Radius

TP_1 Trial Pit one

List of Units

cm/sec	Centimeters per second
km	Kilometres
km^2	Square kilometres
kn/m^2	Kilo Newton per metre square
kn/m^3	Kilo Newton per cubic metre
m	Metres
m^3/day	Cubic metres per day
m^3/s	Cubic Metres per second
masl	Metres above sea level
mm	Millimetres
N/mm^2	Newton per square milimetre
ha	hectares

1 INTRODUCTION
1.1 Background

Drought Resilience and Sustainable Livelihoods in the Horn of Africa (DRSLP) - Kenya Project, is a project under the Ministry of Agriculture, Livestock and Fisheries (MALF). The project covers six arid and semi-arid counties namely Baringo, Isiolo, Marsabit, Isiolo, Turkana and West Pokot. The project is funded through a loan between the Kenya Government and African Development Bank (AfDB).

The need for this project emanates from the necessity to address the effects of droughts sustained by the population, especially the poor and vulnerable communities of the arid and semi-arid lands (ASALs) in order to have the capacity to bounce back and resume economic and social activities. The livestock sector sustained a very significant share of the damage and losses with agriculture coming second. In rural areas, individual family water systems sustained partial damage due to the lowering of the groundwater table and rural inhabitants were forced to collect water from far away sources.

The overall sector goal of the programme is to contribute to poverty reduction, food security and accelerated sustainable economic growth in the Horn of Africa (HOA) through enhanced rural incomes. DRSLP Kenya Component will contribute to the sector goal in the interventions in the target 6 counties.

1.2 Project Goal & Objectives

1.2.1 Goal
The project's goal is to enhance drought resilience and improve livelihoods of the communities in the arid and semi-arid lands of Kenya.

1.2.2 Objectives
The objectives of the project include the following: -

1: To increase the number of people and livestock accessing water for domestic and irrigation.

2: To improve quality and availability of pasture

3: To develop and improve rural feeder roads

4: To improve access to animal health services

5: To increase the number of personnel capable of handling pastoral livestock production systems

6: To increase the percentage of community members with improved capacities

1.2.3 Purpose of the Survey and Design

The purpose of exercise was to:-

Undertake dam site identification through involvement of the County Government and the beneficiary community

Undertake detailed survey and Design in line with the best practices

Prepare a drawing booklet to aid in setting out and construction

Prepare Construction Requirements (Specifications) for the dam and irrigation scheme

Prepare off take Sheets

Prepare Bid Document in line with PPOA Requirements and

Confidential Engineer's Estimate

1.2.4 Report Layout

The Report is presented in Eight chapters as follows:-

- Chapter 1 – Introduction; Introduces the Project.
- Chapter 2 – Project Area; Describes the characteristics of Project Area
- Chapter 3 – Water Demand Studies; Undertakes Assessment of Water needs during Planning Horizon.
- Chapter 4 – Hydrological and Meteorological analysis
- Chapter 5 - Geological and Geotechnical Investigation; Undertakes Geological and Geotechnical Investigations
- Chapter 6 – Site Identification and Detailed Design; Identify the dam site, undertakes sizing and Detailed Design
- Chapter 7- Book of drawings and Cost Estimates; Estimates the required investment

- Annex -Contains Supporting Information

2 PROJECT AREA

2.1 Location

Kilimani Butress Dam is located about 15km South of Isiolo Town. The Dam site lies in Kilimani Village, Kilimani Sub-location, Burrat Location, Isiolo Central Sub-County, Isiolo County.

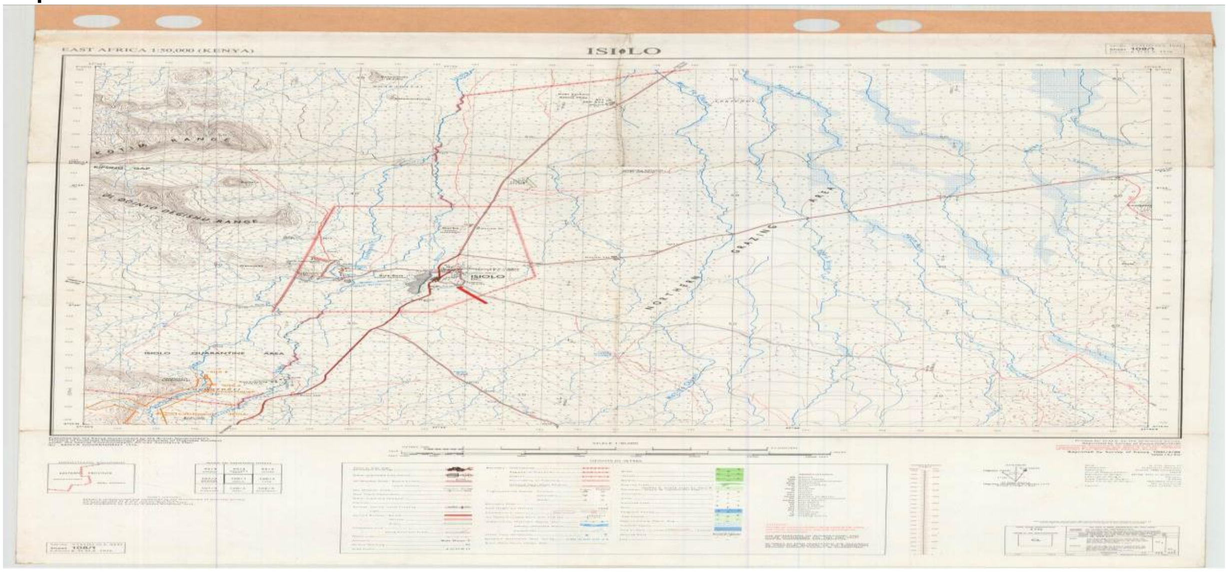
The axis of the proposed dam is across a perennial stream called Lewa , a tributary of Ewasi Ngiro River.

The Dam Site can be located on SK No. 108/1-Isiolo scale 1:50,000 at:-

Region	37N
Longitude	0336228E UTM
Latitude	00331348N UTM
Altitude	1295M

Map 2-1 and figure 2-1 has this location.

Map 2-1:Location of Kilimani Dam on SK sheet 108/1- Isiolo



2.2 Climate

The climate falls into three agro-climatic zones (Herlocker et al. 1993; Sombroek et al. 1982), semi-arid (occupying 5% of the area), arid (30%) and very arid (65%). The climate in the towns of Isiolo and Kinna is semi-arid and the median annual rainfall is in the range of 400-600 mm. The arid region stretches from Ol Donyiro region to Archers Post and Garbatulla areas, where the annual rainfall ranges from 300-350 mm.

The very arid zones cover Merti and Sericho divisions, where the annual rainfall is between 150-250 mm (figure 3-14). Isiolo suffers high rainfall intensities with poor temporal and spatial distribution, resulting in short-lived excessive flooding. Under these conditions, rain-fed agriculture is unsustainable (Jaetzold and Schmidt 1983).

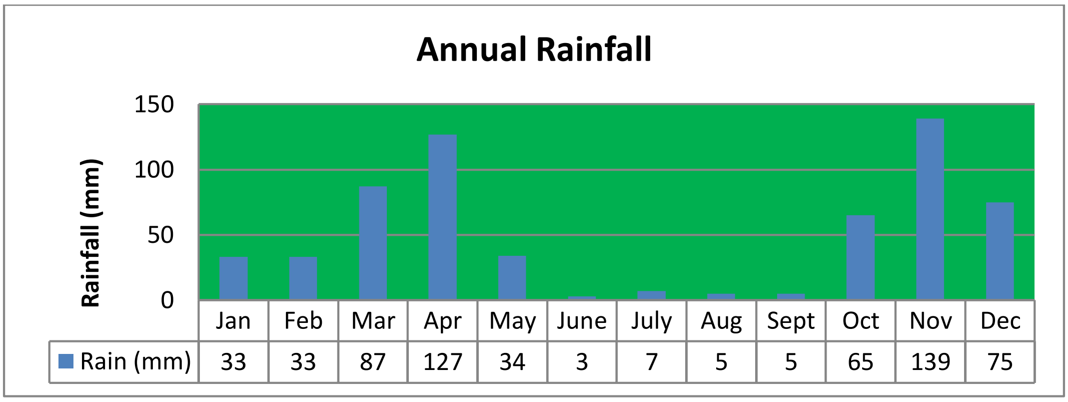


Figure 2-2: Annual rainfall

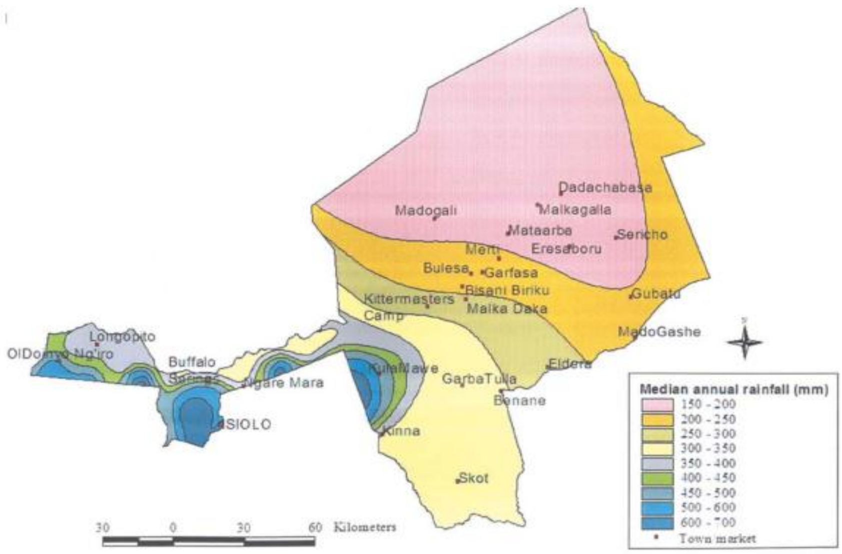


Figure 2-3 Rainfall Distribution in Isiolo County

2.3 Temperatures

High temperatures are recorded in the county throughout the year, with variations in some places due to differences in altitude. The mean annual temperature in the county is 29 degrees centigrade. The county records more than nine hours of sunshine per day and hence has a huge potential for harvesting and utilization of solar energy. Strong winds blow across the countythroughout the year peaking in the months of July and August.

The strong winds provide a huge potential for wind generated energy.

Table 2-1 : Temperature variations

Month	Min Temp °C	Max Temp °C	Humidity %	Wind km/day	Sun (Hours)	Rad (MJ/m²/day)	Eto (mm/day)
January	15.6	30.7	57	173	8.8	22.3	5.21
February	16.2	32.2	52	173	9.1	23.5	5.72
March	17.5	31.6	54	216	8.3	22.5	5.85
April	17.7	30	64	216	7.9	21.3	5.16
May	17.7	29.8	62	285	8.6	21.2	5.43
June	16.8	29.5	59	328	8.8	20.7	5.64
July	16.2	28.8	58	354	8.2	20.1	5.64
August	16.5	29.3	56	354	8.1	21	5.96
September	16.8	30.7	53	328	8.8	22.9	6.49
October	17.5	30.8	54	242	7.9	21.6	5.81
November	16.5	28.5	66	156	7.1	19.8	4.43
December	15.5	29	67	156	7.8	20.4	4.45
Average	16.7	30.1	58	248	8.3	21.4	5.48

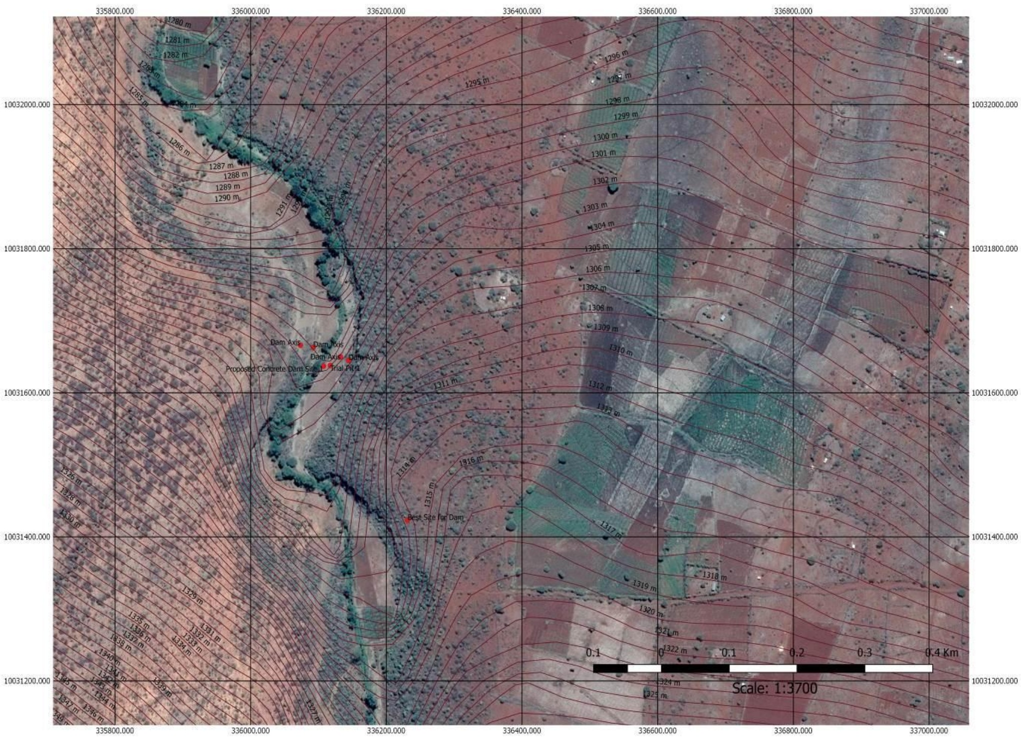
2.4 Topography

Most of the area of Isiolo County is flat low lying featureless plain escepecially in the lower Ewaso Ng'iro Basin resulting from weathering and sedimentation. The plains rise gradually from an altitude of about 200m above sea level at Lorian Swamp (Habaswein) in the northern part of the District to about 300m above sea level at Merti Plateau. To the north of the Ewaso Ng'iro River, plateau lavas form low but clear escarpments above the surrounding plains.

The Western part of the District is an extensive poorly developed plain land, associated particularly with the basin of the Ewaso Ng'iro River which roughly corresponds with the end tertiary erosion. This plain lying at about 1,000m has leveled extensive tracts of quite diverse metamorphic rocks. The Pleistocene basalt flows originating from the northern slopes of Mount Kenya and the Nyambene Hills have covered large areas of this surface, surrounding isolated inselbergs such as Shaba Dogo.

The dam area lies in the sloppy region of the County. The land is relatively sloppy with slopes at about 6.67%. This is indicative of the rapid stage of Lewa river starting at 1314 masl at check dam to 1295 masl at dam axis and therefore a protection check dam should be constructed upstream of the dam.

Figure 1
: Google map for Topography of Kilimani Dam Site and Environs



2.5 Geology

Isiolo County is wholly underlain by the Precambrian Basement System. The Basement System rocks are predominantly outcropping in the furthest end of the western arm of the District and also in the areas to the west and south of the Merti Plateau. The South-west of the District (slopes of Mount Kenya and Nyambeni Hills) is mainly covered by the volcanic flows which spread from a multitude of parasitic cones of Mount Kenya and Nyambeni volcanic centres. The rest of the District is part of the Anza Basin and such is dominated by sedimentary rocks which are sporadically overlain by volcanic rocks as a result of either isolated fissures or lava flow from the Marsabit area.

The Basement System rocks include different types of gneisses and schists, crystalline limestones, quartzites, migmatites and grabulites, locally affected by different types of intrusions. The sedimentary rocks found in the District are sandstones, limestones, marls, shales, conglomerates, grits, sands, clays and gravels. The volcanic rocks include basalts and pyroclastic deposits. (Refer Map 3.15 below)

The county has a combination of metamorphic rocks and other superficial rock deposits. Tertiary rocks (Olive Basalt) are found in the northern parts of the county, where oil exploration has been going on. The areas covered with tertiary marine sediments that have a high potential for ground water harvesting

Map 0-1:Landforms and soils of Isiolo County

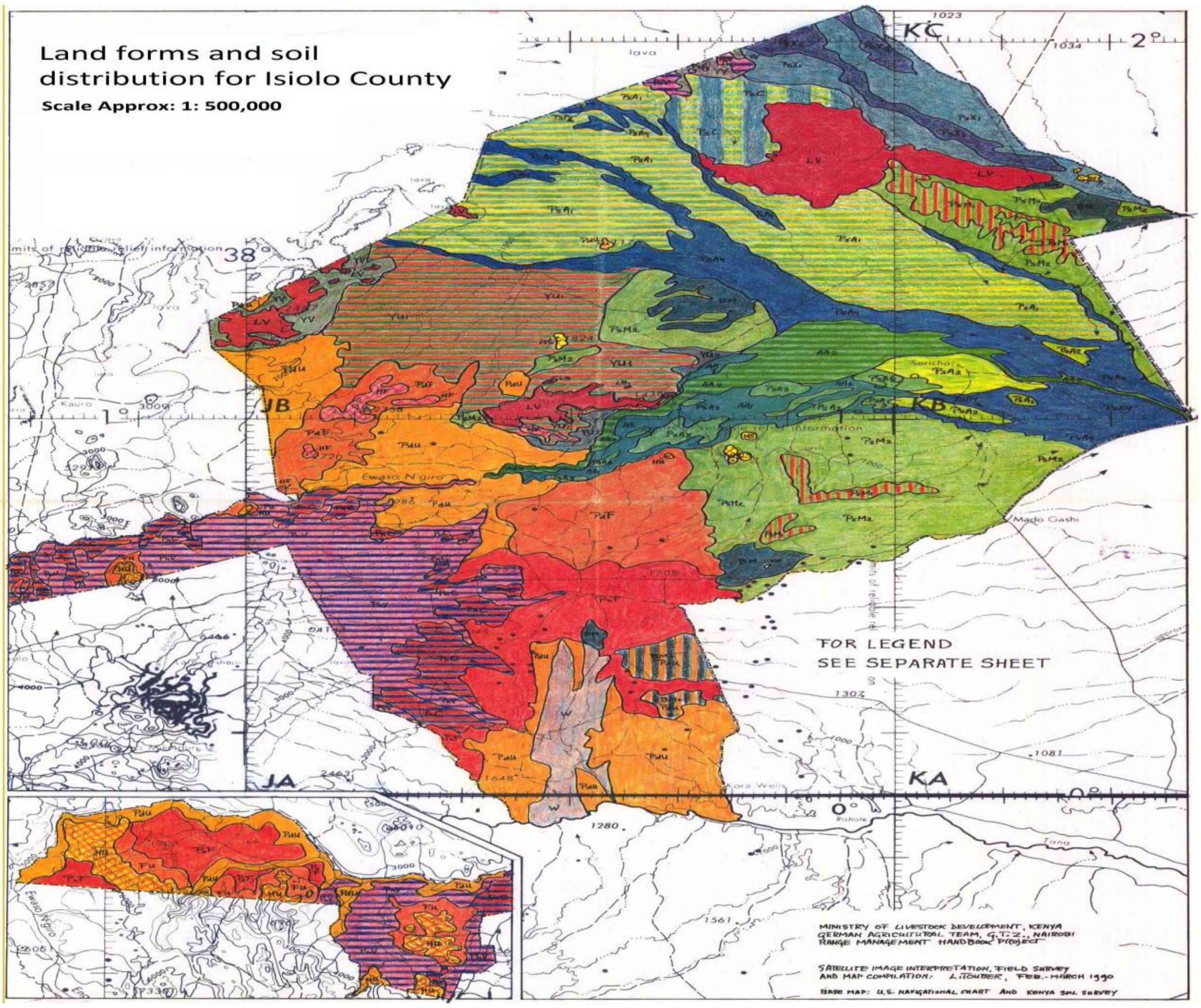


Table 0-1:Landforms and soils of Isiolo County

Kenya -Arid and Semi Arid lands
Land forms and Soil Evalauation for Isiolo County

MAJOR LANDFORM	PREDOMINANT GEOLOGY AND SOIL-PARENT-MATERIAL	SEQUENCE NO	MAP UNIT SYMBOL	SURFACE AREA %	SURFACE AREA KM²	TOPOGRAPHY; PREDOMINANT SLOPE %	EROSION HAZARD (E.H.) BY OVER-UTILIZATION 1): SHEET & GULLY E.H.	EROSION HAZARD: WIND EROSION AND -DEPOSITION	CONSTRAINTS TO THE ACCESSIBILITY FOR LIVESTOCK 2): GOAT & SHEEP	CAMEL	CATTLE	ADDITIONAL WET SEASON CONSTRAINTS	HAZARD OF FLOODING, PONDING
HILLS	UNDIFFERENTIATED BASEMENT SYSTEM ROCKS	1	HU	1.5	369	IRREGULAR STEEP SLOPES, VARIABLE %	STRONG	LOW	MODERATE	SEVERE	SEVERE	NONE	NONE
	BASEMENT SYSTEM ROCKS RICH IN FERROMAGNESIAN MINERALS	2	HF	0.5	113	REGULAR, MODERATE SLOPES; VARIABLE %	STRONG	LOW	SLIGHT	MODERATE	MODERATE	NONE	NONE
	MESOZOIC SANDSTONE	3	HS	0.2	38	IRREGULAR PLATEAU-LIKE LANDFORM	STRONG	LOW	SLIGHT	MODERATE	MODERATE	NONE	NONE
PLATEAUS	PLIO-PLEISTOCENE BASALTS	4	LV	4.2	1038	ALMOST FLAT; < 1%; WITH STEEP ESCARPMENT	VERY LOW	SLIGHT	SLIGHT	MODERATE	MODERATE	MODERATE	LOCALLY PONDING
FOOTSLOPES	COLLUVIUM DERIVED FROM BASEMENT SYSTEM ROCKS	5	FU	1.2	300	GENTLE, REGULAR SLOPES, CONCAVE; UP TO 8%	STRONG SHEET & MODERATE GULLY E.H.	LOW	NONE	NONE	NONE	NONE	NONE
PIEDMONT PLAINS	ALLUVIUM FROM UNSPECIFIED ORIGIN	6	YU1	7.2	1769	ALMOST FLAT; ≤ 1%; IN PLACES GULLIED MESO TOPOGRAPHY	1 MODERATE 2 LOW	LOW	NONE	NONE	NONE	1 NONE 2 MODERATE	1 NONE 2 LOCALLY
		7	YU2	0.4	106	ALMOST FLAT; < 1%	LOW	MODERATE	NONE	NONE	NONE	MODERATE	OCCASIONAL LOCALLY
	COLLUVIUM/ALLUVIUM FROM VOLCANIC ROCKS	8	YV	1.1	281	ALMOST FLAT; < 1%	LOW	MODERATE	NONE	NONE	NONE	LOCALLY MODERATE	OCCASIONAL LOCALLY
NON-DISSECTED EROSIONAL PLAINS	BASEMENT SYSTEM ROCKS, RICH IN FERROMAGNESIAN MINERALS	9	PnF	6.6	1631	VERY GENTLY UNDULATING; SLOPES 1-2 %	MODERATE SHEET E.H.	LOW	NONE	NONE	NONE	NONE	NONE
	VOLCANIC ROCKS; QUATERNARY BASALTS	10	PnV	8.7	2131	ALMOST FLAT; LOCALLY IRREGULAR TOPOGRAPHY	LOW; LOCALLY GULLY E.H.	MODERATE - LOW	SLIGHT	MODERATE	SEVERE - MODERATE	MODERATE - SEVERE	OCCASIONAL LOCALLY
	COMPLEX OF VARIOUS MATERIALS	11	PnC	3.1	763	ALMOST FLAT; SLOPES < 1%	COMPLEX OF VARIOUS SOIL TYPES						
DISSECTED EROSIONAL PLAINS	UNDIFFERENTIATED BASEMENT SYSTEM ROCKS	12	PdU	11.3	2781	GENTLY - VERY GENTLY UNDULATING; SLOPES 3-5 %	MODERATE SHEET E.H.	LOW	NONE	NONE	NONE	NONE	NONE
	BASEMENT SYSTEM ROCKS, RICH IN FERROMAGNESIAN MINERALS	13	PdF	5.4	1331	GENTLY UNDULATING; SLOPES 3-5 %	MODERATE TO STRONG SHEET & RILL EROSION	LOW	NONE	LOCALLY SLIGHT	LOCALLY SLIGHT	NONE	NONE
SEDIMENTARY PLAINS	SEDIMENTS OF MARINE ORIGIN (PLIO-PLEISTOCENE BAY SEDIMENTS)	14	PsM1	1.8	431	VERY GENTLY UNDULATING; SLOPES 1-2 %	MODERATE SHEET EH	LOW	NONE	NONE	NONE	NONE	NONE
		15	PsM2	12.2	2988	ALMOST FLAT - VERY GENTLY UNDULATING; SLOPES UP TO 1%	MODERATE SHEET EH	LOW	NONE	NONE	NONE	NONE	NONE
	UNDIFFERENTIATED SEDIMENTS, PARTLY DERIVED FROM VOLCANIC ROCKS	16	PsX1	3.2	794	ALMOST FLAT	LOW	MODERATE	NONE	NONE	NONE	LOCALLY SEVERE	OCCASIONAL LOCALLY
		17	PsX2	1.4	338	FLAT	LOW	LOW	NONE	NONE	SLIGHT	SEVERE	OCCASIONAL FLOODING
	UNDIFFERENTIATED ALLUVIAL SEDIMENTS,	18	PsA1	11.6	2838	ALMOST FLAT, WITH VERY GENTLY UNDULATING MESOTOPOGRAPHY	1 SLIGHT SHEET EH. 2 NONE	1 MODERATE 2 LOW	NONE	NONE	NONE	1 NONE 2 MODERATE	1 NONE 2 FREQUENT
		19	PsA2	1.2	294	ALMOST FLAT, SLOPES UP TO 1-2 %	MODERATE SHEET E.H.	LOW	NONE	NONE	NONE	NONE	NONE
		20	PsA3	1.1	269	ALMOST FLAT, WITH GENTLY UNDULATING MESOTOPOGRAPHY	1 SLIGHT	MODERATE	NONE	NONE	NONE	NONE	NONE
		21	PsA4	7.3	1788	FLAT	NONE	MODERATE	NONE	NONE	SLIGHT	SEVERE	OCCASIONAL FLOODING
	SEDIMENTS OF VARIOUS ORIGIN	22	PsC	1.8	450	ALMOST FLAT	COMPLEX OF VARIOUS SOIL TYPES						
RECENT AND SUB RECENT FLOODPLAINS	SUBRECENT RIVERINE ALLUVIUM	23	AA1	1.6	394	ALMOST FLAT	NONE	SLIGHT	NONE	NONE	NONE	MODERATE	OCCASIONAL LOCAL FLOODING
	RECENT RIVERINE ALLUVIUM	24	AA2	2.6	644	ALMOST FLAT; LOCALLY GENTLY UNDULATING MESOTOPOGRAPHY	NONE	NONE	NONE	NONE	NONE	SEVERE	LOCALLY FREQUENT FLOODING
BOTTOMLANDS	SEDIMENTS OF MARINE ORIGIN	25	BM	1.7	425	FLAT	NONE	SLIGHT	NONE	NONE	NONE	MODERATE	OCCASIONAL PONDING
BADLANDS	PLIOCENE SANDY AND CALCAREOUS SEDIMENTS	26	W	1.7	419	IRREGULARLY DISSECTED MESOTOPOGRAPHY	SEVERE SHEET AND GULLY	NONE	SLIGHT	MODERATE	MODERATE - SEVERE	NONE	NONE
		27	BM + PdU	0.9	213		ASSOCIATION OF MAPPING UNITS 25: BM AND 12: PdU						

SEQUENCE NO	MAP UNIT SYMBOL	LOCAL SOIL NAME (BORAN)	SOIL PROPERTIES: DRAINAGE CLASS 3)	SOIL DEPTH	COLOUR	SALINITY, SODICITY, CALCAREOUSNESS 3)	ROCKINESS, STONINESS	TEXTURE	INFILTRATION CAPACITY OF THE SURFACE SOIL 1)	WATER HOLDING CAPACITY 1)	RELATIVE SOIL CHEMICAL FERTILITY 1)
1	HU	BULE ; CHARI	WELL	VERY SHALLOW	VARIOUS	NONE	ROCKY AND STONY	COARSE SANDY CLAY LOAM	VARIOUS	LOW	MODERATE
2	HF	BULE	WELL	SHALLOW	DARK BROWN - GRAYISH BROWN	LOCALLY CALCAREOUS	STONY	FINE SANDY CLAY-LOAM - CLAY	MODERATE - HIGH	LOW	HIGH
3	HS	BULE	WELL	SHALLOW	PALE BROWN	NONE	VERY STONY	LOAMY FINE SAND	MODERATE - LOW	LOW	LOW
4	LV	MALBE-BULE	MODERATELY WELL	VERY DEEP	DARK REDDISH BROWN	STR.-CALC.; SALINE DEEPER S.S.	LOCALLY SURFACE STONES	CLAY LOAM OVER CRACKING CLAY	HIGH (WHEN DRY) LOW (WHEN WET)	MODERATE - HIGH	MODERATE
5	FU	WAYAMA	WELL	VERY DEEP	DARK REDDISH BROWN	NONE	NONE	COARSE SANDY LOAM OVER COARSE SANDY CLAY LOAM	LOW	HIGH	LOW - MODERATE
6	YU1	1 OMARA-DIMA ; -KOBE 2 MALBE ; OMARA-BOR	1 WELL 2 IMPERFECT	VERY DEEP	1 REDDISH BROWN 2 GRAYISH BROWN	1 SALINE DEEPER S.S. 2 SALINE-SODIC	NONE	1 SANDY CLAY LOAM 2 CLAY	1 LOW 2 VARYING	1 MODERATE 2 HIGH	1 MODERATE 2 HIGH
7	YU2	MALBE	IMPERFECT	VERY DEEP	DARK BROWN	NON-SALINE STR. CALC.	NONE	SILTY CLAY LOAM - CLAY	MODERATE - HIGH	MODERATE - HIGH	HIGH
8	YV	MALBE DIMTU	MODERATELY WELL	VERY DEEP	DARK BROWN TO GRAYISH BROWN	STRONGLY CALC.; SALINE AND SODIC	LOCALLY SURFACE STONES	CLAY LOAM - FINE SANDY LOAM	MODERATE - HIGH	HIGH	MODERATE - HIGH
9	PnF	WAYAMA	WELL	VERY DEEP - MODERATELY DEEP	DARK RED - DARK REDDISH BROWN	NONE	NONE	SANDY CLAY LOAM AND SANDY CLAY	LOW - MODERATE	MODERATE	LOW
10	PnV	MALBE - BULE ; BULE	IMPERFECT - MOD. WELL	VERY DEEP	DARK REDDISH BROWN AND BLACK	LOCALLY CALC. AND/OR SLIGHT SALINE	SURFACE STONES AND BOULDERS; ROCKY	CLAY	MODERATE - HIGH	MODERATE	MODERATE - HIGH
11	PnC	BOJI ; WAYAMA ; MALBE ; RAMATA	COMPLEX OF VARIOUS SOIL TYPES								
12	PdU	CHARI	WELL	SHALLOW	DARK BROWN - DARK RED	NONE	GRAVELLY; LOCALLY ROCK OUTCROPS	COARSE SANDY CLAY LOAM	MODERATE - LOW	LOW	MODERATE - HIGH
13	PdF	CHARI	WELL	SHALLOW	GRAYISH BROWN	STRONGLY CALC.; NON-SALINE	LOCALLY GRAVELLY LOCALLY ROCKY	FINE SANDY LOAM	MODERATE - LOW	LOW	HIGH
14	PsM1	OMARA-ABI ; CHARI	WELL	DEEP - MODERATELY DEEP	YELLOWISH RED	STRONGLY CALC.; NON SALINE	GRAVELLY	MEDIUM SANDY CLAY	LOW	LOW	MODERATE
15	PsM2	OMARA-ABI ; OMARA-BOR	MODERATELY WELL	VERY DEEP	GRAYISH BROWN	STRONGLY SALINE & SODIC SUBSOIL	NONE	COARSE SANDY LOAM OVER SANDY CLAY	1 HIGH 2 LOW	LOW - MODERATE	MODERATE - HIGH
16	PsX1	MALBE HURUFI	MODERATELY WELL - POOR	VERY DEEP	DARK GRAYISH - REDDISH BROWN	STRONGLY CALC.; SALINE - SODIC	NONE	FINE SANDY CLAY LOAM OVER CLAY	MODERATE	MODERATE	MODERATE - HIGH
17	PsX2	MALBE	IMPERFECT	VERY DEEP	DARK BROWN	STRONGLY CALC.; SALINE - SODIC	NONE	DUSTY CLAY LOAM OVER CRACKING CLAY	HIGH (WHEN DRY) LOW (WHEN WET)	MODERATE - HIGH	HIGH
18	PsA1	1 OMARA ; RAMATA 2 MALBE ; OMARA-BOR	1 S. EXC. DR 2 POOR	VERY DEEP	1 YELLOWISH BROWN 2 DARK GRAYISH BROWN	1 NONE 2 SALINE SUBSOIL	NONE	1 FINE SAND - SANDY LOAM 2 CLAY	MODERATE	1 LOW 2 MODERATE - HIGH	1 LOW 2 MODERATE
19	PsA2		MODERATELY WELL	VERY DEEP	DARK GRAYISH BROWN	CALCAREOUS; SALINE, SODIC	NONE	SILTY CLAY LOAM OVER CLAY	LOW	LOW	MODERATE
20	PsA3	RAMATA ADE	WELL	VERY DEEP	YELLOWISH BROWN	SLIGHTLY CALC.; SALINE	NONE	FINE SAND OVER FINE SANDY CLAY	MODERATE	HIGH - MODERATE	HIGH
21	PsA4	MALBE HURUFI ; MALBE DIMTU	IMPERFECT - POOR	VERY DEEP	DARK REDDISH - DARK GRAYISH BROWN	SLIGHT SALINE & SODIC SUBSOIL	NONE	DUSTY CLAY LOAM OVER CRACKING CLAY	HIGH (WHEN DRY) LOW (WHEN WET)	MODERATE	HIGH
22	PsC	COMPLEX OF VARIOUS SOIL TYPES									
23	AA1	MALBE ; MALBE SILAI	MODERATE - IMPERFECT	VERY DEEP	YELLOWISH - REDDISH BROWN	LOCALLY SLIGHT SALINE & CALC.	NONE	SILTY CLAY LOAM TO CLAY (STRATIFIED)	MODERATE	HIGH	HIGH
24	AA2	1 RAMATA ADE 2 MALBE	1 WELL 2 IMPERFECT	VERY DEEP	GRAYISH - YELLOWISH BROWN	LOCALLY SLIGHT SALINE & CALC.	NONE	1 STRATIFIED SANDY 2 STRATIFIED CLAYEY	1 MODERATE 2 LOW - HIGH	HIGH	HIGH
25	BM	MALBE KOTICHA ; OMARA BOR	IMPERFECT - POOR	VERY DEEP	DARK GRAYISH BROWN	STRONGLY CALC.; SALINE	NONE	DUSTY LOOSE CLAY OVER CRACKING CLAY	HIGH (WHEN DRY) LOW (WHEN WET)	MODERATE	HIGH
26	W	YATO	WELL	STRATA OF VARIOUS SANDY, PEBBLY, CALCAREOUS AND/OR CLAYEY DEPOSITS							
27	BM + PdU	ASSOCIATION OF SOILS OF MAPPING UNITS 25: BM AND 12: PdU									

NOTES :
1) QUALITATIVE ESTIMATIONS ONLY
2) DUE TO SLOPE STEEPNESS, STONINESS ONLY ; VEGETATION (E.G. DENSE BUSH) NOT TAKEN INTO ACCOUNT, NOR NEARNESS TO WATERING POINTS, ETC.
3) ABBREVIATIONS :
S. EXC. - SOMEWHAT EXCESSIVELY
MOD. - MODERATELY
STR. - STRONGLY
CALC. - CALCAREOUS
S.S. - SUBSOIL

MINISTRY OF LIVESTOCK DEVELOPMENT, KENYA
GERMAN AGRICULTURAL TEAM, NAIROBI
RANGE MANAGEMENT HANDBOOK PROJECT

LEGEND COMPILATION: L. TOBBER MARCH 1990

2.6 Ecological Zone,Land availability and Livelihood

Isiolo County is one of the counties in the lower eastern region of Kenya. It borders Marsabit County to the North, Isiolo and Laikipia Counties to the West, Garissa County to the South East, Wajir County to the North East, Tana River and Kitui Counties to the south and Meru and Tharaka Nithi Counties to the south West. The county covers an area of approximately 25,700 km^2. Figure 3-13 below indicates the position of the county on the map of Kenya.

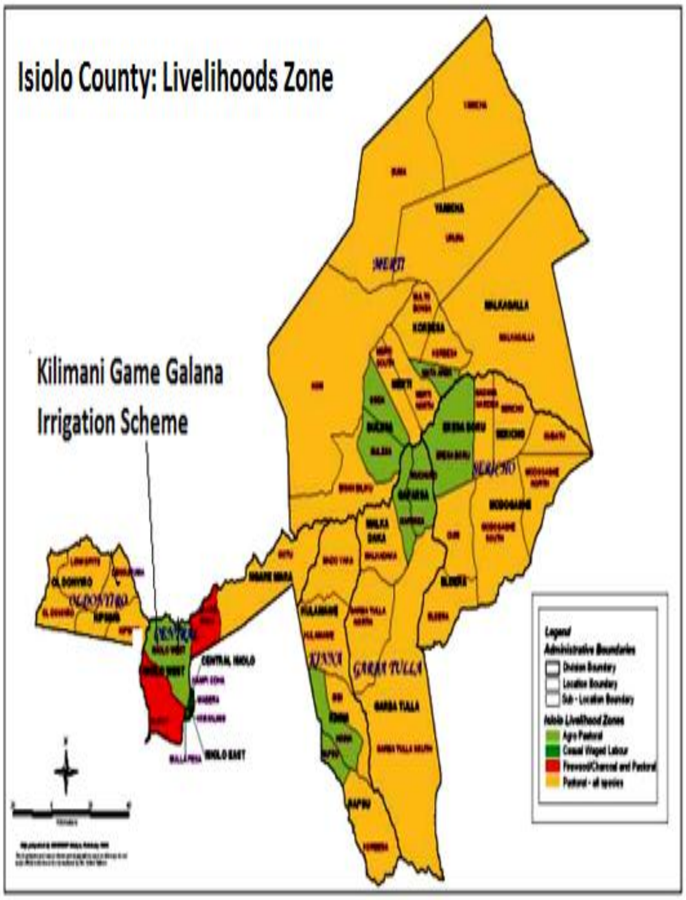
The analysis shows that the county has 3 distinct agro-ecological zones as follows:

1. Lower Midland (LH 3-5)- 1,275 km2

2. Lower midlands (LM 6-7)-7,710 km2

3 Intermediate Lowlands (IL) -16.705km^2

Figure 0.5: Livelihood Zones of Isiolo County



3 WATER DEMAND STUDIES

3.1 Levels of service

Water consumption is greatly influenced by the levels of income, the type of housing and the type of service. People with high and medium incomes can afford individual connections. However, low incomes groups will fetch water from shared facilities such as water kiosks. The recommendations by the MW&I are shown in table 3-1 below were adopted.

Table 3-1: Level of Service

	IC %			NC %		
	Initial	Future	Ultimate	Initial	Future	Ultimate
Rural Areas						
High potential	20	40	80	80	60	20
Medium potential	10	20	40	90	80	60
Low potential	5	10	20	95	90	80

Source: Ministry of Water and Irrigation Practice Manual for Water Supply services in Kenya.

3.2 Consumption Projections

The consumption rates recommended in the Practice Manual for ater Supply service in Kenya were adopted and are tabulated below.

Table 3-2: Consumption Rates

CONSUMER	UNIT	RURAL AREAS		
		High potential	Medium potential	Low potential
People with individual connections	1/head/ day	60	50	40

People without connections	1/head/ day	20	15	10
Livestock unit	1/head/ day	50		
Boarding schools	1/head/ day	50		
Day schools with WC	1/head/ day	25		
Day schools without WC	1/head/ day	5		
Hospitals Regional District	1/bed/ day	400		

3.3 Water Demand

The calculated total water demand is 239 m^3/ day as presented in the table 3-3 below

Table 3-3: Summary of Projected Water demand in m^3/day

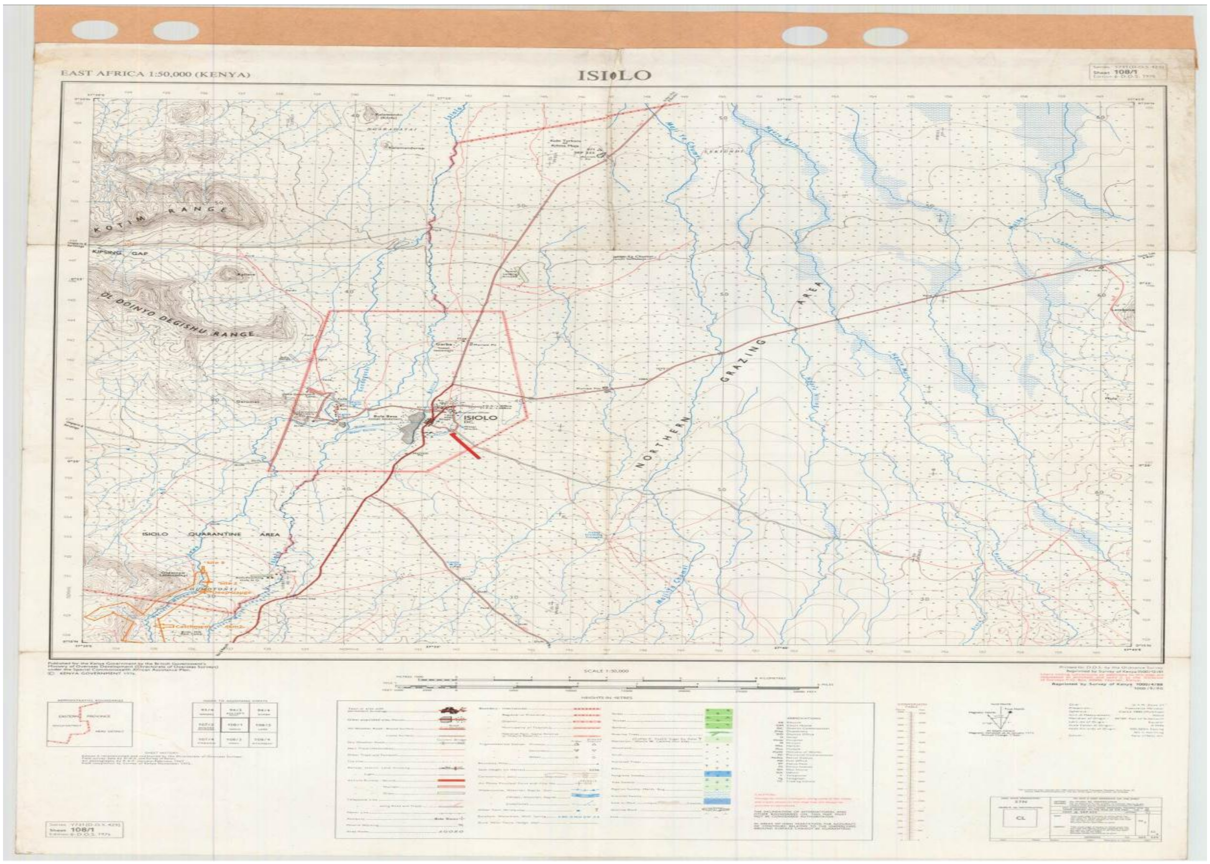
Estimating Water Demand of Kilimani Village, Kilimani Sub-Location, Burrat Location			
Item	Population	Consumption (Litres/Day)	Total (m^3/ Day)
1. People			
People	800	20	16
Kilimani Primary School	200	5	1
2. Livestock's			
Camels	20	15	0.3
Cattle	1,000	15	150
Sheep's/Goats	10,000	3.5	35
Donkeys	0	15	0.00
3. Irrigation			
Allow for Irrigation	500		
Total			239
Current Sources			
Kilimani Buttress Dam			103,275
Total Daily Deficit			142,275
Catchment yield			255,000
Estimating Water Storage Required for the Reservoir			
Total Storage Required			255,000
Average Storage Required			255,000
Estimated Loss (25%)			63,750

Estimated Seepage Loss (10%)			25,500
Required Storage			344,250
A Dam of Capacity 344,250m^3 is required			
Source: Water for Small Dams-A Handbook for farmers, Technicians and others on site investigations, designs, cost estimates, construction and maintenance of small earth dams by Erik Nissen Petersen for Danish International Development Assistance (Danida) dated 2006 page 8 to 10			

4 HYDROLOGY AND METEOROLOGY STUDIES

4.1 Size of Catchment

The area demarcated as the catchment in figure 4-1 and 4-2 is approximately 4.0km^2. The catchment rises from an altitude of 1295 masl to 1326masl. The average catchment slope was found to be 6.67%. This slope has been used in the determination of flood from the catchment.



Catchment of Kilimani DamCatchment Yield

The catchment yield is estimated at 255,000m^3/year as detailed in table 4-1 below

Table 4-1:Catchment Yield for Kilimani Dam

CATCHMENT YIELD OF DAM SITE Kilimani 1
The annual runoff for the catchment (the catchment yield in an average year),
Y, in m^3, is given by:
Y = Rr x A x 1 000
Where A is catchment area in km^2
Rr is Annual Rainfall in mm times Runoff Coefficient mostly assumed to be 10%
Source:_FAO Irrigation and Drainage Paper 64-Manual on Small Earth Dam, a guide to siting, design and construction dated Rome, 2010

A	Rr	Y				
km^2	%	m^3/year				
4	10	255,600				
Note						
The Catchment yield is 255,6000m^3/year which implies that the dam takes about 2.3 Months to get filled						

4.2 Sedimentation

Sedimentation analysis for Dam Site S1							
Categorization							
Catchment can be categorized as Heavy with Sediment Yield of				1,500	m^3/km^2/Year		
Catchment Area	Annual sediment Catchment Yield						
Km^2	m^3/Year						
4	6,000						
Hence the Dam can be filled with Sediment within a period of (103,275*2)/6000 = 34							Years
Hence Dam Lifespan is estimated at about 34 years at estimated capacity of 103,275m^3							

The dam is expected to be filled by sediments in a period of about 8 years as evidenced by table 4-2.

5 GEOLOGICAL AND GEOTECHNICAL INVESTIGATION

5.1.1 Geology

The Geology of the proposed project area is composed of rocks of the Basement System comprising of highly weathered basement rock. The area is covered superficially with deposits of calcrete type. Some deposited are highly weathered and the weathering becomes pronounced upstream and downstream of the dam site. These rocks are overlain by a thin layer of overburden consisting fine grey sands and silts derived from the parent rocks.

5.1.2 Soil Column analysis at dam axis site

According to the trial pit dug (2.1 M deep) on the dam axis at the GPS coordinates region 37N,Longitude0336213E,Latitude 0031336N altitude 1292masl;the following was noted to aid the decision for the type of the dam to be constructed.

Table 5-1: Soil profile at dam axis

No	Depth (m)	Type of soil
1	0.3	Fine sand and silt
2	0.3-1.3	Brown coarse sandy soil
3	1.3- 1.7	White Coarse Sandy soil
4	1.7-2.1	Sandy soil mixed with loose rocks

5.2 Identification

Identification of potential dam sites commenced by using the following criteria:-

Topographic characteristics-The sites need be having narrow cross section for the embankment and have deep narrow gorge that opens up to create sufficient reservoir storage and slopes gently upstream to achieve long reservoir fetch, and should have a sufficient catchment area

Land use- Areas with little investments or infrastructures such as permanent housing, bridges, schools and tarmac roads to reduce on compensation costs during construction

Geological conditions-Good rock formation with proximal availability of good soil for embankment filling and water retention

Cost of water conveyance-Ease of the water to flow, as much as possible, by gravity to the desired point of use.

The Dam should affect the owner's farm

5.3 Evaluation of the possible dam sites

The Design Team liaised with the land owners to show them the dam site identified earlier during public consultation and feasibility study carried out.

The team undertook Rapid Field Assessment of the Dam sites

Determined the viability, characteristics and ranked.

Proceeded to other Study Phases for the best ranked dam site.

5.3.1 Results

The Study Team recommended moving the proposed intake site by about 750m downstream where there is a constriction and the highest contour at 1311.50m closes with ease to create a reservoir of about 103,275 m^3 capacity after excavation of about 3m on the area with high depositions. This further creates a dam height of about 8m at spillway way level .

The Spillway is designed to have a stilling basin to normalize the down slope to reduce soil erosion Conditions for choice of the Dam

Generally, dams are classified according to the construction material:-

5.3.2 Earth fill dam

Earth fill dams are the most common type of dam, principally because their construction involves the use of materials from required excavations and the use of locally available natural materials requiring a minimum of processing.

Using large quantities of required excavation and locally available borrow are positive economic factors related to an earth fill dam.

Moreover, the foundation and topographical requirements for earth fill dams are less stringent than those for other Technical Feasibility' solutions.

Rolled-fill earth fill dams are further classified as "homogeneous," "zoned," or "diaphragm".

Earth fill dams require appurtenant structures to serve as spillways and outlet works. The principal disadvantage of an earth fill dam is that it will be damaged or may even be destroyed under the erosive action of overflowing water if sufficient spillway capacity is not provided.

5.3.3 Rock fill Dams

Rock fill dams use rock of all sizes to provide stability and an impervious membrane to provide water tightness. The membrane may be an upstream facing of impervious soil, a concrete slab, asphaltic-concrete paving, steel plates, other impervious elements, or an interior thin core of impervious soil.

Like the earth embankments, rock fill dams are subject to damage or destruction by the overflow of water and so must have a spillway of adequate capacity to prevent overtopping. An exception is the extremely low diversion dam where the rock fill facing is designed specifically to withstand overflows. Rock fill dams require foundations that will not be subject to settlements large enough to rupture the watertight membrane. The only suitable foundations, therefore, are rock or compact sand and gravel.

The rock fill type dam is suitable for remote locations where the supply of good rock is ample, where the scarcity of suitable soil or long periods of high rainfall make construction of an earth fill dam impractical, or where the construction of a concrete dam would be too costly. Rock fill dams are popular in tropical climates because their construction is suitable for long periods of high rainfall.

5.3.4 Concrete Gravity Dams

Concrete gravity dams are suitable for sites where there is a reasonably

sound rock foundation, although low structures may be founded on alluvial foundations if adequate cutoffs are provided. They are well suited for use as overflow spillway crests and, because of this advantage, are often used as spillways for earth fill or rock fill dams or as overflow sections of diversion dams.

Gravity dams may be either straight or curved in plan. The curved dam may offer some advantage in both cost and safety. Occasionally the dam curvature allows part of the dam to be located on a stronger foundation, which requires less excavation.

The topography is an important factor in the selection and location of a concrete dam and its apputent structure. Construction at a site with a narrow canyon profile on sound bedrock close to the surface is preferable, as this location would minimize the concrete materials requirement and the associated costs.

5.3.5 Concrete Buttress Dams

Buttress dams are comprised of flat deck and multiple arch structures. They require about 60 percent less concrete than solid gravity dams, but the increased formwork and reinforcement steel required usually offset the savings in concrete. A number of buttress dams were built in the 1930’s, in USA when the ratio of labor costs to material costs was comparatively low.

The cost of this type of construction is usually not competitive with that of other types of dams when labor costs are high.

5.3.6 Results and conclusion for the Proposed Dam site

The Dam axis, the river bed and the whole of the left contain natural rock outcrop while part of left contain natural rock outcrop

The site has a narrow canyon profile founded on sound bedrock close to the surface. This will minimize the concrete material required and the associated costs.

The area is covered by sandy stony soil which cannot form the core of the dam.

In consideration of site condition and stability of the dam the following conclusion was arrived at Kilimani dam site:

Concrete Buttress Dam is proposed for this site.

Retaining walls on the reservoir sides to prevent loose stones falling will need to be constructed,

A check dam upstream of the channel is required to act as stop-logs measure as well as increase the life of the reservoir downstream.

6 DAM DESIGN CRITERIA STABILITY ANALYSIS

6.1 Dam

6.1.1 Adopted Dam Type

A gravity concrete structure is selected as the proposed dam type considering the near vertical abutment slopes at the dam site. Furthermore the non-availability of earth-fill materials in sufficient quantities for an earth cored dam in the area under study.

The other essential aspects influencing the selection of the dam type is the impact on the arrangement of the other project components:

- A concrete dam allows the incorporation in its body of spillways and low level outlets.
- A concrete dam can tolerate overtopping during construction and thus accept a lower design flood for the river diversion facilities than required.

6.1.2 General Design considerations for a gravity concrete dam

Fundamentally a gravity dam should satisfy the following criteria:

i. It shall be **safe against overturning** at any horizontal position within the dam at the contact with the foundation or within the foundation.
ii. It should be **safe against sliding** at any horizontal plane within the dam, at the contact with the foundation or along any geological feature within the foundation.
iii. The section should be so proportioned that **the allowable stresses in both the concrete and the foundation should not exceed**.

Criteria i and ii will be satisfied with respect to the profile above all horizontal planes within the dam and the foundation. Overstress criteria will be satisfied for the dam concrete and for the rock foundation.

The forces that give stability to the dam include:

- Weight of the dam
- Thrust of the tail water

The forces that try to destabilize the dam include:

- Reservoir water pressure
- Uplift
- Forces due to waves in the reservoir
- Temperature stresses
- Silt pressure
- Seismic forces
- Wind pressure

The forces to be resisted by a gravity dam fall into two categories as given below:

- Forces, such as weight of the dam and water pressure which are directly calculated from the unit weight of materials and properties of fluid pressure,
- Forces such as uplift, earthquake loads and silt pressure are assumed only on the basis of assumptions of varying degree of reliability.

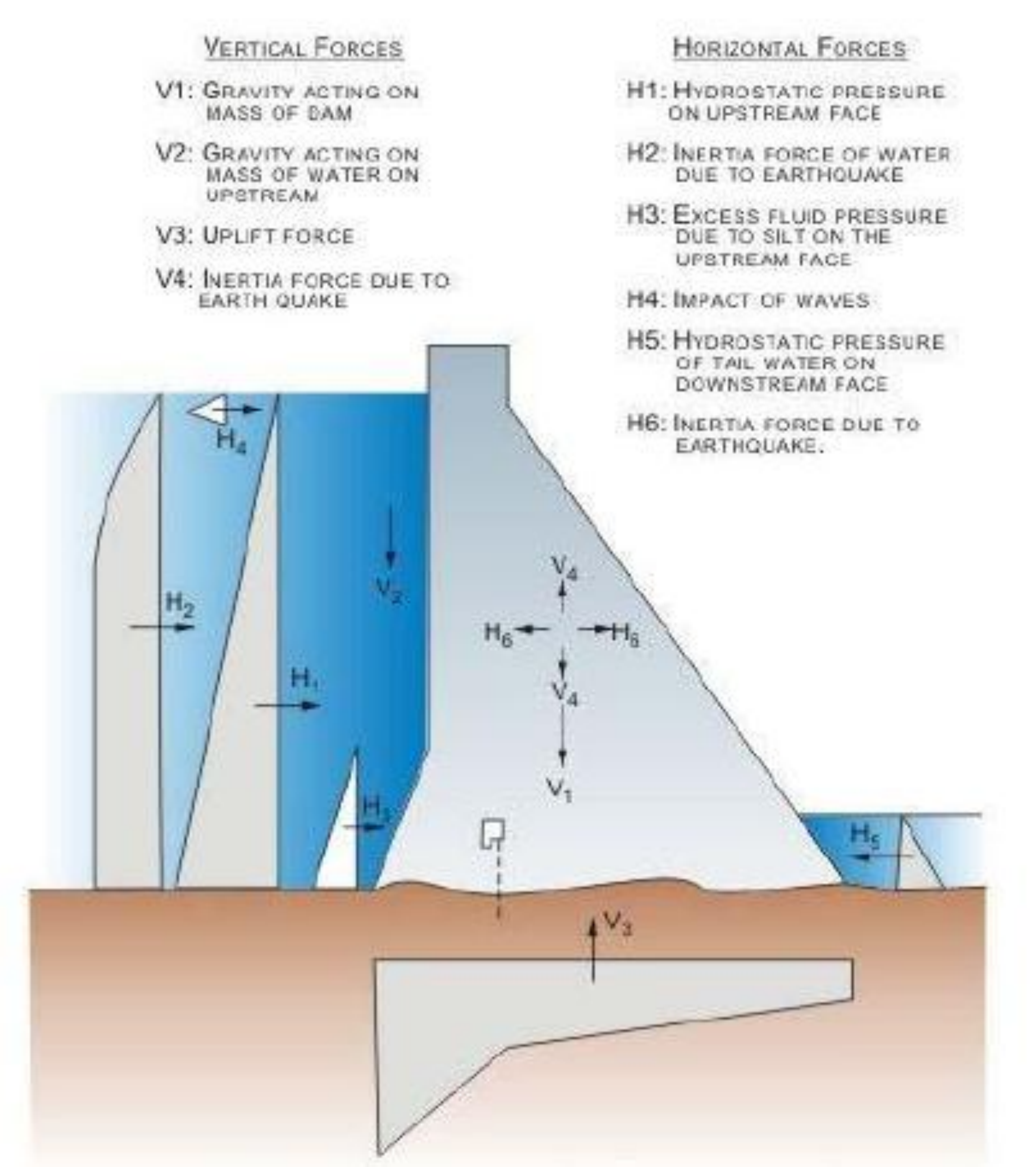
For consideration of stability of a concrete dam, the following assumptions are made:

- That the dam is composed of individual transverse vertical elements each of which carries its load to the foundation without transfer of load from or to adjacent elements. However for convenience, the stability analysis is commonly carried out for the whole block.
- That the vertical stress varies linearly from upstream face to the downstream face on any horizontal section.

Figure 2 below shows the position and direction of the various forces expected in a concrete gravity dam.

6.1.3

Figure 6.1: Forces acting in a concrete Butress/gravity dam



6.1.4 Stability Analysis

6.1.4.1 Factor of safety against overturning.

$$FS_O = \frac{\Sigma M_R}{\Sigma M_O} = \frac{W \times b_w + W_{HW} \times b_{HW} + W_{tw} \times b_{tw}}{P_{wh} \times h_1 / 3 + P_{sh} \times h_s / 3 + P_u \times b_u - P_{twh} \times h_2 / 3}$$

Where W = Weight of the dam (W)

(W_{HW}) = Weight of the water wedge over the u/s & batter/slope

(W_{TW}) = Weight of the water wedge over d/s

(P_{wh}) = water pressure at the upstream face

(P_u) = uplift pressure at the base

(P_{sh}) = pressure at u/s face from silt / ice/wind/wave.

b_w, b_{HW}, b_{tw}, b_u is distance from toe to centroid of dam section, to centroid of u/s water wedge, to centroid of tail d/s water wedge, and centroid of uplift distribution diagram, respectively and h_1, h_2 and h_s is depth of u/s water depth, d/s water depth and silt deposition.

During an earthquake the dam weight will decrease, but the water pressure (hydrodynamic) will increase.

6.1.4.2 Safety Factor against sliding.

$$SSF = \frac{CA + (N - U)\tan\theta}{H}$$

$$SSF = Sliding Safety Factor$$

$$C = Cohesion$$

$$A = Area of section under consideration$$

$$N = \sum downward forces$$

$$U = (Upward) Uplift force$$

$$Tan\theta = coefficient of internal friction$$

$$H = Sum of shear forces$$

Table6 .1: Range of shearing resistance parameters

Description		Cohesion c MN/m^2	Friction Tanφ
Mass concrete	intact	1.5-3.5	1.0-1.5
	H or construction joint	0.8-2.5	1.0-1.5
Concrete rock interface		1.0-3.0	0.8-1.8
Rock mass	sound	1.0-3.0	1.0-1.8
	inferior	< 1.0	< 1.0
Sound conditions [competent parent rock, few significant discontinues in mass, no significant alteration or weathering]	gneiss	1.6	1.7
	granite	1.5	1.9
	Mica schist	3.0	1.3
	Sandstone	1.0	1.7
Inferior conditions	Gneiss unaltered	0.6	1.0
	Granite weathered	0.3	1.3
	Grey wacke	< 0.1	0.6
	Lime stone open jointed	0.3	0.3
	Mica schist	0.4	0.7
	Sand stone	0.1	0.6
Critical foundation features	Faults/crush zone materials	< 0.2	< 0.3
	Clay seams / joints infill	< 0.1	< 0.2
Shale	dry	0.2	0.4
	saturated	0.0	< 0.2

Source: Dam and Reservoir Engineering, Tariq 2008

6.1.5 Stress Analysis

Concrete dams are designed to ensure:

- No tension in any part of the concrete,
- Compression stresses are within the maximum permissible limit (in the elastic range)
- Shear stresses are within the maximum permissible limit (in the elastic range)

Stress evaluation is made for every plane in the section for: (Fig. Navak p-103)

- Vertical normal stress, σz on horizontal plane
- Horizontal normal stress, σy on vertical planes
- Horizontal and vertical shear stress τ zy and τyz
- Principal stresses σ1 and σ3(for direction and magnitude)

6.1.5.1 Vertical normal stress, σ_z

This is given as (Novak et al):

$$\sigma_z = \frac{\Sigma W}{A} \pm \frac{\Sigma M^* y'}{I}$$

Where ΣW = sum of vertical loads excluding uplift

ΣM*=sum of moments with respect to centroid of plane

y' = distance from the neutral axis to the point where the stress is being determined,

I = second moment of the area A of the plain w.r.t. its centroid (for a rectangle section area A = T x d and I = d $T^3/12$, where T = thickness from u/s to d/s side, d = section width and for d of unit width (d = 1), A = T, I = $T^3/12$.

The stresses at two faces are as below.

U/s face, i.e. heel: $$\sigma_{z:u} = \frac{\Sigma W}{T}\left(1 - \frac{6\,e}{T}\right),$$

D/s face, i.e. toe: $$\sigma_{z:d} = \frac{\Sigma W}{T}\left(1 + \frac{6\,e}{T}\right)$$

The eccentricity e = ΣM*/ΣV and ΣM*= (ΣMR – ΣMO). For e > T/6, the u/s face becomes under tension. Therefore the resultant R must intersect the plain d/s of its centroid for reservoir full conditions. The vertical normal stress varies linearly from u/s to d/s faces.

6.1.5.2 Horizontal and vertical shear stress τ_{zy} and τ_{yz}

The horizontal and vertical shear stresses are numerically equal and complimentary and are generated due to variation in vertical normal stress over a horizontal plain. The boundary values at u/s and d/s faces are as;

$$\tau_u = (p_w - \sigma_{z:u})\tan\phi_u$$

$$\tau_d = \sigma_{z:d}\tan\phi_d$$

Where;$\O_u$ and $\O_d$ = upstream and downstream slope angles from vertical

$\sigma_{z:u}$ and $\sigma_{z:d}$ = vertical normal stresses at u/s and d/s faces

p_w = external hydrostatic pressure.

The maximum shear stress is at u/s face as;

$$Max\ \tau_u = (\sigma_{z:u} - uplift)\tan\phi_u .$$

The shear stress variations from τ_u and τ_d depends on rate of change of vertical normal stress and usually have a parabolic distribution.

6.1.5.3 Horizontal normal stress, σ_y

These operate on vertical plains. Boundary values are as:

U/S Face:
$$\sigma_{y:u} = p_w + (\sigma_{z:u} - p_w)\tan^2\phi_u$$

D/S Face:
$$\sigma_{y:d} = \sigma_{z:d}\tan^2\phi_d \qquad [p_w = \gamma_w h]$$

6.1.5.4 Principal stresses σ_1 and σ_3

These are determined from σ_z and σ_y and the Mohr circle diagram. Major stresses are:

Major:
$$\sigma_1 = \frac{\sigma_z + \sigma_y}{2} + \tau_{max}$$

Minor: $$\sigma 3 = \frac{\sigma_z + \sigma_y}{2} - \tau_{\max}$$

$$\tau_{\max} = \sqrt{(\sigma_z - \sigma_y)/2 + \tau^2}$$

Where max;

The u/s and d/s faces are each plains of zero shear and therefore plains of principal stress. Boundary values are as:

U/s face: $$\sigma_{1:u} = \sigma_{z:u}(1 + \tan^2 \phi_u) - p_w \tan^2 \phi_u \text{ and } \sigma_{3:u} = p_w$$

D/s face: $$\sigma_{1:d} = \sigma_{z:d}(1 + \tan^2 \phi_d) \text{ and } \sigma_{3:d} = 0$$

Punmia defined minor principal stress as:

$$\sigma_{3u} = -(\sigma_{zu} - p_w)\tan \phi_u \text{ and } \sigma_{3d} = \sigma_{zd} \tan \phi_d \,.$$

6.1.5.5 Horizontal Cracks

Horizontal cracks may appear on u/s face if vertical stress $\sigma_{z:u}$ is small. The minimum stress required to stop cracks is as:

$$\text{Min } \sigma_{zu} = \frac{K'_d \, \gamma_w \, z - \sigma'_t}{F'_t}$$

Where: K'_d = drainage factor (~ 0.4 if relief drains are effective and 1.0 if no drains),

$\sigma' t$ = tensile strength of concrete across a horizontal joint surface,

$F' t$ = factor of safety.

6.1.5.6 Permissible stresses:

Compressive stresses are generally low as 2-3 N/mm^2, but may exceed for large structures. Factor of safety Fc ≥ 3.0 is usually prescribed. In some cases both factor of safety and maximum stress are defined as:

Table 6-2: Factor of safety and maximum stress

Load combinations	Fc (Concrete)	Fr (Rock)
Normal	3.0 ($\sigma_{max} \leq 10 N/mm^2$)	4.0
Unusual	2.0 ($\sigma_{max} \leq 15 N/mm^2$)	2.7
Extreme	1.0	1.3

6.1.6 Foundation

Bed rock foundations that are hard and erosion resistant are the most desirable for dams. All materials in cracks, faults, or deep pits that may eventually erode into the embankment from the abutments or foundation will be filled with filters or backfilled with concrete. All joints and cracks beneath the core and filters will be also cleaned and filled with concrete. The usual methods of treating foundations to prevent under seepage i.e. grouting will be considered. Such treatment of the foundation must be sufficient to satisfy the following criteria:

- Minimum leakage
- Prevention of piping

- Limited settlement
- Sufficient friction development between abutments and foundation to ensure sliding stability

6.1.6.1 Curtain grouting

The depth of curtain grouting is determined by the following formula:

D = □ H

Where,	D	: hole depth (m)
	H	: dam height (m)
	□	: 0.5 to 1.0

6.1.7 Freeboard

The spillway equation used to determine the head in an overflow Dam (O-gee Spillway) above the spillway crest is as follows:

$$Q = \mu B \sqrt{2g} H^{3/2}$$

Where

$Q - Design flood flow in\ m^3/\sec$

$\mu = disch\arg e coefficient = 0.49$

$\mu\sqrt{2g} = Spillway Coefficient = 2.1$

$g = gravitational acceleration in\ m^{-2}/\sec$

$H = Depth of water$

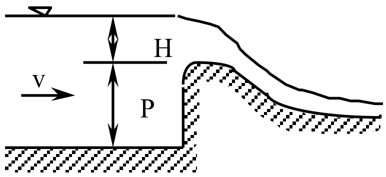
Where piers are to be constructed to facilitate the crest as a road, then pier contraction effect has to be considered.

6.2 SPILLWAY

6.2.1 Basic Design Concept

6.2.1.1 Control structure

The control structure is designed to have an ample capacity to release the design flood of a magnitude of 500-year probable flood. The type of weir should be ungated free overflow weir. The velocity of approach to the spillway crest is lower than 4 m/sec, and the height of the overflow section above the floor of the entrance channel is greater than one-fifth the maximum head on the crest.



The crest length is determined by comparing the cost of weir on various lengths with the cost of other features affected by the crest length such as excavation volume of right abutment due to extensive excavation.

6.2.1.2 Chute way

The chute way having an enough capacity to convey the design discharge should be designed with straight center line. A covering section toward the downstream should be economy and best hydraulic performance. The height of side walls of the chute way is decided at least 0.5 m high from the flowing surface.

6.2.1.3 Energy dissipater

An energy dissipater should be constructed at downstream of chute way. Thorough this structure, the flow is returned to the river without serious scour or erosion of the toe of the dam and without damage to adjacent structures. This energy dissipation is done through the construction of USBR Stilling basin or ski jump dissapater or a combination of both. The design discharge of stilling basin is the magnitude of 100-year flood without regulating reservoir.

6.2.2 Hydraulic Analysis

6.2.2.1 Overflow crest

6.2.2.2 Shape of overflow crest

The portion downstream from the origin of crest with a vertical upstream face and negligible velocity of approach is defined by the following equation (see figure below):

$X^{1.85} = 2Hd^{0.85}\ Y$

where, Hd : Design head (m)

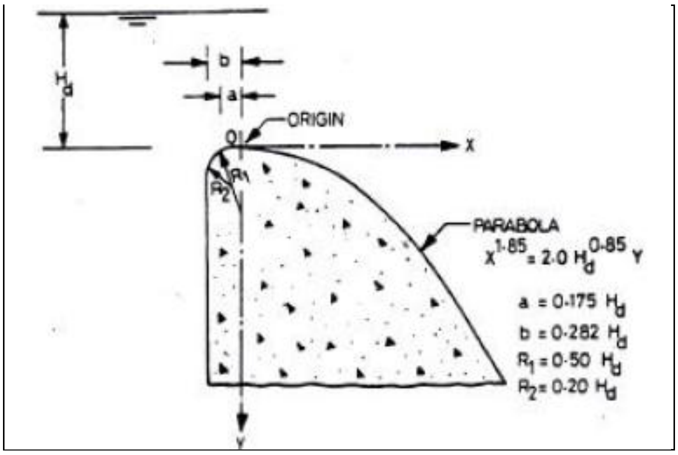
X : Horizontal distance (m)

Y : Vertical distance (m)

The end of Harold's curve is considered to be constant gradient. A gradient of 1:0/7 will be adopted for the project. Then, the beginning point of the constant gradient is expressed by the following formula:

$X = 1.096 \text{ Hd Yd}^{1.176}$

Where, Yd : Gradient of downstream



6.2.2.3 Crest length

The crest length is estimated as below:

$$L = \frac{Q}{Cd \cdot Hd^{3/2}}$$

where, Q : discharge (m^3/sec)

Cd : coefficient of overflow discharge

$$Cd = 2.200 - 0.0416\ (Hd/P)^{0.990}$$

P : Crest height (m)

L : effective length of crest (m)

Hd : total head on the crest, including velocity head in approach (v=0) (m)

6.2.2.4 Chute way

6.2.2.4.1 Velocity and depth

The velocities and depths of free surface and supercritical flow in the chute way are expressed by the Bernoulli's theorem as shown below:

$$\Delta Z + d1 + hv1 = d2 + \Delta hL + hv2$$

The term hL includes all loses which occur in the reach of channel, such as friction, turbulence, impact and transition losses. Since in most channels changes are made gradually, ordinarily all losses except those due to friction can be neglected. The friction loss can then be expressed as shown below:

$$\Delta hL = S \cdot \Delta L$$

Where S is the average friction slope expressed by either the Chezy or the Manning formula. For the reach □L, the head loss can be expressed as shown below:

$$\Delta hL = \left(\frac{S1 + S2}{2} \right) \cdot \Delta L$$

The wall height of chute way is determined by a water depth considered an air bulking and freeboard.

6.2.2.5 Stilling basin

6.2.2.5.1 Length of stilling basin

$$\frac{h_2}{h_1} = \frac{1}{2}\left(\sqrt{1+8Fr1^2} - 1\right)$$

$$Fr1 = V_1/\sqrt{gh^2}$$

$$L = 6.0h_2$$

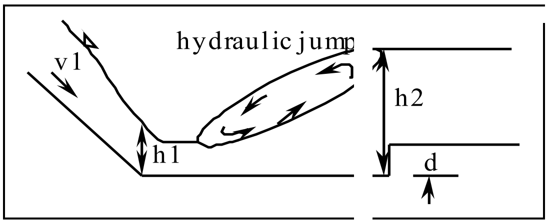
where, h_1 :water depth at end of chute way (m)

h_2 : jumped water depth (m)

Fr1 : Froude number at the end of chute way

L : : required length of stilling basin (m)

V_1 : Velocity (m/sec)



6.2.2.5.2 Height of sub-dam

$$\frac{d}{h_1} = \frac{(1+2Fr^2)\sqrt{1+8Fr^2} - 1 - 5Fr^2}{1+4Fr^2 - \sqrt{1+8Fr^2}} - \left(\frac{\sqrt{g}}{C} \cdot Fr\right)^{2/3}$$

Where, c : discharge Coefficient

g: acceleration gravity

6.2.2.5.3 Height of wall

The height of wall in the stilling basin is estimated follows:

$$h = h_2 + F_b$$

$$F_b = 0.1x(h_2 + V_1)$$

Where, h : height of wall (m)

F_b : freeboard (m)

h_2 : water depth after hydraulic jump (m)

V_1 : inflow velocity (m/sec)

6.2.2.6 Flip bucket

The equation of the flip bucket is as follows:

$$L = \frac{V2}{2g} Cos\alpha\{Sin\alpha + \sqrt{Sin2\alpha + \frac{2gy}{V2}})$$

If the angle of inclination is equal to 0^0, then the equation is represented as follows:

$$L = \frac{V2}{2g}\sqrt{\frac{2gy}{V2}}$$

$$L = V\sqrt{\frac{2y}{g}}$$

Where:

L	- Horizontal distance from the flip to the point where the flood flow hits the foundation.
v	- Velocity of water at the exit point.
α	- Angle of inclination to the horizontal
y	- Difference in elevation between the heel and the erosion depth.

6.3 DIVERSION WORKS

6.3.1

A temporary diversion which consists of an upstream open channel, a waterway through the dam body and a downstream open channel will be during construction work to divert river flow.

Since the dam is constructed by concrete on which the water is allowed to overflow, the temporary diversion should have a capacity equal to a 5-year return flood. In this study, the design discharge of temporary diversion is determined to be 7.12 m^3/sec. Stop-logs will be installed at upstream portal of waterway after construction of the gravity concrete dam.

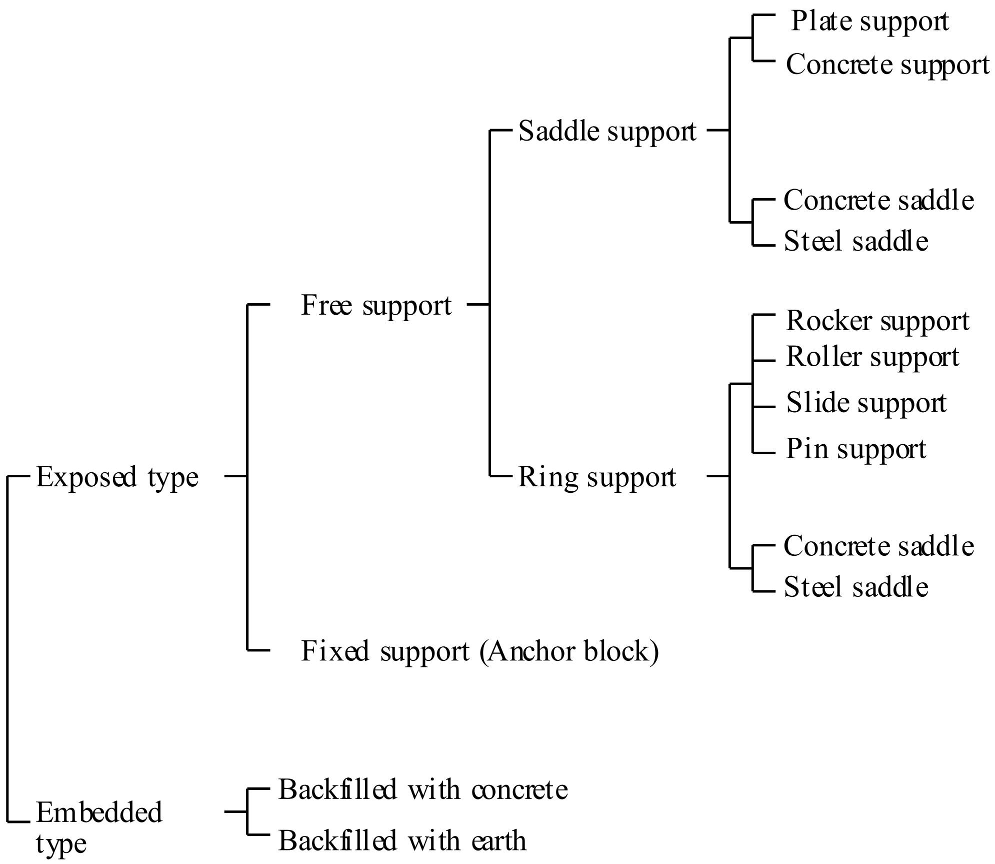
6.4 INTAKE STRUCTURE

6.4.1 Basic design concept

The intake structure of drop-inlet type is constructed at the inlet of the diversion tunnel. Steel conduit is employed as the intake pipe to deliver water of the design discharge with pressure flow. A trash rack is to be provided at the inlet to prevent floating logs and debris intrusion.

6.4.2 Type of conduit

There are two (2) types of steel conduit, i.e., exposed type and embedded type, and they are classified as follows:



The embedded type backfilled with concrete is employed for the design of the steel conduit for the intake pipe.

6.4.3 Determination of diameter of intake pipe

The diameter of the intake pipe is sized to supply the demand of **213m^3**/day.

7 DAM DESIGN

7.1 Background

The final dam design and geometry was based on a number of factors explained in chapter above and in this chapter. Among the factors are the construction material locally available and other engineering analyses like stability.

The design has been accomplished by making out successive layout, each one being progressively improved based on the result of stress and stability analysis of the preceding layouts.

7.1.1 Dam Design Components

A Buttress concrete structure is proposed and the main parameters of the proposed dam are as follows;

Height above river bed	9.5 m
Length of dam crest	91m
Crest width	1.5m
Upstream slope	Vertical
Downstream slope	0.7H: 1V
Concrete Volume	60,361m^3
Reservoir Capacity	103,275m^3

7.2 Elevation-Area-Volume Relationship

The elevation-volume-area relationship for a reservoir/dam describes the variations of volume and surface area with elevation/height. This relationship has been developed from topographic information and is represented in table 10 and figure 7 below.

7.2.1 Reservoir Reliability

From the water demand analysis it was estimated that the dam would require a storage capacity of 103,275**m^3** to cater for the demand during the longest dry period in the locality normally while the rest of catchment yield 255,000m^3 /year will be stored as on-farm at individual farms .

7.2.2 Dam Height

The height of any dam above the lowest level in the river channel is determined from

- The gross storage (live storage + dead storage) capacity of the dam,
- The space required to pass maximum design flood over the spillway (called flood surcharge),
- The wave height generated from extreme winds,
- The wave run-up over the upstream sloping face due to wind gusts and
- The free board.

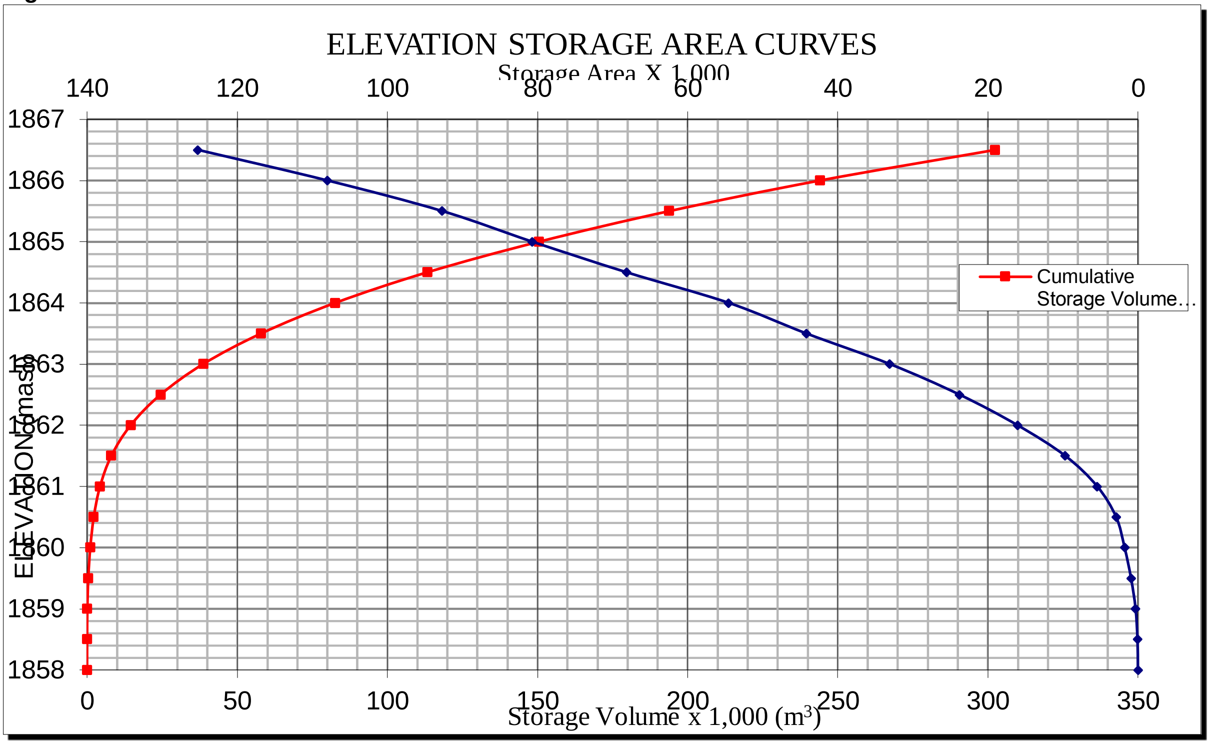
A 8.0 m high dam (reservoir capacity **103,275 m^3**) was adopted in order to meet the storage requirements for the water project.

Table 0-1: Reservoir Characteristics

Elevation (m)	Dam Height (m)	Dam crest (m)	Flooded Area (m^2)	Storage Volume (m^3)	Cumulative Storage Volume (m^3)
1,858.0	0.0	0.0	0.000	0.00	0.00
1,858.5	0.5	10.8	54.260	13.57	13.57

1,859.0	1.0	24.7	306.354	90.15	103.72
1,859.5	1.5	35.7	913.523	304.97	408.69
1,860.0	2.0	44.2	1,769.018	670.64	1,079.32
1,860.5	2.5	67.9	2,901.578	1,167.65	2,246.97
1,861.0	3.0	108.3	5,416.285	2,079.47	4,326.44
1,861.5	3.5	159.8	9,686.609	3,775.72	8,102.16
1,862.0	4.0	217.8	16,038.729	6,431.33	14,533.50
1,862.5	4.5	253.9	23,777.750	9,954.12	24,487.62
1,863.0	5.0	286.1	33,066.296	14,211.01	38,698.63
1,863.5	5.5	326.4	44,196.253	19,315.64	58,014.26
1,864.0	6.0	362.5	54,544.570	24,685.21	82,699.47
1,864.5	6.5	397.8	68,157.232	30,675.45	113,374.92
1,865.0	7.0	427.4	80,725.553	37,220.70	150,595.62
1,865.5	7.5	460.6	92,699.877	43,356.36	193,951.97
1,866.0	8.0	492.7	108,011.988	50,177.97	244,129.94
1,866.5	8.5	523.5	125,259.963	58,317.99	302,447.93

Figure 0.1: Reservoir Characteristics



7.3 Dam Layout, Geometry and Shape

The U/S face of the dam is made vertical to concentrate the weight at U/S face to resist reservoir water loading. The base width required to satisfy the stress and stability requirements has been used to determine the D/S slope. A 0.7H: 1V slope has been adopted for the D/S face.

The thickness of dam at crest is set at 1.5m wide, which has been assumed for pedestrian access requirements for the non- overflow section. The d/s face of the crest is vertical from the d/s edge of crest to an intersection with the sloping d/s face..

The Spillway has been incorporated in the dam by providing an overflow section. The layout of the spillway section is similar to the non-overflow section. The curves describing spillway crest and the energy dissipater are designed to meet the hydraulic requirements and slopes are set as tangent to straight segments. The maximum water surface elevation should not exceed the top of non-overflow section of dam. A gross freeboard of 1.5m is provided.

Figure 4 shows the layout plan of Kilimani Dam. The proposed typical non-overflow dam section is presented on Figure 5 and proposed typical overflow dam section is presented on figure 6 below

Dam safety analysis

7.3.1 Load Conditions

The Bureau of Indian Standards code IS 6512-1984 “Criteria for design of solid gravity dams” recommends following adverse load conditions for which a dam is to be designed using the safety factors prescribed:

- Load combination A (construction condition):

Dam completed but no water in reservoir or tail water

- Load combination B (normal operating conditions):

Full reservoir elevation, normal dry weather tail water, normal uplift and silt (if applicable)

- Load combination C: (Flood discharge condition):

Reservoir at maximum flood pool elevation, all gates open, tail water at flood elevation, normal uplift, and silt (if applicable)

- Load combination D:

Combination of A and earthquake

- Load combination F:

Combination C, but with extreme uplift, assuming the drainage holes to be Inoperative

7.3.2 Stability analysis against overturning

The check against overturning is made to be sure that the total stabilizing moments weigh out the de-stabilizing moments. The factor of safety against overturning may be taken as **1.5**. As such, a gravity dam is considered safe also from the point of view of overturning if there is no tension on the upstream face.

7.3.3 Stability analysis against sliding

The stability of the dam against sliding is evaluated by comparing the minimum total available resistance along the critical path of sliding (that is, along that plane or combination of planes which mobilizes the least resistance to sliding) to the total magnitude of the forces tending to induce sliding.

The required safety factor is **2.4** for normal loading and **1.25-1.5** for extreme loading.

7.3.4 Failure against Overstressing

The maximum compressive stresses occur at heel (mostly during reservoir empty condition) or at toe (at reservoir full condition) and on planes normal to the face of the dam. Stress concentrations develop near heel and toe, and modest tensile stresses may develop at heel

The results of the dam safety analysis are presented below;

FOS against sliding **1.07**

FOS against overturning **1.82**

7.4 Grouting

Grouting below the main dam will be included in the typical cross section. However, detailed geotechnical investigations (drilling and coring) has not been carried out. This is proposed to prevent seepage beneath the dam (under general reservoir service conditions) within the alluvial sediments below the downstream shell of the dam. It is recommended that this component of the dam design be re-assessed once detailed foundation investigations have been concluded.

7.4.1 Abutment Seepage Control

Grouting is proposed to prevent seepage through the abutments; however the extent and scope of the works will be discussed in detail once the detailed investigations are concluded.

7.5 DIVERSION DRAW-OFF WORKS

7.5.1 Diversion Works

A temporary diversion which consists of an upstream open channel, a waterway through the dam body and a downstream open channel will be provided on the left side bank of the Lewa River during construction work to divert river flow.

Since the dam is constructed by concrete on which the water is allowed to overflow, the temporary diversion should have a capacity equal to a flood which occurs 2 to 3 times in a year. In this study, the design discharge for temporary diversion is determined to be 0.031**m^3/sec** (from the hydrological studies).

A 4.0m high rock-fill coffer dam will be constructed to facilitate release of the diversion flow. The freeboard below the crest of the coffer dam is 0.5m which means that a water depth of 3.5m is considered for purposes of the design of this component. The sizing of the waterway is computed as follows;

$$Q = CA\sqrt{2gH}$$

Where

$C = discharge....coefficient....1.0$

A = Cross sectional Area

Assuming a freeboard of 0.5m, the depth of water H, therefore, is equal to 3.5m

$$Q = 7.12$$

$$7.12 = CA\sqrt{2gH}$$

$$A = \frac{Q}{C\sqrt{2gH}}$$

$$A = \frac{7.12}{\sqrt{2x9.81x3.5}}$$

$$A = 0.86m^2$$

The waterway through the dam body has a dimension of 1.0m square section (area = 1.00m^2). Stop logs will be installed at upstream portal of waterway after construction of the dam.

7.5.2 Intake works

The intake pipe (DN 100) is placed within the dam wall and is connected to a 3m high tower surrounded by a granular filter. The intake pipe within the tower is perforated. A 250mm diameter Epoxy coated steel pipe shall be connected to act as the raw water main.

7.6 Spillway Design

7.6.1 Introduction

The water resources management authority has drafted rules for water resources management purpose. Among the rules are the minimum spillway design floods. The risk is determined from the size of the catchment and the expected impoundment. Table 8 shows classes of dams while table 9 shows the recommended return periods for design of spillways.

Table 0-4: Classes of dams

Class of dam	Maximum depth ofWater at NWL (m)	Impoundment at NWL (m^3)	Catchment area (km^2)
A (low risk)	0 - 4.99	<100,000	<100
B (medium Risk)	5.00 - 14.99	100,000 - 1,000,000	100 - 1,000
C (High Risk)	>15.00	>1,000,000	>1,000

Source: Water resources management draft rules, June 2006

Table 0-5: Recommended return periods for design of spillways

	Minimum return period (years)
A (low risk)	1 in 50
B (medium Risk)	1 in 100
C (High Risk)	1 in 500

Source: Water resources management draft rules, June 2006

For the case of the Kilimani dam that is proposed dam is 8.0m high with storage of approximately 103,275m^3 and a catchment area of 4.0km^2 is thus considered a medium risk dam. For this reason, a design return period of 500 years was adopted. From the flood analysis the flood for a return period of 500 years was **16.75m^3/s.**

7.6.2 Description and Type

The proposed spillway is an overflow type where water flows down to the river course without causing much erosion because the foundation is solid rock material with sufficient hardness.

The spillway has been located on the dam crest, with chute channel, terminal flip bucket and stilling basin arranged on the downstream face. Due consideration has be given to aeration along the chute and to assure that erosion in the plunge pool area will not affect the foundations of the dam.

7.6.3 Hydraulic design

7.6.3.1 Spillway crest length

The concrete structure will be located on the embankment wall and its hydraulic sizing is done as follows:

$$Q = \mu B \sqrt{2g} H^{3/2}$$
$$\mu = Disch\arg eCoeficient$$
$$\sqrt{2g}\mu = 2.2$$

Given a spillway front of **10m**

$$H = \left[\frac{Q}{2.2 \times B}\right]^{2/3}$$ = **0.834m**

7.6.3.2 Spillway Crest:

The Calculation for the size of the spillway is as in the table below

Table 7-6 :Dam spillway Sizing

Crest Length L (m)	Head Over Broad Crested Weir (m)
	95% high flows flood
10	1.0437
11	0.9794
12	0.9242
13	0.8762

14	0.8339
15	0.7964
16	0.7628
17	0.7326
18	0.7052
19	0.6802
20	0.6573
21	0.6363
22	0.6169
23	0.5988
24	0.5821
25	0.5664

Table 7-7: Spillway determination table

Comment: The height of the spillway will be 1.5m

7.6.3.3 Stilling basin design:

The stilling basin has been designed as follows:

Design of Dissipater Sub dam type

Discharge (Q100)	Q100 =	16.75 m^3/s		
Width of channel	B =	10.0 m		
Elevation at slab of stilling basin		1857.7 m		
Gravity acceleration	g =	9.8 m^2/s		
Flow velocity at end of chute	v1 =	11.000 m/s		
Water depth at end of chute (supercritical flow)	d1 =	0.100 m		
Froude number (Fr) = $v1/\sqrt{g \cdot d1}$	Fr =	11.112		
Depth of hydlaulic junp = $\frac{d1}{2}(\sqrt{1+8Fr^2}-1)$	d2 =	1.522 m		
Length of stilling basin = 4.5 x d2	L =	6.85 m	→	6.9
Free board = 0.1(v1 + d2)	Fb =	1.252 m		
Height of side wall = d2 + Fb	h1 =	2.774 m	→	2.8
Height of sub dam (W)	W =	0.878 m	→	0.9

$$\frac{W}{d1} = \frac{(1+2Fr^2)\sqrt{1+8Fr^2}-1-5Fr^2}{1+4Fr^2-\sqrt{1+8Fr^2}} - \left(\frac{\sqrt{g}}{C}Fr\right)^{2/3}$$

C = 2.0

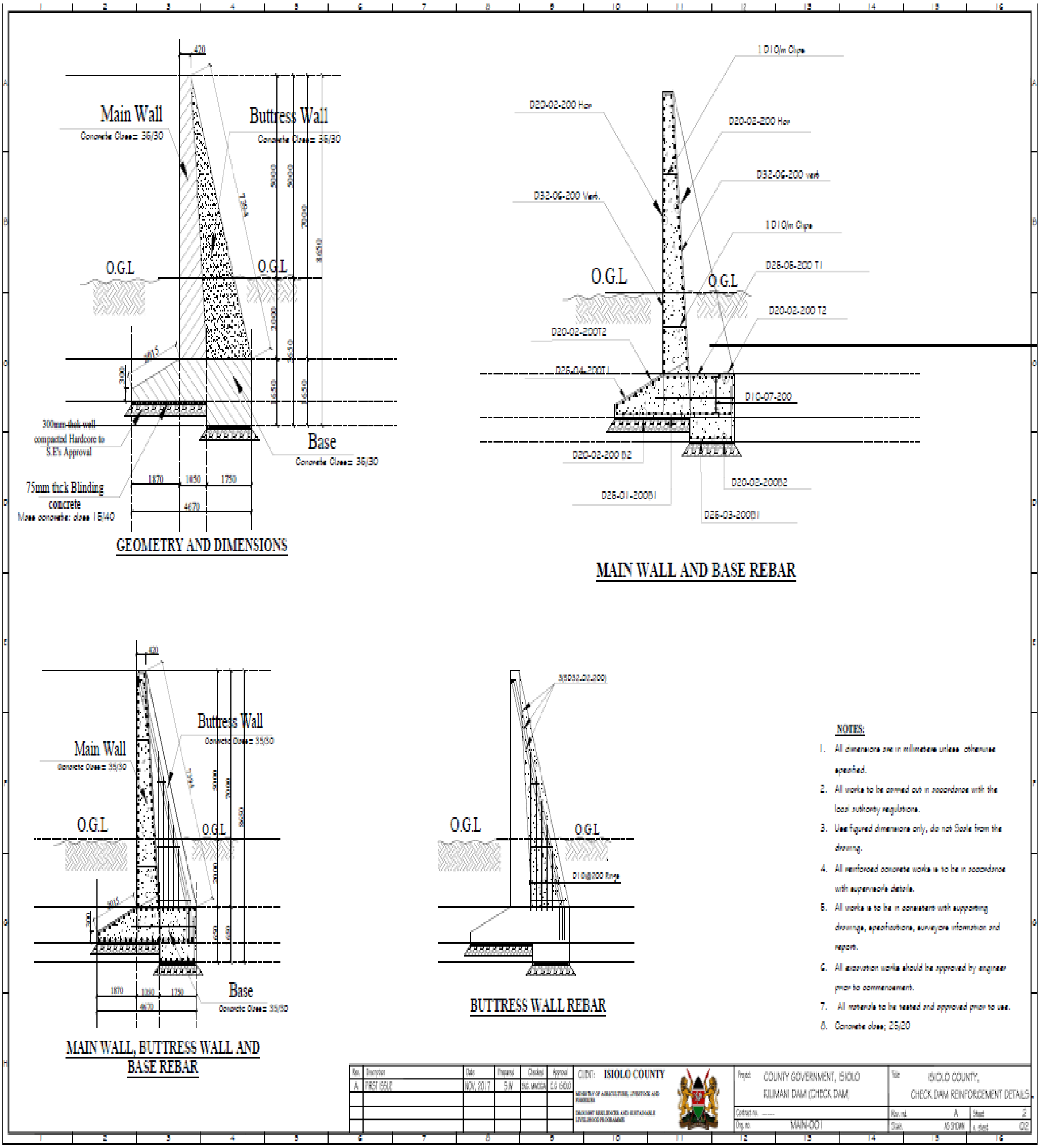
Fr^2 = 123.469

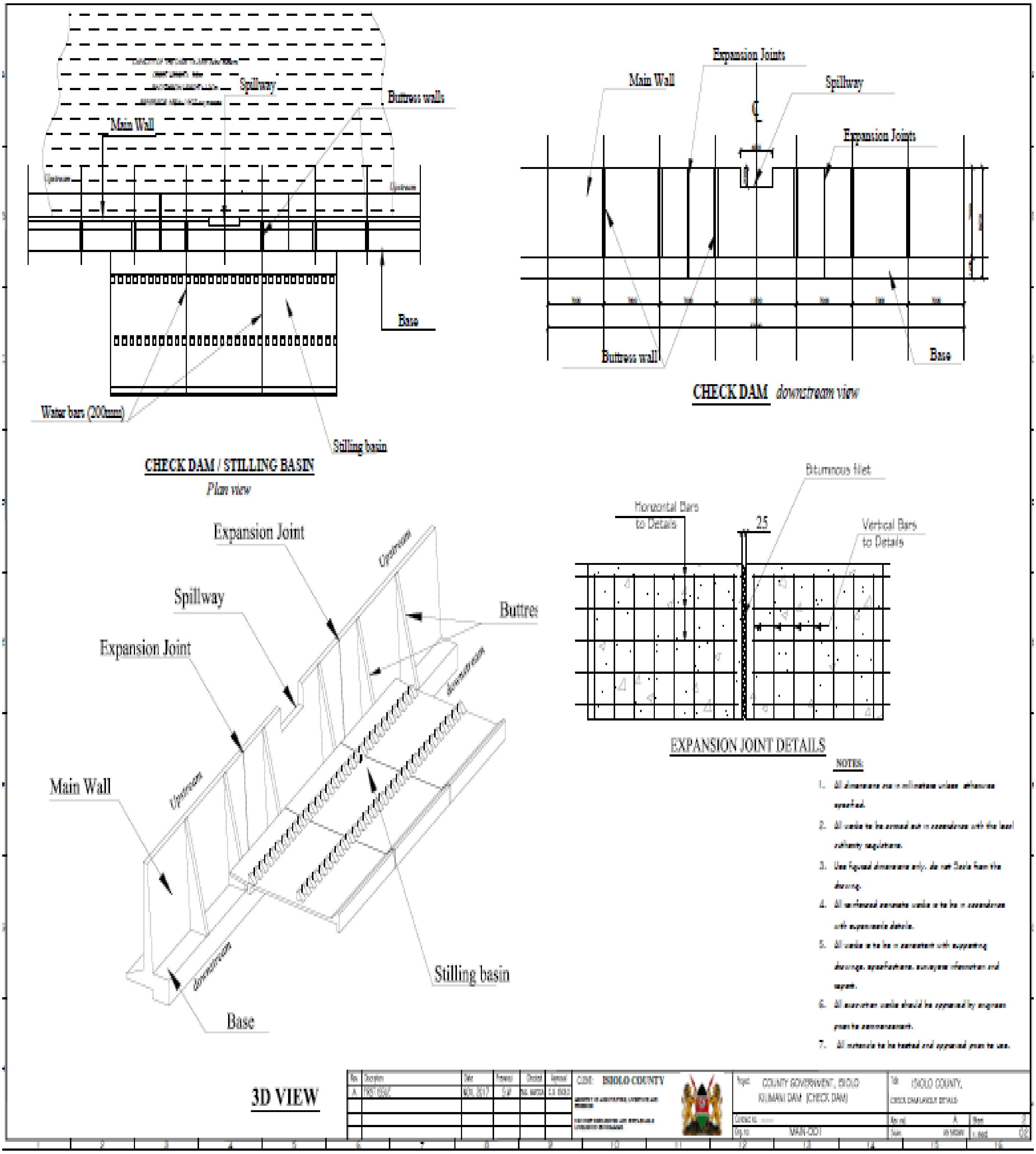
W/d1 = 8.776

Elevation at top of side wall EL. 1860.5 m

Chute block	Height = d1 =	0.100 m	→	0.1 m
	Width = d1 =	0.100 m	→	0.1 m
	Interval of each block = d1 =	0.100 m	→	0.1 m
	Space between side wall = d1/2 =	0.050 m	→	0.05 m

11.1.5 Design drawings




Spillway
Buttress walls
Main Wall
Base
Water bars (200mm)
Stilling basin
CHECK DAM / STILLING BASIN
Plan view
Expansion Joints
Main Wall
Spillway
Expansion Joints
Buttress wall
Base
CHECK DAM downstream view
Bituminous filet
Horizontal Bars to Details
25
Vertical Bars to Details
EXPANSION JOINT DETAILS
NOTES:
Expansion Joint
Spillway
Expansion Joint
Buttres
Main Wall
Upstream
downstream
Stilling basin
Base
3D VIEW
ISIOLO COUNTY
COUNTY GOVERNMENT, ISIOLO
KILIMANI DAM (CHECK DAM)
ISIOLO COUNTY,

11.1.6 Geological and geophysical investigations

REPUBLIC OF KENYA

MINISTRY OF AGRICULTURE, LIVESTOCK AND FISHERIES

DROUGHT RESILIENCE AND SUSTAINABLE LIVELIHOOD PROGRAMME

GEOLOGICAL & GEOPHYSICAL INVESTIGATIONS REPORT

KILIMANI GAME GALANA BUTRESS DAM

KILIMANI SUB-LOCATION, BURRAT LOCATION

ISIOLO CENTRAL SUB-COUNTY

ISIOLO COUNTY

November, 2017

PREPARED BY:-

MINISTRY OF AGRICULTURE,LIVESTOCK AND FISHERIES,

STATE DEPARTMENT OF AGRICULTURE

SUMMARY

Introduction

This report describes the results of geophysical and geological site investigations carried out at the proposed Kilimani Game Galana Buttress dam located in Isiolo Central Sub-County in Isiolo County. This project is being implemented under The Drought Resilience and Sustainable Livelihoods Programme in the Horn of Africa (DRSLP) by the Ministry of Agriculture, Livestock and Fisheries (MALF). The overall goal of the programme is to contribute to poverty reduction, food security and accelerated sustainable economic growth in the Horn of Africa (HOA) through enhanced rural incomes.

Location

The proposed weir dam is located approximately **13.5km** spouth-west of Isiolo town and about **3.6km** off Isiolo-Moyale road. The dam axis is defined approximately by the coordinates:- **37N 336178E, 31370N** (Left bank highest water line) and **37N 336250E, 313431N**. Elevation on either bank is approximated at **1304m** above mean sea level (a.m.s.l.). Administratively the site is located in *Kilimani Sub-Location, Burrat Location, Isiolo Central Sub-County, Isiolo County.*

Physiography

The area can be divided into five physiographic units:- 1) The Nyambene range, 2) the north-eastern slopes of Mt Kenya 3) The north-western Basement System, 4) The Basement System inlier of Mboroko and 5) The Lowlands.

Drainage

The general area is drained by Ewaso Nyiro River. It is a perennial stream acquiring much of its flow from Nyambene range to the south-west and an intricate network of laggas dissecting the country north of its course.

Climate and Vegetation

The climate of the area is hot and dry with two wet seasons, the long rains generally occurring between late March and the end of May, followed by a second rainy season between mid-October and December. Maximum annual temperatures range from 26^0-35^0C and the evaporation rates are in excess of 2400mm/year. Annual rainfall figures range between 280-600mm.

Soils

Soils within the surveyed area are mainly erosion products of contrasting rock types and fall into the following groups:- reddish brown sandy soils, chocolate-brown soils, volcanic soils, calcrete and calcareous sinter, pebbly deposits and alluvial silts.

Geophysics and Results

Resistivity tomography survey was employed to acquire subsurface resistivity distribution. The geophysical resistivity measurements were used to locate the fractured and weathered zones along the dam axis. Depths to the compact layer and the water bearing layer were also determined.

A **40** electrode array was used to obtain resistivity data along the dam axis with **AB/2 =65m.** Data was obtained on **13 datums** and analyzed by means of **RES2DINV** (Loke, 2000) software. The data was inverted with the robust inversion option thus emphasizing geological boundaries.

Conclusions

From the results of geological survey and geophysical (resistance/resistivity) measurements in the project site conclusions have been made on the basis of geophysical interpretation and geological appraisal of the site conditions. It has been established that:-

Lewa river is structurally controlled by a set of faults with a general **N-S** trend

The **Lewa** channel follows the middle sunken graben block

The geology at the site comprises basaltic rock overlying Basement System rocks

The section of Lewa river containing the check dam, reservoir area and the dam axis is entirely located on volcanic rocks.

The right bank at the proposed dam axis location comprises of faulted and jointed basaltic rock cliff which is presumed to be a fault-line.

On the left bank, the fault-line is obscured by an accumulation of blocky basalt but is very distinct about **120m** upstream.

The **Lewa** channel has been in-filled with alluvium admixed with hill-wash/colluvial deposits and volcanic clastic material which varies in size from gravel , through cobbles to massive blocks, thus the relationships between various rock and soil components within the channel is quite complex

The right abutment has good anchorage rock for a buttress dam; the left bank requires stripping of colluvial accumulation to expose the foundation rock .

Two anomalous zones were identified near the fault-zones on either bank and were interpreted to be water saturated silty to clayey zones.

- The fault line zones were partially resolved by the survey and show possible seepage loss paths.

Both abutments are formed of sound basalt rock.

Inside the channel, sound rock was not detected on the right half of the axis. On the other left half of the axis sound rock occurs at a depth of about **8m** above it are weathered horizons with blocky jointed basalt.

Due to variable characteristics of materials at the foundation, differential settlement may adversely affect the dam.

The seismicity of the area is in **Zone IV** (very strong) hence the design of the weir dam must take this into consideration.

The presence of fault-lines and the seismicity classification of the area should inform the design criteria in the event of any tectonic events.

A buttress dam can be constructed on this site further detailed geotechnical and materials strength investigations to check conformity of the materials to design standards for a buttress dam.

Recommendations

The following recommendations are hereby made before construction of the proposed buttress dam:

(1) Exploratory drilling is recommended at locations indicated by **BH1**, **BH2** and **BH3** to a depth not exceeding **30m bgl**. This will confirm the integrity of the foundation at anomalous zones delineated by the geophysical survey and at the faultlines. The coordinates of the borehole locations are:

   (a) **BH1:** 0° 17.006'N; 37° 31.714'E
   (b) **BH2:** 0° 17.009'N; 37° 31.702'E
   (c) **BH3:** 0° 17.014'N; 37° 31.681'E.

   The analysis of drill samples will enable appropriate remedial measures to control seepage losses to acceptable levels.

(2) Geotechnical testing of strengths of foundation materials is also recommended
(3) Rock formation at the abutments is jointed and should be treated appropriately to minimize seepage
(4) At the interpreted, fault-lines seepage losses may be considerable hence appropriate cut-offs should be instituted to curb the losses.
(5) Additional detailed geophysical measurements are recommended to cover other parts of the dam not covered by the present study.

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ABBREVIATIONS (All S.I Units unless indicated otherwise)

agl	above ground level
amsl	above mean sea level
bgl	below ground level
E	East
HEP	Horizontal Electrical Profiling
m	metre
N	North
S	South
Sec	second
VES	Vertical Electrical Sounding
W	West
^{o}C	degrees Celsius: Unit for temperature

GLOSSARY OF TERMS

Alluvium: General term for detrital material deposited by flowing water.

Aquifer: A geological formation or structure, which stores and transmits water and which is able to supply water to wells, boreholes or springs.

Fault: A larger fracture surface along which appreciable displacement has taken place.

Gradient: The rate of change in total head per unit of distance, which causes flow in the direction of lowest > head.

Heterogeneous: Not uniform in structure or composition.

Hydraulic head: Energy contained in a water mass, produced by elevation, pressure or velocity.

Hydrogeological: Those factors that deal with sub-surface waters and related geological aspects of surface waters.

Infiltration: Process of water entering the soil through the ground surface

Joint: Fractures along which no significant displacement has taken place.

Percolation: Process of water seeping through the unsaturated zone, generally from a surface source to the saturated zone.

Peneplain: A level surface, which has lost nearly all its relief by passing through a complete cycle of erosion (also used in a wider sense to describe a flat erosional surface in general)

Permeability: The capacity of a porous medium for transmitting fluid.

Piezometric level: An imaginary water table, representing the total head in a confined aquifer, and is defined by the level to which water would rise in a well.

Porosity: The portion of bulk volume in a rock or sediment that is occupied by openings, whether isolated or connected.

Recharge: General term applied to the passage of water from surface of sub-surface sources (e.g. rivers, rainfall, lateral groundwater flow) to the aquifer zones.

Lineament: A linear feature which expresses itself in terms of the underlying structural features such as valleys controlled by faulting and jointing.

Flexure: A bending or curving that appears on the earth surface.

1. INTRODUCTION

1.1 Back ground

This report summarizes the results of geological survey and geophysical resistivity investigations at the proposed buttress dam across Lewa river . The results of the investigations will be used to determine the weak points in the proposed dam site which need to be treated appropriately to ensure stability and longevity of the dam.

1.2 Objectives of the Survey

The objective of the study is to determine the physical properties of the dam site and validate the design, and if necessary adjust some of the design parameters in concordance with the interpretation results of the measured and interpreted geo-electric values with respect to geology and structure.

2. BACKGROUND INFORMATION

2.1 Location

The proposed weir dam is located approximately **13.5km** spouth-west of Isiolo town and about **3.6km** off Isiolo-Moyale road. The dam axis is defined approximately by the coordinates:- **37N**

336178E, 31370N (Left bank highest water line) and **37N 336250E, 313431N**. Elevation on either bank is approximated at **1304m** above mean sea level (a.m.s.l.). Administratively the site is located in *Kilimani Sub-Location, Burrat Location, Isiolo Central Sub-County, Isiolo County.*

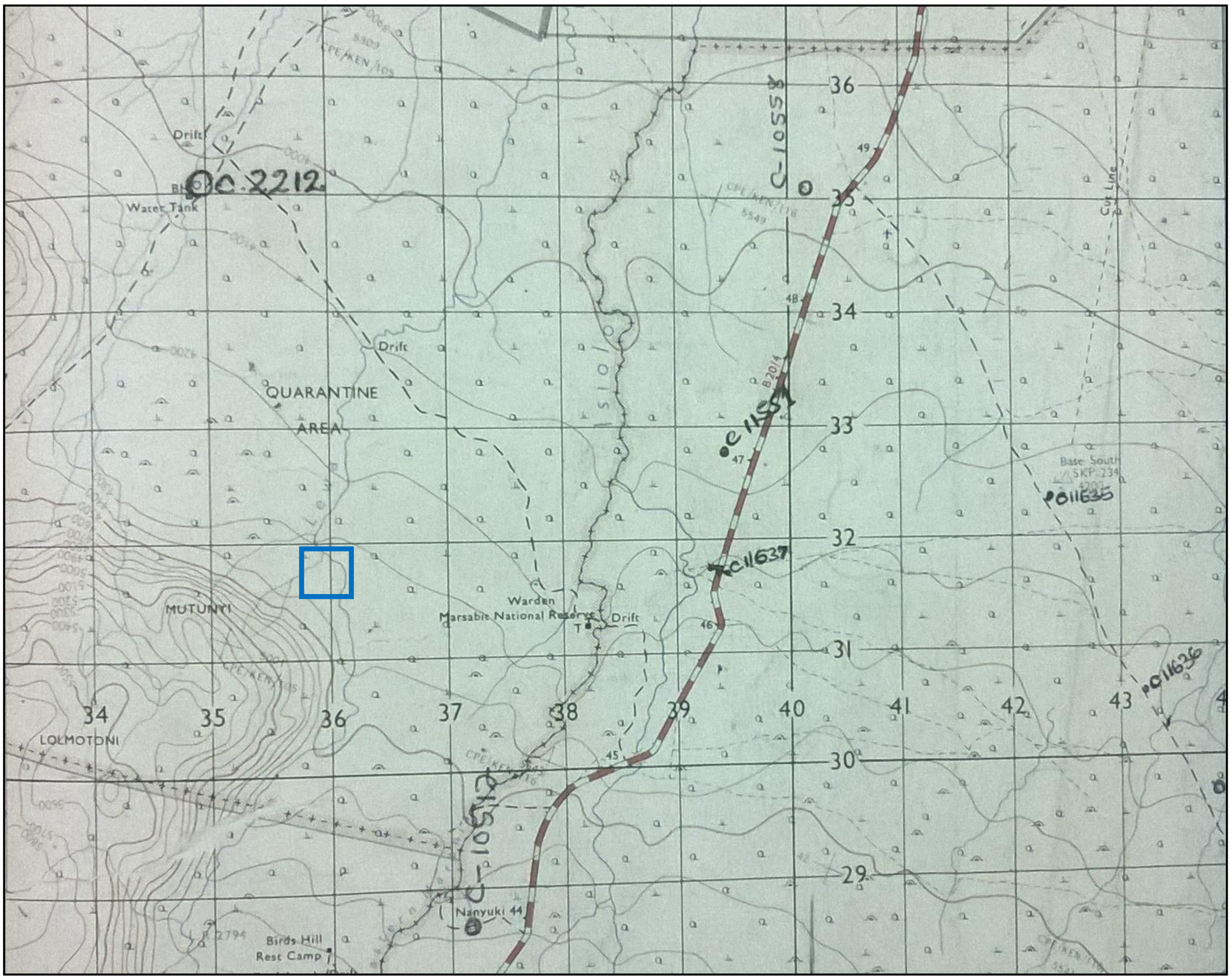


Figure 2: General Location Map of the Investigated Area (1:50,000). Dam location is marked with a box.

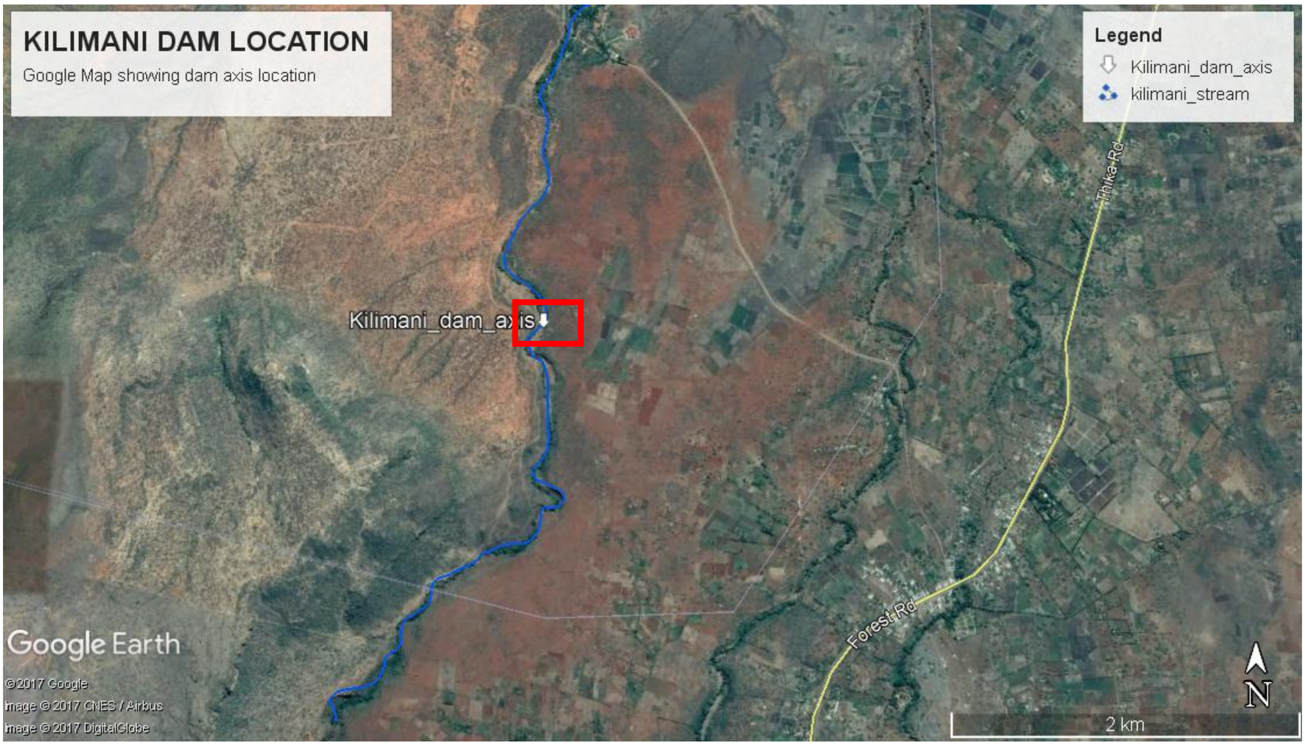


Fig-2:- Google map extract showing the location of Location of Kilimani Dam Axis marked in red box.

2.2 Physiography

The area can be divided into five physiographic units:-

1) The north-eastern slopes of Mt. Kenya
2) The Nyambene range
3) The north-western Basement System monadnocks/inselbergs
4) The Basement System inlier of Mbokoro
5) The Lowlands

.

(1) The south-western part of the study area lies at the foot of Mt. Kenya (5325m a.m.s.l.) varying in altitude between 1400-2800m a.m.s.l. Parasitic cones are found on the lower foothills of Mt. Kenya.
(2) The Nyambene volcanic range is elongated in a north-east to south-west direction from the foothills of Mt. Kenya and rises to an elevation of 2200m amsl. The range is basically comprised of an accumulation of extrusive rocks ranging in composition from basic, alkali to intermediate. Terminal lavas form serrated outline features .
(3) The Basement System monadnocks of Lengishu and Lolmotoni in the north-west are the southern-most extensions of a discontinuous zone of mountains, which includes the Ngurie hills, Uaraguess and the Matthews range and trends approximately north-south. The gneiss hills near Isiolo have been eroded down to about 1800m amsl lower than end-Cretaceous peneplain which lies at approximately 2200m to 2340m.
(4) The Mbokoro inlier of quartzo-felspathic gneisses rising to over 625m above the surrounding lava and float covered lava lowlands are relics of another discontinuous zone of hills trending approximaterly north-south direction. The top of these hills are relics of end-Cretecious peneplain.
(5) The lowland areas are either lava or float covered. With the lower Nyambene basalts extending over a far greater area than the Mt. Kenya volcanics. Figure 3 summarizes the Physiography.

2.3 Drainage

The drainage pattern is essentially determined by three major factors:

(1) The north-eastern slopes of Mt. Kenya
(2) The north-east to south east water shed of the Nyambene range
(3) The structures in the Basement System

A radial drainage system is developed on Mt. Kenya volcanic shield with deep steep sided valleys. Tana river receives much of the drainage from the eastern slopes of Mt. Kenya and the southern flanks of Nyamabene range.

Streams and rivers flowing from the Nyambene watershed have general north-west to south-east trend, flowing essentially at right angles to the elongation of the range.

The drainage of the Basement System areas is generally controlled bu dip joints and by the strike of the rocks. The phenomenon of streams flowing at right angles to the strike of Basement rocks is coomon in Embu-Meru area. The main River Isiolo flows northwards along the foot of Basement System hills. The drainage of Mbokoro is essentially radial though there is a tendency for streams to follow the dip and strike directions.

In summary, most of Isiolo County is drained by the Ewaso Ngiro and its tributaries . A small portion to the south is drained by Tana River. The Ewaso Ngiro forms the Isiolo/Laikipia boundary from the junction and then the

2.4 Climate

Isiolo County falls into three agro-climatic zones namely:- semi-arid, arid and very arid. The semi-arid zone is at the surroundings of Isiolo Town and receives an average of annual rainfall of about 400-650mm. The arid zone extends from Barsalinga area to Archer's Post-Garba Tula areas and receives an average rainfall of about 300-350mm. The very arid zone covers Malka Galla, Merti, Sericho and Modo Gashe areas receiving an average annual rainfall of about 150-250mm. The mean annual temperatures ranges between 24 and 30^0C.

2.5 Vegetation Cover

All ground below 1500m amsl supports a poor thorn scrub , mainly species of acacia with succulents and larger trees only along water courses. Above 1500m and with increasing rainfall, patches of indigenous forest still remain. These are interspersed with rolling grassy plains, which have resulted from forest clearing though some may have been original. In forested areas, soil cover is thick, however in the lower areas, soil is thin or absent due to poor vegetation cover due to aridity and overgrazing. Soil erosion on the lower areas has been accelerated by this state of affairs.

The project area lies about 1300m amsl and is largely covered by indigenous thorn scrub and a host of other flora. Dessert palms are common along the river courses and where water tables are relatively shallow.

2.6 Soils

(a) Pleistocene

These mainly occupy NW, W and SW of Isiolo and exceeds 10m as can be observed along river courses. The following succession has been observed:

(4) False bedded, consolidated poorly graded arenaceous deposit

(3) Rhythmical deposits of friable shales

(2) Red-brown argillaceous soil

(1) Vesicular porphyritic basalt

The investigated area lies largely on these deposits which were probably laid down as a result of torrential conditions during the upper Pleistocene times. There is evidence that further Recent material was deposited from Basement hill-wash. Rivers that cut through the area have alluvial deposits in their channels.

(b) Recent

Recent soil deposits consist of soils and kunkar limestones. Soil types depend on (a) the distribution of rainfall, (b) the underlying geology, and (c) the drainage conditions. In volcanic areas with high rainfall, thick fertile red-brown to dark-brown soils and sub-soils have developed. This is common around the foot-slopes of Mt. Kenya and Nyambene range.

An impure superficial limestone known as kunkar has developed over drier parts of the County. This is as a result of dry leaching in lime rich soils.

Around Basement areas typical pale reddish, sandy granular soils occur. To the west of Isiolo, these deposits obscure the contact between lower Nyambene volcanics and the Basement rocks. Lewa river on which the current dam is proposed roughly follows this contact.

(2) Soils cover on study area

(iii) Banks

On both bank along the proposed dam axis, the country rock is exposed and is either bare or has a shallow cover of sandy stony soils. Beyond the bank and away from the river channel the soils are more developed. Figure 4 show soil cover on both banks.

(iv) Lewa river channel

The Lewa river channel is filled with a thick alluvial deposit, being thickest in the middle and thinning out towards the banks where the country rock is exposed. The alluvial deposits are an admixture of sands, silts and volcanic rock fragments. Stratification of the deposits was observed reflecting depositional episodes during floods. This is exemplified in figure 5.

.

Fig 3.: Stony soils on basalt on the right bank in the foreground of the picture. The left bank in the background shows a thick layer of bouldery volcanic material probably overlying jointed basaltic rock. The approximate orientation of dam axis is shown by yellow double arrow.

Fig 4:- Sandy alluvium Lewa channel-fill in the reservoir area. Inset shows 2m thick soil profile in the excavated section of the reservoir.

(v) Reservoir area

The reservoir area is also dominated by stony soils derived from the host rock on either bank and the alluvium filled river channel.

3. GEOLOGY AND HYDROGEOLOGY

The geology of the investigated area is described in the Report No 103 titled: The geology of the Isiolo area by Ministry of Environment & Natural Resources (Mines and Geology Department),1989. The report describes an area bounded by 1^0 00' N and longitudes 37^0 00' and 38^0 30'E.

3.1 Regional Geology

Much of the area is underlain by Precambrian Basement System. The Basement System rocks are predorminantly outcropping in the furthest end of the western arm of the Sub-County and also in the areas to the west and south of Merti plateau.The south-west of the County is mainly covered by volcanic flows which spread from a multitude of parasitic cones of Mt. Kenya and Nyambene volcanic centres.

The Basement System rocks include different types of gneisses and schists, crystalline limestones, quartzites, migmatites and granulites, locally affected by different types of intrusions. Sedimentary rocks found in the County are sandstones, limestones, marls , shales, conglomerates, grits, sands, clays, and gravels. The volcanic rocks include basalts and pyroclastics deposits.

3.2 Stratigraphy

The rock formations in can be divided into seven groups:-

Basement System …………………………………………………………….Precambrian

Metamorphosed basic and ultrabasic intrusives and associated leucocratic rocks……………………. Precambrian

Dykes …………………….Precambrian and Tertiary/Pleistocene

Merti beds…………………Tertiary

Limestone and clays………….Lower Pleistocene

Volcanic rocks………………..Tertiary to Pleistocene

Superficial deposits……………Quaternary

The project area lies on the Tertiary Volcanic rocks and will be discussed in the following sections.

3.3 Geology of the Investigated Area

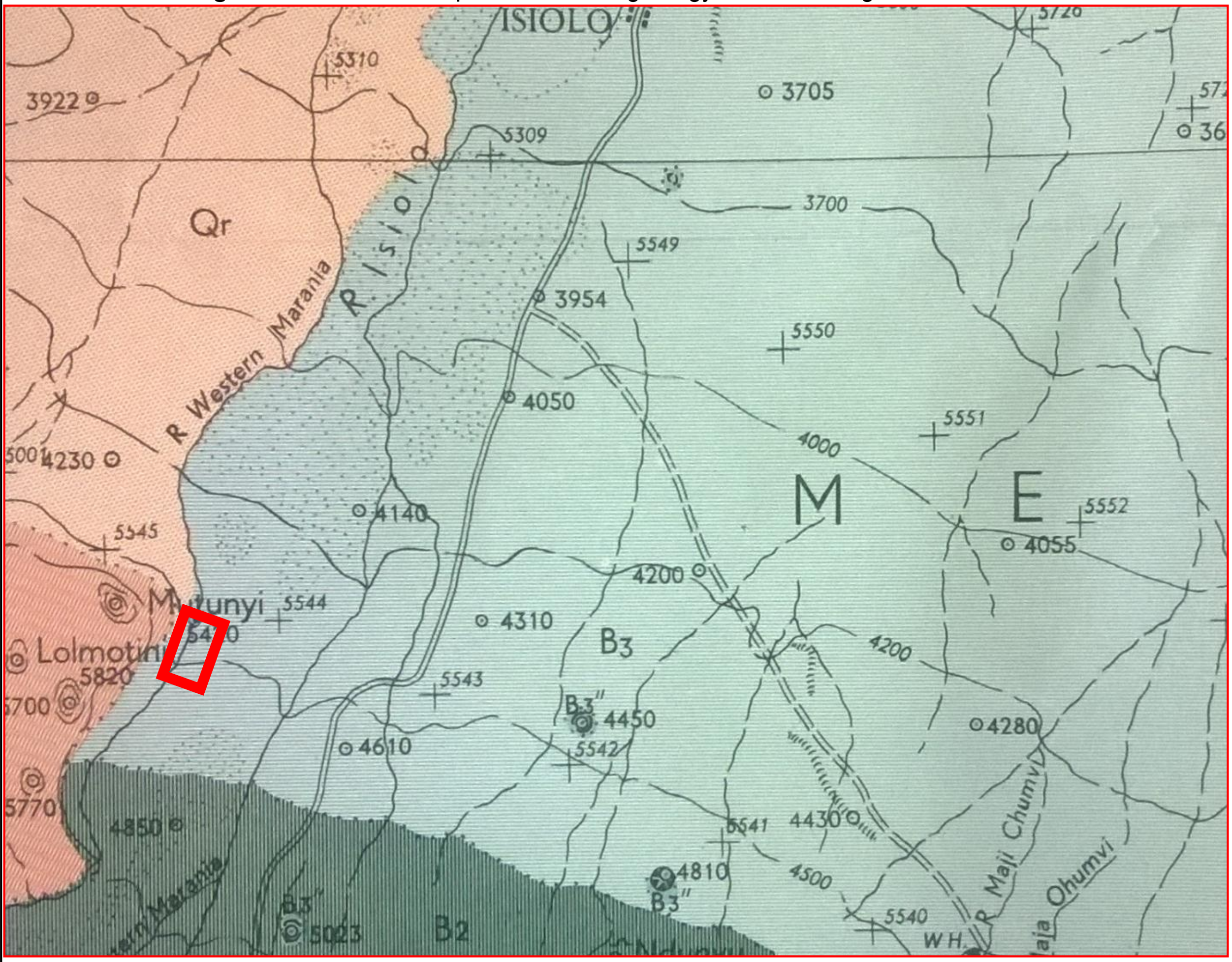
The dam axis is located along a narrow section of the Lewa River valley. The cross section along the designed dam axis shows an assymetrical U-shaped profile.

Geology around and on the proposed intake weir is dominated by:-

(vi) Pleistocene Lower Nyambene basalts which occupy east of Lewa River

(vii) Basement System of rocks comprising quartz-feldspar gneisses and schists covered with red sandy soils to the west of Lewa River.

Figure 6 shows a map extract of the geology of the investigated area.



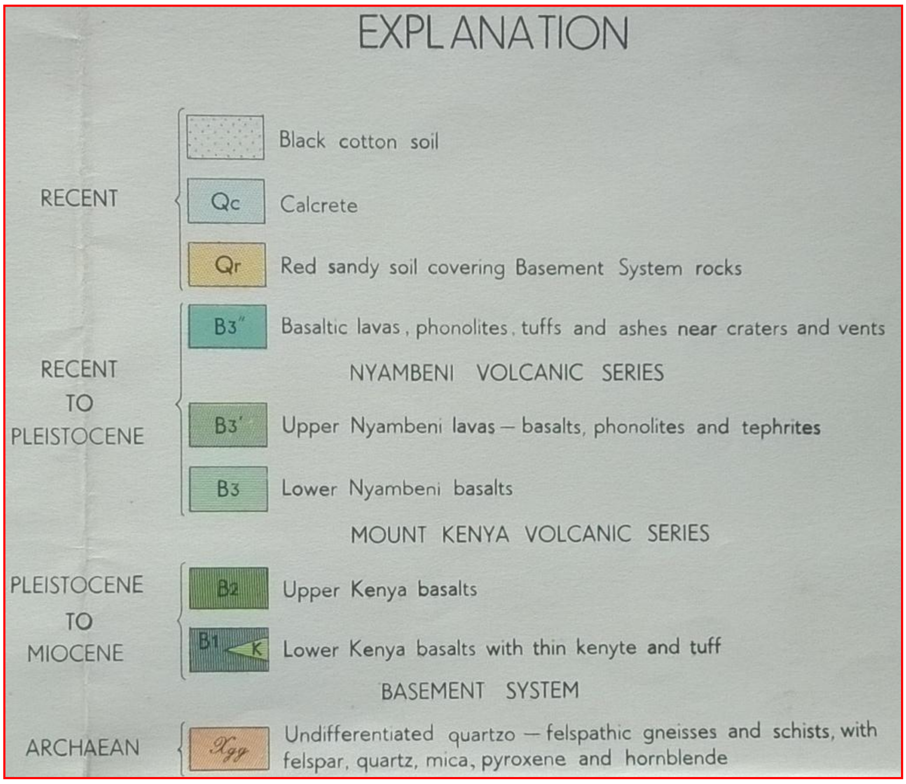


Figure 5 Map extract showing the geology of the investigated area. The position of the proposed weir is marked by a red box.

(i) Geology of the right bank

The right bank of the study area is comprised of the Lower Nyambene basalt overlying a rock suite of the Basement System of rocks at depth. At outcrop level, on the proposed dam axis on the right bank, an almost vertical cliff of basalt rock was observed as shown on figure 7.

Figure 6:- Basalt cliff on the right bank of Lewa river around the dam axis. The rock exhibits moderate jointing.

(ii) Geology of the left bank

Rock exposures on the left bank are similar to those on the right bank in composition except for a thick bouldery accumulation probably overlying jointed basalts at depth. The formation comprises of rock breccia of various sizes admixed with soils. This brecciation may be related to mass movement due to wetting. **Figure 10** shows rock exposures on the left bank over the dam axis. The boundary with Basement rocks is further to the west.

Figure 7 Blocky basalt formation on the right bank. The rock fragments are admixed with sandy soils.

(iii) Geology of the channel

The Lewa channel is in-filled with a thick layer of alluvium and colluviums. These are presumed to overlie basalts at depth. The deposit is presumed to comprise of crudely stratified mixture of sands, silts, clays , cobbles and bouldery float blocks of basaltic composition.

3.4 Hydrogeology

Two aquifer systems are recognized for the area, viz. regional aquifer systems allowing continuous groundwater flow over large areas, and localized aquifer systems with isolated groundwater pockets the surroundings.

(iii) Regional aquifer systems

These are composed of Tertiary marine sedimentary and volcanic rocks. The first aquifer system comprises pervious sedimentary rocks ie sands , gravels, pebbles, sandstones and basalts. These rocks cover the Basement rocks in a large part of eastern Isiolo. They are sporadically overlain by volcanic rocks.

The second category of aquifer system consists of fissured and weathered volcanic rocks with interbedded sediments (paleosols, lucustrine deposits, and pyroclastics) between lava flows. These rocks overlie in the central western part of Isiolo County.

The regional aquifer system is an important recharge source for the Ewaso Nyiro river.

(iv) Local aquifer systems

This system is made up of fissured and weathered Basement and sedimentary deposits. The fissured Basements forms pockets of isolated groundwater bodies. These pockets are scattered all over the Basement areas and also occur at the interface of the Basements and the overlying sedimentary or volcanic rocks.

Local sedimentary deposits comprise fluviatile deposits, lucustrine deposits and deposits of other origins. Groundwater in these deposits is isolated from that in other aquifer systems by impervious layers of clay or rock. Important system exist in flood plain deposits of Ewaso Nyiro and limestones in Garba Tula.

3.5 Structural Features

No major structural features have been indicated on geological maps except for a northerly pitching anti-clinal axis with dips only recorded west of Isiolo (Mason, 1954). Recently published geological map of the area indicates major faults in both the Basement System rocks and sedimentary rocks.

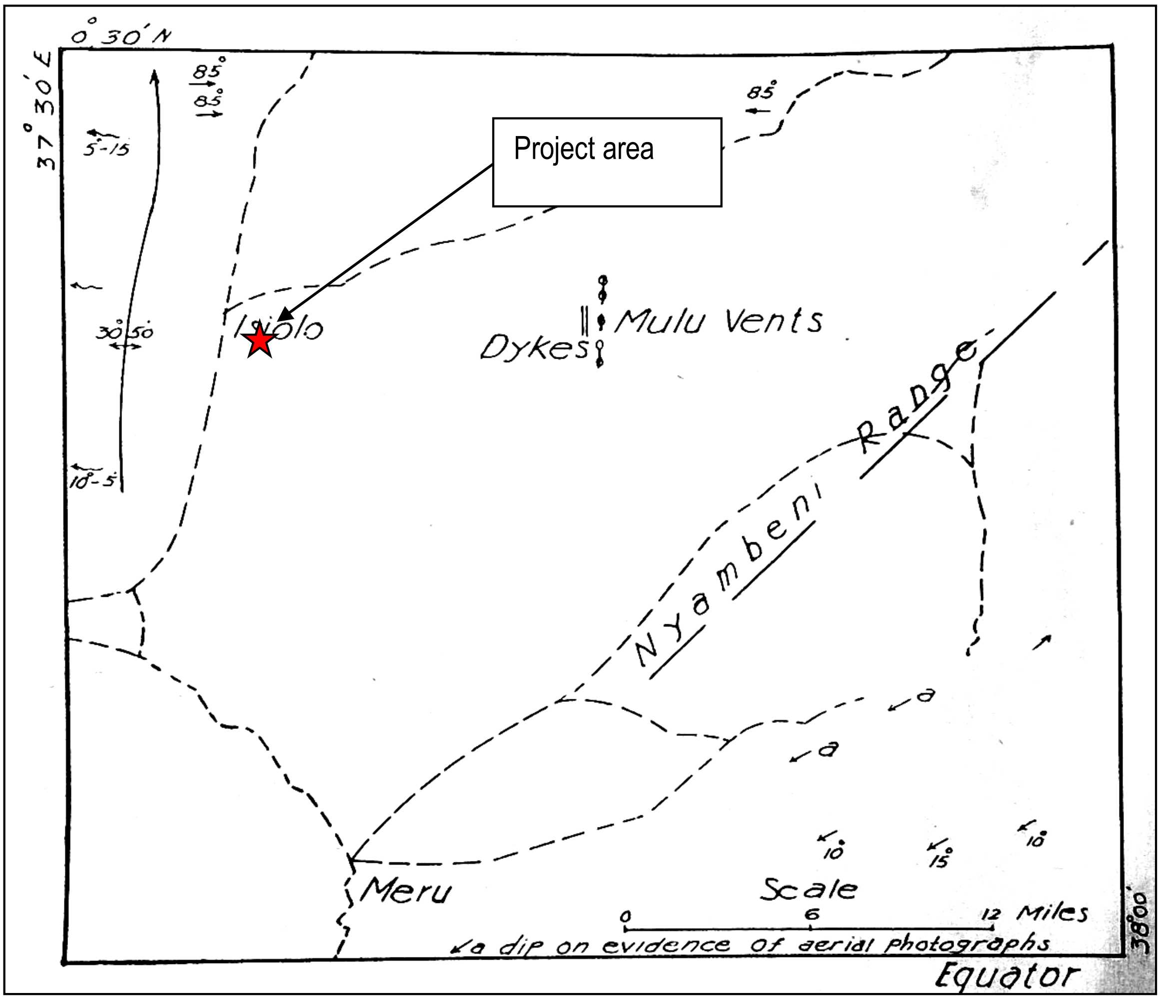


Figure 8:- Detailed structural map of the study area. Most structural features are obscured by sediments and lavas.

3.6 Analysis of structural elements of the study area

(iii) Faults

There is evidence on the ground that Lewa channel is structurally controlled by faults that define the direction of the river channel. Two vertical cliffs characteristic of faulting event were observed on either bank around the dam site. Figure 16 shows the faultlines as mapped from Google maps.

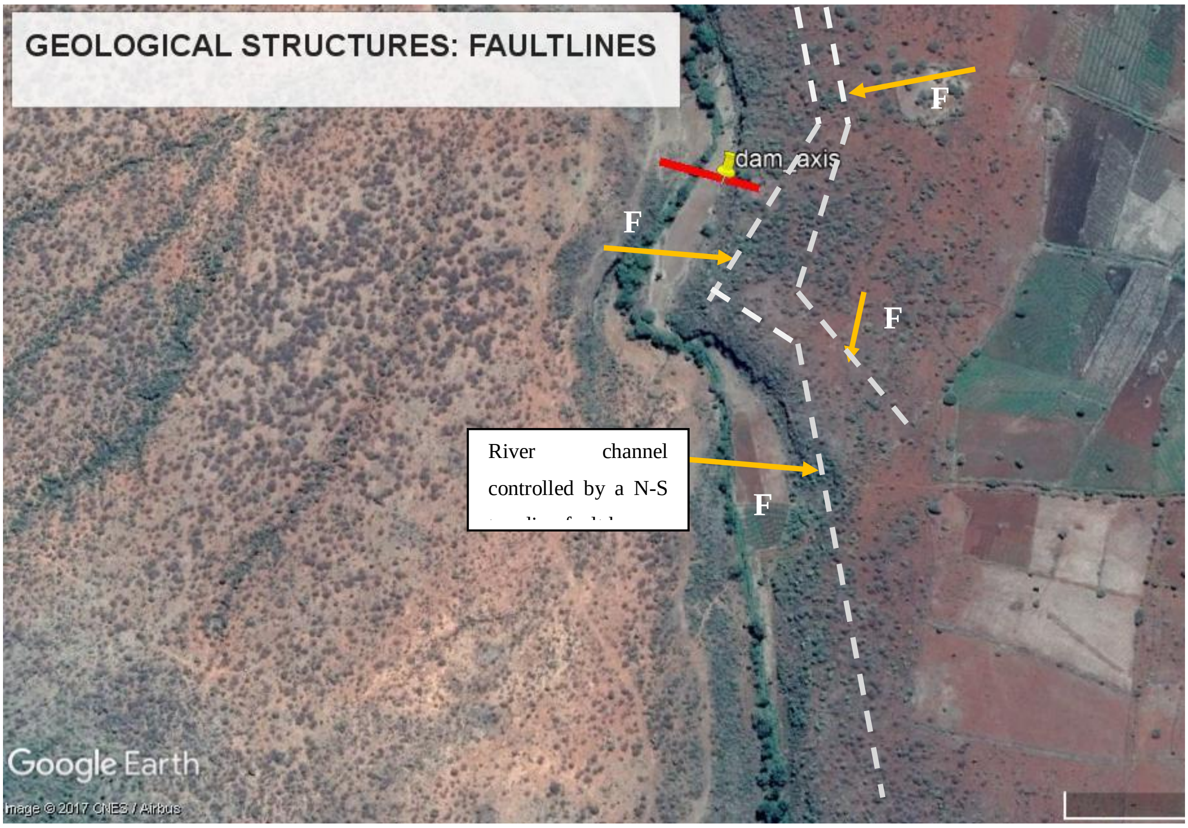


Figure 9:- Geological structure around the proposed dam

It is deduced that both banks define the up-throw sides with a central sunken graben block like a miniature rift valley along which Lewa has curved its channel. Consequently the sunken block has been covered by both alluvial and colluvial sediments. Basalt blocks transported from upstream fall-blocks are embedded in the alluvium.

(iv) Joints

Rocks exposed over the dam axis and reservoir area have significant jointing which does not have any specific orientations. The joints are deduced to be shrinkage joints upon cooling of lava.

Figure 10 :- Jointed basalt rock on the left bank. White arrows show he joints

NB: These joints may allow seepage losses from the dam and hence require to be sealed if identified.

4. SEISMICITY

The seismicity of the project area may be assessed from existing reports. The geology of the area is dominated by tertiary volcanics east of the Rift valley where faulting is present. This is an area known to be tectonically active. In the seismic zoning map of Kenya (Loupekine , 1971), the proposed dam lies in **zone VI** in the Modified Marcalli (Figure-7). Scale of earthquake intensities as summarized on **Table-1**. The project area is approximately shown on the figure. Acceleration (g) on zone V is 0.02-0.05 which should form the basis of design criteria.

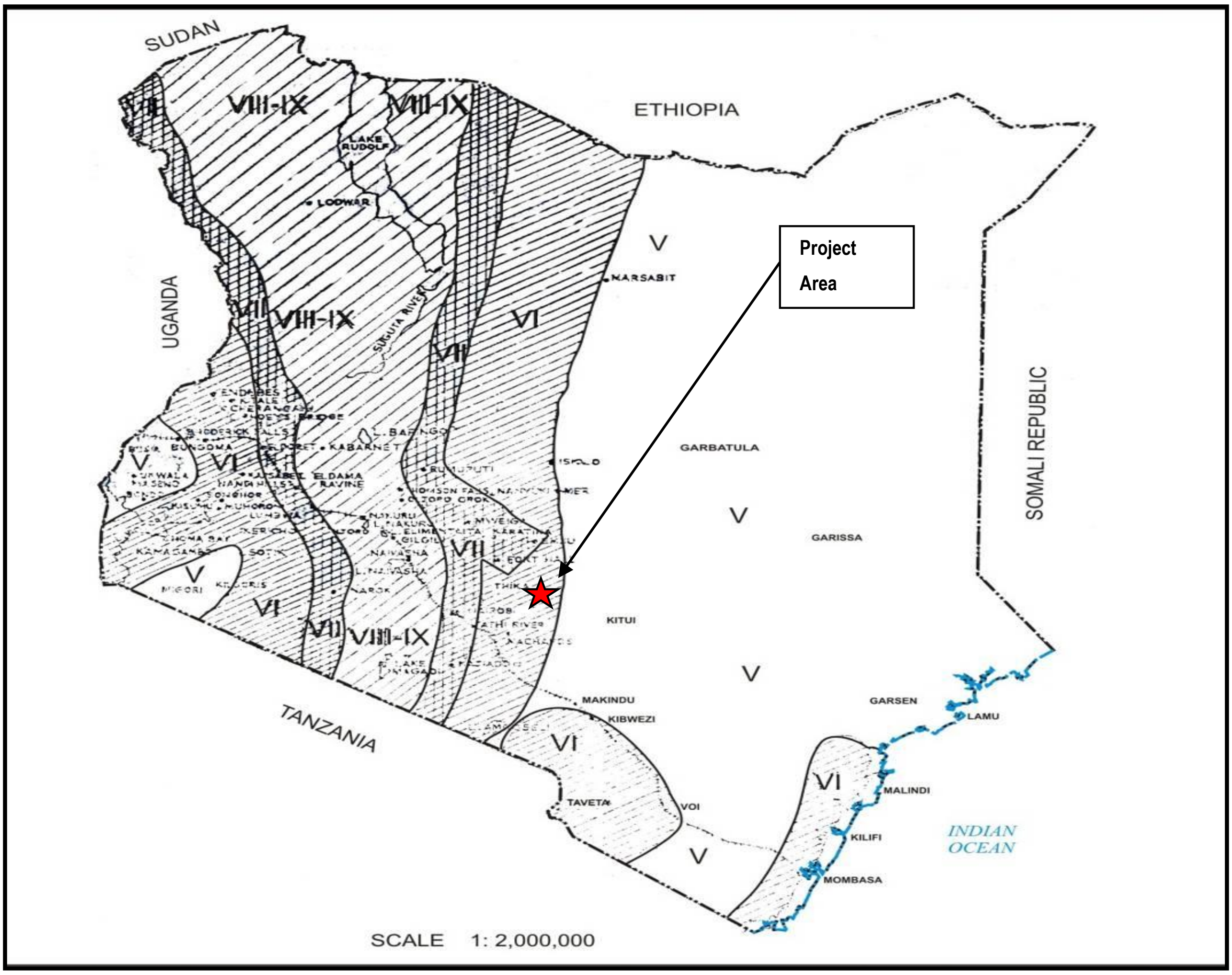


Figure 11:- Seismic Zoning Map of Kenya (I. S. Loupekine, 1971)

Table 1: Modified Mercalli Scale (1956) of Intensities

Intensity Zone	Descriptive Term	Effects	Acceleration (cm/s^2)	Acceleration (g)
I	Imperceptible	Not felt. Registered only by seismographs.	< 1	< 0.001
II	Very slight	Felt in upper storeys solely By persons at rest.	1 – 2	0.001 – 0.002
III	Slight	Felt indoors. Vibrations like those caused by light trucks passing by.	2 – 5	0.002 – 0.005
IV	Moderate	Hanging objects swing. Vibrations like those caused by heavy trucks or a jolt such as that occasioned by a heavy object striking the wall. Parked cars are set in seesaw motion. Windows, doors and crockery rattle.	5 – 10	0.005 – 0.01
V	Fairly Strong	Felt outdoors. Sleeping persons wakened. Small objects not anchored are displaced or overturned. Doors open and close. Shatters and pictures are set in motion. Pendulum clocks stop and start or change their speed.	10 – 20	0.01 – 0.02
VI	Strong	Walking is made difficult. Windows, crockery and glass break. Knick-knacks, books, etc. fall off shelves; pictures fall from wall. Furniture moves or is overturned. Cracks in weak plaster and materials of construction Type D. Small bells ring (church, school).	20 – 50	0.02 – 0.05
VII	Very Strong	Noticed by car drivers and passengers. Furniture breaks. Materials of construction Type D sustain serious damage. In some cases, cracks in materials of construction Type C. Weak chimneys break at roof level. Plaster, loose bricks, stones, tiles, shelves collapse. Waves created on ponds.	50 – 100	0.05 – 0.10
VIII	Destructive	Steering of cars made difficult. Very heavy damage to materials of construction Type D and some damage to materials of Type C. Partial collapse. Some damage to materials of Type B. Stucco breaks away. Chimneys, monuments, towers and raised tanks collapse. Loose panel walls thrown out. Branches torn from trees. Changes in flow or temperature of springs. Changes in water levels of wells. Cracks in moist ground and on steep slopes.	100 – 200	0.10 – 0.20
IX	Highly Destructive	General panic. Materials of construction Type D completely destroyed. Serious damage to materials of Type C, and frequent collapse. Serious damage also sustained by materials of Type B. Frame structures lifted from their foundation, or they collapse. Loadbearing members of reinforced-concrete structures are cracked. Pipes llying below ground burst. Large cracks in the ground. In alluvial areas, water, sand and mud ejected.	200 – 500	0.20 – 0.50
X	Extremely Destructive	Most masonry and wooden structures destroyed. Reinforced steel buildings and bridges seriously damaged; some of them destroyed. Severe damage to dams, dykes and weirs. Large landslides. Water hurled onto the banks of canals, rivers and lakes. Rails bent.	500 – 1000	0.50 – 1.00
XI	Disaster	All structures collapse. Even large, well constructed bridges are destroyed or seriously damaged. Only a few buildings remain standing. Rails greatly bent and thrown out of position. Underground wires and pipes break apart.	1000 - 2000	1.00 – 2.00
XII	Major disaster	Large-scale changes in the structure of the ground. Overground and subterranean streams and rivers change in many ways. Waterfalls are created, lakes are dammed up or burst their banks. Rivers alter their courses.	> 2000	> 2.00

Construction method A: Good workmanship, mortar and design; reinforced especially laterally, and bound together using steel, concrete, etc.; designed to resist lateral forces.
Construction method B: Good workmanship and mortar; reinforced but not designed to resist strong lateral forces.
Construction method C: Ordinary workmanship and mortar; no extreme weaknesses such as failing to tie in at corners, but neither reinforced nor designed to resist horizontal forced.
Construction method D: Weak materials such as adobe; poor mortar, low standards of workmanship; horizontally weak.

In accordance to available data on earthquake parameters, other areas with similar geological setting have applied the following design parameters:

Turkwell Dam:

Design Basis Earthquake (DBE): a_{max} = 0.2g;

Maximum Credible Earthquake (MCE): a_{max} = 0.45g.

Chemususu Dam:

Design Basis Earthquake (DBE): a_{max} = 0.22g;

Maximum Credible Earthquake (MCE): a_{max} = 0.50g.

As a rule of the thumb, a design basis earthquake (DBE) loading of a_{max} = 0.20g and maximum credible earthquake (MCE) of a_{max} = 0.35g can be applied in stability analysis during the designing of Kilimani buttress dam.

Consideration is also made on other earthquake factors that may have influence on dam stability, namely close proximity to earthquake epicentres and the historical background of earlier earthquakes. The distribution of earthquake epicentres in Kenya is shown on **Figure 8.**

Other considerations are the effects of the filling of dams: in a number of reported cases the filling of dam reservoirs has resulted in induced seismicity. The mechanism behind induced seismicity is generally thought to be:

The triggering effect of additional stresses from the weight of the water, and

The reduced friction along faults because of increased pore water pressure.

Historical data have shown that no induced earthquake of magnitudes greater than 5 have occurred for dams lower than 100m height. The filling of the dam of 18m crest height is not expected to result in induced earthquake.

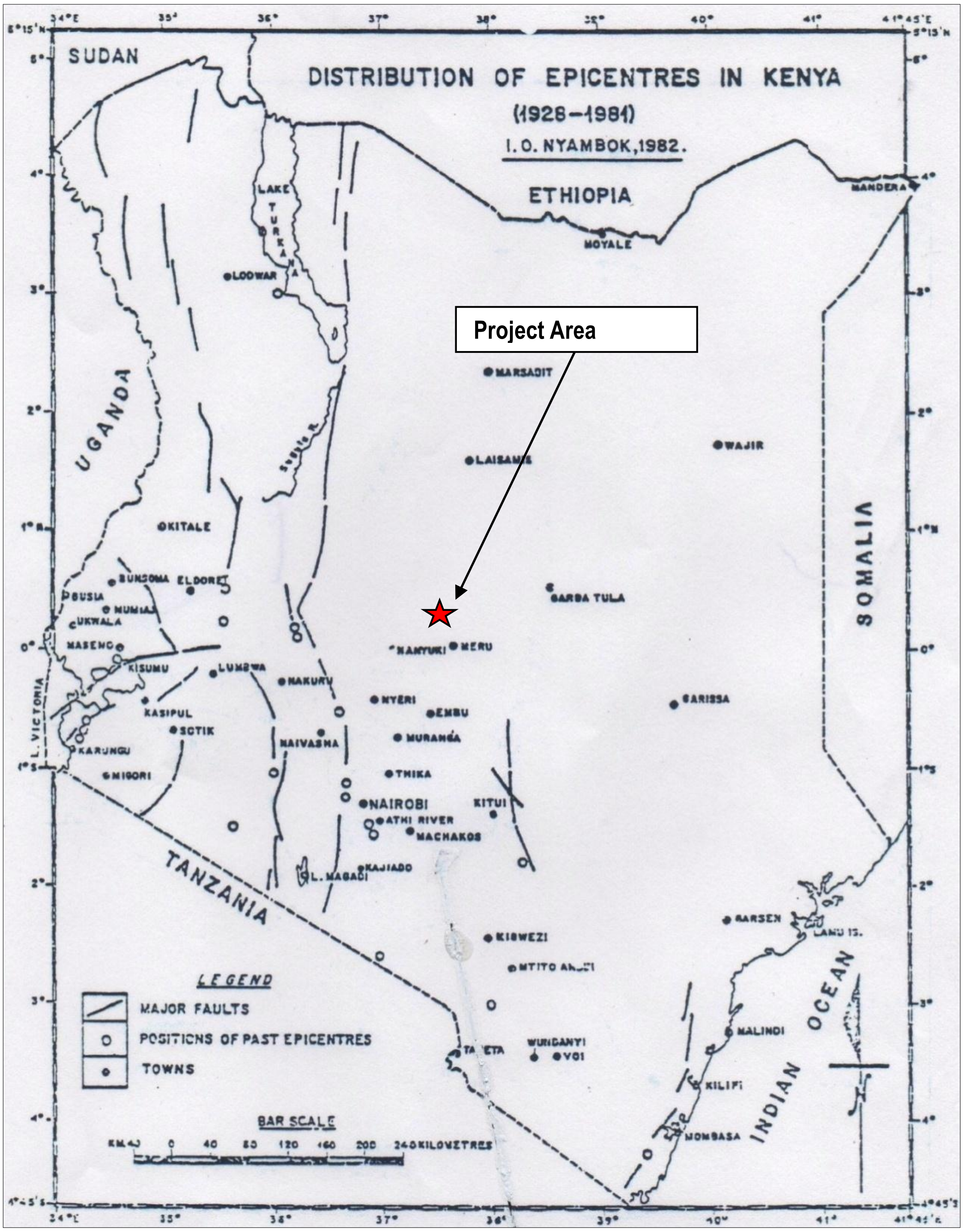


Figure 12: Distribution of Earthquake Epicentres in Kenya (I. S. Nyambok, 1982)

o - Epicentre

5. GEOPHYSICAL INVESTIGATION METHODS

A great variety of geophysical methods are available to assist in the assessment of geological subsurface conditions. In the present survey the geo-electrical method was used. Investigations of the electrical resistance at the project area included the use of geophysical techniques to probe the sub-surface. The main emphasis of the fieldwork undertaken was to determine the electrical resistance of the underground rock to locate the weathered zones, fault lines and other weak points that need to be appropriately treated to enhance water retention in the dam to ensure sound anchorage of the buttress dam..

This information was principally obtained in the field by means of signal averaging system (SAS) earth resistivity equipment model **No SSR-MP-ATS.**

5.1 Resistivity Method

The VES and HEP measurements were carried out to probe the condition of the sub-surface. The VES investigates the resistance and resistivity layering below the site of measurement while the HEP gives the lateral resistance variation at a particular depth below the ground surface. This technique is described below.

5.2 Basic Principles

The resistivity of earth materials can be studied by measuring the electrical potential distribution produced at the earth's surface by injection of low frequency electric current. Two fundamental considerations are the basis of the theory behind galvanic resistivity methods viz:-

(1) Ohm's law :

$$\mathbf{E} = \rho \mathbf{i}$$

Where: **E** = Potential gradient (**Volts per meter**)

i = Current density (**Am^{-2}**)

ρ = Resistivity of the earth medium(**Ω-m**)

(2) The divergence condition for the current flux into the ground:

$$\Delta \times i = 0$$

It follows from above that the potential function **V** for a single point source at a distance of **r** meters on the earth's surface is given by:

(i) $V_r = \rho I/2\Pi r$ (Volts)

In hydro geological field surveys using galvanic Resistivity methods the quantities measured are current **I**, flowing between two electrodes **A** & **B** and potential difference **ΔV** between two measuring points **M & N.** The following relationship applies to various electrodes configurations.

(ii) $\rho = K \times \Delta V/I_{AB}$ (Ω-m)

Where K is defined as the geometrical factor derived from electrode configuration adopted. The most common field arrays are the Schlumberger and Wenner configurations.

Data obtained is normally subjected to modelling analysis using a digital computer. This is combined with data from existing boreholes to come up with a more realistic interpretation and recommendations.

5.3 Electrical Resistivity Tomography (2-D)

The greatest limitation of **1-D** resistivity sounding method is that it does not take into account horizontal changes in the subsurface resistivity. A more accurate model of the subsurface is a two-dimensional (2-D) model where the resistivity changes in the vertical direction, as well as in the horizontal direction along the survey line. In this case, it is assumed that resistivity does not change in the direction that is perpendicular to the survey line. In many situations, particularly for surveys over elongated geological bodies, this is a reasonable assumption. In theory, a 3-D resistivity survey and interpretation model should be even more accurate. However, at the present time, 2-D surveys are the most practical economic compromise between obtaining very accurate results and keeping the survey costs down. Interpretation of the data has been done using **RES2DINV** program. The program uses an iterative method whereby starting from an initial model, the program tries to find an improved model whose calculated apparent resistivity values are closer to the measured values. One well known iterative inversion method is the smoothness constrained method (deGroot-Hedlin and Constable, 1990) that has the following mathematical form:-

$$(\mathbf{J}^{\mathbf{T}}\mathbf{J} + u\mathbf{F})\mathbf{d} = \mathbf{J}^{\mathbf{T}}\mathbf{g} - u\mathbf{F}\mathbf{r}$$

where

F = a smoothing matrix

J = the Jacobian matrix of partial derivatives

r = a vector containing the logarithm of the model resistivity values

u = the damping factor

d = model perturbation vector

g = the discrepancy vector

The discrepancy vector, **g**, contains the difference between the calculated and measured apparent resistivity values. The magnitude of this vector is frequently given as a RMS (root-mean-squared) value. This is the quantity that the inversion method seeks to reduce in an attempt to find a better model after each iteration. The model perturbation vector, **d**, is the change in the model resistivity values calculated using the above equation which normally results in an "improved" model. The above equation tries to minimize a combination of two quantities, the difference between the calculated and measured apparent resistivity values as well as the roughness (i.e. the reciprocal of the model smoothness) of the model resistivity values. The damping factor, *u*, controls the weight given to the model smoothness in the inversion process. The larger the damping factor, the smoother will be the model but the apparent resistivity RMS error will probably be larger.

In the present survey 18 electrodes were employed with a separation of 5m using the Schlumberger array with a total spread of 60m. No roll-on was implemented due to terrain limitations. A total of 252 readings were taken.

5.4 Interpretation of Resistivity Data

Preliminary (visual) interpretation of resistivity soundings is based on experience which is gained in particular while doing computer interpretation in the office. The geologist/geophysicist is able to estimate the approximate interpretation from the shape of the sounding. Interpretation of the VES curve is based on the convolution method of Ghosh (1971), a mathematical curve-fitting procedure. Without additional data for correlation it can easily lead to a fitting solution which does not quite correspond to the real geological layering. The layered earth model is actually very much a simplification of the many different layers which may be present. The various equivalent solutions which can be generated by a computer programme should therefore be carefully analysed. In general, a single resistivity sounding should never be interpreted in isolation as this leads to a meaningless result. Interpretation of field data can be done with hand-fitted curves, but this method is time consuming, and practically limited to 3-layer solutions. Modern interpretation is computer-aided, using a curve fitting procedure based on a mathematical convolution method developed by Ghosh (1971).

While the resistivity method is a useful tool in geological and structural investigations, its applicability and reliability should not be overestimated. The modelling of field data is often attended by problems of equivalence and suppression. Each curve has an infinite number of possible solutions with different layer resistivities and depths (this is known as *equivalence*). Mathematical convolution can easily lead to a well-fitting solution, which nonetheless does not correspond to reality. In general, the number of possible solutions is reduced by mutual correlation of several sounding curves, knowledge of the local geology and drilling data. To minimize the errors, proper geological data and borehole control is essential. When deposits with similar resistivities border each other, it is usually not possible to make a differentiation. Intermediate layers, occurring between deposits of contrasting conductivity, may go undetected, as they tend to be obscured within the rising or falling limb of the sounding graph (*suppression*). Additional data, in the form of borehole records, air photography and geological field observations, are required to produce a realistic interpretation.

a) Equivalence Problem

Equivalence is the problem of having different interpreted computer models for the same resistivity curve. This is the result of the fact that usually more than one solution is possible e.g. a relatively thin layer with an extremely low resistivity may give the same result as a thick layer with only a slightly low resistivity.

b) Suppression Problem

When the thickness of a layer intercalated within a sedimentary sequence is relatively small, it may not be noticed in the resistivity graph, and is ‘suppressed’ and therefore not sensitive to the computer interpretations. Nevertheless, where justified (e.g. when it is known to exist from borehole data records) this ‘invisible’ layer may be introduced into the interpreted model.

6. FIELDWORK AND RESULTS

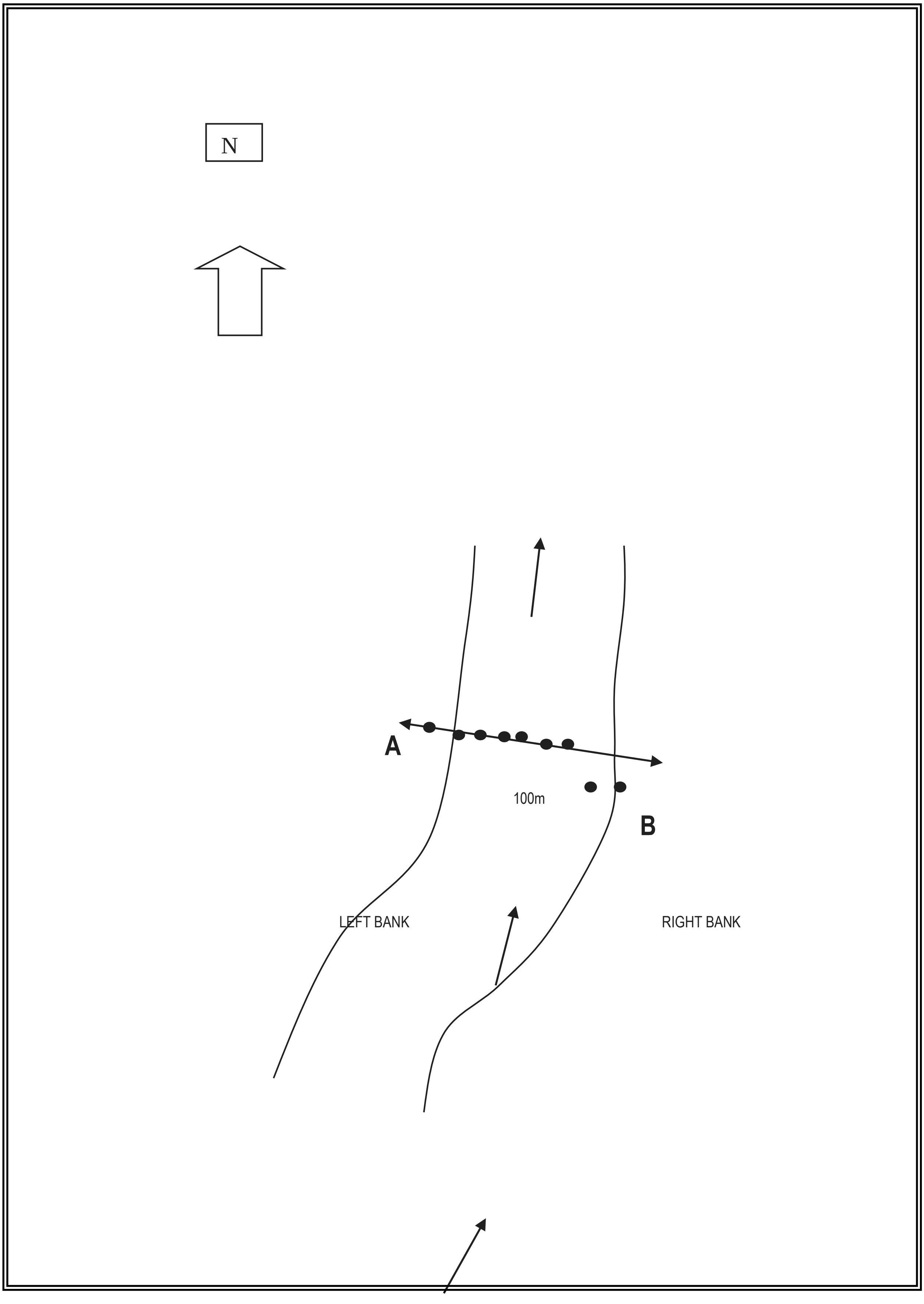
6.1 Fieldwork

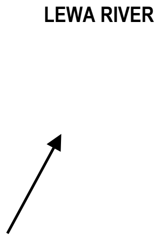
Fieldwork was carried out in **31st October, 2017**. The geophysical resistivity measurements were used to delineate the fractured, faulted and weathered zones along the dam foundation. Depths to the compact layer and the water bearing layer were also investigated. Resistivity sounding and profiling were simultaneously used in order to obtain a **2D** impression of the materials underlying the dam axis. The mainstay of the geophysical survey was to indentify the depth of sound foundation rock and also infer on its integrity.
In the current survey, vertical electric soundings were carried out along the dam axis defined approximately by the coordinates **37N 336178E, 31370N** and **37N 336250E, 313431N**. Elevation on either bank is approximated at **1304m** above mean sea level (a.m.s.l.). The dam axis is about **100m** long. The **Schlumberger** array was adopted **with AB/2** increased from **5m** to **65m** bgl thus data was acquired with **13 datum levels.** Thus data for tomography section was generated by simulating **a 40electrode data** acquisition layout with a total number of **169** datum points. The table below summarizes the data entry scheme for **RES2DINV** algorithm.

S/NO	QUANTITY	VALUE/DESCRIPTION
1)	*Electrode Spacing*	*5m*
2)	*Array type*	*Schlumberger*
3)	*Type of measurement*	*Apparent resistivity*
4)	*Number of datum points*	*169*
5)	*Data plotting position*	*Position of mid-point of array*
6)	*Maximum electrode location*	*0.0000m*
7)	*Minimum electrode location*	*240.000m*
8)	*Minimum electrode spacing*	*5m*
9)	*Total number of data levels*	*12*
10)	*Total number of electrodes*	*40*
11)	*First electrode location*	*-60m*
12)	*Last electrode location*	*135m*
13)	*Maximum apparent resistivity*	*107ohm-m*
14)	*Minimum apparent resistivity*	*18.2 ohm-m*
15)	*Maximum geometrical factor*	*2858*
16)	*Minimum geometrical factor*	*31.4*
17)	*Average geometrical factor*	*1099*

Table 2: Settings for data inversion.

Data inversion was carried out using the smoothness-constrained and robust inversion routine to emphasize geological boundaries. This would enable the delineation of anomalous zones with fair accuracy.


N
A
100m
B
LEFT BANK
RIGHT BANK



Explanation:

● VES-point

Survey profile

Figure-13 : Survey layout schematic

6.2 Fieldwork Constraints

During the fieldwork operations the following constraints were met:

The topography was very steep on the right bank with an almost vertical cliff along the traverse line. It was not possible to obtain data on the cliff.

In some areas, there existed rock outcrops which led to high electrode contact resistance which directly affected the quality of the data collected.

The Table presents the measured resistivity in ohm-m at an apparent probe depth of up to **65m bgl (the true probe depth is about 30m).** The variations along the profiles are caused primarily by differences in the characteristics of the subsurface strata. Thus, resistance decreases as porosity, hydraulic conductivity, groundwater conductivity and salinity increase. Dry compact formations are poor electrical conductors and show very high resistivities.

Table 3: Smoothed Electrical Profiling Data

Electrode Mid-point		1	2	3	4	5	6	7	8	9	10	11	12	13
Datum	AB/2	ρ1	ρ2	ρ3	ρ4	ρ5	ρ6	ρ7	ρ8	ρ9	ρ10	ρ11	ρ12	ρ13
1	5	96.50	34.50	61.60	59.80	65.00	59.30	44.00	58.40	72.80	80.60	88.40	96.20	104.00
2	10	60.20	42.80	58.10	57.30	60.10	78.70	60.40	56.40	52.40	50.10	47.80	45.50	43.20
3	15	51.40	26.80	55.50	53.90	71.50	86.30	64.40	60.90	57.40	52.13	46.85	41.58	36.30
4	20	52.60	25.80	53.30	60.50	77.50	93.20	77.00	70.95	64.90	57.33	49.75	42.18	34.60
5	25	58.30	25.60	50.40	57.10	75.40	93.20	83.50	74.20	64.90	57.58	50.25	42.93	35.60
6	30	62.80	26.50	49.20	55.70	71.80	94.00	83.80	78.15	72.50	64.13	55.75	47.38	39.00
7	35	64.20	26.50	51.30	48.50	70.00	87.20	81.60	81.00	80.40	71.25	62.10	52.95	43.80
8	40	67.00	28.70	48.40	43.90	65.50	100.00	81.00	83.15	85.30	75.60	65.90	56.20	46.50
9	45	66.70	26.30	48.20	39.40	60.00	90.60	83.30	87.20	91.10	81.33	71.55	61.78	52.00
10	50	67.60	25.10	41.50	35.50	56.80	74.60	84.20	90.60	97.00	86.90	76.80	66.70	56.60

11	55	67.60	23.80	38.50	30.20	52.70	80.20	83.40	95.20	107.00	95.13	83.25	71.38	59.50
12	60	67.60	18.20	37.70	30.40	54.40	73.70	83.10	91.55	100.00	89.88	79.75	69.63	59.50
13	65	67.60	21.00	38.10	30.20	54.20	71.10	83.10	91.45	99.80	90.00	80.20	70.40	60.60

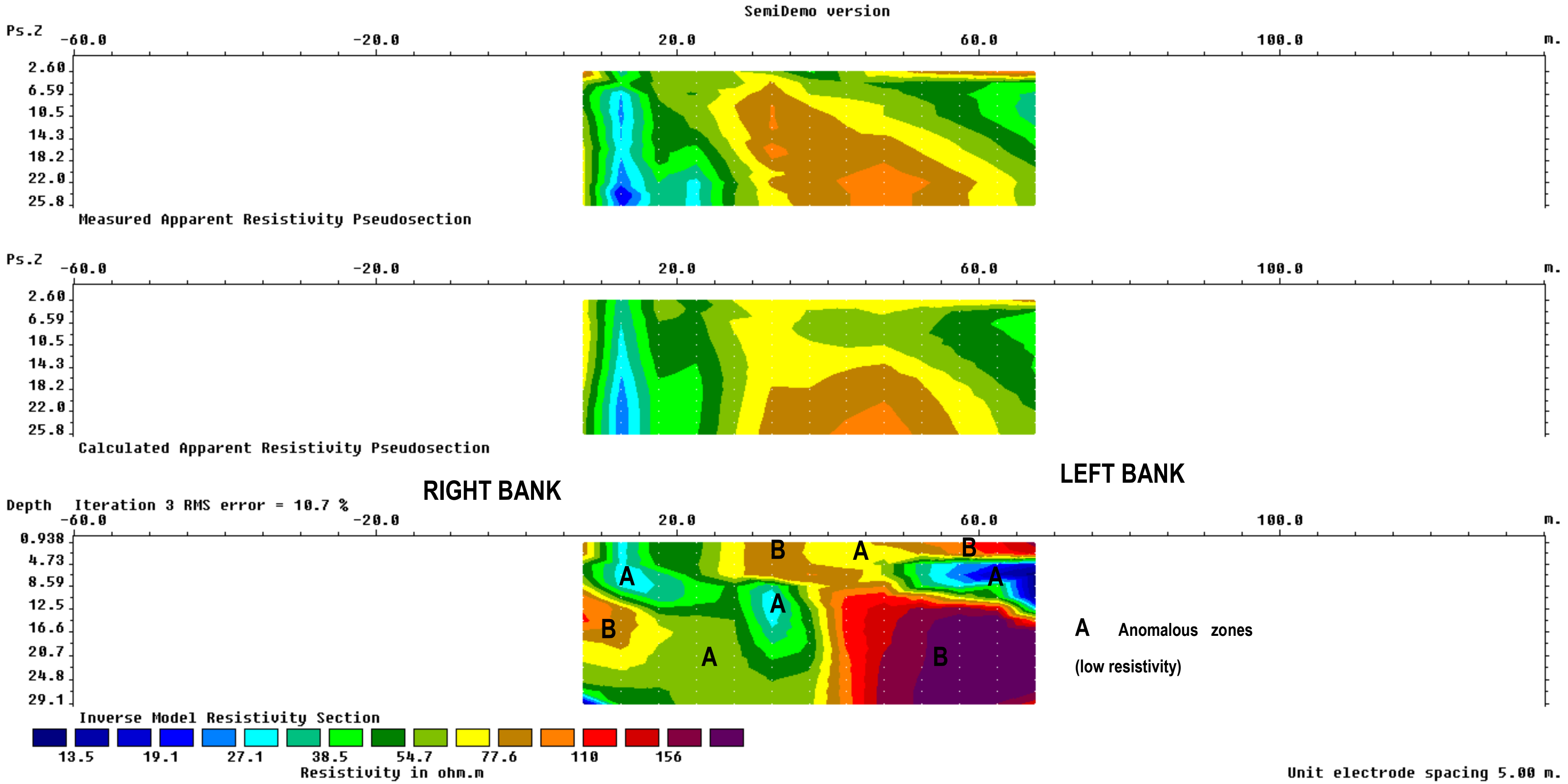
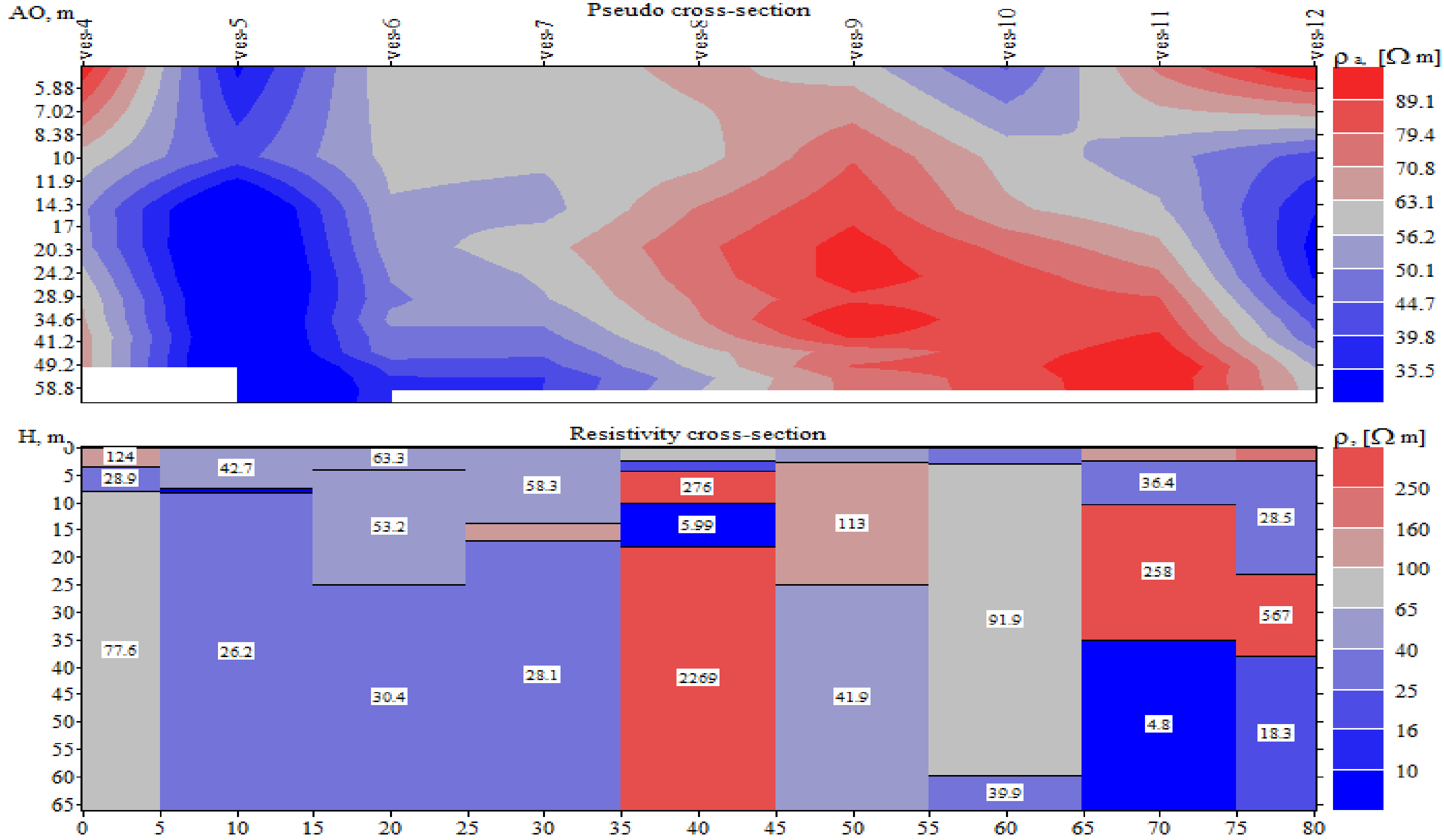

SemiDemo version
Ps.Z
-60.0
-20.0
20.0
60.0
100.0
m.
2.60
6.59
10.5
14.3
18.2
22.0
25.8
Measured Apparent Resistivity Pseudosection
Ps.Z
-60.0
-20.0
20.0
60.0
100.0
m.
2.60
6.59
10.5
14.3
18.2
22.0
25.8
Calculated Apparent Resistivity Pseudosection
RIGHT BANK
LEFT BANK
Depth
Iteration 3 RMS error = 10.7 %
-60.0
-20.0
20.0
60.0
100.0
m.
0.938
4.73
8.59
12.5
16.6
20.7
24.8
29.1
A
B
A
A
A
B
A
B
A
B
A Anomalous zones
(low resistivity)
Inverse Model Resistivity Section
13.5
19.1
27.1
38.5
54.7
77.6
110
156
Resistivity in ohm.m
Unit electrode spacing 5.00 m.

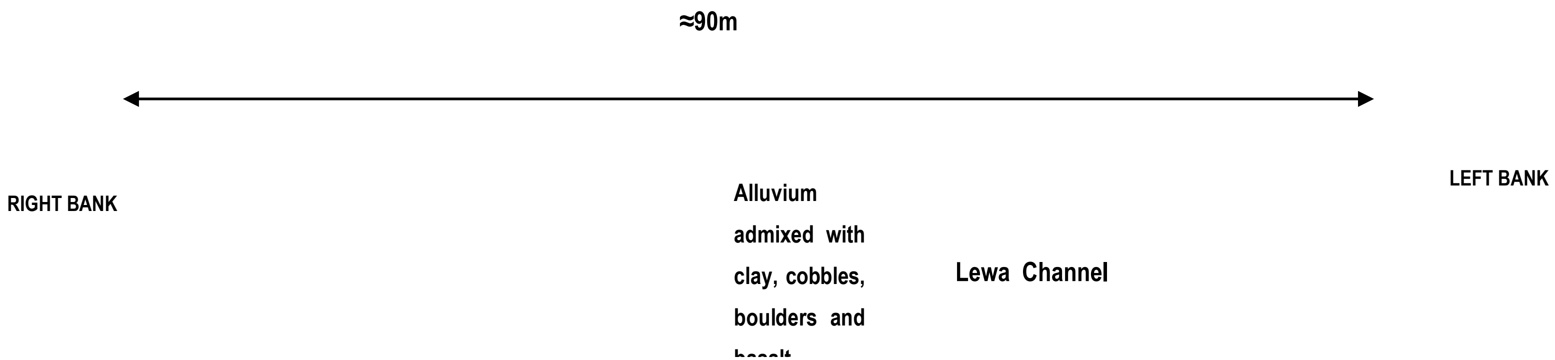
Figure 14:- Resistivity model section of the dam axis

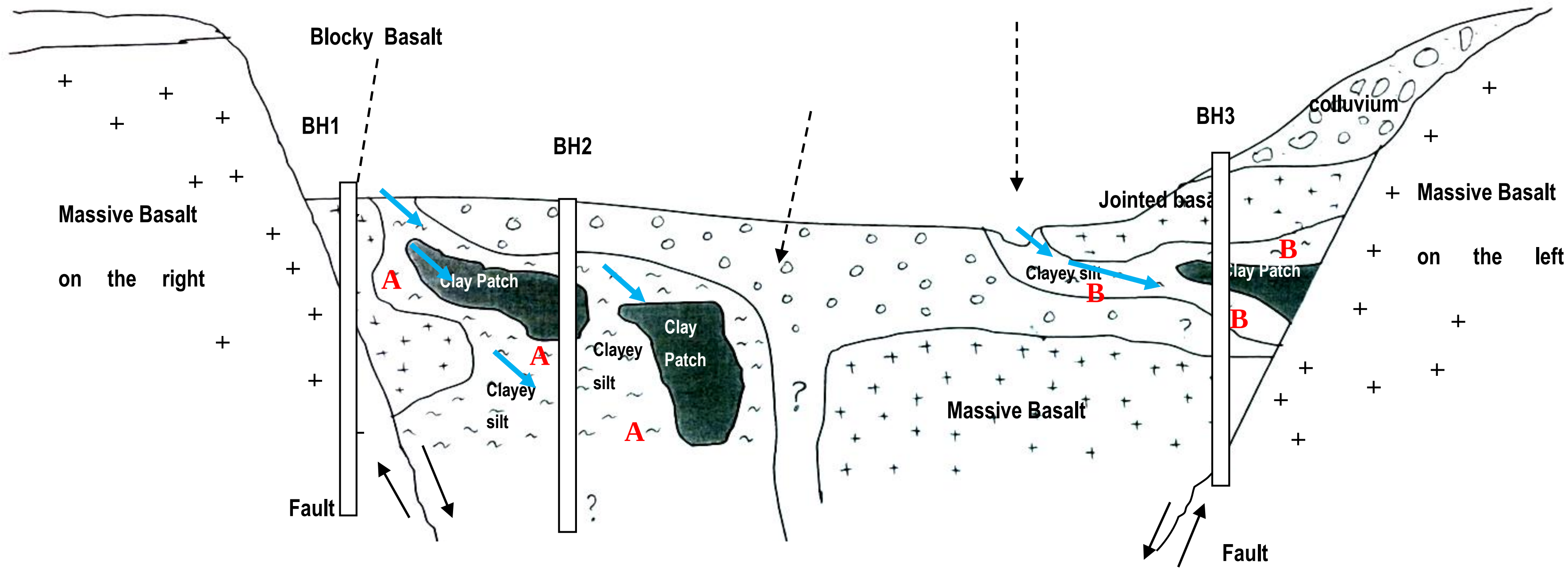


Explanation :- 1. 2.

Jointed weathered basalt (100-2300 ohm-m) Clayey silt (5-60 ohm-m)

Fig 15: Discrete resistivity Section Model using IPI2(Win) Algorithm





NOTES:

- Blue arrows show possible seepage loss path.
- Core trench should be excavated sufficiently to reveal the foundation formation so that its integrity can be ascertained
- Then appropriate treatment should be carried out to arrest any seepage through cracks, joints and fractures.
- Anomalous zone A (deduced to be aquiferous) will be determined by exploratory boreholes 1, 2 & 3
- Right bank has a sound foundation rock

Figure 16:-.Interpreted geological Section on Kilimani Dam Axis looking upstream

7. CONCLUSIONS AND RECOMMENDATIONS

From the results of geophysical (resistance/resistivity) measurements in the project site conclusions have been made on the basis of geophysical interpretation and geological appraisal of the site conditions.

7.1 Conclusions

Lewa river is structurally controlled by a set of faults with a general **N-S** trend

The **Lewa** channel follows the middle sunken graben block

The geology at the site comprises basaltic rock overlying Basement System rocks

The section of Lewa river containing the check dam, reservoir area and the dam axis is entirely located on volcanic rocks.

The right bank at the proposed dam axis location comprises of faulted and jointed basaltic rock cliff which is presumed to be a fault-line.

On the left bank, the fault-line is obscured by an accumulation of blocky basalt but is very distinct about **120m** upstream.

The **Lewa** channel has been in-filled with alluvium admixed with hill-wash/colluvial deposits and volcanic clastic material which varies in size from gravel , through cobbles to massive blocks, thus the relationships between various rock and soil components within the channel is quite complex

The right abutment has good anchorage rock for a buttress dam; the left bank requires stripping of colluvial accumulation to expose the foundation rock .

Two anomalous zones were identified near the fault-zones on either bank and were interpreted to be water saturated silty to clayey zones.

- The fault line zones were partially resolved by the survey and show possible seepage loss paths.

Both abutments are formed of sound basalt rock.

Inside the channel, sound rock was not detected on the right half of the axis. On the other left half of the axis sound rock occurs at a depth of about **8m** above it are weathered horizons with blocky jointed basalt.

Due to variable characteristics of materials at the foundation, differential settlement may adversely affect the dam.

The seismicity of the area is in **Zone IV** (very strong) hence the design of the weir dam must take this into consideration.

The presence of fault-lines and the seismicity classification of the area should inform the design criteria in the event of any tectonic events.

A buttress dam can be constructed on this site further detailed geotechnical and materials strength investigations to check conformity of the materials to design standards for a buttress dam.

7.2 Recommendations

The following recommendations are hereby made before construction of the proposed buttress dam:

(6) Exploratory drilling is recommended at locations indicated by **BH1**, **BH2** and **BH3** to a depth not exceeding **30m bgl**. This will confirm the integrity of the foundation at anomalous zones delineated by the geophysical survey and at the fault-lines. The coordinates of the borehole locations are:

(d) **BH1:** 0° 17.006'N; 37° 31.714'E
(e) **BH2:** 0° 17.009'N; 37° 31.702'E
(f) **BH3:** 0° 17.014'N; 37° 31.681'E.

The analysis of drill samples will enable appropriate remedial measures to control seepage losses to acceptable levels.

(7) Geotechnical testing of strengths of foundation materials is also recommended
(8) Rock formation at the abutments is jointed and should be treated appropriately to minimize seepage
(9) At the interpreted, fault-lines seepage losses may be considerable hence appropriate cut-offs should be instituted to curb the losses.
(10) Additional detailed geophysical measurements are recommended to cover other parts of the dam not covered by the present study.

8. REFERENCES

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Electrical resistivity tomography data

Kilimani WEIR DAM AXIS

5……………Rem…………………………...Electrode Spacing

7……………Rem……………………………..Schlumberger array

169…………Rem……………………………..No. of datum points

1……………Rem……………………………..Code for center of array data position

0…………….Rem……………………………Code for resistivity measurements

7.5	5	1	96.50	x position, electrode separation, datum level, Resistivity
12.5	5	1	34.50	
17.5	5	1	61.60	
22.5	5	1	59.80	
27.5	5	1	65.00	
32.5	5	1	59.30	
37.5	5	1	44.00	
42.5	5	1	58.40	
47.5	5	1	72.80	
52.5	5	1	80.60	
57.5	5	1	88.40	
62.5	5	1	96.20	
67.5	5	1	104.00	

7.5	5	2	60.20
12.5	5	2	42.80
17.5	5	2	58.10
22.5	5	2	57.30
27.5	5	2	60.10
32.5	5	2	78.70
37.5	5	2	60.40
42.5	5	2	56.40
47.5	5	2	52.40
52.5	5	2	50.10
57.5	5	2	47.80
62.5	5	2	45.50
67.5	5	2	43.20
7.5	5	3	51.40
12.5	5	3	26.80
17.5	5	3	55.50
22.5	5	3	53.90
27.5	5	3	71.50
32.5	5	3	86.30
37.5	5	3	64.40
42.5	5	3	60.90

47.5	5	3	57.40
52.5	5	3	52.13
57.5	5	3	46.85
62.5	5	3	41.58
67.5	5	3	36.30
7.5	5	4	52.60
12.5	5	4	25.80
17.5	5	4	53.30
22.5	5	4	60.50
27.5	5	4	77.50
32.5	5	4	93.20
37.5	5	4	77.00
42.5	5	4	70.95
47.5	5	4	64.90
52.5	5	4	57.33
57.5	5	4	49.75
62.5	5	4	42.18
67.5	5	4	34.60
7.5	5	5	58.30
12.5	5	5	25.60
17.5	5	5	50.40

22.5	5	5	57.10
27.5	5	5	75.40
32.5	5	5	93.20
37.5	5	5	83.50
42.5	5	5	74.20
47.5	5	5	64.90
52.5	5	5	57.58
57.5	5	5	50.25
62.5	5	5	42.93
67.5	5	5	35.60
7.5	5	6	62.80
12.5	5	6	26.50
17.5	5	6	49.20
22.5	5	6	55.70
27.5	5	6	71.80
32.5	5	6	94.00
37.5	5	6	83.80
42.5	5	6	78.15
47.5	5	6	72.50
52.5	5	6	64.13
57.5	5	6	55.75

62.5	5	6	47.38
67.5	5	6	39.00
7.5	5	7	64.20
12.5	5	7	26.50
17.5	5	7	51.30
22.5	5	7	48.50
27.5	5	7	70.00
32.5	5	7	87.20
37.5	5	7	81.60
42.5	5	7	81.00
47.5	5	7	80.40
52.5	5	7	71.25
57.5	5	7	62.10
62.5	5	7	52.95
67.5	5	7	43.80
7.5	5	8	67.00
12.5	5	8	28.70
17.5	5	8	48.40
22.5	5	8	43.90
27.5	5	8	65.50
32.5	5	8	100.00

37.5	5	8	81.00
42.5	5	8	83.15
47.5	5	8	85.30
52.5	5	8	75.60
57.5	5	8	65.90
62.5	5	8	56.20
67.5	5	8	46.50
7.5	5	9	66.70
12.5	5	9	26.30
17.5	5	9	48.20
22.5	5	9	39.40
27.5	5	9	60.00
32.5	5	9	90.60
37.5	5	9	83.30
42.5	5	9	87.20
47.5	5	9	91.10
52.5	5	9	81.33
57.5	5	9	71.55
62.5	5	9	61.78
67.5	5	9	52.00
7.5	5	10	67.60

12.5	5	10	25.10
17.5	5	10	41.50
22.5	5	10	35.50
27.5	5	10	56.80
32.5	5	10	74.60
37.5	5	10	84.20
42.5	5	10	90.60
47.5	5	10	97.00
52.5	5	10	86.90
57.5	5	10	76.80
62.5	5	10	66.70
67.5	5	10	56.60
7.5	5	11	67.60
12.5	5	11	23.80
17.5	5	11	38.50
22.5	5	11	30.20
27.5	5	11	52.70
32.5	5	11	80.20
37.5	5	11	83.40
42.5	5	11	95.20
47.5	5	11	107.00

52.5	5	11	95.13
57.5	5	11	83.25
62.5	5	11	71.38
67.5	5	11	59.50
7.5	5	12	67.60
12.5	5	12	18.20
17.5	5	12	37.70
22.5	5	12	30.40
27.5	5	12	54.40
32.5	5	12	73.70
37.5	5	12	83.10
42.5	5	12	91.55
47.5	5	12	100.00
52.5	5	12	89.88
57.5	5	12	79.75
62.5	5	12	69.63
67.5	5	12	59.50
7.5	5	13	67.60
12.5	5	13	21.00
17.5	5	13	38.10
22.5	5	13	30.20

27.5	5	13	54.20
32.5	5	13	71.10
37.5	5	13	83.10
42.5	5	13	91.45
47.5	5	13	99.80
52.5	5	13	90.00
57.5	5	13	80.20
62.5	5	13	70.40
67.5	5	13	60.60
0	0		0
0	0		0
0	0		0
0	0		0
0	0		0
0	0		0
0	0		0
0	0		0