REPUBLIC OF KENYA

MINISTRY OF DEVOLUTION AND PLANNING

ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

FOR

ARROR MULTIPURPOSE DAM DEVELOPMENT PROJECT ON ARROR RIVER

May 2017

Proponent	Lead Expert
Kerio Valley Development Authority 13th Floor KVDA Plaza, P.O Box , 2660 - 30100 Eldoret, Kenya info@kvda.go.ke	Prof. Elijah Biamah Maier consulting limited P.O Box 41736-00100, Nairobi, Kenya Tel: 020 2213511 info@maierconsulting.co.ke

FACT SHEET

Assignment name	Environmental and Social Impact Assessment (ESIA) for Arror Multipurpose dam
Proposed dam Project design details	The dam will be in loose materials, of the zoned type, with a waterproof core and lateral transitions, and will have a maximum height of 91 m and length at the crest of 615 m. The capacity of the reservoir amounts to approximately 60 MCM and the reservoir area is 2.8 Km^2. The diversion works for the construction of the Arror dam consist of a 600 m long tunnel of the horseshoe type with 3.5 m diameter in the right bank of Arror River. The spillway is sized to discharge downstream the floods with 1000 years return period which run into the reservoir, thus safeguarding the stability of the loose materials dam. A traditional concrete spillway collects the waters to be discharged and conveys them, through a 300 m long concrete chute, to a stilling basin and there form to the Arror River bed. The threshold of the spillway is of the “free” type, with a maximum water head of 2 m and a length of 67 m.
Name and address of the Proponent	Kerio Valley Development Authority 13th Floor KVDA Plaza, P.O Box , 660 - 30100 Eldoret, Kenya info@kvda.go.ke
Location	Arror area in Elgeyo Marakwet county
Start Date	October, 2016
Completion Date	January, 2017
Consultant	Maier consulting limited P.O Box 41736-00100, Nairobi, Kenya Tel: 020 2213511 info@maierconsulting.co.ke
Lead experts	Prof. Elijah Biamah Vitalis Kibiwott Too

Declaration

This ESIA study report was done in accordance to the requirements of the Environmental (Impact Assessment and Audit) Regulations, 2003, pursuant to The Environmental Management and Coordination Act, (EMCA) 1999 and acceptable international standards.

LEAD EXPERTS:

1. **Name:** Prof. Elijah K. Biamah **NEMA Registration No.** 308

   Signature: ………………………… **Date:** …………………………

2. **Name:** Vitalis Kibiwott Too **NEMA Registration No.** 1871

   Signature: ………………………… **Date:** …………………………

PROPONENT:

Kerio Valley Development Authority
13th Floor KVDA Plaza,
P.O Box, 660 - 30100
Eldoret, Kenya
info@kvda.go.ke

For and on behalf of KVDA: -

Name:………………………… **Designation:** …………………………

Signature: ………………………… **Date:** …………………………

(Official stamp)

Acronyms and Abbreviations

μg	Microgram (μg or mcg)
ASU	Areal Standard Unit
CITES	Convention on International Trade in Endangered Species
Cryptosporidium (oocysts/100 lit.)	Number of oocysts per 100 Litres
DAF	Dissolved Air Flotation
DD	Deficient Data
EA	Environmental Audit
EBS	Environmental Baseline Study
EIA	Environmental Impact Assessment
EMP	Environmental Management Program
EN	Endangered Species
EWF	Environmental Water Flow
Giardia (cysts/100 lit.)	Number of cysts per 100 litres
GWH	Giga Watt Hour
ICID	International Commission on Irrigation and Drainage systems
IUCN	International Union for Conservation of Nature
KFS	Kenya Forest Service
KNBC	Kenya National Bureau of Statistical
KVDA	Kerio Valley Development Authority
KWS	Kenya Wildlife Service
LC	least concern Species
Leq	Equivalent Continuous Noise Level / Sound Level
m.a.s.l	Meter above sea level
MW	Mega Watt equal to 1000 kW
NE	Near Vulnerable Species
NEMA	National Environmental Management Authority
NEPA	National Environment Action Plan
NGO	Non-Governmental Organization
NT	Near threatened Species
NTM	Naqsh Tarsim Milad
NTU	Nephelometric Turbidity Unit
PM	Particulate Matter
PPM	Parts per Million

SERC	Standards and Enforcement Review Committee
SIA	Social Impact Assessment
TCU	True Color Unit
TH	Total Hardness
TON	Threshold Odor Number
UNCED	United Nations Conference on Environment and Development
UNDP	United Nation Development Program

Table of contents

List of Tables

List of Figures

Executive Summary

Overview

The Arror Multipurpose Dam Development Project is located in Elgeyo Marakwet County, Arror Location. The latitude and longitude coordinates for the study area are approximately 0°54′ to 1 °18′ N and 35°25′E to 35° 40′. The area forms part of the Rift valley system, and the proposed area for irrigation is located on the valley floor of the Kerio at an altitude around 1000-1100 meters above mean sea level.

The main Components of the project are:

1) Dam
2) Hydro-electric power plant
3) Irrigation project that are described hereunder:

Important activities from the environmental viewpoint for three main components of the project in construction phase are given in the Table I.

Table I: Important Activities of the Project in Construction Phase

Dam	Hydro Electrical Power Plant	Irrigation network
Employment	Employment	Employment
Excavation and embankment	Excavation and embankment	Excavation and embankment
Pavement	Pavement	Construction of temporary camps and workshops
Clearing rocks/stones	Construction of penstock access road	Installations of equipment
Construction of dam access road	Asphalting the road	Camping of staff/workers in temporary camps
Asphalting the road	Construction of temporary camps and workshops	Transport of materials and equipment
Construction of temporary camps and workshops	Camping of staff/workers in temporary camps	Traffic of trucks
Camping of staff/workers in temporary camps	Spilling of oil, grease and fuel products on the land	Influx of workers in the region
Store room for explosives	Transport of materials and equipment	Activities of heavy and light machinery
Operation with explosives (1)	Traffic of trucks	Workshop activities
Transport of materials and equipment	Influx of workers in the region	Water consumption
Traffic of trucks	Activities of heavy and light machinery	Electricity consumption
Influx of workers in the region	Workshop activities	Concrete operations

Dam	Hydro Electrical Power Plant	Irrigation network
Activities of heavy and light machinery	Water consumption	Excavation from borrow areas
Workshop activities	Electricity consumption	Waste matters and debris depot
Diversion of water	Borrow resources	Solid wastes disposal
Water consumption	Waste matters and debris depot	Effluent disposal
Electricity consumption	Solid wastes disposal	Store room for material
Concrete operations	Effluent disposal	Spilling of oil, grease and fuel compounds on the land
Excavation from borrow areas	Construction of intake	Laying pipelines
Construction of diverting tunnels	Construction of concrete pipe	Site clearance
Cofferdams	Construction of penstock tunnel (2)	Dismantling workshops
Site clearance & deforestation of reservoir area (before water inflow)	Construction of access tunnel (2)	
Grouting	Laying of penstock	
Grout curtain	Construction of power house	
Foundation and construction of dam body	Construction of transmission line	
Construction of spillway	Site clearance	
Waste matters & debris depot	Dismantling workshops	
Solid wastes disposal	*1) For constructing the diverting tunnels, dam body, spillway, penstock tunnel and access tunnel explosive operations shall be required. 2) During construction phase of hydroelectric power plant two tunnels shall be constructed, one is main tunnel that the penstock is passed along it and the other is access tunnel that links the main tunnel to road in downstream.*	
Effluent disposal		
Spilling of oil, grease and fuel compounds on the land		
Resettlement		

Significant Environmental Impacts

Most important negative impacts of the project are as follows:

- Land acquisition within reservoir area and population displacement
- Reduction of water flow in downstream of the dam site
- Reduction of water quality in downstream of the dam site
- Probability of thermal stratification and eutrophication in the reservoir

Most important positive impacts of the project are as follows:

- Electricity generation

- Supplying drinking and irrigation water
- Protection against flood and other natural hazards
- Improvement of infrastructure, especially communication roads
- Migration to the region and reduction of willingness to migrate to other towns
- Increase of new job opportunities
- Creation of a new and attractive landscape due to formation of the dam water

Mitigation of Negative Impacts

Chapter Eight provides the negative impact mitigation. Chapter Nine presents a detailed Environmental and Social Management Plan where applicable for implementation by responsible parties or stakeholders.

Issues raised during public consultations

During public consultations, various aspects of the project were discussed. The issues raised by the community members touched on land acquisition process, employment and anticipated benefits. Detailed account of the discussions is presented in chapter five.

Recommendation

It is strongly recommended that a concerted effort is made by all the stakeholders to implement the Environmental and Social Management Plan. During the operation and maintenance of the project, it is necessary that environmental regulations be strictly adhered to. The performance of the system should also be monitored against the recommended mitigation measures to ensure sustainability.

Overall Public Opinion

The construction of the proposed project in the area will have far reaching positive environmental impact on the community in terms of accessibility to quality water and irrigation water. The project area has water challenges which continue to stifle socio-economic development and threaten livelihoods. It is for this reason that the community members are supportive of the project. It was also established that all the identified negative environmental impacts will be effectively mitigated through full implementation of the ESMP.

Glossary of terms

Baseline: A set of measurements, statistics, or conditions used as a basis for later comparison. The baseline refers to the pre-project conditions, prior to the initiation of the project, against which post-project changes can be compared.

Cultural heritage: The legacy of physical artefacts and intangible attributes of a group or society that are inherited from past generations, maintained in the present and bestowed for the benefit of future generations.

Cumulative impacts: Cumulative impacts are those that result from the incremental impact of the project when added to other past, present, and reasonably foreseeable future actions.

Displaced persons: Persons who lose land or the right to use land or access to legally designated parks and protected areas resulting in adverse impacts on livelihoods whether such losses and restrictions are full or partial, and permanent or temporary.

Flow: Volume of water, expressed as cubic feet or cubic meters per second, passing a point in a given amount of time.

Head: Vertical change in elevation, expressed in either feet or meters, between the head water level and the tailwater level.

Impact: Effect or consequence of an action or event; the degree to which an impact is interpreted as negative or positive depends on context and perspective.

Involuntary Resettlement: Resettlement is involuntary when it occurs without the informed consent of the displaced persons or if they give their consent without having the power to refuse resettlement.

Management plan: A management plan is a tool used as a reference for managing a particular project issue, and establishes the why, what, how, who, how much, and when for that issue.

Management system: The framework of processes and procedures used to ensure that an organisation can fulfil all tasks required to achieve its objectives.

Mitigation: Moderation, alleviation, and/or relief of a negative impact.

Project Displaced Persons: All the people affected by a project who through involuntary acquisition and/ or encumbrance placed upon the land on account of the execution of the project, necessitating the moving and resettlement from the affected land; includes any person, household, firms, or public or private institutions who as a result of a project would have their standard of living adversely affected; right, title or interest in all or any part of a house, land (including residential, commercial, agricultural, plantations, forest and grazing land) or any other moveable or fixed assets acquired or possessed, in full or in part, permanently or temporarily adversely affected; or business, occupation, place of work, residence, habitat or access to forest or community resources adversely affected, with or without displacement.

Project-Affected Person: Any person who, as a result of the implementation of a project, loses the right to own, use, or otherwise benefit from a built structure, land (residential, agricultural, or pasture), annual or perennial crops and trees, or any other fixed or moveable asset, either in full or in part, permanently or temporarily.

Relocation: Physical moving of PAPs from their pre-project place or residence, place for work or business premises, to an area that is not affected by the project.

Reservoir area: The area that is inundated when the reservoir is at its maximum expected level and the dry buffer zone above this level.

Resettlement Action Plan: The document in which a project sponsor or other responsible entity specifies the procedures that it will follow and the actions that it will take to mitigate adverse effects, compensate losses, and provide development benefits to persons and communities affected by an investment project.

Stakeholders: Any and all individuals, groups, organizations, and institutions interested in and potentially affected by a project or having the ability to influence a project.

Vulnerable Groups: People who by virtue of gender, ethnicity, age, physical or mental disability, economic disadvantage, or social status may be more adversely affected by resettlement than others and who may be limited in their ability to claim or take advantage of resettlement assistance and related development benefits.

1.0: Introduction

1.1. General Background

As each kind of development exerts some effects on the environment, it is required that the environmental criteria of any development project be carefully considered. The increasing anxieties of environment destruction during the last decade made the world authorities reconsider development policies and planning. Following such developments and destructive processes of the environment, sustainable development as a modern approach was proposed for discussion to solve the world development problem. Such a development shall be fulfilled when all components of it including environment component, from the beginning of the programs and policies, are put in the development process. The environment protection in the planning system not only should be put in its proper status but also it should be important enough to be considered in regional, national and international planning.

Environmental Impact Assessment (EIA) is a planning tool to promote sustainable development by integrating environmental costs and benefits into proposed development activities. In the long term, it should minimize environmental impacts and save costs by preventing unnecessary environmental degradation. EIA study must take place in such a manner that is a preventive factor concerning environmental destruction, in confronting investment wastage, attaining development objectives and socio-economic improvement. Thereby, in such conditions, not only the actual value of EIA study will be specified, but the consequences and the obstacles of the project shall be decremented and EIA report can be utilized as guideline by the project designers. Totally, what EIA can do is ensure political decision makers are making their decision based on a complete, clear, quantified (where possible) description of the positive and negative impacts.

The Kenya government policy on all new projects requires that an Environmental Impact Assessment (EIA) study is carried out at the project planning stages to ensure that significant impacts on the environment are taken into consideration. Large dams are some of the projects listed under the second schedule of the Environmental Management and Coordination Act (1999) that should undergo an EIA.

1.2 Objectives of the Environmental Study

This study seeks to meet the following objectives:

- To identify elements of environment likely to be affected by the project and/or likely to cause adverse impacts to the project including natural and man-made environment.
- To identify any potential losses or damage to flora, fauna and natural habitats.

- To identify the negative impacts and propose the provision of infrastructure or mitigation measures so as to minimize pollution, environmental disturbance and nuisance during construction and operation of the project.
- To specify environmental monitoring and audit requirements, if necessary, to ensure the implementation and the effectiveness of the environmental protection and pollution control measures adopted.
- Access to a sustainable development.

1.3 Objectives of the Project

The main objectives of the Arror Multipurpose Dam are electricity generation and to provide a large-scale water resource catering for irrigation and drinking water supplies. Furthermore, improvement of agricultural activities, fisheries and ecotourism can be noted as secondary objectives.

1.4 Project Justification

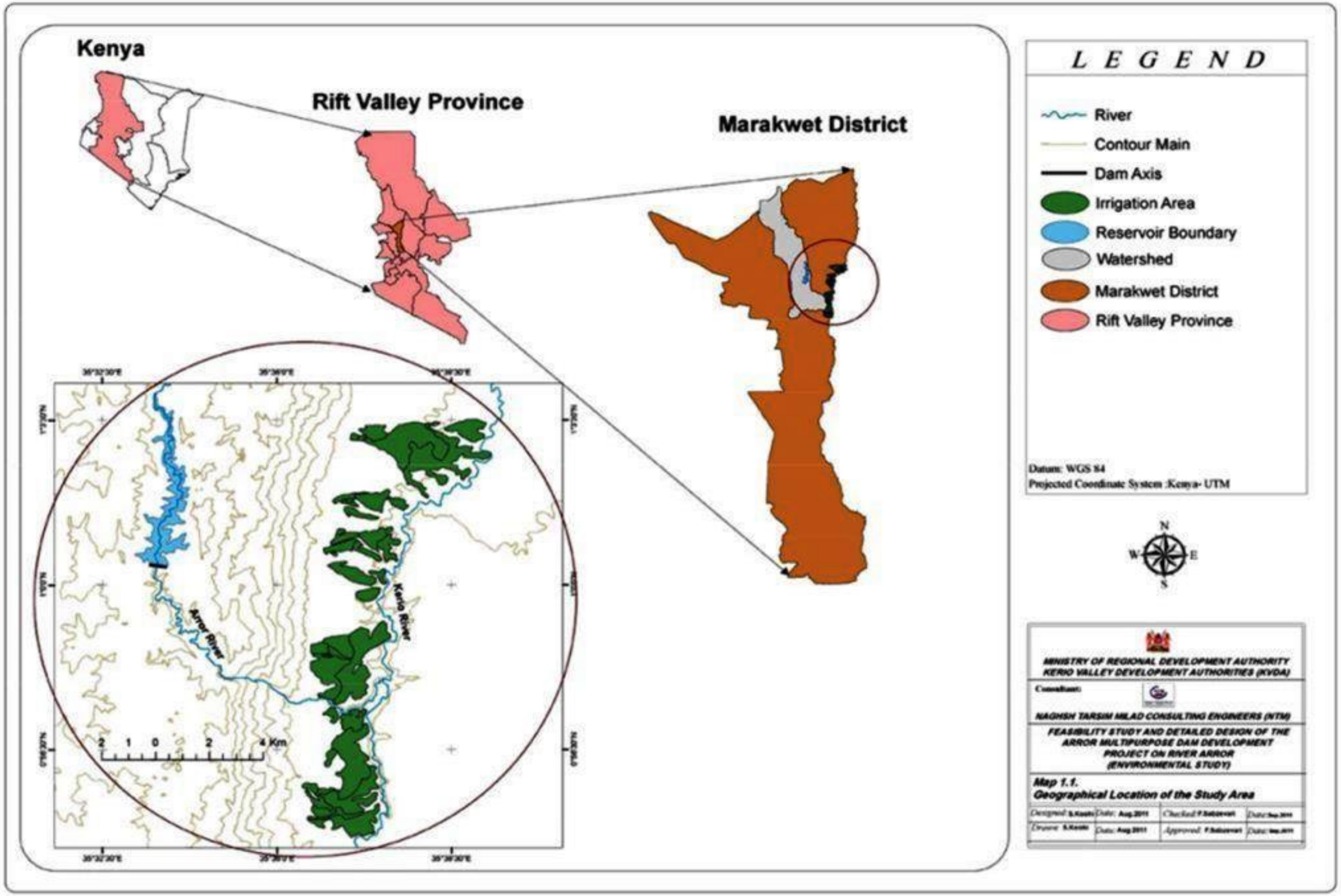
Present generation power plants are of the hydroelectric, thermal, geothermal and renewable (cogeneration, wind) types, that the hydroelectric generation is the most important. On the basis of the latest available documents, more than 55.8% of the available capacity of the power generating is concentrated in hydropower plants, consuming water flow as a renewable, clean and cheap energy.

The Arror project is also designed to positively affect the local population suffering from a chronic food deficit, by increasing the area of irrigated agriculture in the suitable lands of the valley floor. The implementation of the downstream irrigation project shall result in the achievement of food self-sufficiency and improvement of incomes (through the sales of surplus crops and livestock) of the population by the project; also would bring a great number of job opportunities for inhabitants in Kerio Valley, Kapsowar and adjacent sub counties.

1.5 Geographical Location of the Project Area

The latitude and longitude coordinates for the study area are approximately 0°54′ to 1 °18′ N and 35°25′E to 35° 40′. The area forms part of the Rift valley system, and the proposed area for irrigation is located on the valley floor of the Kerio at an altitude around 1000-1100 meters above mean sea level.

Geographical Location of the project Area is shown in Map 1.1.


Kenya
Rift Valley Province
Marakwet District
Arror River
Kerio River
2 1 0 2 4 Km
L E G E N D
River
Contour Main
Dam Axis
Irrigation Area
Reservoir Boundary
Watershed
Marakwet District
Rift Valley Province
Datum: WGS 84
Projected Coordinate System :Kenya- UTM
N
W
E
S
MINISTRY OF REGIONAL DEVELOPMENT AUTHORITY
KERIO VALLEY DEVELOPMENT AUTHORITIES (KVDA)
Consultant:
NAGHSH TARSIM MILAD CONSULTING ENGINEERS (NTM)
FEASIBILITY STUDY AND DETAILED DESIGN OF THE ARROR MULTIPURPOSE DAM DEVELOPMENT PROJECT ON RIVER ARROR (ENVIRONMENTAL STUDY)
Map 1.1.
Geographical Location of the Study Area
Designed:
Date: Aug.2011
Checked:
Date:
Drawn:
Date: Aug.2011
Approved:
Date:

1.6 Access Road

Access to the Dam Site area is through the road which links Eldoret-Chebiemit-Cheptongei-Kapsowar which is about half an hour driving along a paved road and one hour and a half along an earth road to get to Kapsowar from Eldoret. Kapsowar is nearest town to dam site. It is about 10 minutes driving on a paved road till intersection road and Arror River (bridge).

Access to the Kerio Valley is gained via Eldoret to top of the Elgeyo escarpment at Iten by about 35 km of paved road. This metalled road then loops down the escarpment to Tambach, a distance of 5 km, providing spectacular views across the Kerio valley to the Tugen Hills. Beyond Tambach the road is all weather albeit loose surfaced but is presently being upgraded. A series of torturous bends descend to the village of Biretwo over a distance of 7 km. This village lies at the foot of the escarpment and the total descent from Iten is about 1200 meters. Two km south east of Biretwo an all-weather track, in very bad condition and clearly infrequently maintained, runs northwards along the foot of the escarpment to Arror which is reaches after 21 km. Figure 1.1 shows the access roads to the project area.

1.7 Objectives and Framework of the Environmental Study

In order to predict the environmental impacts of development plans, so as to bring about measures to decrease the negative impacts and fortify the positive ones, environmental impact assessment (EIA) methods are given. Objectives in performing environmental assessment study are to formulate environmental considerations in the planning, designing and implementation phases, so as to gain access to a sustainable development. In this context, Environmental Impact Assessment (EIA) Study of the Arror Dam is performed.

The discussions under consideration are surveyed in 11 Chapters as given hereunder:

Chapter One: Introduction including objectives of the project, geographical location, access roads, objectives and methodology of the environmental study, etc.

Chapter Two: Policy and Legal Framework

Chapter Three: Project Description

Chapter Four: Baseline Setting including physical and biological environment and socio-economical characteristics of the study area

Chapter Five: Public consultation and participation

Chapter Six: Analysis of project alternatives

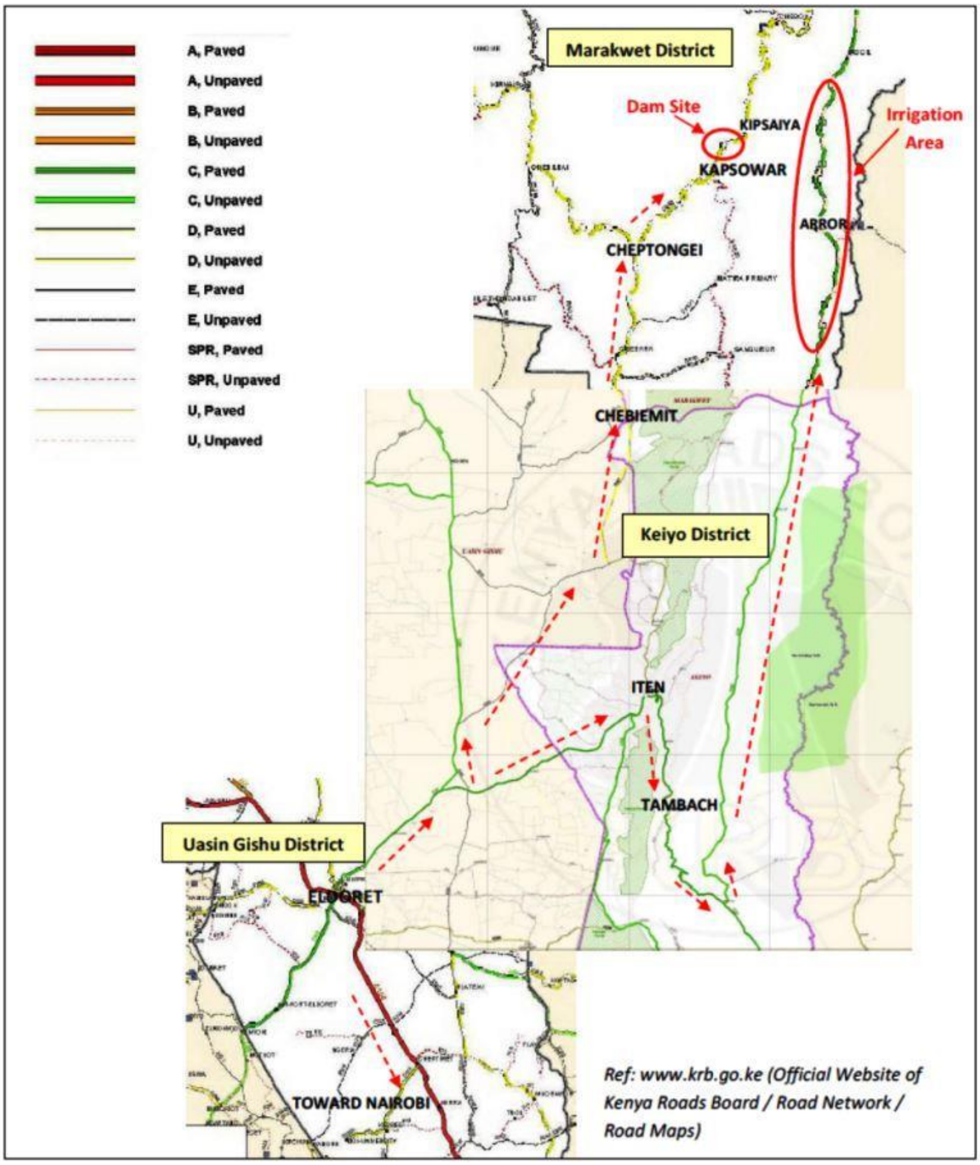
Chapter Seven: Potential Environmental Impacts

Chapter Eight: Proposed mitigation measures

Chapter Nine: Environmental and social management plan

Chapter Ten: Environmental monitoring plan.

Chapter Eleven: Conclusion and recommendations



Ref: www.krb.go.ke (Official Website of Kenya Roads Board / Road Network / Road Maps)

Fig. 1.1: Access Roads to the Project Area

1.8 Scope of the Study

This environmental impact assessment (EIA) study is designed in accordance with the terms of reference to address the following issues:

- Review of the activities of the project
- Review of policy and institutional framework
- To verify compliance with the environmental regulation and industry standards;

- To identify and assess all potential impacts of the proposed project;
- To identify all potential significant adverse impacts of the project and recommend measures for mitigation;
- To identify problems (non-conformity) and recommend measures to improve the existing management system;
- Scoping and screening of impacts
- Public consultation
- Development of an environmental management framework
- To assess compliance with Company's corporate environmental policy requirements;
- To prepare an Environmental Impact Assessment Report compliant to the Environmental Management and Coordination Act (1999) and the Environmental (Impact Assessment and Audit) Regulations (2003), detailing findings and recommendations.

1.9 Methodology

1.9.1 Identifying the Study Area

The first step in environmental study of Arror Dam project is identifying study area based on main components of the project, the direct and indirect environmental impacts; which is so important to determine the scope and depth of the study.

1.9.2 Data Gathering

Required data is gathered about activities and main components of the project as well as characteristics of the study area which is done through desk and field study.

Desk study

- Review of environmental laws, regulations and standards,

All environmental Acts, laws and regulations of Kenya and national and international standards, related to the project and potential pollutions are surveyed. In addition, all national protected areas system and categories are identified.

- Review of books, articles, issues, national and international reports through Kenya and study area, Kipkunur forest, Kamnorak Park, Arror and Kerio Rivers,
- Search in reputable internet websites
- Getting data and information from KVDA about characteristics of the project and study area. A description of the project is rendered in the environment report and all project activities in construction and operation phases separately with emphasize on destructive activities on environmental parameters are identified. From the environmental viewpoint, the main components of the project are as below:

- Dam Project (including dam body, side facilities and dam reservoir)
- Tunnel, penstock, power Plant and side facilities
- Irrigation Network (lands proposed for irrigation and agricultural development)

Enquiry of data from related organizations and meeting with officials in order to completing existing data,

The organizations and government agencies that have been consulted are as below:

- Water sub county office (Kapsowar)
- Kenya Forestry Service (Kapsowar)
- KVDA- Livestock Expert Office (Eldoret)
- Fisheries Development Ministry (Eldoret)
- Ministry of Health (Eldoret)
- NEMA (Eldoret)
- NEMA (Nakuru)
- Public Health Office (Nakuru)
- Water Resources Management Authority (Nakuru)
- Ministry of Environment and Natural Resources (Nairobi)
- Kenya Forestry Service (Nairobi)
- Kenya Wildlife Service (Nairobi)
- Ministry of Agriculture (Nairobi)
- Ministry of Health (Nairobi)
- Water Resources Management Authority (Nairobi)

Field Study

Considering the different components of the project, such as Arror dam, tunnel, Penstock, power plant and the area proposed for irrigation project in the Kerio Valley, the primary visit was focused on these regions. Thus, Arror River in the upstream and downstream of the dam axis, ecosystems and habitats around Arror River, catchment area in the rain forest regions of Kipkunur, the tunnel route, and Penstock as well as Kamnarok have been visited.

Complementary visits have been made to identify and study the environment of the project region from the important viewpoints such as flora and fauna species and habitats. To identify the fauna species and collecting sufficient data from the region, the study area is evaluated on the basis of the region transects considered.

Collecting the data and information on the basis of the desk and field studies, leads to perfect understanding of the rules, regulations and standards of the environment and the organizational structure (institutional chart) of the related organs, as well as the project and its components, the existing status of the study area environment comprising physical-chemical, biological-ecological and economical-social and cultural parameters.

1.9.3 Environmental Baseline Study (EBS)

EBS is provided based on the gathered data in desk and field studies. In fact EBS is a survey about present status of the environment of the project including dam watershed and downstream. In this step, Physio-chemical, Biological-Ecological and Sociological characteristics of the environment are studied.

The main parameters of physical study include:

- Meteorology (main factors of climate and air quality)
- Topography and landscape
- Hydrology (quantity and quality of surface and ground waters)
- Pedology (soil characteristics of the lands proposed for agricultural development, soil contamination)
- Geology (mostly in terms of potential effect on ground water)
- Seismology (recognition of the faults near dam site)

To study the present condition of pollution in the study area, questionnaires have been filled out by asking questions from the local people, along with field studies and obtaining information from the state centers and organizations.

To study the human-related pollution, obtaining the information from the population centers located in the catchment area and estimation of the sewage and solid wastes in each population center as well as study on the impact on the river and its branches are of importance, which is taken into account in this study. To study the agricultural pollution, the area of the farms situated in the catchment area and amount of fertilizers and pesticides used in the farms and means of the drainage finding its way to the river and its impact on the quality of water resources is studied. As the major part of the catchment area is covered with forest, natural pollution shall be considered as a source of pollution. Change of land use from forest to cultivated areas, as well as increase in the rate of erosion and the sediment entering the river is of most important natural pollution parameters that are considered.

The main parameters of Biological-ecological study (in terrestrial & aquatic ecosystems) include:

- Flora (important and threatened plant species, plant and forest communities)
- Fauna (important and threatened fauna species, biodiversity, possible migration routes)
- Habitats (habitat types, vulnerable habitats and protected areas)
- The main parameters of Sociological study include:
- Social criteria (population, migration, education)
- Economic criteria (employment, economic activities, land use, infrastructure,
- Cultural criteria (language, religion, cultural heritage)

It should be mentioned, social and resettlement study is made parallel to environmental study to determine the project cultural & socio – economic effects such as dispossession of cultural heritage, as well as, the Project effect on migration to the study area. The result of such study is used in decision making.

1.9.4 Environmental Impact Assessment (EIA)

The approach of EIA study is:

- To determine all positive and negative environmental impacts of the project for construction and operation phases separately,
- Analysis and assessment,
- Environmental Management Program (EMP) including mitigation plan

First of all, the possible environmental impacts (negative and positive) in construction and operation phases are identified and classified based on the recognition of the environment, project activities, main components and side facilities.

After identifying the impacts, the best assessment method is selected based on the project characteristics, scale of work, availability of data and information and time schedule of the study; and impacts are assessed and analyzed through a proper assessment method. In this regard, the ICOLD matrix method (provided by International Commission of Large Dams) shall be used for assessment the proposed Dam and the checklist method (provided by International Commission of Irrigation and Drainage-ICID) is used for assessment the irrigation system; and overlay mapping method can be used as a complementary method to show the locality of negative impacts. Identifying the most important environmental impacts and effects is resulted from the analysis of impacts; it should be mentioned that the significant environmental impacts of each project are long-term and irreversible impacts.

1.9.5 Environmental Management Program (EMP)

This program comprises of sections as follows:

Mitigation Measures (Environmental Action Plan):

in order to prevent, reduce or manage the negative environmental impacts of the project, mitigation measures are identified including approximate cost estimation and introducing implementation and supervision responsible organizations;

Environment Monitoring Program:

The important impacts of the project such as surface and ground water quantity and quality, water quality of reservoir, soil contamination, etc. will be under monitoring. Monitoring program includes determining monitoring indices, monitoring frequency, monitoring place, monitoring cost and introduces responsible organization on monitoring implementation and supervision.

Environmental Education or Training Program:

This program has an essential role to reduce and control destructive factors and environmental pollution and includes determining training requirements, the persons to be training, the level of training, and the time schedule of the training workshops.

Public Participation:

In order to attract public participation, all comments and recommendations of inhabitants were considered about the proposed project. Contacts with the local communities were used in order to obtain information, feedback, and opinions on the proposed project. Public participation program is performed by dissemination of information, holding general meetings, etc.

1.10. Study Records

Feasibility study on the integrated development of the Arror river basin was done by B & B consulting engineers, an Italian company, about 25 years ago, that did not include environmental study. Surveys show that no environmental study has been done for the proposed project. However some studies and surveys have been done on the main and basic environmental and ecological issues throughout Kenya which are mentioned hereinafter:

- Study on flora of Kenya began in 1952; in this study, BeentijeHenk (British botanist) with 122 other botanists from which 12 botanists were from Africa continent, worked on writing the book "Flora of tropical east Africa". All experts gathered lots of flora samples from Uganda, Tanzania and Kenya during 10 years field study. Publication of the first volumes began in 1962. This volume comprises of nearly 12,500 flora species of East Africa that mostly are endemic species and are seen from dessert to rain forests in the said countries. The list of gathered species was published in 128 volumes (from family Acanthaceae to Velloziaceae) by Royal Botanic garden kew in 2008.
- John Karmali, illustrated the pictures and characteristics of more than 128 flowering species of Kenya in the book "The beautiful plants of Kenya" in the year 1993.
- In 1999 Lesile & Little studied comprehensively the condition of the fauna and flora of Turkana catchment area and compiled and published the information obtained thus, in the book "Turkana herders of the dry Savana". The status of the cultivated and natural plants of Turkana catchment area are elaborated in

this book and a list of Euphorbiaceae and Cactaceae and Acacia spp. of the upstream plains of Kerio River is given as well.

- In 1999, Agnew prepared a collection of “Upland Kenya wild flower”, from which a number of species are similar to the species of the study area and were used to recognize and identify the plant samples of the Arror project study area.
- In 2002, Najma Dharani presented the trees and shrubs of east Africa in the book “Field guide to common trees & shrubs of east Africa” including their taxonomic specifications.
- In 2003, Kiringe & Okello in an attempt to define the specifications of Kamnarok National Park provided the list of some plant and animal species of the protected areas of Kenya. In the same year, Abuto the “Zonal forest manager” in Kenya Forestry Service (KFS) described the status of the forests of Kapsowar basin in the “Marakwet east, Embobut forest taskforce report”; and pointed out the endangered species, tourism condition, public participation and future programs for protection of the forest.
- In 2008, an unpublished list of the tree and shrub species of the Kipkunur forest area in the Arorr River catchment area was prepared by Abuto the zonal forest manager which received recognition for the purpose of comparing the names of the identified species with the species of the study area.

Accordingly, the current information which may be used in the identification of the flora species and/or the ecological status of the study area forests are as follows: (Flora of tropical east Africa has 128 volumes from among which a few are named below.)

i. Flora of tropical East Africa, Acanthaceae, H. S. Beentje & S. A. Ghazanfar
ii. Flora of tropical East Africa, Aizooaceae, C. Jeffrey.
iii. Flora of tropical East Africa, Alangiaceae, B. Verdcourt

128- Flora of Tropical East Africa velloziaceae, L. B. Smith & E. S. Ayensu

And,

- Ryding.O. (2001): Biodiversity Research in the Flora of Africa Region
- Steenfort. M. (1988): Flowering Plants in West Africa
- Glen. H. F. (2002): Cultivated Plants of Southern Africa
- Friis. IB &Vellesen.K. (1998): Catalogue of vascular plants
- Newmark. W. D. (2002): Conserving Biodiversity in East Africa Forest
- Jons.R. j (1991): Pterodiophytes of Tropical South Africa
- Agnew & Agnew (1999): The beautiful plants of Kenya
- Dharani. N. (2002): Field Guide to common Tree & Shrubs of East Africa
- Abuto in AFS (2003): Marakwet east district, Embobut forest task force report.

Study records on fauna are as given hereinafter for each class separately:

Mammals:

- Field Guide to African Wildlife (Alfred A. knopf, 2009)
- Mammals of East Africa (Chris &Tilde stuart, 2009)
- The Kingdon Pocket Guide to African mammals (Jonathan Kingdon, 2004)
- The Kingdon Field Guide to African mammals (Jonathan Kingdon, 1997)

Birds:

- Field Guide to the Birds of East Africa (Stevenson, Fanshawe, 2001)
- Birds of Kenya & Northern Tanzania (Zimmerman, Turner, Pearson, Willis & Pratt, 1996/1999)
- Photographic Guide to Birds of prey of Southern, Central and East Africa (David Allan, New Holland)
- Collins Field Guide: Birds of East Africa (Harper Collins, 1995)
- Beautiful Birds of Kenya (John Karmali, Text Book Center, 1993)
- Birds of Kenya (Dave Richards)

Reptiles & Amphibians:

- Pocket Guide to the reptiles and amphibians of East Africa (Spawls, Howell & Drewes, A & C Black Publishers, 2006)
- A Field Guide to the reptiles of East Africa (Spawls, Howell, Drewes & Ashe, Academic Press, 2001)
- A Photographic Guide to Snakes and other Reptiles of Southern Africa (Bill Branch, 2001)
- East African Wildlife (Insight Guide, 1997)
- Collins Guide to African Wildlife (Harper Collins, 1996)
- Nature in general a Field Guide to the tracks & signs of Southern and East African Wildlife (Chris & Tilde Stuart, 1994)
- Check list of the reptiles and amphibians of East Africa (Uganda; Kenya; Tanganyika; Zanzibar) Published 1957 by The Museum in Cambridge

Also there are some published researches on wildlife and protected areas which have been published by governmental organizations such as:

- KWS (Kenya Wildlife Service)
- KFS (Kenya Forestry Service)
- Nature Kenya (The East Africa Natural History Society)
- IBA (Important Birds' Areas)
- National Museum of Kenya
- CIA World Fact book on Kenya

Thus, the general data with regard to the type and number of the fauna species of Kenya and the endangered species as well as the protected areas of the country are available: therefore, the information needed for the environment impact assessment must be obtained by careful field study in the Arror project study area.

With respect to the preparation of 128 volumes of Flora of tropical east Africa lists (including Kenya) which is the result of 50 years of study, this list comprises a large portion of the plant species of the study area; but specifically in Kapsowar area, except the KFS studies on a certain portion of the forest species of Arror River upstream done by Abuto in 2003, there has been no studies done in this region, therefore, field visits and comprehensive field studies in the proper time is necessary to provide the information needed in environment impact assessment of the Arror project.

Regarding the Kerio plain which is extended up to Turkana Lake basin, and the irrigation area therein, there is no sufficient information and the only source to refer to is some general information describing the Kamnarok Park Flora and the report of Savana Region in the Turkana upstream, in which just a list of species of Leguminosae, Cactaceae and Euphorbiaceae could be accessed.

Likewise, for wild life and habitats, there is only general information about Kenya as well as some national parks and protected regions available. But, as a major part of the study area of the Arror project is not in the list of the protected regions, therefore, very limited information is available and most of the data are of a general sense. The other part of the study area which is in the protected regions of Namarok, have no detailed and precise information and as a result there is a need to supply of necessary information to perform environment impact assessment of the project in terms of complementary field data.

2. Project Description

2.1. Project Components

The main Components of the project are:

1) Dam
2) Hydro-electric power plant
3) Irrigation project that are described hereunder:

1) Dam

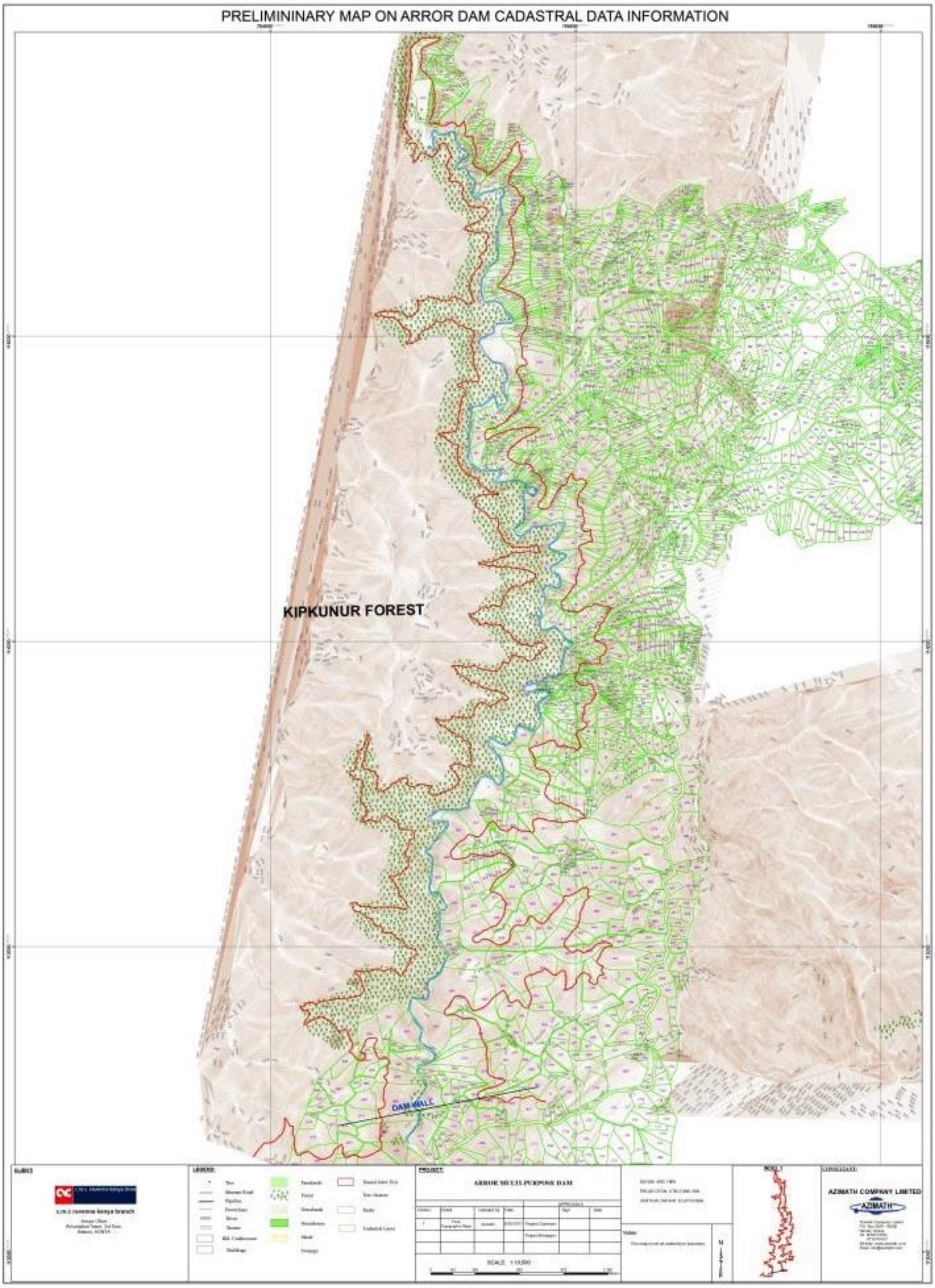
The dam will be in loose materials, of the zoned type, with a waterproof core and lateral transitions, and will have a maximum height of 91 m and length at the crest of 615 m.

The capacity of the reservoir amounts to approximately 60 MCM and the reservoir area is 2.8 Km^2.

The diversion works for the construction of the Arror dam consist of a 600 m long tunnel of the horseshoe type with 3.5 m diameter in the right bank of Arror River.

The spillway is sized to discharge downstream the floods with 1000 years return period which run into the reservoir, thus safeguarding the stability of the loose materials dam. A traditional concrete spillway collects the waters to be discharged and conveys them, through a 300 m long concrete chute, to a stilling basin and there form to the Arror River bed. The threshold of the spillway is of the “free” type, with a maximum water head of 2 m and a length of 67 m.

Due to the access to the whole conveyance route, the NTM engineers (in this study) decided to change the path of conveyance route. This alternative is considered about the route and the location of power house, but the gross head and water potential are not changed compared to feasibility study scheme by Italian Co. According to this approach the pressure tunnel which was suggested by B & B Consultant Engineers replaced by a penstock from the reservoir to the power house.


PRELIMININARY MAP ON ARROR DAM CADASTRAL DATA INFORMATION
KIPKUNUR FOREST
DAM WALL
ARROR MULTIPURPOSE DAM
AZIMATH COMPANY LIMITED
AZIMATH
SCALE 1:10,500
N

2) Hydroelectric power plant scheme

The power intake includes an inlet structure protected by fine gratings which control the entrance of the water and shaft structure for the down flow with minimal losses. The intake structure, in length of 100 m, would be connected to the penstock after stop-log. In order to control the water flow into the penstock a butterfly valve would be considered at the entrance of the penstock.

Having sufficient access to the valve house and penstock route is important, so an access tunnel, in length of 1000 m and slope of 1%, is predicted at the first part of the route. This tunnel connects the downstream to the upstream (Chepkum – Kapsowar) as a service road and an access road at the construction period. The access tunnel is in shape of horse-shoes with a diameter of 5 meter.

The penstock with the diameter of 1.6 m will be located at the corner of the access tunnel, and the besides area in the tunnel is consider to be as the access road. The penstock is dimensioned for a plant factor of 0.36, which corresponds to the maximum flow of 6 CMS. The penstock, with alignment which adapts itself to the nearly constant slope of the escarpment is formed by a steel pipe with a diameter ranging from 1.6 m at the access tunnel to 1.0 m at the entrance of the power plant.

The penstock access road, in the slope of 13% and length of 10 km, follows the penstock alignment, would be constructed for the installation of the penstock and, successively, for its maintenance and for the public transportation from the power house to the dam site (Chepkum – Kapsowar), by this layout time is saved about four hours to travel from Chepkum to Kapsowar.

The power house located in the valley floor near the village of Chepkum, includes three turbine-generator groups, two of them are composed of a two-jet Pelton horizontal axis turbine, with nominal power of 25 MW (yielded by a 2.5 CMS water flow and 1,100 m net head). The other turbine is also a two-jet Pelton horizontal axis turbine, but its nominal power is 10 MW (yielded by a 1 CMS water flow and 1,100 m net head). The annual energy production is envisaged to be 189.5 GWh.

A 220 kV transmission line, which connects the Turkwel Hydro Electric Power Plant to Lessos, will connect the Chepkum power house to the grid. The power house switchyard will enable the parallel between the 220 kV departure-arrival lines. As well as 11 kV distribution line will provide power to the villages in the valley floor and to the Kapsowar, Maina, Chesoi and Kitinos areas.

The daily water flow of turbine is approximately 170,000 CM which is made available for drinking and irrigation purposes. Since the maximum daily consumption of water, when all the envisaged irrigation schemes are implemented, is estimated at 50,000 CMD, a tailrace channel, fed by the overflow of 6 CMS, has been foreseen to discharge the surplus water into Kerio River. The re-regulating pond includes the inlets of the irrigation water conveyance system. Table 2.1 shows the characteristics of the project suggested by NTM Consulting Engineers.

Table 2.1: The Characteristics of the Project Suggested by NTM Consulting Engineers

Description	Amount
Catchment Area till Dam Site (Km^2)	185
Normal Water Level (m)	2260
Reservoir Capacity Below Normal Level (MCM)	70
Dead Water Level (m)	2230
Dead Storage (MCM)	10
Regulating Capacity (MCM)	60
Tail water Level (m)	1120
Flow When Generating Power(CMS)	6
Weighted Average Head (m)	1100
Installed Capacity (MW)	60
Average Annual Output (GWH)	189.5
Guaranteed Output (90%) (GWH)	157.7
Annual Utilization Hours	3185
Plant Factor	0.36
Crest Length	615
Dam Height (m)	91
Tunnel Length (km)	1800
Penstock Length (km)	4700
Volume of Daily Re-regulating Pond	50000
Length of 220 KV Transmission Line (km)	1.5
Length of 132 KV Transmission Line (km)	-
Length of 11 KV Transmission Line (km)	2.5
Length of Penstock Access Road (km)	10 + 1 Tunnel

3) Irrigation project

A region with an area about 6000 ha has been under study in Kerio Plain to develop irrigation and agriculture plans. Areas with limitation such as forests with higher density have been excluded and an area equal 2250 ha has been selected for pedology study as areas with capability of agriculture. In initial survey of irrigation plan, some other areas such as roads or pipeline routes have been excluded and ultimately an area about 1400 ha has been selected for irrigation project study.

After electricity generation from input water at power house, output water is discharged in a re-regulating pond with capacity of 50,000 m^3 that shall be constructed in the downstream the power house.

Water taking shall be done through a steel pipeline from the pond for agricultural and drinking consumptions in Kerio Valley. Inside diameter of the pipeline is 1000 mm that have ability to pass a maximum of 2 m^3/s water at peak times. Depending on the pattern and area under cultivation, the volume of water passing varies (1-2 m^3/s) through the year.

Surplus water discharges directly into Kerio River through overflow of the pond and a drain. Due to the topography, Kerio River is the main drain of the region and with attention to the direction of water flow in the river, general slope of the region is from south to north.

Main pipeline is divided into two branches after 100 m:

- North conveyance line and
- South conveyance line.

At the point of split, a water intake (namely water intake Zero) is embedded to supply water for irrigation (98.3 lit/s) and drinking water for inhabitants and animals (10 lit/sec).

A pond is established at the place of each water intake; that its volume capacity is dependent to regulated and/or required water at each water intake.

The irrigation is through irrigation system under pressure (sprinkler and drip irrigation). Pipeline route have been selected so that, it is not required to establish pumping stations as much as possible (in fact, need to construct pumping stations is cleared during phase 2 of the study using large-scaled maps).

General characteristics of north and south main pipelines are described as below:

North conveyance line

Total length of the pipeline is 5150 m, with 900 mm diameter at the beginning of the route and 700 mm diameter at the end at Mogil.

Along the line, the diameter of the pipes decreases as branches are provided to serve the single perimeters. The alignment of the pipelines has been selected to avoid as much as possible critical points like rock outcrops, steep slopes, deep and wide gullies and to cross the Arror River in the most suitable point.

Three water intakes (N1, N2 and N3) are embedded throughout the pipeline. Volume of water taken for different purposes is as Table 2.2:

Table 2.2: Water intake from North conveyance line

Water intake	Irrigation (lit/s)	Drinking (Inhabitants & Animals) (lit/s)
N1	192	10
N2	71.4	10
N3	516	20
Total	**779.4**	**40**

South conveyance line:

Total length of the pipeline is 10350 m, with 900 mm diameter at the beginning of the route and 500 mm diameter at the end. Nine water intakes (S1 to S9) is embedded throughout the pipeline. Volume of water taken for different purposes is as Table 2.3:

Table 2.3: Water intake from South conveyance line

Water intake	Irrigation (lit/s)	Drinking (Inhabitants & Animals) (lit/s)
S1	215.5	10
S2	262	10
S3	48	10
S4	65.5	10
S5	97	10
S6	51.8	-
S7	34	-
S8	26	-
S9	202.5	20
Total	**1002.3**	**70**

Totally in the irrigation plan, 15500 m main conveyance line is established, that 120 lit/s water for drinking purpose and 1880 lit/s for agricultural purpose are supplied through it. Conveyance line is placed in depth 2-2.5 m that parts of excavation may be in the rock.

Distribution pipelines (or lateral pipelines) are splitted from the main conveyance line at the water intake points. These pipelines are made of polyethylene and are placed in depth 1.5 m.

2.2 Project Activities

2.2.1 Pre-construction Activities

The most important pre-construction activity is land acquisition that is the same for all main components of the project.

2.2.2 Construction Activities

Important activities from the environmental viewpoint for three main components of the project in construction phase are given in the Table 2.4.

Table 2.4: Important Activities of the Project in Construction Phase

Dam	Hydro Electrical Power Plant	Irrigation network
Employment	Employment	Employment
Excavation and embankment	Excavation and embankment	Excavation and embankment
Pavement	Pavement	Construction of temporary camps and workshops
Clearing rocks/stones	Construction of penstock access road	Installations of equipment
Construction of dam access road	Asphalting the road	Camping of staff/workers in temporary camps
Asphalting the road	Construction of temporary camps and workshops	Transport of materials and equipment
Construction of temporary camps and workshops	Camping of staff/workers in temporary camps	Traffic of trucks
Camping of staff/workers in temporary camps	Spilling of oil, grease and fuel products on the land	Influx of workers in the region
Store room for explosives	Transport of materials and equipment	Activities of heavy and light machinery
Operation with explosives (1)	Traffic of trucks	Workshop activities
Transport of materials and equipment	Influx of workers in the region	Water consumption
Traffic of trucks	Activities of heavy and light machinery	Electricity consumption
Influx of workers in the region	Workshop activities	Concrete operations
Activities of heavy and light machinery	Water consumption	Excavation from borrow areas
Workshop activities	Electricity consumption	Waste matters and debris depot
Diversion of water	Borrow resources	Solid wastes disposal
Water consumption	Waste matters and debris depot	Effluent disposal
Electricity consumption	Solid wastes disposal	Store room for material
Concrete operations	Effluent disposal	Spilling of oil, grease and fuel compounds on the land
Excavation from borrow areas	Construction of intake	Laying pipelines

Dam	Hydro Electrical Power Plant	Irrigation network
Construction of diverting tunnels	Construction of concrete pipe	Site clearance
Cofferdams	Construction of penstock tunnel (2)	Dismantling workshops
Site clearance & deforestation of reservoir area (before water inflow)	Construction of access tunnel (2)	
Grouting	Laying of penstock	
Grout curtain	Construction of power house	
Foundation and construction of dam body	Construction of transmission line	
Construction of spillway	Site clearance	
Waste matters & debris depot	Dismantling workshops	
Solid wastes disposal	*1) For constructing the diverting tunnels, dam body, spillway, penstock tunnel and access tunnel explosive operations shall be required. 2) During construction phase of hydroelectric power plant two tunnels shall be constructed, one is main tunnel that the penstock is passed along it and the other is access tunnel that links the main tunnel to road in downstream.*	
Effluent disposal		
Spilling of oil, grease and fuel compounds on the land		
Resettlement		

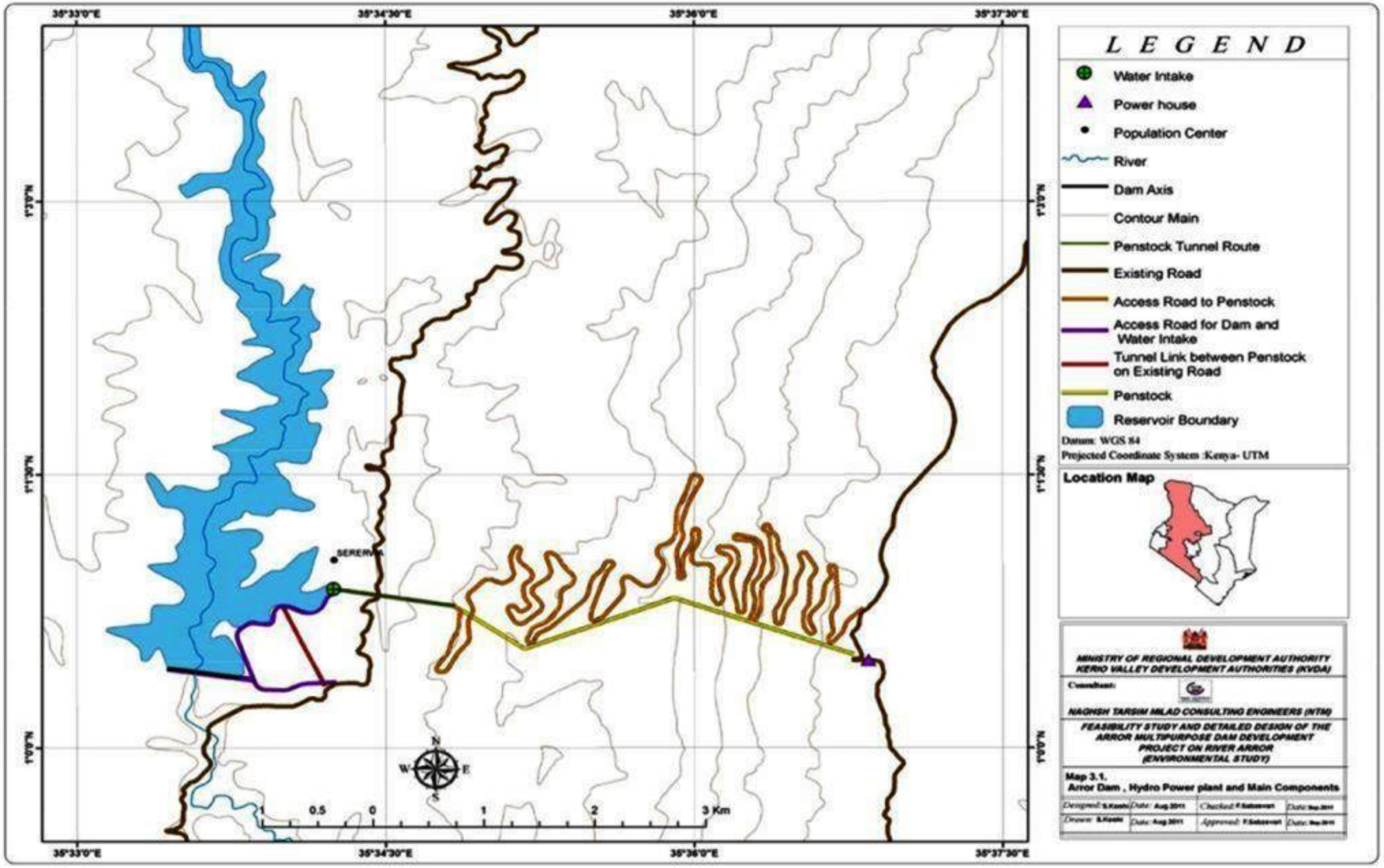
2.2.3 Operational Activities

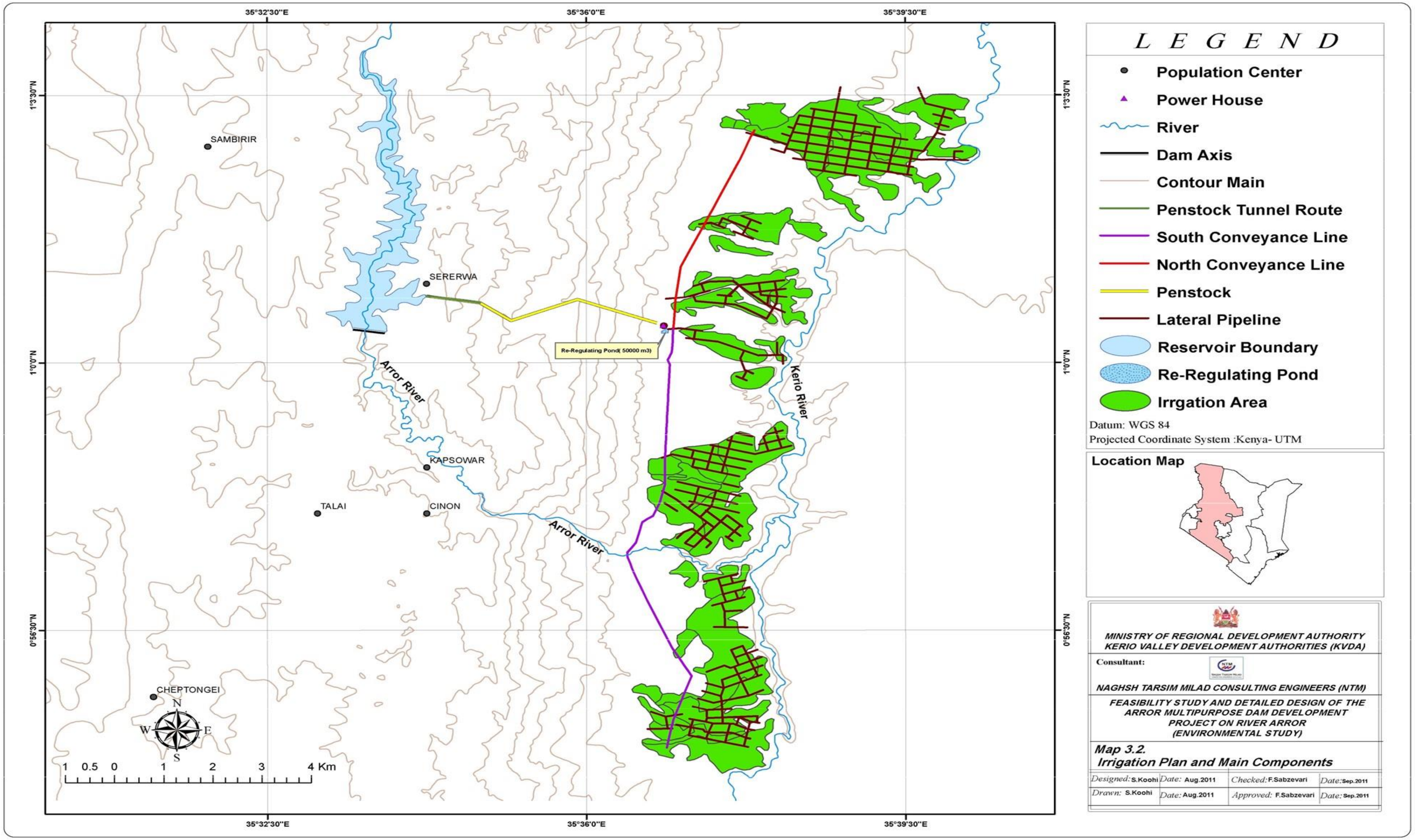
Important activities from the environmental viewpoint for three main components of the project in operation phase are given in the Table 2.5 and project components are shown in the Maps 2.1 and 2.2.

Table 2.5: Important Activities of the Project in Operation Phase

Dam	Hydro Electrical Power Plant	Irrigation network (scheme)
Employment	Employment	Employment
Presence of dam	Operation of power plant	Agricultural activities
Formation of reservoir	Electricity generation	Irrigation
Release of water	Monitoring and maintenance	Use of fertilizer
River regulation	Presence of transmission line	Use of Pesticides
Electricity generation	Irrigation water supply in Kerio Valley	Activity of agricultural machineries
Irrigation water supply in Kerio Valley	Drinking water supply for community in Kerio Valley	Transportation of agricultural products
Drinking water supply for the community in highland areas		Local consumption of agricultural products
Environmental water flow		Selling of agricultural products

Reservoir fluctuation		
Operational team		
Sedimentation in reservoir		
Effluent disposal		
Solid waste disposal		


35°33'0"E
35°34'30"E
35°36'0"E
35°37'30"E
1°3'0"N
1°1'30"N
1°0'0"N
SERERWA
N
W
E
S
1
0.5
0
1
2
3 Km
LEGEND
Water Intake
Power house
Population Center
River
Dam Axis
Contour Main
Penstock Tunnel Route
Existing Road
Access Road to Penstock
Access Road for Dam and Water Intake
Tunnel Link between Penstock on Existing Road
Penstock
Reservoir Boundary
Datum: WGS 84
Projected Coordinate System :Kenya- UTM
Location Map
MINISTRY OF REGIONAL DEVELOPMENT AUTHORITY
KERIO VALLEY DEVELOPMENT AUTHORITIES (KVDA)
Consultant:
NAGHSH TARSIM MILAD CONSULTING ENGINEERS (NTM)
FEASIBILITY STUDY AND DETAILED DESIGN OF THE ARROR MULTIPURPOSE DAM DEVELOPMENT PROJECT ON RIVER ARROR (ENVIRONMENTAL STUDY)
Map 3.1.
Arror Dam , Hydro Power plant and Main Components
Designed:
Date: Aug.2011
Checked:
Date:
Drawn:
Date: Aug.2011
Approved:
Date:


35°32'30"E
35°36'0"E
35°39'30"E
1°3'30"N
1°0'0"N
0°56'30"N
SAMBIRIR
SERERWA
KAPSOWAR
TALAI
CINON
CHEPTONGEI
Arror River
Arror River
Kerio River
Re-Regulating Pond(50000 m3)
N
S
W
E
1 0.5 0 1 2 3 4 Km
L E G E N D
● Population Center
▲ Power House
River
Dam Axis
Contour Main
Penstock Tunnel Route
South Conveyance Line
North Conveyance Line
Penstock
Lateral Pipeline
Reservoir Boundary
Re-Regulating Pond
Irrgation Area
Datum: WGS 84
Projected Coordinate System :Kenya- UTM
Location Map
MINISTRY OF REGIONAL DEVELOPMENT AUTHORITY
KERIO VALLEY DEVELOPMENT AUTHORITIES (KVDA)
Consultant:
NAGHSH TARSIM MILAD CONSULTING ENGINEERS (NTM)
FEASIBILITY STUDY AND DETAILED DESIGN OF THE ARROR MULTIPURPOSE DAM DEVELOPMENT PROJECT ON RIVER ARROR (ENVIRONMENTAL STUDY)
Map 3.2.
Irrigation Plan and Main Components
Designed: S.Koohi
Date: Aug.2011
Checked: F.Sabzevari
Date: Sep.2011
Drawn: S.Koohi
Date: Aug.2011
Approved: F.Sabzevari
Date: Sep.2011

2.3. Quarries and borrow areas

The construction dam's auxiliary structures and power plant, will utilize tones of sand, rocks, gravels, murram etc. which will be sourced within the project area or the surrounding areas. It is envisaged that the construction materials will be sourced in areas approved by the National Environment Management Authority (NEMA) as per the regulations. During this study, the construction material sites were not mapped because the classification and characterization of the soil with laboratory test have not been done so as to ascertain compatibility with those specified in the design, nevertheless, there are approved exiting quarries in the project area which can be used to source the materials.

Only the materials that are compatible with those specified for the execution of the necessary services will be transported for utilization. Waste disposal areas will be identified and approval sought be the contractor and/or proponent from NEMA and Elgeiyo Marakwet county government before construction commences.

3. Policy and Legal Framework

3.1 General Overview

Environmental Impact Assessment is a tool for ensuring new projects and programmes incorporate appropriate measures to mitigate adverse impacts to the environment and peoples' health and safety as well as enhancing sustainable operations with respect to environmental resources and co-existence with other socio-economic activities in their neighbourhood. Necessary policies and legislation that ensures annual environmental audits (EA) are carried out on every running project, activity or programme and a report submitted to National Environmental Management Authority (NEMA) for approval and issuance of relevant certificates.

According to the Kenya National Environment Action Plan (NEAP, 1994) the Government recognized the negative impacts on ecosystems emanating from industrial, economic and social development programmes that disregarded environmental sustainability. Following on this, establishment of appropriate policies and legal guidelines as well as harmonization of the existing ones have been accomplished and/or are in the process of development. The NEAP process introduced environmental assessments in the country with among the key stakeholders being industrialists, business community and local authorities. This culminated into the enactment of the Policy on Environment and Development under the Sessional Paper No. 6 of 1999.

3.2 National Policy Framework

The national policy on Environment and Development presents broad categories of development issues that require sustainable approach. Among the goals of the policy are to:

- Incorporate environmental management and economic development as integral aspects of the process of sustainable development; and
- Encourage sustainable utilisation of resources and ecosystems for the benefit of the present generations, while ensuring their potential to meet the needs of the biosphere and future dependants.

Following on this, the policy outlines the following objectives among others:

- Conservation and management of the natural resources of Kenya including air, water, land, flora and fauna,
- Promotion of environmental conservation through the sustainable use of natural resources to meet the needs of the present generations while preserving their ability to meet the needs of future generations,

- Meeting national goals and international obligations by conserving bio-diversity, arresting desertification, mitigating effects of disasters, protecting the ozone layer and maintaining an ecological balance on earth.

3.3 National Legal Framework

Application of national statutes and regulations on environmental conservation suggest that the Proponent has a legal duty and social responsibility to ensure that the proposed development is carried out without compromising the status of the environment, natural resources, public health and safety. This position enhances the importance of this environmental impact assessment for the proposed site to provide a benchmark for its sustainable operation.

Kenya has approximately 77 statutes that relate to environmental concerns. Most of these statutes are sector specific, covering issues such as public health; SOB erosion; protected areas; endangered species; water rights and water quality; air quality, noise and vibration; cultural, historical, scientific and archaeological sites; land use; resettlement; etc. Previously, environmental management activities were implemented through a variety of instruments such as policy statements and sectoral laws, and also through permits and licences. For example, the Physical Planning Act of 1996 empowers local authorities to request existing facilities to conduct environmental assessments, while under the Local Government Act of 1998, it is an offence to emit smoke, fumes or dust which may be a source of danger, discomfort or annoyance.

The key national laws that govern the management of environmental resources in the country have been briefly discussed below, although it is important to note that wherever any of the laws contradict each other, the Environmental Management and Co-ordination Act 1999 prevails:

3.3.1. The Environment Management and Coordination Act, 1999

The Act entitles every person in Kenya to a clean and healthy environment and aims to safeguard and enhance the environment. Through there are other sectoral laws on environmental conservation, this is the supreme Act. It provides guidelines on issues of environment. Stipulates offences and penalties and establishes NEMA. The Act also lists the types of projects, which must be subjected to the conduct the EIA project report study to comply and meet the requirements of this legislation.

Part II of the Environment Management & Coordination Act, 1999 states that every person in Kenya is entitled to a clean and healthy environment and has the duty to safeguard and enhance the environment. In order to partly ensure this is achieved, Part VI of the Act directs that any new programme, activity or operation should undergo environmental impact assessment and a report prepared for submission to the National

Environmental Management Authority (NEMA), who in turn may issue an EIA license as appropriate.

Part VIII section 72 of the Act prohibits discharging or applying poisonous, toxic, noxious or obstructing matter, radioactive or any other pollutants into aquatic environment. Section 73 require that operators of projects which discharges effluent or other pollutants to submit to NEMA accurate information about the quantity and quality of the effluent. Section 74 demands that all effluent generated from point sources be discharged only into the existing sewerage system upon issuance of prescribed permit from the local authorities or from the licensee. Finally, section 75 requires that parties operating a sewerage system obtain a discharge license from NEMA to discharge any effluent or pollutant into the environment.

Section 87 sub-section 1 states that no person shall discharge or dispose of any wastes, whether generated within or outside Kenya, in such a manner as to cause pollution to the environment or ill health to any person, while section 88 provides for acquiring of a license for generation, transporting or operating waste disposal facility. According to section 89, any person who, at the commencement of this Act, owns or operates a waste disposal site or plant or generate hazardous waste, shall apply to the NEMA for a license.

Sections 90 through 100 outline more regulations on management of hazardous and toxic substances including oils, chemicals and pesticides.

Finally, the environmental impact assessment guidelines require that the ESIA study be conducted in accordance with the issues and general guidelines spelt out in the second and third schedules of the regulations. These include coverage of the issues on schedule 2 (ecological, social, landscape, land use and water considerations) and general guidelines on schedule 3 (impacts and their sources, project details, national legislation, mitigation measures, a management plan and environmental auditing schedules and procedures.

3.3.2. The Factories and Other Place of Work Act (Cap. 154)

The Factories and Other Places of Work Act makes provision for the health, safety and welfare of persons at such workplaces. The Act is predominantly socio-economic in nature and focuses on the shop floor conditions of the factory, safety devices, machine maintenance, safety precautions in case of fire, gas explosions, electrical faults, provisions of protective equipment among others. In 2004, a subsidiary legislation (legal Notice NO.30) was enacted to provide for the formation of Safety Committees by the occupier of every factory or other workplaces. The Committee is responsible for all health and safety issues of enterprises including undertaking safety audits.

Part VI provides for the general welfare of the workers. Part VII section 51 states in part “In every factory or work place in which, in connection with any process carried on, there is given off any dust or fumes or other impurity of such a character and to such an extent as to be likely to be injurious or offensive to the persons employed, or any substantial quantity of dust of any kind, all practicable measures shall be taken to protect the persons employed against inhalation of the dust or fume or other impurity and to prevent it accumulation in any workroom, and in particular, where the nature of the process makes it practicable exhaust appliances shall be provided and maintained as near as possible to the point of origin of the dust or fumes … ”.

Section 4 of Kenya subsidiary legislation of 2004, Legal Notice No. 31 of Kenya Gazette Supplement No. 25 of 24th May, 2004 of the Factories Act Cap 514, requires that, all factories or other workplace owners to establish a safety and health committee, which shall consist of safety representatives from the management and the workers. The number of the committee members will range from 3 to 7 depending on the size (number) of employees. The Act also requires the management to appoint a competent person who is a member of the management staff to be responsible for safety, health and welfare in the factory or workplace.

Section 13 goes ahead to state that a health and safety audit of the workplace be carried out every twelve months by a registered Health and Safety Adviser. If the owner(s) or management contravenes any of the rules, he/she shall be guilty of an offence.

Part IV of the Factories Act. Chapter 514 addresses provisions concerning health. These provisions are to be enforced by the Department of Occupational Health and Safety of the Ministry of Labour.

Part V of the Factories Act elaborately deals with safety requirements, mainly from the point of view of avoiding accidents and injuries at work.

Noise Prevention and Control Rules: These rules are described in Legal Notice No. 25 of the Kenya Gazette Supplement No. 22 of April 2005 and state the noise regulations that apply to every factory, premises, place, process and operations to which the provisions of the Factories and Other Places of Work Act (Cap 514) applies.

Health and Safety Committee Rules: These rules are described in Legal Notice No.31 of the Kenya Gazette Supplement No.25 of May 14, 2004 and apply to all factories and other workplaces that regularly employ twenty or more employees. Among other items, the rules state that:

- The occupier of every factory or other workplace shall establish a Health & Safety committee; the Committee shall consist of safety representatives from the management and the workers;
- The occupier of every factory or workplace shall cause a health and safety audit of the workplace to be carried out at least once in every period of twelve months by a registered health and safety Adviser;

The above legal notice also describes the functions and duties of the Health & Safety committees, meetings and minutes, and roles in the Committee. It further describes the duties of the occupier and those of the Health & Safety Adviser.

3.3.3. The Public Health Act (Cap. 242)

In part XII, the prevention and destruction of mosquitoes. Section 136 describes breeding places of mosquitoes that are a nuisance to include all collection of water which permit or facilitate the breeding or multiplication of disease vectors for men or domestic animals.

3.3.4. Water Act (2002)

The Act provides for national monitoring and information systems on water resources. The Act regulates abstraction and storage of water from water courses depressions or channels. Section 25 on water rights and works and Section 26 permit not required for certain activities. To formalize the project, the proponent should notify the sub county water officer on the project and its components.

Part IX section 115 of the Act states that no person/institution shall cause nuisance or condition liable to be injurious or dangerous to human health. Section 116 requires Local Authorities to take all lawful, necessary and reasonably practicable measures to maintain their jurisdiction clean and sanitary to prevent occurrence of nuisance or condition liable for injurious or dangerous to human health. Such nuisance or conditions are defined under section 118 and include nuisances caused by accumulation of materials or refuse which in the opinion of the medical officer of health is likely to harbour rats or other vermin.

3.3.5. The Occupational Health and Safety Act (2007)

This is an Act of Parliament to provide for the safety, health and welfare of workers and all persons lawfully present at workplaces, to provide for the establishment of the National Council for Occupational Safety and Health and for connected purposes.

The Act has the following functions among others:

- Secures safety and health for people legally in all workplaces
- Prevents employment of children in workplaces where their safety and health is at risk.
- Encourages entrepreneurs to set achievable safety targets for their enterprises.
- Promotes reporting of work-place accidents, dangerous occurrences and ill health with a view to finding out their causes and preventing of similar occurrences in future.
- Promotes creation of a safety culture at workplaces through education and training in occupational safety and health.

3.3.6. Physical Planning Act (Cap. 286)

Section 24 of the Physical Planning Act gives provision for the development of local physical development plan for guiding and coordinating development of infrastructure facilities and services within the area of authority of County, municipal and town council and for specific control of the use and development of land. The plan shows the manner in which the land in the area may be used. Section 29 of the physical Planning Act gives the county councils power to prohibit and control the use of land, building, and subdivision of land, in the interest of proper and orderly development of its area. The same section also allows them to approve all development applications and grant development permissions as well as to ensure the proper execution and implications of approved physical development plans. On zoning, the act empowers them to formulate by-laws in respect of use and density of development.

Section 30 states that any person who carries out development within an area of a local authority without development permission shall be guilty of an offence and the development shall be invalid. The act also gives the local authority power to compel the developer to restore the land on which such development has taken place to its original conditions within a period of ninety days. If no action is taken, then the council will restore the land and recover the cost incurred thereto from the developer. In addition, the same section also states that no person shall carry out development within the area of a local authority without development permission granted by the local authority.

Section 36 states that if in connection with development application a local authority is of the opinion that, the proposed activity will have injurious impact on the environment, the applicant shall be required to submit together with the application an Environmental Impact Assessment report. The environmental impact assessment report must be approved by the National Environmental Management Authority (NEMA) and followed by annual environmental audits as spelled out by EMCA 1999. Section 38 states that if the local authority finds out that the development activity is not complying to all laid down regulations, the local authority may serve an enforcement notice specifying the conditions of the development permissions alleged to have been contravened and compel the developer to restore the land to its original conditions.

3.3.7. Local Government Act (Cap. 265)

In section 166 the act provides that a local authority may prohibit and control the development and use of land and buildings in the interest of the proper and proponent will notify the county government of Marakwet of the intended activities and the objective of the project.

Part XI section 168 provides that every municipal council, town council or urban council may establish and maintain sewerage and drainage works within or without its area of jurisdiction. For purposes of the land required for such development, section 144 states in part “A local authority may, subject to the approval of the Minister, apply to the government or any other authority having power to acquire land required for purposes of any of its functions, to be acquired compulsorily for and on behalf of, and at the expense of the local authority”. The Act, however, does not indicate the repercussions of impacts on landowners.

Section 160 helps local authorities ensure effective utilisation of the sewerage systems. It states in part that municipal authorities have powers to establish and maintain sanitary services for the removal and destruction of, or otherwise deal with all kinds of refuse and effluent and where such service is established, compel its use by persons to whom the service is available. However, to protect against illegal connections, section 173 states that any person who, without prior consent in writing from the council, erects a building on: excavate or opens-up: or injures or destroys and sewers, drains or pipes shall be guilty of an offence. Any demolitions and repairs thereof shall be carried out at the expense of the offender.

Section 165 allows the local authority to refuse to grant or renew any license which is empowered in this act or any other written law on the grounds that the activity does not conform to the requirements of any by-laws in force in the area of such local authority the granting of the license would be contrary to the public interest.

Section 170, allows the right of access to private property at all times by local authorities, its officers and servants for purposes of inspection, maintenance and alteration or repairs. In addition, the municipal Council may establish and maintain sewage farms or disposal works, and dispose of the effluent therefrom, but shall not be liable for any nuisance or damage as a consequence of proper and ordinary conduct of the sewage farms or disposal works (section 171). To ensure sustainability in this regard, the local authority is empowered to make by-laws in respect of all such matters as are necessary or desirable for the maintenance of health, safety and wellbeing of the inhabitants of its area as provided for under section 201 of the Act.

The Act under section 176 gives power to the local authority to regulate sewerage and drainage, fix charges for use of sewers and drains and require connecting premises to meet the related costs. According to section 174, any charges so collected shall be deemed to be charges for sanitary services and will be recoverable from the premise owner connected to the facility. Section 264 also requires that all charges due for sewerage, sanitary and refuse removal shall be recovered jointly and severally from the owner and occupier of the premises in respect of which the services were rendered. This in part allows for application of the “polluter-pays-principle”.

3.3.8. The Land Planning Act (Cap. 303)

Section 9 of the subsidiary legislation (The development and use of land regulations 1961) requires that before the local authorities submit any plans to the Minister for approval, steps should be taken as may be necessary to acquaint the owners of any land affected by such plans. Particulars of comments and objections made by the landowners should also be submitted. This is intended to reduce conflict with other interests such as settlement and other social and economic activities.

3.3.9. Building Code By-laws

The By-laws of Building code 3 (1) states 'A person who erects a building or develops land or changes the use of a building or land, or who owes or occupies a building or land shall comply with requirements of these by-laws'. By-law 5 states that a person who intends to erect a building or materially change the use of a building or part of a building shall furnish the council in the manner provided in Part A of the First Schedule to these By-laws. Section 194 requires that where a sewer exists, the occupants of the nearby premises shall apply to the local authority for a permit to connect to the sewer line and that all wastewater must be discharged into the sewers.

3.3.10. Occupiers Liability Act (Cap. 34)

Section 3 requires that an occupier of premises owe the "common duty of care" to all visitors and workers. Rules of Common Law regulates the duty which an occupier of premises owes to his visitors in respect of danger and risk due to the state of the premises or to things omitted or attributes an affliction on his/her health to a toxic material in the premises.

3.3.11. West Management Regulations (2006)

The Waste Management Regulations (2006) are contained in the Kenya Gazette Supplement No 69, Legal Notice No 121. Of immediate relevance to proposed development for the purposes of this project report is Part II, Sections 4(1-2), 5 and 6.

Section 4 (1) states that 'No person shall dispose of any waste on a public highway, street, road, recreational area or in any public place except in a designated waste receptacle' sections 4 (2) and 6 explain that the waste generator must collect, segregate (hazardous waste from non-hazardous) and dispose waste in such a facility that shall be provided by the relevant local authority.

Section 5 provides methods of cleaner production (so as to minimize waste generation) which includes the improvement of production processes through: conserving raw materials and energy.

3.3.12. Land Acquisition Act (Cap. 295)

This Act provides for the compulsory or otherwise acquisition of land from private ownership for the benefit of the general public. Section 3 states that when the Minister is satisfied on the need for acquisition, notice will be issued through the Kenya Gazette and copies delivered to all the persons affected. Full compensation for any Damage resulting from the entry onto land to things such as survey upon necessary authorization will be undertaken in accordance with section 5 of the Act. Likewise where land is acquired compulsorily, full compensation shall be paid promptly to all persons affected in accordance to sections 8 and 10 along the following parameters:

- Area of land acquired,
- The value of the property in the opinion of the Commissioner of land (after valuation),
- Amount of the compensation payable,
- Market value of the property,
- Damages sustained from the severance of the land parcel from the land,
- Damages to other property in the process of acquiring the said land parcel,
- Consequences of changing residence or place of business by the land owners,
- Damages from diminution of profits of the land acquired.

3.3.13. The Limitations of Actions Act (Cap. 22)

There is currently no law in Kenya that provides for recognition and protection of the rights or for compensation for loss of these rights for squatters. Squatters do not have legally recognized rights to public land which they occupy. The above provisions relate to compensation for those who have a legal right to land and whose land has been compulsory acquired for public purposes. However, if squatter have been in occupation of private land for over twelve (12) years, then they would have acquired rights as adverse possessors of that land as provided under the limitation of Actions Act, section 7. They would however need to seek a declaration from the High Court and prove that their entry into the land was open, without consent of land owner and was uninterrupted for 12 years if the land is Government land (as is the case for this project). Then they have no rights to it, as the doctrine adverse possession cannot be invoked against the government.

3.3.14 The Environmental Management and Coordination (noise and excessive vibration pollution) (control) Regulations (2009)

Part II section 3 (I) states that: no person shall make or cause to be made any loud, unreasonable, unnecessary or unusual noise which annoys, disturbs, injures or endangers the comfort, repose, health or safety of others and the environment and section 3 (2) states that in determining whether noise is loud, unreasonable, unnecessary or unusual, the following factors may be considered:

- time of the day;
- proximity to residential area;
- whether the noise is recurrent, intermittent or constant;
- the level and intensity of the noise;
- whether the noise has been enhanced in level or range by any type of electronic or mechanical means; and,
- whether the noise can be controlled without much effort or expense to the person making the noise.

Part II Section 4 states that: except as otherwise provided in these Regulations, no person Shall (a) make or cause to be made excessive vibrations which annoy, disturb, injure or endanger the comfort, repose, health or safety of others and the environment; or (b) cause to be made excessive vibrations which exceed 0.5 centimetres per second beyond any source property boundary or 30 metres from any moving source.

Part III, Section 11 (1) states that any person wishing to (a) operate or repair any machinery, motor vehicle, construction equipment or other equipment, pump, fan, air-conditioning apparatus or similar mechanical device; or (b) engage in any commercial or industrial activity, which is likely to emit noise or excessive vibrations shall carry out the activity or activities within the relevant levels prescribed in the First Schedule to these Regulations. Any person who contravenes this Regulation commits an offence.

Section 13 (1) states that except for the purposes specified in sub-Regulation (2) hereunder, no person shall operate construction equipment (including but not limited to any pile driver, steam shovel, pneumatic hammer, derrick or steam or electric hoist) or perform any outside construction or repair work so as to emit noise in excess of the permissible levels as set out in the Second Schedule to these Regulations. These purposes include emergencies, those of a domestic nature and /or public utility construction.

Section 14 relates to noise, excessive vibrations from construction, demolition, mining or quarrying sites, and states that: where defined work of construction, demolition, mining or quarrying is to be carried out in an area, the Authority may impose requirements on how the work is to be carried out including but not limited to requirements regarding (a) machinery that may be used, and (b) the permitted levels of noise as stipulated in the Second and Third Schedules to these Regulations.

It further states that the relevant lead agency shall ensure that mines and quarries where explosives and machinery used are located in designated areas and not less than two kilometres away from human settlements and any person carrying out construction, demolition, mining or quarrying work shall ensure that the vibration levels do not exceed 0.5 centimetres per second beyond any source property boundary or 30 metres from any moving source.

3.3.15. The Factories Act (Cap. 514)

This Act deals with factories and other places of work. Part VI provides for the general welfare of the workers with respect to supply of drinking water, washing facilities and first aid among other aspects. Related to the workers welfare, Part VII section 51 states in part "In every factory or work place in which, in connection with any process carried on, there is given off any dust or fumes or other impurity of such a character and to such an extent as to be likely to be injurious or offensive to the persons employed, or any substantial quantity of dust of any kind, all practicable measures shall be taken to protect the persons employed against inhalation of the dust or fume or other impurity and to prevent it accumulation in any workroom, and in particular, where the nature of the process makes it practicable exhaust appliances shall be provided and maintained as near as possible to the point of origin of the dust or fumes …….".

Section 4 of Kenya subsidiary legislation of 2004, Legal Notice No. 31 of Kenya Gazette Supplement No. 25 of 24th May, 2004 of the Factories Act Cap 514, requires that, all factories or other workplace owners to establish a safety and health committee, which shall consist of safety representatives from the management and the workers. The number of the committee members will range from 3 to 7 depending on the size (number) of employees. The Act also requires the management to appoint a competent person who is a member of the management staff to be responsible for safety, health and welfare in the factory or workplace. Section 13 goes ahead to state that a health and safety audit of the workplace be carried out every twelve months by a registered health and safety adviser.

3.4. National Administrative Framework

3.4.1. The National Environment Council

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

3.4.2. The National Environment Management Authority

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.

3.4.3. The Standards and Enforcement Review Committee

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 (SERC).

3.5 Administration of EIA

The projects to be subjected to EIA are specified in the Second Schedule of the Environmental Management and Coordination Act (1999). Environmental audit is also a legal requirement under Sections 68 and 69 of the Act. Strategic Environmental Assessment (SEA) aimed at guiding implementation of policies, plans and programmes as well as groups of projects is also mandatory under Part IV Sections 37 – 41 of the Act. Besides the schedule activities, the Act empowers the cabinet secretary for the time being responsible for environmental matters to prescribe for EIA appraisal any other activity which in his view may cause significant adverse environmental impacts.

NEMA is ultimately responsible for issuing, varying or cancelling environmental impact assessment licenses, will coordinate the EIA process. NEMA is also responsible for coordinating powers over all public and private sectors. However, each sector plays a role in the implementation of the EIA Guidelines. This requires the establishment of Environmental Liaison Units (ELU's). Each sector is responsible for the costs of maintaining their ELU. For the purpose of overseeing implementation of the EIA Guidelines at county levels, the NEMA will set up environmental committees. These committees will be close allies and strong partners at the local levels and are empowered in the Act.

The administrative and decision-making process regarding formal submissions of project proposal is schematically illustrated in Figure 3.1. The project approval process will involve decision-making at various levels and the necessary authorization will be given once all EIA requirements have been fulfilled and accepted by NEMA and the relevant lead agencies. The EIA license will be issued when NEMA are satisfied that an EIA has been satisfactorily conducted and a satisfactory Environmental Management Plan (EMP) to developed.

The relevant lead agencies and NEMA will ensure that the EMP is implemented. In addition, NEMA will provide a framework for conflict resolution with respect to:

- Disputes within and between Central Government departments
- Disputes between Central Government and Local Authorities
- Dispute involving the public sector, private enterprise and the public.

Any complaint regarding compliance with EIA requirements which NEMA may not resolve will be subject to a review by the Environment Tribunal, with the provisions to bring proceedings in a court of law where necessary, for judicial review.

Plans and projects based on the World Bank classification are divided into 4 categories (A, B, C & D). Since the Arror Dam is accounted as a large dam and will have significant impacts on the environment, it is vital to make a thorough analysis in order to make a sound decision; so it is in the category A; that means performing EIA study for the project is necessary. The EIA process of projects in World Bank is shown in Figure 3.2.

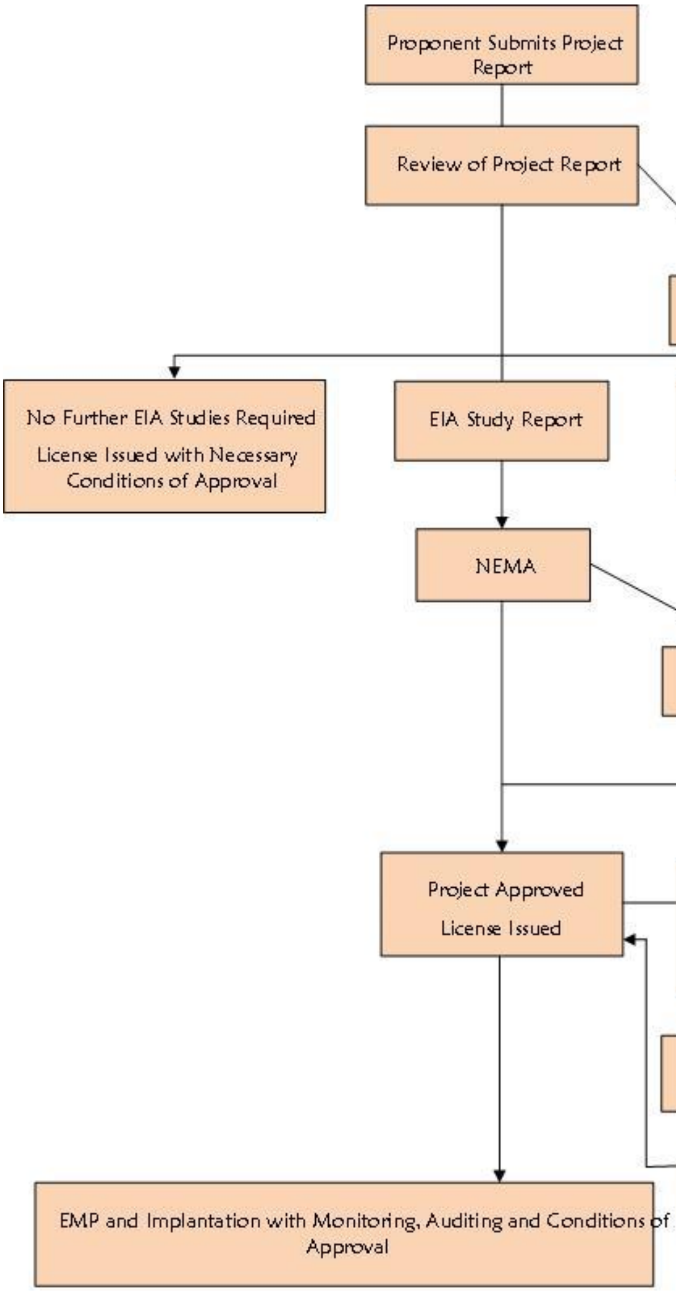


Fig. 3.1: EIA process in Kenya

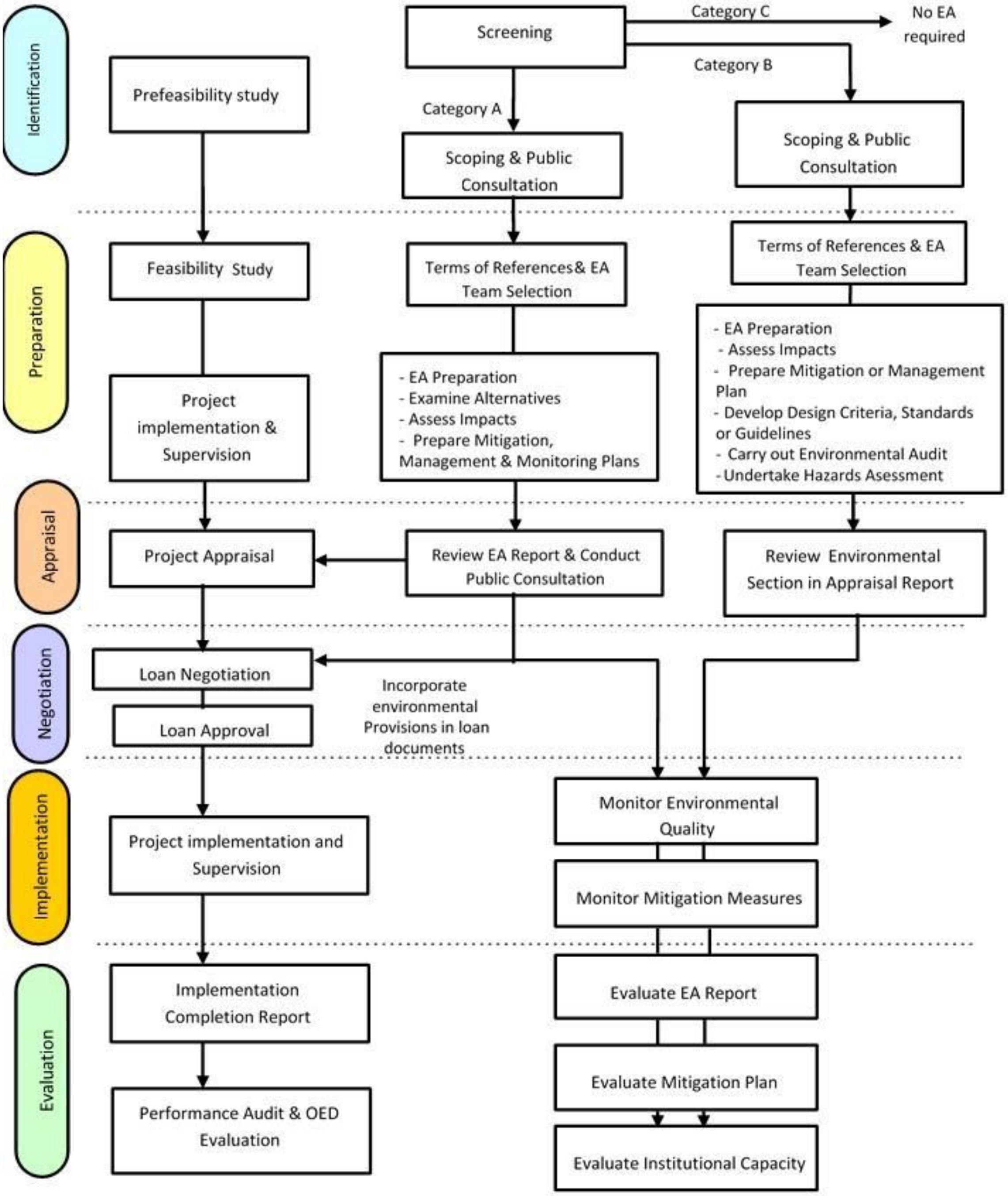


Fig. 3.2: EIA process in World Bank

3.6. International Environmental Organizations

Two most important international environmental organization related to the project are IUCN and CITES that are introduced as follows:

3.6.1. International Union for Conservation of Nature (IUCN)

IUCN, the International Union for Conservation of Nature, helps the world find pragmatic solutions to most pressing environment and development challenges. It supports scientific research, manages field projects all over the world and brings governments, non-government organizations, United Nations agencies, companies and local communities together to develop and implement policy, laws and best practice. IUCN is the world's oldest and largest global environmental network - a democratic membership union with more than 1,000 government and NGO member organizations, and almost 11,000 volunteer scientists in more than 160 countries.

IUCN's work is supported by over 1,000 professional staff in 60 offices and hundreds of partners in public, NGO and private sectors around the world. The Union's headquarters are located in Gland, near Geneva, in Switzerland. Endangered species under the IUCN Red List refers to a specific category of threatened species, and may include critically endangered species.

IUCN Red List of Threatened Species uses the term endangered species as a specific category of imperilment, rather than as a general term. Under the IUCN Categories and Criteria, endangered species is between critically endangered and vulnerable. Also critically endangered species may also be counted as endangered species and fill all the criteria.

The more general term used by the IUCN for species at risk of extinction is threatened species, which also includes the less-at-risk category of vulnerable species together with endangered and critically endangered. IUCN categories are shown in the Figure 3.3.

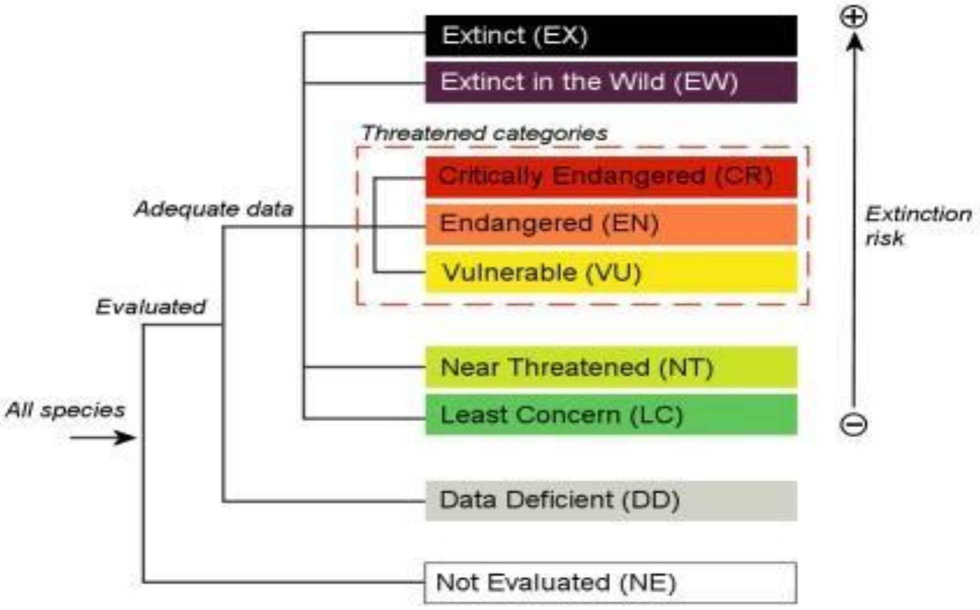


Fig. 3.3: IUCN Categories-2009

Specific terms used in the figure are as defined below:

Extinct: the last remaining member of the species has died, or is presumed beyond reasonable doubt to have died.

Extinct in the wild: captive individuals survive, but there is no free-living, natural population.

Critically Endangered: faces an extremely high risk of extinction in the immediate future.

Endangered: faces a very high risk of extinction in the near future.

Vulnerable: faces a high risk of extinction in the medium-term.

Near Threatened: may be considered threatened in the near future.

Least Concern: No immediate threat to the survival of the species.

Data Deficient: Taxa that cannot be evaluated because of insufficient information.

Not Evaluated: Only a small number of the world's plant and animal species have been assessed. Thousands of species which have not yet been assessed are called not evaluated.

3.6.2 . Convention on International Trade in Endangered Species (CITES)

CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) is an international agreement between governments. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival.

The ideas for CITES were first formed, in the 1960s. International wildlife trade is estimated to be worth billions of dollars and to include hundreds of millions of plant and animal specimens. The trade is diverse, ranging from live animals and plants to a vast array of wildlife products derived from them, including food products, exotic leather goods, wooden musical instruments, timber, tourist curios and medicines. Levels of exploitation of some animal and plant species are high and the trade in them, together with other factors, such as habitat loss, is capable of heavily depleting their populations and even bringing some species close to extinction. Many wildlife species in trade are not endangered, but the existence of an agreement to ensure the sustainability of the trade is important in order to safeguard these resources for the future.

Because the trade in wild animals and plants crosses borders between countries, the effort to regulate it requires international cooperation to safeguard certain species from over-exploitation. CITES was conceived in the spirit of such cooperation. Today, it accords varying degrees of protection to more than 30,000 species of animals and plants, whether they are traded as live specimens, fur coats or dried herbs.

Roughly 5,000 species of animals and 28,000 species of plants are protected by CITES against over-exploitation through international trade. They are listed in the three CITES Appendices. The species are grouped in the Appendices according to how threatened they are by international trade. They include some whole groups, such as primates, cetaceans (whales, dolphins and porpoises), sea turtles, parrots, corals, cacti and orchids. But in some cases only a subspecies or geographically separate population of a species (for example the population of just one country) is listed.

3.7. International standards

In addition to the applicable host Country Laws, this ESIA Report presents the Project impacts and mitigation measures with explicit reference to the following international standards and guidelines:

- ✓ international law including conventions and treaties adopted by the host country and applicable to the Project; o IFC Performance Standards (2012); and
- ✓ WB Group's EHS Guidelines, as applicable to the Project, including EHS General Guidelines.

3.7.1: World Bank Operational Policy OP4.37 - Safety of Dams

The WB Operational Policies (OPs) have been identified by WB as being particularly important in ensuring that Bank operations do no harm to people and the environment. There are ten (10) Safeguard Policies (SPs), comprising the Bank's policy on Environmental Impact Assessment (EIA) and policies on:

- ✓ cultural property;
- ✓ disputed areas;
- ✓ forestry;
- ✓ indigenous peoples;
- ✓ international waterways;
- ✓ involuntary resettlement;
- ✓ natural habitats;
- ✓ pest management; and,
- ✓ safety of dams.

OP 4.37 (issued in October 2001 and revised in April 2013) refers to Safety on Dams. For the life of any dam, the owner is responsible for ensuring that appropriate measures are taken and sufficient resources provided for the safety of the dam, irrespective of its funding sources or construction status. Because there are serious consequences if a dam does not function properly or fails, the Bank is concerned about the safety of new dams it finances and existing dams on which a Bank-financed project is directly dependent.

The Policy requires that experienced and competent professionals design and supervise construction, and that the borrower adopts and implements dam safety measures throughout the project cycle. The policy also applies to existing dams where they influence the performance of a project. In this case, a dam safety assessment should be carried out and necessary additional dam safety measures implemented. OP 4.37 recommends, where appropriate, that Bank staff discuss with the borrowers any measures necessary to strengthen the institutional, legislative, and regulatory frameworks for dam safety programs in those countries.

3.7.2 The World Commission on Dams

The World Commission on Dams (WCD) was a global multi-stakeholder body initiated in 1997 by the WB and the International Union for Conservation of Nature (IUCN) in response to growing opposition to large dam projects. The WCD established comprehensive guidelines for dam building (in the WCD Report, 2000) that are intended to protect dam affected people and the environment and ensure that the benefits from dams are more equitably distributed.

The WCD has developed five core values that must be applied to all decisions relating to water and energy development projects. If applied throughout the project cycle, these values will ensure improved decision-making processes that will deliver improved outcomes for all stakeholders. The WCD has grouped the core values under five principal headings:

- ✓ equity;
- ✓ efficiency;
- ✓ participatory decision-making;
- ✓ sustainability; and
- ✓ accountability.

Seven Strategic Priorities (SP) and related policy principles have been identified by the WCD for future decision-making. These strategic priorities provide guidelines for achieving equitable and sustainable development through a process that successfully integrates social, economic and environmental considerations into decision-making on large dams and their alternatives (WCD, 2000).

Fig. 3.4: World Commission on Dams Strategic Priorities (WCD SPs)

The WCD SPs are:

- ✓ gaining Public Acceptance: public acceptance of key decisions is essential for equitable and sustainable water and energy resources development. Acceptance emerges from recognising rights, addressing risks, and safeguarding the entitlements of all groups of affected people, particularly indigenous and tribal peoples, women and other vulnerable groups. Decision making processes and mechanisms are used that enable informed participation by all groups of people, and result in the demonstrable acceptance of key decisions. Where projects affect indigenous and tribal peoples, such processes are guided by their free, prior and informed consent;
- ✓ comprehensive Options Assessment: alternatives to dams do often exist. To explore these alternatives, needs for water, food and energy are assessed and objectives clearly defined. The appropriate development response is identified from a range of possible options. The selection is based on a comprehensive and participatory assessment of the full range of policy, institutional and technical options. In the assessment process social and environmental aspects have the same significance as economic and financial factors. The options assessment process continues through all stages of planning, project development and operations;
- ✓ addressing Existing Dams: opportunities exist to optimise benefits from many existing dams, address outstanding social issues and strengthen environmental mitigation and restoration measures. Dams and the context in which they operate are not seen as static over time. Benefits and impacts may be

transformed by changes in water use priorities, physical and land use changes in the river basin, technological developments, and changes in public policy expressed in environment, safety, economic and technical regulations. Management and operation practices must adapt continuously to changing circumstances over the project's life and must address outstanding social issues;

- ✓ sustaining Rivers and Livelihoods: rivers, watersheds and aquatic ecosystems are the biological engines of the planet. They are the basis for life and the livelihoods of local communities. Dams transform landscapes and create risks of irreversible impacts. Understanding, protecting and restoring ecosystems at river basin level is essential to foster equitable human development and the welfare of all species. Options assessment and decision-making around river development prioritises the avoidance of impacts, followed by the minimization and mitigation of harm to the health and integrity of the river system. Avoiding impacts through good site selection and project design is a priority. Releasing tailor made environmental flows can help maintain downstream ecosystems and the communities that depend on them;
- ✓ recognising Entitlements and Sharing Benefits: joint negotiations with adversely affected people result in mutually agreed and legally enforceable mitigation and development provisions. These recognise entitlements that improve livelihoods and quality of life, and affected people are beneficiaries of the project. Successful mitigation, resettlement and development are fundamental commitments and responsibilities of the State and the developer. They bear the onus to satisfy all affected people that moving from their current context and resources will improve their livelihoods. Accountability of responsible parties to agreed mitigation, resettlement and development provisions is ensured through legal means, such as contracts, and through accessible legal recourse at the national and international level;
- ✓ ensuring Compliance: ensuring public trust and confidence requires that the governments, developers, regulators and operators meet all commitments made for the planning, implementation and operation of dams. Compliance with applicable regulations, criteria and guidelines, and project-specific negotiated agreements is secured at all critical stages in project planning and implementation. A set of mutually reinforcing incentives and mechanisms is required for social, environmental and technical measures. These should involve an appropriate mix of regulatory and non-regulatory measures, incorporating incentives and sanctions. Regulatory and compliance frameworks use incentives and sanctions to ensure effectiveness where flexibility is needed to accommodate changing circumstances; and
- ✓ sharing Rivers for Peace, Development and Security: storage and diversion of water on transboundary rivers has been a source of considerable tension

between countries and within countries. As specific interventions for diverting water, dams require constructive co-operation. Consequently, the use and management of resources increasingly becomes the subject of agreement between States to promote mutual self-interest for regional cooperation and peaceful collaboration. This leads to a shift in focus from the narrow approach of allocating a finite resource to the sharing of rivers and their associated benefits in which States are innovative in defining the scope of issues for discussion. External financing agencies support the principles of good faith negotiations between riparian States. If we are to achieve equitable and sustainable outcomes, free of the divisive conflicts of the past, future decision-making about water and energy resource projects will need to reflect and integrate these strategic priorities and their associated policy principles in the planning and project cycles.

Five key stages and critical decision points have been identified as having a particularly strong influence on the final outcome. These key stages provide a framework within which decision-makers and stakeholder groups can be assured of compliance with agreed procedures and commitments. The first two key stages relate to water and energy planning, leading to decisions on a preferred development plan:

- ✓ needs assessment: validating the needs for water and energy services; and
- ✓ selecting alternatives: identifying the preferred development plan from among the full range of options.

Where a dam emerges from this process as a preferred development alternative, three further critical decision points occur:

- ✓ project preparation: verifying that agreements are in place before tender of the construction contract;
- ✓ project implementation: confirming compliance before commissioning; and
- ✓ project operation: adapting to changing contexts.

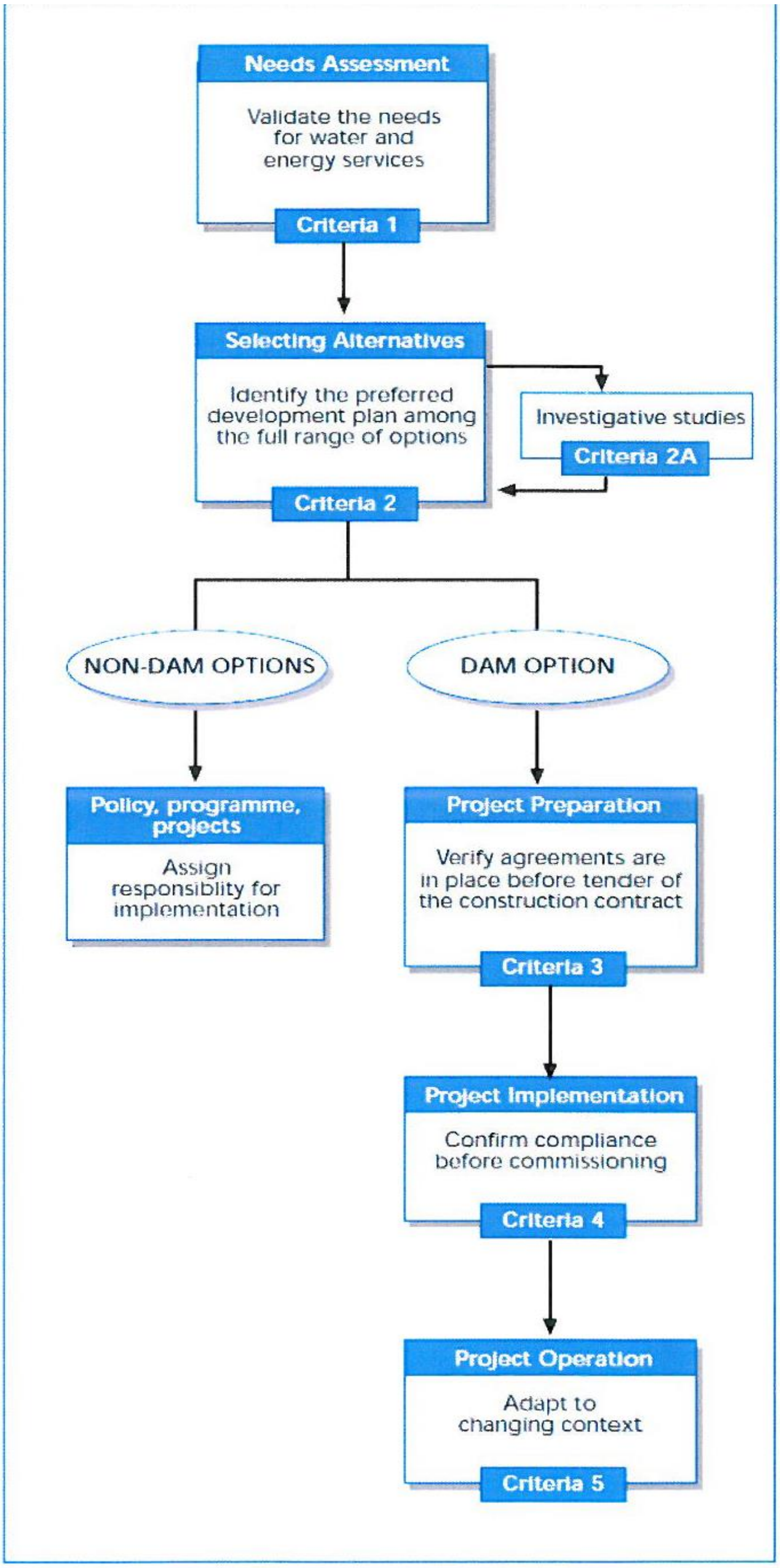


Fig. 3.5: Five Key Decision Points in Planning and Project Development

The five key stages/decision points are supported by a set of key criteria that describe the processes required for compliance. The criteria are presented in the form of checklists for each decision point that provide a clear and open mechanism for determining whether the WCD's recommendations have been followed and the process can proceed to the next stage of planning or implementation.

The WCD strategic priorities are also matched with corresponding guidelines. These guidelines describe in general terms how to assess options and plan and implement dam projects to meet the WCD's criteria and to meet good practice. They are advisory tools to support decision-making and need to be considered within the framework of existing international guidance and current good practice.

3.7.3 International Finance Corporation Performance Standards

IFC, a member of the WB Group, has published the IFC PS on Environmental and Social Sustainability (2012) which define clients' responsibilities for managing their environmental and social risks.

IFC uses a process of environmental and social categorization to reflect the magnitude of risk and impacts of the Project it finances, as summarized below:

- ✓ Category A: business activities with potential significant adverse environmental or social risks and/or impacts that are diverse, irreversible, or unprecedented;
- ✓ Category B: business activities with potential limited adverse environmental or social risks and/or impacts that are few in number, generally site-specific, largely reversible, and readily addressed through mitigation measures; and
- ✓ Category C: business activities with minimal or no adverse environmental or social risks and/or impacts.

The IFC PSs on Environmental and Social Sustainability are made of eight components, which provide guidance on how to identify risks and impacts, and are designed to help avoid, mitigate, and manage risks and impacts as a way of doing business in a sustainable way. The PS establishes standards that the client is to meet throughout the life of an investment. IFC PSs are listed below:

- ✓ PS 1 : Assessment and Management of Environmental and Social Risks and Impacts;
- ✓ PS 2: Labour and Working Conditions;
- ✓ PS 3: Resource Efficiency and Pollution Prevention;
- ✓ PS 4: Community Health, Safety, and Security;
- ✓ PS 5: Land Acquisition and Involuntary Resettlement;
- ✓ PS 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources;
- ✓ PS 7: Indigenous Peoples; and

- ✓ PS 8: Cultural Heritage.

IFC PSs are in turn supported by Guidance Notes that serve to explain the means to achieve compliance with the PSs. A brief description of each IFC PS is listed below:

- ✓ PSI: Assessment and Management of Social and Environmental Risks and Impacts. The Principle states the importance of managing environmental and social performance throughout the life of a project. PS 1 requires the client to conduct a process of environmental and social assessment and to establish and maintain an Environmental and Social Management System (ESMS), appropriate to the nature and scale of the project and commensurate with the level of its environmental and social risks and impacts. PSI aims to:
    - identify and evaluate environmental and social risks and impacts of the projects,
    - adopt a mitigation hierarchy to anticipate and avoid, or where avoidance is not possible, minimize, and, where residual impacts remain, compensate/offset for risks and impacts to workers, affected communities, and the environment,
    - promote improved environmental and social performance of clients through the effective use of management systems,
    - ensure that grievances from affected communities and external communications from other stakeholders are responded to and managed appropriately,
    - promote and provide means for adequate engagement with affected communities throughout the project cycle on issues that could potentially affect them, and
    - ensure that relevant environmental and social information is disclosed and disseminated;
- ✓ PS2: Labour and Working Conditions. The Principle recognizes that the pursuit of economic growth through employment creation and income generation should be accompanied by protection of the fundamental rights of workers. PS2 aims to:
    - promote fair treatment, non-discrimination and equal opportunity of workers,
    - establish, maintain and improve the worker-management relationship,
    - promote compliance with national employment and labour laws,
    - protect workers, including vulnerable categories of workers such as children, migrant workers, workers engaged by third parties and workers in the client's supply chain, and

  - promote safe and healthy working conditions and the health of workers; and avoid the use of forced labour;
- ✓ PS3: Resource Efficiency and Pollution Prevention. The Principle recognizes that increased economic activity and urbanization often generate increased levels of pollution to air, water, and land, and consume finite resources in a manner that may threaten people and the environment at the local, regional, and global levels. Thus, PS3 aims to:
  - avoid or minimise pollution from project activities,
  - promote more sustainable use of resources (including energy and water), and
  - reduce project-related Greenhouse Gas (GHG) emissions.
- ✓ PS4: Community Health, Safety and Security. The Principle recognizes that project activities, equipment, and infrastructure can increase community exposure to risks and impacts. PS4 aims to:
  - anticipate and avoid adverse impacts on the health and safety of affected communities during the project life from both routine and non-routine circumstances, and
  - ensure that the safeguarding of personnel and property is carried out in accordance with relevant human rights principles and in a manner that avoids or minimizes risks to the affected communities.
- ✓ PS5: Land Acquisition and Involuntary Resettlement. The Principle recognizes that project-related land acquisition and restrictions on land use can have adverse impacts on communities and persons that use this land. PS5 thus aims to:
  - avoid, and when avoidance is not possible, minimize displacement by exploring alternative project designs,
  - avoid forced eviction,
  - anticipate and avoid, or where avoidance is not possible, minimize adverse social and economic impacts from land acquisition or restrictions on land use by (i) providing compensation for loss of assets at replacement cost and (ii) ensuring that resettlement activities are implemented with appropriate disclosure of information, consultation and the informed participation of those affected, and
  - improve or restore, the livelihoods and standards of living of displaced persons;
- ✓ PS6: Biodiversity Conservation and Sustainable Management of Living Natural Resources. The Principle recognizes that protecting and conserving biodiversity, maintaining ecosystem services and sustainably managing living natural resources are fundamental to sustainable development. PS6 aims to:
  - protect and conserve biodiversity,

  - maintain the benefits from ecosystem services, and
  - promote the sustainable management of living natural resources through the adoption of practices that integrate conservation needs and development priorities.
- ✓ PS7: Indigenous Peoples. The Principle recognizes that Indigenous Peoples, as social groups with identities that are distinct from mainstream groups in national societies, are often among the most marginalized and vulnerable segments of the population. PS7 thus aims to:
  - ensure that the development process fosters full respect for human rights, dignity, aspirations, culture and natural resource-based livelihoods of Indigenous Peoples;
  - anticipate and avoid adverse impacts of projects on communities of Indigenous Peoples, or when avoidance is not possible, to minimize and/or compensate for such impacts;
  - promote sustainable development benefits and opportunities for Indigenous Peoples in a culturally appropriate manner,
  - establish and maintain an ongoing relationship based on informed consultation and participation with the Indigenous Peoples affected by a project throughout the project's life-cycle,
  - ensure the Free, Prior and Informed Consent of the affected communities of Indigenous Peoples when the circumstances described in this Performance Standard are present; and
  - respect and preserve the culture, knowledge and practices of Indigenous Peoples.
- ✓ PS8: Cultural 1--Heritage. The Principle recognizes the importance of cultural heritage for current and future generations. As such, PS8 aims to:
  - protect cultural heritage from the adverse impacts of project activities and support its preservation; and
  - promote the equitable sharing of benefits from the use of cultural heritage.

In conclusion, PSI thus establishes the importance of:

- ✓ integrated assessment to identify the environmental and social impacts, risks, and opportunities of projects;
- ✓ effective community engagement through disclosure of project-related information and consultation with local communities on matters that directly affect them; and
- ✓ the client's management of environmental and social performance throughout the life of the project.

IFC PS's 2 through 8 present requirements to avoid, reduce, mitigate or compensate for impacts on people and the environment, and to improve conditions where appropriate. Where social or environmental impacts are anticipated, the client is required to manage them through its ESMS consistent with PSI.

The IFC PS's are matched with corresponding Guidance Notes that provide guidance on the requirements contained in the standards and on good sustainability practices to help clients improve project performance.

3.7.4 International Finance Corporation Environmental, Health, and Safety Guidelines

The IFC EHS Guidelines are technical reference documents with general and industry specific examples of good international industry practice. The General EHS Guidelines are designed to be used together with the relevant industry sector EHS guidelines that provide guidance to users on EHS issues in specific industry sectors. The EHS Guidelines contain the performance levels and measures that are generally considered to be achievable in new facilities by existing technology at reasonable costs.

When host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever is more stringent.

3.7.4.1 General Guidelines

The General EHS Guidelines are organized as reported in the following Table.

Table 3.1: Organization of the IFC EHS General Guidelines

Main area	Topic
Environmental	- Air Emissions and Ambient Air Quality Energy Conservation - Wastewater and Ambient Water Quality - Water Conservation - Hazardous Materials Management - Waste Management - Noise - Contaminated Land
Occupational health and safety	- General Facility Design and Operation - Communication and Training - Physical Hazards - Chemical Hazards - Biological Hazards - Radiological Hazards - Personal Protective Equipment (PPE) - Special Hazard Environments - Monitoring

Community health and safety	- Water Quality and Availability - Structural Safety of Project Infrastructure - Life and Fire Safety - Traffic Safety - Transport of Hazardous Materials - Disease Prevention - Emergency Preparedness and Response
Construction and decommissioning	- Environment - Occupational Health & Safety - Community Health & Safety

IFC Guidelines refer to World Health Organization (WHO) standards that include the following:

- ✓ WHO Ambient Air Quality Standards;
- ✓ WHO Guidelines for Community Noise;
- ✓ WHO Drinking Water Quality; and
- ✓ WHO Guidelines for the Safe Use of Wastewater, Excreta and Greywater.

In addition, the following guidelines and standards may be applicable:

- ✓ Dutch Intervention Values for Soil Quality;
- ✓ International Union for Conservation of Nature (IUCN) Red Data Book for protected species (fauna and flora);
- ✓ Occupational health and Safety Administration (OHSA) standards — United States Department of Labour; and
- ✓ United Nations Framework Convention on Climate Change (UNFCCC) Baseline and Monitoring Methodologies for Large Scale Clean Development Mechanism (CDM) Project Activities.

3.7.4.2 Environmental Issues

The present section presents the respective applicable limits as defined by the IFC EHS Guidelines for:

- ✓ air quality;
- ✓ noise;
- ✓ wastewater and ambient water quality;
- ✓ waste management; and
- ✓ contaminated soil.

Air Quality

According to IFC requirements, air emissions should not result in pollutant concentrations higher than the relevant national ambient quality guidelines and standards. In their absence, the current WHO Air Quality Guidelines or other internationally recognized sources, such as the United State Environmental Protection Agency (USEPA), National Ambient Air Quality Standards (NAAQS) and the relevant European Council Directives can be also referred to.

In the following Table, Ambient Air Quality values outlined in the IFC El--IS General Guidelines are reported.

Table 3.2: Ambient Air Quality Values - IFC EHS General Guidelines

Pollutant	Averaging period	Maximum limit value (gg/m^3)
Sulphur Dioxide ($S0_2$)	10 min	500
	1 hour	-
	24 hours	20
	Year	-
Nitrogen Dioxide ($N0_2$)	1 hour	200
	24 hours	-
	Year	40
Ozone (0_3)	1 hour	-
	8 hours	100
Carbon Monoxide (CO)	1 hour	-
	8 hours	-
Black Smoke (BS)	24 hours	-
	Year	-
Total Suspended Particles (TSP)	24 hours	-
	Year	-
Particular Matter <10 pm (PM_{IO})	24 hours	50
	Year	20
Particular Matter < 2.5 pm ($PM_{2.5}$)	24 hours	10
	Year	25
Lead Pb	Year	-

In addition, IFC EHS General Guidelines require as a general rule that Project specific ground concentration does not contribute more than 25% of the above mentioned applicable air quality standard to allow additional, future sustainable development in the same airshed.

Noise

As outlined in the IFC EHS General Guidelines, noise impacts should be estimated by the use of baseline noise assessments for developments close to local human populations to verify that the levels presented in the following Table are not exceeded, or result in a maximum increase in background levels of 3 dB at the nearest receptor location off-site.

Noise Level Guidelines		
Receptor	**IFC - One Hour L_{Aeq} (dBA)**	
	Day-time 07:00 - 22:00	**Night-time 22:00 - 07:00**
Residential; institutional; educational	55	45
Industrial; commercial	70	70

Noise monitoring programs should be designed and conducted by trained specialists. Typical monitoring periods should be sufficient for statistical analysis and may last 48 hours with the use of noise monitors that should be capable of logging data continuously over this time period, or hourly, or more frequently, as appropriate (or else cover differing time periods within several days, including weekday and weekend workdays). The type of acoustic indices recorded depends on the type of noise being monitored, as established by a noise expert. Monitors should be located approximately 1.5 m above the ground and no closer than 3 m to any reflecting surface (e.g., wall). In general, the noise level limit is represented by the background or ambient noise levels that would be present in the absence of the facility or noise source(s) under investigation.

In terms of Occupational Health and Safety (OHS) aspects, IFC noise limits for different working environments are provided in the following Table.

Table 3.3: Noise Limits for Different Working Environments — IFC EHS General Guidelines

Noise limits for various working environments		
Location /Activity	**Equivalent Level LA_{eq} 8hr**	**Maximum LA_{max}, fast**
Heavy industry (no demand for oral communication)	85 dB A	110 dB (A)
Light industry (decreasing demand for oral communication)	50-65 dB(A)	110 dB(A)
Open offices, control rooms, service counters or similar	45-50 dB(A)	-
Individual officers (no disturbing noise)	40-45 dB (A)	-
Classrooms lecture halls	35-40 dB (A)	-
Hospitals	35-40 dB (A)	B

Water Quality

"Community Health and Safety Water Quality" of the General ESH Guideline, states that "where the project includes the delivery of water to the community or to users of facility infrastructure (such as hotel hosts and hospital patients), where water may be used for drinking, cooking, washing, and bathing, water quality should comply with national acceptability standards or in their absence the current edition of with WHO Drinking Water Guidelines".

In the following table the Guidelines values for drinking water derived by the fourth edition of the Guidelines for drinking-water quality (WHO, 2011).

Table 3.4: Guideline Values for Chemicals that are of Health Significance in Drinking-Water (WHO, 2011)

Chemical	**Guideline Value[a] mg/litre**	**Remarks**
Acrylamide	0.0005[a]	
Alachlor	0.02[a]	
Aldicarb	0.01	Applies to aldicarb sulfoxide and aldicarb sulfone
Aldrin and dieldrin	0.00003	For combined aldrin plus dieldrin
Antimony	0.02	
Arsenic	0.01 (A,T)	
Atrazine and its chloro-s-triazine metabolites	0.1	
Barium	0.7	
Benzene	0.01[a]	
Benzo[a]pyrene	0.0007[a]	
Boron		
Bromate	0.01[a] (A,T)	
Bromodichloromethane	0.06[a]	
Bromoform	0.1	
Cadmium	0.003	
Carbofuran	0.007	
Carbon tetrachloride	0.004	
Chlorate	0.7 (D)	
Chlordane	0.0002	
Chlorine	5(C)	For effective disinfection, there should be a residual concentration of free chlorine of 0.5 mg/l after at least 30 min contact time at pH < 8.0. Chlorine residual should be maintained throughout the distribution system. At the point of delivery, the minimum residual concentration of free chlorine should be 0.2 mg/l.
Chlorite	0.7 (D)	
Chloroform	0.3	
Chlorotoluron	0.03	
Chlorpyrifos	0.03	
Chromium	0.05 (P)	For total chromium
Copper	2	Staining of laundry and sanitary ware may occur below guideline value
Cyanazine	0.0006	
2,4-D	0.03	Applies to free acid

Chemical	**Guideline Value[a] mg/litre**	**Remarks**
2,4-DBC	0.09	
DDT and metabolites	0.001	
Dibromoacetonitrile	0.07	
Dibromochloromethane	0.1	
1,2-Dibromo-3-chloropropane	0.001 [a]	
1 ,2-Dibromoethane	0.0004[a] (P)	
Chemical	Guideline value (mg/litre)	Remarks
Dichloroacetate	0.05 [a]	
Dichloroacetonitrile	0.02 (P)	
1 ,2-Dichlorobenzene,		
1 ,4-Dichlorobenzene	0.3(C)	
1 ,2-Dichloroethane	0.03 [a]	
1 ,2-Dichloroethene	0.05	
Dichloromethane	0.02	
1 ,2-Dichloropropane	0.04 (P)	
1 ,3-Dichloropropene	0.02	
Dichlorprop	0.1	
Di (2-ethylhexyl) phthalate	0.008	
Dimethoate	0.006	
1 ,4-Dioxane	0.05	Derived using tolerable daily intake approach as well as linearized multistage modelling
Edetic acid	0.6	Applies to the free acid
Endrin	0.0006	
Epichlorohydrin	0.0004 (P)	
Ethylbenzene	0.3 (C)	
Fenoprop	0.009	
Fluoride	1.5	Volume of water consumed and intake from other sources should be considered when setting national standards
Hexachlorobutadiene	0.0006	
Hydroxyatrazine	0.2	Atrazine metabolite
Isoproturon	0.009	
Lead	0.01 (A,T)	
Lindane	0.002	
MCPA[e]	0.002	
Mecoprop	0.01	
Mercury	0.006	For inorganic mercury
Metho chlor	0.02	
Metolachlor	0.01	
Microcystin-LR	0.001 (P)	For total microcystin-LR (free plus cell-bound)
Molinate	0.006	
Monochloramine	3	

Chemical	**Guideline Value[a] mg/litre**	**Remarks**
Monochloroacetate	0.02	
Nickel	0.07	
Nitrate (as NO $^{-}$2)	50	Short-term exposure
Nitrilotriacetic acid	0.2	
Nitrite (as NO $^{-2}$)	3	Short-term exposure
N-Nitrosodimethylamine	0.0001	
Pendimethalin	0.02	
Pentachlorophenol	0.009[a] (P)	
Selenium	0.04 (P)	
Simazine	0.002	
Sodium	50	As sodium dichloroisocyanurate
Dichloroisoc anurate	40	As cyanuric acid
Styrene	0.02 (C)	
2,4,5-T[f]	0.009	
Terbuthylazine	0.007	
Tetrachloroethene	0.04	
Toluene	0.7 (C)	
Trichloroacetate	0.2	
Trichloroethene	0.02 (P)	
2,4,6-Trichlorophenol	0.2[a] (C)	
Trifluralin	0.02	
Trihalomethanes	-	The sum of the ratio of the concentration of each to its respective guideline value should not exceed 1
Uranium	0.03 (P)	Only chemical aspects of uranium addressed
Vinyl chloride	0.0003[a]	
Xylenes	0.5 (C)	

Notes:

A: provisional guideline value because calculated guideline value is below the achievable quantification level;

C: concentrations of the substance at or below the health-based guideline value may affect the appearance, taste or odour of the water, leading to consumer complaints;

D: provisional guideline value because disinfection is likely to result in the guideline value being exceeded;

P: provisional guideline value because of uncertainties in the health database;

T: provisional guideline value because calculated guideline value is below the level that can be achieved through practical treatment methods, source protection, etc.

[a] For substances that are considered to be carcinogenic, the guideline value is the concentration in drinking-water associated whit upper-bound estimated excess

lifetime cancer risks of 10^4 and 10-5 can be calculated by multiplying and dividing, respectively, the guideline value by 10.

[b] 2 ,4-Dicholorophenoxyacetic acid.

[c] 2,4-Dichlorophenoxybutyric acid.

[d] Dichorodiphenyltrichloroethane.

[e] 4-(2-Methyl-4-chlorophenaxy) acetic acid.

[f] 2,4,5-Trichlorophenoxyacetic acid.

Waste Management

As described in the Water and Sanitation IFC EHS Guideline, solid waste residuals generated by water treatment include process residuals, used filtration membranes, spent media and miscellaneous wastes. Process residuals primarily consist of settled suspended solids from source water and chemicals added in the treatment process, such as lime and coagulants. Pre-sedimentation, coagulation (e.g. with aluminum hydroxide [alum] or ferric hydroxide), lime softening, iron and manganese removal, and slow sand and diatomaceous earth filtration all produce sludge. Composition of the sludge depends on the treatment process and the characteristics of the source water, and may include arsenic and other metals, radionuclides, lime, polymers and other organic compounds, microorganisms, etc. Damaged or exhausted membranes are typically produced from water treatment systems used for desalination. Spent media may include filter media (including sand, coal, or diatomaceous earth from filtration plants), ion exchange resins, granular activated carbon [GAC], etc.

Recommended measures to manage solid wastes from water treatment include:

- ✓ minimize the quantity of solids generated by the water treatment process through optimizing coagulation processes;
- ✓ dispose of lime sludges by land application if allowed, limiting application rates to about 20 dry metric tons per hectare (9 dry tons per acre) to minimize the potential for mobilization of metals into plant tissue and groundwater;4
- ✓ dispose of ferric and alum sludges by land application, if allowed and if such application can be shown through modelling and sampling to have no adverse impacts on groundwater or surface water (e.g. from nutrient runoff). Balance use of ferric and alum sludges to bind phosphorous (e.g. from manure application at livestock operations) without causing aluminum phytotoxicity (from alum), iron levels in excess of adulteration levels for metals in fertilizers, or excessively low available phosphorous levels;
- ✓ potential impact on soil, groundwater, and surface water, in the context of protection, conservation and long term sustainability of water and land resources,

should be assessed when land is used as part of any waste or wastewater treatment system;

- ✓ sludges may require special disposal if the source water contains elevated levels of toxic metals, such as arsenic, radionuclides, etc.;
- ✓ regenerate activated carbon (e.g. by returning spent carbon to the supplier).

3.7.4.3 Sector Specific Guideline: Water and Sanitation EHS Guideline

The applicable Sector Specific Guideline is the Water and Sanitation Environmental, Health, and Safety Guideline, in particular the Drinking Water section.

The guideline considers three phases of the drinking water process, which imply different impacts on the environment:

1. water withdrawal;
2. water treatment:
   - solid waste,
   - wastewater,
   - hazardous chemicals,
   - air emissions;
3. water distribution:
   - water system leaks and loss of pressure,
   - water discharges.

Water Withdrawal

Traditional sources for potable water treatment include surface water from lakes, streams, rivers, etc. and groundwater resources. Where surface or groundwater of adequate quality is unavailable, other sources of water including seawater, brackish water, etc.. may be used to produce potable water. Development of water resources often involves balancing competing qualitative and quantitative human needs with the rest of the environment. This is a particularly challenging issue in the absence of a clear allocation of water rights which should be resolved with the participation of appropriate parties in advance of project design and implementation.

Recommended measures to prevent, minimize, and control environmental impacts associated with water withdrawal and to protect water quality include:

- ✓ evaluating potential adverse effects of surface water withdrawal on the downstream ecosystems and use appropriate environmental flow assessment to determine acceptable withdrawal rates;
- ✓ designing structures related to surface water withdrawal, including dams and water intake structures, to minimize impacts on aquatic life. For example:
  - limit maximum through-screen design intake velocity to limit entrainment of aquatic organisms,

    - avoid construction of water intake structures in sensitive ecosystems. If there are threatened, endangered, or other protected species within the hydraulic zone of influence of the surface water intake, ensure reduction of impingement and entrainment of fish and shellfish by the installation of technologies such as barrier nets (seasonal or year-round), screens, and aquatic filter barrier systems,
    - design water containment and diversion structures to allow unimpeded movement of fish and other aquatic organisms and to prevent adverse impacts on water quality,
    - design dam outlet valves with sufficient capacities for releasing the appropriate environmental flows;
- ✓ avoiding construction of water supply wells and water intake structures in sensitive ecosystems; and
- ✓ evaluating potential adverse effects of groundwater withdrawal, including modelling of groundwater level changes and resulting impacts to surface water flows, potential land subsidence, contaminant mobilization and saltwater intrusion. Modify extraction rates and locations as necessary to prevent unacceptable adverse current and future impacts, considering realistic future increases in demand.

Water Treatment

Environmental issues associated with water treatment include:

- ✓ solid waste;
- ✓ wastewater;
- ✓ hazardous chemicals;
- ✓ air emissions; and
- ✓ ecological impacts.

Solid waste residuals generated by water treatment include process residuals, used filtration membranes, spent media and miscellaneous wastes. Process residuals primarily consist of settled suspended solids from source water and chemicals added in the treatment process, such as lime and coagulants. Pre-sedimentation, coagulation (e.g. with aluminum hydroxide [alum] or ferric hydroxide), lime softening, iron and manganese removal, and slow sand and diatomaceous earth filtration all produce sludge. Composition of the sludge depends on the treatment process and the characteristics of the source water, and may include arsenic and other metals, radionuclides, lime, polymers and other organic compounds, microorganisms, etc. Damaged or exhausted membranes are typically produced from water treatment systems used for desalination. Spent media may include filter media (including sand, coal, or diatomaceous earth from filtration plants), ion exchange resins, Granular Activated Carbon (GAC), etc.

Recommended measures to manage solid wastes from water treatment include:

- ✓ minimize the quantity of solids generated by the water treatment process through optimizing coagulation processes;
- ✓ dispose of lime sludges by land application if allowed, limiting application rates to about 20 dry metric tons per hectare (9 dry tons per acre) to minimize the potential for mobilization of metals into plant tissue and groundwater;
- ✓ dispose of ferric and alum sludges by land application, if allowed and if such application can be shown through modelling and sampling to have no adverse impacts on groundwater or surface water (e.g. from nutrient runoff). Balance use of ferric and alum sludges to bind phosphorous (e.g. from manure application at livestock operations) without causing aluminum phytotoxicity (from alum), iron levels in excess of adulteration levels for metals in fertilizers, or excessively low available phosphorous levels;
- ✓ potential impact on soil, groundwater, and surface water, in the context of protection, conservation and long term sustainability of water and land resources, should be assessed when land is used as part of any waste or wastewater treatment system;
- ✓ sludges may require special disposal if the source water contains elevated levels of toxic metals, such as arsenic, radionuclides, etc.; and
- ✓ regenerate activated carbon (e.g. by returning spent carbon to the supplier).

Wastewater from water treatment projects include filter backwash, reject streams from membrane filtration processes, and brine streams from ion exchange or demineralization processes. These waste streams may contain suspended solids and organics from the raw water, high levels of dissolved solids, high or low pH, heavy metals, etc.

Recommended measures to manage wastewater effluents include:

- ✓ land application of wastes with high dissolved solids concentrations is generally preferred over discharge to surface water subject to an evaluation of potential impact on soil, groundwater, and surface water resulting from such application;
- ✓ recycle filter backwash into the process if possible; and
- ✓ treat and dispose of reject streams, including brine, consistent with national and local requirements. Disposal options include return to original source (e.g. ocean, brackish water source, etc.) or discharge to a municipal sewerage system, evaporation, and underground injection.

Water treatment may involve the use of chemicals for coagulation, disinfection and water conditioning. In general, potential impacts and mitigation measures associated with storage and use of hazardous chemicals are similar to those for other industrial projects and are addressed in the General EHS Guideline.

Recommended measures to prevent, minimize, and control potential environmental impacts associated with the storage, handling and use of disinfection chemicals in water treatment facilities include:

- ✓ for systems that use gas chlorination:
    - install alarm and safety systems, including automatic shutoff valves, that are automatically activated when a chlorine release is detected,
    - install containment and scrubber systems to capture and neutralize chlorine should a leak occur,
    - use corrosion-resistant piping, valves, metering equipment, and any other equipment coming in contact with gaseous or liquid chlorine, and keep this equipment free from contaminants, including oil and grease,
    - store chlorine away from all sources of organic chemicals, and protect from sunlight, moisture, and high temperatures;
    -
- ✓ store sodium hypochlorite in cool, dry, and dark conditions for no more than one month, and use equipment constructed of corrosion-resistant materials;
- ✓ store calcium hypochlorite away from any organic materials and protect from moisture; fully empty or re-seal shipping containers to exclude moisture. Calcium hypochlorite can be stored for up to one year;
- ✓ isolate ammonia storage and feed areas from chlorine and hypochlorite storage and feed areas;
- ✓ minimize the amount of chlorination chemicals stored on site while maintaining a sufficient inventory to cover intermittent disruptions in supply;
- ✓ develop and implement a prevention program that includes identification of potential hazards, written operating procedures, training, maintenance, and accident investigation procedures; and
- ✓ develop and implement a plan for responding to accidental releases.

Air emissions from water treatment operations may include ozone (in the case of ozone disinfection) and gaseous or volatile chemicals used for disinfection processes (e.g., chlorine and ammonia). Measures related to hazardous chemicals discussed above will mitigate risks of chlorine and ammonia releases. In addition, specific recommended measures to manage air emissions include installation of an ozone-destroying device at the exhaust of the ozone reactor (e.g., catalytic oxidation, thermal oxidation, or GAC).

Water Distribution

The most fundamental environmental health issues associated with distribution networks is the maintenance of adequate pressure to protect water quality in the system as well as sizing and adequate maintenance to assure reliable delivery of water of suitable quality. The most significant environmental issues associated with operation of water distribution systems include:

- ✓ water system leaks and loss of pressure; and
- ✓ water discharges.

Water system leaks can reduce the pressure of the water system compromising its integrity and ability to protect water quality (by allowing contaminated water to leak into the system) and increasing the demands on the source water supply, the quantity of chemicals, and the amount of power used for pumping and treatment. Leaks in the distribution system can result from improper installation or maintenance, inadequate corrosion protection, settlement, stress from traffic and vibrations, frost loads, overloading, and other factors.

Recommended measures to prevent and minimize water losses from the water distribution system include:

- ✓ ensure construction meets applicable standards and industry practices;
- ✓ conduct regular inspection and maintenance;
- ✓ implement a leak detection and repair program (including records of past leaks and unaccounted- for water to identify potential problem areas); and
- ✓ consider replacing mains with a history of leaks of with a greater potential for leaks because of their location, pressure stresses, and other risk factors.

Water lines may be periodically flushed to remove accumulated sediments or other impurities that have accumulated in the pipe. Flushing is performed by isolating sections of the distribution system and opening flushing valves or, more commonly, fire hydrants to cause a large volume of flow to pass through the isolated pipeline and suspend the settled sediment. The major environmental aspect of water pipe flushing is the discharge of flushed water, which may be high in suspended solids, residual chlorine, and other contaminants that can harm surface water bodies. Recommended measures to prevent, minimize, and control impacts from flushing of mains include:

- ✓ discharge the flush water into a municipal sewerage system with adequate capacity;
- ✓ discharge the flush water into a separate storm sewer system with storm water management measures such as a detention pond, where solids can settle and residual chlorine consumed before the water is discharged; and
- ✓ minimize erosion during flushing, for example by avoiding discharge areas that are susceptible to erosion and spreading the flow to reduce flow velocities.

3.7.5 Stakeholder Engagement and Consultation

Stakeholder engagement and information disclosure requirements are outlined under IFC PSI, which is considered as the umbrella PS and sets a framework for a life cycle approach and adoption of a mitigation hierarchy to avoid, minimize or compensate/offset impacts over the life of a project. The principal requirements of IFC PSI relevant to stakeholder engagement include, but not limited to, the following:

- ✓ clients should identify the range of stakeholders that may be interested in their actions and consider how external communications might facilitate a dialog with all stakeholders. Nature, frequency and level of effort vary, being commensurate with the project's risks/adverse impacts;

- ✓ the client will develop and implement a SEP that is scaled to the project risks and impacts and development stage, and be tailored to the characteristics and interests of the affected communities;
- ✓ where applicable, the SEP will include differentiated measures to allow the effective participation of those identified as disadvantaged or vulnerable;
- ✓ when affected communities are subject to identified risks and adverse impacts from a project, the client will undertake a process of consultation in a manner that provides the affected communities with opportunities to express their views on project risks, impacts and mitigation measures, and allows the client to consider and respond to them;
- ✓ for projects with potentially significant adverse impacts on affected communities, the client will conduct an Informed Consultation and Participation (ICP) process that will build upon the steps outlined above in consultation and will result in the affected communities' informed participation;
- ✓ for projects with adverse impacts to Indigenous Peoples, the client is required to engage them in a process of ICP and in certain circumstances the client is required to obtain their Free, Prior, and Informed Consent (FPIC);
- ✓ clients will implement and maintain a procedure for external communications that includes methods to (i) receive and register external communications from the public; (ii) screen and assess the issues raised and determine how to address them; (iii) provide, track, and document responses, if any; and (iv) adjust the management program, as appropriate. In addition, clients are encouraged to make publicly available periodic reports on their environmental and social sustainability;
- ✓ community engagement should be ongoing and involve the project proponent's disclosure of information and consultation with local communities that may be affected by risks or adverse impacts of the project;
- ✓ clients are required to at least report annually to affected communities to describe progress on actions plans for issues that involve them. Relevant project information should be disclosed to help affected communities understand the risks, impacts and opportunities of the project;
- ✓ consultation should take place in a manner that provides affected communities with opportunities to express their views on project risks and impacts and mitigations measures and that allows the project proponent to consider and respond to them. Consultation is to be tailored to the language preferences of affected communities, the decision-making process, and the needs of disadvantaged or vulnerable groups;
- ✓ participatory monitoring may also be considered, where appropriate; and
- ✓ establishment of a grievance mechanism to receive and facilitate resolution of affected communities' concerns and grievances.

3.7.6 Land Acquisition and Involuntary Resettlement

The International Financial Institutions (IFIs) policies which are of greatest relevance to the acquisition of Land Rights for the Project include the:

- ✓ IFC PS 5 - Land Acquisition and Involuntary Resettlement;
- ✓ European Bank for Reconstruction and Development (EBRD) Performance Requirement 5 - Land Acquisition, Involuntary Resettlement and Economic Displacement; and
- ✓ European Investment Bank (EIB) Statement of Environmental and Social Principles and Standards (2009) paragraphs 45 - 53.

In particular, IFC PS5 defines 'land acquisition' as including outright purchase of property and purchase of access rights. For the purposes of IFC PS5, land acquisition is commonly understood to refer to purchase of both temporary and permanent rights to land. IFC PS5 defines 'involuntary resettlement' as referring to both physical displacement (relocation or loss of shelter) and to economic displacement (loss of assets or access to assets that leads to loss of income sources or means of livelihood) as a result of project land acquisition.

Resettlement is considered involuntary when affected individuals or communities do not have the right to refuse land acquisition that results in displacement.

This occurs in cases of:

- ✓ lawful expropriation or restrictions on land use based on eminent domain; and
- ✓ negotiated settlements in which the buyer can resort to expropriation or impose legal restrictions on land if negotiations with the seller fail.

The key objectives and requirements of IFI Policies can be summarised as follows:

- ✓ avoid, or at least minimise, permanent or temporary project induced physical displacement and economic displacement whenever feasible by exploring alternative project designs;
- ✓ develop appropriate livelihood restoration action plans where significant economic displacement or physical displacement is unavoidable;
- ✓ improve or, at a minimum, restore to pre-project levels livelihoods and income earning capacity of affected persons, including those who have no legally recognisable rights or claims to land and support them during the transition period (based on a reasonable estimate of the time required to restore their income-earning capacity, production levels, and standards of living);
- ✓ improve or, at a minimum, restore the standard of living of physically displaced people/households and provide them with a choice of options for adequate housing with security of tenure;

- ✓ mitigate adverse social and economic impacts from the acquisition of land rights or restrictions on affected persons' use of and access to land, physical assets or natural resources by: (i) providing compensation for loss of assets at replacement cost prior to taking possession of acquired assets; and (ii) ensuring that compensation and livelihood restoration activities are planned and implemented with appropriate disclosure of information, consultation, and the informed participation of those affected, using existing social and cultural institutions wherever possible,
- ✓ make special provisions for assisting disadvantaged or vulnerable individuals or groups (insofar as they are potentially affected by Land Right acquisition) who may be more adversely affected by physical displacement and/or economic displacement than others and who may be limited in their ability to claim or take advantage of compensation, livelihood assistance, and related benefits;
- ✓ establish a grievance mechanism to receive and address in a timely fashion specific concerns about compensation and relocation that are raised by displaced persons, including a recourse mechanism designed to resolve disputes in an impartial manner; and
- ✓ monitor and evaluate the implementation and results of implementation measures.

3.7.7 Gap Analysis between the National EIA Legislation and International ESIA Requirements

The following table presents the gap analysis between the national EIA legislation and the requirements for a bankable ESIA according to the IFC PS. In general, the Kenyan legislation complies with the international ESIA requirements in terms of main procedures and content, as highlighted in the "Compliance analysis" column. Even if the terminology used by the law does not clearly refer to the social component of the assessment, the evaluation takes into account the projects' impacts also on the socio-economic context. However, the main gap highlighted is the lack of the stakeholder identification phase and consequent analysis. Only a general description of the population and socio-economic profile is necessary according to the EIA legislation.

Table 3.5: Gap Analysis between Kenyan EIA legislation and International Standards

No.	International ESIA requirements	National EIA requirements	Compliance analysis
1	**Initial screening of the project and scoping of the assessment process** The initial screening of the project against the local laws and the PS should indicate whether the project may pose	**Screening of activities and scoping of impacts** Screening involves determining whether or not an EIA study is required for a particular development activity. This depends on the significance of the project's environmental impacts.	√

No.	International ESIA requirements	National EIA requirements	Compliance analysis
	social or environmental risks that need to be further analyzed through additional steps of the identification process to ascertain their nature and scale, Affected Communities, and possible mitigation measures. Where the initial screening process concludes that a project will have no or minimal potential risks and adverse impacts, the proponent should document this screening process and its conclusions.	A project that the Authority considers should be subjected to an EIA study must first undergo a scoping study. Scoping is a procedure used to determine the range of issues to be addressed in the EIA study; it is also the process of identifying the significant issues, which are related to the proposed project. Its main objective is to focus the EIA on the key issues, while ensuring that indirect and secondary effects are not overlooked and eliminating irrelevant impacts.	
2	**Public consultation and disclosure** A consultation process should be conducted whenever a project is likely to generate adverse environmental and social impacts on Affected Communities. Affected Communities have to be engaged to identify potential impacts and risks, to assess the consequences of these impacts and risks for their lives; and to provide input into the proposed mitigation measures, sharing of development benefits and opportunities and implementation issues. The consultation process should be commensurate with the project's risks and impacts, and with the concerns raised by the Affected Communities. For the consultation process to be effective, project information needs to be disclosed and explained to the	**Consultation and Public Participation (CPP)** CPP should be undertaken mainly during project planning, in implementation and decommissioning phases. It should involve the affected persons, lead agencies, private sector, among others. The methodology for CPP may include: meetings and technical workshops with affected communities; interpersonal contacts; Dialogue with user groups and local leaders; questionnaire/survey/interview; and participatory rural appraisal or rapid rural appraisal techniques. Two steps of public consultation are foreseen for the EIA procedure: one during the scoping phase, and the other one during the preparation of the EIA report. The process of community involvement during the whole EIA process has to be presented already in the scoping report.	√

No.	International ESIA requirements	National EIA requirements	Compliance analysis
	stakeholders, and sufficient time should be allocated for them to consider the issues. A process of consultation that is ongoing during the project planning process (including the process of environmental and social assessment), such that: (i) Affected Communities have been engaged in: (a) identifying potential impacts and risks; (b) assessing the consequences of these impacts and risks for their lives; and (c) providing input into the proposed mitigation measures, the sharing of development benefits and opportunities and implementation issues; and that (ii) new impacts and risks that have come to light during the planning and assessment process have also been consulted upon.		
	Content of an ESIA report		
3	**Non-technical executive summary** Concisely discusses significant findings and recommended actions in lay language.	**Non-technical summary,** reporting the main findings, conclusions and recommendations of the study.	√
4	**Policy, Legal and Administrative Framework** This section should discuss the policy, legal and administrate framework within which the assessment is carried out, including host country regulations, including obligations implementing relevant international social and environmental treaties,	**Policy, Legal and Institutional Framework** Concise description of the national environmental legislative and regulatory framework.	√

No.	International ESIA requirements	National EIA requirements	Compliance analysis
	agreements, and conventions, IFC Performance Standards, as well as any additional priorities and objectives for social or environmental performance.		
5	**Project Description** Concisely describes the proposed project and its geographic, ecological, social, health and temporal context, including any related facilities that may be required. Normally includes maps showing the project site and the project's area of influence.	**Project Description** This section provides for a summarized description of the project, zoning requirement, main characteristics of the implementation process e. nature and quantity of materials to be used, equipment's to be involved, estimation, by type and quantity, of expected residues (wastes) and emissions (water, air and soil pollution, noise, vibration, light, heat, radiation etc. resulting from operation of the proposed project; Land use requirement and status of land ownership (e.g. freehold, leasehold, community land, private land). Include maps and location coordinates.	√
6	**Analysis of Alternatives.** Compares reasonable alternatives to the proposed project site, technology, design, and operation in terms of their potential environmental impacts; the feasibility of mitigating these impacts; their capital and recurrent costs; and their suitability under local conditions. States the basis for selecting the particular project design proposed and justifies recommended emission levels and approaches to pollution prevention and abatement.	**Analysis of Alternatives,** including project site, design and technologies and reasons for preferring the proposed site, design and technologies.	√
7	**Baseline data.**	**Baseline information.**	√

No.	International ESIA requirements	National EIA requirements	Compliance analysis
	Assesses the dimensions of the study area and describes relevant physical, biological, socioeconomic, health and labour conditions, including any changes anticipated before the project commences. Data should be relevant to decisions about project location, design, operation, or mitigation measures. The section indicates the accuracy, reliability, and sources of the data.	A description of the potentially affected environment, namely: population, animals and plants, soil, water, air, climate factors, road network, power supply, water, communication, administrative, geo-political, any other important or unique information of the area, possible location near or within sensitive natural resources (including archaeological and sacred sites and cultural principles, believes), existing developments in the area.	
8	**Stakeholder identification and analysis** Determine who are the project stakeholders (in particular the directly affected and including groups and subgroups) and analyzes them to understand how they will be affected and to what degree and what influence they could have on the project. The identification should not consider only the influence from the primary project site(s) but also all related facilities (including associated facilities, transport routes, areas potentially affected by cumulative impacts, or unplanned but predictable developments).	No stakeholder identification and analysis is foreseen	✘
9	**Social and Environmental impacts and mitigation measures** Predicts and assesses the project's likely positive and negative impacts, in quantitative terms to the extent possible. Identifies	**Impact assessment and identification of mitigation measures** Presentation of the environmental effects of the project including the social and cultural effects (positive and negative). In particular, the ESIA should focus on: Impact Identification; Impact Prediction; Impact Evaluation.	√

No.	International ESIA requirements	National EIA requirements	Compliance analysis
	mitigation measures and any residual negative impacts that cannot be mitigated. Explores opportunities for enhancement. Identifies and estimates the extent and quality of available data, key data gaps, and uncertainties associated with predictions, and specifies topics that do not require further attention. Evaluates impacts and risks from associated facilities and other third party activities. Examines global, transboundary, and cumulative impacts as appropriate.	The evaluation should report the category of impact, whether the impact direct/indirect, reversible/ irreversible, temporary/permanent, major/Minor and the phase of occurrence (during construction, operation and decommissioning). Transboundary and cumulative impacts have also to be taken into consideration. The mitigation measures are envisaged to: prevent/avoid, reduce and where possible offset the negative impacts of the project.	
10	**Social and Environmental Management Plan** A social and environmental management plan (SEMP) defines resources, roles and responsibilities required to manage the identified impacts and implement mitigation measures as well as a timeline.	**Environmental and Social Management Plan** It proposes the measures for eliminating, minimizing or mitigating adverse impacts on the environment and socio-economic context including the cost, time frame and responsibility to implement the measures, monitoring and reporting regime. It should include the measures to prevent health hazards and to ensure security in the working environment for the employees and for the management of emergencies.	√

4. Baseline Setting

4.1 Environmental Study Area

The study limits of this project, with respect to the main components of the project and radial distances of its environmental impact, comprises of:

- Arror River basin comprising of the Arror Dam basin and the river basin in the lower extreme of the dam (middle basin) till its adjoining with the Kerio River.
- Area along with penstock route and tunnel till power house
- Proposed area for irrigation in Kerio valley

In these limits, the physical and biological environments are surveyed and the status present, regarding the pollutant sources, such as urban, rural, agricultural and industrial pollution, are under consideration. The area of dam basin is about 185 Km^2.

The Arror River catchment area is being under study, with aims to determine the ecosystems, habitats and to recognize the probable source of pollutants that may present in this area, estimations of the amount of pollution that finds its way to the river and the impacts on the water quality.

With respect to the intensity and radial distances of the impacts arising from the implementation of the project, the study area can be divided into 3 parts as follows:

Immediate Limits

- Dam site,
- Dam reservoir and the population centers that will be submerged by water taking of the dam,
- Route of Conveyance line (tunnel and penstock) and penstock access road from Arror dam to power house,
- Power house site,
- Area proposed for irrigation,
- Dam access road
- Place of borrow materials

Direct Impact Limits

- Immediate basin of dam reservoir with population centers located in this area;
- Arror river and its fringes on upstream and downstream of the dam up to the confluence with Kerio River including Arror waterfall and all residential centers in adjacent that their life is dependent to this river in some ways,
- Vicinity of power house and irrigation area and people affected by the implementation of the project

- Kerio River in downstream of the irrigation area till adjoining the first tributary

Indirect Impact Limits

- Catchment area of Arror River,
- Kapsowar as the nearest town to dam site and in a larger scale Marakwet sub county.

4.2 Physical Environment

4.2.1. Physiographic Characteristics

Arror River catchment area lies entirely within the Eastern Rift valley in Kenya and drains into Lake Turkana through Kerio River. It is located roughly between longitudes 35^0 25´E and $35^0$40´E and latitudes 0^0 55´ N and 1^0 15´ N. The catchment area is characterised by three physiographic regions: the highlands, formed by the Cherangany Hills (forested); the midlands which is characterised by the Elgeyo escarpment; and the lowlands which is the base of Kerio valley within the Great Rift Valley.

The Arror River, having headwaters in the eastern side of the Cherangani Hills, crosses the Uasin Gishu Plateau where the Embobut and Kipkunur Forests occupy the bulk of its catchment area at altitudes between 2200-3200 m.a.s.l. These mountains receive large amounts of rainfall and are densely forested.

The Arror River, with a watershed of about 270 Km^2, drains in a south to south-east direction to a point about 6 Km west of Chesoi where it turns south and runs parallel to the escarpment as far as Kapsowar. Then the Arror River turns east and plunges over the Elgeyo escarpment, falling a height of 1100 m, to eventually join the Kerio Valley in the middle sub-basin of the Kerio River.

Most areas of the basin with 78.8 Km^2 are allocated to the slope class 15-25 that covers 29% of the Arror River basin. The slope classes in the Arror River basin is given in the Table 4.1 and shown in the Map 4.1.

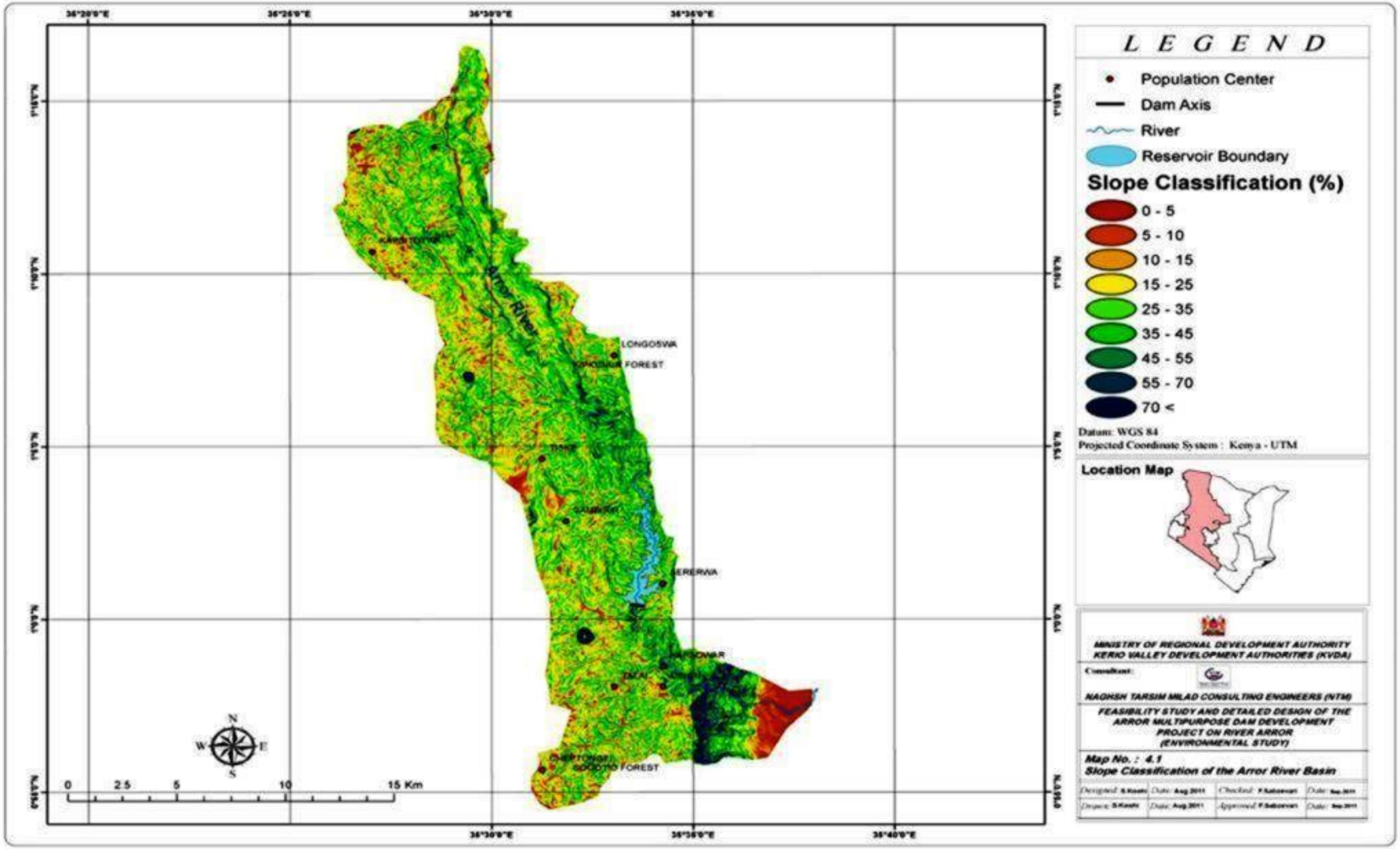
Table 4.1: Slope Classification in the Arror River Basin

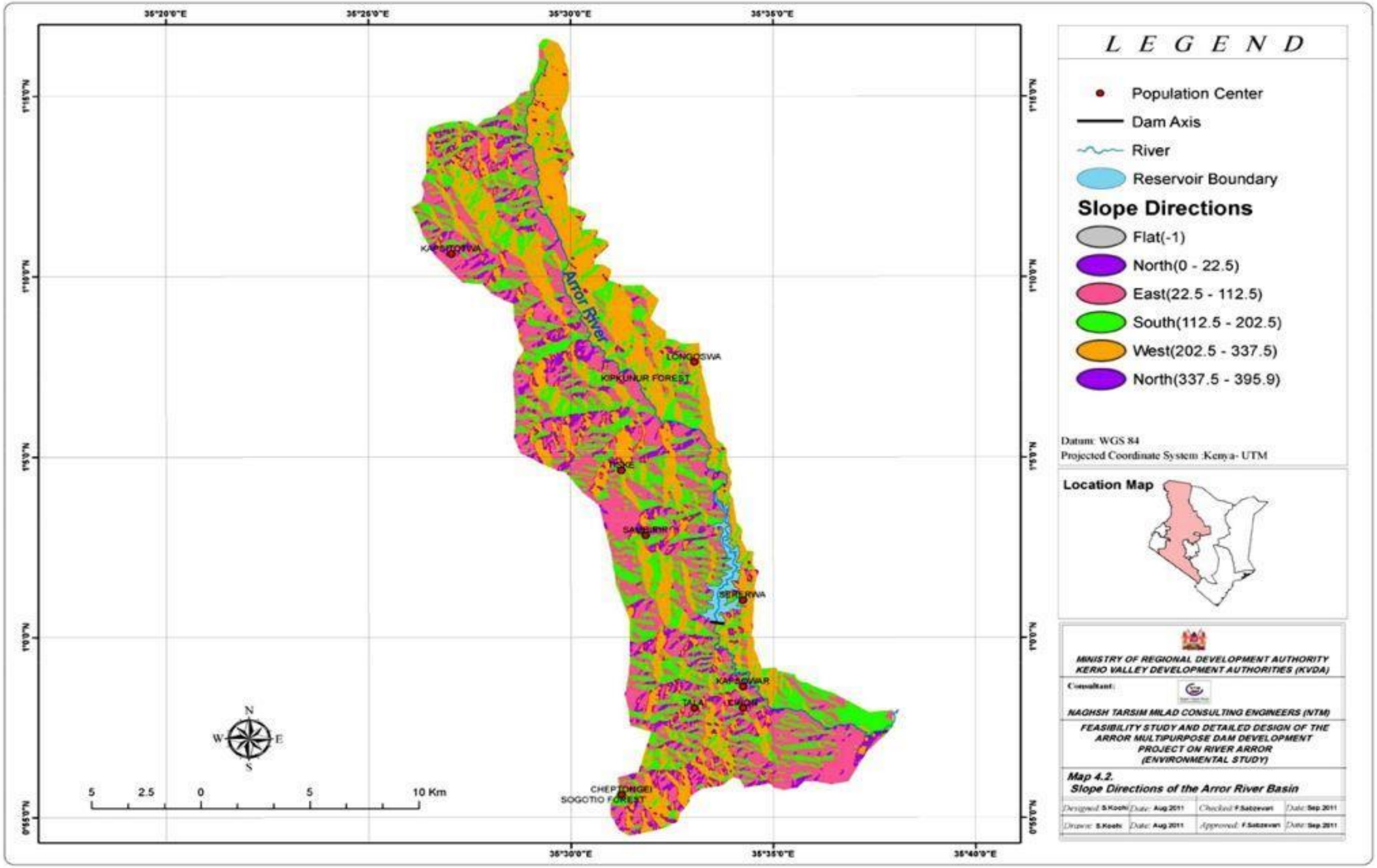
Slope Classes	Area (Km^2)	(%)
0-5	14.7	5.4
5-10	18.9	7
10-15	25.1	9.2
15-25	78.8	29.0
25-35	68.5	25.4
35-45	33	12.1
45-55	20.2	7.4
55-70	8.1	3
70-556	4.2	1.5

West is the dominant slope direction in the Arror River basin that is shown in the Map 4.2. The lowest and highest elevation in the Arror River basin is 993 and 3836 m respectively. The largest area of elevation classes is allocated to class 2500-3000 m with 92.4 Km^2 (33.8%) that covers most upper parts of the basin. The elevation class 2000-2500 with 86.99 Km^2 (31.8%) is the next large class that dam and reservoir is situated in. The elevation classes in the Arror River basin is given in the Table 4.2 and shown in the Map 4.3.

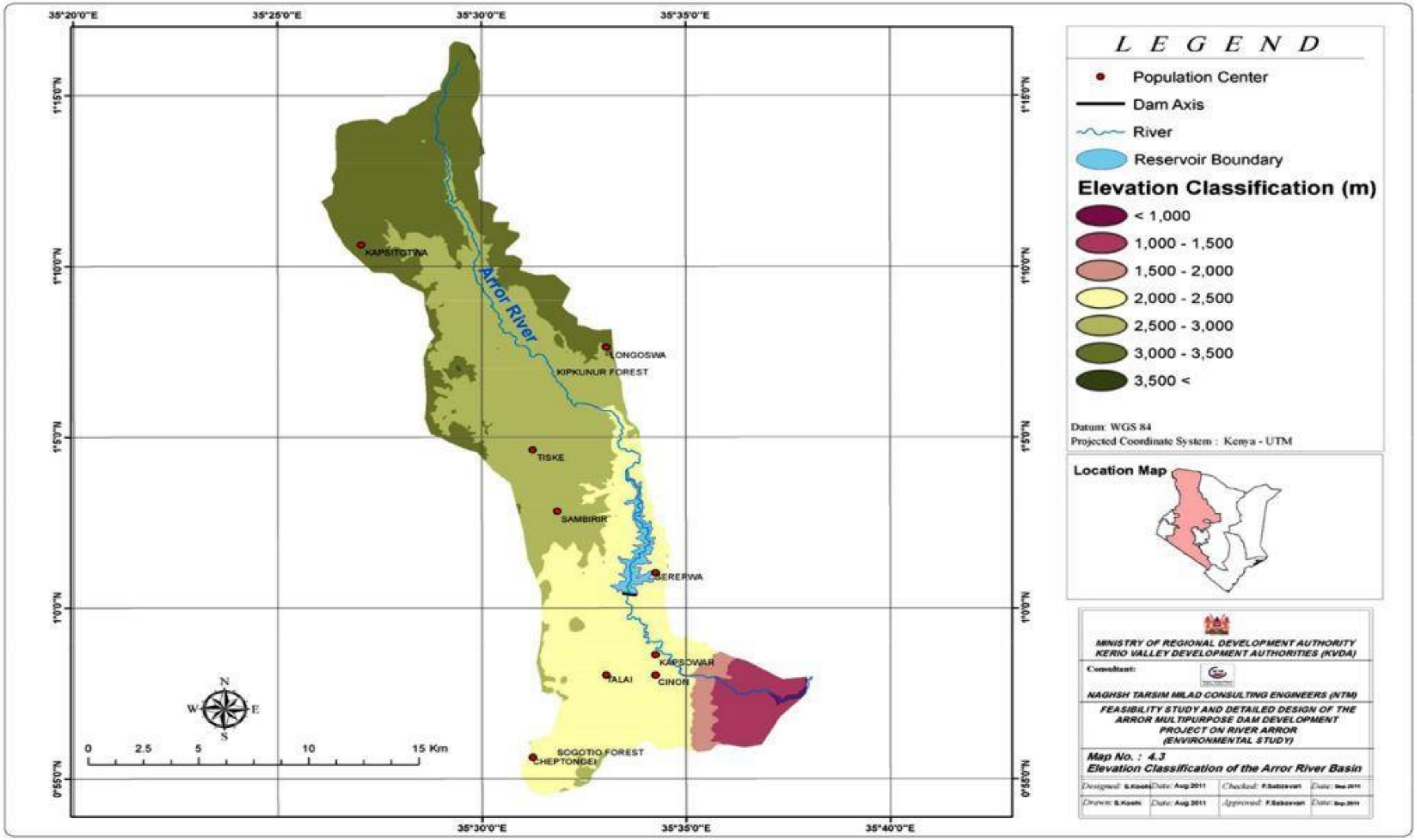
Table 4.2: Elevation Classification in the Arror River Basin

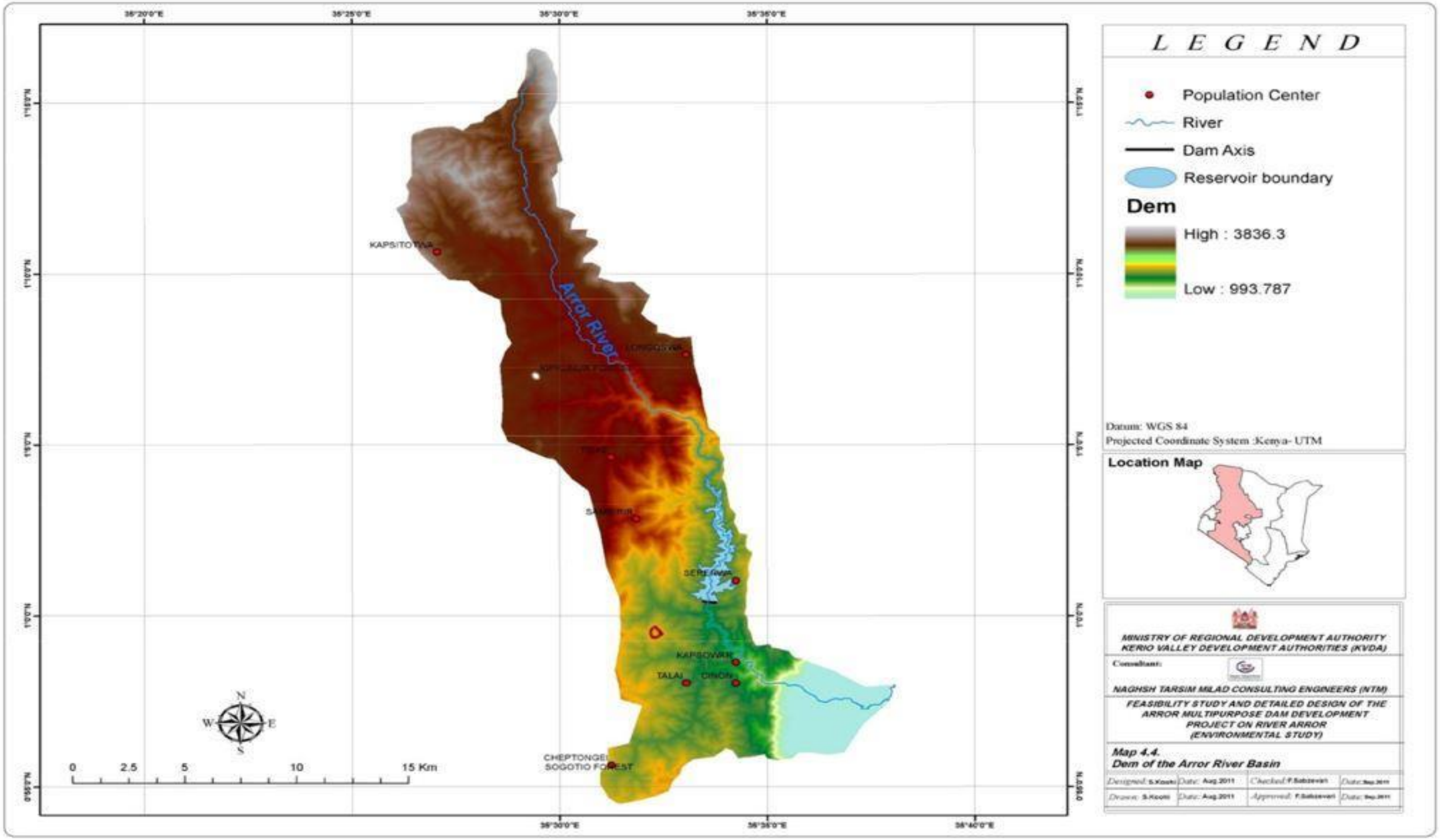
Elevation Class (masl)	Area (km^2)	(%)
E < 1000	0.0	0.0
1000-1500	12.1	4.4
1500-2000	5.6	2.1
2000-2500	86.9	31.8
2500-3000	92.4	33.8
3000-3500	75.9	27.8
E > 3500	0.1	0.1


L E G E N D
Population Center
Dam Axis
River
Reservoir Boundary
Slope Classification (%)
0 - 5
5 - 10
10 - 15
15 - 25
25 - 35
35 - 45
45 - 55
55 - 70
70 <
Datum: WGS 84
Projected Coordinate System : Kenya - UTM
Location Map
MINISTRY OF REGIONAL DEVELOPMENT AUTHORITY
KERIO VALLEY DEVELOPMENT AUTHORITIES (KVDA)
Consultant:
NAGHSH TARSIM MILAD CONSULTING ENGINEERS (NTM)
FEASIBILITY STUDY AND DETAILED DESIGN OF THE ARROR MULTIPURPOSE DAM DEVELOPMENT PROJECT ON RIVER ARROR (ENVIRONMENTAL STUDY)
Map No. : 4.1
Slope Classification of the Arror River Basin
Designed:
Date: Aug 2011
Checked:
Date:
Drawn:
Date: Aug 2011
Approved:
Date:
Arror River
LONGOSWA
FOREST
SERERWA
FOREST
N
S
E
W
0
2.5
5
10
15 Km



Map 4.2.
Slope Directions of the Arror River Basin


35°20'0"E
35°25'0"E
35°30'0"E
35°35'0"E
35°40'0"E
1°15'0"N
1°10'0"N
1°5'0"N
1°0'0"N
0°55'0"N
Arror River
KAPSITOTWA
LONGOSWA
KIPKUNUR FOREST
TISKE
SAMBIRIR
KERERWA
KAPSOWAR
TALAI
CINON
SOGOTIO FOREST
CHEPTONGEI
N
S
E
W
0
2.5
5
10
15 Km
LEGEND
Population Center
Dam Axis
River
Reservoir Boundary
Elevation Classification (m)
< 1,000
1,000 - 1,500
1,500 - 2,000
2,000 - 2,500
2,500 - 3,000
3,000 - 3,500
3,500 <
Datum: WGS 84
Projected Coordinate System : Kenya - UTM
Location Map
MINISTRY OF REGIONAL DEVELOPMENT AUTHORITY
KERIO VALLEY DEVELOPMENT AUTHORITIES (KVDA)
Consultant:
NAGHSH TARSIM MILAD CONSULTING ENGINEERS (NTM)
FEASIBILITY STUDY AND DETAILED DESIGN OF THE ARROR MULTIPURPOSE DAM DEVELOPMENT PROJECT ON RIVER ARROR (ENVIRONMENTAL STUDY)
Map No. : 4.3
Elevation Classification of the Arror River Basin
Designed: S.Koohi Date: Aug 2011
Checked: F.Sabzevari Date: Sep 2011
Drawn: S.Koohi Date: Aug 2011
Approved: F.Sabzevari Date: Sep 2011


35°20'0"E
35°25'0"E
35°30'0"E
35°35'0"E
35°40'0"E
1°15'0"N
1°10'0"N
1°5'0"N
1°0'0"N
0°55'0"N
Arror River
KAPSITOTWA
LONGOTWA
TEKE
SAMERIR
SEREMWA
KAPSOWAR
TALAI
CINON
CHEPTONGEI
SOGOTIO FOREST
N
S
W
E
0
2.5
5
10
15 Km
LEGEND
Population Center
River
Dam Axis
Reservoir boundary
Dem
High : 3836.3
Low : 993.787
Datum: WGS 84
Projected Coordinate System :Kenya- UTM
Location Map
MINISTRY OF REGIONAL DEVELOPMENT AUTHORITY
KERIO VALLEY DEVELOPMENT AUTHORITIES (KVDA)
Consultant:
NAGHSH TARSIM MILAD CONSULTING ENGINEERS (NTM)
FEASIBILITY STUDY AND DETAILED DESIGN OF THE ARROR MULTIPURPOSE DAM DEVELOPMENT PROJECT ON RIVER ARROR (ENVIRONMENTAL STUDY)
Map 4.4.
Dem of the Arror River Basin
Designed: S.Kouhi
Date: Aug.2011
Checked: F.Sabzevari
Date: Sep.2011
Drawn: S.Kouhi
Date: Aug.2011
Approved: F.Sabzevari
Date: Sep.2011

4.2.2. Climate and Air Quality

For meteorological study, 11 stations have been investigated, most of which have been situated out of Arror River basin, dam site and downstream. Since the downstream of the dam site is extended to the Kerio Valley where the irrigation area located in, means of downstream in the meteorology report is Kerio Valley as well as hydrology report. Location of meteorological stations is shown in Figure 4.1.

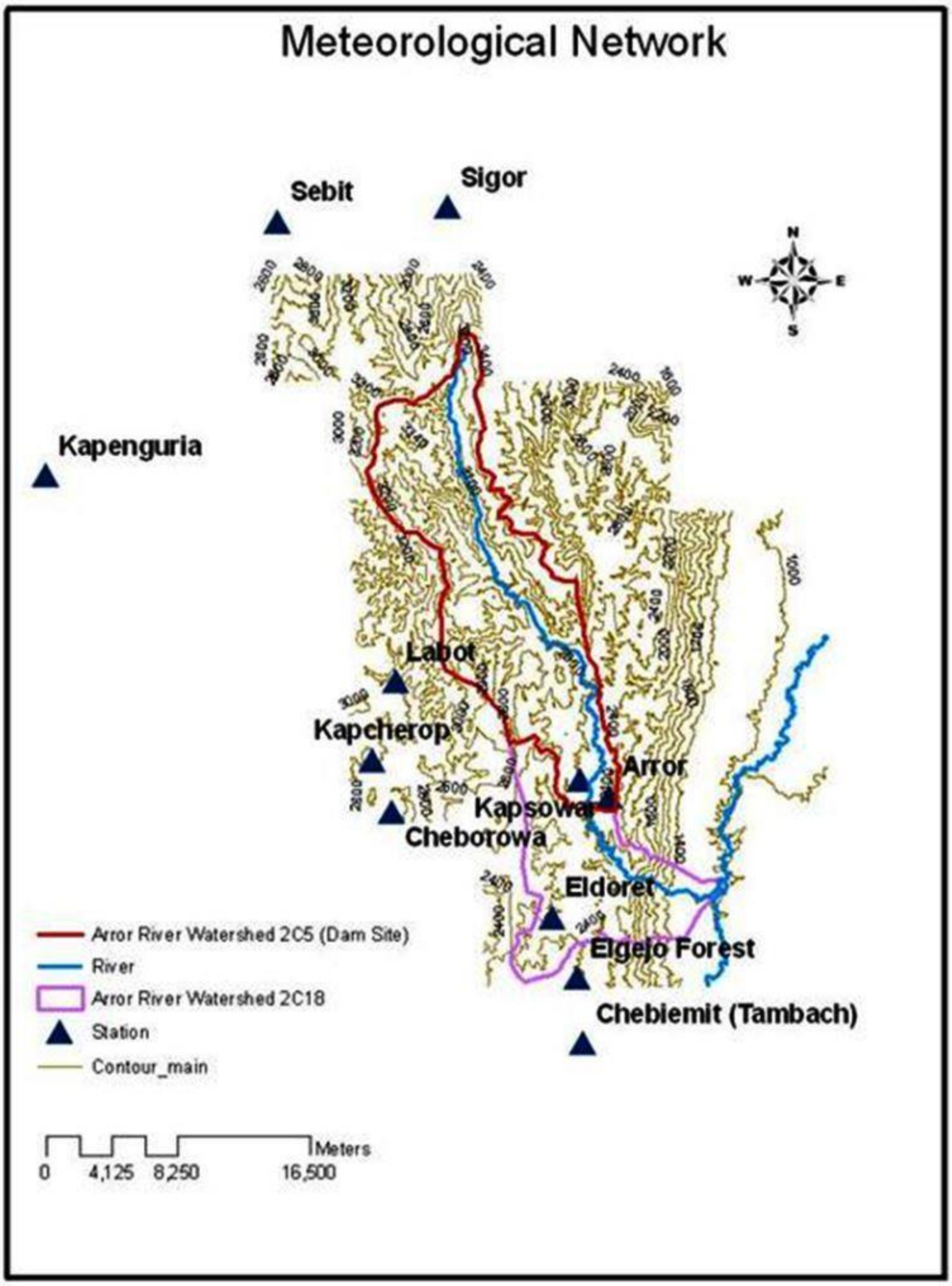


Fig. 4.1: Location of Meteorological Stations

Rainfall

Rainfall in the study area is according to the Table 4.3.

Table 4.3: Mean rainfall (mm)

Location	Month												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Arror River Basin	38.6	54.3	109.6	237.4	225.1	96.0	123.2	114.1	82.8	128.9	152.5	69.2	1431.7
Arror Dam Site	47.7	43.5	60.0	157.5	116.2	100.7	117.2	100.2	74.9	91.2	113.5	43.8	1066.5
Downstream	23.3	38.5	67.6	147.6	125.6	62.5	97.1	92.1	58.8	57.7	77.2	31.2	879.1

Ref: NTM Consulting Engineers, Feasibility Study and Detailed Design of the Arror Multipurpose Dam Development Project on River Arror, Meteorological Report, 2011

The analysis shows that even in 7 year moving average, a dry and wet period doesn't follow a specific trend and rule. It means that the climatologic characteristics (especially rainfall) of this region follow a moderate condition.

In Kerio Plain, the monthly rainfall fluctuates greatly from year to year and in the drier months the standard deviation is of the same order as the monthly average. Rain fall decreases from about 1100 mm at Chebloch (south of the proposed area for irrigation in Kerio Valley) to 700 mm at Tot (north of the proposed area for irrigation in Kerio Valley). In average rainfall is about 900 mm. The long term average monthly rainfall at Chebloch has been computed for the period 1958-1970 (water Resources department, 1984) and is given in Table 4.4.

Table 4.4: Long term average monthly rainfall in Kerio Plain (1958-1972)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean Annual
Long Term Monthly Average(mm)	29.8	42.5	74.9	176.2	134.6	79.3	142.6	135.7	55.1	56.6	124.7	33.5	90.5
(%)	2.7	3.9	6.9	16.2	12.4	7.3	13.1	12.5	5.1	5.2	11.5	3.1	

Ref: - water Resources department, 1984

NTM Consulting Engineers, Feasibility Study and Detailed Design of the Arror Multipurpose Dam Development Project on River Arror, Soil Survey Report, 2011

The mean monthly rainfall shows a tendency for a double peak, the first in April- May and the second in July- August. This is associated with the passage of the intertropical convergence zone northwards in April and southwards in July.

Temperature

Mean temperature in the study area is according to the Table 4.5.

Table 4.5: Mean Temperature (°C)

Location	Month												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Arror Dam Site	24.3	23.7	24.1	23.1	23.4	23.5	23.0	24.5	24.1	23.5	23.9	24.7	23.8
Downstream	25.4	26.1	26.1	25.4	24.8	24.1	23.4	23.7	24.6	25.3	24.7	24.8	24.8

Ref: NTM Consulting Engineers, Feasibility Study and Detailed Design of the Arror Multipurpose Dam

Development Project on River Arror, Meteorological Report, 2011

The temperature in this area varies smoothly with time. Its variation in dam site and downstream shows a range of 23-23.4 and 23.4- 26.1 consecutively.

Wind Speed and Direction

Wind speed in the study area is according to the Table 4.6.

Table 4.6: Wind speed (km/day)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Arror Dam Site	533.4	466.7	488.9	466.7	355.6	288.9	288.9	266.7	377.8	466.7	533.4	533.4	422.3
Downstream	220.0	199.9	205.7	180.2	161.6	156.9	166.6	167.8	183.1	171.1	216.7	198.7	185.7

Ref: NTM Consulting Engineers, Feasibility Study and Detailed Design of the Arror Multipurpose Dam Development Project on River Arror, Meteorological Report, 2011

The annually mean value of this parameter is 422.3 and the high speed wind is usually occurred in January. The prevailing winds are from the east.

Relative Humidity

Relative humidity in the study area is according to the Table 4.7.

Table 4.7: Mean Relative Humidity (%)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Arror Dam Site	47.0	48.0	48.0	57.0	64.0	67.0	72.0	70.0	61.0	53.0	60.0	45.0	58.0
Downstream	39.0	38.5	38.5	39.0	39.7	40.5	42.0	41.7	40.2	39.0	40.0	39.7	39.8

Ref: NTM Consulting Engineers Feasibility Study and Detailed Design of the Arror Multipurpose Dam Development Project on River Arror, Meteorological Report, 2011

Sun shine

Sun shine in the study area is according to the Table 4.8.

Table 4.8: Mean Sunshine (hr/day)

	Month												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Arror Dam Site	9.3	9.3	9.0	8.2	7.5	7.1	6.2	6.3	7.7	8.4	8.1	9.3	8.0
Downstream	7.0	8.6	7.9	8.1	5.8	6.5	5.0	5.9	8.1	6.4	5.8	6.7	6.8

Ref: NTM Consulting Engineers, Feasibility Study and Detailed Design of the Arror Multipurpose Dam Development Project on River Arror, Meteorological Report, 2011

Evaporation

Evaporation in the study area is according to the Table 4.9. Also long term average monthly evaporation in Kerio Plain is given in Table 4.10.

Table 4.9: Evaporation in Arror Dam Site and downstream (mm)

Location	Month												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Arror Dam Site	195.0	175.8	188.5	157.5	164.5	170.5	153.3	203.3	190.8	170.5	183.0	209.0	2161.5
Downstream	231.0	231.2	245.1	216.7	198.8	177.8	160.9	196.8	227.3	224.6	183.2	208.8	2502.1

Ref: NTM Consulting Engineers, Feasibility Study and Detailed Design of the Arror Multipurpose Dam Development Project on River Arror, Meteorological Report, 2011

Table 4.10: Long term average monthly evaporation in Kerio Plain (mm)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Perkerra Elevation: 1050 m (1959-1982)	254	239	262	205	207	199	184	189	215	229	201	222	2597
Sigor Elevation: 1050 m (1966-1982)	235	216	236	180	165	165	150	160	190	200	171	215	2283

Ref: - water Resources department, 1984

NTM Consulting Engineers, Feasibility Study and Detailed Design of the Arror Multipurpose Dam Development Project on River Arror, Soil Survey Report, 2011

A comparison between amount of rainfall and evaporation in Kerio Plain shows that mean monthly evaporation exceeds the mean monthly rainfall throughout the year. This is of particular importance to this area where, although rainfall may appear high during the wetter months, the actual amount penetrating in to the soil is low.

Although slopes in Kerio Plain are generally gentle, few areas are flat and most of the rainfall runs of laterally. Therefore, even during the rainy season many of the soils are dry. Thus, the rainfall penetrating in to the lower profile is medium. The runoff is clearly related to the rainfall intensity, since surface infiltration rates measured on undisturbed soils are often adequate. The intensity of rainfall is important in defining the risk of erosion and rainfall erosivity is defined as its potential capacity to cause erosion. Run off tends to occur when rainfall exceeds a certain threshold intensity which is considered to be 25 mm per hour.

Conclusion

Most important meteorological parameters are summarized in the Table 4.11.

Table 4.11: Mean Meteorology Parameters in the Study Area

Parameter	Dam Site (Mean Annual)	Downstream (Mean Annual)
Mean Rainfall (mm)	1066.5	879.1
Mean Temperature (°C)	23.8	24.8
Mean Evaporation (mm)	2161.5	2502.1

Ref: NTM Consulting Engineers, Feasibility Study and Detailed Design of the Arror Multipurpose Dam Development Project on River Arror, Meteorological Report, 2011

The climate of Arror basin is of the tropical semi-arid type (sub-tropical) with moderate temperature and high rainfall. Temperature, rainfall and evaporation are strongly influenced by altitude.

Air Quality

Air pollution in a region can have a natural or unnatural source. Artificial or unnatural pollutant sources comprise of activities concerning mines and industrial activities, traffic and motor vehicles, as well as heating devices. In the area of study, due to the absence of industrial units (large and small industries), pollution in this relative is not present and with regards to rich forest cover and limitation of vehicles, air pollution is negligible and is not an important issue. Since majority of people rely on fuel wood for heating and cooking, burning fuel wood is the most important air pollutants in the region, but still is not a concern.

4.2.3. Hydrology

Surface water resources in the study area with regards to main components of the project comprises of Arror and Kerio Rivers.

Arror is a river in Elgeyo/Marakwet County, which is perennial is approximately 112 km long. The Arror River flows down from the Elgeyo Escarpment, after having drained the Cherangani Hills in its upper basin, into the Kerio Valley; its basin (about 260 Km^2) is the largest among those which drain into the Kerio Valley. The part of the catchment area which is not under forest consists almost entirely of open moorland with good grass cover and cultivation. There is little evidence of soil erosion.

Kerio flows northward into Lake Turkana. It is one of the longest rivers in Kenya, originating near the equator. In south it flows through the Kerio Valley between Tugen Hills and Elgeyo escarpment. The river also partly bounds the South Turkana National Reserve. The river starts from the north slopes below Timboroa and Eldama Ravine and ends at Lake Turkana.

There are two gauging stations on the Arror River:

- The 2C5 station located in the south of the road Kapsowar-Chesoi at about +2190 m.a.s.l with a catchment area of 185 Km^2. The gauging station is located in sererwa area.
- The 2C18 station located at the foot of the escarpment at about +995 m.a.s.l, downstream of the offtakes of all the irrigation furrows built by local people.

The discharge data at these two stations is recorded since almost fifty years. Since the recent data of these stations are not available, a total revision of previous study has been done using the new approaches in the hydrology report.

Fig. 4.2: River Arror downstream of dam site

Fig. 4.3: River Arror downstream of dam site

July 2010

Fig. 4.4: River Arror in Kerio Valley before Adjoining to Kerio River

Jan. 2011

Fig. 4.5: River Arror in Kerio Valley before Adjoining to Kerio River

July 2010

Fig. 4.6: Kerio River - July 2010

Jan. 2011

Fig. 4.7: Kerio River- Jan. 2011

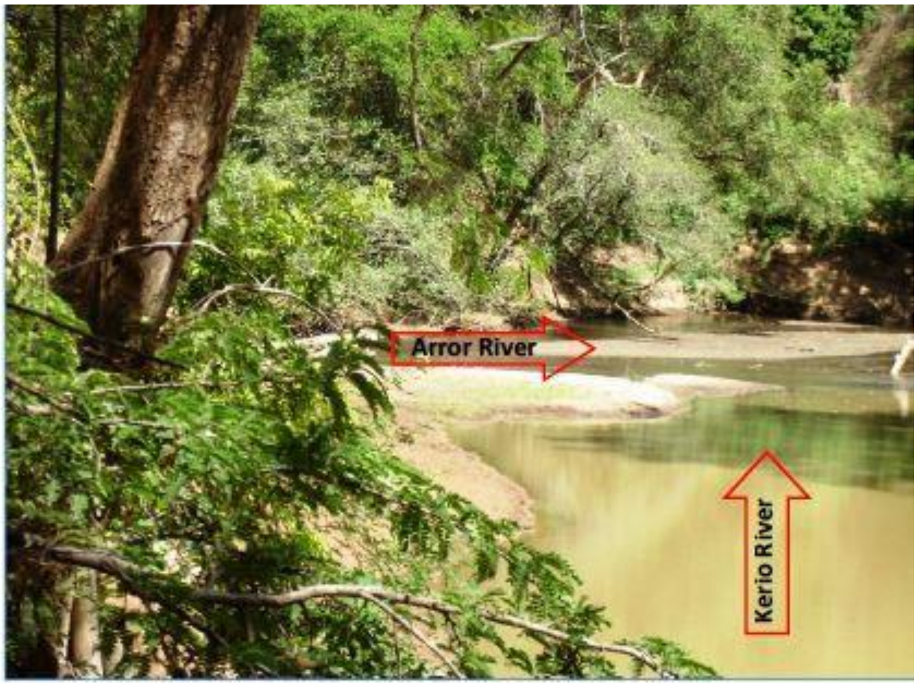


Fig. 4.8: Confluence of Arror and Kerio Rivers

4.2.3.1. Water Flow

The discharge of Arror River varies from 0.67 to 3.32 with a mean of 2.15 m³/s during 25 years recorded data. The Standard deviation and Coefficient of variation and skewness of data show that the discharge of this river has not an important variation. The Table 4.12 shows monthly and annually variation of Arror water flow.

Table 4.12: Arror River water flow at Arror Dam Site (m3/s)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1961	0.91	0.75	0.64	0.99	1.45	1.46	2.37	4.26	1.55	5.05	15.03	3.56	3.23
1962	1.66	1.21	1.47	3.06	4.22	1.46	1.58	2.09	2.40	1.54	4.51	1.01	2.17
1963	1.06	1.02	1.03	3.38	4.80	1.67	1.03	2.33	0.98	0.89	2.33	4.53	2.09
1964	1.44	1.05	1.33	2.65	2.28	1.28	1.89	4.92	3.30	2.30	1.40	1.31	2.10
1965	1.05	0.92	0.83	1.72	1.60	1.21	1.17	0.80	0.81	1.67	3.49	1.08	1.36
1966	1.06	1.18	1.62	5.27	2.91	1.16	3.66	4.46	3.21	2.34	2.99	1.06	2.58
1967	0.85	1.03	0.75	1.83	4.23	1.57	2.93	3.65	1.39	5.38	6.64	2.87	2.76
1968	1.41	2.05	3.13	2.95	3.84	2.10	1.65	3.34	1.33	2.14	12.46	3.47	3.32
1969	1.72	2.67	2.87	1.32	3.10	3.44	1.66	1.50	2.67	2.78	3.44	1.37	2.38
1970	2.22	1.32	1.98	4.44	2.63	1.79	1.48	4.82	2.20	1.39	1.32	1.19	2.23
1971	1.37	0.78	0.79	1.82	1.95	1.52	2.01	4.99	2.29	2.97	6.02	2.36	2.41
1972	1.08	1.02	1.02	1.31	2.61	3.49	3.80	3.35	3.20	2.76	7.46	2.39	2.79
1973	1.07	0.89	0.95	1.19	1.45	1.26	1.47	2.42	2.75	1.75	6.15	1.41	1.90
1974	….	….	….	….	….	….	….	….	….	….	….	….	….
1975	1.08	1.04	0.98	1.36	1.57	1.28	1.71	4.93	2.98	1.38	1.13	0.92	1.70
1976	0.88	0.84	0.78	1.15	1.77	1.01	1.23	2.02	1.82	0.65	0.97	0.74	1.19

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1977	0.77	0.73	0.67	3.50	6.23	1.28	1.99	3.03	1.36	2.61	12.24	1.94	3.03
1978	1.24	2.07	2.73	1.62	2.39	1.91	3.54	2.46	2.09	3.18	2.33	1.96	2.29
1979	1.78	2.55	3.35	3.77	2.06	1.89	1.32	1.69	1.20	1.05	0.93	0.71	1.86
1980	0.67	0.57	0.67	0.95	1.85	1.10	0.67	0.84	0.63	0.60	1.18	0.65	0.87
1981	0.64	0.66	2.18	3.17	1.81	0.87	1.51	3.01	1.98	1.49	1.32	1.21	1.65
1982	0.79	0.66	0.76	2.95	5.41	1.80	1.58	3.54	1.55	4.36	7.37	4.06	2.90
1983	1.31	1.04	0.87	1.72	3.62	1.84	2.16	4.46	2.56	4.20	4.46	1.55	2.48
1984	1.00	0.56	0.63	1.00	1.14	1.04	1.03	0.91	0.98	0.83	1.15	0.71	0.92
1985	0.81	0.70	1.78	3.38	2.32	1.40	1.24	1.95	1.53	0.96	1.48	0.81	1.62
1986	0.60	0.47	0.47	4.53	3.41	2.73	2.75	2.68	2.43	1.77	1.43	0.99	2.02
Mean	1.14	1.11	1.37	2.44	2.83	1.66	1.90	2.98	1.97	2.24	4.37	1.75	2.15
SD	0.40	0.60	0.86	1.26	1.34	0.68	0.85	1.34	0.80	1.35	3.99	1.13	0.67
CV	0.35	0.54	0.63	0.52	0.47	0.41	0.45	0.45	0.40	0.60	0.91	0.64	0.31
Cs	0.97	1.60	1.16	0.59	1.00	1.66	1.05	0.01	0.11	0.96	1.41	1.21	0.19

Ref: - NTM Consulting Engineers, Feasibility Study and Detailed Design of the Arror Multipurpose Dam Development Project on River Arror, Hydrology Report, 2011.
- B & B Consulting Engineers, Feasibility Study on the Integrated Development of the Arror River Basin, Studies of the Hydroelectric Scheme, 1988.

4.2.3.2. Flood

According to 25-year hydrology statistics, maximum daily discharges of Arror River have been recorded with minimum, mean and maximum values of 2.86, 15.86 and 84.49 m³/s (Table 4.13).

Table 4.13: Arror River Annually Maximum Discharge at Arror Dam Site

Year	Maximum Discharge (m³/s)
1961	27.04
1962	11.17
1963	13.56
1964	16.39
1965	13.13
1966	12.43
1967	23.72
1968	84.49
1969	15.70
1970	10.92
1971	13.70
1972	13.09
1973	4.77
1974	....
1975	9.47
1976	4.91
1977	29.14
1978	7.50
1979	19.89
1980	3.47

Year	Maximum Discharge (m³/s)
1981	6.29
1982	17.56
1983	16.29
1984	2.86
1985	6.19
1986	18.60
1987	10.14
Max	84.49
Mean	15.86
Min	2.86

Ref: - NTM Consulting Engineers, Feasibility Study and Detailed Design of the Arror Multipurpose Dam Development Project on River Arror, Hydrology Report, 2011.

B & B Consulting Engineers, Feasibility Study on the Integrated Development of the Arror River Basin, Studies of the Hydroelectric Scheme, 1988.

The peak values of Arror River at Arror dam site have been estimated and the result is shown in the Table 4.14.

Table 4.14: Arror River Annually Maximum and Peak Floods at Arror Dam Site

Return Period					**(Year)**					
Parameter	**2**	**5**	**10**	**20**	**50**	**100**	**200**	**1000**	**2000**	**10000**
Maximum Discharge (m^3/s)	11.4	22.9	32.7	43.8	60.6	75.2	91.5	136	159	220
Peak (m^3/s)	17.1	34.4	49.1	65.7	90.9	113	137	204	239	330

Ref: NTM Consulting Engineers, Feasibility Study and Detailed Design of the Arror Multipurpose Dam Development Project on River Arror, Hydrology Report, 2011.

4.2.3.3 Low Flow

The Arror River data at Arror dam site has been estimated for this purpose using the 1, 3, 5, and 7-day minimum discharge. The results are illustrated in the Table 4.15.

Table 4.15: Arror River low flow analysis results at Arror Dam Site (m³/s)

	Probability (%)							
Parameter	**50**	**60**	**70**	**75**	**80**	**90**	**95**	**99**
1 Day Minimum Discharge	0.39	0.32	0.26	0.22	0.19	0.12	0.07	0.02
3 Day Minimum Discharge	0.60	0.55	0.50	0.47	0.45	0.39	0.34	0.27
5 Day Minimum Discharge	0.60	0.55	0.51	0.49	0.47	0.43	0.40	0.38
7 Day Minimum Discharge	0.66	0.61	0.56	0.54	0.52	0.45	0.41	0.34

Ref: NTM Consulting Engineers, Feasibility Study and Detailed Design of the Arror Multipurpose Dam Development Project on River Arror, Hydrology Report, 2011.

River flow rate will decrease in the downstream through dam construction. Due to the extent river basin in the downstream, the annual runoff in the middle basin has been estimated through analyzing the results of long-term measurements at the two stations located on the River Arror. Based on this, required Environment Water Flow (EWF) can be estimated to release from the dam to maintain the ecological conditions of the river in downstream.

4.2.3.4. Sediment Deposition

The sediment of River Arror is estimated 2.16 m^3/s that equals to 68.1 MCM/Y; so total sediment deposition is about 44135.5 Ton/Y that equals to 1.47 MCM/Y. If the average unit density of the compacted sediments is conservatively assumed around 1.5 ton /m^3, then around 1 MCM of the storage volume will be lost due to the sediment deposition in 25 years and 2 MCM during 50 years of the reservoir life which is 3.3% of the normal volume, [Volume at Normal Water Level]= 60 MCM.

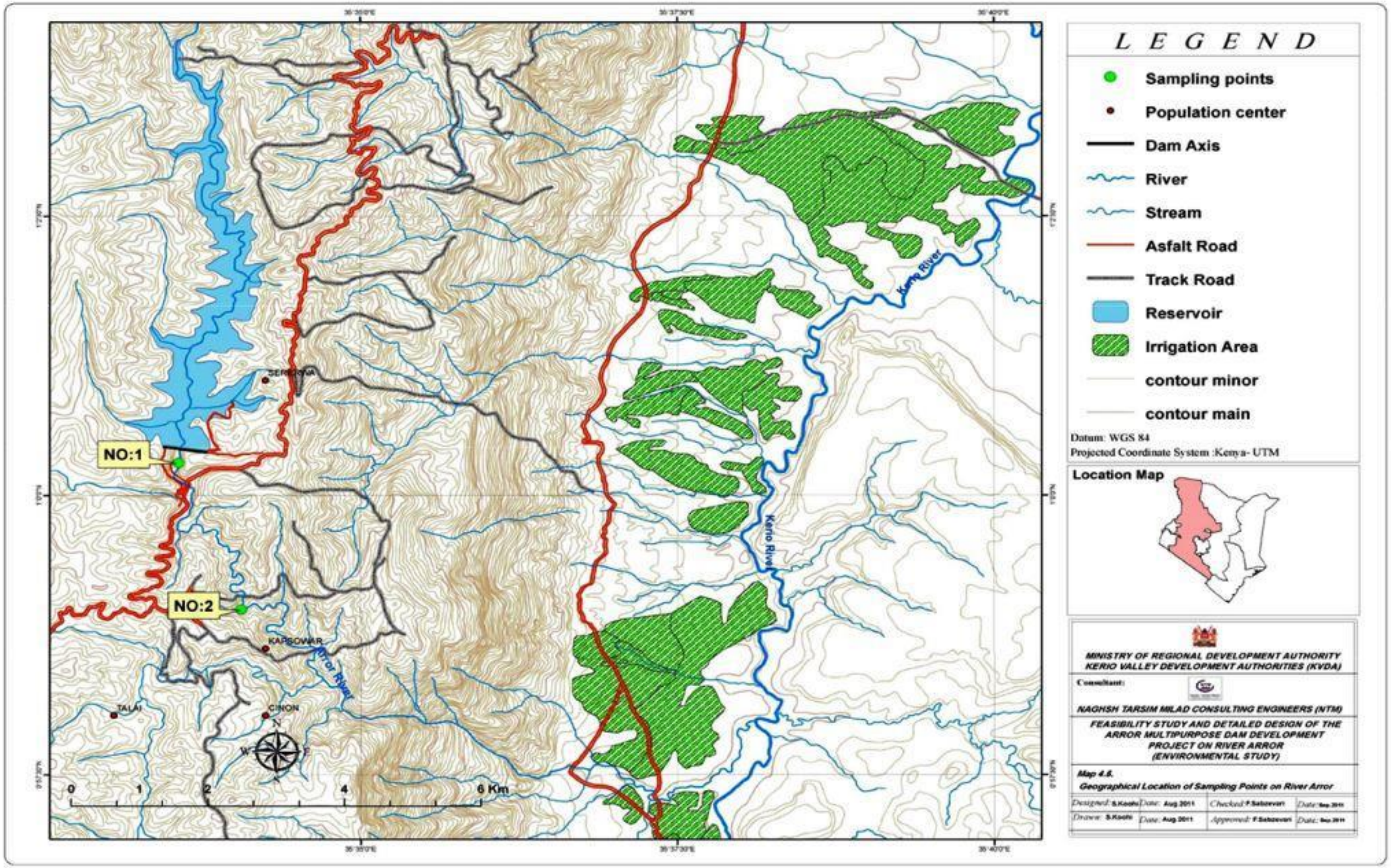
4.2.3.5 Water Quality

With respect to construction of the dam on River Arror, reviewing the water quality of this river is important in terms of prediction the reservoir water quality as well as future water quality in downstream of dam axis.

River Arror has not been under monitoring program. However, according to (Feasibility Study on the Integrated Development of the Arror River Basin) conducted by Italian B & B Consulting Engineers in 1987-1988, river water has enjoyed relatively good quality for various purposes. Only in some samples, levels of some physical-chemical parameters such as (Fe) and (Mn) have been beyond the drinking water standards limits.

The results of analysis carried out on samples of river water in this study (2010) also indicate Arror good quality water for various uses. Comparing these results with gained results from previous study indicates an increase in the parameters of Total Hardness (TH) and Total Alkalinity, however the quality of Arror River water for various uses is still acceptable. The results of analysis carried out on Arror and Kerio Rivers are presented in Annex A. Map 4.5 shows the location of sampling points on Arror River in this study.

Fig. 4.9: Sampling of Arror River (by environmental team)–Jan.2011


LEGEND
Sampling points
Population center
Dam Axis
River
Stream
Asfalt Road
Track Road
Reservoir
Irrigation Area
contour minor
contour main
Datum: WGS 84
Projected Coordinate System :Kenya- UTM
Location Map
MINISTRY OF REGIONAL DEVELOPMENT AUTHORITY
KERIO VALLEY DEVELOPMENT AUTHORITIES (KVDA)
Consultant:
NAGHSH TARSIM MILAD CONSULTING ENGINEERS (NTM)
FEASIBILITY STUDY AND DETAILED DESIGN OF THE ARROR MULTIPURPOSE DAM DEVELOPMENT PROJECT ON RIVER ARROR (ENVIRONMENTAL STUDY)
Map 4.6.
Geographical Location of Sampling Points on River Arror
Designed: S.Koohi Date: Aug 2011
Checked: F.Sabzevari Date: Sep 2011
Drawn: S.Koohi Date: Aug 2011
Approved: F.Sabzevari Date: Sep 2011
NO:1
NO:2
SERENGA
KAPSOWAR
TALAI
CINON
Arror River
Kerio River
N
S
E
W
0
1
2
4
6 Km
35°35'0"E
35°37'30"E
35°40'0"E

4.2.3.6. Water Sampling Program

With attention to the objectives of the project, determining the current water quality of the river and prediction it for future is necessary. In order to determine the current status of river water quality, the results of analysis of the various parameters (physical, chemical and biological) is needed. In feasibility study done by Italians, some sampling and analysis have been done, however due to changes of water flow in the Arror River basin during last two decades; the professional judgement is not possible only based on the gained results of those samplings. So if the updated information is not available, samplings should be repeated. New proposed water sampling program is as follows:

Parameters

Proposed parameters for sampling including physical-chemical, heavy metals, biological and bacteriological are according to Table 4.16.

Table 4.16: Proposed Parameters for Water Sampling Program

		Parameter		
No.	**Physical & Chemical**	**Biological**	**Bacteriological**	**Heavy metals**
1	Temperature	Diatomaceae	Total Coli form	Chromium (Cr)
2	pH	Chlorophyceae	Fecal Coli form	Cobalt (Co)
3	Colour	Cyanophyceae	Heterotrophic Bacteria	Cadmium (Cd)
4	Turbidity	Protozoa	Fecal streptococcus	Copper (Cu)
5	Conductivity	Rotifera		Lead (Pb)
6	Calcium	Crustaceae		Nickel (Ni)
7	Magnesium	Nematode		Zink (Zn)
8	Sodium			Iron (Fe)
9	Total Hardness			Manganese (Mn)
10	Total Alkalinity			Arsenic
11	DO			Selenium (Se)
12	BOD_5			Mercury (Hg)
13	COD			
14	Total Nitrogen			
15	Ammonia			
16	Nitrate			
17	Nitrite			
18	TDS			
19	TSS			
20	Total Phosphate			
21	Chloride			

Frequency

Frequency of sampling for physical-chemical, biological and bacteriological is recommended monthly, whereas for heavy metals, seasonal sampling is sufficient.

Gauging Stations

To identify water quality of the River Arror, two aforementioned gauging stations (2C5 and 2C18) are selected. These stations are chosen to make possibility to compare new results with previous gained results.

Implementation of irrigation project shall have some direct impacts on the Kerio River quality, and also Arror River ultimately flows into the Kerio River. So in order to identify current water quality of the Kerio River and determine future impacts of irrigation project on this river, three gauging stations are recommended as below:

- Kr-C1 station located upstream of the irrigation area on the Kerio River
- Kr-C2 station located on the Kerio River before its confluence with Arror River
- Kr-C3 station located downstream of the irrigation area on the Kerio River

Geographical location of the gauging stations in the proposed sampling program is shown in the Map 4.6.

4.2.4. Soil

Distribution of soils in the Arror basin is complex having been influenced by the extensive variations in relief, volcanic activity and underlying rock types. The soils are derived primarily from weathered volcanic and basement rock system and also vary with location and altitude. Owing to differences in geographical zones i.e. the Highland, the Escarpment and the Valley, the upland soils are of two categories: those developed on olivine basalt and ashes of old volcanoes and those developed on undifferentiated basement system rocks, mainly gneiss. The highlands soils are fertile and deep except for the north-western part, where soils are generally shallow. The upland soils often occur with rock outcrops and their top soil is rich in organic matter and thus of high water absorption capacity. On the other hand, the escarpment comprises of infertile and shallow soils due to erosion on the steep slopes. Soil erosion is also aggravated by cleared vegetation leaving the land surface bare.

The Kerio valley floor consists of poorly drained alluvial soils normally eroded from the highlands and too developed from sediments of volcanic ashes. The soils are fertile and suitable for agriculture.

Since one of the purposes of Arror Dam is irrigation and agriculture development in Kerio Valley, soil survey (in this phase of the study) has been conducted the fall of 2010 covering over 2250 ha of land in this area that the most important parameters (in terms of environmental study) is described hereinafter:

4.2.4.1. Land use in Proposed Area for Irrigation

Land use in this area is shown in Figure 4.10.

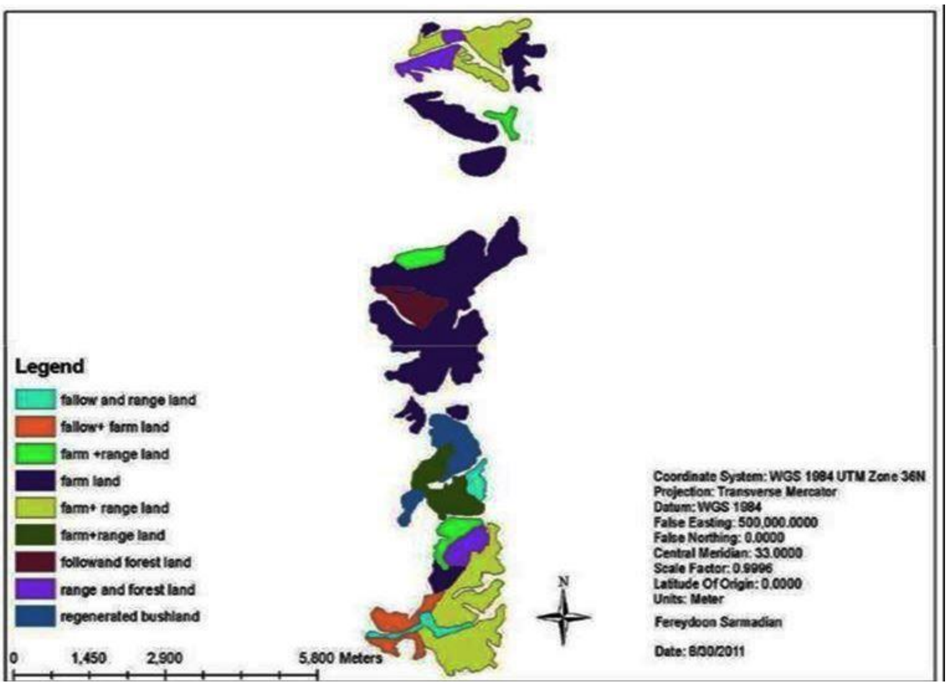


Fig. 4.10: Land use of Proposed Area for Irrigation

4.2.4.2. Land classification for Irrigation

It was found that only some 2250 hectares of land are suitable for surface irrigation development with different suitability classes. Whereas if overhead irrigation is adopted the area of suitable land increases to 2250 hectares with better suitability classes.

4.2.4.3. Land Capability Classification

Land capability classification shows, in a general way, the suitability of soils for most kinds of field crops. Crops that require special management are excluded. The soils are classified according to their limitations for field crops, the risk of damage if they are used for crops, and the way they respond to management. The criteria used in classification the soils do not include major and generally expensive land forming that would change slope, depth, or other characteristics of the soils. In the capability system, soils are generally grouped at three levels: capability class, subclass, and unit. Only class and subclass have been used in soil survey of the study. Capability classes, the broadest groups, are designated by numerals I through VI. The numerals indicate progressively greater limitations and narrower choices for practical use. The classes are defined as follows:

Class I: Land and soils have few limitations that restrict their use

Class II: Land and soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices

Class III: Land and soils have severe limitations that reduce the choice of plants or that require special conservation practices, or both
Class IV: Land and soils have very severe limitations that reduce the choice of plants or that require very careful management, or both
Class V: Land and soils are not likely to erode but have other limitations, impractical to remove, that limit their use
Class VI: Land and soils have severe limitations that make them generally unsuitable for cultivation and irrigation.

Capability subclasses are soil groups within one class. They are designated by adding a small letter, A, S, T, or W, to the class numeral that are defined as follows:

(T): shows that the main hazard is the topographic limitations unless close-growing plant cover is maintained;

(W): shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage);

(S): shows that the soil is limited mainly because it is shallow, droughty, or stony;

(A): shows that the main hazard is soil salinity and or sodicity.

Land suitability for sprinkler and gravity irrigation are shown in Figures 4.11 to 4.14.

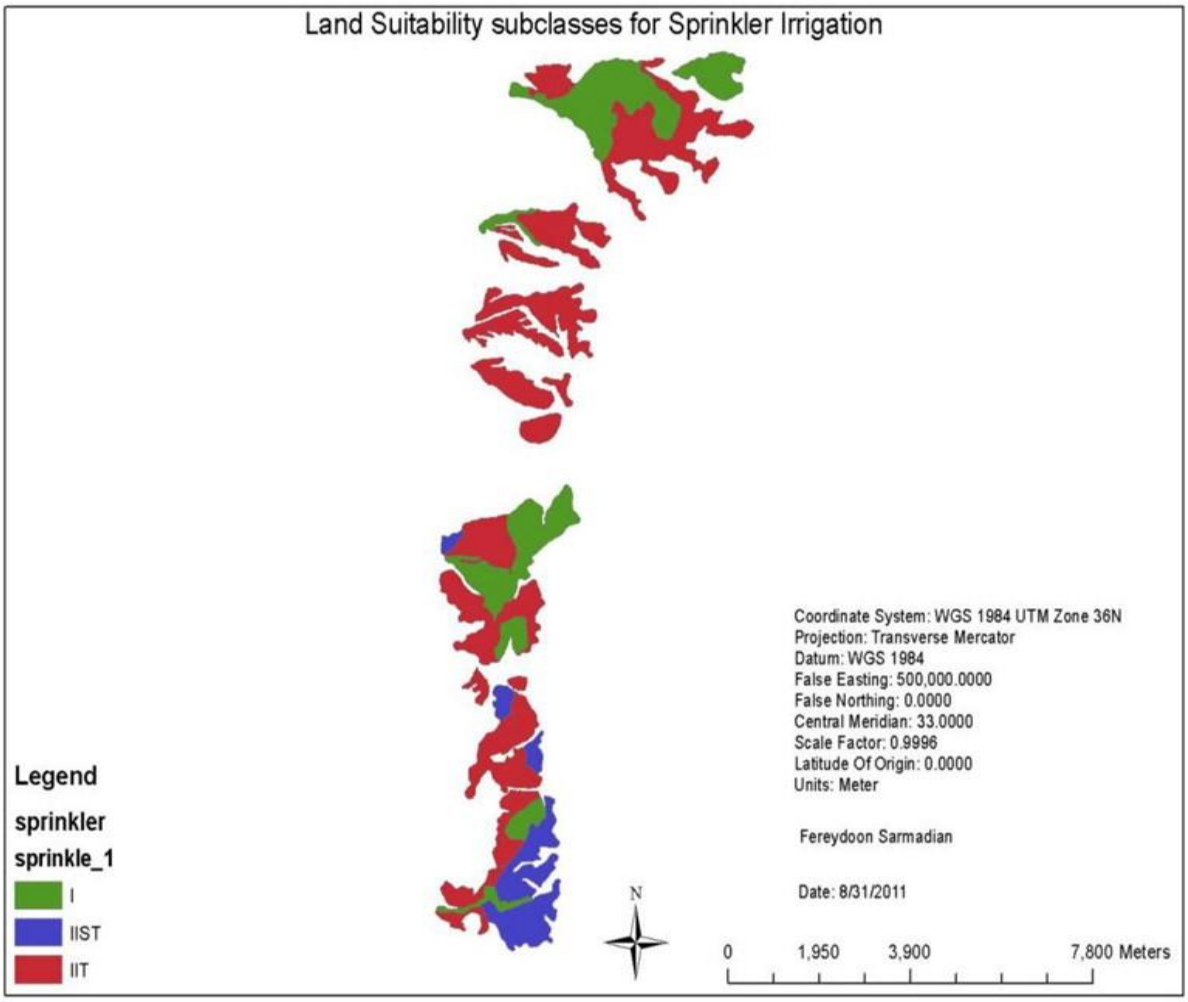


Fig. 4.11: Land Suitability Subclasses for Sprinkler Irrigation

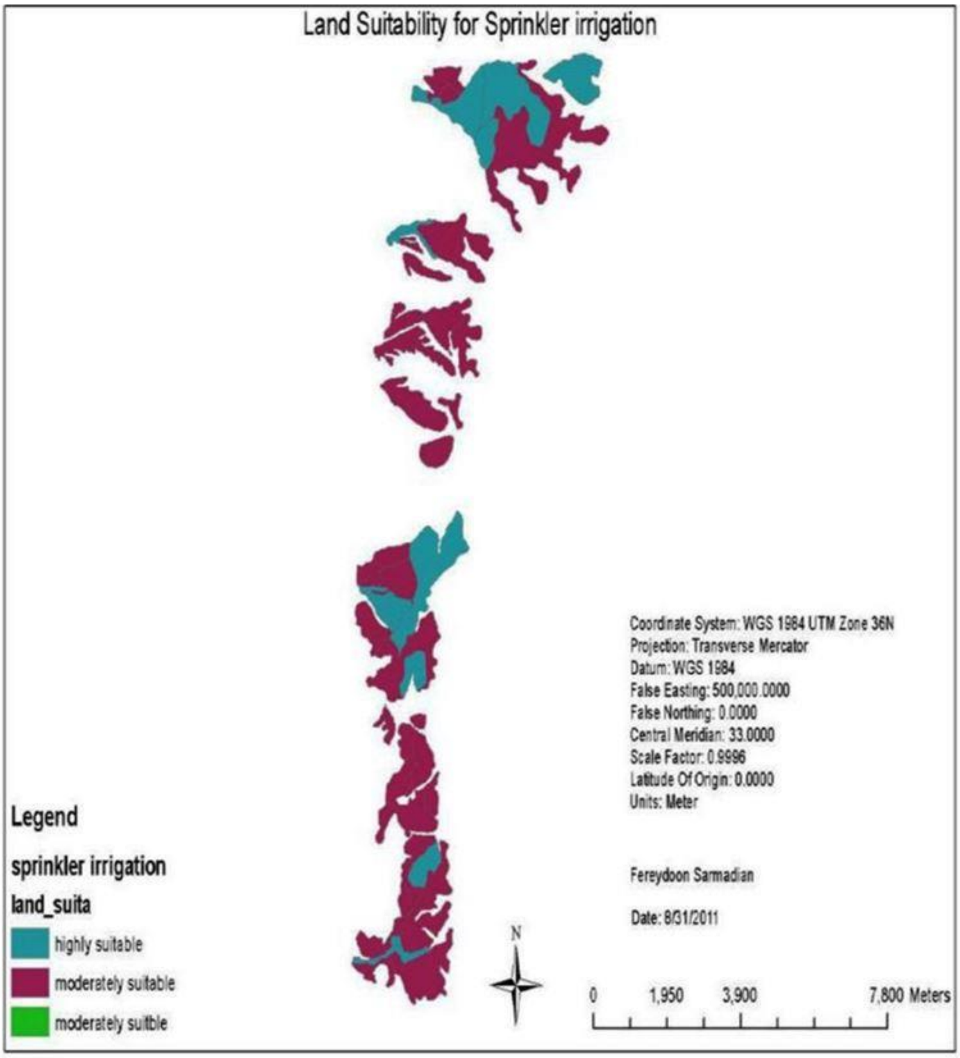


Fig. 4.12: Land Suitability Evaluation for Sprinkler Irrigation

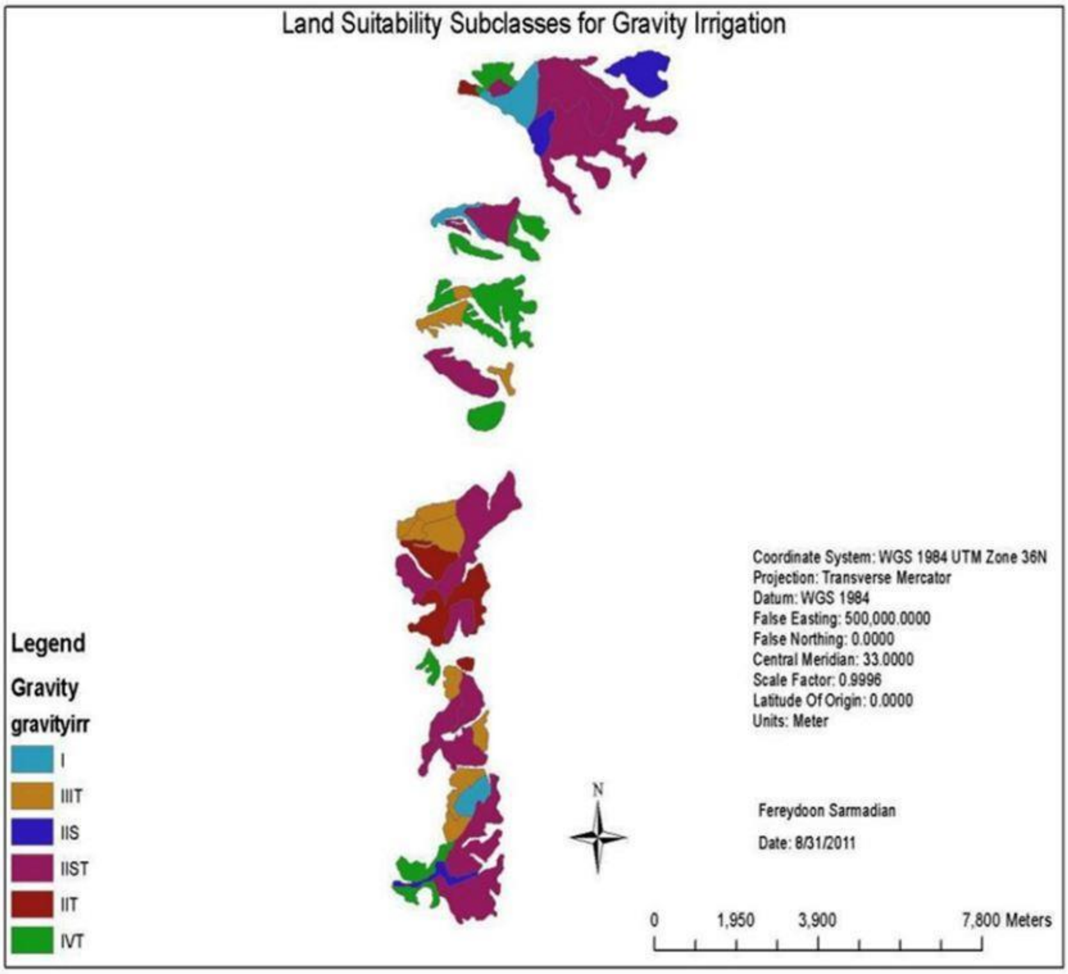


Fig. 4.13: Land Suitability Subclasses for Gravity Irrigation

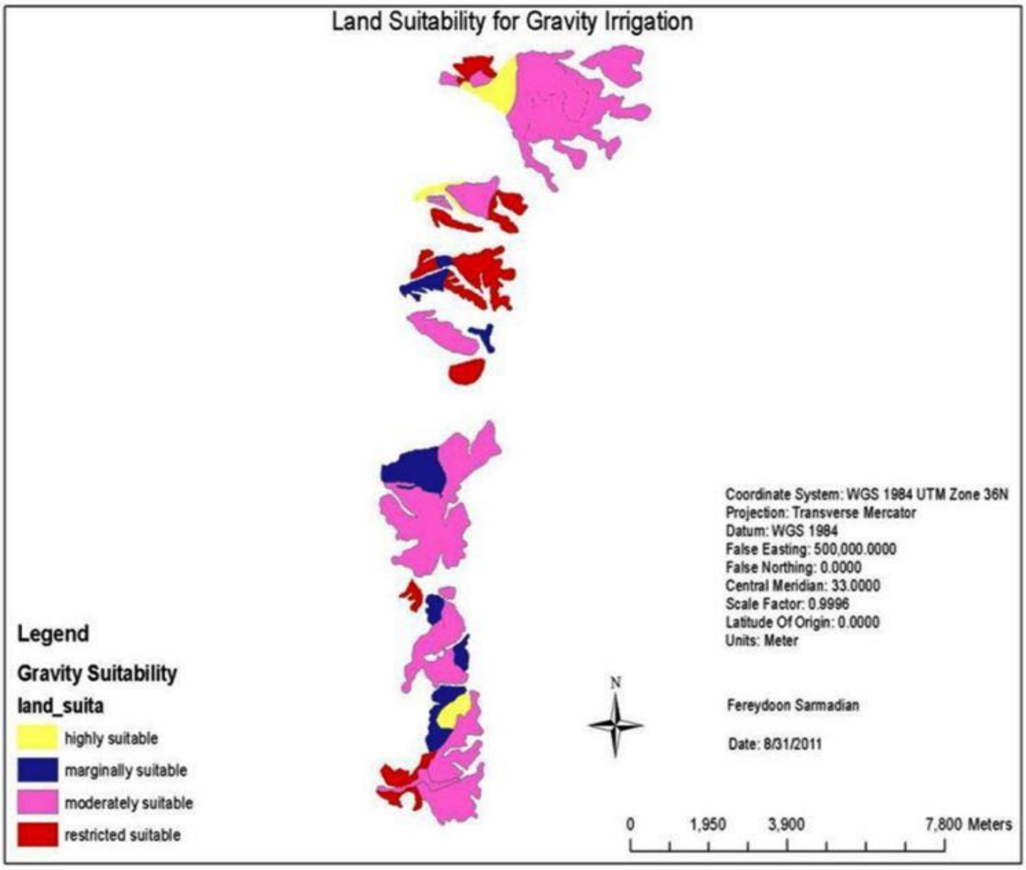


Fig. 4.14: Land Suitability Evaluation for Gravity Irrigation

Based on the soil survey, land class and subclasses for sprinkler and gravity irrigation are given in Tables 4.17 and 4.18.

Table 4.17: Land Class, Subclasses, Area and Suitability Evaluation for sprinkler irrigation

No.	Class/Subclass	Area (ha)	Land Suitability
1	I	668	Highly suitable
2	IIT	1313	Moderately suitable
3	IIST	299	Moderately suitable

Ref: NTM Consulting Engineers, Arror Multipurpose Dam Project, Soil Survey Report, 2011.

Table 4.18: Land Class, Subclasses, Area and Suitability Evaluation for gravity irrigation

No.	Class/Subclass	Area (ha)		Land Suitability
1	I	136		Highly suitable
2	IIT	183		Moderately suitable
3	IIS	140	1274 ha	Moderately suitable

4	IIST	951		Moderately suitable
5	IIIT	263		Marginally suitable
6	IVT	361		Restricted suitable

Ref: NTM Consulting Engineers, Arror Multipurpose Dam Project, Soil Survey Report, 2011.

4.2.4.4. Soil Series

Soil series is shown in Figure 4.15 and the characteristics of each unit is given in the Table 4.19.

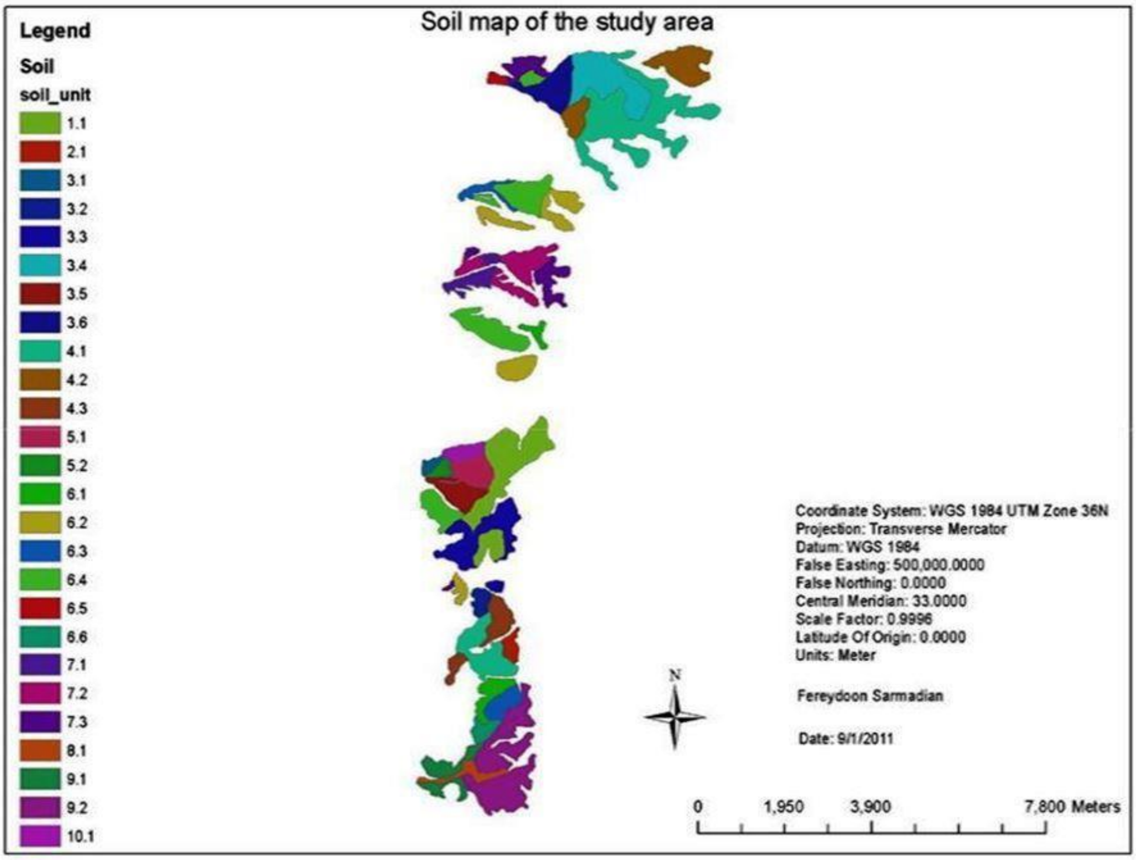


Fig. 4.15: Soil Map of the Study Area (soil series and phases)

Table 4.19: Soil units, Area and Description

Soil Unit	Area (ha)	Soil Description
1.1	189.151	very deep, sandy clay loam topsoil, sand clay subsoil
2.1	19.5425	very deep, sandy loam topsoil, clay to loam subsoil
3.1	11.5041	very deep, sandy loam topsoil, sand clay loam subsoil
3.2	21.868099	very deep, sandy loam topsoil, sand clay loam subsoil
3.3	120.762	very deep, fine sandy loam topsoil, sand clay loam subsoil

3.4	141.04201	very deep, fine sandy loam topsoil, clay loam subsoil
3.5	51.687401	very deep, fine sandy loam topsoil, sandy clay loam subsoil
3.6	75.099197	very deep, fine sandy loam topsoil, sandy clay loam subsoil
4.1	361.80701	very deep, sandy clay loam top, clay loam to clay subsoil
4.2	114.271	very deep, sandy loam topsoil, clay loam subsoil
4.3	60.2752	very deep, sandy loam topsoil, sandy clay loam subsoil
5.1	51.568199	very deep, sandy loam, top and subsoil
5.2	13.8392	very deep, sandy loam top and subsoil
6.1	49.8158	very deep, sandy clay loam top and subsoil
6.2	117.814	very deep, sandy loam topsoil, sandy clay loam subsoil
6.3	60.7146	very deep, sandy clay loam top and subsoil
6.4	199.23599	very deep, sandy loam topsoil, sandy clay loam subsoil
6.5	9.89611	very deep, sandy clay loam top and subsoil
6.6	22.426399	very deep, sandy loam topsoil, sandy clay loam subsoil
7.1	44.241901	very deep, sandy loam topsoil, sandy subsoil
7.2	96.290497	very deep, sandy clay loam topsoil, sandy loam subsoil
7.3	86.803497	very deep, fine sandy loam top and subsoil
8.1	26.214199	very deep, sandy loam topsoil, clay subsoil
9.1	59.992199	very deep, sandy loam topsoil, loamy sand subsoil
9.2	213.188	very deep, loamy sand topsoil, loamy sand to sand subsoil
10.1	28.1439	very deep, sandy clay loam top and subsoil

Ref: NTM Consulting Engineers, Arror Multipurpose Dam Project, Soil Survey Report, 2011.

4.2.4.5. Soil contamination

Due to forest cover and agricultural lands in the River Arror basin, the rate of soil organic materials is high that would be effective on quality of water stored in the reservoir. With respect to lack of industrial and mining activities in the dam basin, soil contamination is limited to:

- Fertilizers and pesticides used in agricultural lands,
- Improper sewage and waste disposal in the population centers.
- This also holds true in Kerio Plain, except that pesticide and fertilizer consumption in this area is very low. It is due to the following reasons:
- Lower area of agricultural lands,
- Unavailability of chemical fertilizers and pesticides,
- Not afford to purchase of fertilizers and pesticides,

Overall, based on the current environmental status, medium to high density of vegetation cover, population and the compatible way of living with environment (except for using of wood as firewood), lack of large or small industrial units, soil contamination issue is not important.

4.2.5. Geology and Hydrogeology

4.2.5.1. Geology

The dam site is located between a horst zone (characterized by the presence of Basement metamorphic rocks-pre-paleozoic) and a graben zone (known as the Rift valley, where Tertiary and Quaternary volcanic rocks are present), in the western margin of the Gregory Rift (East African Rift).

Owing to the fact that the basin lies within the Great Rift Valley where several phases of intensive volcanic activity have occurred, its geology is mainly of volcanic in nature. The rocks include the following types; basalts, phonolites, trachytes and pyrmiassic rocks. The rock formation in the basin is basically divided into three groups:

- Basement system or metamorphic rocks
- Tertiary volcanic or "extrusive" igneous rocks
- Quaternary alluvial deposits or sediments (Sombroek *et al.*, 1990).

The land surface of Arror basin is by hornblende gneisses with mica schists, milestones and minor quartzites, on the valley floor basalts and trachytes outcrop. The junction between the Basement and valley floor (Kerio valley) volcanic is obscured by thick layers of sediment wash from the escarpment although it appears that in general the Kerio River has cut its bed along the adage of the volcanic flows, of least within the present study area.

Main faulting in the lower to Middle Pliocene affected this valley in fill lavas as well as effecting formation of the Tugen Hills. Further lavas (basalts and trachytes) flowed into the basin from the east. The present form of the valley was attained in the Quaternary when further tectonic movements along the Elgeyo and Tugen faults resulted in back tilting of the western (uasin Gishu) block, since that time the only modification to the valley form has been due to deposition and erosion processes by the agency of water and gravity. These processes have resulted in screed fans, piedmont alluvial fans and alluvial terraces.

4.2.5.2. Hydrogeology

The well-developed hydrographic network, its sub-angular pattern and the numerous erosional minor cuts give the evidence of a fairly intense runoff. This fact, associated to the strong evapotranspiration, points at a reduced infiltration coefficient.

Local hydrogeological information is missing. However, it can be safely assumed that in the Basement rocks the rainfall infiltrates into the weathered zone (where it forms a small aquifer in the basal argillaceous sands) and in the open fratures of the underlying unaltered rock (where there is a second aquifer slightly greater but still modest).

The colluvial deposits at the foot of the escarpment can be considered quite permeable due to the very coarse nature of its components, ranging from small size debris up to large boulders. The water infiltrating from the small local torrents is thus drained toward the Kerio alluvium zone.

4.2.5.4. Erosion, stability, Landslides

The field observations confirm this assumption as no evidence of collapse or sliding or of large scale instability has been noticed in the rocky substratum.

The few examples of instability which have been seen in the field affect the superficial cover and are due to erosion of the river banks, or to degradation or to intense weathering and strong runoff in connection with a pronounced steepness of the slopes. Therefore, during particularly heavy rainfalls some small landslides of the cover layer, with shearing plane near the substratum, may occur. This problem may, in particular, affect the projected dam live storage capacity since the cover layer friability may increase solid transport and the rate of earth-filling; moreover, under saturation conditions, also large soil masses may break away and slide into the reservoir.

The highest intensity of sliding phenomena is found in the areas lacking a thick vegetation cover. The most evident soil deteriorations affect the areas used for cultivation where trees and grass cover have been removed.

In order to protect the dam from accelerated sedimentation it seems therefore necessary to foresee soil stabilization and water regulation works and, where necessary, revegetation and reforestation by means of appropriate practices.

4.2.6. Earthquake

Western margin of the Rift is generally considered to belong to the (Mobile Belt) rather than to the stable cratonic zone sensu strictu. For this reason, the sector is likely to be affected by tectonic movements. The results of a bibliographical research on seismic activity in the project area show that earthquakes, some of which of magnitude larger than 4 (Richter scale), have occurred in the region, interesting the northern prosecution of the Elgeyo fault.

Their general distribution shows that significant seismic activity is certainly present in the region although no specific data are available within the study area. Moreover, seismic activity is apparently more frequent in the plateau areas than in the Rift floor.

4.2.7. Sources of pollution

Pollution in study area is investigated from two points of view:

- Study of pollutant Sources affecting the project that occurs through the effect on quality of stored water in reservoir as well as decrease of water quality in downstream of dam (present status of pollution in the environment surrounding the project). This subject is examined in forms of pollution caused by urban and rural areas, agricultural, industrial and mining activities and also pollution due to natural sources and sediment input to the dam reservoir.
- Study of Pollution due to project activities that will be presented in the framework of impact prediction.

To study domestic pollution, obtaining data on population in the river basin, estimation of sewage and waste in each of the population centers are important as well as study the way of impact on the river and its tributaries that will be examined in this report. General recognition of the study area in terms of pollution status is gained through local people and filling out questionnaire. Pollution questionnaire is given in Annex B. Table 4.20 shows the households by main way of sewage disposal.

Table 4.20: Households by main way of sewage disposal

	Main Sewer	Septic Tank	Cesspool	VIP Pit Latrine	Pit Latrine (Covered/ Uncovered)	Bucket	Bush	Other	Total
Marakwet	29	49	23	335	29449	24	9579	9	39497
Rural	11	30	17	312	27626	13	9563	9	37581
Urban	18	19	6	23	1823	11	16	-	1916

Ref: Kenya National Bureau of Statistics, "Statistical Abstract", 2009

In order to study agricultural pollution, agricultural lands area in the basin and the amount of fertilizers and pesticides used in farms and how to drain into the river is considered and its effect on water quality is investigated.

Land use change from forest to agriculture and increasing erosion and input sediment into rivers are the most important parameters of natural pollution. Due to extensive forest cover within the reservoir and surrounding, if the trees and organic soils remain during water taking of dam, occurrence of eutrophication phenomenon will be inevitable. Therefore, planning for land clearance in reservoir and slopes overlooking the lake is necessary to prevent from eutrophication.

4.2.8. Water balance and Geomorphology assessment

The geomorphology and sedimentation assessment will be carried out by AECOM with preliminary report and the action plan shown in Annex I. The following section discuss the preliminary findings of the report.

4.2.8.1. Water balance model

Model selection and configuration

As part of this assessment a monthly time-step water balance model was developed for Arror Dam. For this purpose, the *Water Resources Yield Model* (WRYM) was selected since it provides a number of key benefits, including (i) scenario analysis and management functionalities; and stochastic analysis capabilities. The model was developed in South Africa by the Department of Water and Sanitation (DWS) and has been used for modelling and managing complex water resource systems water resources across Africa for over 30 years.

The model configuration includes data, information and results as described in the preceding sections, namely:

- Naturalised stream flow hydrology based on measured flows at gauging station 2C5 (Arror River at Road Bridge).
- Results from the hydro-census based on satellite imagery, specifically existing upstream cultivated areas and irrigation on the lower Arror River.
- Environmental water requirements from the NTM study.
- A selected MOL of 2 228.6 masl that results in a dead storage volume of 9 million m^3 to allow for the projected deposition of sediments in the dam basin over a planning period of 50 years.
- Dam basin characteristics for the proposed dam from the NTM feasibility study. This was assessed by AECOM and found to be correct.

A schematic diagram of the model configuration is shown in **Figure 4-1**, including model elements representing the dam, runoff from the upstream catchment, existing waters use and water abstractions, the downstream river reach and environmental water requirements.

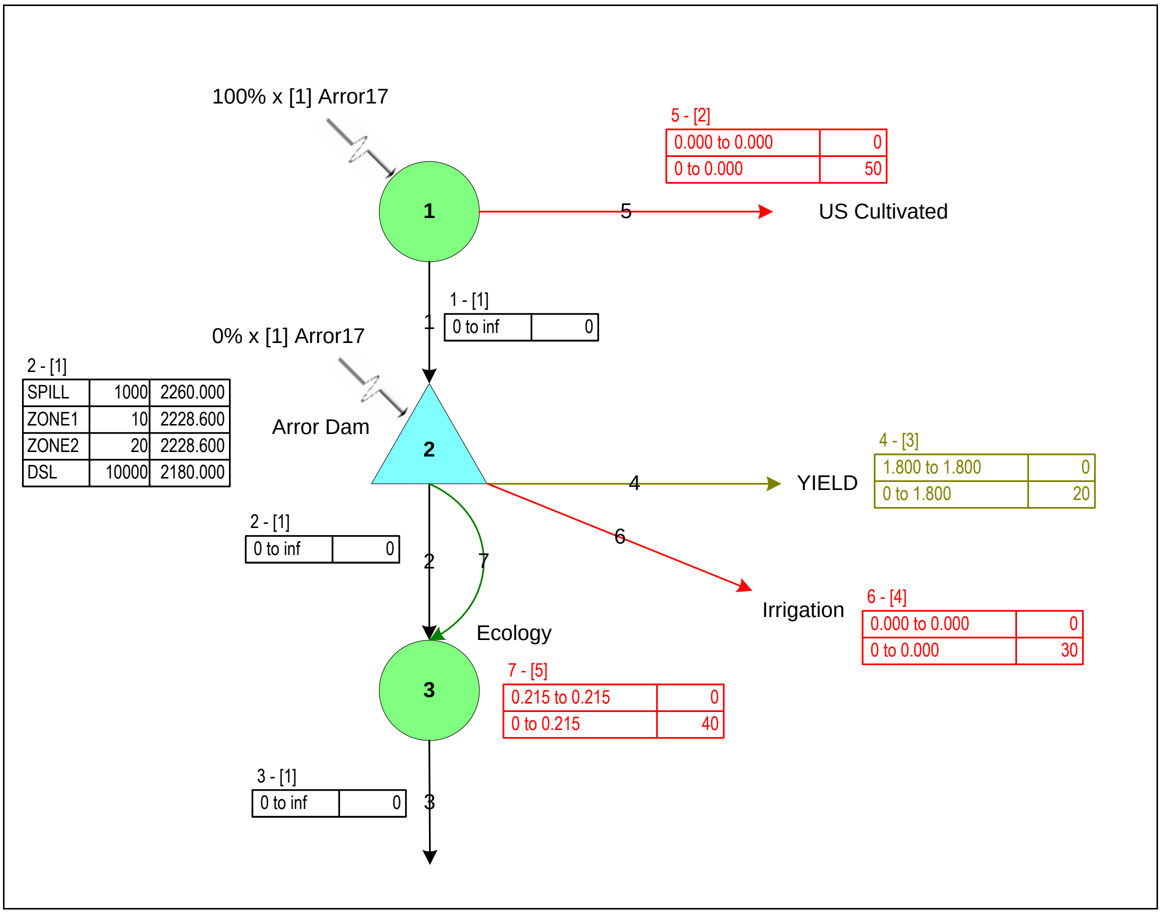


Figure 4-1: Schematic diagram of water balance model configuration for Arror Dam

Yield results

Yield analyses were undertaken with the water balance model (WRYM) based on both historical and stochastically generated hydrological time-series data sets. The results are presented in **Table 4-** including yields at the annual assurances of supply of both 50% and 90% (i.e. at recurrences intervals of failure of 1:2 and 1:10 years, respectively). **Figure 4-2** shows the relationship between the gross storage volume of the dam and system yield.

Table 4-21: Relationship between storage volume and yield for Arror Dam

FSL(1)	**Storage volume (million m³)**		**Yield (million m³/a), at indicated annual assurance of supply (RI(2) of failure)**	
	Gross	**Live(3)**	**50% (1:2 years)**	**90% (1:10 years)**
2 280.0	126.7	117.7	66	63
2 270.0	93.8	84.8	63	60
2 260.0	65.1	56.2	61	56
2 250.0	39.7	30.7	54	49

Notes: (1) Modelled full supply level.

(2) Recurrence interval.

(3) Volume above the selected MOL of 2 228.6 masl.

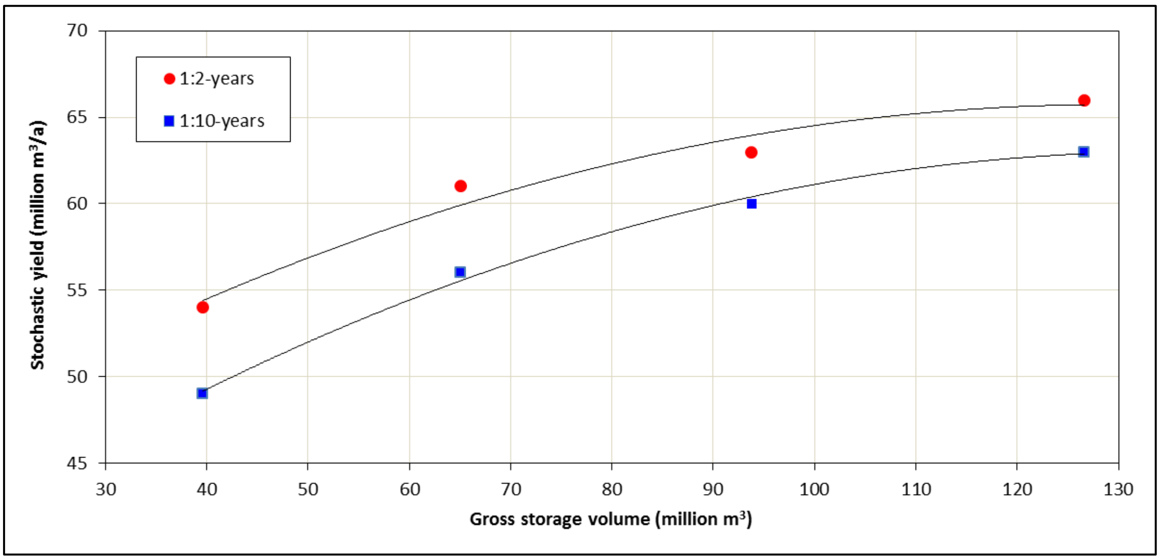


Figure 4-2: Storage-yield-curve for Arror Dam

4.2.8.2. Geomorphology assessment

AECOM has been commissioned to carry out geomorphology assessment (see annex I for the water balance assessment report and action plan). Geomorphology and sedimentation assessment will be undertaken including the following:

- Detailed sediment studies of the Arror Dam. This includes the determination of the sediment load and the sediment deposition within the reservoir that could affect the water supply security, water quality and reservoir capacity. Sedimentation deposition modelling will be executed to confirm the sedimentation levels at the dam intake after a 50-year period using the Mike 11, Mike 21C or HEC-RAS software.
- Dam embankment slope stability and reservoir rim stability analyses to determine the safety of the dam using the *Geo-Studio Slope/W* software.
- The development of a robust mitigation and monitoring plan.

The methodology of the above includes the following:

- Soil mapping of the area from satellite imagery and aerial photographs.
- Detailed sediment studies of the Arror Dam will include the determination of the catchment's sediment yield followed by the sediment load (volume) that will be contained in the reservoir over a 50-year period.
- The sediment deposition within the reservoir could affect the reservoir capacity and the intake level of the dam outlet works, subsequently affecting water supply

security and water quality. Sedimentation deposition modelling will be executed to confirm the sedimentation levels at the dam intake after a 50-year period using the Mike 11, Mike 21C or HEC-RAS software.

- This will be done for cases with and without the dam to also cover the impact of the dam on the downstream geomorphology on potential erosion and deposition. The above-mentioned programmes will be considered for this purpose.
- The reservoir rim will be assessed by a combination of studying contour drawings, a walk over survey to identify geomorphological features which could have a low safety factor against slipping under saturated conditions which could happen under reservoir draw down conditions.

As part of the detail design process the following will also be conducted with regard to stability and safety of the dam:

- Dam embankment slope stability analyses for various static and dynamic load conditions will be conducted using the *Geo-Studio Slope/W* software.
- The possibility of landslides, based on geotechnical and topographical information, and subsequent landslide generated impulse waves in the reservoir using the Laboratory of Hydraulics, Hydrology and Glaciology of the Swiss Federal Institute of Technology (VAW, 2009) guidelines.

4.2.8.3 Sedimentation

Earlier feasibility studies clearly state the importance of sedimentation, particularly with regard to its potential impact on the live storage of the proposed dam.

Sediment yields were estimated for the Arror River catchment in the BeB ingg. study based on tests carried out with sand traps positioned at various points on the river bed. Results from these tests and a number of water analyses (details in this regard are not provided) were used to estimate the average sediment yield of the catchment, with a range from 1400 to 1800 tons/km^2/a. Although these estimates appear to be relatively high, even if compared to other high sediment yielding catchments in Kenya and elsewhere, the results were considered to be conservative and therefore used in the water resource assessment. Adopting an average value of 1 600 tons/km^2/a, a weight of 1700 kg/m^3 and a catchment area of 85 km^2 the total sediment volume over a planning period of 50 years (V50) was calculated as 8.7 million m^3.

Characteristics for the proposed Arror Dam storage basin were obtained from the NTM feasibility study. Based on preliminary design parameters for the dam a minimum operating level (MOL) of 2228.6 masl was used, together with various possible full supply levels (FSLs) as discussed in the following subsection. In this regard it should be noted that the selected MOL provides a dead storage volume of 9 million m^3, which allows for the V50 of 8.7 million m^3 discussed above.

AECOM has been commissioned to carry out sedimentation assessment (see annex I for the water balance assessment report and action plan).

4.3. Biological and Ecological Environment

4.3.1. Identification of the Regional Study Area

The resulting area (hereafter RSA) has an area of 18,587ha and a perimeter of 56.0km (Fig 4.16). The linear dimensions are 17.5km (North to South) and 14.0km (East to West) The NW and SE coordinates of the corners of the rectangle that includes the entire RSA are 1°03'54N, 35°32'32E and 0°54'18"N, 35°39'45". The elevation ranges between 980m and 2590m.

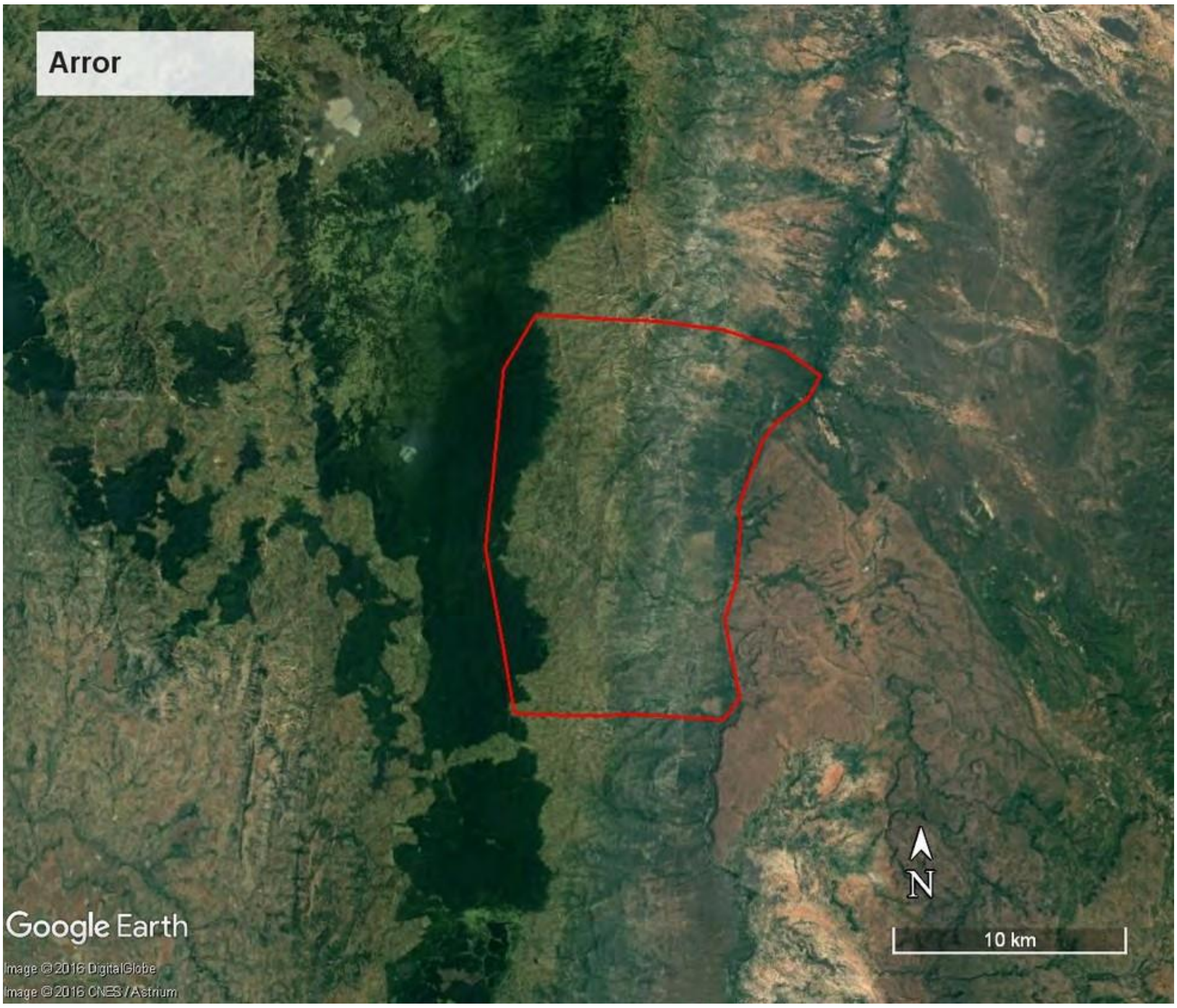


Fig.4.16: Arror Regional Study Area in Elgeyo Marakwet County, Kenya

4.3.2. General methodology adopted

After the identification of the RSA, the work proceeded through the following steps:

a) Identification of habitats polygons. This was done using the satellite images freely available through Google Earth (date of the images Feb 2015, pixel size approximately 1m). Polygons were drawn by hand on the satellite images to delimit the physiognomic types of habitat occurring in the RSA
b) Habitat classification. The hand-drawn polygons were then classified in types of vegetation matching the classification of White (1983), which is also the base for the map of the Potential Vegetation of Africa (World Agroforestry Centre & U Copenhagen 2017)
c) Identification of lists of potential fauna. The focus was on all the Vertebrates (Mammalia, Aves, Amphibia, Reptilia, Pisces). These lists were compiled extracting information from all the available printed and online literature (lists in the sections dealing with the different taxa) as well as from online databases of observations (www.inaturalist.org)
d) Identification of lists of Species of Conservation Concern (SCC). This was done by comparing the lists of potential fauna with the IUCN Red List database (IUCN, 2017) and by analyzing the published literature as listed in the relevant sections. According to IFC guidelines (IFC, 2012a,b), SCC are any of the following: *Globally-threatened species as defined by IUCN categories VU (Vulnerable), Endangered (EN) and CR (Critically Endangered); Nationally-threatened species that are protected according to National laws and agreements; restricted-range and endemic species, species that are protected according to National or International laws and agreements (e.g. species listed in the Bern, Bonn or CITES Conventions); congregatory and migratory species that might be using sites within the RSA; or species for which relevant national and international experts have identified the risk of extinction and suggested the inclusion in conservation mechanisms.*
e) Identification of Critical, Natural and Modified habitats based on the synthesis of the results obtained in the previous steps. In particular, following the IFC definitions (IFC, 2012a), Critical Habitats are defined as: *(i) habitat of significant importance to Critically Endangered and/or Endangered species; (ii) habitat of significant importance to endemic and/or restricted-range species; (iii) habitat supporting globally significant concentrations of migratory species and/or congregatory species; (iv) highly threatened and/or unique ecosystems; (v) areas associated with key evolutionary processes*

4.3.3. Vegetation in the Regional Study Area

Five vegetation macrohabitats were found inside the RSA (Table 4.21). The following paragraphs describe in detail their characteristics and biological importance.

i. **Forest.** The forest on the South-East side of the Cherangani is reported to be relatively dry, and dominated by Afrocarpus gracilior, Olea welwitschii, Euphorbia klotzschii and Juniperus procera in the canopy layer (which is usually 15-30m high), while the undergrowth has abundant cover of various herbaceous species of family Acanthaceae. The forests in the Cherangani hills have been heavily disturbed and impacted by human activities (Mabberley 1975). This vegetation falls inside the "Undifferentiated Afromontane Forest" vegetation type of White (1983).

ii. **Agricultural landscape.** Highly anthropized, Agricultural landscapes are the largest mapping units, which form altogether about 40% of the Arror RSA. This landscape includes a mixture of villages, cropped areas and remnant patches of natural and semi-natural vegetation, including highland grassland and evergreen bushland. In the RSA, Agricultural landscapes occur in two spatially separated areas, the first of which occupies a continuous belt between 2000 and 2400m, while the second is more discontinuous and runs along the River Kerio between approximately 1000 and 1200m elevation. The Agricultural Landscape, being highly modified by human activities, is difficult to characterize in terms of vegetation, but can be subsumed into mapping unit 17 (Cultivation and secondary grassland replacing upland montane forest) of White (1983).

iii. **Evergreen Bushland.** Evergreen Bushland forms a belt at intermediate altitudes surrounding the forests on most East African mountains. This vegetation includes several species of shrubs (Carissa edulis, Tarchonanthus camphoratus, Dodonaea viscosa, Euclea divinorum) and trees (Teclea simplicifolia, Euphorbia spp., Acacia spp., Croton spp.). The vegetation is mostly <8m high, with a canopy cover of less than 40% (White 1983). In the RSA, the evergreen bushland occurs in a belt located between 1150 and 2270m (based on the photointerpretation of Google satellite images). Evergreen Bushland shades into the Agricultural landscape at the higher edge, and towards the dry Acacia-Commiphora woodland/bushland at the lower elevations. Dense homogeneous bushland is included in White (1983) mapping unit number 38, while at the lower elevations, the mosaic of evergreen bushland and Acacia-Commiphora bushland falls into Withe (1983) mapping unit #45.

iv. **Acacia-Commiphora bushland.** This dry bushland (when 3-7m tall) and woodland (when >8m tall) mosaic runs as a more or less continuous belt fringing the Riverine vegetation around the Kerio river. At the highest edge, at altitudes ranging between 1200 and 1600m, Acacia- Commiphora vegetation shades into Evergreen Bushland. At the lowest edge (980-1100m), Acacia-Commiphora is cut by fingers of Riverine vegetation fringing the Arror river and other small tributary streams of River Kerio. In the River Kerio floodplain, some patches of Acacia- Commiphora have been cleared and transformed into cropped farms (mapped as Agricultural Landscape in Fig. 4.17). As the name implies, the flora of this vegetation unit is dominated by several species of Acacia and Commiphora. Acacia-Commiphora is included in unit 42 of White's (1983) classification of African vegetation.

v. **Riverine.** A belt of Riverine vegetation runs around the Kerio and its tributaries, including the Arror river. As the satellite images do not show enough detail to unequivocally distinguish Riverine from the adjoining types of vegetation, the extent of this vegetation mapped in Fig 4.17 must be considered relatively inaccurate. Moreover, as its elevation range is quite broad (980-2100m, Table 4.21a) is very likely that from a floristic point of view this vegetation does not form a homogeneous unit. However, only field work will allow to clarify this problem. The riverine belt includes the river itself, and the trees growing on its banks. These include characteristic species such as Acacia albida, A. sieberiana, A. elatior, Ficus sur and Lecaniodiscus fraxinifolius (Davies & Vercourt, 1998).

Table 4.21a: List of the habitats of Arror RSA.

Name	White (1983)	WAC (2017)	Elevation range (m)	Size (ha)	IFC Classification
Forest	19a (Undifferentiated Afromontane forest)	Fb	2250-2590	2,289	Natural
Agricultural landscape	17 (Cultivation and secondary grassland replacing upland montane forest)	Not mapped	1020-2410	7,431	Modified
Evergreen bushland	38 (East African Evergreen and semi-evergreen bushland and thicket)	Be	1150-2270	2,811	Natural
Acacia-Commiphora bushland	42 (*Acacia-Commiphora* deciduous bushland and thicket)	Wdk	980-1570	4,766	Natural
Riverine	Not mapped	R	980-2100	1,290	Critical?
Total			**980-2590**	**18,587**	

White (1983) reports the codes used in White's "Vegetation of Africa" manual, while WAC (2017) lists the codes used on the online resource vegetationmap4africa.org

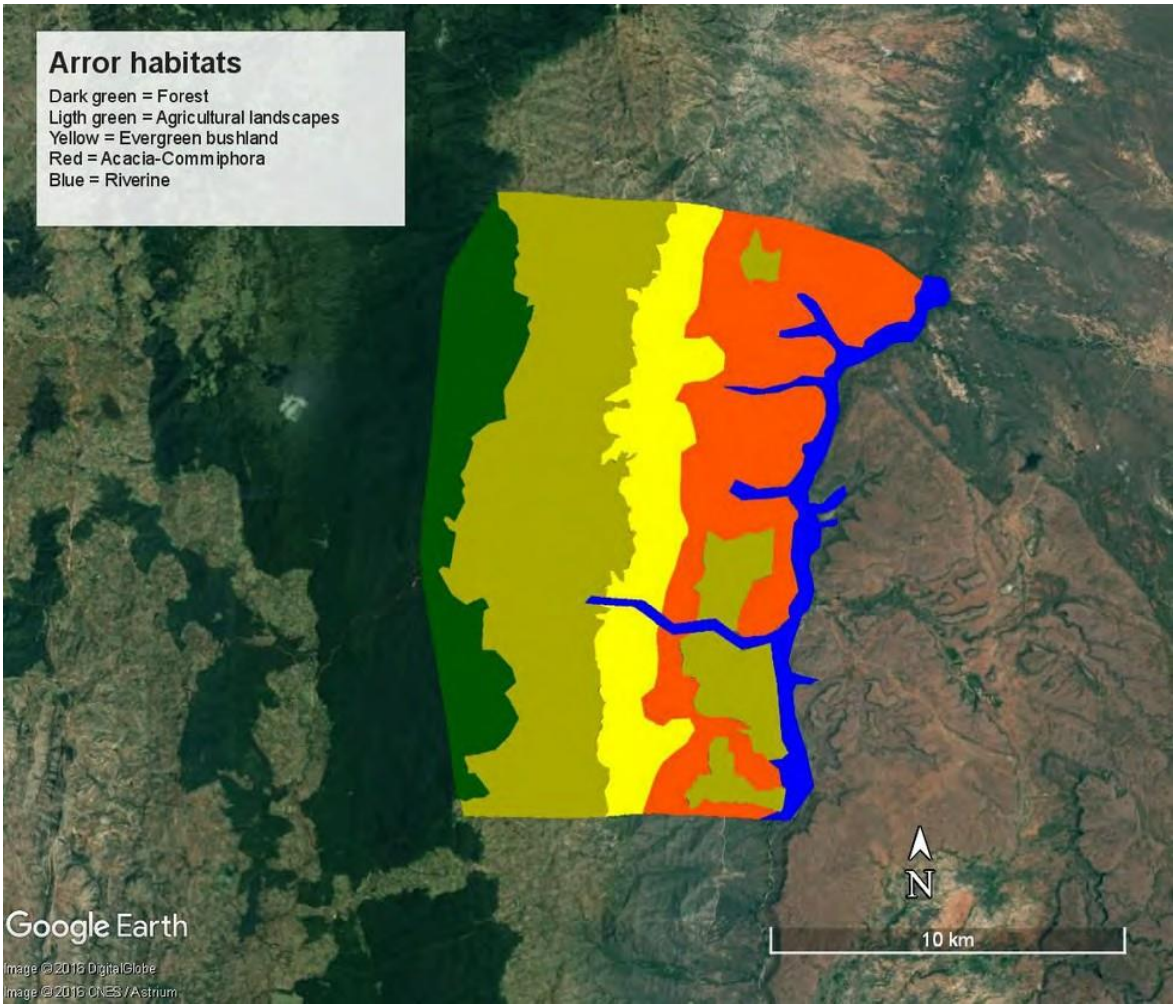


Fig 4.17: Vegetation map of the RSA based on the interpretation of Google Earth images

4.3.4. Fauna of the Area of Interest

The analysis of published literature and online databases showed that the RSA has a potential fauna of 708 Vertebrate species. These include 19 Red-listed species (5 CR, 5 EN, 6 VU and 3 DD) and 10 Kenyan endemics.

The five macrohabitats of the RSA also host different levels of vertebrate species richness. Riverine habitats are the most species rich (443 potentially occurring species), while Acacia- Commiphora, Evergreen Bushland and Agricultural Landscapes have similar (respectively 343, 363 and 378 species), but slightly lower richness than Riverine habitats. Forest has a markedly lower richness (246 species) than all the other habitats.

a) Mammalia

The starting point for this analysis was the list of the Mammalian species of Kenya downloaded from the IUCN Red List database (IUCN, 2017). From here, the potential fauna of the RSA was assessed considering the distribution maps and ecological information provided in Kingdon (1988, 1997) and Kingdon et al. (2013).

The final list obtained includes 123 species (Appendix C). Three species are included in the IUCN Red List with Vulnerable (VU) status and four are considered Near Threatened; one CR subspecies might also occur in the RSA. No Kenyan endemic species occurs in the RSA, but the Mountain bongo (Tragelaphus eurycerus isaaci) is considered an endemic subspecies.

In terms of habitat use, the most biodiverse habitats are the Evergreen bushland (89 species), Riverine vegetation (86 species) and Acacia-Commiphora (85 species), while Agricultural landscapes (70 species) and Forest (50 species) have lower species richness.

The following paragraphs provide more detailed assessments focused on the Species of Conservation Concern only.

Leopard (Panthera pardus, IUCN = VU). The Leopard is classified in a relatively low IUCN Threat category, and the Arror RSA is not expected to hold a numerically large population, given that the average territory of this species is 9-60 km² (Kingdon 1997). On the other hand, it is likely that the realization of the Arror Dam project will significantly increase the intensity and range of human activities in the RSA, and therefore have an unavoidable negative impact on the Leopard territories that might be present in the RSA.

Ground pangolin (Smutsia temminckii, IUCN = VU). Despite being still widespread and relatively common in Sub-Saharan Africa, the Ground Pangolin has a decreasing population and an unfavorable population status due to the increasingly unsustainable levels of poaching to which it is subjected (Pietersen et al. 2014). It is likely that increased human presence in the RSA might have negative impact on the Groud pangolin, mainly through poaching, and secondarily through direct loss of habitat. These impacts could be mitigated through appropriate anti- poaching and conservation awareness programs in the RSA.

African elephant (Loxodonta africana, IUCN = VU). Due to heavy and increasing levels of poaching throughout Africa, the population of African elephant has rapidly decreased in recent years. A significant population of African elephant occurs along the river Kerio and it is known to seasonally migrate between the Kerio and Kamnarok (south of the RSA) and the South Turkana and Nasolot National Reserves (Thouless et al. 2008). The most recent estimate of this population yielded counts of 352 inds for Nasolot/South Turkana and of 311 for Kerio/Kamnarok (Thouless et al. 2016). Despite the fact that the direct, continued use of the RSA by Elephants is probably irregular, the RSA could be important as a biological migration corridor between the National Reserves listed above. Moreover, Elephant populations necessitate regular access to water, therefore, subtraction of water from River Kerio might threaten the persistence of this species in the entire South Turkana/Nasolot/Kerio/Kamwarer network of Protected areas. Since the Elephant population located in River Kerio area is regionally important, IFC (2012a) definition of Critical habitat could be triggered (iii) habitat supporting globally significant concentrations of congregatory species).

Mountain Bongo (Tragelaphus euryceros isaaci, IUCN = CR). This is a Kenyan endemic subspecies of a widespread species that lives in montane and lowland forests. Given the longtime of isolation between the Central African and Kenyan populations, T. e. isaaci might be considered a full species (IUCN SSC Antelope Specialist Group, 2008). There are reports of the presence of this mammal in the Cherangani hills forest (Kenneth et al 2014), and it would be important to clarify whether it occurs in the RSA.

b) Aves

The starting point for this analysis was the list of the Birds of Kenya maintained by the Ornithological Sub-committee of the East Africa Natural History Society (OS-C 2009). From here, the potential fauna of the RSA was assessed considering the distribution maps and ecological information provided in Lewis & Pomeroy (1989) and Zimmerman et al. (1996). The work of Wayaki (1996) was also consulted and yielded a considerable amount of additional information.

The final list obtained includes 463 species (Appendix D). Twelve species are classified as Threatened (3 VU, 5 EN, 4 CR) in the IUCN Red List, and an additional 7 species are Near-threatened. One Kenyan endemic species occurs in the RSA.

In terms of habitat use, the most biodiverse habitats are the Riverine vegetation (262 species) and Agricultural landscapes (258 species). Evergreen bushland has 207 species, Acacia-Commiphora 183 and Forest 170.

The following paragraphs give more detailed assessments focused on the Species of Conservation Concern only.

Secretary Bird (Sagittarius serpentarius, IUCN = VU). The Secretary bird has a broad distribution range in tropical Africa, but a rapidly decreasing population, mostly cause by habitat loss (BirdLife International, 2017). The Secretary bird inhabits grasslands and bushland habitats, and could occur in the RSA, but the number of birds that could be affected by the Arror project is low and probably not significant at the continental level.

Egyptian Vulture (Neophron percnopterus, IUCN = EN). The Egyptian vulture has a rapidly decreasing population trend across its entire (Afrotropical and Palaearctic) range (BirdLife International, 2017). This species could occasionally forage in the RSA, but certainly not breed as the colonies of this species are always located on rock faces and steep cliffs, which do not occur in the Arror RSA.

Hooded Vulture (Necrosyrtes monachus, IUCN = CR). This vulture has a broad Sub-Saharan range, but is undergoing extremely fast decline in recent years, mainly due to direct human persecution, poaching and poisoning (BirdLife International, 2017). It nests in trees and occurs in a broad range of habitats, thus it is likely to occur in the Arror RSA. Potential impacts of increased intensity of land use on this species should be assessed.

African White-backed Vulture (Gyps africanus, IUCN = CR). As all species of African vultures, even the White-backed has declined precipitously in recent decades, due to habitat loss, electrocution, direct persecution and indirect poisoning (BirdLife International, 2017). This species probably occurs in the RSA as a non-nesting, foraging visitor. Impacts caused by the Arror Project are probably of minor importance in global terms for this species.

Rüppell's Griffon Vulture (Gyps rueppellii, IUCN = CR). Rüppell's Griffon Vulture occurs only in Africa, in the Sahel and East African regions. It has decreased by about 97% in the last 50 years (BirdLife International, 2017). This species could occasionally forage in the RSA, but certainly not breed as the colonies of this species are located on rock faces and steep cliffs, which do not occur in the Arror RSA.

Lappet-faced Vulture (Torgos tracheliotus, IUCN = EN). As all the vultures, the Lappet-faced vulture has experienced a dramatic decrease in its African Range over the last 5 decades (BirdLife International, 2017). This species usually occurs in areas with large numbers of wildlife. It might occasionally occur in the RSA, but its presence could almost be discontinuous.

White-headed Vulture (Trigonoceps occipitalis, IUCN = CR). This vulture has both a small population (<10,000 mature hinds) and a rapidly declining population. It has disappeared from most of Kenya, where it used to be a widespread species up to few years ago (BirdLife International, 2017). The occurrence of White-headed vultures in the RSA as foraging visitor is possible, but likely not frequent.

Steppe Eagle (Aquila nipalensis, IUCN = EN). A Palaearctic migratory species that has been in a steep decline in recent years. This species could potentially occur in the RSA, but only in small numbers.

Martial Eagle (Polemaetus bellicosus, IUCN = VU). Martial eagle has declined significantly in numbers due to habitat loss, electrocution and direct persecution (BirdLife International, 2017). This species might occur occasionally as a foraging visitor in the RSA, but likely not in significant numbers.

Grey Crowned Crane (Balearica regulorum, IUCN = EN). The Grey Crowned Crane has declined by 65-79% in the last 20 years, due to habitat loss and poaching (BirdLife International 2017). This is a wetland bird, and is often observed in wet montane grasslands. In general, it shows a preference for short to medium height open grasslands adjacent to wetlands for foraging (BirdLife International 2017). There are several records of the species in the Uasin Gishu plateau and Cherangani hills area, and satellite images show that patches of montane grassland exist in the RSA. Thus, the Grey Crowned Crane is likely to occur inside the RSA. The Crowned Crane is a gregarious species, and is usually observed in flocks of 10-100 inds. The construction of the Arror dam might cause negative impacts to Crowned cranes, mainly due to loss and alteration of preferred habitats (montane grasslands at >2000m elevation). Field work would be necessary to further elucidate the presence of Crowned cranes in the RSA.

Southern Ground Hornbill (Bucorvus leadbeateri, IUCN = VU). This species is declining mainly due to habitat loss caused by clearance for agriculture, and also due to poaching and persecution. Collisions with powerlines may also be a threat. It inhabits woodland and savanna, also frequenting grassland adjoining patches of forest up to 3,000 m in parts of its range in eastern Africa. The Ground Hornbill is not likely to occur in significant numbers inside the RSA, but field work would be required to more precisely assess the presence of this species.

Sharpe's Longclaw (Macronyx sharpei, IUCN = EN). Sharpe's longclaw is endemic to the Kenyan highlands. It is a Restricted Range species (extent of occurrence 2500 km^2) with a global population of less than 15,000 mature individuals and decreasing population trend (BirdLife International 2016). The range of Sharpe's Longclaw includes the Uasin Gishu Plateau (Records from Eldoret, Kipkabus and Burnt Forest) and the Cherangani Hills (BirdLife International 2016). Sharpe's Longclaw has a very specialized ecology and is strictly dependent from highland grassland habitats during all the stages of its life cycle. The Arror RSA falls inside the potential range of Sharpe's longclaw, and the assessment of satellite images suggested that appropriate habitat (highland grassland >2000m elevation) might occur in the RSA, even though the size of potentially suitable grassland patches does not appear to be large (estimated 50ha from Feb 2015 Google Earth images). However, without specific field work it is impossible to precisely assess the (potential) presence and population of Sharpe's longclaw in the RSA of this report.

Jackson's Widowbird, (Euplectes jacksoni, IUCN = NT). Jackson's widowbird is a highland grassland specialist, with similar ecology to Sharpe's longclaw, but a significantly larger range, extending to Northern Tanzania (Birdlife International 2017). Part of the range of Jackson's widowbird is protected in National Parks (Serengeti), therefore the species has been assessed to be in a better conservation status than Sharpe's longclaw (NT versus EN respectively). There are no records of Jackson's Widowbird in the Arror RSA, but the area falls inside its potential range. Field work would be necessary to properly evaluate the status inside the Arror RSA.

c) Reptilia

The starting point for this analysis was the list of the Reptiles of East Africa published by Spawls et al (2002), which was also the source of most of the ecological information on these species. As only a minor proportion of the species of Reptiles have been evaluated under the IUCN criteria, the IUCN Red List database was of limited use in this study. Moreover, as the available information on the Kenya reptiles is scanty, the current list of potential species must be considered incomplete and preliminary.

The final list includes 67 potential species (Appendix E). One species is classified as Data Deficient (DD) in IUCN Red List, the remaining species are all in the Least Concern status. Four Kenyan endemic species occur in the RSA.

In terms of habitat use, the most biodiverse habitats are the Acacia-Commiphora bushland (51 species) and Riverine vegetation (50 species). Evergreen bushland has 42 species, while Agricultural landscapes (25 species) and Forest (8 species) have lower species richness.

The following paragraphs provide more detailed assessments focused on the Species of Conservation Concern only.

Nile crocodile (Crocodylus niloticus, IUCN = LC). The Nile crocodile has a broad distribution in Africa, and its global population is estimated to 250,000-500,000 individuals, with a slightly declining population trend (Autin, 2014). Despite the Lower Concern IUCN status, the Nile crocodile qualifies as SCC because the population of this species in River Kerio area has been estimated to above 10,000 individuals, but the lake has been damaged by recent droughts and non-sustainable use of resources by a growing human population (Koross, 2009; Kahare 2012). Alteration of the Kerio River flow could impact negatively on this large population of Nile crocodile, but impacts cannot be properly assessed without more precise information on the size of the Kerio river crocodile population. However, considering that the Crocodile population located in River Kerio is regionally important, IFC (2012a) definition of Critical habitat could be triggered (iii) habitat supporting globally significant concentrations of congregatory species)

Bayon's Skink (Trachylepis bayonii, IUCN = DD). Bayon's Skink is a poorly known species reported from few sites in Kenya, Congo and Tanzania (Menegon and Spawls, 2011). It is a montane grassland species and could potentially occur in the RSA. However, the impacts of the project will be small given the large range of this species.

Endemic species (Agama caudospinosa, Dasypeltis scabra, Lygodactylus keniensis, Bitis worthingtoni). Four endemic species potentially occur in the RSA, all of them have been evaluated against the IUCN criteria and are classified as Lower Concern.

d) Amphibia

The starting point for this analysis was the list of Amphibian species of Kenya downloaded from the IUCN Red List database (IUCN, 2017). From here, the potential fauna of the RSA was assessed considering the distribution maps and ecological information provided in Channing & Howell (2006) and IUCN Red List species factsheets (IUCN, 2017).

The final list obtained includes 35 species (Appendix F). All the species in the RSA have been assessed by IUCN and are currently categorized as Lower Concern (LC) status. Three Kenyan endemic species occur in the RSA.

In terms of habitat use, the most biodiverse habitats are the Evergreen bushland and Agricultural Landscapes (25 species each). Riverine vegetation and Acacia-Commiphora have 24 species each while Forest (19 species) has lower species richness.

The following paragraphs provide more detailed assessments focused on the Species of Conservation Concern (Kenya Endemics) only.

Mountain reed frog (Hyperolius montanus, IUCN = LC). Despite the favorable IUCN conservation status, this is considered an SCC because it is an endemic of the Kenyan highlands that could potentially occur in the Arror RSA. The impacts caused by the Arror Project on this species are assessed to be slight and mitigable because H. montanus is tolerant of human disturbance and often occurs in inhabited landscapes (IUCN SSC, 2013a).

Kenya river frog (Phrynobatrachus keniensis, IUCN = LC). The Kenya river frog is a restricted range Kenyan endemic with a global range of approx 19,000 km². Records of this species have been obtained in the Cherangani hill forest (IUCN SSC, 2015). It occurs in montane forest and forest edges, and it is usually abundant and tolerant of human disturbance in its range (IUCN SSC, 2015). The direct removal and increased disturbance of forest habitats caused by the Arror dam will cause inevitable negative effects on this species, but these are estimated to be slight as they will affect only a minor part of the species' range.

Molo Frog (Amietia wittei, IUCN = LC). A restricted range Kenyan endemic reported to occur in mountain massif of Kenya (Cherangani, Mt. Kenya, the Aberdare, Molo-Mau; global range size 11,184 km² (IUCN SSC, 2013c)). It occurs in montane grassland and low-intensity agricultural areas above 2000m and it is usually abundant and tolerant of human disturbance in its range (IUCN SSC, 2013c). The direct removal and increased disturbance of Agricultural landscapes caused by the Arror dam will cause inevitable negative effects on this species, but these are estimated to be slight as they will affect only a minor part of the species' range.

e) Pisces

The starting point for this analysis was the list of the freshwater fish species of Kenya downloaded from the online resource Fishbase (Froese & Pauli, 2016). From here, the potential fauna of the RSA was assessed considering the distribution maps and ecological information provided in Froese & Pauli (2016), Okeyo (2004) and Seegers et al (2003).

In general, it was found that the knowledge on the Kerio river fish fauna is very sparse. The final list obtained includes 21 potential species (Appendix H). Two species are included in the IUCN Red List with Data Deficient (DD). One specie is endemic to the upper Kerio River.

The following paragraphs provide more detailed assessments focused on the Species of Conservation Concern only.

Bottego's Minnow (Neobola bottegoi, IUCN = DD). This is an endemic species of Lake Turkana drainage basin; its DD status qualifies it as a potential Species of Conservation Concern. The presence of this species in the RSA has not been confirmed, but Seegers et al (2003) and Okeyo (2004) suggest that it might occur in river Kerio because Bottego's Minnow usually prefers riverine habitats. Icthyological field work will be necessary to properly assess the potential presence of N. bottegoi in the RSA.

Kerio suckermouth (Chiloglanis kerioensis, IUCN = DD). This recently described species is strictly endemic to the upper course of river Kerio (Schmidt et al., 2015). The IUCN lists C. kerioensis as Data Deficient, which means that it is suspected to be globally endangered (VU, EN or CR), but information on its biology is currently not sufficient to carry out an assessment. Only two records exist of C. kerioensis, both of them from river Kerio, just south of the RSA at 1060 and 1145m of elevation respectively. C. kerioensis was considered common where it was collected (Schmidt et al. 2015), but River Kerio is the only place where it occurs. The range of the species probably includes the entire course of river Kerio and of its tributaries inside the RSA (i.e. the entire extent of Riverine habitat in the RSA). For this reason, any alteration of the riverine habitat, through reduction of water flow, pollution, or physical disturbance, could seriously threaten the survival of this species. More detailed data from specifically focused field work are required to assess the threat posed by the Arror Hydropower Project to C. kerioensis.

4.3.5. Habitat classification (IFC Performance Standard 6)

According to the results of this preliminary assessment, both Natural, Modified and Critical habitats might exist in the Arror RSA. Table 4.21 and Figure 4.18 show the preliminary classification based on the results of this desktop assessment. Field work will be necessary to further clarify this preliminary habitat classification, because accurate count data do not exist for most of the SSC occurring in the RAS.

More than half of the RSA (60% or 11,156ha, Table 4.21) is composed of Natural habitats. These include Afromontane Forest, Evergreen Bushland, Acacia-Commiphora bushland and Riverine formations.

Agricultural Landscapes are the only Modified habitat in the RSA. They are the largest single habitat category (40% of the RSA, 7,431 ha, Table 4.21).

The data reported in previous sections suggested that Critical habitat might also occur in the RSA. This is represented by Riverine Vegetation. The factors that could possibly cause unavoidable, non-mitigable effects (thus triggering the Critical habitat status) are the following:

- ✓ the RSA might represent a migration corridor for a nationally-important population of African elephants (662 individuals or 2% of an estimated c31,000 inds at the Kenyan level (Thouless et al, 2016)). This might trigger IFC (2012a) Critical Habitat tier 2 criterion 3 (habitat supporting globally significant concentrations of migratory species and/or congregatory species)
- ✓ the population of Nile Crocodile of River Kerio is large (>10,000 inds?) and significant at the continental level (total estimates for Nile crocodile in Africa 250,000-500,000 inds (Autin, 2014)). This might trigger IFC (2012a) Critical Habitat tier 2 according to IFC criterion 3 (habitat supporting globally significant concentrations of migratory species and/or congregatory species)
- ✓ one narrowly endemic fish (Chiloglanis kerioensis) is reported to occur in River Kerio just south of the RSA and might also occur in the project RSA. This might trigger IFC (2012a) Critical Habitat criterion 2 (habitat of significant importance to endemic species). Since the available evidence suggests that Chiloglanis kerioensis only occurs in the upper course of river Kerio, the presence of this species is of particular concern, because it could potentially trigger the definition of Tier 1 Critical Habitat (IFC, 2012b) in this case

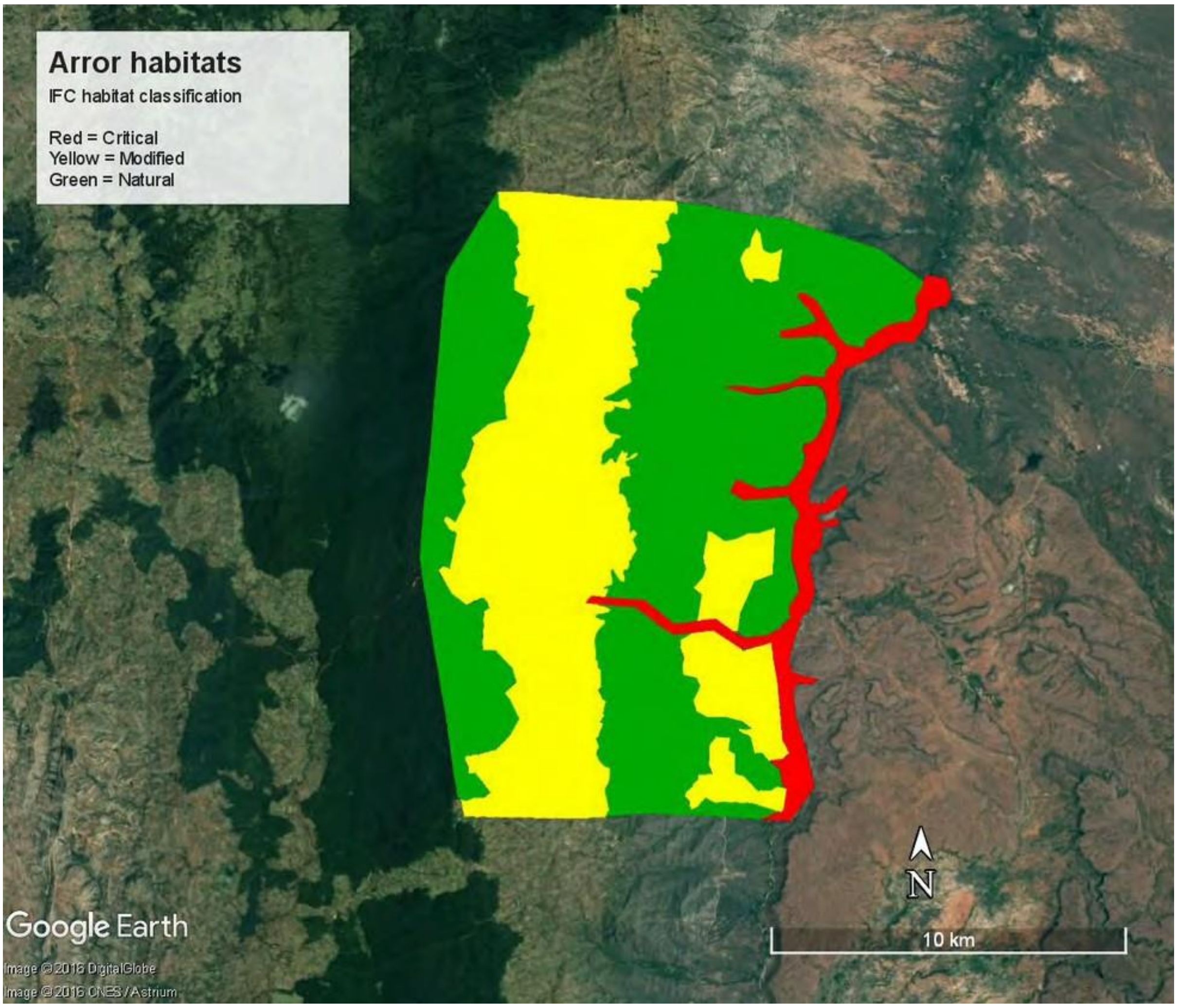


Fig 4.18. Habitat classification according to IFC (2012a) criteria

4.3.6. Conclusions and action plan

This assessment showed that some critical elements could potentially occur in the Arror Project RSA.

In particular, critical aspect might include the alteration of Riverine habitats, and disturbance to various species of Mammals, Birds and Fish. Moreover, 3 Protected Areas (South Turkana, Kerio river and Kamnarok National Reserves) occur along the River Kerio, and the wildlife of these Protected areas could depend on River Kerio (Fig 4.19). It is important to assess how the project could affect these protected areas. Impact could be generated through wildlife migration routes, reduction of water flow in the river, and through increased levels of eutrophication due to expanded agricultural uses in the proposed Arror irrigation scheme.

In all cases, this assessment could not accurately determine the impacts of the project on the species and habitats, because the available information is not sufficiently detailed.

Fig 4.19. Setting of the RSA (in red), showing the Protected Areas (in yellow: South Turkana NP, Kerio Valley and Kamnarok National Reserves) located along River Kerio

Proposed timetable

The proposed timetable (March-December 2017) is shown in Table 4.21b. For each Fauna and Flora group, a wet season and a Dry season survey is scheduled. These are highlighted as "W" and "D" respectively in Table 4.21b.

For each group, a preliminary (Interim) report and a Definitive report are also scheduled.

Specimen determination, data entering and report writing are all subsumed in the "reporting" lines of Table 4.21b.

The final, harmonized report for all groups will be submitted by 31st Dec 2017.

Table 4.21b. Proposed Work Timetable. For each month of 2017 "I" and "II" refer to the first and the last two weeks of the month respectively.

W = Wet
Season Field
work D = Dry
Season field
work IN =
Interim reports
DE = Final Reports

Fortnight intervals (2017)	Mar II	Apr I	Apr II	May I	May II May II	Jun I	Jun II	Jul I	Jul II	Aug I	Aug II	Sept I	Sept II	Oct I	Oct II	Nov I	Nov II	Dec I	Dec II
Plants desktop assessment	x	x																	
Plants field work		d	d			w	w	w	w										
Plants reporting				IN						DE									
Mammals field			w	w	w							d	d	d	d				
work Mammals						IN										DE			
Birds field			w	w	w							d	d	d	d				
work Birds						IN										DE			
Herpetofauna field			w	w	w							d	d	d	d				
work Herpetofauna						IN										DE			
Fish field work			w	w	w							d	d	d	d				
Fish reporting						IN										DE			
Benthic invertebrates field work			w	w	w							d	d	d	d				
Benthic invertebrates reporting																DE			
Synthesis & harmonization of the data							IN	IN									DE	DE	DE

4.4 Socio-economic environment

There is a growing concern that projects of all types (from large dams to the small rural development NGOs), are efficiently conducted, do not disadvantage local people, and do not generate negative social and environmental impacts. Over the past several decades, there have been heated debates over the pros and cons of constructing large dams. Beyond the physical and ecological impacts associated with dam and hydropower projects, such debates also focus on the administrative decision making process, the inclusion of relevant stakeholders, the relocation and resettlement of displaced inhabitants, and the disruption of social, cultural and economic life in communities affected by dam construction.

Therefore, the objective of this part of the study is to identify the present status of social, economic and cultural characteristics of the study area to evaluate and predict the effects and consequences of the project on local community.

4.4.1. Methodology

To social study, the following steps are done:

- Identifying the study area on the administrative boundaries map according to main components of the project
- Preparation a social questionnaire based on the social-economic and cultural status of the study area (social questionnaire is given in Annex E)
- Field visits and observations
- Interview with inhabitants and filling out questionnaire in order to data gathering, making people aware of the project and getting public opinion
- Data gathering, review of study records and existing related reports
- Enquiry of data and statistics from related organizations (such as National Bureau of Statistics)
- Holding meetings with local officials, plan review and discussion about related local social issues
- Classification of gathered data from different sources and make it conform with the study area boundaries
- Analysis of classified information
- Reporting

The demographic data reported in this section are according to the national census-2009; therefore, constitute sound basis for planning purposes.

4.4.2. Administrative and Political Divisions

The Republic of Kenya is a country in East Africa. Lying along the Indian Ocean to its southeast and at the equator, it is bordered by Somalia to the northeast, Ethiopia to the north, Sudan to the northwest, Uganda to the west and Tanzania to the south. Lake Victoria is situated to the southwest, and is shared with Uganda and Tanzania.

The capital of Kenya is Nairobi. In the eastern African region, Nairobi has maximum population. The city is also the center for culture and business.

Kenya was formerly divided into eight provinces during feasibility study namely Central, Coast, Eastern, Nairobi, North eastern, Nyanza, Rift Valley and Western. Currently, the country is subdivided into 46 counties after the promulgation of the constitution of Kenya 2010 as devolved units.

Project area is located in Marakwet sub-county which is situated in Elgeyo-Marakwet County. Administrative boundary of the study area is shown in the Map 4.10. Elgeyo – Marakwet county borders these counties: Baringo to the east, Uasin-gishu to the South, Trans nzoia to the West and West pokot to the north. Marakwet sub-county is divided into 7 administrative divisions namely Chebiemit, Kapsowar, Tunyo, Kapcherop, Kapyego, Tirap and Tot.

The Marakwet sub-county has a population of 187,123. Local people are predominantly of the Marakwet tribe. The sub-county was created in 1927 as *Elgeyo/Marakwet District*. It was split into Marakwet and Keiyo Districts in 1994.

The administrative town of Marakwet sub-county is Kapsowar. It is the nearest town to the Arror Dam site. The town is located between the Kerio Valley and the Cherangani Hills and sits at an elevation of 2,300 meters.

4.4.3. Population and Demographics

The 2009 Kenya Population and Housing Census indicate that Marakwet sub-county has a total population of 187,123 composed of 92,889 men and 94,234 women. The sub-county has 39,497 households and an average household size of 5 persons. The Table 4.22 presents population and demographic features of Marakwet sub-county.

Fig. 4.20: Kapsowar in Marakwet sub-county- nearest town to the dam site

Table 4.22: Population Distribution and Demographic information of Marakwet sub-county (Census 2009)

	Male	Female	Total	Households	Area (Km ^{2})	Average Household Size	Population Density (Person/Km^2)
Total	92,889	94,234	187,123	39,497	1588.9	5	118
Rural	89,136	90,322	179,458	37,581	1583.9	5	113
Urban	3,753	3,912	7,665	1,916	5	4	1521

Ref: Kenya Population and Housing Census, Volume IV, 2010.

The average population density in Marakwet sub-county, based on (KNBC), is about 118 Persons per Km^2. According to above table, household size in the rural areas of the county is more than urban areas.

Arror dam site is situated in Kapsowar and Tirap Divisions of Marakwet sub-county. Four (4) Locations and 10 Sub-locations are affected by the proposed dam project area. Proposed area for irrigation in Kerio Valley is situated in Tunyo Division of Marakwet sub-county. Almost 4 Locations and 12 Sub-locations are affected by the proposed project in this division (Tables 4.23 and 4.24).

Table 4.23: Population Distribution and Demographic information of the Dam Project Area (Census 2009)

		Male	Female	Total	Household	Area (Km^2)	Population Density (Person/Km^2)
Location	KAPSOWAR	6,102	6,447	12,549	2,616	57.4	218
Sub- Location	KAPSUMAI	2,876	3,046	5,922	1,108	28.2	210
	KAPSOWAR	3,226	3,401	6,627	1,508	29.2	227
Location	KIPSAIYA	2,817	2,862	5,679	1,145	30.3	188
Sub-	SISIYA	1,424	1,497	2,921	613	13.3	219

Location	KIPSAIYA	1,393	1,365	2,758	532	16.9	163
KAPSOWAR (DIVISION)		8,919	9,309	18,228	3,761	87.7	208
Location	KOIBATEK	2,349	2,510	4,859	1,044	18.8	258
Sub-Location	MAINA	793	849	1,642	349	6.5	252
	METIPSOO	605	662	1,267	278	7.7	165
	NYIRAR	951	999	1,950	417	4.6	424
Location	SAMBIRIR	2,752	3,034	5,786	1,266	14.8	391
Sub-Location	CHESOI	885	914	1,799	437	6.5	275
	CHEMWOROR	1337	1470	2,807	579	4.4	636
	KAPKUTO	530	650	1180	250	3.8	307
TIRAP	(DIVISION)	5,101	5,544	10,645	2,310	33.6	317
	Total	14020	14853	28873	6071	121.3	238

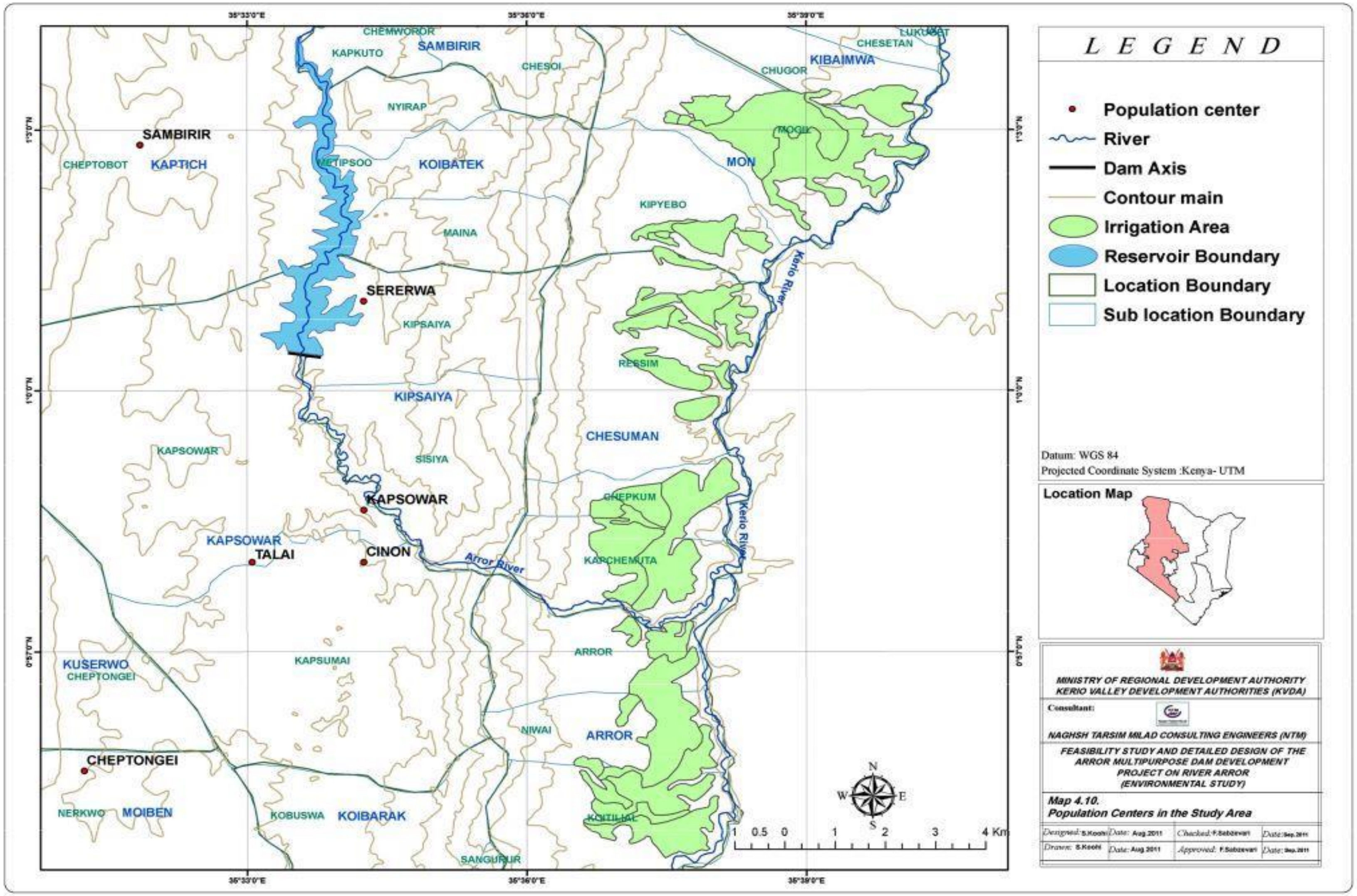
Ref: National Bureau of Statistics, Kenya Population and Housing Census, Volume IV, 2010.

Table 4.24: Population Distribution and Demographic information of Irrigation Area - Census 2009

		Male	Female	Total	Households	Area (Km)	Population Density (Person/Km^2)
Location	MON	1,519	1,512	3,031	757	25.6	119
Sub-Location	MOGIL	808	797	1,605	384	16	100
	KIPYEBO	711	715	1,426	373	9.5	150
Location	ARROR	1,827	1,880	3,707	896	47.2	79
Sub-Location	ARROR	901	971	1,872	415	8.8	214
	NIWAI	375	387	762	174	7	109
	KOITILAL	551	522	1,073	307	31.4	34
Location	CHEMSUMAN	1,366	1,415	2,781	701	31.4	89
Sub-Location	RESIM	491	540	1,031	269	18.4	56
	CHEPKOM	261	246	507	141	4.8	106
	KAPCHEMUTA	614	626	1,243	291	8.2	151
Location	KIBAIMWA	1,916	2,070	3,986	900	29.5	135
Sub-Location	KOMBASES	457	505	962	220	5.5	176
	LUKUGET	531	582	1,113	266	10.3	108
	CHUGOR	397	401	798	178	7.3	110
	CHE[SATAN	531	582	1,113	236	6.4	173
TUNYO (DIVISION)		6,628	6,877	13,505	3,254	133.6	101

Ref: National Bureau of Statistics, Kenya Population and Housing Census, Volume IV, 2010.

Based on the above tables, population density in dam site area with 238 person/Km^2 is more than irrigation area with 101 person/Km^2 in Tunyo division.



Map 4.10.
Population Centers in the Study Area

Table 4.25 shows the trends in average annual population growth rates from year 1969 to 2009. At national level, the growth rate increased marginally from 2.9 to 3 percent annually in the last decade. In the 1999-2009 period, population growth rates in all the former provinces except Rift Valley have reduced.

Table 4.25: Average annual population growth rates of former provinces in Kenya (Census 2009)

Regions/former provinces	1969-1979	1979-1989	1989- 1999	1999-2009
Kenya	3.4	3.4	2.9	3
Nairobi	4.9	4.7	4.8	3.8
Central	3.4	2.8	1.8	1.6
Coast	3.5	3.1	3.1	2.9
Eastern	3.6	3.3	2.1	2
North Eastern	4.2	-0.1	9.5	8.8
Nyanza	2.2	2.8	2.3	2.1
Rift Valley	3.8	4.2	3.4	3.6
Western	3.8	3.4	2.8	2.5

Ref: National Bureau of Statistics, Kenya Population and Housing Census, Volume IV, 2010.

The Kenya National Bureau of Statistics (KNBS) population projections estimates for Marakwet sub-county was about 48% of the population in 2009, under 15 years of age and that about 5.8% above 59 years of age.

Review of age diagrams shows that population of Marakwet sub-county is younger than the country (Table 4.26). With regard to high young population of the sub-county, population of active (but unemployed) people is likely to increase in future and there is also a potential of the area for agricultural development. The implementation of proposed project especially water dam and irrigation sub projects are welcomed by public.

Table 4.26: Age characteristics in Kenya and Marakwet sub-county (Census 2009)

Age group	Kenya		Marakwet Sub-county	
	Population	Percent	Population	Percent
0-15	16,571,877	42.92	89,832	48.01
15-59	20,091,083	52.04	86,290	46.11
>59	1,926,051	4.99	10,937	5.85
No state	21,086	0.05	64	0.03
Total	38,610,097	100	187,123	100

Ref: National Bureau of Statistics, Kenya Population and Housing Census, Volume IV, 2010.

4.4.4. Literacy Level

Review of literacy level in the study area shows that literacy level in Marakwet sub-county is more than 83%; meanwhile it is 80.8% throughout the Country. In other words, educated population in the sub-county is more than the Country. Also according to statistics, literacy level between men is more than women in all sub-county and Country (Table 4.27).

Table 4.27: Population Aged 3 Years and Above by Sex, School Attendance Status (Census 2009)

		At school	%	Left school	%	Never attended	%	Not started	%	Total
	Total	14113292	40.2	14232843	40.6	6058419	17.3	680997	1.9	35085551
KENYA	Male	7289988	41.9	7074964	40.6	2658926	15.3	387334	2.2	17411212
	Female	6823304	38.6	7157879	40.5	3399493	19.2	293663	1.7	17674339
	Total	3648710	40.3	3233878	35.7	1982132	21.9	181729	2	9046449
MARAKWET	Male	41643	50.1	29164	35.1	10309	12.4	1987	2.4	83103
	Female	39434	46.6	29400	34.7	13942	16.5	1903	2.2	84679

Ref: National Bureau of Statistics, Kenya Population and Housing Census, Volume II, 2010.

4.4.5. Employment

The available workforces in each area are the individuals that are considered part of the active population from the viewpoint of age group and or economic situation, but they are currently unemployed. Thus in order to determine the number and or percentage of workforce at each area, the unemployment rate of the area could be used.

In accordance with the theory definition, the number for employment is the relation of number of employed individuals to the 5-year or more population, but since some of the age groups over 5 years form a high population are in school and are not eligible for employment and or some have income without working and are not looking for work, in order to determine the real rate of employment, usually the proportion of employed individuals over the active population is calculated. Thus the students, housewives, etc. that are considered inactive are not taken into account and or are not considered unemployed, so the real rate of employment is obtained. Determination of the unemployment rate is done on this basis. It means that the percentage of unemployed population over the active population gives the unemployment rate.

In order to determine the ready workforce in the proposed project area, the results of the census-2009 (Kenya National Bureau Census) has been used (Table 4.28).

Table 4.28: Unemployment Rate in Kenya and Marakwet Sub County (Census 2009)

		Sex	Total	Employed	Seeking Work	Economically Inactive	Unemployment Rate
Total	KENYA	Total	32,478,570	15,786,331	2,186,882	14,505,357	12.17
		Male	16,052,205	8,406,866	1,160,959	6,484,380	12.13
		Female	16,426,365	7,379,465	1,025,923	8,020,977	12.21
	MARAKWET SUB-COUNTY	Total	154,411	82,094	7,530	64,787	8.40
		Male	76,434	42,162	4,427	29,845	9.50
		Female	77,977	39,932	3,103	34,942	7.21
Urban	KENYA	Total	21,870,367	10,779,500	1,337,579	9,753,288	11.04
		Male	10,752,145	5,538,333	740,428	4,473,384	11.79
		Female	11,118,222	5,248,167	597,151	5,279,904	10.22
	MARAKWET SUB-COUNTY	Total	148,214	79,391	7,121	61,702	8.23
		Male	73,418	40,667	4,210	28,537	9.38
		Female	74,796	38,724	2,911	33,161	6.99

		Sex	Total	Employed	Seeking Work	Economically Inactive	Unemployment Rate
Rural	KENYA	Total	10,608,203	5,006,831	849,303	4,752,069	14.5
		Male	5,300,060	2,868,533	420,531	2,010,996	12.79
		Female	5,308,143	2,138,298	428,772	2,741,073	16.7
	MARAKWET SUB-COUNTY	Total	6,197	2,703	409	3,085	13.14
		Male	3,016	1,495	217	1,304	12.68
		Female	3,181	1,208	192	1,781	13.71

Ref: National Bureau of Statistics, Kenya Population and Housing Census, Volume II, 2010.

In general, employment status in rural areas of the country with 14.5% unemployment rate is faced to more problems comparing to urban areas with 11% unemployment rate.

According to above table, unemployment rate in total Marakwet sub-county is 8.4 %. Unemployment rate in rural areas of the sub-county with 13.14% is worse than urban areas. Statistics shows that employment status in Marakwet (both in rural and urban areas) with a lesser unemployment rate is better than Kenya as a country.

The important point is that the employment status between women of urban areas of Marakwet Sub County is better than Kenya as a country, so that it has the least unemployment rate. Seeing many women vendors in towns is a confirmation on this.

In rural areas, women's participation in active economic production is minimal, in spite of having more responsibilities in both domestic and community activities.

Fig. 4.21: Women vendors selling fruits beside Chepkum- Iten Road

Fig. 4.22: Different types of fruits produced in orchards of Kerio valley and surroundings

4.4.6. Infra-structure

Insufficient infrastructure such as access roads, electricity, Safe drinking water, telecommunication increases production and distribution costs.

Generally, roads even asphalt and main roads between towns in Kenya are not in good conditions. The Eldoret-Kapsowar Road (access road to dam site area) is partly asphalted, it is a murram road and in a bad condition for a long distance (half an hour on asphalted road and one hour and a half on murram road).

To access the irrigation area, the way is Eldoret-Iten Road that is an asphalted road in good condition with spectacular viewpoints, but after the crossroad to get Chepkum and irrigation area in Kerio Valley, there is a long murram road in a very bad condition.

Poverty in Marakwet sub-county is manifested in terms of poor access to health care services due to the high cost of medical services and inaccessibility of health facilities which arise from poor roads.

Poverty also manifests itself in the inability of the local people to obtain safe drinking water. Pipelined water only is available in Kapsowar supplying from upper lakes. Likewise, inhabitants of Kerio plain utilize river water as drinking water directly without any treatment. Lack of safe and healthy drinking water is considered as other deficiencies in the study area (both in dam site and irrigation area).

The Marakwet sub-county also experiences low food production due to the under-developed agricultural sector, wildlife menace, lack of land security, the high cost of education and inadequately staffed and poorly equipped schools.

Only some villages such as Resim, Chepkum, Kapchemuta are connected to electricity network. Lack of electricity has imposed heavy damages on natural resources. It has happened through usage wood and fossil fuel to supply heat and light.

It seems there are enough primary, secondary and high schools in study area (both in dam site and irrigation area), however they have no sufficient education equipment and or adequate teachers.

Health facilities in Marakwet Sub County are inadequate especially in the rural areas. Also as a result of high poverty levels, women are discouraged from visiting the facilities due to fee charges. In the study area and nearby divisions, health facilities including hospitals, health centers and dispensaries have been established in Tot, Chesoi, Arror, Chestum and Kapsowar.

Based on the field visits in the year 2010, all regions in the study area are covered by the cell phone network.

It must be taken into consideration that the implementation of the project (dam and power plant scheme, irrigation scheme and related activities) and or other projects in Kapsowar and Kerio valley will bring infrastructure and facilities, job opportunities and a more open and market oriented economy which will eventually lead to an increase in the standard of life.

This will provide an incentive for local people to remain in the native land and it can be a reason that the annual growth rate will increase progressively.

4.4.7. Economic Activities

The major activities and source of income within the Marakwet sub county is farming (mostly maize and in next priorities beans, peas, …) as well as orchards (mostly mango, papaya, passion, banana, citrus, tomato), livestock keeping and traditional beekeeping.

Farming maize in dam site is in priority; meanwhile planting mango is accounted as most common job in Kerio Valley.

Agriculture, gardening and beekeeping are the main sources of income in Kerio Plain. Fishing is occasionally observed in upstream and downstream reservoir area and also in Kerio River that has potential to develop in future. Some people in lower Kapsowar make livelihood partially through wood selling.

4.4.8. Migration

Survey on migration (immigration of people to the study area and emigration of local people to out of the study area) as a major effective factor on the demographic changes in the study area is essential.

Based on the interviews with local people, residents of Chepkum and Resim are willing to migrate to towns such as Kapsowar and Eldoret due to low income and severe life condition. Also, inhabitants of Kapsowar tend to migrate to Trans nzoia and people of Keiyo are willing to migrate to Kitale and Iten. However, residents of Simbirir do not like to abandon their settlements, due to beekeeping and wood selling as a source of livelihood.

Generally, main reasons of migration in the study area include: unemployment, low income, lack of infrastructure, shortage of health facilities and lack of security.

In case of implementation of development plans such as Arror Dam and irrigation network, willingness of residents, especially youth, to migrate to urban areas decrease because of improvement in infrastructure, availability of safe water for drinking & agriculture and new job opportunities.

4.4.9. Language and Religion

Inhabitants of the proposed project area are the Marakwet a segment of the kalenjin ethnic cluster, sections being the elgeyo, pokot, kipsigis, sabot, Jugen, Nandi and Terik all these segments have a common lexical root but each of them developed an individual language. As far as the territorially based social units are concerned, the Marakwet are in divided into 7 sections, two of which are found in Arror and Mon Locations, namely Almo and Markweta each section is organized in clans.

The Kalenjin are called Highland Nilotes because they live in the Highlands of the Rift Valley and are related to the people in the Nile area of Sudan and Uganda.

73 percent of Kenyan people are Christian, 19 percent are Animist and 6 percent are Moslem. Official languages in Kenya are English and Swahili.

According to field study and filling out questionnaire, the religion of majority of people in the study area is Christian and official languages follow the country. Academic language in schools is English, whereas national language is Swahili.

4.4.10.Health and Diseases

With regard to different climates in dam site and irrigation area, health and diseases issue is studied in 2 parts separately. Prevalence of diseases in Arror catchment area and dam site is low due to mountainous and cold weather, whereas statistics of diseases and people affected in Kerio valley is higher because of warm climate.

During construction phase of the project, a large number of workers will come and stay at the project area that could be effective on spreading and breaking-out diseases. On the other hand, implementation of dam and formation of the reservoir would increase the potential of incidence of waterborne diseases. Therefore, existing status of common diseases in the study area is studied. Since all the main components of the project are located in the Marakwet Sub County, the data on diseases in this sub-county is taken into consideration (Table 4.29).

Table 4.29: Top Ten Diseases in Marakwet sub-county-2010

No.	Diseases	Prevalence
1	Respiratory Diseases	67,093
2	Clinical Malaria	56,733
3	Diseases of the Skin	24,213
4	Diarrhoeal	18,135
5	Pneumonia	9,814
6	Accidents	7,832
7	Confirmed Malaria	4,635
8	Rheumatism	3,094
9	Typhoid	2,916
10	Dental	2,600

Ref: - District Health Information System (DHIS 2010) - Marakwet District.
District Health Plans (DHP 2009/2010)
District Statistics Office - Marakwet District

Since waterborne and contagious diseases are related to the project, are more important and should be under consideration (Table 4.30). Other diseases expected to rise by formation of the reservoir includes: Malaria, Bilarzhia and Diarroheal diseases.

Table 4.30: Waterborne and Contagious Diseases in Marakwet sub county-2010

No.	Water borne Diseases	Prevalence	Contagious Diseases	Prevalence
1	Dysentry	1,129	Measles	11
2	Typhoid	2,995	Chicken-Pox	1,703
3	Cholera	156	Tubercullosis	193

4	Amoebiasis	1,745	Mumps	178

Ref: - District Health Information System (DHIS 2010)- Marakwet District.
District Health Plans (DHP 2009/2010)
District Statistics Office - Marakwet District

4.4.11 . Medical and Health Facilities

The Kenyan health system is based upon three types of health facilities: hospitals, health centers and health sub centers. These sub centers are further subdivided into dispensaries and mobile clinics. National referral facilities at Kenyatta National Hospital in Nairobi and Moi Teaching and the Referral Hospital in Eldoret form the peak of a pyramidal health system structure. Level IV, and Sub county hospitals form the pyramid's middle tier and health centers and dispensaries form its base [Kimalu, 2004].

Kenya has over 5000 health care facilities in total. Public facilities, or those that are owned and operated by the government, make up approximately 41% of these. Private, for-profit facilities make up 44% of the facility total. The remaining 15% of facilities are non-profit; these include NGOs and Mission-based facilities [Kimalu, 2004]. Health facilities and population of Kapsowar, Tirap and Tunyo Divisions are given in Tables 4.31 to 4.33.

Table 4.31: Health Facility and Population in Kapsowar Division (Dam & Reservoir Area)

No.	Health Facility	Pop. 2010	Pop. 2011
1	Kipsaiya Disp.	2,758	2,828
2	Sisiya Disp.	2,921	2,997
3	Kapsowar Disp.	2,961	3,038
4	Aic Kapsowar Hosp.	6,627	6,799
5	Kaptoror Disp.	2,961	3,038
6	Matira Disp.	1,510	1,549
7	Kaptabuk Disp.	1,849	1,897
8	Sangurur Disp.	3,836	3,936
	Total	**25,423**	**26,084**

Ref: - District Health Information System (DHIS 2010) - Marakwet District.
District Health Plans (DHP 2009/2010)
District Statistics Office - Marakwet District

Table 4.32: Health Facility and Population in Tirap Division (Dam & Reservoir Area)

No.	Health Facility	Pop. 2010	Pop. 2011
1	Mugwa Disp	4,093	4,199
2	Maron-Marichor Disp	2,398	2,460
3	St. Michael Embobut Disp	2,626	2,694
4	Kamogo Disp	3,161	3,243
5	Kapchebau Disp	2,771	2,843
6	Chesiyo Disp	1,537	1,577
7	Tuturung Disp	1,604	1,646
8	Kimuren Disp	1,942	1,992
9	Chemworor Disp	2,807	2,880
10	Chesoi H/C	1,799	1,846

11	Chesoi Med.Clinic	1,180	1,210
12	Maina Disp	4,859	4,985
	Total	**30,777**	**31,577**

Ref: - District Health Information System (DHIS 2010)- Marakwet District.
District Health Plans (DHP 2009/2010)
District Statistics Office - Marakwet District

Table 4.33: Health Facility and Population in Tunyo Division (Irrigation Area)

No.	Health Facility	Pop. 2010	Pop. 2011
1	Kapkata Disp.	1,073	1,101
2	Arror H/C	2,634	2,702
3	Tunyo Disp.	2,781	2,853
4	Chesetan Disp.	3,986	4,090
5	Mogil H/C	3,031	3,110
	Total	**13,505**	**13,856**

Ref: - District Health Information System (DHIS 2010)- Marakwet District.
District Health Plans (DHP 2009/2010)
District Statistics Office - Marakwet District

Other important health issue is hygiene and healthy drinking water. The number of households by main source of drinking water is given in Table 4.34.

Table 4.34: Households by Main Source of Water

	Pond/ Dam	Lake	Stream	Spring/ Well/ Borehole	Piped into dwelling	Piped	Rain Harvested	Water Vendor	Other	Total
Marakwet	275	46	26748	4879	968	6454	34	31	26	39497
Rural	273	45	26657	4843	722	4966	34	16	25	37581
Urban	2	1	127	36	246	1488	-	15	1	1916

Ref: National Bureau of Statistics, "Statistical Abstract", 2009.

Above table shows that the most population centers in the study area are villages and rural areas.

Fig. 4.23: Stream as a source of drinking water

4.4.12. Tourism

With attention to many tourist attractions of Kenya, this country welcomes a large number of tourists (interested in ecotourism) every year. Kapsowar, Tirap and Tunyo Divisions in which study area is located, have prominent attractions due to specific natural geography, climatic characteristics, scenic and pristine landscapes.

After construction and water taking of the Arror Dam and formation of the reservoir, due to being located in mountainous forest and moderate climate, it can create an opportunity to develop tourism.

Other tourist attractions in the study area are as follows:

- A few viewpoints such as Kolol viewpoint as a tourist attraction site on the Iten-Tambach road made by Ministry of Tourism. There is a breath-taking and spectacular view of Kerio Valley from this point.
- The dirt road toward Tot along with Kerio Valley with forest and plain views at the same time.
- The bridge on the Kerio River (before its confluence with Arror River) is another scenic landscape by having Possibility of crocodile seeing.
- Arror waterfall that flows down through mountain and forest and finally reaches to Kerio River in the Kerio Valley.

Based on the above mentioned, regional planning for ecotourism such as establishment of equipped camps or residences for tourists and side required facilities, could create job for local people, furthermore cause income improvement, encouragement handicraft making and finally improvement of life standard.

4.4.13. Agriculture

The most common and important crops grown in the dam basin are maize and beans. These crops constitute the main staple food in the region. Other crops grown in the basin are pyrethrum, bananas, potatoes, sorghum, millet, vegetables, cassava, cotton and fruits. Due to sufficient rainfall, dry-farming or rain-dependent farming is common in the region.

The two main farming activities in the irrigation area are agriculture and livestock rearing. Crop production is mainly by irrigation. Farm size is remarkably uniform and averages 0.5- 0.8 ha per family. The farmers mainly grow banana, cassava, finger millet, maize and sorghum.

Ownership of land is by clan and under traditional law. The land allocation across the clans is not uniform; some clans have abundant land while others have very little arable land. The forefathers of the clan are the determining factor of the extent to which a particular clan own land. It is said that the families in the lineage of a hardworking patriarchs own more land than the rest. This goes with the founder applied in clearing of bushes and forests to make farm land. A family can however purchase land in another's clan area. Clan elders have supreme power in matters of land tenure and their decision cannot be superseded by the chief. The whole of the study area has a well-established land management system that will take care of the irrigation system.

Generally, categories of agricultural lands in Marakwet sub-county are given in the Table 4.35.

Table 4.35: Categories of Agricultural Lands -1995

	High Potential	Medium Potential	Low Potential	Total	All other Lands	Total Land Area
Marakwet sub county	104000	-	92000	196000	77000	273000

Ref: National Bureau of Statistics, "Statistical Abstract", 2009.

4.4.14 Animal Husbandry

Open pastures and Napier grass are found for animal production. Livestock population in Marakwet sub-county is given in the Table 4.36.

Table 4.36: Livestock Population by Type

	Cattle	Sheep	Goats	Camels	Donkeys	Pigs	Indigenous Chicken	Chicken Commercial	Bee Hives
Marakwet sub county	99,969	202,260	108,093	17	10,636	218	143,608	12,207	33,422

Ref: National Bureau of Statistics, "Statistical Abstract", 2009.

4.4.15 Forestry

Over 60% of the total basin area was under natural forests by 1960's (MDFAR, 2005). The forest resources in the basin are of great economic significance and can easily surpass that of any other resource in the basin. The forests are utilised both for commercial timber and as water catchment areas. In most of the forest areas, indigenous trees and bamboo are found. The predominant tree species are African pencil cedar, (juniperus procera), East African yellow wood (prodocarpus gracilior), rosewood and East African olive (olea Africana) (ibid). The forests are administered by Chesoi, Cheptongei and Cherangani forest stations (all located within the basin).

Fig. 4.24: Agricultural lands in Dam Reservoir

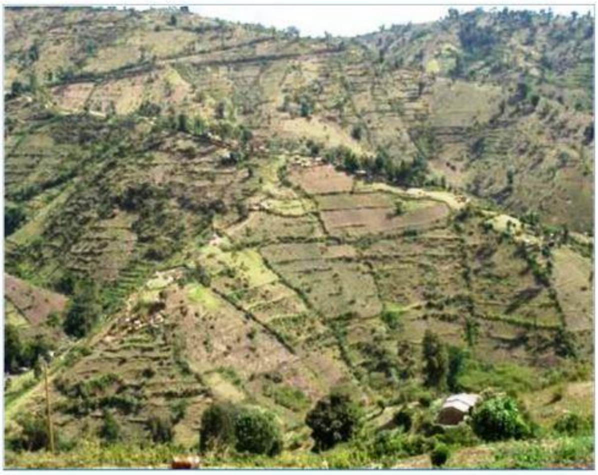


Fig. 4.25: Agricultural lands in downstream of Dam

4.4.16 Land use

In environmental study, land use maps through Arror River catchment area and Arror Dam reservoir have been prepared through Google Earth satellite images and scrutinized by field visits and finally checked with topography maps (scale 1:50000). Study of land uses in Arror River catchment area shows a vast destruction of forest areas and land use changes to cultivate and grassland. However, the largest area in the basin is still allocated to forest. The area of each land use is given in the Table 4.37.

Table 4.37: Land uses in Arror River Catchment Area

No.	Land use	Area (ha)
1	Cultivated Area	3,456
2	Forest	12,983
3	Grassland	1,121
4	Scrub	868
5	Woodland	1,156
6	Cultivated & Grassland	4,595
7	Woodland & Cultivated Area	2,124
8	Scattered Trees	1,310
9	**Total**	27,613

5. Public Consultation and Participation

5.1. Introduction

In accordance with the description of the United Nation Development Program (UNDP), close and direct involvement of people without a mediator in the social, cultural and political processes, which influence their life, is called public participation. With due attention to this matter, public participation in development plans is not restricted to draw their approval in the taking of possession of their lands, but comprises of all fields, such as policies and initial decision makings till the implementation. In other words, to gain the optimum results, in the execution of any development plan, the attraction of participation of the regional inhabitants is essential. Since the critical objective of development plans is the welfare of inhabitants, clarity and the expression of advantages and disadvantages of the development plan in order to absorption for participation in propulsion of the objectives is of extreme importance.

Public participation in all cases has numerous positive effects, of which the following can be indicated to:

- A better conformity of the project with the requirements and needs of the people,
- Conserving the social values under study in relative with the project impacts,
- Incrementing the awareness level, inclinations and the functions of the general public,
- Strengthening the cooperative spirit in people,
- Securing the required manpower for the project implementation,
- Facilitations and acceleration in the project implementation,
- Efforts and cooperation of the people in the maintenance and care of the implemented project.

Even though the assessment of the Arror Project can be of good standing and feasible, regardless of the views of the general public, but by acquiring their outlooks and participation, including that of the groups under influence, the investor and or the client of the project will be able to attain their support and eliminate the deficiencies and short comings of the project designing and be more successful. Hence, utilizing the views and outlooks of the local society, beneficial groups and those under influence of the plan, as well as public gatherings, NGO s of the region for the optimum leadership in EIA study is necessary. In other words, public participation is accounted, as being a critical part of the environmental assessment, utilized in several phases for the preparation of a report from its results.

Utilizing the views and outlooks of the general public by manipulating various scientific methods such as rendered hereunder:

- Information supply and rendering awareness to the local society as to the project implementation,

- Rendering a report of the operational time-table and procedures to the people and authorities by group medias,
- Attaining views of the local society, government organizations, NGO s, scientific and educational centers etc. in order to alleviate the activities and reduce the probable adverse impacts,
- The formation of regional planning committees with public participation or their representatives,

In order to utilize the views and facility potentials present, it is necessary to obtain sufficient information, from the beneficial groups under influence of the plan. This information must be channelled to specify and determine the beneficial groups and or those incurred with a loss because of the plan, recognition and determining the influenced groups and finally determining the number of the various groups prone to the impacts in the limits and location of the project implementation must be collected.

5.2 Stakeholder identification and analysis

The stakeholder identification and analysis has been considered during ESIA process. Just as the degree of stakeholder relevance may vary throughout the Project lifecycle, the most appropriate communication and consultation method also vary between stakeholders. Examples of communication and consultation methods used to date include:

i. *Focus group discussions*, whereby target groups are invited to come together to brainstorm and discuss various issues related to the project.

ii. *Public barazas* (i.e. public consultations), whereby the public is invited to attend a meeting to discuss key issues like project benefits, drawbacks and impacts as well as mitigation measures. During the public *barazas,* attendees are encouraged to ask questions, seek clarifications and raise grievances.

iii. *Consultative meetings* with institutions, e.g. county commissioner, schools, churches, women and youth groups. In these meetings, key issues like project benefits, drawbacks and impacts are discussed along with possible mitigation measures.

An analysis of Project stakeholders, interests, and suggested communication and consultation methods is summarised in table 5.1 below.

Table 5.1: Stakeholder identification and analysis

Stakeholder group	**Key stakeholders**	**Relevance to the proposed project**	**Communication & consultation channels**
I. Directly Affected Stakeholders			
Project Affected Persons (PAPs)	As of November 2016, there are 300 affected land owners.	Directly affected by the Project because of resettlement activities affecting land, structures and / or crops.	Communicated through the Local Administration Officers (i.e. chiefs and sub-chiefs) and through direct consultations, focus groups discussions and public barazas and direct discussions with PAPs.
Schools	- Hossen secondary school - Hossen primary school	The school will be affected by the proposed project	
II. Indirectly Affected Stakeholders			
People, groups, businesses, organisations and service providers (e.g. health care and education) located on land that is within the dam site, but not directly affected by resettlement activities (i.e. no loss of land,	The proposed project will affect the following locations: ✓ Kipsaiya ✓ Maina ✓ Arror	Interested in how the proposed project will affect them during its lifetime, in particular in regard to employment opportunities, economic opportunities, land acquisition impacts, health impacts and livelihoods.	Communicated through the Local Administration Officers (i.e. chiefs and sub-chiefs) and through direct consultations, focus groups discussions and public barazas and direct discussions with PAPs.

Stakeholder group	Key stakeholders	Relevance to the proposed project	Communication & consultation channels
structures or crops).			
III. Other Stakeholders			
Development Partners and Contractors	KVDA and CMC	The development partners for the Project will be interested in the project impacts and status, while contractors are the implementing agencies	Coordination meetings
Land Encumbrance overseeing body	NLC (National Land Commission)		Consultative Meetings
Relevant Kenyan Ministries	- Ministry of Energy and Petroleum; - The National Treasury; - Ministry of Land, Housing and Urban Development - Ministry of Agriculture; - Ministry of Environment and Natural Resources; - Ministry of devolution; - Ministry of water; - Ministry of Interior and Coordination of National Government		Consultative Meetings
Environment Regulating Bodies	- NEMA (National Environment Management Authority)	Interested in the project impacts and approves the ESIA.	
Emergency Service Providers	- Kapsowar Mission Hospital - Red Cross Ambulance Services	Need to be informed about the Project's progress and possible threats/safety hazards as they may play a crucial role in	

Stakeholder group	Key stakeholders	Relevance to the proposed project	Communication & consultation channels
		providing emergency services when required.	
Project employees and job seekers			
Employees and prospective employees (direct/indirect)	Construction, operation and decommissioning phase employees and prospective employees (direct/indirect)	Interested in employment opportunities throughout lifecycle of the Project, health and safety issues and in labour standards (including workers accommodation standards, if relevant).	To be communicated through the Local Administration Officers (i.e. chiefs and sub-chiefs) and through direct consultations, focus groups discussions and public barazas and direct discussions with PAPs.
Media	- Daily Nation Newspaper - Standard Newspaper - Star Newspaper - Citizen TV - NTV - KTN TV - K24 TV	Seeking updates on the project	Any communications will be through KVDA's Communications Department

5.3 View of the public concerning the project

In this prospect, awareness of the regional inhabitants is accomplished and taking their views into stock is performed. Based on the study, the types of probable social reactions, arising from the implementation of the project is surveyed.

In line with the EIA/EA regulations, face to face interviews with local people were accomplished. A wide range of people was selected to consult on the project that includes farmers, provincial administration, business people, health workers, youth, women, etc. Their views are assumed to represent those of the entire community that will be affected by the project. Already there is a cordial relationship between the community and the proponent. (*See appendix H for the minutes, list of attendance and photos*)

During the three scheduled consultative meetings (barazas) at Kapsaiya, Maina and Arror the leaders and affected persons raised some pertinent issues of concern which are hereby summarized.

1. Sensitization/Education of the community

There is the need for further consultations and sensitizations of the Marakwet community regarding many projects related issues like resettlements/compensations, extent of dam area as per the produced map(s) of dam sites, buffer zones and catchment area. It was agreed that KVDA and CMC Ravenna facilitate the professionals to conduct the exercise during this holiday period.

2. Approach of community Engagement

KVDA agreed to adopt a bottom up approach when undertaking the planning and implementation of projects. Men, women, youth, and persons with disabilities to be consulted at all stages of the project planning and implementation

3. Historical Injustices on Land Alienations and Displacement

Cases of land alienation in 1918 and 2013 were reported. Marakwet people were not compensated as promised. Marakwet people displaced during the 2007/2008 post-election violent were not resettled or compensated. Likewise, those displaced by construction of Chebara dam and Murung dam were not considered for compensation.

4. Cases of Murung Dam in West Pokot

Marakwet despite being the source of 86 streams and Pokot having 6 streams were not compensated. The issue must be revisited and resolved.

5. Engagements of professional in Dam Process

Marakwet professionals should be engaged in the dam process through participation and consultative meetings, area based local projects committees/CBOs. Their involvement is key to enabling the community be fully informed about the dam project process. This would minimize any propaganda of misinformation peddled by anti-projects activities. The professional should be from the four wards of Marakwet West and East sub counties namely: Kapyego, Sambirir, Kapsowar and Arror.

6. Organize Exposure Tour(s)

KVDA and county administrative personnel should organize educational trips to areas with successful dam projects like Ndakaini, Gatanga; Murang'a County.

7. Benefits of Dam to Community

Whereas the benefits of the multipurpose dam are known, the local community wants to be assured that they will get subsidised electricity supply, water supply to the dam area and escarpment residents. They also requested for employment opportunities of skilled and unskilled labour to the local people.

8. Corporate Social Responsibility

The local Marakwet community requested for CSR in terms of education scholarships/bursaries, provision of health and education facilities. Already Tullow, the oil prospecting company in the area has initiated and provided scholarships. The same is expected of the dam projects.

9. Land adjudication in Arror Ward

The entire land in Arror ward is communally owned. No individual land ownership was reported. The local community has called for expeditions land adjudications and issuance of title deeds to deserving individuals before compensation is affected. It was reported that some land grabbers could have obtained title deeds of the same land in order to benefit from Tullow oil exploration.

10. Supply of Irrigation Water to Arror during Dam Construction

The local people consulted expressed fear that there might be no water supply to the downstream water users during the five year period of dam construction. However, they were assured that this would not happen. In fact, water supply downstream is guaranteed by the contractor, CMC Ravenna.

11. Regulated Water Flow from Completed Dam

The local community of Arror ward were assured that the new dam when constructed will ensure constant water supply to downstream water users year round as opposed to intermittent flow as of now.

12. Compensation for Land in Arror Ward

The local community were assured that there would be no displacement of people by the dam project except for the area earmarked for the power house. However, there would be compensation for affected properties and way leave areas for the surface water pipelines where provided for.

The consultative meetings were held as follows:

Date	Day	Venue
7/12/2016	Wednesday	Kipsaiya location in Marakwet West Sub County
8/12/2016	Thursday	Maina Location in Marakwet East Sub County
9/12/2016	Friday	Arror location in Marakwet West Sub County

Attached in the annex are the minutes, attendance list, photos and the questionnaire used to collect the local community members' view on the project.

6: Analysis of Project Alternatives

Given the objectives of the Arror multipurpose dam, the results of the policy and legal framework and key issues identified in the field, two alternatives were selected for study.

6.1 Alternative 1: Do nothing option/zero alternative/business as usual

The “no action” or no project alternative would maintain the status quo of the situation in the Arror catchment. As such, the project proposed interventions would not be implemented. This alternative would thus result in (i) the ongoing scarcity of potable drinking water, (ii) little or no improvement in the low agricultural production of farms in the project area, the high poverty levels of catchment communities, and the social hardships endured by local populations. In fact, the social situations and environmental degradation can only become worse with rising populations, with continued unsustainable exploitation of the natural resources, making the poverty–environmental degradation cycle even more vicious.

Indeed, the project concept identifies poverty as the main cause of environmental degradation, which leads to even worse poverty levels in the long term. This makes the no project alternative both expensive and unacceptable to the local communities.

For these reasons, this alternative was rejected in favor of the proposed projects under the Arror Multipurpose dam project.

6.2 Alternative 2: Fully implement the Multipurpose project

The main goal of the project is to contribute to reduction of rural poverty in the project area through increased access to clean water supplies, sustainable food production and incomes for poor rural households and generation of clean energy (hydro-electricity) for local use and injection into the national Grid.

To meet the objectives, the following were taken into consideration. This ESIA process is happening after the geographical location of the dam had been determined and substantial work in the design process undertaken. However in order to make maximum use of the water stored, sub projects comprising of water supply and irrigation were conceptualized. The dam location influences the location of the sub projects conceptualized as the power plant has to be downstream of the dam, irrigation project too has to be located downstream of the dam to utilize gravity flow. Subsequently with the location of the dam determined then that leaves the alternatives to be evaluated to include; Mode or process of how it should be done and timing and detailed implementation.

under the mode or process of how things should be done there were considerations of technologies or methods that can meet the need with less environmental damage than 'obvious' as opposed to traditional methods. The project also proposes to use the most environmentally friendly technologies available. This will include promoting drip rather than overhead Irrigation, piped conveyance as over open canals and renewable hydropower energy rather than diesel fuel for pumping water. The technologies chosen are also simple, easy to use, and low cost.

Under the timing and detailed implementation the points considered included when, in form and in what sequence, should development be carried out at best. What details matter and what requirements should be formulated to ensure their effective implementation. Again in this deliberation since the sub projects as conceptualized radiated from the proposed existence of the dam to utilize the stored water, the logical sequence would be to implement the dam first. In their order of importance water supply come second as they support life, electricity generation comes second as since it is a non-consumptive use while implementation of irrigation follows.

This alternative evaluates the impacts of fully implementing the Arror Multipurpose Dam (and its key objectives: increased water, electricity and food supply through irrigation). The key thrust of this ESIA is to obtain data on the Environmental feasibility of the proposed sub-projects namely;

1. Dam Embankment
2. Hydropower generation
3. Water Supply
4. Irrigation

In each of the project component areas the Consultant has evaluated the positive and negative impacts for the above components. For the adverse impacts, mitigation measures were identified while measures for enhancement of opportunities were also sought. Where win-win' scenarios are not possible, the more common scenario involving both 'winners' and 'losers' necessitating ''trade-off' shall be considered.

7. Potential Environmental & Social Impacts

7.1 Introduction

Environmental Impact Assessment (EIA) is a planning tool to promote sustainable development by integrating environmental costs and benefits into proposed development activities. In the long term, it should minimize environmental impacts and save costs by preventing unnecessary environmental degradation.

Environmental Impact Assessment (EIA) study must take place in such a manner that is a preventive factor concerning environmental destruction, in confronting investment wastage, attaining development objectives and improvement in the socio-economic sphere. Thereby, in such conditions, not only the actual value of EIA study will be specified, but the consequences and the obstacles of the plan will be decremented and EIA report can be utilized as guideline by the project designers. Totally, what EIA can do is ensure political decision makers are making their decision based on a complete, clear, quantified (where possible) description of the positive and negative impacts to achieve sustainable developments.

In this regard, the National Environment Action Plan (NEAP) process introduced environmental assessments in the country with among the key stakeholders being industrialists, business community and local authorities. This culminated into the enactment of the Policy on Environment and Development under the Sessional Paper No. 6 of 1999.

7.2. Impact Assessment Methodology

In the present section, the key components described in the previous sections are analyzed in order to identify and assess all the potential project-related environmental and social impacts and to identify the mitigation measures and procedures to be adopted to reduce them.

7.2.1 Impacts Identification

In order to identify all of the potential impacts (positive and negative), any single project activity is analyzed in relation to the investigated environmental, social and health components (described in chapter 4) related to the construction and operation phase.

In many cases, impacts on environmental, social or health issues are interconnected. Therefore, it is important that integrated impacts identification is undertaken, so that the relationships between individual components are recognised and understood and indirect but relevant consequences on the affected area are considered.

7.2.2 Impact Assessment

The present section describes the procedure implemented to assess the significance of the impacts potentially induced by the different components of the project described in chapter 2 (the dam, irrigation project, the power plant and the distribution pipeline) on the environmental and social components. The predicted impacts are evaluated using a significance ranking process. This assessment is done taking into full account the regulatory requirements described in Chapter 3.

Once identified, potential impacts need to be assessed in order to enable a judgement of their significance that allows a prioritization of the mitigation/enhancement and management measures. Potential Project impacts are assessed in relation to environmental and biological resources as well as socio-economic resources (community, individuals, and social, economic and cultural assets) within the Project area of influence.

In assessing the significance of all the impacts (positive or negative), the criteria presented in the following table are applied.

Table 7.1: Impact Assessment Criteria

Temporal scale	Short-term: impacts limited to the duration of the activity.	Long-term: impacts that may last for longer periods of time.	Permanent: impacts that cause a permanent change in the baseline conditions.
Spatial scale	Local: impact affecting the communities within the Project area of influence.	Regional: impact affecting a wider area or socioeconomic asset of importance going beyond the communities in the Project Area of Influence.	National: impact extending to the national level, or affecting assets of national importance.
Probability	Likely: past experiences in similar projects give some substantiated evidence that the impact frequently occurs in a similar context	Possible: could occur but is not frequent	Unlikely: very rare in the country and in a similar context, very low probability
Intensity	Low: limited impact that does not lead to any long-lasting change.	Medium: impact causing change but not affecting the core livelihood of affected people or main structure of the socioeconomic asset.	High: impact causing a complete change of livelihood; or change/destruction of the asset.

Based on the aforementioned criteria, a comprehensive evaluation is provided for each impact, considering a four-level rating of impact significance: negligible, low, medium, high. These evaluations are then tailored to the main features of the involved receptors, the local environment and socio-economic context and the definitions below.

Table 7.2: Definitions of the Impact Significance Assessment Rating

Negligible	Negligible magnitude impacts on low or medium sensitive environmental, biological and socio-economic resources. The impact is hardly distinguishable from background conditions and expected development in a no-project situation.
Low	Low impact on medium or low sensitive environmental, biological and socio-economic resources, medium impact on low sensitive resources. The negative impact can still be minimized to a negligible level through best practices and mitigation measures
Medium	Low magnitude impact on highly sensitive environmental, biological and socio-economic resources, medium magnitude impact on medium sensitive resources, high magnitude impact on low sensitive resources. For negative impacts, mitigation measures are required and, as needed, compensation measures.
High	High or medium magnitude impact on highly sensitive environmental, biological and socio-economic resources. Negative impact must be avoided, mitigated or compensated to an acceptable level through implementation of specific mitigation or compensation measures.

Once the impact is identified and assessed, suitable mitigation measures are defined to reduce or totally avoid the impacts. Where the total elimination of the impact is not possible, residual impact is codified and its significance is assessed after the implementation of the mitigation measures, on the basis of the principle that, after mitigation and/or compensation, the negative impact should be reduced to minor or negligible. Positive impacts should be enhanced through enhancement measures. In the following paragraphs, the key components described in the previous sections are analyzed in order to identify and assess all the potential project-related environmental and social impacts and to identify the mitigation measures and procedures to be adopted to reduce them.

The impacts that describe the induced impact and propose suitable mitigation measures to be adopted to avoid or minimize the effects of the induced impact.

Mitigation measures are proposed based on national requirements, best practices, IFC PS, preliminary stakeholders' views, ESIA experts' advice, and according to the following mitigation hierarchy:

- avoid as much as possible;
- where avoidance is not possible, minimize following best practices;
- where minimisation is not sufficient, mitigate through specific measures;
- where mitigation is not sufficient, compensate for residual risks and impacts.

Impacts have been assessed separately for the different Project phases, construction and operation and for the different Project components, as explained above. Considering the time lapse before decommissioning, a specific decommissioning management plan will be developed before the start of decommissioning on the basis of an updated baseline survey.

The impact assessment is shown by the colour of the cell:

🟦	Positive Impact
🟩	Negligible Impact
🟨	Low Impact
🟧	Medium Impact
🟥	High Impact

7.3. Potential impacts by Dam and hydro-power generation

Dams have impact on the environment and the environment, in turn, can have major impacts on dams. The term "environmental effects", in its broad definition, includes the physical, biological and social aspects. Changes in water quantity or quality, or soil erosion and sedimentation, are physical environmental effects. Different impacts on terrestrial and aquatic fauna and flora are biological effects. The involuntary resettlement of people and the disruption of their life styles are social effects, as well as the impact of resettlement on the affected population. The key to this approach is to emphasize that all these impacts together are caused by the dam project and affect the project's viability and its benefits and costs. It would be errors to take into account only one of the aspects. Indirect impacts need also to be taken into account just as much as the direct output of drinking water supply, irrigation water or flood control.

Therefore, in this section of the study, primarily based on the environmental baseline study, the probability of the incidence of impacts, in relative to the construction and operation phases, for the main components of the plan is determined. Then by using the checklist method, the impacts of the project in segregated form as to the construction and operation phases are predicted and described. Finally, the characteristics of each impact, such as type, probability, occurrence, importance, intensity, duration and reversibility of the impact are summarized in form of tables. In Table 7.3 probability of potential impacts regardless of being positive or negative is given.

Table 7.3: Scoping of Environmental Parameters and Issues for the Arror Dam Project

	Environmental Factor	**Potentially an Environmental Issue During Construction**				**Potentially an Environmental Issue During Operation**			
		Certain	**Likely**	**Unlikely**	**Not Known$^{(1)}$**	**Certain**	**Likely**	**Unlikely**	**Not Known**
(Impact on Man) Economics	Industrialization			√			√		
	Employment	√				√			
	Tourism			√			√		
	Crop & Livestock Farming			√		√			
	Communications (Roads)	√						√	
	Land Values	√					√		
(Impact on Man) Society	Social Acceptance		√			√			
	Recreation & Leisure			√			√		
	Local Landmarks & Character			√				√	
	Landscape	√				√			
	Domestic Water Supply			√		√			
	Land Acquisition	√				√			
	Diminishing Rural Population			√			√		
	Protection Against Natural Dangers			√		√			
	Health and Disease		√				√		
	Migration		√				√		
	Population Displacement		√			√			
	Land Use	√				√			
Geophysical Impact	Morphology	√				√			
	Erosion	√				√			
	Slope Stability			√			√		
	Induced Earthquakes			√			√		
	Soil Salinity			√			√		
	Soil Contamination		√				√		
	Flooding			√		√			
Impact on Water	Biology (BOD, etc.)	√					√		
	Physics & Chemistry	√					√		
	Salinity	√					√		
	Solid Loads & Turbidity	√					√		
	Temperature			√			√		
	Evaporation			√			√		
	River Flow		√			√			

	Environmental Factor	Potentially an Environmental Issue During Construction				Potentially an Environmental Issue During Operation			
		Certain	Likely	Unlikely	Not Known(1)	Certain	Likely	Unlikely	Not Known
Impact on Water	Groundwater Table		√				√		
	Groundwater Quality		√					√	
	Water Quality of Reservoir			√		√			
	Thermal Stratification in Reservoir			√			√		
	Eutrification in Reservoir			√			√		
Climate	New Mesoclimate			√			√		
	Air Quality	√					√		
	Noise	√					√		
Terrestrial Flora	Forest		√					√	
	Moor & Fallow			√				√	
	Grass Growth		√				√		
	Cropped Lands	√				√			
Aquatic Flora	Higher Plants (Waterweeds, etc.)		√				√		
	Active Microflora (moulds, algae, fungi, etc.)		√				√		
	Phytoplankton		√				√		
	Rare/Endangered Plants (both aquatic & terrestrial)		√				√		
Terrestrial Fauna	Mammals		√				√		
	Birds		√				√		
	Reptiles & Amphibians		√				√		
	Protected Areas			√		√			
Aquatic Fauna	Fish Species		√				√		
	Macro-Invertebrates		√				√		
	Zooplankton		√				√		
	Microorganisms		√				√		
	Rare/Endangered species (both aquatic & terrestrial)		√				√		

(1): No judgement possible at present

7.3.1. Impacts on Socio-Economic and Built Environment

The principal aim of every development plan is the improvement of socio-economic status of the local people residing in the limits of the plan. Moreover, the regional socio-economic prosperity can have side benefits on other regions, like the utilization of agricultural products.

But at times, a dam does not act in the manner of the predicted objectives that were determined. With due attention to the points rendered hereunder, there are uncertainties in predicted impacts:

- Complexities of social predicaments
- There is the possibility that at any period of time, distinctive social, economic and political conditions prevail over the region
- Unforeseen problems, such as civil war

Action on the environment includes all the purposes for which a multiple purpose dam is built in addition to induced effects (those not planned in the scheme). All water development plans are built to make beneficial effects for society; the main ones in this project include:

- Electricity generation
- Irrigation,
- Drinking water supply,
- Flood control,
- Recreational and fish-culture activities

On the other hand, adverse impacts such as population displacement, the submerging of arable lands and danger to downstream population must be included on the debit side of water development plans.

With due attention to the above mentioned, the survey of socio-economic predicaments dominating the project region, is one of the main indices, the consideration of which is necessary. Thereby, in this section, the socio-economic impacts arising from the project, as to the construction and operation phases are separately foreseen and specified.

7.3.1.1. Industrialization

Construction Phase

By way of the awareness of other ministries, organization and other industrial authorities are drawn together, for the implementation of plans such as, the Arror Dam and its associated components including the hydro power and irrigation project by the Ministry of devolution.

Development Authorities, the founding and facilities for planning the forthcoming prospects of the region and the development of affiliated and side industries. But comprehensive and regional planning requires coordination between the related organizations, which, due to the present drawbacks in the administrative and organizational framework in Kenya, is one of the main obstacles that can be accounted for in this issue, suitable grounds in this connection for the construction period is far from expectations. Therefore, the impacts of the project on industrialization, in the construction phase, can be considered as unlikely.

Operation Phase

The major objective of executing development plans, particularly multipurpose dams, such as the Arror Dam and hydro power, is to supply the minimum of requirements and welfare facilities, an alleviation of life-style status and the social development of the inhabitants. The prevention of flood hazards, access to drinking and irrigation water resulting in the production of food stuff, industrial development and the creation of new occupations, can be said to be the beneficial impacts of the socio-economic facets of such plans.

Electricity supply (as main objective of the Arror Dam) that at the present is one of the main obstacles of urban and rural areas, pave the way for development of small and large industrial units and industries shall find their place as a necessitation. In fact, industry development is a positive and indirect impact that also improves the infrastructure facilities and increase the urban welfare level. Based on the amount of electricity generated through the project, this impact is assessed with low suitability and moderate importance.

Industries affiliated to agriculture, the type of which depends on the cropping pattern, is one of the key industries that have the possibility of development, during the operation period; however, it is considered amongst benefits of irrigation plan in the Kerio Valley.

7.3.1.2. Employment

Construction Phase

Even though the construction activities of the dam, conveyance tunnel, penstock and the power house, offer various job opportunities during construction, employment rate increase in the project area which in major entails the unskilled, semi-skilled and the skilled worker category, lead to increment of income of the inhabitants. This beneficial effect mostly is seen in Kapsowar Division in which dam site is located. But, these kinds of occupations are temporary and do not create a long lasting effect on aspects such as job security, welfare and income increment for the local inhabitants.

It should be mentioned, impact of construction of the power house on employment is seen in Tunyo Division (Kerio Valley).

This effect is assessed as a positive and direct impact, with medium suitability and importance.

Operation Phase

Operation of the project can create job opportunities, direct and indirect occupations in various sections, culminating to the more flourishing concepts of regional economic activities. Occupations arising from the project can be summarized as follows:

- Direct occupations pertaining to the operation period comprising of the dam operation team, surveillance team, repair and maintenance of the dam, tunnel and water pipeline, and power house
- Indirect occupations such as, tourist service jobs related to the probability of expansion of tourism in the region

Generally, employment status in Marakwet sub-county (both in rural and urban areas) with a lesser unemployment rate is better than Kenya as a country; however, it is still high and unemployment rate in rural areas of the sub county with average 13.14% is higher than urban areas. Therefore, this phase has desirable impacts concerning the creation of jobs, welfare of the inhabitants and income, with higher suitability in rural areas. This can be obtained by enforcement of improved management in implementing the plan, as this brings about the maximum exploitation to hand.

The effect of operational phase of Arror Dam and hydropower on the employment factor is assessed as positive, indirect and long-term impact with low suitability and moderate importance (since it is beyond the project area).

7.3.1.3. Tourism

Construction Phase

No impact.

Operation Phase

The subject of tourism today is known as a part of industry, which illustrates an economic boom for any region. The impact of the Arror Dam project on the issue of tourism is due to the formation of the Arror Dam reservoir. The conception of beautiful scenery in the mountainous region, as well as taking advantage of the recreational potentials of the lakes of such dams, can lead to the attraction of tourists to the region.

Since, tourists of Kenya are mostly Eco tourists looking for virgin and natural scenery and watching wildlife in their natural habitats, they may not enjoy watching a dam lake (that is accounted as a manmade lake) and so it is not of a high attraction. Moreover, the current natural scenery of the dam area with presence of the Kipkunur Forest is a spectacular landscape for everyone.

Although, absorption of tourists to the dam lake region is accounted as a positive and indirect impact, it is assessed with low suitability and importance.

It should be mentioned, from the environmental point of view, entering tourists into natural environment is not so desirable; as whichever region that man has set foot upon, nothing but the devastation of natural resources has remained. In addition, the probability of the dam lake water getting polluted due to excessive tourism activities is also under discussion.

The issue of tourism must be dealt with extreme caution. If this issue comes under the appropriate management and surveillance of the Ministry of Environment, its socio-economic benefits can be exploited without environmental destruction; otherwise, with environmental devastation and pollution of the dam lake water, not only after a short period the regional tourism potentials is lost, but due to water pollution, the project is drawn away from its objectives, as well as the heavy costs that is incurred for reclamation.

7.3.1.4. Crop and Livestock Farming

Construction phase

No impact.

Operation Phase

Improvement of crop and livestock farming is considered amongst positive and direct impacts of the irrigation plan which is evaluated separately in next chapter. However, it is accounted as an indirect impact of Arror Dam.

7.3.1.5. Communication (Roads)

Construction phase

The main road to the dam site is through the road which links Eldoret-Chebiemit-Cheptongei-Kapsowar which is about half an hour driving along a paved road and one hour and a half along an earth road to get Kapsowar from Eldoret.

Due to beginning of construction activities and need to transportation of constructional materials and staff commuting, paving of this road is necessary. Improving of this road not only is beneficial for the project and its personnel, but for inhabitants of different population centers located on the way is advantageous. Since, this road is main link between Eldoret to Kapsowar and then Chesoi, it can be said inhabitants of these population centers are affected indirectly by this positive effect of the project as well as all other villages located along this way. So, the scope of this impact is beyond the borders of the project area.

Also, for construction and preservation of tunnel and penstock, an access path is constructed with length about 10 Km. This path links power house in Kerio Valley to the dam site. Moreover, an access road with length of 3-4 Km is constructed to link the main road to the dam site; that in construction phase is used just by staff and or workers. It is worth to mention that no main road, except for sheep-tracks, is submerged by water taking of the Arror Dam reservoir.

Improvement of communication roads is amongst positive and indirect impacts that are assessed with high suitability and importance.

Operation Phase

Since communication roads should be improved during construction phase, all advantages and disadvantages is related to that phase, so no meaningful impact is expected during operation phase. However, as a long-term impact, its benefits remain.

The improvement and development of the local road conditions will encourage exchanges and bring about closer mutual relationships between various sectors and different social environments, all to the advantage of the socio-economic development.

7.3.1.6. Land Values

Construction Phase

Through different studies of the feasibility study and field visits, local people especially residents of the reservoir area have been aware of the implementation of the Arror Dam. When local people are aware that their homes and agricultural lands shall be submerged by formation of the dam lake (or occupied by side facilities such as penstock or power house) they expect the authorities to compensate the damages. This can be lead to increase of land values. In construction phase, it happens just in immediate limits of the project, meanwhile during operation phase, it occurs beyond the limits of the project area due to variety of reasons.

During this phase, only prices of the houses (cottages) and farms located in the Arror Dam site, reservoir limits, tunnel and penstock route, access road and power house have probability of increase. According to the social assessment, several types of reactions regarding the project implementation is a possibility by the inhabitants. But in any case the sale of land and taking leave of the region is a reaction on the part of the inhabitants. Increase of land values in this phase is accounted as a positive, short-term and indirect impact with medium suitability and low importance.

Operation Phase

Due to formation of the dam lake, increment of the price of lands located in the surroundings of the reservoir limits with advantage of having a view over the lake is expected. In fact, possibility of tourism development can be lead in increase of land value. So changing of land uses in surrounding the lake, requires appropriate management. This is a positive impact with low suitability and importance.

Table 7.4: Summary of impacts of the Project on the man-economic factors

Environmental Factor		Phase	Quality			Type		Intensity/Suitability					Importance			Duration		Reversibility		Scope		When		
			No impact	Positive (1)	Negative	cumulative	non-cumulative	Negligible	Low	Medium	High	Very high	Minor	Moderate	Major	Temporary	Permanent	Reversible	Irreversible	Direct	Indirect	Immediate	Medium term	Long term
Impacts on Man-made economics	Industrialization	Construction	√																					
		Operation		√		-	-		√					√			√	-	-		√			√
	Employment	Construction		√		-	-			√				√		√		-	-	√		√		
		Operation		√		-	-		√					√			√	-	-		√			√
	Tourism	Construction	√																					
		Operation		√		-	-		√				√				√	-	-		√		√	
	-2 Crop & Livestock Farming	Construction	√																					
		Operation		√		-	-											-	-		√			
	Communications (Roads)	Construction		√		-	-				√				√		√	-	-		√		√	
		Operation	√																					
	Land Values	Construction		√		-	-			√			√			√		-	-		√		√	
		Operation		√		-	-		√				√				√	-	-					√

(1) Being (cumulative or non-cumulative) and (reversible or irreversible) is matter of concern for only negative impacts, therefore these qualities have not been determined for positive impacts.

(2) It is evaluated amongst direct impacts of irrigation plan.

7.3.1.7. Social Acceptance

Construction phase

The total activities of the project in general, during the construction phase, from various angles create disturbances in the life of the local inhabitants.

The most tangible consequences of this project are:

- The presence of a number of aliens in the region (may creating a sense of insecurity),
- Commuting of a numerous number of trucks and heavy vehicles,
- The Arror River water getting grimy or muddy,
- Air Pollution (the dispersal of dust particles),
- Noise pollution (the region loses its tranquillity),

Generally, the possibility of adverse reactions and retaliations as to the implementation of such plans, in particular in regards to the inhabitants of the limits of dam reservoirs is feasible. This conception is dominant as to the group of people that, all the adverse consequences arising from the plan execution has befallen them, but all the benefits of the plan shall pertain to the others.

Field study and interview with local people (especially with residents of the dam reservoir area) shows peaceful and irenic dominant characteristics of inhabitants. Although they are aware about the consequences of the dam project on their houses and farms, there is a positive public opinion towards the project, in condition of compensation. Probably, high level of poverty, deprivation, financial expectations for lost houses and farms and hope for a better future are the main motivation behind this positive idea.

Therefore, it is predicted that social acceptance in the construction phase shall be extremely strong and convincing; thus this effect can be stated to be a positive one. Hence, an appropriate implementation plan to absorb public participation and abide to its principle is of great importance in this period.

Based on the above mentioned, social acceptance of the project is assessed as a positive impact with medium suitability and importance.

Operation Phase

Upon the termination of the construction activities and the commencement of the operation stage, tranquillity overwhelms the region again. This is a period when the process of land acquisition in the reservoir area by authorities is finished because the consent of the inhabitants must be attained prior to the water intake of the dam reservoir.

In accordance with the securing electricity, drinking and irrigation water through the project, an approved level of social acceptance is expected, which is accounted for being one of the most critical positive impacts of the plan.

7.3.1.8. Recreation and Leisure

Construction Phase

Environment that villages located in and even Kapsowar as nearest city to the dam site is in the heart of nature. The entire surrounding environment is mostly pristine, natural (forest and shrubby) and semi-natural (farms). In fact, it can be stated that local people have been grown up in nature. Therefore, nature is considered as a place for living not for recreation and leisure. Moreover, the concept of leisure for people who live under poverty line is not an important aspect of life.

On this basis, no adverse impact due to construction activities is expected. Through peaceful, high tolerance and hard-working characteristics of local people, it is predictable.

Operation Phase

Although the dam lake is not so attractive for ecotourists, it has some attraction for local people as a new feature of their natural environment. So, they may spend a few hours beside the dam lake as a place for leisure.

Therefore, the impact of the plan on this factor is positive in this phase, with low suitability and importance.

7.3.1.9. Local Landmarks and Character (Archaeological and historical sites, monument)

Construction & operation phases

Since no cultural heritage or important landmarks has been recognized in the project area, no negative impact with respect to this matter is expected during construction or operation phases.

7.3.1.10. Landscape

Construction phase

The disorder and disarrangements arising from construction activities impose a negative impact on the region during this phase. In other words, the limits of the plan in the Arror Dam site, throughout the length of the tunnel and penstock route, access roads and at the location of the construction of the power house is transformed into a large constructional workshop, which creates a disagreeable landscape.

With due attention to the length of the construction period, this negative impact is accounted for being inevitable, reversible and short term.

Operation Phase

The presence of dam body, Dam Lake, tunnel, penstock, power house, access roads and electricity transmission line change the appearance of the environment. However, the landscape impact of the work is quite acceptable as it concerns structures which are buried and susceptible to greenery protection.

All the other works foreseen by the project up to the yard and the intake structures have a precise technical function and are designed with criteria of stability, and do not make significant negative impact on the landscape, both for their modest dimensions and for the fact that they are mostly underground.

The lake will be a pleasant addition to the surroundings. The water conveyance works are mostly underground, except for the penstock. The penstock, which winds along the slope of the escarpment, has a landscape impact of some order being an artificial continuous work which requires a belt of deforestation and treatment and protection with a width variable from 10 to 30 m. fortunately, the complete visibility of the run is excluded from any point of view of the Kerio Valley.

The power house does not have noticeable landscape impact due to the reduced dimensions of the surface works, which include the overhead structures of the substation and the high voltage lines.

Dimensions of the re-regulating pond and switchyard are modest in relation to the vast surrounding spaces.

Amongst the project components, tunnel (as an underground structure) has least negative impact; meanwhile the outlook of the lake is considered as a positive impact.

Since the landscape impact of the dam lake outweigh to other impacts, totally, it is assessed as a positive impact with medium suitability and importance.

7.3.1.11. Domestic Water Supply

Construction phase

No impact.

Operation Phase

Drinking water supply of some population centers in downstream and upstream of the dam site is as a secondary objective of the project. At present, local people supply their drinking water from the river without any treatment or purification, just a few people prefer to boil water before consumption. So it is one of the positive impacts of the project during operation phase that is assessed with high suitability and importance.

7.2.2.12. Land Acquisition

Construction Phase

Discussion regarding land possession is usually the most crucial social matter relevant to dam projects that are considered as negative impact of the plans.

The issue of land possession in the construction phase pertains to the limits of the dam site, access roads (access road to dam body and water take and penstock access road), penstock route and site of power house. These lands must be purchased from the authentic owners and the approval of the inhabitants sought, prior to the construction activities. The real price of lands should be paid and land rights taken.

The effects of these impacts are considered as negative and short term ones. Though, for the people who are compelled to leave the region, the consequences shall remain for a long time.

Operation Phase

The cottages and farms situated in the limits of the dam reservoir, upon approval of the owners, are purchased and possession taken over by the proponent (Kerio Valley Development Authorities, KVDA). Population displacement and resettlement is an important subject that should be under consideration due to land acquisition.

This effect is assessed as a negative, inevitable and irreversible impact with medium intensity and importance.

7.3.1.13. Diminishing Rural Population

Construction phase

Employment opportunities that are created in this period and with attention to the current high unemployment rate, the local inhabitants (in project area or near or far villages) prefer to get employed in the project and earn an income, even if it is for a duration of four or five years.

Moreover, the process of purchasing lands, payment of compensation for damages incurred and land possession, is usually a time consuming process and usually continues till commencement of the operation phase. Hence, even if the land owners wish to leave the region sooner, they are compelled to wait till their compensations are paid. Thereby, diminishing rural population is not expected.

Operation Phase

This impact during operation phase is expected just due to watertaking of dam reservoir. The rural populace (villagers) whose houses and agricultural lands are submerged due to water intake of the reservoir and thus lose their dwellings, occupation and source of income are obliged to leave their homes.

Rural areas or villages in the study area are not in form of concentrated (a complex of rural houses or cottages). They are in the format of decentralization (scattered cottages on farms). This cause low population density. Population centers in the reservoir area also follow this norm.

Reservoir area is about 2.8 Km^2, about half of which is covered by dense forest that is almost uninhabitable. Population mostly inhabit on farms located on the left bank of the Arror River. On this basis, a high population living in the reservoir area is not expected.

Therefore, diminishing rural population due to watertaking the reservoir is not a negative impact with high intensity. It is assessed as a negative impact with medium intensity and importance.

7.3.1.14. Protection against Natural Dangers (flooding, drought, famine)

Construction phase

No impact.

Operation Phase

With due attention to the potentials of being prone to flood (maximum discharge and flood peak with 1000 years return period are estimated about 136 and 204 m^3/s respectively), the positive impact of the plan in concern with this phenomenon is certainly positive.

The climate of Arror basin is of the tropical semi-arid type (sub-tropical) with moderate temperature and high rainfall. Long period statistics show a high mean annual rainfall (1431.7 mm) in Arror River basin. Therefore, drought in the study area is not a significant issue.

Irrigation plan in Kerio Valley is as secondary objective of the project. Climate of Kerio Valley is thoroughly different from the highlands. It is a region with lesser mean annual rainfall (879.1 mm) and higher mean temperature (24.8 °C). Hence, in the case that drought occurs, due to securing consistent water for agricultural lands, damage to the crops is not inflicted and or it is to the minimum. Based on this, the multi-purpose Arror Dam is also a manner to confront famine and its positive impact as to this phenomenon is also a certainty. It is an indirect impact of the Arror Dam that is considered directly in the environmental assessment of irrigation plan.

According to the above mentioned cases, the operation of the Arror Dam has positive impacts on all the three aspects of flood, drought and famine, which is a strong justification in compelling the implementation of the project. It is assessed as a positive impact with high suitability and importance.

7.3.1.15. Health and diseases

Construction Phase

One of the major principals of a sustainable development is for the blooming and improvement of life quality. Health is the most important issue in the life quality.

Large dams are often criticized because of their negative social impacts such as increases in communicable diseases. Social impact assessment (SIA) can help promote development strategies that address the concerns of local populations, thus enhancing the long-term sustainability of dam projects (Tilt, et al., 2009).

In the construction phase, the occurrence of diseases in relative to water is improbable. However, the occurrence of other types of diseases arising from the non-endemic manpower in the region is likely. In spite of sufficient active population as manpower in the project area, there is probability of employment of non-endemic manpower.

The nearest city to dam site is Kapsowar, because of close distance and commuting of local inhabitants to the city, in the case that manpower is obtained from the city, they cannot be considered as non-endemic. The location of power house is close to Chepkum; in a similar manner, manpower from Chepkum or farther villages such as Koitilial and Chesetan are accounted as endemic.

On this basis, a few non-endemic manpower is employed for the construction phase of the project, that mostly are specialists and experts (usually non-skilled workers are employed from the local people). Therefore, health issues and diseases arising from non-endemic workforce is not a significant issue. However, safety points about this case should always be under consideration.

The impact of the project on the health and disease factor in the construction phase is a negative one with low intensity and moderate importance.

Operation Phase

Large water projects cause dramatic changes in regional ecology. These changes can include wrenching disruptions to communities, fatal epidemics of water-associated malaria and bilharzia. On the other hand, dams particularly with aims of securing drinking water can provide suitable opportunities for improvement of health index.

Generally, the following factors can be problematic as to increment the possibility of incidence of water borne diseases:

- Entrance of point and non-point pollution into the dam reservoir
- The creation of lentic water at the margin of the dam lake, which is a suitable habitat for insects as carriers of diseases

One of the ways of disease transfer is by aqua life and pests which are carriers of water borne diseases. One of these water borne diseases that can be indicated to is Schistosomiasis and its cause is the *Schistosoma haematobium* worm and its carrier is the snail Bolinus. Due to its connection with the construction of dams, it is also known as Dam Disease. Similarly, the Drachuntiasis disease which is caused by *Dracunculus medinensis* or *Dracunculus medinensis* and its carrier is Cyclops is also conveyed in this manner.

The most common diseases carried by aqua pests are namely Malaria. This is transferred by the Anopheles mosquitoes and its carrier is *Protozoa Plasmodium.* With the formation of the dam lake, there is possibility of the collection and growth of this mosquito.

Another disease that is conveyed by pests is Onchocerciasis Onchocerca volvulus or river blindness and its carrier is the Simulium fly and its cause is the Filariasis worm. The multiplication of pests and spawning of mosquitoes in marshes and or the multiplication of snails in shallow waters surrounding the dam lake causes an increase in the number and kinds of disease carriers.

Totally, the possibility of water borne diseases is an issue relative to the operation period of dams. Therefore, control and the monitoring sanitation and health index during this period are of special importance.

Because of the following reasons, the possibility of incidence of water borne diseases in Arror Dam project is not expected to be high:

- A few number of villages in the Dam basin, so that it is mostly covered by Kipkunur Forest,
- There is no small or large industrial units in the dam basin,
- The only main pollution source of the reservoir is agricultural lands,
- Fluctuation in water level due to water transmission to power house, so possibility of having lentic waters at margin of the reservoir is low.

On this basis, this impact is assessed as a negative one with low intensity and moderate importance.

7.3.1.16. Migration

Construction phase

Employment in the project is the main motivation for migration to the project area during construction phase. So the Arror Dam Project impact on the migration of people is very likely in the region. The requirement of manpower in construction activities, especially unskilled and semi-skilled workers, which are usually supplied from the rural areas nearby the project, can be the cause of attracting active population especially young men to the project area, preventing them from migration to areas beyond the region or encouraging their return.

With due attention to main reasons of migration in the study area include: unemployment, low income, lack of infrastructure, shortage of health facilities and lack of security, in case of implementation of development plans such as Arror Dam and irrigation network, willingness of residents, especially youth, to emigrate to urban areas decrease because of new job opportunities, supplying infrastructures, safe water for drinking and agriculture.

It is accounted for as being a temporary effect with medium suitability and moderate importance.

Operation Phase

The impact of the operation phase of the plan with respect to migration is assessed positive due to the following reasons:

- Direct job opportunities such as monitoring, repair and maintenance of dam installations, tunnel, pipeline, access roads, power house,
- Indirect job opportunities such as tourist service jobs

Since, the number of these kinds of jobs is low and limited; this impact in operation phase is not as strong as construction phase.

7.3.1.17. Population Displacement

Construction Phase

Population displacement in this phase is related to the people whose houses or agricultural lands are located in the immediate area of the project and construction activities. Since, the number of these people is not high, this effect is not severe.

About the people whose properties are located in the reservoir area, it should be stated, planning in regards to the initial talks with local people, including compromise to purchase and taking possession of lands, usually commences prior to the dam construction, however, it is possible that this is prolonged till the termination of the construction stage of the dam. Global experiences have shown that in some dam projects, some of the residents refrain from leaving their dwellings even till the stage of the water intake of the reservoir. Hence, in the best conditions, it is foreseen that the major procedures of the resettlement plan must be performed after the termination of the construction phase and before the water intake of the reservoir. Thereby, this impact is considered and valued in the operation phase.

Operation Phase

In all the countries of the world, the construction of dams takes place with the displacement of a number of people, majority of who are rural, farmers and herdsmen, who in fact do not have a suitable financial status. These people are compelled to leave their homes.

As it mentioned before (see item 7.3.1.13. diminishing rural population), there are not a large number of people living in the dam reservoir. So, the displacement of population arising from the implementation of the plan is assessed a negative, inevitable and irreversible impact with medium intensity and importance.

7.3.1.18. Land use

Construction Phase

In the construction phase, land use at the location of the dam site, upstream and downstream, entrance and exit of the tunnel, penstock route, access roads and the location of power house is altered. The current land use of these lands is farm, grassland and woodland.

Although, change in land use during the construction phase is considered as an undesirable impact of the plan, but from the viewpoint of extent, in comparison to the operation period is accounted for, as being insignificant.

Operation Phase

Land use in the limits of the dam reservoir that shall be submerged due to the water intake, consists of agricultural lands on the left bank of the Arror River and forest on the right bank of the river including some sporadic rural units.

The change of land uses and simplification (conversion process of different land uses to one land use) to an aquatic ecosystem is considered as a negative impact of the plan. This impact is relevant to the limits of the dam reservoir. It is accounted as an inevitable and irreversible impact with medium intensity and importance (because of the small area of the reservoir).

Alteration in the land use of the water conveyance tunnel and pipeline route is taken place in the construction phase.

Summary of impacts of the project on the man-society factors is given in the Table 7.5.

Table 7.5: Summary of impacts of the Project on the man-society factors

Environmental Factor		Phase	Quality			Type		Intensity/Suitability					Importance			Duration		Reversibility		Scope		When		
			No impact	Positive (1)	Negative	cumulative	non-cumulative	Negligible	Low	Medium	High	Very high	Minor	Moderate	Major	Temporary	Permanent	Reversible	Irreversible	Direct	Indirect	Immediate	Medium term	Long term
Impacts on man-society	Social Acceptance	Construction		√		-	-		√					√		√		-	-		√		√	
		Operation		√		-	-		√					√			√	-	-		√			√
	Recreation	Construction			√		√	√					√			√		√		√			√	
		Operation		√		-	-		√				√				√	-	-		√			√
	Local Landmarks & Character	Construction	√																					
		Operation	√																					
	Landscape	Construction			√		√			√			√			√		√		√			√	
		Operation		√		-	-			√				√				-	-					
	Domestic Water Supply	Construction	√																					
		Operation		√		-	-			√				√			√	-	-	√			√	
	Land Acquisition	Construction			√		√		√					√			√		√	√			√	
		Operation			√		√			√				√			√		√		√		√	
	Diminishing Rural Population	Construction	√																					
		Operation			√		√			√				√			√		√		√		√	
	Protection Against Natural Dangers	Construction	√																					
		Operation		√		-	-				√				√		√	-	-	√			√	

	Health and Disease	Construction			√		√		√					√		√		√				√		√	
		Operation			√		√		√					√			√	√			√		√	
	Migration	Construction		√		-	-			√				√		√		-	-		√		√	
		Operation		√		-	-		√					√			√	-	-		√			√
	Population Displacement	Construction	√																					
		Operation			√		√			√				√			√		√		√		√	
	Land Use	Construction			√		√		√				√			√		√		√			√	
		Operation			√		√			√				√			√		√		√		√	

(1) Being (cumulative or non-cumulative) and (reversible or irreversible) is matter of concern for only negative impacts, therefore these qualities have not been determined for positive impacts.

7.3.2. Geophysical Impacts

7.3.2.1. Morphology

Construction Phase

The topography and land form during the construction phase, due to the activities, such as, soil excavation, embankment, cutting rocks, construction of access roads, excavation from borrow areas, power house, etc. relative to the dam body, spillway, water intake, tunnel, conveyance pipeline alter outstandingly. These changes, are accounted for as being the adverse impacts of the plan, as these kinds of activities, usually cause the natural status, to transform into a manmade status. This negative impact is limited to the length of the construction period, which occurs with great intensity, however is accounted as an irreversible effect.

Operation Phase

In the operation stage, this impact is in major, in the form of impact on morphology and occurs on the general regional visage. The formation of the dam lake causes a transformation in the general landscape of the region and creates a new one.

In fact, upon the termination of the construction phase, a lake remains in the region. Since the water conveyance pipeline and tunnel is implemented under the ground, it is not noticed after implementation. In that, the crucial part involves the lake landscape, this impact is considered positive.

7.3.2.2. Erosion

Construction Phase

In pre-construction and construction phases, activities such as, diverting the river course, construction of cofferdams, the construction of a diversion tunnel, the clearance of ground cover in the locations where construction activities is taking place, soil excavations and embankment, excavation of construction materials from the bed rock, debit depot, access roads, commuting heavy vehicles and … relevant to the dam body, the water conveyance tunnel and pipeline to the power house are aspects that create an impact on the surface prone to erosion, along with the possibility of accelerated erosion. This negative impact is limited to the construction period and appears on in a temporary manner.

Operation Phase

The conception of identifying the environmental impacts is to survey on the mutual impacts of the project and the environment. Erosion and the consequences arising from it, is phenomenon of which, the adverse impacts of the project are absolutely perceptible with it.

Hence, surveying the erosion, in connection with the project in the operation period of the plan, is taken into consideration from two points of view. One is the impact of the project on erosion and the other is the impact of erosion on the project.

- In the stage of reservoir water intaking, erosion of river bed and flanks attain the maximum level, and the sedimentation process in the reservoir, due to the intense turbulence of river water in the dam slope, gets to its minimum. But with the formation of the Dam Lake and commencement of operation phase, the abundance of this phenomenon gradually reduces and a change in the natural behaviour of the river erosion in the midterm culminates in a new balance with respect to erosion and deposition resulting in the ecology of the river.
- The effective or useful volume of the reservoir decreases, due to erosion and sediment transportation to the reservoir. The erosion phenomenon, in agricultural lands is many times more than the lands with natural ground cover. Thereby, the farms in the basin of the Arror Dam can particularly, in the rainy seasons cause soil erosion and sediment deposition in the reservoir. Agricultural development in the future, in the upstream, could be a factor in accelerating erosion prospect. The predicament of soil erosion from the viewpoint the deposition of the load of sediment and suspended solids in the reservoir is of utmost importance.

According to hydrology study, sediment deposition in Arror Dam reservoir is estimated about 2 MCM during 50 years of the reservoir life which is 3.3% of the normal volume (volume at normal water level is 60 MCM). So, it is predicted that the negative impact of the plan, in concern with soil erosion during the operation period could occur with a low intensity.

7.3.2.3. Slope Stability

Construction Phase

No impact.

Operation Phase

One of the natural processes that take place after the formation of the dam lake is the permeation of the water into the stratum of lands surrounding it. In the case that the stratum is inappropriate, several formations such as, marl, limestone and … in cases where there is a steep slope towards the dam reservoir, due to water permeation the durability between the layers decreases and the stability of the slope is disrupted, resulting in landslides and the vibration of soil masses and rock. The unsuitable exploitation from the fringes of the reservoir for construction materials and steep slopes in the flanks of the reservoir can exacerbate the vibration of the slope.

In general, an absence in the slope sustainability can create potential damages in dams and bring about major predicaments such as:

The creation of high waves on the dam lake surface, the danger of overflow and an intense pressure on the body of slope, shall form breakages and a complete destruction of the installations, which culminates in intense human and financial loss.

As a result of the piling up of soil and stones (rocks) within the dam reservoir, the useful volume of the dam reduces. Due to the decrease of the volume of dam reserves, the utilization planning of water resources is disturbed and the dam investments are wasted, issuing social, political and economic damages.

The falling of stone masses and soil into the lake shall lead to the blockage of the water intake systems, lake destruction, litter and the absence of efficiency in the operation system.

According to geology and geomorphology studies, no evidence of collapse or sliding or of large scale instability is noticed in the rocky substratum. The few examples of instability which are seen in the field affect the superficial cover and are due to erosion of the river banks, or to degradation or to intense weathering and strong runoff in connection with a pronounced steepness of the slopes.

This problem may, in particular, affect the projected dam live storage capacity since the cover layer friability may increase solid transport and the rate of earth-filling; moreover, under saturation conditions, also large soil masses may break away and slide into the reservoir.

In concern with the importance of this issue, sites with a probability of minute danger(s) must also be taken under serious survey. Therefore, on the whole, it can be expected that the impact of the formation of the lake on the slope stability occurs with a low intensity.

7.3.2.4. Induced Earthquakes

Construction Phase

No impact.

Operation Phase

Due to construction of the dam and creation of a large water body, quite a few million or even billion tons of fresh loads, is endured by the dam and the rock floor of the reservoir. The tolerance of such weight or loads has not been experienced in the location, prior to the dam construction. There are many evidences that demonstrate the occurrence of earthquake(s) due to water intake of dams. Research in the case of the occurrence of an inductive earthquake during the water intake of 20 large dams in the world has been performed. Results show that presently, this conviction can be believed that, during the filling of the dam reservoir, induced earthquakes of various intensities have taken place.

Based on past experiences, some of the induced earthquakes take place in such a manner that upon the commencement of the water intake of the dam, weak or micro earthquakes occur and their intermittence and intensity, because of the increment in water depth, increase extremely, till it attains a particular level. Due to the impacts of the weight of water incased in the reservoir on the lake floor, there is a high possibility that a moving fault could cause an earthquake. Normally, when the water depth reaches to more than 100 m and or the volume of water reserved is approximately one billion cubic meters, a more intense earthquake occurs, the intensity of which are about 3 to 5 on the Richter scale and in rare cases reaches over 5 Richter. After this phase, weak earthquakes take place and ultimately stop.

The total volume of the Arror reservoir is estimated to be approximately 60 MCM, of which, 6% of the amount mentioned is (one billion cubic meters). The elevation of the dam has been calculated to be 91 m. Based on this, the water depth at the dam axis location is not over 100 m. Hence, the occurrence of an induced earthquake is not probable or is of very low possibility.

7.3.2.5. Soil Contamination

Construction Phase

Due to the activities of the machineries, so as to construct the various components of the plan and the settling of oil compounds and fuel, soil contamination is taken place in some areas of the immediate limits of the plan.

Soil contamination in the construction phase is mainly due to spilling of oil compounds on the ground, oil refill of machinery, oil and gasoline leakage due to machinery activities and machinery repair, effluent disposal, land filling and waste depot. Activities and soil contamination parameters during the project construction is given in Table 7.6.

Table 7.6: Parameters of soil contamination during construction phase

	Parameters of Soil Contamination			
Activities	Anions/ Cations	Heavy Metals	Organic Matter	Other
Activities and repair of machinery		*		Oil and gasoline compounds and grease
Oil refill of machinery				Oil and gasoline compounds and grease
Fuel storage				Oil and gasoline compounds and grease
Waste depot			*	Oil and gasoline compounds and grease
Land filling	*	*	*	
Effluent disposal			*	

Operation Phase

A predicament that can be discussed in relation to soil contamination due to dam operation, is the probability of increase in tourism in the region (see sub-section 7.3.2). This could lead to an increment of sewage and wastes disposal, this impact is considered as a negative and indirect impact of the project. Since,

Soil contamination due to consumption of fertilizers and pesticides for agricultural lands is evaluated as a direct negative impact of the irrigation plan, so its description is given in the next chapter.

7.3.2.6. Flooding

Construction Phase

No impact.

Operation Phase

Flood control is accounted for as a secondary objective of the Arror Dam. According to 25-year hydrology statistics, maximum daily discharges of Arror River have been recorded with maximum values of 84.49 m^3/s and peak flood at Arror Dam site with 1000 years return period has been estimated approximately 204 m^3/s. On this basis, huge floods in the Arror River is not expected.

Since the survey of the flood regime of the dam basin from the viewpoint of self-purification of the river and similarly, dam design so as to determine the capacity of the diversion tunnel and the spillway is extremely crucial. This issue must be taken under consideration by the project designers. In addition to which, the presence of the villages and population centers in the downstream of the Arror Dam, emphasizes on the importance of this matter. Thereby, the impact of the plan in concern with flood is accounted for being a long term and a desirable impact.

Summary of impacts of the project on the geophysical factors is given in the Table 7.7.

Table 7.7: Summary of impacts of the Project on the geophysical factors

Environmental Factor		Phase	Quality			Type		Intensity					Importance			Duration		Reversibility		Scope		When		
			No impact	Positive (1)	Negative	cumulative	non cumulative	Negligible	Low	Medium	High	Very high	Minor	Moderate	Major	Temporary	Permanent	Reversible	Irreversible	Direct	Indirect	Immediate	Medium term	Long term
Geophysical impact	Morphology	Construction			√		√				√			√		√			√	√		√		
		Operation		√							√			√			√			√			√	
	Erosion	Construction			√		√				√			√		√		√		√		√		
		Operation			√	√			√						√		√	√			√			√
	Slope Stability	Construction	√																					
		Operation			√		√		√					√			√	√			√		√	
	Induced Earthquakes	Construction	√																					
		Operation			√		√		√					√		√		√			√	√		
	-2 Soil Salinity	Construction	√																					
		Operation			√																√			√
	Soil Contamination	Construction			√	√				√			√			√		√		√		√		
		Operation			√	√			√				√				√	√			√		√	
	Flooding	Construction	√																					
		Operation		√						√					√		√			√		√		

(1) Being (cumulative or non-cumulative) and (reversible or irreversible) is matter of concern for only negative impacts, therefore these qualities have not been determined for positive impacts.

(2) It is evaluated amongst direct impacts of irrigation plan.

7.3.3. Impact on Water

7.3.3.1. Biology, Physics-chemistry and Salinity (River)

Construction Phase

Since the Arror Dam is constructed on the River Arror, all the construction activities effect on the water quality directly and indirectly.

With the commencement of the construction phase of the project, temporary residential camps for workers and staff, construction workshops, warehouse of materials and repair workshops for light and heavy machinery are erected, each of these have a special impact of their own.

For the construction of the Arror Dam and its main components, including its side installations, such as access roads and conveyance line, in concern with the type of dam which is an earth dam, a large volume of construction materials are required and a large area including borrow areas are affected (tunnel and penstock are too far to have an impact on the River Arror).

Construction activities and the establishment of access roads to the location of securing construction materials, is a collection of activities, which, due to the change in the natural environment, leave various environmental impacts behind. The most critical of these impacts is the accelerated erosion and an increment in the sedimentation, which enters the river and results in the reduction of the river water quality.

The depot of construction materials in locations where are excavated, including the depot for construction wastes at the dam site, causes an increment in the sedimentation entering and the suspended solid loads of the Arror River. So a suitable site selection for the depot of materials and the management of these sites is of great importance.

Sewage and wastes produced in the temporary residential camps is considered as an important pollutant factor during construction phase. In the case of the absence of a sanitary system for sewage and waste burial, these pollutants enter the river and the BOD, COD and biology parameters of the river increase. Average sewage production is 30 lit per day for each worker or staff.

Activities and the servicing of machinery cause pollutants like total suspended solids (TSS), oil compounds and other polluting material to enter the river. The polluting parameters of surface water resources during the construction stage of the project are demonstrated in Table 5-6.

One of the important factors in self-purification capabilities of the river is the concentration of dissolved oxygen (DO) in water, as the self-purification factor is in major in a biological manner. It is such that, the organic matter present in water, in the presence of DO in the water and bacteria is transformed into sustainable mineral matter, whereas, in self-purification, it is purified in a physical manner, with a reduction of water speed, the suspended matter settles down and purification is performed (Hence, in the dam lake, the location where the speed of the river lessens, self-purification mainly will take place). Similarly, the UV rays also have slight disinfecting capabilities; but in self-purification according to the biological manner, DO play the major role and even so its role is greater than that of the bacteria. Therefore, the more DO in the river illustrates that the self-purification capacities and potentials are more; and all the factors which influence DO, such as, river gradient, turbulence, flow speed, temperature, tangible surface, depth, sunlight and minerals in the water indirectly have an impact on the self-purification of the river. In this project, with due attention to the lack of data regards the amount of DO in the Arror River (based on the results of the water analysis), expressing views and making predictions about the future conditions of self-purification of the river, is a difficult matter.

In the construction phase, and due to the water withdrawal and consumption and sanitary utility for the camps and likewise, the entrance of pollutants arising from the construction activities, in addition to the water becoming grimy (muddy), due to the extraction of construction material (rocks, stones) and other construction activities, the water flow and amount of DO in the downstream of the dam site reduce.

Assuming being constant of pollutant sources effective on the river water quality, a decrease in the river flow causes an increase in the pollutant materials, infiltrating into the river and a reduction in the self-purification capacity of the river, which ultimately results in the water quality decrement.

This effect is an adverse, inevitable and reversible impact of the project that is apparent on a short term basis during construction phase.

Table 7.8: Polluting parameters of water in the construction phase of dam

Activity	Pollution Parameters						
	BOD	COD	TDS	TSS	pH	Heavy Metal	Other
Embankment			Y	Y			
Explosion			Y	Y			
River Diversion			Y	Y			
Diversion tunnel, Dam body, spillway, coffer dams			Y	Y			
Access road			Y	Y			Oil, grease…
Transportation			Y	Y			Oil, grease…
Activity of machineries			Y	Y			Oil, grease…
Waste waters and sewage (of camps)	Y	Y					
Solid waste disposal (of camps)	Y	Y					
Excavation from borrow areas			Y	Y			
Solid waste and debris depot	Y		Y	Y			
Spilling of oil, grease and fuel compounds on the land							Oil, grease…

Construction and implementation of water conveyance line, tunnel, penstock and power house are the main components of hydropower to generate electricity. All the components except penstock and power house are located on the highlands. The penstock passes through steep slopes that connect highlands to Kerio Valley, and power house is located in the valley about 3 Km far from Chepkum.

Many of construction activities of water conveyance line, tunnel, penstock and power house such as excavation, embankment, construction or improvement of access road, temporary residential camps, etc. are the same with the dam. But due to the far distance from the main river, it cannot directly affect on the Arror River quality and impacts of these activities are indirectly through streams and tributaries.

Land clearance in areas of entrance and exit of the tunnel, route of water conveyance line, service road and penstock, also site of power house increases erosion potential. Also, excavation, embankment and debris depot increase erosion and some of the eroded materials enter into streams during rainfall. So the negative impact of the construction activities of hydro power on water quality is not as severe as the dam.

Operation Phase

With commencement of operation phase, natural regime of the river changes and water flow in downstream of River Arror decreases. Decrement of water flow causes increment of polluting parameters in water.

In the operation phase, with the formation of the reservoir dam and the alteration of the river flow to a lake, as well as a greater amount of contact in a more extensive surface with organic matter present in the reservoir base, the amount of DO decreases. This factor has a negative impact on the quality of water reserves in the reservoir in the future. With a water flow reduction on one side and the infiltration of agricultural drainage into the river on the other, the amount of DO and as a result the self-purification capability of the river in the downstream reduces.

In this phase, the role of water conveyance line and other hydropower facilities, through water transmission to power house, is decrement of water flow in the River Arror in downstream, so indirectly causes water quality decrement.

7.3.3.2. Solid Loads and Turbidity

Construction Phase

During the construction phase, activities relevant to the Arror Dam, water conveyance line and the impacts of various activities like: excavation, embankment, debris depot, activity of machineries, road construction, construction of installations, facilities and camps and likewise, excavation from borrow areas, amount of suspended solid loads in the Arror River increases. Water consumption and securing the required water for construction activities exacerbate this effect through decrement of water flow. This causes muddiness and turbidity of the water, resulting in a drop in the quality of water in the downstream of the dam.

Implementation of the first parts of conveyance line can also have a role in decrement of water quality through increasing turbidity, but the other components of hydro power do not have significant impact.

This is an adverse impact of the project, but temporary and confined to the construction period.

Operation Phase

In the operation period, impact on the amount of solid load and turbidity of the river, can only be conceived, by the presence of the dam. Other components and side installations of the plan do not have a role in it. This impact is surveyed from two point of views:

- The dam as a barrier on the river course, causes sediment deposition in the reservoir. Thereby, the solid load and turbidity of water reaches its minimum and the water that is conveyed to the downstream would be transparent and limpid water. Therefore, operation of Arror Dam reduces sediments in the downstream. The flow of such water has immense capacities in creating erosion in the flanks of the river walls and the transportation of sediment. But, since during the operation of the Arror Dam, an immense portion of the water is transferred to power house, the volume of water released is not enough for intense erosion in the flanks of the river walls. In this regard, releasing the environmental water flow that is calculated in this study is important.
- In order to increase or elevate the beneficial life of a dam and or the utilization of sediments to make agricultural lands fertile, water flow containing a large amount of sediment are suddenly released from the reservoir. Although it occurs rarely and in a short time, the muddy flow can encompass negative environmental impacts. Of these impacts, the adverse effects on fish and other aqua life can be indicated to.

Based on the above mentioned cases, although decrement and increment of solid load and water turbidity of the Arror River, is accounted for being a negative environmental impact of the project in the downstream of the Arror River, there is no high intensity and special importance in this concern.

7.3.3.3. Temperature

This impact is related to dam lake, and hydropower and its components have no role in its incidence.

Construction Phase

No impact.

Operation Phase

With due attention to the thermal reserves of water in dam lakes, at times, this aspect leads to the fact that in different types of climates, the extent of temperature changes, reduce in the region.

The lake of dam, during nights instigate the warming of the environment and during days cause the region surrounding the lake to be cool. From the seasonal point of view too, in winter, from the end of autumn and the beginning of spring, the lakes are responsible for warming the environment. Whereas, from the end of spring and in the summer season, as well as the beginning of autumn, lakes are the reason for making the environment temperature cooler. As for the indirect impacts of this phenomenon, is the conservation of plant species in the proximities of the dam area, due to their sensitivity with respect to cold or heat. Temperature changes till even 3°C can have a crucial impact on the sensitive ecosystem.

During summers, due to the sustainable atmosphere, which results from the presence of the lake, air conventions are reduced. But during winter, because of the absence of this sustainability, air conventions increase. Based on these experiences, even though it is possible that the increase or decrease of temperature is not perceptible in the annual temperature, but the changes in the local temperature surrounding the Arror Dam Lake is a certain, which is accounted for being a desirable and positive impact of the plan. But, with attention to high annual relative humidity of the dam area (about 40-58%), this positive impact will be negligible.

7.3.3.4. Evaporation

This impact is related to dam lake, and hydropower and its components have no role in its incidence.

Construction Phase

No impact.

Operation Phase

Evaporation from the lake surface is surveyed from two angles. Each of which has their own impact:

- Evaporation from the lake surface and its impact on the microclimate, which is described in the sub-section of climate.
- Evaporation from the lake surface and its impact on the lake water salinity, which is taken under survey in this sub-section.

The evaporation from the dam lake surface brings about an increase in the amount of sodium that remains in the water. In the case that this is intense, this leads to the salinity of the dam lake water. An increment in the sodium content in the water of dam lakes has a destructive effect on the agricultural lands and reduces the crop production. The salinity of land resulting from being irrigated with such waters can be observed in many countries.

Since, one of purposes of Arror Dam is use the output water from power house for irrigation, it is accounted as an indirect adverse impact of the project on the proposed area for agricultural development in the Kerio Valley.

The annual mean temperature in the Arror Dam site is 23.8°C, and evaporation equates to 2161.5 mm which is considered a high amount. This shows that the evaporation impact will be severe (medium to high intensity) with increment of water salinity.

7.3.3.5. River Flow

Construction Phase

Water consumption during construction phase for various uses of the plan comprising of access roads, diversion tunnel, dam body, coffer dams, spillway, temporary residential camps and … lead to a significant reduction of the river flow in downstream as negative with medium intensity and importance, direct and reversible impact.

As for secondary impact, increase of suspended solid loads in the downstream (due to lower river flow) can be named that has adverse and undesirable impact on the water quality of the Arror River, throughout the duration of the construction period.

Operation Phase

The river flow regime of the Arror River, upon the water intake of the reservoir shall undergo outstanding transformations. That is a change from a river to a lake system, including the formation of a reservoir with an approximate volume of 60 MCM. This leads to a change in the flood regime of the river.

The main impact consists in the drastic reduction of the downflows of the Arror by the dam at the Kapsowar impluvium, with periods of low water which can last for more than a year (due to the type of storage regulation), it is evaluated as a negative and direct impact.

This also accounts for an indirect impact on the river ecosystem. This change has several environmental impacts, from the viewpoint of transformation in the river bed, at the reservoir location and or in the downstream of the dam, the quality and power of self-purification (of the river) and similarly, the ecological connection of aqua life (between upstream and downstream). In rivers with rich biodiversity in relative to aqua life species, this factor causes a disturbance in the balance of the environmental river ecosystem and is hazardous for fish life.

The annual flow of the Arror River according to the 25-year data (1961-86) is almost 66 MCM, with maximum monthly average 4.37 m^3/s that occurs in November.

At the present time, the Arror River flow is not prone to plenty of changes and fluctuations. However, during operation phase, the natural river regime shows a grave change through storage in the reservoir and water transmission to power house. Thus, especially in the warm months, the river will face with reduction of flow in downstream.

Status of the Arror River flow, during operation of the Dam changes in the downstream of in this manner that:

Flood is eliminated and reserved in the reservoir,

Throughout the year, the amount of water required for electricity generation purpose is entered into the water conveyance pipeline in the left margin of the river from the reservoir, and

The environmental water flow (EWF) that is estimated in this study is released throughout the year.

With commencement of the operation of the Arror Dam, the Arror River flow is regulated in accordance with the water resources program of the dam, so that, in the warm months of summer, with release of the environmental water flow, the minimum river flow is conserved in the downstream.

The decrease of river flow in the downstream, during the operation period is accounted for being an adverse impact of the project, however with supervision and management of the environmental water flow, it is not as a high intensely impact.

7.3.3.6. Groundwater Table

Since there is not any data, statistics or information on quantity and quality of groundwater in the study area, prediction the impact of the project on this issue is faced with uncertainty. However, based on the topography of highlands in the dam area, a medium to high depth to groundwater resources is expected.

Construction Phase

Construction activities of dam have no impact on the groundwater level in the study area, but the impact of hydropower plant is much likely through excavation of the tunnel.

By tunnel excavation, a part of groundwater is drained through tunnel. So, the quantity of groundwater (wells and springs) will be severely affected. However, with due attention to limited groundwater in the tunnel route, this effect will be negligible.

Operation Phase

Field visits have indicated that due to excessive rainfall, the inhabitants' life is not dependent on groundwater, so indirect social effects due to any probable negative impact on groundwater will not be an important matter in the study area. However, identifying indirect ecological effects related to any probable impact on groundwater should be based on the up-to-date data and detailed study that is not in the framework of this report.

Totally, with water storage in the reservoir and reduction of natural river flow in downstream, occurrence of negative impact on the groundwater level in downstream is likely. However, with due attention to this fact that the River Arror is the drainage of the area, this impact will not be significant.

7.3.3.7. Groundwater Quality

Construction Phase

At this phase, there is likely to have adverse impact on groundwater quality through sewage disposal from temporary settlement camps, debris and solid waste depot in case of lack of proper management. But, due to lack of any important or large aquifer in the region (based on the preliminary geological data) and the role of soil in filtration of these types of pollutants, this impact would be negligible.

It should be mentioned, the role of dam and hydropower plant, and components of each, in incidence of this impact are the same.

Operation Phase

At the current status, the utilization of chemical fertilizers or pesticides for agricultural lands can cause the pollution of groundwater resources, but due to lack of data about groundwater quality, professional judgement on groundwater quality is not possible.

Overall, no effect on groundwater quality from the dam or hydropower during operation phase is not expected.

7.3.3.8. Water Quality of the Reservoir

Construction Phase

No impact.

Operation Phase

With the transformation of a river ecosystem to a lake ecosystem, without taking into contemplation any other factor, a change in the water quality occurs. This alteration of quality arises from the lentic feature of the water in the lake that be followed by a reduction in the reserved water quality.

The principal aim of establishing a dam is to supply water of a specified quality and quantity. Though, effective factors in decreasing of water quality in reservoirs are immense, these can be divided into three groups generally, which can be said to be, physical, chemical and biological pollution.

At times, one or more of the above mentioned factors, could be the reason for confronting a predicament for the utilization of the reserved water; and or make its consumption hazardous. Sometimes these impacts could usher serious environmental dangers like, the elimination of wildlife, aqua life and livestock.

Physical –Chemical Factors:

Solvable gases are factors which affect the water quality of the dam lake. Substances that are freed due to the aerobe and non-aerobe microorganisms and or, gases resulting from biological activities such as, photosynthesis, the direct entrance of minerals, resulting from the transportation of mineral matter in floods and or the contact of the mother rock with the flood, solvable minerals which are discharged into rivers are of those mentioned. The chemical reaction that takes place with respect to the temperature of the water increases the exchange of ions.

Solvable gases in the water can namely be oxygen, hydrogen, sulfuric, carbonic gas, methane, ethane and azote. Amongst the mentioned gases, dissolved oxygen (DO) is the crucial factor which is effective in the amount of self-purification of the reservoir water, from the environmental point of view, DO plays an important role in the continuance of the life of fauna, aqua life and plants. A decrease in the amount of DO leads to a decrement in the water quality, which has a disagreeable environmental consequence. The DO in the reservoir water is nourished by the entering flow and or as a result of photosynthesis of phytoplankton that feed and is secured by the solvable salts and carbon dioxide. The maximum natural amount of DO in cold and warm waters reaches 13 and 7.5 mg/l respectively. The traversing of floods from the mountains, rocky lands and stones and or the rocky bed of rivers, leads to the turbulence of water, and this flow in the place of entering the reservoir, gets saturated with oxygen and azote of the atmosphere. In this state, the self-purification capability of the dam lake reaches its maximum. The water of such reservoirs are extremely appropriate and suitable for being utilized in several modes such as for agriculture, industry, potable, survival of aqua life within the lake and or the environment in the downstream of the dam.

The lack of attention to the amount of mineral solvents in the reservoir water, salinity stratification, oxidation mechanisms, reduction and the imbalance in exchanges in the water leads to an irretrievable environmental loss. In some plans, due to the intensity of these problems, exploiting the water of the dam lake is impossible and uneconomical.

Usually in low discharges and or in summers, the river flow contains the maximum amount of solvable salts and in the turbulence season, this amount is the minimum. When a flood takes place, the salt concentration in the flood is low and probably this flow does not intermingle completely with the reservoir water, in this case, overflow discharged from the spillway contains less sodium in comparison with the reservoir water.

Due to the lack of drastic changes in weather conditions and river flow, severe changes in rates of physical factors of River Arror and in the reservoir (in the future) is not expected.

Biological Factors:

One of the factors which have an important role in the quality of water is the presence of organic matter in water. According to the kind of (water) utilization, that can be for agriculture and drinking, the acceptable level of pollution with respect to organic matter in water differs. If within the duration of a year, the reservoir water is filled and emptied and the water is only used for agricultural purposes, its destructive environmental impacts are negligible, even in such cases, water containing sedimentation, helps in the way of alleviating the soil texture and fertility. But, if in the case that the water is utilized for potable or industrial purposes, the presence of organic matter, exceeding the permissible amounts of standards of water, can make the plan utilization futile. Organic sources of the reservoir water are as follows:

- Forests and rangelands, human and livestock residue, organic wastewaters of factories, toxins, and organic fertilizers.

Since in the limits of the reservoir and upper basin of the Arror Dam, under present status, there are not particular industrial activities, in assuming that this condition remains stable as of the present, crucial wastewaters do not enter the reservoir; so the major infiltration of organic matter into the reservoir is mostly through: transmission of soil organic materials through runoff and wastewater of agricultural lands that influence river water entering the reservoir.

It should be mentioned, that there is no data on biological parameters of River Arror; so with attention to supplying drinking water through Arror Dam for some population centers such as Kapsowar, being this river under monitoring and sampling based on an integrated and regular program is necessary and should be taken under consideration.

With due attention to the continuous discharge of the reservoir for power plant, environmental flow and drinking water during operation, the retention time within the reservoir is limited and it is expected that with appropriate exploitation, its negative impact on the water quality be in minimum level. Likewise, control the infiltration of agricultural wastewaters and livestock residue into the river is absolutely effective in controlling biological factors.

7.3.3.9. Sedimentation in the Reservoir

Construction Phase

No impact.

Operation Phase

One of the critical problems in the dam reservoirs is sediment and sedimentation. In small or large dams (for reserve or regulation), river sediments are deposited in the reservoir which make the water clear and limpid, so clear water (without sediment) emits from the valves and or spillway. The impacts of sediment deposition in the reservoir can be surveyed from various points of view, as described below:

Decrease in the beneficial life of the dam: deposition of sediments causes a rapid increase in the dead volume of the reservoir and decreases the beneficial life of the dam. The direct impacts of which, is apparent economically in the plan as a loss in national investment and social difficulties.

A decrease in the nutrients of water in the dam downstream: Totally, in a natural river flow, a large amount of nutritional materials comprising of azote, phosphorous and other elements are transported through the sediment flow of the river and gets to the downstream; usually with the water diverting towards the agricultural lands, the soil texture is rectified and the nutrients which have been taken from the land by the crops, is compensated. But the presence of dam and control of river water cause a change in the natural behavioral pattern of sedimentation and the transfer of sediments to the downstream of the river, as well as a decrease in the load of suspended solids in the river, which culminate in a decrement of sedimentation in the agricultural lands.

The acceleration of erosion in the dam downstream: In a gradient and a constant waterflow, the erosion capacity of a river, due to the increment of the concentration of suspended solids decreases. If the concentration of the sediments elevates to more than a certain level, erosion and transportation of sediments is not possible by the river. Waterflow released from the dam is usually transparent and limpid and provides immense capacities for erosion and transporting sediments. It can be lead to a transformation in the morphology of the river in the downstream. Usually the impacts arising from this erosion, can be clearly observed in the walls flanking the river, but as it mentioned before, since during the operation of the Arror Dam, an immense portion of the water is transferred to power house, the volume of water released (for environment and drinking water) is not enough for intense erosion in the flanks of the river walls.

Damage to control systems: It is possible that the sediments and other materials which are transported by the river, can lead to a disturbance in the functioning systems and installations of dams. For example, sediment such as, grains of sand and sandy siliceous matters encountering with the edges of the partition walls or interior compilations of valves, body of pipes and discharge tunnels, causing them to get erosive and worn out; and sedimentation of suspended solids behind the discharging valves demonstrates that the plan has made an inaccuracy in the selection of an appropriate location for the water intake in the discharging system.

Prevention of water leakage from the reservoir: The permeation and leakage of water from the dam reservoir, is more or less possible to take place in several ways. The fine grained sediment that settle at the base of the reservoir, are at times taken to be utilized as a certified element in the prevention of water leakage. (Though, dam designers must not utilize this characteristic for the prevention of water leakage).

Impact of muddy flows in the shallow of the dam: Transparent and limpid water discharged from the dam can have adverse impacts on the living environment and endanger aqualife.

Other impacts of sedimentation in reservoirs are such as mentioned hereunder:

- Impact on water quality (reservoir and downstream),
- Effect regards the absorption of waste material,
- Effect on the recreational attractions of the river.

The amount of annual sedimentation in the Arror Dam Basin has been estimated to be equivalent to 44135.5 ton/y. This amount is not considered a large amount, in comparison with the area of the Arror Dam Basin which is about 185 Km^2. The sediment volume for a period of 50 years equates to 2 MCM. Thereby, by taking into consideration the reservoir volume of about 60 MCM, this volume of sediment, which is equal to 3.3 percent of the volume of the reservoir, is occupied the reservoir during a period of 50 years.

Even though, sedimentation in the reservoir is accounted for as being a negative impact confronting the project and the environment, but with due attention to the fact that for the 50 year sediment volume (dead volume of the reservoir), in comparison with the total volume of the reservoir, a relative logic is come to hand, so the negative impact of this phenomenon in regards the project is not of high intensity.

7.3.3.10. Thermal Stratification in the Reservoir

Construction Phase

No impact.

Operation Phase

Due to construction of the Arror Dam on the Arror River, two principal changes take place in the upstream of this river. One is a decrease in the water speed in the river from its entrance location to the reservoir and its stagnancy in the dam reservoir. The other is the creation of a thermal stratification arising from the change of temperature and water density in various depths, causing the formation of various layers or stratums of differing qualities.

Stratification often occurs in large water bodies during the spring and summer periods. It is essentially the development of distinct layers of different temperature, density and/or water quality at various depths in a water body and the restriction of mixing throughout the water column.

During winter and early spring, most water bodies are well mixed throughout their water column. Thermal stratification develops in late spring or summer when the upper layers of the dam are heated by solar radiation faster than the heat can disperse into the lower depths of the dam. The difference in the density of the surface and bottom layers retards circulation within the water column and can lead to the top and bottom layers having significantly different water qualities.

There are three defined depth layers that develop as a water body becomes stratified:

<u>Epilimnion</u> - the surface layer of warm, generally well oxygenated water, circulated by wind action and minor currents
<u>Hypolimnion</u> - the bottom water layer of cooler water, generally anoxic and isolated from wind and thermal effect.
<u>Metalimnion</u> - the layer between the epilimnion and the hypolimnion, a zone of steep decline in temperature and dissolved oxygen with depth.

The thickness and depth of the epilimnion, metalimnion and hypolimnion layers in a stratified storage are influenced by many factors, such as temperature variation, wind mixing and flow through water storage. Once the dam reservoir has stratified, a large amount of energy is often required to break down the layers while summer conditions persist.

In autumn, stratification is normally naturally broken down (a process called "turnover" of the water body) by a decrease in surface temperatures and by wind induced mixing. Isothermal conditions are normally present in dam reservoirs during winter and into spring, until a rise in ambient temperatures may initiate the next season's stratification.

In a stratified water body, water circulation is restricted and oxygen is therefore not carried from the surface layers to the hypolimnion, resulting in a rapid depletion of oxygen in this layer. Anoxic conditions in the hypolimnion often result in the development of a reducing environment, in which manganese, iron and phosphorus compounds are released from the sediments. Further, the production of hydrogen sulphide and ammonia in anoxic conditions can impart bad tastes to drinking water.

For water supply storages, the problem of dissolved metals and nutrients in the hypolimnic water may be overcome while stratification persists by drawing water for treatment at levels above the hypolimnion. However, during turnover, or if the stratified layers are disturbed by wind or storm inflow, the polluted water from the hypolimnion can be drawn into the surface layers and affect the quality of water delivered to the power plant.

High levels of dissolved phosphorus in the hypolimnion may contribute to algal blooms if the nutrient is mixed into the surface photic zone by a temporary upset in the stratification layers or by turnover of the water body. Stratified water bodies provide an environment where cyanobacteria (blue-green algae) may have a competitive advantage over other non-buoyant species. Cyanobacterial blooms are a water quality concern both because of the cells clogging process units and because of the production of algal toxins, which have been shown to have chronic health effects on humans. Blooms are also a risk to people using water storages for recreation activities.

Several factors play a role in the occurrence of this phenomenon in the dam reservoir; these can be indicated as:

- Reservoir volume,
- Reservoir morphology,
- Reservoir depth,
- Geographical location of the region,
- Volume of entrance waterflow (relative to the reservoir volume),
- Depth relative to the reservoir length,
- Operation plan of the reservoir water,
- Temperature of the environment, and,
- Temperature of the flood entering the reservoir.

In large reservoirs with long period of retention time, usually in depths of more than 10 meters thermal stratification takes place.

With the warming up of the surface water layer of the reservoir (due to sun rays), the vertical mixing in the lake reduces (mixing of surface warm water layer with underneath cold water layer); When this status is stronger than the mixing caused through waves by wind currents, thermal stratification occurs.

Due to the temperature is an effective factor on the decomposition of organic matters and chemical reactions, incidence of thermal stratification in the reservoir indicates changes of water quality in various depths. Since water quality is accounted as a fundamental factor for the different consumptions and aquatic life, so thermal stratification can be known, as one of the most crucial environmental impacts of dams that are accounted as being worthy of attention.

At the Arror Dam site, the annual mean evaporation is 2162 mm, annual mean temperature is equal 23.8 °C and mean temperature of coldest and warmest months in the year are 23 and 24.7 °C respectively; also mean wind speed is equal 422 km/day. With due attention to low fluctuation of temperature in different months, occurrence probability of thermal stratification in Arror Dam reservoir is not high. However, due to dam height and reservoir geometry (volume, morphology and depth), there is still possibility to incidence of thermal stratification. So, consideration this issue in dam designing (e.g. water discharge from various elevations) is extremely crucial.

7.3.3.11. Eutrophication in the Reservoir

Construction Phase

No impact.

Operation Phase

Eutrophication is a process that occurs in the lakes, as a result of the presence of high amount of nutrients, organic matters (particularly nitrogen and phosphorous), algae and aqua plant growth which leads to a decrease in the quality of the lake water.

Generally, incidence of eutrophication in lakes was a slow process in the past. Since, land use status in the basin and limits of the dam reservoir, sewage and wastes disposal of population centers and particularly the chemical fertilizers used in the agricultural lands are effective in the occurrence of this phenomenon, during recent decades, it occurs extremely rapidly due to consumption of chemical fertilizers, detergents, discharge of industries, urban and rural sewage into the rivers.

Dominant land uses in the Arror Dam reservoir area are dense forests and agricultural lands. Not consideration of proper land clearance and removal organic soils in the reservoir, provides a high potential to decrease the water quality.

After water taking, organic matters are decomposed at the bottom of the lake under non-aerobe condition and concentration of pollutants increases. In case of increment of phosphorus concentration that enters the river through domestic sewage and chemical fertilizers used in agricultural lands, there is likely to happen eutrophication.

With due attention to a few rural population centers in the dam basin, agricultural activities and consumption of pesticides and chemical fertilizers, a part of nutrients find their way into the River Arror through wastewaters, sediments and runoff. Concentration of these matters can result in incidence of eutrophication in the reservoir and decrease of water quality.

Based on the above mentioned, the occurrence of eutrophication in the Arror Dam reservoir is not far from expectation. Long retention time in the reservoir is an accelerator factor of eutrophication; with more period of time, growth and multiplication of algae would be more.

With due attention to diversion of large amount of water from the reservoir to the power house, retention time in Arror Dam reservoir is not a long time that is a positive point.

Temperature effects directly on the intensity of this process, so reservoir depth and thermal stratification are amongst important effective factors.

During the occurrence of eutrophication and with the increment of algae, the transparency of water decreases and due to the consumption of oxygen by the algae, the concentration of DO decreases in the water; with this decrease and the occurrence of the non-aerobe condition at the bottom of the reservoir, the decomposition of the non-aerobe matters causes emission of hot greenhouse gases and the release of elements such as, iron, manganese and aluminium in the water.

Totally, incidence of eutrophication in the reservoir is assessed as a negative and indirect impact with low intensity and moderate to major importance.

Summary of impacts of the project on water is given in the Table 7.9.

Table 7.9: Summary of impacts of the Project on water

Environmental Factor		Phase	Quality			Type		Intensity					Importance			Duration		Reversibility		Scope		When		
			No impact	Positive	Negative	cumulative	non-cumulative	Negligible	Low	Medium	High	Very high	Minor	Moderate	Major	Temporary	Permanent	Reversible	Irreversible	Direct	Indirect	Immediate	Medium term	Long term
Impact on water	Biology (BOD, etc.)	Construction			√	√			√				√			√		√		√		√		
		Operation			√	√			√				√				√	√			√		√	
	Physics & Chemistry	Construction			√	√					√			√		√		√		√		√		
		Operation			√	√			√				√				√	√			√		√	
	Salinity	Construction			√	√				√				√		√		√		√		√		
		Operation			√	√		√									√	√			√		√	
	Solid Loads & Turbidity	Construction			√	√				√			√	√		√		√		√		√		
		Operation			√	√			√				√				√	√			√		√	
	Temperature	Construction	√																					
		Operation		√		-	-	√					√				√	-	-		√			√
	Evaporation	Construction	√																					
		Operation			√	√				√				√			√		√		√			√
	River Flow	Construction			√	√				√				√		√		√		√			√	
		Operation			√						√			√			√		√	√			√	
	Groundwater Table	Construction			√	v	√	√					√			√		√		√			√	
		Operation			√		√	√					√				√	√			√			√
	Groundwater Quality	Construction			√			√					√			√		√		√			√	
		Operation	√																					
	Water Quality of Reservoir	Construction	√																					
		Operation			√	√			√				√				√	√			√			√
	Sedimentation in Reservoir	Construction			√																			
		Operation			√	√			√				√				√	√			√			√
	Thermal Stratification in Reservoir	Construction	√																					
		Operation			√		√		√					√			√	√			√			√
	Eutrification in Reservoir	Construction	√																					
		Operation			√	√			√					√			√	√			√			√

Construction Phase

No impact.

Operation Phase

By construction of a dam, a large volume of water is reserved in a region, which may have not had such a lake in the past thousands, or millions of years. This thereby causes a transformation, particularly, in the physical nature of that region. However much the area of the lake that is formed, is greater, its impact on the regional climate is more prominent. The impacts of large lakes on the regional climate can be briefly summarized as follows:

- Increment in energy absorption attained from the sun rays
- Temperature exchange between the lake and the proximate atmosphere
- A change in the amount of precipitation, evaporation, fog, wind and evapotranspiration of the region

Identical observations in several parts of the globe demonstrate that, the impacts of microclimate, has been apparent in the maximum, to a distance of 50 kilometers and in extremely intense conditions to a distance of 50 to 150 kilometers. In addition, in such these regions, the seasonal changes of climate are normally more than the annual ones. But in the case of small reservoirs, a change in temperature and precipitation till a radius of 20 kilometers is perceptible.

The amount of evaporation from the surface of lakes is relevant to many aspects such as, the lake surface, depth of lake, regional climate and the speed of wind in the region. The amount of evaporation from the lake surface has a direct connection with the area of the lake, whereas, with the depth of the lake its relationship is in the contrary. In other words, an increment in the lake surface coincides with the increase in the amount of evaporation and as a result the annual evaporation increases. Though, seasonal changes of temperature in lakes of lower depth proved to be more severe and in deep lakes the shortest and longest period of evaporation is postponed.

In arid and semi-arid climates the amount of evaporation increases and in humid climates the amount of evaporation decreases. Similarly, if in an area, the wind does not blow, a large portion of the water that evaporates, remains in the proximate layers of the lake surface and due to the saturation of these layers, the amount of evaporation from the dam lake reduces. On one hand, the maximum amount of evaporation occurs in an arid region is when, the wind currents move aside the steam, attained from the evaporation of the water of the lake surface and the surface water is once again, in the threat of evaporation.

Evaporation from the surface of artificial and natural lakes is of particular complexities. During this process, annually, billions of cubic meters of fresh water, which has been accumulated at high cost and stored, once again returns to the atmosphere. In other words, evaporation and changes in climate arising from it, is accounted for being a desirable environmental phenomenon. Though, from the viewpoint of designers, it is an unfortunate one that leads to the loss of fresh water.

According to meteorology report, the amount of annual evaporation from the free water surface in the Arror Dam Reservoir is equivalent to 2162 mm. Based on this; the maximum amount of evaporation takes place in the month of December with 209 mm.

With due attention to the small area of the dam reservoir (approximately 2.8 Km^2), and high rainfall and relative humidity in the region, no perceptible changes can be expected in the amounts of some of the climatic factors such as, precipitation, temperature, evaporation and relative humidity throughout the region.

7.3.3.12. Air Quality

Construction Phase

Almost all of the activities of the construction phase of the dam such as excavation and embankment, explosion, traffic of vehicles and trucks, transportation of construction materials, construction of cofferdams, dam body, spillway, access roads, camps, land clearance, etc. with the creation of dust, suspended solids and dispersion of pollutant gases such as carbon monoxide (CO), azote oxides (NO_x), and hydrocarbons (HC) into the air make air pollution.

Since the machineries in major work with diesel or gasoline, the amount of nitrogen oxide, sulfur oxide and hydrocarbons increase in the air. The amount of gases dispersed and particles emitted from the diesel and gasoline engines (motors), is compared with each other in Table 7.10.

Table 7.10: Amount of gases dispersed and particles emitted in diesel and gasoline engines (Kilogram in lieu of 3, 785 liters of fuel)

Parameter	Diesel	Gasoline
CO	27	1035
Hydrocarbons	61.2	90
NO_x	100	51
SO_x	18	4
Fugitive Dust	50	5.5

This impact is temporary and is limited to the construction phase. Air pollution affects mainly on the workers, staff and residents in the proximities of these activities.

Due to similar construction activities of dam and hydro power, their impacts on air are the same, only affected locations are different (specifically power house that is located in the Kerio Valley).

It is assessed as a negative impact with medium intensity and importance. Air pollutant parameters within the construction of dam and hydropower are given in the Table 7.11.

Table 7.11: Air pollutant parameters within the project construction

	Hydropower Activities	Parameters				
		HC	CO	SO_2	NO_x	Dust
Dam activities	Excavation & embankment				´Y	´Y
	Explosion				´Y	´Y
	Excavation from borrow areas					´Y
	Traffic of Vehicles & Transportation	´Y	´Y		´Y	´Y
	Work of machineries	´Y	´Y	´Y	´Y	´Y
Hydro-power activities	Excavation & embankment				´Y	´Y
	Explosion				´Y	´Y
	Excavation from borrow areas					´Y
	Traffic of Vehicles & Transportation	´Y	´Y		´Y	´Y
	Work of machineries	´Y	´Y	´Y	´Y	´Y

Operation Phase

The impacts of the plan in the operation period with respect to the air quality are capable of being surveyed from two angles:

1) The emission of greenhouse gases from the reservoir

The eutrophication created in the dam reservoir (see sub-section 5.3.3.11) leads to the emission of greenhouse gases from the reservoir into the atmosphere. Agricultural lands in the Arror Dam basin are accounted for as a critical potential of eutrophication. Similarly, due to potentials of erosion and sedimentation in the basin, organic material enters into the reservoir through flood. The deposition of these matte at the bottom of the reservoir and decomposition process due to non-aerobe condition, increase dispersion of greenhouse gases such as carbon dioxide and methane into the atmosphere.

2) Impacts of humidity with respect to dust

With the formation of the lake dam, the relative humidity present in the air increases. An increment of humidity leads to the dust particles suspended in the air to become heavy as a result of which, the dust particles subside.

The impact No. 1 is a negative impact of the project, is accounted for being long term and probable, which, in the case of executing mitigation plans is capable of being controlled. The impact No. 2 is a positive impact of the project. It is long term and a certainty.

The impact No. 1 is more important but is not tangible for local community; meanwhile the impact No. 2 is less important and tangible. Totally, with due attention to possibility of low intensity of eutrophication in the reservoir, on the whole, air quality in the operation period, can be assessed as being positive.

7.3.3.13. Noise

Construction Phase

As the progression of construction activities, staff and nearby villages are affected by the noise generated at sites.

Two kinds of noise pollution are generally recognized and are often tackled with quite different kinds of legislation. Firstly, there is "occupational noise" which affects workers in the course of their jobs and is due to the work environment and/or to the machinery which they must operate. Secondly there is "environmental noise", such as traffic noise or noise from a loud radio, and which is not related to job. People are largely unaware of the dangers of noise pollution and often unmindful of the annoyance that loud noises can cause, particularly in residential and commercial areas.

Reliable estimates of the direct costs due to ill-health from noise pollution put this figure at as much as 2% of the gross domestic product of a country. The psychological and social cost is difficult to assess.

Sound level is one of the most important parameters when predicting performance effects. The level of noise necessary to produce adverse effects is greatly dependent upon the type of task. Simple tasks remain unaffected at noise levels as high as 115 dB (very loud) or above, while more complex tasks are disrupted at much lower levels. Until fairly recently, the level at which the effects are first seen was thought to be quite high for most conditions, but a summary of recent research points to effects at much lower levels, even as low as 80 dB for intermittent noise.

The ears provide two warning signs for overexposure to noise: temporary threshold shift and ringing in the ears (tinnitus). After leaving a noisy area or piece of equipment, many people commonly experience both of these symptoms. The temporary hearing loss is difficult to detect unless a hearing test is performed. Hearing usually returns almost completely in 12 to 14 hours if there is no more noise exposure. Any amount of hearing that does not return becomes a permanent threshold shift or permanent noise induced hearing loss (NIHL). With repeated exposure, the effects are cumulative.

Almost all the activities in the construction period of the Arror Project, in particular with the explosions, culminate in elevating the level of noise in the region; such that the level of noise can increase till approximately 85 to 105 decibels during the peak hours of work. During the periods of explosions, this level goes even farther. The level of noise during operations, at a distance of more than 150 to 250 meters from the operational area can gain the level of 70 decibels. Noise pollution is confined to the construction period and its impacts are in major on the workers and personnel engaged in project activities. It should be mentioned that noise pollutions arising from explosions, have also an undesirable effect on the wildlife. The resources creating noise pollution in the construction phase of the project are demonstrated in Table 7.12.

Table 7.12: Parameters of sound in the construction period of the project

Pollutant Sources	Radius Influenced	Factors Influenced
Construction of: the dam body and its components, tunnel, water conveyance pipeline (penstock), power house	Immediate limits-surrounding villages	Workers and personnel, regional inhabitants and wildlife
Machinery activities and the commuting of trucks	Immediate limits-surrounding villages	Workers and personnel, regional inhabitants and wildlife
Excavations and explosion	Immediate limits and the surrounding population centers	Workers and personnel, the surrounding residents and wildlife

Operation Phase

No specific and meaningful noise pollution is expected during operation phase of the dam site; however, exceeding the acceptable limits of noise levels is possible, due to hydraulic flow on the turbine blades at power house.

With due attention to existing simple and low cost mitigation measures, and having sufficient distance from rural areas, it is assessed as a negligible negative impact.

Summary of impacts of the project on climate is given in the Table 7.13.

Table 7.13: Summary of impacts of the Project on climate

Environmental Factor		Phase	Quality			Type		Intensity					Importance			Duration		Reversibility		Scope		When		
			No impact	Positive	Negative	cumulative	non cumulative	Negligible	Low	Medium	High	Very high	Minor	Moderate	Major	Temporary	Permanent	Reversible	Irreversible	Direct	Indirect	Immediate	Medium term	Long term
Impact on climate	New Mesoclimate	Construction	√																					
		Operation		√					√				√				√				√		√	
	Air Quality	Construction			√	√				√				√		√		√		√		√		
		Operation		√					√				√				√				√		√	
	Noise	Construction			√	√				√				√		√		√		√		√		
		Operation			√		√	√					√				√	√		√		√		

Cumulative or non-cumulative) and (reversible or irreversible) is matter of concern for only negative impacts, therefore these qualities have not been determined for positive impacts.

7.3.4. Impact on Terrestrial and Aquatic Flora

7.3.4.1. Forest

Construction Phase

Land use in the immediate limits of the project in sections of dam body, spillway, water intake, entrance of tunnel and access road to the dam crest is cultivated lands; meanwhile the ground is covered by grassland and scrub at exit of the tunnel, most parts of the penstock access road, penstock route and power house.

Scrubs are seen mostly on the slope of escarpments including a combination of short trees and short and high bushes. Laying the penstock and construction of its access road on the escarpment requires a belt of deforestation with a width variable from 10 to 30 m, so this impact is evaluated as a negative one. With due attention to low area of deforestation compared to the whole area of escarpments ecosystem, this impact is assessed with medium intensity and importance.

Operation Phase

The impact on forest during operation phase is mainly due to formation of the dam lake. Based on the land use map of the dam reservoir, right-hand slopes of the reservoir are covered by a thick forest which extends widely (Kipkunur Forest). Reservoir area is about 2.8 Km^2 (280 ha), so about 140 ha should be deforested before water taking of dam.

It must be pointed out, all the forests in Kenya are under protection of Kenya Forest Service (KFS) under management of Ministry of Forest; so any land use change in forests should be done through coordination and official correspondence with this organization.

According to FAO Forest Resource Assessment 1990, Kenya is classified among the countries with low forest cover of less than 2% of the total land area. Kenya's forests are rapidly declining due to pressure from increased population and other land uses. With the country being arid and semi-arid, there is a lot of strain on the rest of the land since the economy is natural resource based.

Moreover, the operation of the project can have a negative impact on the natural vegetation (including trees) on the Arror River bank in downstream, especially on the escarpments due to drastic reduction of water flow.

On this basis, the impact on forest is evaluated as a negative and indirect one with medium intensity and major importance.

7.3.4.2. Moor and Fallow (Uncultivated Lands)

Construction Phase

There are no moor and fallow area in the immediate limits of constructional works (in highland or at the location of power house in the Kerio Valley). So, it is classified as no impact.

Operation Phase

Similarly, there are no moor and fallow ecosystems in the reservoir area. So, no impact is expected.

7.3.4.2. Grass Growth (grasslands, steppes, lawns)

Construction Phase

As it has been previously indicated, the ground is covered by grassland and scrub at exit of the tunnel, most parts of the penstock access road, penstock route and power house. So, grass growth shall be disturbed due to construction activities.

With due attention to the small area of constructional works compared to the whole area of the grasslands in the region, this effect shall not be significant. In addition, grasslands are of a lower ecological importance compared to forests. So, it is assessed as a negative impact with low intensity and minor importance.

Operation Phase

Often, through microclimate caused by the dam lake, positive effects on the vegetation growth in the surroundings areas can be seen. But, since, the weather condition in the region especially in terms of rainfall and relative humidity is appropriate, and the area of the grasslands in the upstream basin is low, this effect shall not be significant and will minimized.

Generally, reduction in downstream water flow during operation of the dam, in arid areas, can cause decrement in grass growth of the river bank. But, due to enough rain and humidity in downstream of Arror Dam on highland, grass growth is not dependent on the river. So, no negative impact is expected on grasslands situated on highlands. Also, in downstream of the Arror water fall, due to receiving water of interim basin, there is no high possibility of significant impact.

Totally, it is accounted as a positive impact, but with negligible suitability and importance.

7.3.4.3. Cropped Land

Construction Phase

Based on the land use map, the dam site including dam body, spillway, coffer dams, access road to dam crest and water intake are located in the cropped lands. Thus, these farms (mostly maize farms) shall be acquired and changed land use. This negative impact, due to the small acquired area, shall not be of high intensity and importance.

Operation Phase

Almost, half of the lands in reservoir area on the left river bank are agricultural lands that will be submerged due to water taking the reservoir.

Also, a slight negative impact is expected on the agricultural lands in downstream of the Arror water fall (the ones that shall not be under cover irrigation plan) due to the low water flow in Arror River during operation phase. It must be pointed out, the agricultural lands in downstream of the dam on highland (before water fall) are not dependent on the river.

Therefore, the impact on the cropped lands in the operation period is assessed as negative, though in concern with small area of these lands, it is not outstanding (negative, indirect, low intensity, minor importance).

7.3.4.4. Higher Plants (water weeds)

Construction Phase

Under present conditions, the aquatic flora of the Arror River due to the good quantity and quality in the downstream of the dam site display a varied diversity (according to field visits). But, no specific study has been done on these plants; so there is no data about the types, characteristics and ecological values of higher plants in Arror River.

During construction phase, turbidity and suspended solid loads mainly shall cause the decline of water quality. Moreover, water consumption for constructional activities and temporary camps, shall reduce the water flow. Therefore, construction activities would certainly have a negative impact on water weeds, but compared to operation phase, it would be negligible and shall not be of such importance.

Operation Phase

Due to the drastic reduction the water flow, which also affect the water quality, negative effects shall be seen on the water weeds and other types of higher plants in long term. So, negative impact on higher plants will be a certainty. In this regard, releasing the environmental water flow to keep basic condition of the Arror River and alleviation of the impact has an essential role. Through releasing of sufficient flow in the river, the presence of these plants shall be strengthened and from the viewpoint of riparian the river shall attain a new formation. This impact is evaluated as a negative one with medium intensity and minor importance.

7.3.4.5. Active Microflora (moulds, algae, fungi, etc.)

Construction Phase

There is no data on active microflora of the Arror River. However, generally due to an increase in the organic matters and shortage of dissolved oxygen (DO) in the river, these species can become dominant. Based on which, the construction activities which shall certainly lead to an increase of turbidity and a decrease in DO in the aquatic environment on a short term basis could have an impact on the bloom of these species and lead the river towards a non-aerobe condition that requires monitoring and surveillance during the operation period.

Although it shall be a negative and an indirect impact, based on the lack of real data, in terms of intensity and time period of incidence, it is classified as an unknown impact. It means “No judgement possible at present”.

Operation Phase

Due to, remarkable reduction of water flow in the downstream of the dam site, the water quality shall decrease. So, an increment of moulds, algae, fungi, etc. during operation period is very likely. But, inadequacy of data makes it impossible to identify the impact with certainty. The survey on the intensity of this impact is only possible by monitoring and sampling, which is proposed for the operation phase of the plan.

Similar to the construction phase, this negative impact is classified as an unknown effect.

7.3.4.6. Phytoplankton

Construction Phases

Reduction in the quantitative and qualitative aspects of the river (in downstream) arising from the construction and operation activities, make a decrement in presence and diversity of phytoplankton, or else it can be stated will be replaced by more durable phytoplankton, with lesser oxygen demand.

Since, there is no data on existing phytoplankton species of the Arror River (especially about the tolerance threshold of each species and DO demand), this negative impact is classified as an unknown impact (no judgement possible at present) in terms of intensity and incidence time (column “when” in the tables).

Operation Phases

During operation phase, there is a potential negative effect on phytoplankton in two parts:

- Arror river in downstream of the dam, that is similar to construction phase
- reservoir, due to decrement of DO in the dam lake compared to a river ecosystem.

Implementation of corrective actions in controlling and minimizing this impact shall play a major role. In order to control and monitor the phytoplankton, measuring the density and diversity of phytoplankton species in three depths of the reservoir is recommended. The high diversity of phytoplankton in the dam reservoir illustrates the lack of inclination for the blooming of a particular type of species and an absence of eutrophication (see sub-section 7.2.3.11).

7.3.4.7. Rare/Endangered Plants (Both Aquatic & Terrestrial)

Construction Phase

In the highlands (including Kipkunur Forest, dam site, dam downstream, elevation 1000-2000 m on escarpment), 57 plant species (mostly arboreous) have been identified, among which only one tree *(Juniperus procera)* is classified in LC class (Least Concern according to red list of IUCN), meanwhile there are about 32 flora species under protection (according to national regulation). Most protected species are trees, and construction activities shall be mainly done in agricultural and grass lands. So, this impact is evaluated as negative one with low intensity and minor importance. Construction of power house, due to small area would be negligible.

Operation Phase

With due attention to this fact that about 50 percent of the reservoir area (1.4 Km^2) is covered by Kipkunur forest, presence of the protected species within this area is very likely. Before water taking, trees should be cut and removed from the reservoir area. So, impact of the project on endangered plants during operation phase (due to larger affected lands) is evaluated as a negative one with medium intensity and major importance.

Summary of impacts of the project on the terrestrial and aquatic flora is given in the Table 7.14.

Table 7.14: Summary of impacts of the Project on the Terrestrial and Aquatic Flora

Environmental Factor		Phase	Quality			Type		Intensity					Importance			Duration		Reversibility		Scope		When		
			No Impact	Positive(1)	Negative	Cumulative	Non-cumulative	Negligible	Low	Medium	High	Very High	Minor	Moderate	Major	Temporary	Permanent	Reversible	Irreversible	Direct	Indirect	Immediate	Medium Term	Long Term
Impact on Terrestrial and Aquatic Flora	Forest	Construction			√		√			√				√			√	√		√		√		
		Operation			√		√			√					√		√		√		√		√	
	Moor and Fallow	Construction	√																					
		Operation	√																					
	Grass Growth	Construction			√		√		√				√			√		√		√		√		
		Operation		√		-	-	√					√				√	-	-		√			√
	Cropped Lands	Construction			√		√		√				√				√		√	√		√		
		Operation			√		√		√				√				√		√		√		√	
	Higher Plants (waterweeds, etc)	Construction			√		√	√					√			√		√			√			√
		Operation			√		√			√			√				√	√			√			√
	Active Microflora (2) (moulds, algae, fungi, etc)	Construction			√		√	-	-	-	-	-	√			√		√			√	-	-	-
		Operation			√		√	-	-	-	-	-	√				√	√			√	-	-	-
	Phytoplankton (2)	Construction			√		√	-	-	-	-	-	√			√		√			√	-	-	-
		Operation			√		√	-	-	-	-	-	√				√	√			√	-	-	-
	Rare/Endangered Plants (Both Aquatic & Terrestrial)	Construction			√		√		√				√			√		√		√		√		
		Operation			√		√			√					√									

7.3.5. Impact on Terrestrial and Aquatic Fauna

7.3.5.1. Mammals

Construction Phase

Regardless of the fact that Kenya has rich biodiversity, due to proximity the Kipkunur Forest to the dam site and its main components, and proximity the Kerio National Reserve to the power house, there is also high biodiversity in the study area.

The commuting of heavy vehicles, the presence and commuting of workers, activities of machinery, etc. could cause stress on the mammals and make them escape from the surroundings of the project location. Sounds caused due to explosions during the dam construction period could also intensify these impacts. Light emissions from the construction workshops and residential camps of staff during the night could also afflict stress and create an effect on the regional fauna. The presence of workforce could lead to hunting wildlife, which is accounted for as being an adverse and indirect impact of dam and hydro power construction. The infiltration of grease and oil compounds of machinery into the regional soil and water could raise the possibility of creating disease and the loss of mammals in the area.

The impact on mammals during construction phase, is assessed as a negative and direct impact with low intensity and moderate importance.

Operation Phase

After the reservoir filling and formation of the lake, relocating and shifting mammals, due to habitat occupation and or blockage of the movement or traversing route of mammals is a certain. Mammals shall migrate to the upper areas of Kipkunur Forest with higher elevation which will be most similar to their previous habitat.

The abundance and diversity of mammals in downstream of the dam site is not high, due to rural population centers and land use change to agricultural lands. So, reduction of water flow in downstream would not be a substantial effect on mammals.

The impact on mammals during operation phase, is assessed as a negative and indirect effect with medium intensity and moderate importance.

7.3.5.2 Birds

Construction Phase

Birds, due to their power of flight, shall be inflicted with slighter damages, except for the presence of manpower and hunting. In regards waterfowl, in the case that the migration season synchronizes with the construction activities, shall make them leave the region. So, the impact on birds is evaluated as a negative one with negligible intensity and minor importance.

Operation Phase

Previous experiences have shown that dam lakes are suitable habitats for birds. Therefore, Arror Dam lake will play an important role in attracting birds especially waterfowl. Based on the large number of identified waterfowl in the study area, impact on birds are amongst the positive ones with medium to high suitability and moderate importance.

7.3.5.3 Reptiles and Amphibians

Construction Phase

Construction activities of the project, in areas of all main components, could afflict destructive effects on the habitats of reptiles and amphibians; and slow movements or inability to move quickly, exacerbate this effect.

The presence of a large number of workers and other staff in the region can also be another facet for the elimination of reptiles, as the general belief is that reptiles, especially snakes are dangerous and must be eradicated upon observance.

The impact on reptiles and amphibians during construction phase is accounted as a negative and direct one with low intensity and minor importance.

Operation Phase

Due to water intake of the reservoir, a part of the reptile and amphibian habitats shall be submerged. Hence, this matter shall cause the death of a number of reptiles, due to their lack of rapid movement ability. On the other hand, the dam lake can be a positive factor for the increase of some reptiles and amphibians. In actual fact, after the destructions pertaining to the construction phase and the habitats occupation by the reservoir filling, the operation impacts on these fauna, particularly amphibians is assessed as being positive.

No specific impact is expected due to other components of the project such as tunnel, penstock and power house during operation phase.

7.3.5.4. Fish Species

Construction Phase

Two fresh water fish species have been identified in the Arror River. As previously indicated, diversion and consumption the Arror River water for temporary residential camps and construction activities shall lead to a decrement in the quality and quantity of water.

So, the environmental conditions for fish species in the downstream of the Arror River shall be difficult and unsuitable.

Operation Phase

The living condition for fishes in downstream of the dam, due to drastic reduction of water flow shall be very difficult. But based on the following factors, this impact shall not be of a much intensity and importance.

- Abundance and diversity of fishes in Arror River is not high,
- The people living are not dependent on the fishing from the Arror River,
- Releasing environmental water flow could alleviate the impact,
- There is Arror water fall between Arror on highland (elevation 2000 m) and Arror in Kerio (elevation 1000 m), thus fish migration from downstream to upstream for spawning is not naturally possible.

Moreover, the formation of the lake can attract the fishes from the upstream of the Arror River towards the reservoir. The dam reservoir is accounted for being a secure and suitable habitat for fishes and to a certain extent, shall cause the restoration of some of the species.

With due attention to the objectives of the Arror Dam which is mainly to supply electricity and then drinking and irrigation water on the secondary, the fish community in the lake must be under control and no kind of aquaculture and or fish farming is proposed in the dam lake.

7.3.5.5 Macro-invertebrates, Zooplanktons and Microorganisms

Construction and Operation Phases

There is no data on macro-invertebrates, zooplankton and micro-organism due to lack of study. So, at present, professional judgment cannot be for certain and it is desirable to justify the same by sampling and monitoring programs.

It can be said that, through reduction of water flow in downstream during operation phase, living status for micro-organisms and zooplankton, as the first links of the food chain, shall be difficult. On the contrary, through releasing the environmental water requirements and securing the minimum basic river flow, the intensity of the impact shall reduce and the microorganisms of the river shall have more appropriate conditions. This issue demonstrates the importance of enforcing corrective methods, in reducing the negative impacts of the plan. On this basis, no judgement is possible at present, especially on intensity and importance of the impact.

7.3.5.6 Protected Areas

Construction Phases

Based on the conformity and overlaying the map pertaining to the protected areas of Kenya with the limits of the project, it is clear that the immediate limits of the project are not located in any protected area under management of Ministry of environment and natural resources and its agencies. So, no impact is probable.

Operation Phases

As it mentioned before, upper parts of the reservoir area is located in the Kipkunur Forest (about 1.4 Km^2); which shall be cut and removed before water taking the reservoir. All the forests in Kenya are under management and conservation of Ministry of Forestry and Wildlife (KFS), therefore, Kipkunur Forest is known as a protected area. On this basis, this impact is assessed as a negative one with medium intensity and major importance.

Kerio National Reserve is the nearest protected area to the project limits, located in Kerio Valley about 12 Km far from the proposed irrigation area, that is under discussion in identifying of the impacts of irrigation project.

7.3.5.7. Rare/Endangered Species (Both Terrestrial and Aquatic)

Construction Phase

Due to rich biodiversity of the project area, presence of wildlife including endangered species in surrounding area is very likely. About Six (6) mammals and 16 birds, recognized in the study area, are in one of classes of threaten such as EN, NT and VU.

A part of wildlife habitat shall be occupied by construction activities and through high levels of noise (at work peak), fauna species shall have a sense of insecurity. So, the impact on the endangered species is amongst negative one with low intensity and moderate importance.

Operation Phase

Since endangered species are a part of fauna community exist in the region, the impact is similar to impacts on the mammals (see sub-section 7.3.5.1), birds (see sub-section 7.3.5.2), reptiles and amphibians (see sub-section 7.3.5.3) and fishes (see sub-section 7.3.5.4).

On this basis, this impact is evaluated as a negative one (except for impacts on birds), with medium intensity and major importance.

Summary of impacts of the project on the terrestrial and aquatic fauna is given in the Table 7.15.

Table 7.15: Summary of impacts of the Project on the Terrestrial and Aquatic Fauna

Environmental Factor		Phase	Quality			Type		Intensity					Importance			Duration		Reversibility		Scope		When		
			No Impact	Positive(1)	Negative	Cumulative	Non-cumulative	Negligible	Low	Medium	High	Very High	Minor	Moderate	Major	Temporary	Permanent	Reversible	Irreversible	Direct	Indirect	Immediate	Medium Term	Long Term
Impact on Terrestrial and Aquatic Fauna	Mammals	Construction			√		√		√					√		√		√		√			√	
		Operation			√		√			√				√			√		√		√		√	
	Birds	Construction			√		√	√					√			√		√		√			√	
		Operation		√		-	-			√				√			√	-	-		√			√
	Reptiles & Amphibians	Construction			√		√		√				√			√		√		√			√	
		Operation		√		-	-			√			√				√	-	-		√			√
	Fish Species	Construction			√		√		√				√			√		√		√			√	
		Operation			√		√			√				√										
	Macro-invertebrates	Construction			√		√	-	-	-	-	-	-	-	-	√		√		√		-	-	-
		Operation			√		√	-	-	-	-	-	-	-	-		√	√			√	-	-	-
	Zooplankton	Construction			√		√	-	-	-	-	-	-	-	-	√		√		√		-	-	-
		Operation			√		√	-	-	-	-	-	-	-	-		√	√			√	-	-	-
	Microorganisms	Construction			√		√	-	-	-	-	-	-	-	-	√		√		√		-	-	-
		Operation			√		√	-	-	-	-	-	-	-	-		√	√			√	-	-	-
	Protected Areas	Construction	√																					
		Operation			√		√			√					√		√		√		√		√	
	Rare/Endangered Species (Both Aquatic & Terrestrial)	Construction			√		√		√					√										
		Operation			√		√			√					√									

Being (cumulative or non-cumulative) and (reversible or irreversible) is matter of concern for only negative impacts, therefore these qualities have not been determined for positive impacts

7.3.6. Impact of the dam on lake Turkana

Lake Turkana is located within northern Kenyan, within the arid and and the world's largest desert lake. Lake Turkana's surrounding areas border Ethiopia, South Sudan, and Uganda.

Lake Turkana is sustained by the inflows of Ethiopia's Omo River, which alone provides about 90% of the lake inflow while The Kerio and Turkwell rivers contribute 10% (Avery, 2010).

Arror river, where the proposed dam will be built, flows to Kerio river. The Kerio River rises on the north slopes of the Amasya Hills to the west of Lake Bogoria. It flows northward through the Kerio Valley between Tugen Hills and Elgeyo Escarpment. The Kerio continues northward, often through deep and narrow valleys, to enter Lake Turkana in a delta just south of the delta formed by the Turkwel and Lokichar rivers. In their lower courses both these rivers are seasonal.

Kerio river bed during dry season

Kerio river flooding during rain seasons

The proposed project is envisaged to have minimal/low impact on Lake Turkana.

7.3.7. Most Important Adverse and Beneficial Impacts of the Dam & Hydropower

Most important negative impacts of the project are as follows:

- Land acquisition within reservoir area and population displacement
- Reduction of water flow in downstream of the dam site
- Reduction of water quality in downstream of the dam site
- Probability of thermal stratification and eutrophication in the reservoir
- Loss of forest within the reservoir area (as both a valuable ecosystem and a protected area)
- Impact on protected flora species
- Impact on rare/endangered fauna species

Most important positive impacts of the project are as follows:

- Electricity generation
- Supplying drinking and irrigation water
- Protection against flood and other natural hazards
- Improvement of infrastructure, especially communication roads
- Migration to the region and reduction of willingness to migrate to other towns
- Increase of new job opportunities
- Creation of a new and attractive landscape due to formation of the dam lake

7.4. Potential Impacts of the Proposed Irrigation Project

7.4.1. Introduction

The importance of environmental protection and conservation measures has been increasingly recognized during the past four decades. It is now generally accepted that economic development strategies must be compatible with environmental goals. This requires the incorporation of environmental criteria into the process of development. It is important to make choices and decisions that will eventually promote sound development by understanding the environment functions. The United Nations Conference on Environment and Development (UNCED) in its Agenda 21(Chapter 18: Protection of the Quality and Supply of Freshwater) underscored the importance of environmental protection and conservation of the natural resource base in the context of water resources development for agriculture and rural development.

Irrigated agriculture often radically changes land use and is a major consumer of freshwater. Irrigated agriculture is crucial to the economy, health and welfare of a very large part of the developing world. It is too important to be marginalized as it is vital for world food security. Irrigation development thus has a major impact on the environment. All new irrigation development results in some form of degradation. The impacts may be both to the natural, physical environment and to the human environment. Therefore, identifying the acceptable level of environmental degradation through environmental impact assessment (EIA) study and its compensation through mitigation plans is necessary.

Clearly an EIA will not resolve all problems. There will be trade-offs between economic development and environmental protection as in all development activities. However, without an EIA, informed decision making would be impossible.

In this chapter, the environmental impacts of the irrigation project will be predicted and assessed. These include positive and negative impacts, direct and indirect ones, short and long term effects, and also inevitable and irreversible ones during the operation level as well as after the beneficial life of the project. Although agricultural development has always had positive impacts on human life, irrigation project might have negative impacts on the environment that may affect the sustainability of the project. In the prediction of the impacts, both the project impacts on the environment and the impact of environmental factors on the project should be taken into consideration.

Like that of dam and power plant, the assessment of the environmental impacts of the irrigation project was done through the check-list method. With this method, all the data were classified and all the possible impacts were covered. In addition, this method makes it possible to easily sum up the impacts of all main components of the project at the same scale.

7.4.2. Impacts on Physical Environment

Among the most important physical parameters of the environment which will be affected during the construction and operation phases are climate, air quality, soil properties, water quality and quantity of the rivers in the region, and self-purification of river. These parameters will be considered as follows:

7.4.2.1. Impact on Climate (Micro-Climate)

Construction Phase

No impact.

Operation Phase

The main objective for the proposed construction of the Arror Dam is for generation of electricity and the irrigation project is considered as a secondary objective. The irrigation water requirement will be supplied by the output water from power house, after its potential is used for generating electricity. In the operation phase, based on water demand, the output water from power plant is stored in a re-regulating pond with a volume of 50,000 m^3 and is then conveyed to the irrigation network through conveyance pipelines.

Impact on climate or creating micro-climate is usually caused by water storage and formation of large lakes. Therefore, due to the low volume of the re-regulating pond, operation of the project does not have any impacts on weather and climate. It is worth mentioning that the impacts of Arror Dam reservoir on climate are considered and assessed in the operation of the dam and the power plant.

Expansion of irrigated farming area and creation of a wet surface of about 1400 ha can contribute to make the surrounding weather mild. This is the only conceivable impact that the operation of the irrigation project can have on the micro-climate.

This impact is considered as positive and inevitable which will appear with low suitability and importance, and permanent and irreversible.

7.4.2. 2. Air Quality

Construction Phase

In the construction phase, excavation activities, embankment for the creation of re-regulating pond, pavement, cutting rocks, laying of pipelines, commuting of trucks, activities of heavy machinery, cutting trees, land clearance and all the construction activities will make dust, and disperse smoke and emission in the air. The effective range of these activities is the immediate area which mainly affects workers, employees and residents of population centers located near the project area. Thus, the intensity of negative impacts will be on the residents of Koitilial, Arror, Chepkum, and Chesetan villages.

The pipeline route with the length of approximately 15 Km is almost parallel with the only main road in Kerio Valley (depending on the topographic condition, at some parts the pipeline is located on the right side of the road while at some parts it is located on the left). Therefore, all the people commuting from this road (especially children and teenagers who walk to school through this road) are affected by the air pollution. Based on the above-mentioned points, the impacts of construction phase on weather quality are assessed to be negative, inevitable, temporary and reversible with medium intensity and low importance.

Operation Phase

Kerio Plain is a natural and virgin region which is currently far from any industrial units and thus has a clean and healthy air. However, the main road and the side roads which lead to Kerio River are dirt roads. Therefore, dust is dispersed in the air when vehicles pass by these roads. Given the limited number and traffic of the vehicles and local residents' low level of life expectation, this issue is not important.

During the construction phase of the irrigation project, by asphalting the only main and access road to the region, the potential of generating dust is minimized. In addition, as the weather humidity increases, especially in areas under sprinkler irrigation, aerosols and dust are suppressed on the ground.

Therefore, the operation of the project is indirectly positive on weather quality, which will appear with negligible suitability and low importance considering the conditions of the region.

7.4.2.3. Impact on Soil Properties

Construction Phase

The traffic of graders, excavators and hoes which are used for construction of water intake facilities and laying pipelines leads to soil compaction. This makes the water pipeline route to be linear (i.e. long with low width). Cutting trees and land clearance in parts where the pipeline passes through forest areas, before excavation, in addition to disturbing the soil structure, causes severe erosion.

The impact of construction phase on soil, compared to other impacts of the project and with regard to limited affected areas, is of low importance and will be reversible in short-term with mitigation plans.

Operation Phase

The accumulation of salts in soils can lead to irreversible damage to soil structure essential for irrigation and crop production. Effects are most extreme in clay soils where the presence of sodium can bring about soil structural collapse. This makes growing conditions very poor, makes soils very difficult to work on and prevents reclamation by leaching using standard techniques.

The danger of potential soil acidification needs to be considered. The transfer from rain fed to irrigated farming or intensification of existing irrigated farming requires a higher level of nutrient availability in the soil profile. If this aspect is not given adequate attention, the irrigation efficiency remains low.

High water losses through the soil profile cause washing out useful cations from the soil-complex. A general lowering of pH may result in a decrease of the plants capability to absorb nutrients. The decrease of pH may also result in an increased availability/release of heavy metals in the soil profile. For similar reasons, the content of organic material in the soil may decrease. Such decrease leads to a degradation of soil structure and to a general decrease of soil fertility.

With regard to the following reasons, the probability of destruction of soil structure is very low in the operation phase:

- The soil type is mainly Sandy loam and Sandy clay loam
- The soil has very good natural drainage
- High permeability
- High efficiency of under pressure irrigation (sprinkler and drip) compared to other types of irrigation

Accordingly, this negative impact is assessed to be of low intensity and negligible importance. It is worth mentioning that project management plays an important role in its stability and in case of lack of planning and management, the impacts which are predicted to be negligible can become main obstacles in the long run and make the project unprofitable.

7.4.2.4. Soil Salinity

Soluble salts can pass through layers of soil with water, or be kept in pores or on clay soil particles. Therefore, the soil has a potential of salinity and salt can be compressed in it or it can be discharged through leaching.

Construction Phase

No impact.

Operation Phase

The evaporation rate is high in Kerio Plain (i.e. 2597 mm annually in Perkerra station). Therefore, (based solely on evaporation factor) at the time of irrigation of lands, due to water evaporation from surface soils, there is a possibility of soil salinity.

Given the fact that based on soil surveys, none of the soil unit components is limited regarding salinity and that irrigation method is considered to be under pressure (i.e. sprinkler and drip), the impact of the project on changing soil salinity and quality is not likely. In under pressure irrigation, volume of water is low and efficiency of irrigation is high. Accordingly, the problem of soil salinity in the project does not have much importance.

Although the impact of project on soil salinity is assessed with low intensity and importance, soil monitoring during operation to ensure the sustainability of the project is necessary.

7.4.2.5 Impact on Local Erosion

The method of irrigation profoundly affects the vulnerability of the land to erosion. As the irrigated land is wet, it is less able to absorb rainfall and runoff will therefore be higher. Field size, stream size (drop size), slope and field layout are all difficult to change and they all significantly affect erosion rates. Careful design can avoid the occurrence of erosion problems.

Construction Phase

Construction activities generally expose soil to erosion. Excavation and embankment for piping the main pipelines (north and south line) is done with a total length of 15,500 m in a depth of 2-2.5 m, and with a total length of 80,320 m in an approximate depth of 1.5 m for the sub-main pipelines which will lead to accelerated erosion. Cutting trees and bushes which are within the pipeline bound and land clearance will also exacerbate this erosion.

According to the slope direction, eroded soils enter Kerio River with runoff and increase the total suspended solids of the water. Given the fact that the turbidity of Kerio River is already high, the entrance of extra solid loads can exceed the tolerance threshold of aquatic creatures of the river (especially fish) and make their living conditions difficult.

The important point is that after the pipe laying activities, the vegetation should be reclaimed.

The impact of construction phase on soil erosion is considered as negative and inevitable which is assessed with relatively high intensity, yet temporary and reversible.

Operation Phase

Right now, land use of cultivable lands which have been under soil studies include various combinations of farm land, fallow, bush land, range land, and forest. Based on field studies and interviews with local residents, the most important factors for fallow lands and ploughed yet abandoned lands are lack of sufficient water and drought in recent years.

With the start of project operation, due to changing the lands use to agriculture, exacerbation of erosion is expected which is a negative and inevitable impact. With regard to climate condition, vegetation with moderate to high density in Kerio Plain, and the not very large area of the irrigation project, this impact will show up with low intensity and importance and will be reversible.

7.4.2.6 Impact on River Morphology

Construction and Operation Phases

The capacity and shape of a river result from its flow, the river bed and bank material, and the sediment carried by the flow. Reduction in low flows and flood flows may significantly alter the river morphology, reducing the capacity to transport sediment and thereby causing a build-up of sediments in slower moving reaches and possibly a shrinking of the main channel, as well as increasing flows will have the reverse effect.

Since the water needed for the proposed irrigation project is supplied by the water from the power plant, and as the main objective of constructing Arror Dam is not the irrigation project.

During operation phase, runoffs from agricultural land under the irrigation project will be discharged into Kerio River. Meanwhile, with the exacerbated erosion, loads of sediments entering the river will also increase. Given the wide bed and high water volume of Kerio River, and also several tributaries which join this river in the upstream and downstream of the project, the negative impact of runoffs and sediments on the morphology of Kerio River was assessed to be low, with less importance and reversible.

7.4.2.7 Impact on River Water flow

Construction Phase

The water needed for construction activities and temporary residential camps is supplied from Arror River and other rivers, floodways, and drains which all merge with Kerio River in Kerio Valley. In this valley, many rivers join Kerio River from left and right banks. Since the irrigation p area is located on the left of Kerio River, it is possible to supply the water of the project from these rivers. The most important rivers in the project area which join Kerio River from the left are Embamachukwa in the south of Arror River, and Chesoi and Embamonin the north of Arror River.

Due to water usage from Arror River and other streams which join Kerio River, the construction phase of the project will not only reduce the flow of these rivers (especially Arror River) directly, but also will have an indirect negative impact in the flow in Kerio River (especially during dry season). Comparing the needed amount of water for the project and the high flow in Kerio River, this impact is not of great intensity and importance.

Reducing river flows is considered as an inevitable impact of the project which is evaluated to be of low intensity and importance, temporary, and reversible.

Operation Phase

The impact of operating the irrigation project on the river flow can be considered from two aspects, one of which proves to have negative impacts while the other bears positive ones. In what follows, these impacts will be dealt with if the irrigation project is not operated, output water from the power plant will be discharged directly into Kerio River through a natural drainage. Thus, water that is taken from Arror River in the upstream will discharge into Kerio River in the downstream. Despite the adverse impacts on a longitude distance of Arror River, its adverse consequences will not be significant in nature (since Kerio and Arror Rivers are located in the same catchment area of Lake Turkana).

In case of operation of the irrigation project, the output water from power plant will be transferred through water pipelines for agricultural and drinking purposes of the residents. So that 120 lit/s water for drinking purpose and 1880 lit/s for agricultural purpose are supplied through it.

Therefore, during operation phase of the proposed irrigation project, about 2 m^3/s of the output water from the power plant will not be discharged directly into Kerio River, and the water intake from Arror River will not return to Kerio River neither from the natural course of Arror River, nor from the output of power plant. In fact, utilized water returns to nature in the form of sewage or agricultural waste water.

Due to high flow of Kerio River and the fact that many branches join this river in the downstream, although this is considered as a negative, inevitable, permanent, and irreversible impact of the project, it is assessed with moderate intensity and importance.

Currently, near Arror River in Kerio Valley, there are small scattered lands which are under cultivation. The main source of water supply for these lands is Arror River with a traditional irrigation system. Within the distance between the waterfall to where the Arror joins Kerio River, water is diverted to agricultural lands through 8 furrows (made by local residents). Before joining Kerio River, a total of about 600 lit/sec of water is withdrawn from Arror River through the mentioned furrows.

With the operation of the project, around 202.5 lit/sec of water take S9 in south conveyance line will be dedicated to irrigation of these lands and part of their needed water is supplied through the project. Therefore, the project has a direct positive impact on the flow in this part of Arror River and an indirect positive one on the flow in Kerio River. Accordingly, other agricultural lands which are currently irrigated by other available streams in the region will be covered by the irrigation network. Hence, from this viewpoint, the impact of the project on river flow is assessed to be positive.

As a result, the impact of operation of the irrigation project on Arror and Kerio Rivers flow is assessed to be negative, with low to moderate sustainability and importance.

7.4.2.8. Impact on Water Quality

Construction Phase

Although excavation and embankment volumes have not been calculated yet, a preliminary comparison shows that in order to lay main pipes in a 2-2.5m depth and 15.5km length, excavation is done less compared to when sub main pipes are laid in a depth of 1.5m and a total length of about 80km. In addition, submain pipes within the network limits will establish in the banks of Kerio River, while main pipelines laid are almost parallel with the main road of Arror-Chepkum-Tot which is in sufficient distance from Kerio River.

Accordingly, due to high volumes of excavation and also closeness to Kerio River, construction activities related to sub main pipes will have greater impact on water quality of this river, compared to other activities of this phase. This impact is mainly in the form of an increase in the suspension of solid loads and turbidity of water. Since Kerio River already has high turbidity (based on field observations and experiments conducted by the Italian consultant from physico-chemical factors), the entering excess loads of suspended solids in a range of approximately 15 km length (length of network limit in the left bank of the river) can make living conditions difficult for the aquatic animals which are compatible with the current conditions of the river.

The impact of construction phase on water quality is of moderate intensity and importance due to high flow of Kerio River and the temporariness of this impact.

Operation Phase

Arror and Kerio Rivers are the most important rivers of Kerrio Valley in the study area which are exposed to pollution during the operation phase due to receiving agricultural drainage water. Therefore, increase in concentration of the pollutants in these rivers is among the most important impacts of the irrigation project, which will definitely occur since the early years if mitigation plans are not implemented. Since agricultural lands drainage water are rich in nutrients (potassium, phosphorus, and nitrate) and high soluble materials, in case of reaching rivers or ground waters will pollute waters and threaten the lives of aquatic animals.

Due to their low solubility, phosphate fertilizers cannot easily penetrate deep in the soil. Therefore, they will easily transport to surface waters through erosion and runoffs and pollute surface waters. Nitrate fertilizers with different combinations, on the other hand, can penetrate deep in the soil due to their high solubility in water. Hence, they can easily contaminate ground waters. In addition, they can reach surface water sources through surface runoffs and contaminate them.

Pesticides are another source of pollutants which mainly include insecticides, fungicides, and herbicides. Pesticides with high solubility in water penetrate deep in the soil through runoffs and are capable of contaminating surface and ground waters.

Using pesticides and phosphate or nitrate fertilizers in agricultural lands which are covered by the irrigation project is inevitable. The usual amount of fertilizer consumption is 50 kg/ha. Therefore, for about 1,400 ha of agricultural lands, 70,000 kg of fertilizer is used, some of which will enter the river. Given the soil fertility of the region, it is likely to use less fertilizer.

The usual amount of pesticides consumption is about 250 gr/ha, therefore, about 350 kg of pesticide is used in 1,400 ha. Even though pesticides that are produced today are unstable and quickly decompose in nature, some of them enter the river.

Based on the above-mentioned points, the impact of project operation on water quality is assessed to be negative, inevitable, permanent, and reversible with moderate intensity and low importance.

7.4.2.9. Impact on Low Flow Regime

Construction and Operation Phases

Generally, changes to the low flow regime, downstream users, whether they abstract water in the river for transportation or hydropower may have significant negative impacts on irrigation schemes or domestic use.

In the current project, the impact on low flow regime is related to Arror Dam and hydropower plant which have been described in this chapter (see section 7.2).

If the needed water for irrigation is directly supplied by constructing dam on the river or pumping water from the river, it can be said that the construction and operation of these projects will have a negative impact on the low flow regime of the river, so that in the worst conditions, the river will not even have base flow.

Given the following points, the impact of irrigation project on low flow regime of the important rivers in the study area (i.e. Arror and Kerio Rivers) (with regard to points mentioned in sub-section 7.3.2.7) will be negligible:

- the needed water for the project is supplied by the output water from the power plant
- Arror Dam is not constructed as the main objective of this project
- to supply the needed water for the project, no water is pumped from Arror River
- to supply the needed water for the project, no water is pumped from Kerio River

7.4.2.10. Impact on Flood Flow Regime

Construction and Operation Phases

No impact. The same as the impact on low flow regime.

7.4.2.11. Impact on Diffusion of Salts and Toxic Substances in Water

Construction Phase

No impact.

Operation Phase

Reduction of river flow will increase the concentration of pollutants in different ways through pointed and non-pointed pollutant sources.

In the operation phase, drainage water from lands under irrigation network discharge mainly into Kerio River and partly to Arror River (before joining Kerio River). These drainage waters contain different kinds of soluble pollutants and toxic materials; therefore, there is a possibility of an increase in the concentration of soluble and toxic materials in these rivers. Some soluble salts are toxic in high concentrations. Pesticides are also considered as toxic chemicals. These materials are toxic for plants, fish, birds, animals, and human beings. Even when they are not in the form of solution, some of these materials transport in combination with soil particles through erosion and runoffs. To summarize, operation of the irrigation project will increase the concentration of these substances in water. Therefore, with the current conditions of the area, similar to the impact of the project on water quality (i.e. chapter 7.3.2.8); this impact is assessed to be negative, inevitable, permanent and reversible with moderate intensity and low importance.

7.4.2.12. Impact on Self-purification Capability of the River

Construction Phase

Construction activities such as excavation, embankment, laying main and sub-main pipes of water conveyance under the soil, etc. will decrease self-purification capability of Kerio River and Arror River (before joining Kerio River) through increasing suspended solid loads and water turbidity.

Although mean annual flow of Kerio River is good, high fluctuation is observed in mean monthly flow. In other words, Kerio River flow can be divided into dry seasons and flood flow ones. If the construction activities coincide with the low flow months, the impact of the project on the self-purification capability of Kerio River will be intensified.

Although Arror River is a smaller river compared to Kerio, as it is originated from highlands, it does not fluctuate severely. Therefore, the impact of the project on this river during different months is almost the same.

Given the high mean annual flow of Kerio River, this impact will not be of high intensity. However, it can be said that it will occur with greater intensity in Arror River (within the distance from the waterfall to where it joins Kerio River).

Reduction of self-purification capability of the river during the construction phase is considered as a negative, temporary, and inevitable impact of the project which is assessed to be of moderate intensity and low importance due to the limited affected area compared to the area of Kerio Valley.

Operation Phase

This impact is similar to that of water quality and quantity. In other words, since the project has the potential of affecting the quantity and quality of river flow, its impact on the self-purification capability of the river will also be inevitable.

In the operation phase, with the increasing use of chemical fertilizers and pesticides and the fact that they reach the river through runoffs, self-purification capability will decrease which will occur with greater intensity compared to the construction phase. The intensity and importance of this impact of the project is assessed to be similar to that of water quality.

Characteristics of the impacts of the project on physico-chemical factors are summarized in Table 7.16.

Table 7.16: Impacts of the Irrigation Project on the Physical Parameters in Construction and Operation Phases

Phase	Impact Physical Factor	Quality		Reversibility		Scope		Duration		Type		Intensity (Destructive/Suitability)				
		Positive	Negative	Reversible	Irreversible	Direct	Indirect	Short Term	Long Term	Cumulative	Non-Cumulative	No Impact/Negligible	Low	Moderate	High	Very high
Construction Phase	Climate (Micro-climate)											*				
	Air Quality		*	*		*		*		*				*		
	Soil Properties		*	*		*		*			*		*			
	Soil Salinity											*				
	Local Erosion		*		*	*		*			*				*	
	River Morphology											*				
	River Water Flow		*	*		*		*		*			*			
	Water Quality		*	*		*		*		*				*		
	Low Flow Regime											*				
	Flood Flow Regime											*				
	Diffusion of Salts & Toxic Substances in Water											*				
	Self-Purification Capability of the River		*	*			*	*		*				*		
Operation Phase	Climate (Micro-climate)	*		*		*			*		*		*			
	Air Quality		*	*			*		*		*	*				
	Soil Properties		*	*			*	*			*	*				
	Soil Salinity		*	*			*	*			*	*				
	Local Erosion		*		*	*		*			*		*			
	River Morphology											*				
	River Water Flow		*	*			*		*	*				*		
	Water Quality		*	*		*			*	*				*		
	Low Flow Regime											*				
	Flood Flow Regime											*				
	Diffusion of Salts & Toxic Substances in Water		*	*		*			*	*				*		
	Self-Purification Capability of the River		*	*		*			*	*				*		

7.4.3. Impact on Biological/Ecological Environment

7.4.3.1. Impact on Flora

Construction Phase

Before the constructional activities begin, there is a need for clearing existing vegetation within areas where the pipelines are laid. This leads to loss of existing flora through the clearing process. Loss of flora also leads to increased erosion as a result of unstable top soil, resulting in soils with lower nutrient content.

It is considered as a negative and inevitable impact with low intensity and importance.

Operation Phase

Based on the list published in the official website of Kenya Wildlife Service (KWS), Kerio Valley is considered as an endangered ecosystem. Therefore, protecting this ecosystem which has a rich biodiversity is considered as a primary principle in operation of any development plan in this region.

The irrigation project covers an area of about 1,400 ha in the west bank of Kerio River, of which only some small parcels of land around Koitilial village are currently agricultural. Part of agricultural lands has been laid fallow due to water shortage. Other lands are woodlands with high density. Only in some parts of lands which are located in the south of Chepkum, vegetation with less density can be seen. Various species of Acacia are the dominant species in Kerio Plain which is not on Red List of IUCN, but some of its species are considered as protected based on national laws of Kenya.

Accordingly, with the operation of the irrigation plan, an area of less than 1,400 ha (including lands which are currently under cultivation) will go through land clearance or under agro-forestry cultivation. Given the high density of natural vegetation in the project area, in order to minimize the damage to the natural vegetation of the area, using agro-forestry pattern is inevitable.

Therefore, this impact will be assessed while the following points are taken into consideration:

- according to KWS list, Kerio Plain is considered as an endangered ecosystem
- the dominant species is Acacia which is not considered to be threatened according to Red List of IUCN
- the ecosystem is almost similar throughout the vast plain of Kerio
- the project area is rather small in comparison with the area of Kerio Plain and does not have any special features compared to other parts of the valley
- the main usage in the project area is woodland with high density

Taking all the above-mentioned points into account, this impact is considered as negative, inevitable, and irreversible with moderate intensity and importance.

7.4.3.2. Impact on Rare/Endangered Flora Species

Construction Phase

No impact.

Operation Phase

The criteria for the identification of threatened flora species are the rules set out by Kenya and IUCN. According to the mentioned criteria, none of the identified species in the region is classified under any of the threat categories of "Endangered", "Near Vulnerable", or "Threatened". *Mangiferaindica* is the only species of Kerio Plain which exists under Deficient Data (DD) classification, according to Red List of IUCN.

In addition, in spite of significance and ecological value, none of the species of Kerio Plain, Kerio River bank, and Arror River bank within the altitude 1,000-2,000 m is classified under the threatened species list of KWS. Therefore, damage to rare and endangered plant species due to the execution of the project is considered as a negligible impact.

7.4.3.3. Impact on Pests and Weeds

Aquatic weeds are plants which spend their whole life or at least part of it in the sea. These weeds have various adverse impacts such as causing problems in irrigation and producing unpleasant odors in the environment.

Construction Phase

No impact.

Operation Phase

Agriculture development, type of irrigation, and type of cultivation have an impact on proliferation and spread of weeds. In addition, the moisture resulting from irrigation of the farms and the water flow in irrigation networks will lead to the growth of some fungi.

Operation of agricultural lands is associated with the growth and spread of weeds. These species gradually intrude natural vegetation types and meddle with their combination. If the vegetation type is structurally weak, intruding plants will grow and spread faster.

In addition, growth and spread of weeds will lead into an increase in the consumption of pesticides and herbicides which will eventually discharge into Kerio River along with runoffs directly and (through drainage water) indirectly. Since the general slope of some parts of lands (proposed for irrigation project) is towards this river, consumed pesticides enter the river and lead to its contamination.

Therefore, this impact can be considered as a negative, inevitable, and reversible one with low intensity and importance. Mitigation plans will be effective in reversibility and reducing the intensity of this impact.

7.4.3.4. Impact on Fauna (Animal imbalances)

Generally, Kerio Plain has a rich biodiversity and various species of mammals, birds, reptiles, and amphibians are found in it. The existence of these species is not limited to preserved areas such as national parks or national reserves and only a small number of different animal species live in these conserved areas. Accordingly, environmental studies and implementation of environmental management programs along with development plans play an essential role in minimizing the environmental degradation and achieving sustainable development.

7.4.3.5. Impact on Mammals

Construction Phase

During the construction phase, highest impacts are on mammals through their hearing sense. Constructional activities, traffic, and the presence of a large number of workers in this phase cause a sense of insecurity in the wildlife. The main road, main and sub-main pipelines, ponds and generally all the areas where activities are concentrated, are considered as effective spots. If the animals feel insecure, they live their current territory and will disperse to peripheral areas. Due to the similarity of habitats in Kerio Plain, mammals can adapt quickly to new habitats. Therefore, this impact will not reduce their population. (However, there is the possibility of animal hunting by people who are new to the region).

Based on KWS list, *Giraffa camelopardalis rothschildi* sub-species is considered as threatened and endangered mammals which are likely to exist in the region. Therefore, suitable mitigation measures should be taken into consideration in this regard.

Based on the above points, the impact of construction phase on mammals is assessed to be negative and reversible with moderate intensity and low importance.

Operation Phase

After the construction phase, the region regains its previous peace gradually. Therefore, mammals return to their previous habitats in the long run. Of course in this phase, some parts of the habitats are occupied and have become agricultural lands. Some herbivores species enter agricultural lands in search of food which will increase the probability of them being hunted by the farmers or other regional residents. Gazelle is of large mammals which can be exposed to this threat.

Along with main pipelines, some ponds are constructed for the drinking of the animals. These ponds are located along the pipeline and on sides of the main road. Therefore, due to traffic and proximity to populated areas, they are less probable to be used by the wildlife and are more likely to be used by livestock only. However, it is possible that other mammals be able to use these ponds for drinking in the morning or at night. All in all, this impact is assessed to be negative, reversible, and with low intensity and importance.

7.4.3.6. Impact on Birds

The most important consequences of the project on birds can be created in two steps: 1) short-term impacts during the construction phase and 2) long term impacts during the operation phase.

Construction Phase

Due to their high mobility and compatibility which is the result of flying, birds will not be directly damaged from the execution of the project. Because of constructional activities, presence of a large number of workmen in the region, activities of light and heavy machinery and making noise, migrant birds and endemic ones leave their feeding or nesting areas and go to further areas in the upstream or downstream. Moreover, due to the presence of a large number of workers in the project area, there is also a possibility of birds hunting.

Altogether, although there are many options for habitat selection, negative impacts on birds will occur as short term and reversible with low intensity and importance.

Even though this issue may not be much harmful for birds, it should be taken into consideration. This is because despite the ability of these species in finding their previous living conditions in a new region and adapting themselves to it, if they leave the region, the ecological balance will be disrupted.

Operation Phase

Expansion of agricultural lands and orchards and existence of intakes in the project area can attract herbivore and gallinaceous birds in the area. These kinds of birds are preys of carnivore birds such as eagles and falcons. If carnivore birds advance to plain areas for the purpose of hunting, the abundance of prey in food chain will improve their living conditions in the region. This enriches the food chain and network and results in biodiversity of the region. Therefore, the impact of operation phase on birds is assessed as positive.

7.4.3.7. Impact on Reptiles and Amphibians

Construction Phase

The slow movement speed of reptiles will increase the vulnerability of these species to environmental changes. Moving away from the region is the first reaction of animals when facing danger due to the entrance of any external factors to the region. Therefore, in case of a sudden change, physical inability to move rapidly can cause the extinction of a large number of reptiles. The ability of flight in birds has increased their sustainability power and survival of their generation. Inability to move fast in reptiles, in return, makes them more vulnerable compared to other animal species. However, since reptiles are less known compared to other animal species and fewer studies have been conducted on them, the impacts caused by the execution of the project on these species, especially in the construction phase are not clear and definite. It can only be said that they will probably move away from their current habitats in the early stages of work. Some of their species may also be killed by the staff and workers due to being poisonous and dangerous. In the latter case the food chain condition and ecological balance of the region will change. This issue may have unknown consequences or may establish another balance in the future.

Accordingly, in the construction phase, the impact on reptiles is assessed to be negative, inevitable, and reversible with moderate intensity and low importance.

Operation Phase

Reptiles have a particular sensitivity to vibration and smell. Activities (such as increased traffic and use of pesticides) which have follow-up vibration and olfactory stimuli will probably have negative impacts on reptiles. As it was mentioned earlier, starting construction activities makes the reptiles move away from the area. With the beginning of agricultural activities in the project area, it is usually the case that if farmers see any kind of reptiles, especially snakes which cause physical harms, kill these animals. Therefore, during the operation phase of the project, human beings cause two issues for reptiles which may result in the reduction of their population in the long run: occupying their habitats and risk of being hunted. Hence, the negative, temporary, and short-term impact of the construction phase will turn into a permanent one during the operation phase which is assessed to be with moderate intensity and low importance. As a result, ecological imbalance of the region and occurrence of unpredictable effects in the region along the food chain is likely. For example, reduction of the reptiles' population will lead to an increase in the population of rodents. Since rodents are considered as pests for crops, this will increase the consumption of different types of rodenticides. Use of rodenticides will in return contaminate soil and water, in return.

From among most prominent reptile species in the region which are water dependent, crocodiles can be noted. Crocodiles are found in Kerio River, especially in the joining point of Kerio and Arror Rivers.

The crocodiles are the top predators in their environment, and are responsible for checking the population of species like catfish. The crocodiles also consume dead animals that would otherwise pollute the waters. The IUCN Red List assesses the crocodile as "Least Concern (LR/lc)". The convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) lists the crocodile in Appendix II (not threatened, but trade must be controlled) in the remainder, which either allows ranching or sets an annual quota of skins taken from the wild. Due to water pollution, it is likely that the crocodile's food source, which inhabits in this area, contributes towards placing them in areas at risk of pollution.

During the operation phase, using fertilizers, pesticides, and insecticides and the discharge of these substances through drainage waters, the habitat of these species (i.e. Kerio River) is exposed to contamination. Therefore, given the sensitivity of crocodiles to pollution, it is essential to take this issue into consideration in the monitoring program.

Due to high fertility power of amphibians, no significant impact is expected from the execution of the project on amphibians' population and their reproduction rate and any potential future impacts will be of low importance. Of course, amphibians, like reptiles, will also suffer harm from occupation of their habitats and changes in food chain. However, due to their high fertility power, this impact will be negligible.

All in all, the impact of the project on reptiles and amphibians during the operation phase is assessed to be negative and reversible with moderate intensity and low importance.

7.4.3.8. Impact on Fish

Construction Phase

Constructional activities will cause the discharge of great loads of sediments and suspended solids into Kerio River. Kerio River turbidity is currently very high. However, an increase in the amount of water muddiness may be beyond the tolerance threshold of fishes and make their living conditions and especially their respiration difficult. This will endanger their multiplication and as a result their biodiversity. Therefore, it is essential to note fishes' time of spawning, which is the most sensitive stage in their life cycle, during the construction phase.

Despite the unpleasant impact on fishes which is inevitable and occurs with high intensity during the construction phase, due to short longitudinal distance of the affected region, compared to the length of the river and the fact that this impact is temporary and reversible, it is not of much importance.

Operation Phase

Discharge of chemical manures and pesticides along with agricultural waste water to the Kerio River, will cause water quality decrement. Permanent discharge of chemicals to the river during the operation of agricultural lands will reduce the self-purification capability of the Kerio River.

The Kerio River flow fluctuates in different seasons. Therefore, the impact is assessed to be of more intensity in dry seasons. As the impact is cumulative, in the North and downstream of the study area, the water quality decreases more intensively and can lead to fish mortality.

Although the impact of the operation phase, just like the constructional phase, on aquatic animals is inevitable and will appear with high intensity, as the indirect affected area is much more extended, the importance of the impact compared to constructional phase is assessed to be more (moderate importance).

7.4.3.9. Impact on Animal Migration

Construction and Operation Phase

During resources investigation, infield studies and inspections, questioning the related organizations such as Kenya Wildlife Service and asking for the map of wild life migration in the study area, it is distinct that there are no particular migration routes or corroders in the area. Therefore movement of fauna species (herbivores and carnivores) is limited to the territory and that is for different aims such as feeding, drinking water, hunting etc. Accordingly, the accomplishment of the project has no impact on animal migration.

7.4.3.10. Impact on Endangered Fauna Species

Construction and Operation Phase

Constructional activities will lead to devastation of the natural vegetation and damage to wild life habitats, but this matter is not of high importance compared to occupying the habitat in the operation phase. In addition to that rare and in danger species are often dependant on their habitat and not compatible with environmental changes.

Generally the number of near threatened species compared to the total recognized species in the project area is few and most of the fauna species are classified as LC (least concern). In the study area two types of mammals (African Wild dog and Grevy's Zebra) and two types of birds (Black kite and Egyptian Vulture) are classified as NT (Near threatened species) according to the Red List of IUCN.

Therefore, the impact of the project on fauna species exposed to extinction is assessed to be with low importance and intensity.

7.4.3.11. Impact on Terrestrial and Aquatic Habitats

Construction Phase

As mentioned before, excavation, embankment, laying pipelines, transportation of constructional materials, activity of heavy machinery, workers presence and movement and noise pollution will lead to insecurity for the wild life and will cause their transfer to farther areas. In addition to this, laying about 96000m main and sub main pipes for an area of about 1400 hectares in the project area will cause habitat destruction along the conveyance pipeline.

Constructional activities usually lead to devastation of the natural vegetation even in a region far from the activity area. Thus the natural vegetation will go through negative succession even in lands outside of the project area. In addition to this, while the agricultural activities start, the lands located in the project area lose the suitable opportunity to re-success, therefore formation of consecutive habitats is not possible and the natural efficiency of the habitats will decrease.

According to the limited area of the irrigation network compared to the vast area of Kerio plain which is an even habitat and also the Chesetan-Chepkum access road in the neighbourhood of the project area, the impact of constructional phase activities on destruction of the habitats is assessed to be reversible ,temporary and with low importance and intensity.

Operation Phase

The alteration of pasture and dry farming lands to irrigated farming lands in different areas has always caused environmental changes and the most important reasons are vegetation and as a result removing or attracting different animal species to these areas. Alteration of the land use in an area of about 1400 hectares will cause occupying the animal habitats, scattering the wild life to farther parts and therefore disturbing the ecological balance in the area. On the other hand, an increase in the agricultural productions and existence of water that are both main factors of birds living requirements, will cause attraction of gallinaceous birds especially Passeriformes to these areas. Accordingly, the environmental changes during the operation phase have a negative impact on mammals, reptiles and the amphibian but a positive impact on birds.

Increasing the use of manures and chemical anti pests with negative consequences, is inevitable along with the development of agriculture in the study area. Discharge of drainage water to Kerio and Arror Rivers causes diminution of the water quality. Contamination of these rivers as water habitats of the region causes difficult living conditions for the aquatic animals especially fish and crocodiles (the Kerio River is considered as crocodile habitat in Kenya) and will bring about the means of its death. In addition to that, discharge of new contaminates to Kerio River with high turbidity at the moment, will reduce its self-purification capability.

The erosion of the agricultural lands on the banks of Kerio River and discharge of contaminated sediments with chemicals to this water habitat will cause sediment pile up and occupying many habitat areas and trouble in fish spawning especially cat fish and also crocodile. Reducing the biologic activities of aquatic plants is another impact. This impact is assessed as negative, long term, reversible and of moderate importance and intensity.

7.4.3.12. Impact on Project Lands and their potentials as habitat

Construction and Operation Phases

The lands located in the project area, are mainly woodlands with moderate to high density. Although there are scattered cottages or very small farmlands or gardens, these lands have maintained the habitat capacities and are considered as natural resources. Maintaining the natural conditions is happened due to the following points:

- the project area is remote and not close to any important towns.
- the project area is not located near any main access roads between important towns.
- the inhabitants have a simple traditional life. (It should be mentioned that between the two trips to the region several trees along the road have been fallen and this has changed the view in many areas. This also shows the lack of control and supervision on the natural resources.)

Accordingly, accomplishment of the project in this area, considering the habitat characteristics, is assessed to be a negative impact. In the constructional phase it is short term and reversible but in the operation phase, long term and of moderate importance and intensity.

7.4.3.13. Impact on Habitat Capability in Downstream of the Project Area

Any changes in the quality of the rivers especially in the estuary or the confluence of a river and a larger water body, causes negative consequences on the aquatic animals. Water quality changes might be due to soil (erosion, salinity and alkalinity), toxic materials (pesticides), chemical manures or changes in the direction of natural drains. Therefore it is likely to cause serious consequences on the life of aquatic animals living in the downstream of the study area.

Construction Phase

Discharge of sediment and suspended materials caused by constructional activities to the Kerio River or Arror River before joining the Kerio River, is the most important influence of the project on the water quality in this phase.

Pipe laying, especially sub-main pipes located near the Kerio River, shall be done gradually and stage by stage. This means pipe laying in an area of about 1400 ha and 15 km long is not done simultaneously and every day a small amount of constructional activities shall be done.

Therefore the amount of sediment entering the river occurs daily. According to the cumulative type of the impact, this reduces the intensity.

The daily discharged sediment to the river is transferred by water so that finally settle. Although this causes the turbidity and muddiness of the downstream Kerio River, due to the high flow and length of the Kerio River (Kerio River is one of the longest rivers in Kenya), joining several branches in the downstream from left and right banks and small mass of daily excavation and embankment, this impact is assessed to be negative, reversible and of low importance and intensity.

Operation Phase

One of the most important activities of the operation phase is using manures and pesticides, rural developments and producing sewage and litter. The Kerio River has lost some physical, chemical and biological characteristics due to the discharge of pesticides and fertilizers through natural drains and therefore its life is threatened. According to the cumulative type of this impact, it is assessed to be reversible and with moderate importance and intensity.

7.4.3.14. Impact on Protected Areas

Construction and Operation Phases

None of the protected areas is located under the management of the Ministry of Environment and Mineral Resources in the immediate area or influenced by the project.

Kerio Valley National Reserve is located more than 12 Km. in the South and upstream of the Project area and is not directly influenced by the project, although it might be possible that by moving the wild life away from the study area in the construction or operation phase, different animal species especially birds and mammalian will enter this region as a new habitat .Therefore the accomplishment of the project has no impact on this factor.

Characteristics of the impacts of the project on biological factors are summarized in Table 7.17.

Table 7.17: Impacts of the Irrigation Project on the Biological Parameters during Construction and Operation Phases

Phase	Impact Biological Factor	Quality		Reversibility		Scope		Duration		Type		Intensity (Destructive/Suitability)				
		Positive	Negative	Reversible	Irreversible	Direct	Indirect	Short Term	Long Term	Cumulative	Non-Cumulative	No Impact/Negligible	Low	Moderate	High	Very high
Construction Phase	Flora		*		*	*			*		*			*		
	Endangered flora species											*				
	Pests & weeds											*				
	Animal imbalances		*	*			*	*			*		*			
	Fishes		*	*			*	*		*			*			
	Animal migration		*	*		*		*			*		*			
	Endangered fauna species		*	*			*	*			*		*			
	Terrestrial & aquatic habitats		*	*		*		*		*				*		
	Project lands		*	*		*		*		*			*			
	Habitat capability in downstream		*	*		*		*		*			*			
	Protected areas											*				
Operation Phase	Flora	*		*		*			*	*					*	
	Endangered flora species											*				
	Pests & weeds		*	*			*		*		*		*			
	Animal imbalances		*	*			*	*			*		*			
	Fishes		*	*			*		*	*					*	
	Animal migration	*		*			*	*			*		*			
	Endangered fauna species											*				
	Terrestrial & aquatic habitats		*	*		*		*			*			*		
	Project lands	*		*			*		*		*			*		
	Habitat capability in downstream		*	*			*		*	*				*		
	Protected areas											*				

7.4.4. Impacts on Socio-Economic and Built Environment

The major purpose of irrigated agriculture is to increase agricultural production and consequently improve the economic and social well-being of the area of the project. Although irrigation schemes usually achieve this objective, they could often have been more successful in developing countries if more attention had been paid to the social and economic structures of the project area. Implementation of development plans in each region results in socioeconomic effects that are studied in three groups of social, economic and cultural.

7.4.4.1. Impact on population (Demographic Changes and Migration)

Due to increasing well-being and income, irrigation project attract population. Therefore, by providing adequate infrastructure facilities in the planning step, necessary predictions for the population growth should be taken into consideration.

Construction Phase

In case of using non-local work power in the construction phase, the population of the project area will grow temporarily and for a short time. In addition, there will be a temporary increase in other population parameters (i.e. migration, work power, age structure, and gender Structure).

High unemployment rate in the area on one hand and the need for work power, especially labour men and semi-professional/skilled workmen (who are often provided from rural areas within or near the region), in construction activities on the other hand attract people and prevent them from migrating out of the area.

Operation Phase

It can be predicted that project operation due to improvement of agricultural status, creation of jobs, relative increase of income levels, improvement of infrastructures and living criteria quality of local people will decrease internal migrations (i.e. from rural areas to towns such as Eldoret, Kapsowar, and Iten). Therefore, the plan will lead to relative increase of population in rural areas, at least during the first years of irrigation network operation.

7.4.4.2. Impact on Literacy Level

Despite poverty and deprivation in Kerio Valley, elementary and secondary schools can be seen in appropriate distances of the region. Although these schools have minimum facilities, they highlight the importance of education in this country.

Construction Phase

No impact.

Operation Phase

With the execution of the irrigation project and the subsequent socioeconomic changes, the need for literate people to participate in social and economic activities increases. This participation means employment, income, and achieving a better life. Therefore, the motivation of studying is increased among young people. In addition, relative improvement of the economic status of the households during the operation of the project plays an important role in increasing the number of students. In fact people who cannot afford going to schools during bad economic conditions will be able to do so with the economic recovery. This will make the people in charge to improve the quality and quantity of schools. Hence, with attracting more people to schools, increasing the literacy level in the area/region is considered as positive, indirect, and long-term advantages of the project.

7.4.4.3. Impact on Living Quality

Construction and Operation Phases

Today, people's life in Kerio Valley is totally primitive and the rural areas have the minimum living facilities. There is no urban center in the region and the closest city is Iten. This remoteness from urban centers is one reason for the exclusion of the people living in this area. The only access road is a dirt road, infrastructures such as electricity, piped drinking water or proper sanitation and medical services are not available in most villages and generally the quality of life is at a minimum level. Therefore, it is expected that through importing some services and facilities to the region, the execution of Kerio Valley project leads to relative improvement and fixes some of these deficiencies in the future, in addition to supplying and providing food security for locals.

7.4.4.4. Impact on Public Participation and Role of Women

Construction and Operation Phases

Attraction of public participation at the planning and design stages of both new schemes and the rehabilitation of existing schemes, as well as the provision of extension, marketing and credit services, can minimize negative impacts and maximize positive ones. Assistance of NGOs can be particularly helpful in minimizing adverse socio-economic impacts.

Proper implementation of water projects usually includes popular participation, especially that of interested operators. Operating these kinds of projects leads to high per capita income, success in agriculture, livestock and other similar activities, and benefiting from social welfare. The support of operators and farmers is the most important strength point of this plan.

Another consequence of the plan is steadiness in operating water resources. Due to droughts in recent years, operators' need of sufficient water in the Kerio Valley has increased. Therefore, providing an important part of this need by the irrigation project has brought peace of mind for the farmers in the area. Safeguarding this provided security and comfort for the farmers makes locals cooperate with regional authorities. In this case, local authorities can perform their duties with regard to their job description framework and follow the sustainable development programs.

Development plans in deprived areas of Kenya like the Kerio Valley will increase life quality and standards, followed by cultural developments. This cultural development, especially in rural societies, raises the educational level, leading to higher participation of women in socioeconomic activities. Accordingly, the active population increases. In addition, with higher educational levels among women, lower birth rate and higher marriage age is expected.

Also, the increased income and improved nutrition due to irrigated agriculture benefit women and children in particular.

Therefore, attracting popular cooperation and improving women's role in the area is among the positive and lasting effects of the project/plan which will be observable during the operation of the project/plan with high profitability.

7.4.4.5. Impact on Cultural Heritage

Construction and Operation Phases

Based on field studies, query from local people and authorities, and filled questionnaires, there is not any place of cultural heritage or historical value in the Kerio Valley. Hence, the operation of the project/plan is assessed to have no impact on this factor.

7.4.4.6. Impact on Tourism

Kenya's current general policy for income is based on tourism. Regarding the capabilities and potentials of Kenya, tourists who come to visit this country are ecotourists. Ecotourism is in search of natural virgin areas and viewing wildlife in their natural habitats. Therefore, due to their centralization and maintenance of biodiversity, preserved areas are among the main target areas of ecotourists.

Kerio Valley is accounted as an endangered ecosystem based on the KWS (Kenya Wildlife Service) conservation research.

Due to the fact that Kerio National Reserve is located in a 12 Km distance from the upstream of the irrigation plan area, the region's wildlife, natural landscapes, crocodiles habitat in the Kerio River, Arror Waterfall, very high and unique hills of termites, etc, Kerio Valley is of high potentials and attractions for the ecotourists. However, as a result of poor road access and lack of basic facilities and accommodation for the tourists, not many of them come to visit the region.

Construction Phase

No impact.

Operation Phase

During the operation of the project, with the improvement of infrastructure, basic facilities are expected to be provided in the region to attract tourists. In case of proper planning and management for using these facilities to attract tourists, the potentials of the region can be used for tourism boom. Therefore, execution of the plan can indirectly lead into tourism boom in the region. It should be noted that the entrance of tourists in an area is usually associated with environmental degradation. That is why it requires very precise planning and management. Given the fact that most tourists in Kenya are ecotourists, conservation of nature is the basic principle in the planning. Development of ecotourism and even recreation potentials with the principle of preserving the environment will boom the employment and income for the local residents.

Ecotourism boom and other positive outcomes as a result of proper management are among the positive and indirect impacts of the plan which play an important role in justifying the need for executing the project.

7.4.4.7. Impact on Employment

Construction Phase

During construction, many people will be working on the execution of the irrigation plan. However, these will be temporary jobs and are not considered as permanent ones. Therefore, the main impact of the plan on employment is during the operation period.

Operation Phase

At the present, out of 2250 ha cultivable lands in the irrigation plan area, 55%are fallow lands which are frequently under cultivation in some years. 15% of the lands are pastures and heaths and another 15% are forest and bushland. In fact only 10% of these lands are under cultivation for 5% of which irrigation and for the other 5% dryland farming is used. The remaining 5% of the lands include rivers, roads, and population centers.

With the execution of the irrigation plan and availability of all the required factors for agriculture (i.e. supply and distribution of the required water for irrigation, pesticides and fertilizers, agriculture service centers, solution of land distribution problems, implementation of an appropriate pattern for operation, and cultivation of improved products), all lands will be covered by the irrigation network.

Based on the census made in 2009, 48% of the population in Marakwet Sub County is youth compared to Kenya (43%), this shows that it has a younger population.

Hence, given the high potentials of the region for agriculture, if the water deficit problem is solved, it can be predicted that the employment rate in this region will have an impressive growth, leading to a significant positive effect in reducing the unemployment rate. The current unemployment rate in Marakwet Sub County is 8.4%.

In addition to the jobs which are directly created by the execution of the project, many other jobs are created indirectly including agricultural services, agricultural machinery repairing, packaging and transportation of products, and even tourists servicing jobs to name a few.

7.4.4.8. Impact on Income and Prosperity

According to the 2005 to 2006 survey, the lowest rural poverty was estimated in Rift Valley with 49.7%. The distribution of income, measured by the Gini coefficient (a measure index of inequality of income distribution where the higher percentage shows the higher level of inequality) was estimated 39 % in rural areas and 49 % for urban areas (pre-crisis). Income disparities in the rural areas have decreased since 1997, while they have increased slightly in the urban areas.

Construction Phase

As it was mentioned in the employment section, the jobs during the construction period are (unskilled) laboring or semi-professional/skilled ones which are considered as temporary for the local residents. Despite generating income, problems of the local residents will be relieved for a limited period only. This is while the jobs during the operation period are permanent.

Operation Phase

During the operation, due to increase in the expansion of agricultural lands resulting from execution of irrigation plan and (as a result) an increase in the production efficiency, the income of the farmers will rise. Therefore, the incomes from agricultural and gardening activities will rise directly. Creation of indirect jobs and ones which are dependent on the execution of the plan/project will also raise the income of the locals. Hence, the manufacturing and service jobs together will have a significant impact on the income level of the residents. With the increase in the income level, the welfare level of the people will also increase.

The most important impact of the execution of the irrigation plan is the reduction of economic and social damages in the time of drought. During the drought time in recent years, many of the farmers have left large parts of their lands without cultivation. However, if there had been sufficient water for irrigation, they would not have sustained such damage.

Accordingly, execution of the plan will directly impact the income and prosperity/welfare of the region and will have positive and relatively large and long-term benefits.

7.4.4.9. Impact on Land Value

Construction Phase

No impact.

Operation Phase

Based on the studies, it can be predicted that starting the operation of the irrigation plan, due to expansion of agricultural activities, directly and indirectly related jobs, and also improvement of infrastructures, land value will increase in the long term. Since land is the only valuable possession of the local residents, an increase in land prices will increase life expectancy.

7.4.4.10. Impact on other Development Plans and Land use

Construction Phase

No impact.

Operation Phase

With agricultural development, creation of small agro-industrial units in the region will be likely. The type of these industries depends on the selected cropping pattern. For example, if cotton or tea is cultivated, willow or tea drying workshops may be constructed in the region. Since constructing each of these units will have its own environmental impacts, creation of these types of industries should be under a unit management to preserve the natural landscape of the region. Given the impressive potentials of the Kerio Valley and since this region is currently presented as an endangered ecosystem, execution of land use planning is necessary in this region to recognize its capabilities and execute further development plans.

7.4.4.11. Impact on Infrastructure

The irrigation project limits are located in Tunyo Division. Right now, most sub locations in this division lack basic infrastructure facilities like paved roads, electricity, healthy drinking water etc. Based on field studies, near half of the plan limits, like Arror and Koitilal sub locations, lack electricity.

While the drinking water of population areas located in Koitilal, Chepkum, and Resim sub locations is supplied directly from Kerio River without any filtering, that of Niwai and Arror sub locations is provided from Arror River.

Construction Phase

When the construction phase of the project starts, it will be essential to improve and pave the only access road to the plan area for mapping operations, experts and engineers' visit of the area, and transportation of raw materials and building materials.

Operation Phase

With the execution of the project, not only the required water for irrigation will be supplied, but also the drinking water demand is considered in broker pipelines. Also, in order for maintenance, repair, and operation of facilities and equipment during the operation, acceptable basic facilities should be developed in the region.

The electricity of villages in the region will be provided by power plant. This is among the positive impacts of the power plant.

With agricultural development, creation of direct and indirect jobs, reduction of migration to areas outside the region and supplying road, water, and electricity, other facilities and utilities will also be provided gradually and overtime. As a result, deprivation look or at least primitive life will be erased from the region. Therefore, the impact of execution of the project on infrastructure facilities of the region is positive. However, with regard to the fact that the area of plan/project execution or lands to be under cultivation is only about 1400 ha, the suitability of the project is evaluated to be average.

7.4.4.12. Impact on Diseases

Health index is one of the main bases for sustainable development and is an integral part for improvement of quality of life.

Construction Phase

In the construction phase, if non-native forces enter the region to employ in different parts of the irrigation plan and in case of failure in providing adequate facilities for them, some diseases are likely to outbreak in the region. However, due to high unemployment rate and existence of plenty of work force in the project area, native unskilled labour men, semi-skilled and even skilled ones can be used for the construction. Hence, using non-native forces is unlikely. Entrance of non-native people to the region will be very low and limited to experts and specialists. Therefore, outbreak of some diseases is not expected from the entrance of non-native people.

Operation Phase

In the operation phase, if sink areas are formed in the agricultural lands, appropriate areas are created for insects egg-laying and snails proliferation; this can increase the number and diversity of insects which are vectors of diseases related to water. With regard to the type of irrigation considered in the irrigation plan (i.e. sprinkler irrigation for agricultural lands and drip irrigation for gardens), and the high penetrability of the soil, the formation of such sinks is not likely. If sinks are formed in some spots, depending on the topographical conditions, the impacts will be negligible since the area of land under irrigation is not much.

In surface irrigations, open channels are constructed for transportation and distribution of water in network. If the water flow velocity reduces, these channels become appropriate areas for spawning and proliferation of disease-carrying insects. However, due to the type of selected irrigation in the plan (i.e. under-pressure irrigation) water flows within the pipeline. Therefore, the likelihood of the insects' proliferation as a result of the project execution is reduced to a minimum.

In addition, due to supplying food security through cultivation of staple food crops or needed fruits of the native population, the quality of nutrition is relatively improved and the malnutrition which is currently seen among people, especially in children, will be relieved to some extent. Better nutrition leads to better health.

Therefore, the probability of project execution impact on diseases is evaluated to be positive. Of course, given the uncertainties in the studies, improving health services and providing the required facilities for unpredictable cases is recommended.

7.4.4.13. Impact on Health Center Services

Currently, in Tunyo Division (i.e. irrigation plan area), only Arror and Niwai sub locations have health centers with minimum medical facilities.

Construction Phase

In the construction phase of all construction projects, there is always the risk of disaster. Therefore, it is necessary to consider health care with proper medical equipment (or at least for providing first aids for casualties), in addition to available medical services in the region/area from the beginning of construction activities.

Operation Phase

With the operation of the project and considering all direct and indirect impacts of the plan/project, besides development of infrastructures in the region, development of health services can be expected in the long term. Therefore, the impact of project/plan execution on development of health care is positive, indirect, long-term, and due to the extent of the plan/project, it is evaluated to be of average profit.

7.4.4.14. Occupational Safety and Health (OSH)

Construction Phase

As in any normal workplace, there are occupational hazards. To prevent personal injury and deleterious health effects, good occupational safety and health practice has to be followed, and it will be the responsibility of the proponent to ensure this is done.

Operation Phase

This is the object of the construction phase.

7.4.4.15. Landscape

Construction Phase

Currently, the site is an open field covered in grass and shrubs and woodland landscape. The construction phase of the project is expected to reduce (alter) the morphology and aesthetic aspects of the landscape of the site due to the construction activities. This is by way of excavations and putting up of the temporary camping, solid wastes in the project site.

Operation Phase

In this phase, woodlands shall be changed to agricultural lands that are considered as semi-natural cover. Moreover, the main components shall be underground, so this impact will be negligible.

Characteristics of the impacts of the project on socio-economic factors are summarized in Table 7.18.

Table 7.18: Impacts of the Irrigation Plan on the Socio-Economic Parameters in Construction and Operation Phases

Phase	Impact Socio-Economic Factor	Quality		Reversibility		Scope		Duration		Type		Intensity (Destructive/Suitability)				
		Positive	Negative	Reversible	Irreversible	Direct	Indirect	Short Term	Long Term	Cumulative	Non-	No Impact/ Negligible	Low	Moderate	High	Very high
Construction Phase	Demographic Changes and Migration	*		*		*		*			*			*		
	Literacy level	*			*		*		*		*			*		
	Living quality	*		*			*	*			*			*		
	Public participation and role of women	*		*		*		*			*				*	
	Cultural heritage											*				
	Tourism	*		*			*	*			*		*			
	Employment	*		*		*		*			*					*
	Income and Prosperity	*		*		*		*			*					*
	Land value	*			*	*			*		*			*		
	Development plans	*			*		*		*		*			*		
	Infrastructure	*			*		*		*		*			*		
	Diseases											*				
	Health center services		*	*			*	*			*			*		
	Occupational Safety and Health		*	*			*	*			*			*		
	Landscape		*	*		*		*			*				*	
Operation Phase	Demographic Changes and Migration	*		*			*		*		*			*		
	Literacy level	*			*		*		*		*			*		
	Living quality	*		*			*		*		*				*	
	Public participation and role of women	*		*		*			*		*				*	
	Cultural heritage											*				
	Tourism	*		*			*	*			*			*		
	Employment	*		*		*			*		*				*	
	Income and Prosperity	*		*		*			*		*				*	
	Land value	*			*		*		*		*			*		
	Development plans	*		*			*		*		*			*		
	Infrastructure	*			*		*		*		*			*		

	Diseases	*		*			*		*		*			*		
	Health center services	*			*		*		*		*			*		
	Occupational Safety and Health											*				
	Landscape											*				

7.4.5. Most Important Adverse and Beneficial Impacts of the Irrigation project

Most important adverse impacts of the irrigation plan are as follows:

- Decrement of Air quality during construction phase
- Acceleration of erosion during construction phase
- Reduction of river water flow during operation phase
- Decrement of river water quality during construction and operation phases
- Diffusion of salts and toxic substances in water during operation phase
- Reduction of self-purification capability of river during construction and operation phases

Most important beneficial impacts of the irrigation plan are as follows:

- Decrease of immigration to other areas or towns
- Improvement of literacy level
- Improvement of living quality level
- Improvement of women participation in economic activities
- Improvement of facilities for ecotourism attraction
- Employment creation and income increasing
- Improvement of prosperity
- Improvement of infrastructure
- Improvement of health center services
- Improvement of food security and health
- Increasing amount of crop production in land unit

Scoping of Environmental Parameters and Issues for the Arror Irrigation System based on the checklist ICID is given in the Table 7.19.

Table 7.19: Scoping of Environmental Parameters and Issues for the Arror Irrigation System (Based on the checklist ICID)

For each environmental effect place a (√) in one of the columns		Positive impact very likely	Positive impact possible	No impact	Negative impact possible	Negative impact very likely	No judgement possible at present
		A	B	C	D	E	F
Hydrology Pollution Soils	1-1 Low flow regime			√			
	1-2 Flood regime			√			
	1-3 Operation of dams	√					
	1-4 Fall of water table			√			
	1-5 Rise of water table			√			
	2-1 Solute dispersion				√		
	2-2 Toxic substances					√	
	2-3 Organic pollution					√	
	2-4 Anaerobic effects			√			
	2-5 Gas emissions			√			
	3-1 Soil salinity			√			
	3-2 Soil properties			√			
	3-3 Saline groundwater			√			
	3-4 Saline drainage				√		
	3-5 Saline intrusion			√			
Sediments	4-1 Local erosion					√	
	4-2 Hinterland effect			√			
	4-3 River morphology			√			
	4-4 Channel regime			√			
	4-5 Sedimentation					√	
	4-6 Estuary erosion			√			
Ecology	5-1 Project lands					√	
	5-2 Water bodies			√			
	5-3 Surrounding area				√		
	5-4 Valleys & shores			√			
	5-5 Wetlands & plains			√			
	5-6 Rare species				√		

	5-7 Animal migration			√			
	5-8 Natural industry		√				
Socio-economic	6-1 Population change	√					
	6-2 Income amenity	√					
	6-3 Human migration	√					
	6-4 Resettlement			√			
	6-5 Women's role	√					
	6-6 Minority groups			√			
	6-7 Sites of value	√					
	6-8 Regional effects	√					
	6-9 User involvement	√					
	6-10 Recreation		√				
Health	7-1 Water & sanitation		√				
	7-2 Habitation		√				
	7-3 Health services		√				
	7-4 Nutrition		√				
	7-5 Relocation effect			√			
	7-6 Disease ecology		√		√		
	7-7 Disease hosts			√			
	7-8 Disease control	√					
	7-9 Other hazards				√		
Imbalances	8-1 Pests & weeds				√		
	8-2 Animal diseases			√			
	8-3 Aquatic weeds				√		
	8-4 Structural damage				√		
	8-5 Animal imbalances				√		
	Number of crosses	9	7	23	10	5	

8. Proposed Mitigation Measures

8.1. Objectives

The main purpose of this section is to outline methods and procedures to be undertaken to mitigate the adverse impacts of the project that it is capable of meeting prescribed standards or reaching acceptable levels.

It is evident that, the reduction of environmental impacts is performed in such a manner that, the minimum amount of damage and destruction is incurred on the environment, and is based on the principle of a sustainable development. In this section of the study, it is essential to pay accurate attention to the information of the following sections:

- "Environmental Rules and Regulations", in order to consider the extent and acceptable level in conserving regional and national environmental standards, in the way of a sustainable development and the abidance of international environmental commitments, as well as international organizations.
- "To survey the specifications of the plan", in order to specify the specialties of the project including main components and side facilities, to reduce the environmental impacts in various activities, both, from the viewpoint of construction and operation of the plan.
- "To determine the Environmental Impacts", so as to identify the environmental impacts arising from the implementation of the plan.

8.2. Mitigation Measures

Consequences and or critical adverse environmental impacts arising from the implementation of a plan or project is occasionally capable of being excluded, but with measures these can be reduced. These measures are namely mitigation measures and are procedures that are performed through engineering and management methods. It is an important principal and a fundamental basis and element for an Environmental Impact Assessment (EIA) Report.

The quality of proposed methods for the reduction of the negative environmental impacts depends basically on the specifications and the quality of the impacts, their importance, intensity and the connection between the adverse impacts. So a complete, total and extensive survey of the adverse impacts and their categorization is the first important step to identify the proper mitigation plans.

It is worth mentioning that some of the methods have preventive specifications, whilst some others are compensative and substituting. Thus, the environmental management of the project must be according to the requirements and needs of each phase of the plan and a given method should be selected and applied. In rendering the mitigation plans, the essential methods in the construction phase should be segregated from the operation phase. Points to be considered in reducing the negative impacts of the construction phase are as follows:

- Duration required for the implementation of all the construction activities
- Influence of environmental factors with respect to the short duration of the construction phase
- Management and efficiency of manpower in the construction phase

The selection of methods to reduce the environmental impacts, with the exception of special and regional plans is necessary in the construction and operation phases, with due attention to the general considerations that are mentioned in the following sections should be performed. These considerations are in relative to the selection of methods and or their composition, so as to alleviate and obtain the environmental objectives.

8.2.1. Non-structural Mitigation Measures

In order to decrease the environmental impacts, prior to the utilization of structures and or equipment to enforce structural measures, it is necessary that non-structural methods mentioned hereunder be paid attention to and the possibility of using them together with structural methods should be assessed. Non-structural methods to reduce environmental impacts capable of being utilized in the Arror Dam project are:

a) Zoning the limits of the plan, with due attention to the environmental standards under consideration,
b) Enactment or the enforcement of rules and regulations as well as criteria, particularly in destructive environmental activities such as: solid waste disposal and excavation from borrow areas,
c) Preparing directives applicable to machinery, transport vehicles, equipment required for the plan, with due attention to the environmental impacts,
d) Enactment or the enforcement of health and safety regulations,
e) Fortifying public participation and local inhabitants in the way of reducing the adverse environmental impacts,
f) Applying educational methods for workers, employers, etc. in management of construction and operation,
g) Utilizing monetary tools such as affixing taxes, fines and penalties for polluting activities.

8.2.2. Structural and Semi-structural Mitigation Measures

Structural and semi-structural methods for reducing the environmental adverse impacts of the plan comprise of all methods, where special structures, specific equipment and or modes of biological rectification are used. Points to be applied in these methods, which are necessary to be considered are as below:

- The use of structures without destructive environmental impacts and or with insignificant impacts
- Constructional costs and or exploiting structures of less than 5 percent of the investment in the plan
- Repeated use and recycling of material
- Beneficial application of structures after utilization, particularly in the operation phase
- Applying chemical material, equipment and or suitable tools for reducing the environmental impacts
- Rectifying the aquatic and soil ecological system with due attention to the application and conservation methods of species
- Composing non-structural methods with structural methods, so as to create the maximum efficiency in systems to reduce the environmental impacts

8.2.3. Considerations in Using of Mitigation Measures

In selecting methods to decrease the environmental adverse impacts, both in the structural and or non-structural methods, it is essential to pay attention to its implementation predicaments. Points that must be selected in these methods are:

- Specifications of the local inhabitants in helping towards the implementation of the plan, particularly in methods to decrease the environmental adverse impacts,
- Necessary technicalities for structural application, equipment and tools,
- Level of education needed to apply methods by contractors and project executors,
- Coordination of methods with the various activities of the plan, such as technical, applicable manpower and the implementation time-table,
- Required management to implement the selected methods, especially the structural methods,
- Coordination of methods, particularly with the specification of the aquatic and terrestrial ecosystems under influence.

In recommendation any kind of mitigation measure for the socio-economic environment, initially the points given hereunder should be taken into consideration:

- Legalities, regulations and ownership with due attention to land use particularly in the dam reservoir limits,
- Variety of local communities in the limits of the plan by taking into consideration the demographic specifications as well as cultural and political aspects,
- Mode of exploitation of local communities from the regional resources with due attention to the socio-economic visage, Sensitive and natural protected areas,
- Archaeological and/or cultural sites (It should be mentioned that the study area is devoid of any archaeological or cultural site),

- Accidents and natural calamities,
- Migration and resettlement,
- Public health.

8.2.4 Management of Mitigation Measures

Due to its technicalities, methods to reduce the environmental adverse impacts, in most of its modes, calls for a special management. Therefore, it is necessary that along with selecting corrective measures, the managerial requirements to execute these methods in the construction and operation phases should be determined. Methods proposed so as to decrease the impacts that shall be referred to in this section, must be under accurate control and surveillance. On one hand, it is recommended that measures should be taken through the related organizations and or the proponent (Ministry of Regional Development Authorities); makes the necessary arrangements for the implementation of measures and the surveillance should be performed by the organizations responsible.

The major points that should be taken into consideration in this management are:

- Determining the extent of authority, duties and responsibilities on a short term basis (duration of the construction phase) and on a long term basis (duration of operation phase and/or beneficiary life of the plan)
- Management of the managerial organization of the mitigation plans
- Connection between study group and management group pertaining to the reduction of environmental impacts
- Mode of management as to the decrement in environmental adverse impacts, particularly with emergencies and natural calamities

The management group depends on the type and immensity of the project, include various specialized experts. With due attention to the dimensions of the Arror Dam project, this group must in the minimum comprise of four experts in environment, sociology, watershed management and environmental health. If required, other specialists can be utilized.

8.2.5. Cost of Mitigation Measures

The total costs for the implementation of corrective measures must be determined according to the analysis and assimilations of profits and costs. In general, mitigation measures should be selected in such a manner that it entails the minimum costs. According to the World Bank recommendation, the total costs for methods to reduce the environmental adverse impacts, should not be more than 10 percent of the plan investment. In most of the development plans in developing countries, these costs are figures between 3 to 5 percent of the investment costs of the plan. Hence, alternatives in which the total costs of mitigation measures is more than the figure quoted above, is considered rejected.

With due attention to the above mentioned and the results attained from the EIA study of the Arror Dam Plan, suitable programs, in order to decrement the undesirable impacts in each one of the sections and environmental factors such as, physical, biological and socio-economical are given hereunder.

Since, the releasing of the environmental water flow (EWF) is the most important non-structural and managerial mitigation plan in this project, in the following sections of the report, the estimation of EWF and its important criteria are explained, then other mitigation measures are given for dam, hydropower and irrigation plan.

8.2.6. Environmental Water Flow (EWF) for the Downstream of the Arror Dam

8.2.6.1. Objectives

In general, the currents relative to environmental objectives released in rivers, are known as Environmental Water Flows (EWF). These are assigned to the conservation of the entire aggregation of flora and fauna dependant on water, conserving the natural qualities and an increment in the production of commercial and recreational species and or the support of scientific and sanitary evaluations.

The discharge of water flows from the dam can be brought under notice from a few viewpoints:

- The salvation of wildlife, lives of fish and other aqua species throughout the year
- Observance of migrant birds, as regards nest making, hatching, feeding and growth
- Preparing the river bed for the traversing of large floods
- Restrictions of the encroachment of local inhabitants to the limits of the river
- Recompense for the water flow of the river
- Assisting in feeding of aquifers
- Irrigating crop lands surrounding the river in the downstream

Environmental flows are not the same as ‘minimum flows’ which are now common in many dam projects. Nor are they natural flows but they aim to find a balance for meeting a variety of needs for water volume, quality and timing, including those of ecosystems and downstream communities.

Estimation of EWF is mainly according to the water requirements of aqua life, particularly fishes as prominent index in the higher food chains of the river ecosystem; then other environmental evaluations, including dilution of the pollution load of water resources and natural beauty of landscapes are considered.

Methodology:

In the span of the past 30 years, a large number of EWF estimation methods for the downstream of dams, known to be as one of the tools in the management of water resources, have become extensive in the world. Generally, recent reviews have shown that approximately 207 methods are utilized in 44 countries of the globe. These methods are varied in terms of different aspects alike, required data, aims of method, complexities, application level, required time, expenditure, etc. and are classified in various ways.

The most important methods and approaches for the estimation of EWF, based on the usual divisions are classified in four groups as follows:

1- Hydrological Methods

2- Hydraulic Methods

3- Habitat Simulation Method

4- Holistic Methodologies

In this project, with due attention to the shortage of information and statistics in access from the study area, in order to determine the EWF of the Arror River in the downstream of the Arror Dam, the Montana Method, which is accounted for, as one of the hydrological methods is utilized initially, then it is scrutinized according to professional judgment based on the specific condition of the study area.

8.2.6.2. Important Parameters of the Study Area in Order to Estimate the EWF

In the downstream of dam axis, the Arror River can be divided into two areas which form the middle basin of the river. While the total area of Arror River basin is about 276 Km^2, the area between the basin and dam axis (Area 1) is 185 Km^2 and that of middle basin in the downstream of dam site (Areas 2 & 3) is 91 Km^2. Accordingly, the middle basin forms a large area (33 %) of the total Arror River basin. From an environmental viewpoint, this is a positive factor; since after dam construction and deviation of part of the river flow for the purpose of transfer to the power plant, a large amount of Arror River flow in the downstream of the dam would be compensated through the water entering the river-bed from the middle basin, and therefore the aquatic ecosystem would be protected. Figure 7.1 shows the Arror River basin and the mentioned areas.

In what follows, the dominant landscape of the two areas of middle basin will be described:

- The area located between the dam axis and Arror waterfall (Area 2):
    - The climate of this area is similar to that of upstream of the dam axis. Yet, due to lower average height and the fact that the river exits from forest zone, the average temperature is 2-3 °C higher. The farmlands around Arror River constitute the general features of this area. However, because of suitable amount of rainfall, like the upstream of Arror Dam, the

farmlands are dependent on the rainfall and the river flow is not used for irrigation.

  - In this area, the farmlands are considered as the prominent land use, but also the natural vegetation is dense due to suitable climate. This vegetation helps the water to penetrate in the ground, restraining the extra runoffs from entering the river in the time of rainfall. Of course the Arror basin has denser vegetation in the upstream of dam because of Kipkunur forest, and therefore the penetration rate of the rainfalls in the ground is higher. Therefore, while in the dam upstream the rainfall rate is higher and the runoff is less, in this area there is less rainfall and more runoff.
- The distance between the Arror waterfall and confluence point with Kerio River (Area 3):
  - In the altitude of 2000 m, the Arror River faces a crag which leads to the formation of Arror Waterfall. This River falls from an altitude of 2000 m to 1000 m. Although this change of altitude happens in several stages, the Arror Waterfall looks like one elevated waterfall from far distance. The waterfall enters into the Kerio Valley in the downstream and flows in the valley until it joins the Kerio River in the end.

The Kerio Valley is in fact an extensive plain where the Kerio River flows. This river discharges into the Turkana Lake in the end. The Kerio Valley has a much warmer climate and less rainfall average compared to the highland. The dominant landscape of the region consists of natural and untouched woodlands and shrubberies. The type of the woodlands differs from that of the highland. The trees are shorter and located more distant from one another while the distance between the trees is covered with tall grass bushes. The sporadic rural units are dispersed in these virgin and natural areas. The farmlands and gardens are scattered in small sizes and are dependent on the river water for irrigation. To irrigate the farmlands, the locals have made 8 furrows (ditches) in the distance between the waterfall and the confluence of Arror and Kerio rivers. A total of 600 lit/s of water from the Arror River is deviated towards the lands under cultivation through these furrows.

The agricultural water rights in the downstream of the dam in the planning of water resources of the Arror Dam will be taken into consideration separately from the environmental water flow and the amount of environmental flow is the amount of water that will be remained and flowing in the river bed after the withdrawal of the agricultural water rights.

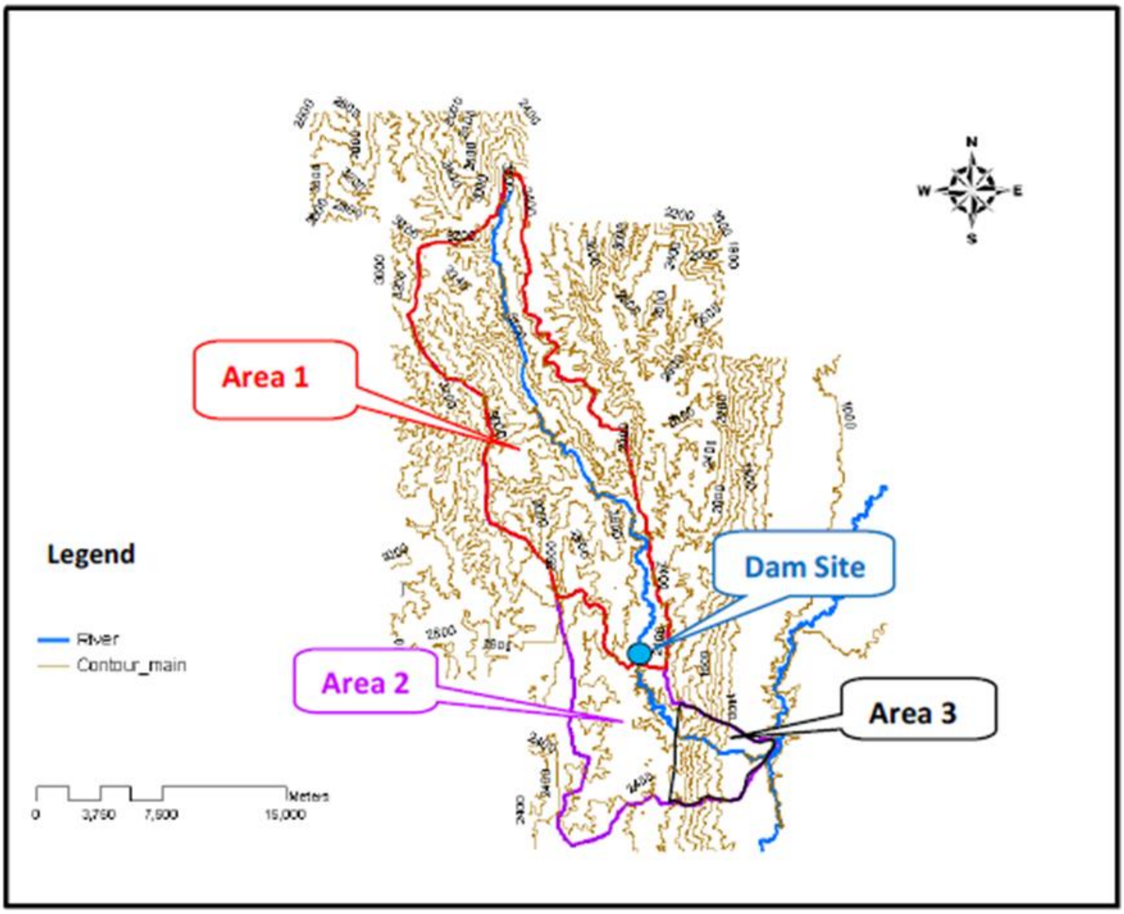


Fig. 8.1: Arror Basin and Location of Areas 1, 2 and 3

The most important aims of discharging the environmental water flow are as hereunder:

1- Conservation of wildlife

2- Lives of fish and other aqua life

3- Being attentive to birds

4- Preparing the river bed for the traversing of large floods

5- Assisting in the feeding of aquifers

It shall be specified, as to what extent each one of the above mentioned objectives will be a certainty and principally, to what amount the environmental water flow shall be determining for each of these aims.

1- Conservation of wildlife:

In the Arror basin (Areas 1, 2 & 3), Area 1 in the upstream of the dam and Area 3 in the Kerio Valley have rich biodiversity. Since in determining the water demand of the environment, the downstream areas of the dam are the main concern, the Arror River flow should be estimated on a basis that reduces the harm to the animal species in areas

2 and 3 to the least. Having more population and farmlands, the destruction of the forests and occupation of the habitats in Area 2 (i.e. the distance between the dam axis and the waterfall) does not include a great number and species of animals. This is while Area 3 (i.e. the distance between Arror Waterfall and Kerio River) has faced less human destruction. That is why conserving this area's natural environment is of great importance due to its wildlife, especially the variety of mammals' species. Therefore, conserving the wildlife, especially in the Kerio Valley (Area 3) is one of the main objectives of water supply of the Arror dam environment. However, it is worth mentioning that a major part of the EWF can be provided by the middle basin.

2- Lives of fish and other aqua life:

Studies confirm the presence of two fish species of *Oncorhynchus mykiss* from the Salmonidae family, and *Tilapia rendalli* from the Cichlidae family in the Arror River which are considered as the species introduced to this river.

Therefore, the variety of fish in the Arror River is not much. In order to determine the abundance of the fish, sampling and further investigations are required which are not within the framework of EIA studies. However, field studies show that people's lives is not dependent on fishing from Arror River, and except for rare cases, people do not fish. This may confirm that the number of identified species is not large in the Arror River. Therefore, supplying the required water for the conservation the fish is not the main concern for determining the EWF.

3- Being attentive to birds:

Birds, due to the power of flight, have high adaptation qualities and in cases of insecurity, select the upstream sections of the river to regulate their requirements.

From among birds, the waterfowls are totally dependent on water, because the river and its marginal vegetation are considered as where they feed, nest, and breed. Therefore, in case of drastic reduction in the water flow of the river, the lives of these birds would be harmed. However, since these waterfowls usually live near lagoons and rivers with smooth and even flows and coasts covered with canebrakes, near marches, or like passing migrants, it can be said that the Arror River is not an important habitat for this kind of birds. This is because this river lacks the required characteristics for these birds due to its slope (longitudinal profile), water pace, and peripheral habitats. The longitudinal profile of the Arror River can be seen in Figure 8.2.

In the Kerio Valley, Arror River is less important and has fewer roles for the lives of the birds because of the flow of the pivot Kerio River. In fact, the social role of the Arror River in the Kerio Valley is more than its ecological one.

Even though, attention to the life of birds and particularly waterfowl are effective in determining the discharge of EWF, but in comparison with other factors in the study area, it has a lower priority.

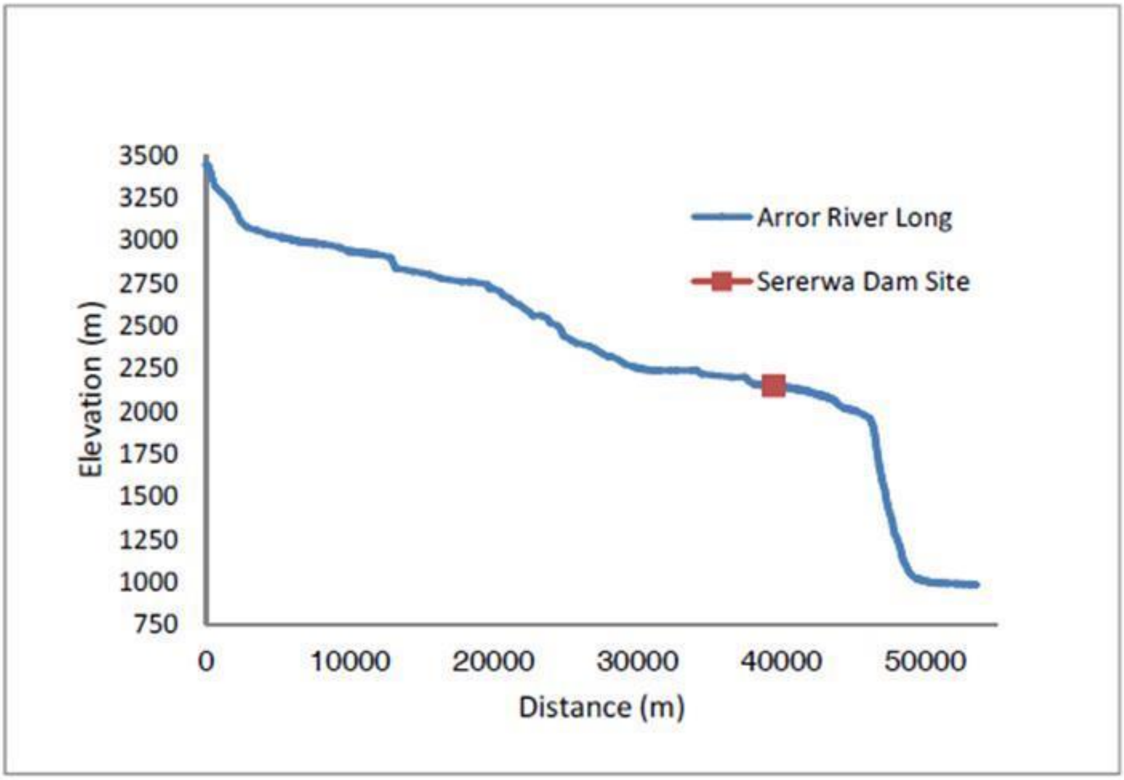


Fig. 8.2: Arror River Long Profile

4- Preparing the river bed for the traversing of large floods:

In dam construction projects, the volume of the flowage with various return periods is of great significance for the calculation of dam resistance and design of the spillway. In the environmental study, one of the objectives of the estimation of the EWF for the downstream is maintaining the river bed conditions for the traversing of large floods.

According to hydrological study, the maximum discharge of Arror River is 84.49 m^3/s which has taken place in 1968. The average of maximum discharge within the 25-year statistical period has been estimated as 15.86 m^3/s. Since the design of the Arror River and its spillway is based on the results of hydrological study, the majority of probable floods within the useful life of the dam (i.e. floods with 50-100 year return period are about 60-75 m^3/s) are controlled by the dam structure and its excess discharge is offloaded to the downstream through spillway. Therefore, the Arror river bed in the downstream should be maintained so that it would be capable of traversing this amount of flood. In this regard, although the EWF is not a considerable amount and constitutes a percentage of the annual flow average of the Arror River only, releasing it can help maintaining the basic conditions of the river bed.

5- Assisting in the feeding of aquifers:

There is no recorded or compiled information and statistical data regarding the quantity and quality of the underground waters in the Study Area. Enquiry from different local organizations revealed that with regard to the high average rainfall, sufficient river flows, living conditions of the local people and little importance of underground waters, there is no specific data in this regard. Based on the results of the field studies, the underground waters have no role in the lives of the inhabitants in neither upstream or downstream areas.

Therefore, even though, one of the objectives in releasing the environmental water flow is to assist in feeding the aquifers, this matter in the study area does not hold a high priority.

In addition to the above-mentioned objectives, other criteria which are of special importance for the release of the environmental water flow in this project are preserving two ecosystems; Arror Waterfall ecosystem and that of the confluence of Arror and Kerio rivers. These two will be discussed as follows:

6- Preserving the Arror Waterfall ecosystem:

Waterfalls are sensitive ecosystems which play such an important ecological role in their surroundings that a variety of plants and animal species can be found in one of these small ecosystems. In addition, waterfalls are always considered as tourism attractions due to their beautiful views. Therefore, considering the macroeconomic policies of Kenya which is based on ecotourism, preserving the Arror Waterfall is necessary. The flow of this waterfall in the Kerio Valley within a short distance in the upstream of Kerio National Reserve adds to the importance of preserving this waterfall, since tourists who come to this region to visit the National Reserve can enjoy their time through watching the views and spending some time near the waterfall. Due to the heat of weather in the Kerio Valley, the dangers of the Kerio River because of the crocodiles living there, and also the length of the return path, spending some time near the waterfall can be pleasant for the tourists. Therefore, preserving the Arror Waterfall is one of the most important aims in releasing the water flow for the downstream.

A significant point is that the Arror Waterfall is located at the farthest ending point of Area 2. Hence, in case of dam construction and reduction in the flow of Arror River, a considerable amount of the water needed for the waterfall is supplied through the middle basin. This will influence the estimation of the EWF for the downstream to a large extent, since due to the significance of the waterfall; its preservation is not utterly dependent on the release of environmental water right from the Arror Dam.

7- Preserving the confluence of Arror and Kerio Rivers' ecosystem:

The estuaries or confluence a river to a larger water body are among the most sensitive parts of a river and is considered as one of the most susceptible ecosystems. Due to the lack of slopes and therefore low rate of water flow, the fish spawn in this part of the river, leading to a great biodiversity in the mentioned area.

It is worth mentioning that the confluence of Arror and Kerio rivers is an evident habitat for the crocodiles in the Kerio River. The low slope, the low speed of water flow and the broad river bed together with climate conditions has formed a suitable habitat for the crocodiles. Regarding the grave changes of flow in the Kerio River and severe fall of discharge in dry seasons, preserving this habitat, especially in the hot and dry months is dependent on the Arror River flow. Like Arror Waterfall, this region too is of both ecological and ecotourism values. Therefore, preserving this ecosystem is among the objectives in releasing the EWF.

However, this place is located in the farthest end point of Area 3, which makes it not entirely dependent on the release of water from the Arror Dam, and that a considerable amount of water from the middle basin of Arror terminates in this area. In fact, this area is located in the farthest point from the dam site.

8.2.6.3. Estimation of EWF on the Basis of the Montana Method

In Montana method, a percentage of the Mean Annual Flow (MAF) within two six monthly periods have been taken under consideration (Table 8.1); for each period, river conditions from the viewpoint of fish habitats, wildlife, sedimentation transfer and access to suitable recreational spots are varied. By utilizing this method and recommended percentages of MAF, the minimum environmental water requirements in different expected conditions can be recommended.

Table 8.1: Determining the EWF of the Rivers According to the Montana Method

No.	Objective Conditions*	Mean Annual Flow (MAF)	
		Apr. – Sep.	Oct. – March
1	Flood or the maximum water flow	200% MAF	200% MAF
2	Optimum extent of flow	60%-100% MAF	60%-100% MAF
	Water flow requirements to conserve	**various conditions of the**	**ecosystem**
3	Outstanding conditions	60% MAF	40% MAF
4	Excellent conditions	50% MAF	30% MAF
5	Good conditions	40% MAF	20% MAF
6	Comparatively good conditions or in state of decline (acceptable)	30% MAF	10% MAF
7	Minimal or weak conditions	10% MAF	10% MAF
8	Intensively destructive conditions attained (intense short comings)	0 – 10% MAF	0 – 10% MAF

Ref: (Orth & Maughan, 1981; Brown & King, 2003; Maunder & Hindley, 2004)

** For fish habitats, wildlife, recreation and other environmental resources.*

There are two principle determining factors in this method:

1- *MAF:* In order to increase the accuracy in the results obtained, this amount must be estimated in accordance with the long-term duration statistics. Likewise, results of the measurements from the nearest hydrometric station to the dam site, that presents the traversing water flow from the dam site should be utilized.

2- *The selected percentage from the above mentioned Table (Nos.1 to 8):* On the basis of an absolute recognition of the status and local specifications of the study area, the percentage determined in one of the series of the above mentioned table, is a coefficient chosen for the exertion of the MAF.

To determine the MAF of the Arror River in the downstream of the Dam, hydrological study of the project has been used. With this respect, the only existing statistics relative to the mean monthly water flow for a 25-year period of the Arror River at 2C5 Station has been used. The 2C5 hydrometric station is approximately located on Arror River dam site.

In Table 8.2, the summarized statistics of the monthly river flow of the Arror River has been rendered.

Table 8.2: Arror River Flow at Dam Site (m3/s)

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Year
1961	5.05	15.03	3.56	0.91	0.75	0.64	0.99	1.45	1.46	2.37	4.26	1.55	3.23
1962	1.54	4.51	1.01	1.66	1.21	1.47	3.06	4.22	1.46	1.58	2.09	2.40	2.17
1963	0.89	2.33	4.53	1.06	1.02	1.03	3.38	4.80	1.67	1.03	2.33	0.98	2.09
1964	2.30	1.40	1.31	1.44	1.05	1.33	2.65	2.28	1.28	1.89	4.92	3.30	2.10
1965	1.67	3.49	1.08	1.05	0.92	0.83	1.72	1.60	1.21	1.17	0.80	0.81	1.36
1966	2.34	2.99	1.06	1.06	1.18	1.62	5.27	2.91	1.16	3.66	4.46	3.21	2.58
1967	5.38	6.64	2.87	0.85	1.03	0.75	1.83	4.23	1.57	2.93	3.65	1.39	2.76
1968	2.14	12.46	3.47	1.41	2.05	3.13	2.95	3.84	2.10	1.65	3.34	1.33	3.32
1969	2.78	3.44	1.37	1.72	2.67	2.87	1.32	3.10	3.44	1.66	1.50	2.67	2.38
1970	1.39	1.32	1.19	2.22	1.32	1.98	4.44	2.63	1.79	1.48	4.82	2.20	2.23
1971	2.97	6.02	2.36	1.37	0.78	0.79	1.82	1.95	1.52	2.01	4.99	2.29	2.41
1972	2.76	7.46	2.39	1.08	1.02	1.02	1.31	2.61	3.49	3.80	3.35	3.20	2.79
1973	1.75	6.15	1.41	1.07	0.89	0.95	1.19	1.45	1.26	1.47	2.42	2.75	1.90
1974	….	….	….	….	….	….	….	….	….	….	….	….	….
1975	1.38	1.13	0.92	1.08	1.04	0.98	1.36	1.57	1.28	1.71	4.93	2.98	1.70
1976	0.65	0.97	0.74	0.88	0.84	0.78	1.15	1.77	1.01	1.23	2.02	1.82	1.19
1977	2.61	12.24	1.94	0.77	0.73	0.67	3.50	6.23	1.28	1.99	3.03	1.36	3.03
1978	3.18	2.33	1.96	1.24	2.07	2.73	1.62	2.39	1.91	3.54	2.46	2.09	2.29
1979	1.05	0.93	0.71	1.78	2.55	3.35	3.77	2.06	1.89	1.32	1.69	1.20	1.86
1980	0.60	1.18	0.65	0.67	0.57	0.67	0.95	1.85	1.10	0.67	0.84	0.63	0.87
1981	1.49	1.32	1.21	0.64	0.66	2.18	3.17	1.81	0.87	1.51	3.01	1.98	1.65
1982	4.36	7.37	4.06	0.79	0.66	0.76	2.95	5.41	1.80	1.58	3.54	1.55	2.90
1983	4.20	4.46	1.55	1.31	1.04	0.87	1.72	3.62	1.84	2.16	4.46	2.56	2.48

1984	0.83	1.15	0.71	1.00	0.56	0.63	1.00	1.14	1.04	1.03	0.91	0.98	0.92
1985	0.96	1.48	0.81	0.81	0.70	1.78	3.38	2.32	1.40	1.24	1.95	1.53	1.62
1986	1.77	1.43	0.99	0.60	0.47	0.47	4.53	3.41	2.73	2.75	2.68	2.43	2.02
Mean	2.24	4.37	1.75	1.14	1.11	1.37	2.44	2.83	1.66	1.90	2.98	1.97	2.15
Max	5.38	15.03	4.53	2.22	2.67	3.35	5.27	6.23	3.49	3.80	4.99	3.30	
Min	0.60	0.93	0.65	0.60	0.56	0.63	0.95	1.14	0.87	0.67	0.80	0.63	

In the Montana Method, with due attention to status of study area and the amount of water in access in rivers, each one of the rows inserted in the Montana Table, can be selected to calculate the EWF in the downstream of dams. If in this project, row (6) or relatively good or acceptable conditions (see Table 8.1) are selected, with due attention to the MAF of the Arror River (2.15 m^3/sec.), in a six month period from April to September, 30 percent and in a six month period from October to March, 10 percent of the MAF of the river must be released as Environmental Water Flow.

The important point about the Arror River is that although the Study Area is located in the northern hemisphere, this region is very close to the equator line and therefore its summers and winters are not similar to those seasons in other areas located in the northern hemisphere. While April to September are considered as months with high water flow, October to March are considered as months with less flow in the river. As this area is located near the equator, there is no significant difference between the temperature and rainfall in different months of the year. Accordingly, no significant changes are observed in the Arror River flow during the year. The 25-year statistical data of the discharge of Arror River confirms this fact.

To conform the months of the year with the Montana method, April to September are regarded as rainy months, while October to Mars are considered as dry months in the table 8.1. Therefore, according to Montana method, 30% of the annual flow average should be released in the six-month span of October to March. This is while 10% should be released from April to September. Thus the following results are gained:

0.30 = 0.645 *(m^3/s)* ~ 9.7 *MCM / 6 months (Oct. – Mar.)*

0.10 = 0.215 *(m^3/s)* ~ 3.2 *MCM / 6 months (Apr. – Sep.)*

The monthly distribution of which, shall be according to Table (8.3).

Table 8.3: Environmental Water Flow Based on the Montana Method

Month / Parameter	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
EWF/Month (m^3/s)	0.645	0.645	0.645	0.645	0.645	0.645	0.215	0.215	0.215	0.215	0.215	0.215

On the basis of Montana method, an equivalent of nearly 12.9 MCM (≈ 13 MCM) from the annual output of the Arror River must be taken into consideration for the EWF throughout the year.

8.2.6.4. Estimation of EWF on the Basis of the Professional Judgment

Based on the objectives of releasing the EWF for the downstream environment, the status of the Study Area are added up as follows (Table 8.4).

Table 8.4: Summarized Status of Downstream in terms of EWF Releasing

No.	Parameter	Importance in the Study Area Based on the EBS (1)			Note
		High	Medium	Low	
1	Wildlife conservation (mostly mammals)		√		Most of the wildlife population is found in Area 3 of the Arror downstream where much of the water requirement is supplied through the middle basin. Therefore, this parameter is of moderate importance regarding EWF.
2	Aqua life		√		With regard to the little number and variety of the aquatics in both 2 and 3 Areas in the Arror River, this parameter is of moderate importance from EWF viewpoint.
3	Birds			√	Considering the high compatibility of the birds, this parameter is of low importance in EWF.
4	Basic condition of river bed		√		With regard to low fluctuation of the Arror River flow within a year, controlling most floods through the dam and the amount of flood volume with probability of the return period of 50-100 years, this parameter is of moderate importance in EWF from a conservative viewpoint.
5	Aquifer feeding			√	Due to insufficient information concerning the quantity and quality of underground waters, and the limited role and low importance of these waters for the local people, this parameter is of little importance regarding EWF.
6	Protection of Arror Waterfall		√		Although Arror Waterfall is considered as the most important ecosystem to preserve in the downstream of the dam, since this waterfall is located in the farthest end of the Area 2, a considerable amount of water that can preserve this ecosystem will be provided by the middle basin.

No.	Parameter	Importance in the Study Area Based on the EBS (1)			Note
		High	Medium	Low	
7	Arror mouth (the point where Arror River issues into Kerio River)			√	Although the confluence of Arror and Kerio rivers is the most important and susceptible part of the Arror River, since it is located in the farthest end of Area 3 and receives all of the water from Area 2 basin, and also with regard to the fact that it is located within a far distance from the dam, this parameter is of low importance concerning EWF.

Reviewing the 25-year statistics of Arror River flow shows that the difference between its lowest and highest monthly discharges (i.e. 1.11 m^3/s and 4.37 m^3/s, respectively) is 3.26 m^3/s. It is noteworthy that both of these two average monthly flows have taken place between October and March. While the lowest flow belongs to February, the highest is that of November. On this basis, dividing the Arror River to two 6-month periods of high and low flow does not follow any particular order. The 25-year statistical review also shows that October and November are also considered as months with high water flow, while the discharge of Arror River is reduced in June, in spite of being among first 6-month period. It is worth mentioning that if statistical information regarding the river water flow since 1987 up to the present time (i.e. 2011) would be available, more accurate results can be obtained.

Thus, according to an expertise view, consideration 10 percent of MAF of the Arror River during the months with higher water flow and 15 percent of MAF during the months with lower water flow to secure the EWF in the downstream will be sufficient. Therefore, the results will be as follows:

$$0.10 = 0.215 \ (m^3/s)$$

$$0.15 = 0.323 \ (m^3/s)$$

The monthly distribution of which, with attention to results in Table 8.2, shall be according to Table 8.5.

Table 8.5: Environmental Water Flow Based on the Professional Judgment

Month / Parameter	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
EWF/Month (m^3/s)	0.215	0.215	0.323	0.323	0.323	0.323	0.215	0.215	0.215	0.215	0.215	0.215

On this basis, an equivalent of 7.53 MCM of the annual output of the Arror River, must be considered for environmental water requirements throughout the year.

It should be mentioned that in the years with high flow regime, the EWF can be released on the basis of Montana Method and secured to the amount of 12.9 MCM per annum, but under any condition, the amount taken under consideration for the EWF, in the downstream of the Arror Dam must not be less than the minimum of 7.5 MCM per annum.

In case of the release of the EWF in the downstream, there must be sufficient control and supervision present, so that this flow is not utilized for other requirements, such as, agriculture. The water rights of agricultural lands present in the downstream (Kerio Valley) must be estimated, so that after diverting water for agricultural utilization, the basic environmental requirement remains in the course of the river.

8.2.7. Mitigation Measures for Construction Phase

Mitigation measures required for the adverse impacts of the project in the construction phase cover the topics in the Table 8.6.

Table 8.6: Mitigation Measures in Construction Phase

Potential Impact	Cause of Impact	Mitigation Measure
Water quality & pollution	- Exposure of loose soil to water and wind by transport and construction activities - Excavation from borrow areas - Spilling of oil, grease and fuel compounds on the land - Waste matters and debris depot - Solid wastes disposal - Effluent disposal	1. Accurate attention should be paid to the amount of water that is withdrawn from the river. 2. Proper and regular maintenance of vehicles. 3. Refraining from the spilling of fuel matter, kerosene and oil compounds into the river and streams. 4. Sewage disposal (produced in the construction workshops and temporary camps) by absorption wells (pits). 5. Sanitary burial of solid wastes (in a sufficient distance from the Arror and Kerio Rivers) and the prevention of wastewaters from entering the river. 6. Any waste should be disposed off according to the NEMA and local authority waste management rules and regulations. 7. Construction solid waste generated by activities can be disposed in areas approved by the local authority/council and NEMA that will be identified before commencement of construction activities. 8. Supervision of a representative of the Ministry of Environment on the implementation of the above mentioned mitigation measures. 9. Staff training before the commencement of construction activities. 10. Consideration all mitigation measures for soil erosion.
Decrease of Self-purification Capability of the River	- Excavation and embankment - Construction of temporary camps and workshops - Installations of	1. All the mitigation measures for soil erosion and water quality. 2. Debris depot in a manner that minimizes wash outs by rainfall leading to siltation of water bodies.

Potential Impact	Cause of Impact	Mitigation Measure
	equipment - Workshop activities - Excavation from borrow areas - Spilling of oil, grease and fuel compounds on the land	
Soil erosion	- Excavation and embankment - Excavation from borrow areas - cutting trees and land clearance	1. Compaction of loose material. 2. Diversion of runoff flows from construction sites. 3. Run-off from rainfall is a water source that can be stored and used for construction activities (especially in initial distance in downstream of escarpment in Kerio Valley). 4. Regular visits lead to the identifying of areas that have problems in regards to erosion and thus are given priority, so that corrective programs are implemented. 5. Soil excavation and embankment must be made for the immediate project area and unessential activities should be refrained from. 6. In order to compensate the damages incurred, due to the accelerated erosion, arising from construction activities, a control of natural erosion during the construction period must be taken under consideration. 7. In laying penstock, north and south water conveyance lines, vegetation clearance of more than the required width should be refrained from and this requires the surveillance of the environmental expert. 8. Improvement river bed such as building some short barriers to trap sediments.

Potential Impact	Cause of Impact	Mitigation Measure
soil contamination	- Solid wastes disposal - Effluent disposal - Spilling of oil, grease and fuel compounds on the land	1. Oil residuals including waste oil, lubricants, used filters, should be carefully collected and stored for safe disposal, in order to prevent spilling of contaminant hydrocarbons into runoff or groundwater. 2. Regular maintenance of site equipment and machinery should be carried out to ensure any leakages are detected and controlled. 3. Construction solid waste generated by activities can be disposed in areas approved by the local authority/council and NEMA that will be identified before commencement of construction activities. 4. Supervision of a representative of the Ministry of Environment on the implementation of the above mentioned mitigation measures.
Air Quality and Dust emission	- Excavation and embankment - Activities of machineries - Commuting of trucks - Cutting trees - Land clearance	1. Pave the main access road to the project area. 2. Sprinkle water on exposed dusty surfaces to reduce dust generation. 3. Trucks hauling soil should be covered with tarpaulins. 4. Checking, repairing and fixing the engines of vehicles and heavy machineries. All machineries and equipment should be maintained in good working order to ensure minimum emissions including carbon monoxide, oxides of nitrogen and sulphur, as well as suspended particles. 5. Affixing filters on the exhausts. 6. Utilizing masks for workers who are directly in the location where dust is dispersed. 7. Creating an alarm system for cases the air pollution exceeds the standard limits. 8. Supervision of a representative of the Ministry of Environment on the implementation of the above mentioned mitigation measures. 9. Staff training before the commencement of construction activities.

Potential Impact	Cause of Impact	Mitigation Measure
Noise	- Activity of machineries - Commuting of trucks - Excavation and embankment - Installations of equipment	1. Measuring the intensity of noise by utilizing the noise meter. In the case that, the level measured is higher than the permissible amount, all the methods to conserve the mental health of workers must be utilized to lessen the level of noise and decrease it to the standard level and shortening the period of noise generated should be taken under consideration. 2. Lubricating and regular repair of equipment and machinery. 3. Insulating engines which create noise. 4. Eliminating worn out machinery. 5. Elevating the speed of work, so as to shorten the construction period as much as possible. 6. Selecting an appropriate period for construction activities and refraining from it being synchronous with sensitive period for wildlife, such as their pregnancy and giving birth duration. 7. Rendering priority to the villages in the closer proximities of the dam site regarding the execution of resettlement program. 8. The Contractor should adopt the best practicable means of minimizing noise. 9. For any particular job, the quietest available machinery should be used. 10. All equipment should be maintained in good mechanical order and fitted with the appropriate silencers, mufflers, or acoustic covers where applicable. 11. Stationary noise sources should be sited as far away as possible from noise-sensitive areas, and where necessary acoustic barriers should be used to shield them. 12. Pneumatic drills and other noisy appliances should not be used after normal working hours. 13. Workers should be given noise protection equipment such as earmuffs and be taught how to use them and supervised to ensure such safety procedures are being adhered to. 14. The public should be informed that short periods of noise may be inevitable but prior warning of when noisy activities are to take place and the days and times noise of when they could be expected should be widely publicized before the activity takes place. 15. Fixing engines and exhausts of heavy machineries. 16. Use of portable acoustic barriers to shield compressors and other noisy equipment where

Potential Impact	Cause of Impact	Mitigation Measure
		necessary. 17. Observe and practice the recommended noise regulations. 18. Supervision of a representative of the Ministry of Environment on the implementation of the above mentioned mitigation measures. 19. Staff training before the commencement of construction activities.
Loss of trees and greenery beauty	- Construction activities and equipment - Laying pipelines - change in land use	1. Minimize number of trees cut. 2. Minimizing clearing and disruption to riparian vegetation. 3. Re-vegetation of disturbed areas with native plant species (plant prominent trees of the region such as Acacia) 4. Protect all the ecologically critical areas such as riparian zones by clear delineation and planting of suitable indigenous plant species. 5. Supervision of a representative of the Ministry of Environment on the implementation of the above mentioned mitigation measures. 6. Staff training before the commencement of construction activities. 7. Selection a proper location to establish temporary camps and construction workshops (a land void of trees with sufficient distance from river) 8. Use of soils resulting from excavation in embankment, soil tabulation and reclamation through planting native trees on the route of pipe laying 9. Supervision of a representative of the Ministry of Environment on the implementation of the above mentioned mitigation measures. 10. Staff training before the commencement of construction activities.
Loss of biodiversity	- Construction activities (different components of the project)	1. Minimize number of trees cut. 2. Control hunting. 3. Prevention from spilling oil and inflammable compounds of vehicles and machinery on the

Potential Impact	Cause of Impact	Mitigation Measure
	- Installations of equipment - Commuting of workers in the region (probability of hunting) - Excavation from borrow areas - Land clearance	ground so as to prevent soil pollution in the terrestrial ecosystem and its secondary impacts as to wildlife through the food chain. 4. Study on abundance and distribution of index fauna species and their changes in the region (e.g. breeding, nesting, feeding) during construction phase.
Fauna (Terrestrial & Aquatic)	- Construction activities (different components of the project) - Installations of equipment - Commuting of workers in the region (probability of hunting and noise) - Commuting of trucks - Excavation from borrow areas - Activities of heavy and light machinery (noise) - Effluent disposal - Land clearance	1. All mitigation measures for noise and effort to maintain it at the permissible standard level. 2. Selecting an appropriate period/season for construction work and refraining from it being synchronous with sensitive period for wildlife, such as pregnancy duration and giving birth. 3. Enumeration of fauna species (with emphasize on protected and important species) especially mammals during different seasons. 4. The performance of mitigation measures for noise pollution and efforts to maintain it at the permissible standard level shall be effective in decreasing this impact. 5. Regulating the time-table for the mobilization of vehicles so as to prevent stress arising from noise pollution. 6. A time-table regarding explosions at dam site, so as to prevent stress arising from noise pollution. 7. Prevention from spilling oil and grease compounds of vehicles and machinery on the ground so as to prevent soil pollution in the terrestrial ecosystem and its secondary impacts on wildlife through the food chain. 8. Prevention from the discharge of oil and grease compounds of vehicles and machinery, wastes and wastewaters into the river and streams so as to prevent the pollution of drinking water resources of wildlife.

Potential Impact	Cause of Impact	Mitigation Measure
		9. Training of workers and staff about meaning and principals of environmental conservation, prevention methods relevant to polluting the terrestrial and aquatic environments, hunting prohibitions and the prevention of excessive disorder of wastes and debris. 10. Supervision of a representative of the Ministry of Environment on the implementation of the above mentioned mitigation measures.
Land acquisition	Land acquisition within reservoir area	1. Timely information supply to the land owners. 2. Explanations to land owners in relative to the project objectives and its positive impacts, both national and throughout the region. 3. Obtaining public views particularly as to the mode of compensation and payment for damages. 4. By taking into consideration appropriate land with better prospects than the land lost for the land owners. 5. Abiding to the current land price.
Occupational Safety and Health (OSH)	- Employment - All construction activities	1. Workers shall be provided with appropriate personal protective equipment, such as coveralls, boots, mittens, gloves, dust and fume masks, all of which must be regularly replaced. 2. The abstract of the Occupational Safety & Health Act 2007 must be displayed at prominent places within the site. 3. Well stocked first aid box which is easily available and accessible should be provided within the construction site as well as at least an ambulance. 4. Ensure the working hours are controlled and that employees are not allowed to extend the working hours beyond an acceptable limit for purposes of gaining extra pay. 5. Ensure that all site personnel are provided with an adequate supply of safe drinking water, which should be at accessible points at all time. 6. Provide conveniently accessible, clean, orderly, adequate and suitable washing facilities within the site.

Potential Impact	Cause of Impact	Mitigation Measure
landscape	- Land clearance - Debris depot - Solid wastes	1. Preventing unessential environmental destruction, particularly the severing of bushes, trees and small trees by the workers. 2. Avoiding building permanent infrastructure which will not be used after construction. 3. Selection of a proper location for constructional materials and debris depot. 4. To allocate a place to park vehicles and heavy machinery to prevent their distribution and make a bad landscape in the region. 5. Managing the precise time-table for construction activities in order to shorten the construction period. 6. Preventing the dispersion of solid wastes and constructional materials in the environment. 7. Supervision of a representative of the Ministry of Environment on the implementation of the above mentioned mitigation measures. 8. Staff training before the commencement of construction activities.

8.2.8. Mitigation Measures for Operation Phase

Mitigation measures required for the adverse impacts of the project in the operation phase cover the topics in the Table 8.7:

Table 8.7: Mitigation Measures in Operation Phase

Potential Impact	Cause of Impact	Mitigation Measure
Water quality & pollution	- Effluent disposal - Solid waste disposal - Agricultural activities - Consumption of Fertilizer & pesticides in irrigation plan	1. Being assured that the absorption wells or pits of villages particularly those that are in the fringes of the river have a suitable distance from the river. 2. Regular sampling from the Arror and Kerio Rivers based on monitoring programs, so as to obtain the latest information as to the qualitative condition. 3. Watershed management and an effective planning with aims to conserve the water and soil resources and the Arror Dam Lake, by relative organizations conducting the dam operation management. 4. Suitable site locations for the solid waste disposal in the upstream basin of dam and in Kerio Valley. Sanitary waste disposal and the prevention of the entrance of the leachate of wastes into the river. 5. Releasing the environmental water flow from the Arror Dam according to its estimation in this report (7.53 MCM/y). 6. Optimum use of chemical fertilizers. 7. Utilizing unsustainable pesticides, which get decomposed faster in the environment, should be considered. 8. Training farmers by regular programs in relative to the dangers of using an excessive amount of chemical fertilizers and pesticides and its impacts on the environment. 9. Apply appropriate irrigation management. 10. Ensure appropriate agricultural practices and control of inputs. 11. Develop and implement an appropriate OS&H policy. 12. Control and regulation in handling, storage, application and disposal of agrochemical containers. 13. Measurements of pesticide residues in drains and kerio River and also in soil should be carried out regularly (twice per year). 14. Adopt recommendations from Tropical Pest Research Institute (TPRI) regarding safe and correct handling, storage, application (pesticide selection, timing, rate and methods) and disposal.

Potential Impact	**Cause of Impact**	**Mitigation Measure**
River water flow	- Presence of dam - Formation of reservoir	1. Releasing the environmental water flow from the Arror Dam according to its estimation in this report (7.53 MCM/y). 2. Creation of small weirs in the Arror River bed, consisting of a system of meshes of logs driven in or anchored to the bottom and protected by stony material and impermeable or semi-permeable earth, so as to create an over-flowable barrier 1-2 m high, where the meteoric waters or those discharged by the spillway are held; the number of weirs and their heights are adapted to the morphology of the river bed and depend on the necessity and the uses foreseen.
Decrease of Self-purification Capability of the River	- Effluent disposal - Solid waste disposal - Agricultural activities - Consumption of Fertilizer & pesticides in irrigation plan	Consideration all mitigation plans for water quality and river water flow.
Groundwater table and quality	- Formation of reservoir - Irrigation - Consumption of Fertilizer & pesticides in irrigation plan	1. Comprehensive study of the qualitative/ quantitative groundwater resources. 2. Monitoring program for groundwater. 3. The use of pesticides and chemical fertilizers should be curtailed to the minimum. In order to combat pests, disease, weeds and to fortify the land, measures devoid of chemicals should be taken. 4. If the use of chemicals is necessary, the amount used must be controlled and excessive applications should be refrained from. 5. Technical environmental surveillance on chemicals is essential. 6. Biological combating with pests and utilizing the natural prayers of pests and parasites. 7. Utilization of durable seeds. 8. Timely ploughing and burial of hay in the soil.

Potential Impact	Cause of Impact	Mitigation Measure
Soil erosion	Change in land use	1. Appropriate terracing in surrounding the dam lake if possible. 2. Minimize soil exposure through intensive cropping patterns. 3. Land use control in the basin, particularly in the conditions of change in the forest, being transformed into agricultural lands. 4. Preventing over-grazing in the basin. 5. Although in the slopes surrounding the limits of the Arror Dam is not specified as an area prone to high potentials of quakes and landslides, stabilizing the slope of the land prior to the reservoir filling in the limits within the reservoir and the fluctuation zone as well as the lands surrounding it, by utilizing suitable engineering methods can give increment to the reliability coefficient. 6. Water intake of the reservoir with a suitable speed in order to control the erosion of the coastline and decrease the probable collapsing of the walls.
Soil properties degradation in irrigation area	Excess water application	1. Avoid water logged conditions. 2. Leach soils regularly. 3. Management of chemical fertilizers and pesticides.
Noise	Operation of power house	The external protections of the machines and the insulation of the building exclude the occurrence of resonances and noise levels exceeding the acceptable limits of 40-50 decibels.
Flora	- Formation of reservoir - Agricultural activities - Agrochemicals and herbicides - Effluent disposal	1. With due attention to the status of flora species in the food chain, the releasing of sufficient EWF from the Arror Dam with the conservation of the riparian species, shall guarantee the survival of the food chain. The discharge of environmental water requirements shall cause an ecological improvement in the river. 2. Manage agrochemicals handling, application and dispose as appropriate. 3. Protect all the ecologically critical areas such as riparian zones by clear delineation and planting of suitable indigenous trees. 4. Promoting agro-forestry in the local community farms. 5. Fuel wood requirements for the local community will also be monitored to determine local demand and develop possible strategies such as agro-forestry, community forest areas and conservation of natural woodlands in the villages around the project.

Potential Impact	Cause of Impact	Mitigation Measure
Loss of biodiversity	- Formation of reservoir - Agricultural activities and change land use - Agrochemicals and herbicides for weed control	1. Hunting is prohibited. 2. Frequently study and monitoring on abundance and distribution of fauna species (especially index and threatened species) and their changes in the region (e.g. breeding, nesting and feeding) during operation phase. 3. Monitoring the terrestrial and aquatic habitats with emphasize on the habitats in downstream of dam as well as irrigation area and also Kerio River in downstream of irrigation plan. 4. Regular visits of a representative of the NEMA.
Fauna (Terrestrial and Aquatic)	- Formation of reservoir and loss of habitat - Agricultural activities and change in land use - Agrochemicals and herbicides for weed control - Wastewater discharges	1. Some areas in Arror Dam basin which is covered by Kipkunur Forest should be conserved strictly and introduced as a hunting-prohibited area. Conservation of the mentioned areas in the dam basin is essential for the survival, conservation and prevention of more damages to wildlife that shall lose their habitats in the dam reservoir limits, particularly, index species. 2. An access route to the reservoir must be considered for wildlife and or grazing livestock. 3. Tourism management for the conservation of the environment and to minimize the adverse impacts due to an expansion of tourism on the environment (especially in Kerio Valley). 4. Monitoring wildlife communities, particularly, index species during definite periods by experts and the assimilation of their communities. 5. Preventing of introducing non-endemic fish species into the dam reservoir 6. Consideration of all the mitigation plans for water pollution. 7. Optimize the consumption of chemical fertilizers and pesticides. 8. Releasing the environmental water flow from the Arror Dam according to its estimation in this report (7.53 MCM/y). 9. Sampling of water biological parameters (including phytoplankton and zooplankton) and checking the increment or decrement of these species in different seasons. 10. Adequate and prompt compensation of any life or crop destroyed by wildlife by the KWS management.
Population displacement	Land acquisition	1. Attraction public participation in the planning and implementation of required resettlement program is under emphasis. 2. Local people should preferably be resettled in regions where they could benefit from interests of the project. 3. Land, house and other damages incurred must be compensated.

Potential Impact	Cause of Impact	Mitigation Measure
		4. Pay attention to the following points in the implementation of displacement and resettlement programs for families within the dam reservoir: - demographic specifications of rural families in segregation with those villages that shall be submerged and those in the reservoir fringes - Social specifications of the submerged villages - categorization of families according to the type of damages incurred due to dam construction and estimations as to the amount and kinds of damages. 5. Identifying of potentials and capacities present as to compensation and displacement (resettlement). 6. Formulation and rendering of implementation and management programs of resettlement.
Health & disease	- Formation of reservoir - Effluent disposal - Solid waste disposal - Consumption of fertilizer and Pesticides - Employment non-local workforce	1. A weekly creation of fluctuation on the lake water surface, so as to prevent the spawning of carrier insects. The water level of the lake must be reduced by 0.5 m, so that larvae of insect carrying disease are confronted with a dry environment that eradicates them. To prevent the anopheles mosquito from spawning, the surface level of the lake water should be brought down at once. This sudden fluctuation can have a remarkable impact in eradicating the eggs of insects. 2. Prevention of the growth of reeds and the presence of a red rush and vegetation on the coasts of the lake. 3. By constructing coastal walls, efforts shall be made to prevent the creation of a shallow depth of water in the coasts of the dam lake which usually has a slight slope. 4. Optimization of fertilizer and pesticide consumption. 5. Establishing health centers with the construction of the initial temporary camps and constructional workshops. 6. Public awareness campaigns and civic education. 7. Staff training before the commencement of construction activities. 8. Optimize irrigation water according to crop pattern to avoid runoff or excessive application. 9. Health control of river water through sampling. 10. Monitoring of health and disease indices.

9. Environmental and Social Management Plan

9.1 Introduction

The purpose of the following Environmental and Social Management Plan (ESMP) for the proposed project is to initiate a mechanism for implementing mitigation measures for the potential negative environmental impacts and monitor the efficiency of these mitigation measures based on relevant environmental indicators. The ESMP identifies certain roles and responsibilities for different stakeholders for implementation, supervision and monitoring.

The objectives of the ESMP are:

- 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 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. A monitoring program, backed up by powers to ensure corrective action when the monitoring results show it necessary, 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.

This ESMP is prepared for the three project stages where potential significant negative impacts manifest. These are:

i. Construction Phase ESMP

ii. Operation Phase ESMP and

iii. Decommissioning Phase ESMP.

Table 9.1: ESMP

Potential Impact	Proposed Mitigation Measure	Responsibility	Cost, USD
	Construction phase		
Water quality & pollution	- Accurate attention should be paid to the amount of water that is withdrawn from the river. - Proper and regular maintenance of vehicles. - Refraining from the spilling of fuel matter, kerosene and oil compounds into the river and streams. - Sewage disposal (produced in the construction workshops and temporary camps) by absorption wells (pits). - Sanitary burial of solid wastes (in a sufficient distance from the Arror and Kerio Rivers) and the prevention of wastewaters from entering the river. - Any waste should be disposed off according to the NEMA and local authority waste management rules and regulations. - Construction solid waste generated by activities can be disposed in areas approved by the local authority/council and NEMA that will be identified before commencement of construction activities. - Supervision of a representative of the Ministry of Environment on the implementation of the above mentioned mitigation measures. - Staff training before the commencement of construction activities. - Consideration all mitigation measures for soil erosion.	Contractor	1000
Decrease of Self-purification capability of the River	- Implement all the mitigation measures for soil erosion and water quality. - Debris should be disposed in a manner that minimizes wash outs by rainfall leading to siltation of water bodies.	Contractor	500

Potential Impact	Proposed Mitigation Measure	Responsibility	Cost, USD
Soil erosion	- Compaction of loose material. - Diversion of runoff flows from construction sites. - Run-off from rainfall is a water source that can be stored and used for construction activities (especially in initial distance in downstream of escarpment in Kerio Valley). - Regular visits lead to the identifying of areas that have problems in regards to erosion and thus are given priority, so that corrective programs are implemented. - Soil excavation and embankment must be made for the immediate project area and unessential activities should be refrained from. - In order to compensate the damages incurred, due to the accelerated erosion, arising from construction activities, a control of natural erosion during the construction period must be taken under consideration. - In laying penstock, north and south water conveyance lines, vegetation clearance of more than the required width should be refrained from and this requires the surveillance of the environmental expert. - Improvement river bed such as building some short barriers to trap sediments.	Contractor	1000
soil contamination	- Oil residuals including waste oil, lubricants, used filters, should be carefully collected and stored for safe disposal, in order to prevent spilling of contaminant hydrocarbons into runoff or groundwater. - Regular maintenance of site equipment and machinery should be carried out to ensure any leakages are detected and controlled. - Construction solid waste generated by activities can be disposed in areas approved by the county government that will be identified before commencement of construction activities. - Supervision of a representative from NEMA on the implementation of the above mentioned mitigation measures.	Contractor	200

Potential Impact	Proposed Mitigation Measure	Responsibility	Cost, USD
Air Quality and Dust emission	- Pave the main access road to the project area. - Sprinkle water on exposed dusty surfaces to reduce dust generation. - Trucks hauling soil should be covered with tarpaulins. - Checking, repairing and fixing the engines of vehicles and heavy machineries. All machineries and equipment should be maintained in good working order to ensure minimum emissions including carbon monoxide, oxides of nitrogen and sulphur, as well as suspended particles. - Affixing filters on the exhausts. - Utilizing masks for workers who are directly in the location where dust is dispersed. - Creating an alarm system for cases the air pollution exceeds the standard limits. - Supervision by a representative from NEMA on the implementation of the above mentioned mitigation measures. - Staff training before the commencement of construction activities.	Contractor	2000
Noise	- Measuring the intensity of noise by utilizing the noise meter. In the case that, the level measured is higher than the permissible amount, all the methods to conserve the mental health of workers must be utilized to lessen the level of noise and decrease it to the standard level and shortening the period of noise generated should be taken under consideration. - Lubricating and regular repair of equipment and machinery. - Insulating engines which create noise. - Eliminating worn out machinery. - Elevating the speed of work, so as to shorten the construction period as much as possible.	contractor	500

Potential Impact	Proposed Mitigation Measure	Responsibility	Cost, USD
	- Selecting an appropriate period for construction activities and refraining from it being synchronous with sensitive period for wildlife, such as their pregnancy and giving birth duration. - The Contractor should adopt the best practicable means of minimizing noise. - For any particular job, the quietest available machinery should be used. - All equipment should be maintained in good mechanical order and fitted with the appropriate silencers, mufflers, or acoustic covers where applicable. - Stationary noise sources should be sited as far away as possible from noise-sensitive areas, and where necessary acoustic barriers should be used to shield them. - Pneumatic drills and other noisy appliances should not be used after normal working hours. - Workers should be given noise protection equipment such as earmuffs and be taught how to use them and supervised to ensure such safety procedures are being adhered to. - The public should be informed that short periods of noise may be inevitable but prior warning of when noisy activities are to take place and the days and times noise of when they could be expected should be widely publicized before the activity takes place. - Fixing engines and exhausts of heavy machineries. - Use of portable acoustic barriers to shield compressors and other noisy equipment where necessary. - Observe and practice the recommended noise regulations. - Supervision of a representative from NEMA on the implementation of the above mentioned mitigation measures. - Staff training before the commencement of construction activities.		

Potential Impact	Proposed Mitigation Measure	Responsibility	Cost, USD
Loss of trees and greener beauty	- Minimize number of trees and other vegetation clearance. - Minimizing clearing and disruption to riparian vegetation. - Re-vegetation of disturbed areas with native plant species (plant prominent trees of the region such as Acacia) - Protect all the ecologically critical areas such as riparian zones by clear delineation and planting of suitable indigenous plant species. - Supervision of a representative from NEMA on the implementation of the above mentioned mitigation measures. - Staff training before the commencement of construction activities. - Selection a proper location to establish temporary camps and construction workshops (a land void of trees with sufficient distance from river) - Use of soils resulting from excavation in embankment, soil tabulation and reclamation through planting native trees on the route of pipe laying - Supervision of a representative from NEMA on the implementation of the above mentioned mitigation measures. - Staff training before the commencement of construction activities.	Contractor	1000
Loss of biodiversity	- Minimize vegetation clearance. - Prohibit hunting. - Prevention from spilling oil and inflammable compounds of vehicles and machinery on the ground so as to prevent soil pollution in the terrestrial ecosystem and its secondary impacts as to wildlife through the food chain. - Study on population and distribution index of fauna species and their changes in the region (e.g. breeding, nesting, and feeding) during construction phase.	Contractor	200

Potential Impact	Proposed Mitigation Measure	Responsibility	Cost, USD
Fauna (Terrestrial & Aquatic)	- Implement all mitigation measures for noise and effort to maintain it at the permissible standard level. - Selecting an appropriate period/season for construction work and refraining from it being synchronous with sensitive period for wildlife, such as pregnancy duration and giving birth. - Enumeration of fauna species (with emphasize on protected and important species) especially mammals during different seasons. - The performance of mitigation measures for noise pollution and efforts to maintain it at the permissible standard level shall be effective in decreasing this impact. - Regulating the time-table for the mobilization of vehicles so as to prevent stress arising from noise pollution. - A time-table regarding explosions at dam site, so as to prevent stress arising from noise pollution. - Prevention from spilling oil and grease compounds of vehicles and machinery on the ground so as to prevent soil pollution in the terrestrial ecosystem and its secondary impacts on wildlife through the food chain. - Prevention from the discharge of oil and grease compounds of vehicles and machinery, wastes and wastewaters into the river and streams so as to prevent the pollution of drinking water resources of wildlife. - Training of workers and staff about meaning and principals of environmental conservation, prevention methods relevant to polluting the terrestrial and aquatic environments, hunting prohibitions and the prevention of excessive disorder of wastes and debris. - Supervision of a representative from NEMA on the implementation of the above mentioned mitigation measures.	Contractor	200

Potential Impact	Proposed Mitigation Measure	Responsibility	Cost, USD
Land acquisition	- Timely information disclosure to the Project Affected Persons (PAPs). - Explanations to PAPs in relative to the plan objectives and its positive impacts, both national and throughout the region. - Implement the Resettlement Action Plan (RAP) to the latter.	KVDA	As per RAP report
Occupational Safety and Health (OSH)	- Workers shall be provided with appropriate personal protective equipment, such as coveralls, boots, mittens, gloves, dust and fume masks, all of which must be regularly replaced. - The abstract of the Occupational Safety & Health Act 2007 must be displayed at prominent places within the site. - Well stocked first aid box which is easily available and accessible should be provided within the construction site as well as at least an ambulance. - Ensure the working hours are controlled and that employees are not allowed to extend the working hours beyond an acceptable limit for purposes of gaining extra pay. - Ensure that all site personnel are provided with an adequate supply of safe drinking water, which should be at accessible points at all times. - Provide conveniently accessible, clean, orderly, adequate and suitable washing facilities within the site.	Contractors	2000
landscape	- Preventing unessential environmental destruction, particularly the severing of bushes, trees and small trees by the workers. - Avoiding building permanent infrastructure which will not be used after construction. - Selection of a proper location for constructional materials and debris depot. - To allocate a place to park vehicles and heavy machinery to prevent their distribution and make a bad landscape in the region.	Contractor	1000

Potential Impact	Proposed Mitigation Measure	Responsibility	Cost, USD
	- Managing the precise time-table for construction activities in order to shorten the construction period. - Preventing the dispersion of solid wastes and constructional materials in the environment. - Supervision of a representative of the Ministry of Environment on the implementation of the above mentioned mitigation measures. - Staff training before the commencement of construction activities.		
	Operation phase		
Water quality & pollution	- Being assured that the absorption wells or pits of villages particularly those that are in the fringes of the river have a suitable distance from the river. - Regular sampling from the Arror and Kerio Rivers based on monitoring programs, so as to obtain the latest information as to the qualitative condition. - Watershed management and an effective planning with aims to conserve the water and soil resources and the Arror Dam Lake, by relative organizations conducting the dam operation management. - Suitable site locations for the solid waste disposal in the upstream basin of dam and in Kerio Valley. Sanitary waste disposal and the prevention of the entrance of the leachate of wastes into the river. - Releasing the environmental water flow from the Arror Dam according to its estimation in this report (7.53 MCM/y). - Optimum use of chemical fertilizers. - Utilizing unsustainable pesticides, which get decomposed faster in the environment, should be considered. - Training farmers by regular programs in relative to the dangers of using an excessive amount of chemical fertilizers and pesticides and its impacts on the environment.	KVDA	1000

Potential Impact	Proposed Mitigation Measure	Responsibility	Cost, USD
	- Apply appropriate irrigation management. - Ensure appropriate agricultural practices and control of inputs. - Develop and implement an appropriate OS&H policy. - Control and regulation in handling, storage, application and disposal of agrochemical containers. - Measurements of pesticide residues in drains and Kerio River and also in soil should be carried out regularly (twice per year). - Adopt recommendations from Tropical Pest Research Institute (TPRI) regarding safe and correct handling, storage, application (pesticide selection, timing, rate and methods) and disposal.		
River water flow	- Releasing the environmental water flow from the Arror Dam according to its estimation in this report (7.53 MCM/y). - Creation of small weirs in the Arror River bed, consisting of a system of meshes of logs driven in or anchored to the bottom and protected by stony material and impermeable or semi-permeable earth, so as to create an over-flowable barrier 1-2 m high, where the meteoric waters or those discharged by the spillway are held; the number of weirs and their heights are adapted to the morphology of the river bed and depend on the necessity and the uses foreseen.	WRMA and KVDA	500
Decrease of Self-purification Capability of the River	- Implementation of all mitigation measures for water quality and river water flow.	KVDA	500

Potential Impact	Proposed Mitigation Measure	Responsibility	Cost, USD
Groundwater table and quality	- Comprehensive study of the qualitative/ quantitative groundwater resources. - Monitoring program for groundwater. - The use of pesticides and chemical fertilizers should be curtailed to the minimum. In order to combat pests, disease, weeds and to fortify the land, measures devoid of chemicals should be taken. - If the use of chemicals is necessary, the amount used must be controlled and excessive applications should be refrained from. - Technical environmental surveillance on chemicals is essential. - Biological combating with pests and utilizing the natural prayers of pests and parasites. - Utilization of durable seeds. - Timely ploughing and burial of hay in the soil.	KVDA, WRMA and county government	1000
Soil erosion	- Appropriate terracing in surrounding the dam lake if possible. - Minimize soil exposure through intensive cropping patterns. - Land use control in the basin, particularly in the conditions of change in the forest, being transformed into agricultural lands. - Preventing over-grazing in the basin. - Although in the slopes surrounding the limits of the Arror Dam is not specified as an area prone to high potentials of quakes and landslides, stabilizing the slope of the land prior to the reservoir filling in the limits within the reservoir and the fluctuation zone as well as the lands surrounding it, by utilizing suitable engineering methods can give increment to the reliability coefficient. - Water intake of the reservoir with a suitable speed in order to control the erosion of the coastline and decrease the probable collapsing of the walls.	KVDA	1000

Potential Impact	Proposed Mitigation Measure	Responsibility	Cost, USD
Soil properties degradation in irrigation area	- Avoid water logged conditions. - Leach soils regularly. - Management of chemical fertilizers and pesticides.	KVDA and county government	1500
Noise	The external protections of the machines and the insulation of the building exclude the occurrence of resonances and noise levels exceeding the acceptable limits of 40-50 decibels.	KVDA	100
Flora	- With due attention to the status of flora species in the food chain, the releasing of sufficient EWF from the Arror Dam with the conservation of the riparian species, shall guarantee the survival of the food chain. The discharge of environmental water requirements shall cause an ecological improvement in the river. - Manage agrochemicals handling, application and dispose as appropriate. - Protect all the ecologically critical areas such as riparian zones by clear delineation and planting of suitable indigenous trees. - Promoting agro-forestry in the local community farms. - Fuel wood requirements for the local community will also be monitored to determine local demand and develop possible strategies such as agro-forestry, community forest areas and conservation of natural woodlands in the villages around the project.	KVDA	1000

Potential Impact	Proposed Mitigation Measure	Responsibility	Cost, USD
Loss of biodiversity	- Hunting prohibited. - Frequently study and monitoring on population and distribution of fauna species (especially index and threatened species) and their changes in the region (e.g. breeding, nesting and feeding) during operation phase. - Monitoring the terrestrial and aquatic habitats with emphasize on the habitats in downstream of dam as well as irrigation area and also Kerio River in downstream of irrigation plan. - Regular visits by NEMA officers.	KVDA, NEMA	500
Fauna (Terrestrial and Aquatic)	- Some areas in Arror Dam basin which is covered by Kipkunur Forest should be conserved strictly and introduced as a hunting-prohibited area. Conservation of the mentioned areas in the dam basin is essential for the survival, conservation and prevention of more damages to wildlife that shall lose their habitats in the dam reservoir limits, particularly, index species. - An access route to the reservoir must be considered for wildlife and or grazing livestock. - Tourism management for the conservation of the environment and to minimize the adverse impacts due to an expansion of tourism on the environment (especially in Kerio Valley). - Monitoring wildlife communities, particularly, index species during definite periods by experts and the assimilation of their communities. - Preventing of introducing non-endemic fish species into the dam reservoir. - Consideration of all the mitigation plans for water pollution. - Optimize the consumption of chemical fertilizers and pesticides. - Releasing the environmental water flow from the Arror Dam according to its estimation in this report (7.53 MCM/y).	KVDA, KWS and county government	2000

Potential Impact	Proposed Mitigation Measure	Responsibility	Cost, USD
	- Sampling of water biological parameters (including phytoplankton and zooplankton) and checking the increment or decrement of these species in different seasons. - Adequate and prompt compensation of any life or crop destroyed by wildlife by the KWS management.		
Health & disease	- A weekly creation of fluctuation on the lake water surface, so as to prevent the spawning of carrier insects. The water level of the lake must be reduced by 0.5 m, so that larvae of insect carrying disease are confronted with a dry environment that eradicates them. To prevent the anopheles mosquito from spawning, the surface level of the lake water should be brought down at once. This sudden fluctuation can have a remarkable impact in eradicating the eggs of insects. - Prevention of the growth of reeds and the presence of a red rush and vegetation on the coasts of the lake. - By constructing coastal walls, efforts shall be made to prevent the creation of a shallow depth of water in the coasts of the dam lake which usually has a slight slope. - Optimization of fertilizer and pesticide consumption. - Establishing health centers with the construction of the initial temporary camps and constructional workshops. - Public awareness campaigns and civic education.	KVDA and county government	1000

Potential Impact	Proposed Mitigation Measure	Responsibility	Cost, USD
	- Staff training before the commencement of construction activities. - Optimize irrigation water according to crop pattern to avoid runoff or excessive application. - Health control of river water through sampling. - Monitoring of health and disease indices.		

10. Environmental & Social Monitoring Plan

The management of environmental and social impacts and consequences of every proposed project is a regular, all purpose and continuous activity, which commences from the beginning of the project and the initial plan of its establishment, and until termination of the project life and thereafter. The performance of this management rests on an appropriate administrative structure, known as the environmental & social management unit, which is a section of the management and operation aggregate of the plan. Outlooks and the principals of environmental conservations must proceed in all the various angles of management.

The objectives of this plan is to render suitable methods and perform effective measures of acceptable costs, in order to reduce the destructive impacts arising from the establishment and operation of the Arror Dam project in regards the regional environment and its accordance with the standard and desirable conditions, in rendering monitoring and control programs, public participation and environmental training. Hence, in this chapter, in addition to rendering the program for each monitoring index, by specifying the responsible or relative organizations and estimating the organizational and implementation requirements, conditions for the execution of environmental program are alleviated.

10.1. Environmental and social monitoring program

Monitoring program is one of the crucial bodies of environmental study, where information attained from it, shall be extremely beneficial with operation potentials in environmental programs and decision making. The aim of rendering these programs is to assess the success or the unsuccessfulness of it in environmental programs and finally, its review and synchronization. In other words, information obtained from monitoring, in addition to the prevention of the occurrence of disturbances in the system and at the same time reaching the objective and simultaneously the implementation progress are procedures for mitigation measures. In the case of a lack of conformity which is obtained with the rules and regulations and standards or even ultimately with the maintenance and monitoring programs, the required measures and corrections will be enforced.

Monitoring programs should be formulated in such a manner that the required information for being aware of the environmental conditions, the amount of its being prone to the impacts from the plan will be attained, and will be effective in the predicting scopes of the future impacts and consequences. Likewise, in the case of observing or predicting unacceptable impacts and or impacts which have not been foreseen in the assessments for any reason, shall give the required opportunity to gain managerial modes and rectification policies to bring about a reduction of the adverse impacts.

Monitoring programs should take attention of the following:

- Control the survival of quality of environmental condition within a desirable level
- Surveillance and monitoring the qualitative and quantitative transformations of indexes in comparison to the accepted standards and criterions
- Assessing and continuous monitoring of predicted impacts in the construction and operation phases
- Monitoring programs to reduce the negative impacts, in order to determine the effects of the methods and several programs to decrease the impacts, including the comparison of the activities with the environmental criteria and regulations

With the commencement of the Arror Project construction and its side installations, the physical, ecological and socio-economic parameters, shall be subjected to change in the region. In this regard, the changes that have come into existence have to be continuously monitored throughout the construction and operation periods of the project. It should be mentioned that, the implementation of management and monitoring programs requires a responsible structural organ with determined duties.

A monitoring program comprises of the following phases:

- Monitoring parameters
- Location or monitoring stations
- Monitoring time frequency
- Organizations responsible for monitoring, both surveillance and implementation

In this section of the report, monitoring programs are rendered for each of the indexes under consideration, in the construction and operation phases.

10.1.1. Construction Phase

Monitoring program for the critical indices in the construction phase has been rendered in Table 10.1.

Table 10.1: Environmental Monitoring Program for the Construction phase

Environmental Parameter	PROCESS/ DESCRIPTION	Measure	Frequency	Monitoring Location	Responsible Organization	
					Performance	QA/QC
Water Quality	- Contamination by fuels and oils - Soil erosion	1. Physico-Chemical parameters 2. Microbiological parameters	Monthly	1. Arror River : - 2C5 Station on the Arror River (nearest station to dam site) - 2C18 Station located on the Arror River (downstream of Arror waterfall in the Kerio Valley) 2. Kerio River: - Kr-C1 station located upstream of the irrigation area on the Kerio River - Kr-C2 station located on the kerio River before its confluence with Arror River - Kr-C3 station located downstream of the irrigation area on the Kerio River	Water Resources Management Authority (WRMA) /Environmental Management Unit of the Project	Ministry of Water and Irrigation & NEMA
		3. Heavy metals	Every 6 months			
Soil erosion	- Soil erosion - Increased runoff	Erosion signs & River water quality (TSS, TDS, TH, EC)	Monthly	1. Arror River Construction site 2. Kerio River downstream of irrigation project area	Environmental management unit of the project	NEMA
Soil contamination	- Contamination by fuels and oils	Oil, grease, etc.	Monthly	Construction sites, access roads, river bank	Environmental management unit of the project	NEMA

Noise	Unhealthy conditions	Noise Intensity	Weekly (at the peak of activities)	construction sites, surrounding areas and affected villages	Contractor, Safety officer	NEMA
Air Quality and Dust	- Unhealthy Conditions - Dust emissions	Dust HC, CO, SO_2 CO_2, NO_x	Weekly (at the peak of activities)	construction sites, surrounding areas and affected villages	Contractor, Safety officer	NEMA
HSE	-	Level of health & safety	Weekly	Construction sites and camps	Contractor, Safety officer	Ministry of Health & NEMA
Flora	Physical destruction of plants	Destruction of ecosystem	Seasonal	construction sites and surrounding areas	Contractor, ecologist	KFS & NEMA
Fauna	Animal killing, Animal migration	Destruction of ecosystem	Seasonal	construction sites and surrounding areas	Contractor, ecologist	KWS & NEMA

NEMA: National Environment Management Authority *KFS: Kenya Forest Service* *KWS: Kenya Wildlife Service*

For conducting sampling and the implementation of monitoring programs, the presence of experts and several technicians are required. Similarly, for analyzing the samples, an equipped laboratory is needed. The laboratory has to be equipped with measuring apparatus of suitable accuracy, for analyzing all the parameters such as, physico-chemical, microbiological, microbial and heavy metals.

10.1.2. Operation Phase

- **Water Quality & quantity**

Since the main objective of the project is to supply drinking water to some population centers, water quality comprising of all the parameters such as, physico-chemical, microbiological, and heavy metals have to be under continuous monitoring. In order to execute the qualitative-quantitative monitoring of the river, in the minimum, one specialist and a technician are required. Parameters requiring monitoring are similar to the monitoring programs of the construction phase, but the number of monitoring stations or locations, shall increase with the formation of the dam lake. The environmental monitoring program of the water quality and quantity of the river and the lake behind the dam is according to Table 10.2.

Table 10.2: Environmental Monitoring Program of Water Quality and Quantity

Environmental Parameter	Measure	Frequency	Monitoring Location	Responsible Organization	
				Performance	QA/QC
River	1- Physico-Chemical parameters 2-Microbiological parameters	Monthly	1. Arror River - 2C5 Station - 2C18 Station 2. Kerio River - Kr-C1 station - Kr-C2 station - Kr-C3 station	Ministry of Regional Development Authorities/ Water Resources Management Authority	NEMA
	3-Heavy metals	Annual			
Reservoir	1- Physico-Chemical parameters 2-Microbiological parameters	Monthly	3 points at upstream of reservoir, amidst and at the dam axis		
	3-Heavy metals	Annual			

- **Groundwater Table**

Due to the consequences of the project and its probable effects, in the rise of the groundwater level in the downstream of the dam site and Kerio plain, the continuous monitoring of this impact is recommended. It should be mentioned that, this program does not only limited to a series of measuring and requires a comprehensive study. The monitoring program of the groundwater level is given in Table 10.3.

Table 10.3: Environmental Monitoring Program of Groundwater Table

Environmental Parameter	Measure	Frequency	Monitoring Location	Responsible Organization	
				Performance	QA/QC
Groundwater	Groundwater level	Seasonal	At least 10 wells, random and outspread in Kerio Plain	WRMA	NEMA

NEMA: National Environment Management Authority

For implementation of this program, at least one specialist and one technician is needed.

- **Groundwater Quality**

Environmental monitoring program of groundwater quality is given in Table 10.4.

Table 10.4: Environmental Monitoring Program of Groundwater Quality

Environmental Parameter	Measure	Frequency	Monitoring Location	Responsible Organization	
				Performance	QA/QC
Groundwater	Groundwater Quality including all physicochemical, microbiological parameter	Twice in the year (in the maximum & minimum levels)	The same wells have been tested for groundwater table	WRMA	NEMA
	Heavy metals	Annual			

Required human resource for implementation of this program is the same as monitoring program of groundwater table.

- **Wastewater quality of agriculture land**

Runnoff water from agricultural lands in the Kerio Plain during the project operation can be discussed as a potential source of pollution.

Monitoring programs and the quality control of runoff is known as one of the methods to reduce the adverse impacts. Therefore, so as to have the scopes to survey the mitigation measures and the changes in pollutants, monitoring programs for the polluting sources is essential. Within the framework of this program, sampling at the location of drain water of a proper alternating time is proposed.

It should be stated that, locations of sampling the runoff (monitoring stations), which are proportionate with the environmental conditions during the relative time, shall be determined by environmental management of the project. This program must be synchronized according to the analysis results and reports of the environmental management group of the project. Since the qualitative-quantitative aspect of the drain water depend on the land under irrigation, according to which it is subjected to intense change, in order to gain access to accurate information about the project conditions and create scopes for comparing results, the time frequency of monitoring program must be coordinated with that of the land under irrigation. This program is according to Table 10.5.

Table 10.5: Environmental Monitoring Program of Wastewater Quality

Environmental Parameter	Measure	Frequency	Monitoring Location	Responsible Organization	
				Performance	QA/QC
Wastewater of Agriculture Land	PH, DO, BOD, NO_2, NO_3, PO_4 & Pesticides	After irrigation	At least 3 pointes of discharges to the river	WRMA	NEMA

For implementation of this program, at least one specialist and one technician is needed.

- **Erosion and Sedimentation**

Erosion is a phenomenon, which in the construction phase is discussed on a minor scale and in the operation phase on a major scale. The direct connection between the conditions of soil erosion and the project erosion and the mutual effect of these two on each other is a difficult issue. Therefore, establishing a link between the results attained from the erosion monitoring program and the amount of the project impact in relative to its acceleration or the contrary is also intricate.

The erosion in the limits of the dam in the operation period, from the viewpoint of its effect on the amount of sedimentation in the dam reservoir and the beneficial life of the Arror Dam is of importance, hence, the results of the monitoring program and sampling from the sediments in these limits, lead to the timely awareness of the relative authorities, of the erosion conditions in the upstream basin and shall be the latest conditions of the Arror Dam reservoir. This program is rendered in Table 10.6.

Table 10.6: Environmental Monitoring Program of Erosion and Sedimentation

Environmental Parameter	Measure	Frequency	Monitoring Location	Responsible Organization	
				Performance	QA/QC
Erosion & Sedimentation	Amount of sedimentation in the reservoir	Annual	River in the upstream of the reservoir Midst of the reservoir River in the downstream of the Dam	WRMA	NEMA

- ### Flora

The objectives of the monitoring program of the flora is to control the methods of reducing the negative impacts on the flora and rendering of a program, in which, the restoration of the natural vegetation cover can be controlled and the assurance that the ecology equilibrium in the downstream of the Arror Dam shall be conserved with the release of sufficient water flow. The monitoring program of flora is given in the Table 10.7.

Table 10.7: Environmental Monitoring Program of Flora

Environmental Parameter	Measure	Frequency	Monitoring Location	Responsible Organization	
				Performance	QA/QC
Flora	Flora species with emphasize on index and protected species	Annual	Reservoir surrounding areas, Arror and Kerio Rivers riparian & Kerio Plain	Ministry of Environment and natural resources & KFS	NEMA

- ### Fauna

Status of the index fauna in the region, particularly species that are in threat, must be regularly controlled and monitored. Highlands surrounding of the Arror Dam reservoir must be under conservation and surveillance, in addition, the hunting of the index fauna species should be prohibited. Occupying the habitats and taking advantage of them by the hunters, due to the fact of an increase in the number of accessible roads in the region, is accounted for, as a critical factor for a threat, to species in the operation period of the plan; which, in order to control and monitor, including security for the wildlife by coordinating with the KWS, attention must be given to this issue.

In addition to this, though, the fish (species) in the Arror River are not of a remarkable number or diversity, with due attention to the impacts of the Arror Dam on the quality and quantity of the Arror River water, the fish in the lake and the downstream of the dam have to be monitored. This program is crucial on two accounts, one is the impacts of the project implementation on the ecological conditions of the river in the downstream and the other is the effect of growth and development of fish on the dam reservoir water quality as being a resource for securing drinking water.

In order to conduct this program, to the minimum, a wildlife specialist and an aquatic life specialist are required. The fauna species monitoring program is recommended according to Table 10.8.

Table 10.8: Environmental Monitoring Program of Fauna

Environmental Parameter	Measure	Frequency	Monitoring Location	Responsible Organization	
				Performance	QA/QC
Index Fauna	population distribution & number	Seasonal	surrounding areas of reservoir (highlands) & Kerio Plain	KWS	NEMA
Fishes	Species diversity & number	Annual	1. Reservoir 2. Arror River in downstream of the Dam 3. Kerio River	KWS	NEMA

Land Use

Information of the land use in the region during the operation period and its comparison with the current land use conditions, not only will bring its changing procedures in hand, but valuable information about destructive processes and or the alleviation of the region, from the viewpoint of the following factors, shall be at the disposal of the environmental management unit of the project.

- Type and density of vegetation cover and the natural visage of the region,
- Status of wildlife habitats,
- Erosion phenomenon in the region,
- Quality of management and the functioning of the responsible organizations.

The land use monitoring program by surveying the most recent satellite photographs of the region and scrutinizing the maps attained from the field visits is possible annually. Thereafter, by comparing the maps produced each year, the process of regional changes can be brought to hand (Table 10.9). The execution of this program requires a biologist or an environmental specialist and a GIS expert.

Table 10.9: Environmental Monitoring Program of Land use

Environmental Parameter	Measure	Frequency	Monitoring Location	Responsible Organization	
				Performance	QA/QC
Land use	Land use changes	Annual	Catchment area of the Dam	Ministry of Regional Development Authorities	Ministry of Environment Kenya Forestry service(KFS)/ NEMA

Health and Disease

Preventing the outbreak of any type of contagious or water-borne disease, entails the regular examination and survey of the health conditions of the regional rural inhabitants of the plan, this can be executed by the health centers. Periodic sampling must be performed in the operation period of the project and due to the possibility of the multiplication of insects in the dam lake in locations where these insects reproduce (shallow regions and the lake fringes). The reproduction period of these insects must be considered for determining the time of sample taking. With due attention to the shortage of medical services in the region, in this program attention must be paid to the possibility and potentials of the outbreak of contagious water-borne disease, which must be under the control of these centers, for the increase of which, facilities and planning should be performed. The monitoring of sewage and solid waste disposal systems in the region, will also aid in securing public health, as well as help the probable diseases tremendously. So as to implement this program, a minimum of two specialists and a technician are required. The health monitoring program is according to the Table 10.10.

Table 10.10: Environmental Monitoring Program of Health and Disease

Environmental Parameter	Measure	Frequency	Monitoring Location	Responsible Organization	
				Performance	QA/QC
Health & Disease	Waterborne diseases	Annual	Villages in the project area	Ministry of Devolution	Ministry of Health
	Clinics and health centers				
	Sewage disposal system				
	Solid waste disposal system				
	Insects (Egg & Larva)	Twice in each season (except winter)	Reservoir		

10.1.3. Costs

The approximate costs for securing the personnel required for the monitoring program is given in Table 10.11.

Table 10.11: Annual Cost of Personnel for Environmental Monitoring (in Kenya)

Staff	Number	Salary Per Month/person ($)	Salary Per year/person ($)
Supervisor of EMP	1	900	900
Executive manager	1	750	750
Expert (Hydrologist)	1	550	550
Expert (Pedologist)	1	550	550
Expert (Environmentalist)	1	550	550
Expert (HSE)	1	550	550
Expert (Botanist)	1	550	550
Expert (Ecologist)	1	550	550
Expert (Fishery)	1	550	550
Expert (GIS)	1	550	550
Expert (Environmental Health)	1	550	550
Technician	4	400	1600
Secretary	1	350	350
Total		7350	8550

To the above mentioned costs, costs pertaining to equipping the laboratory, sample analysis and vehicle costs should be supplemented. The daily car rental is almost 100 $ and the price of fuel is 1.2 $ per liter.

10.2. Environmental Training Program

Environmental training is one of the most important activities in the development of any environmental management program, as rendering environmental training programs plays a crucial role in reducing and controlling the destructive and polluting factors of the environmental plans. The initial measure in these grounds is to determine the responsibilities of the environmental management, at the project location. Basic data collection, formulating management strategies, following operation activities and their control and review, holding courses and training workshops for the workers and specialists employed and alleviating the environmental information system are accounted for as training programs.

In order to prepare, regulate and implement environmental training programs, primarily, the requirements of this training must be specified and categorized and in particular, decisions must be taken in the following cases:

- Determining the group or individuals requiring environmental training
- Determining the training level required
- Preparing the training program
- Implementation methods of training programs
- Monitoring and supervising training programs

All the individuals and groups intervening in the plan, may not require environmental training, so only the individuals in concern with matters and professional criteria require it and must undergo training:

A) Groups and or individuals intervening in the studies and designing

B) Implementation groups, contractors and the supervising group

C) Environmental monitoring authorities

D) Operators and beneficial groups

E) Planners and decision-makers

The level of training required for each group is determined and specified according to the specifications of plan and factors effective in the training. In general, the issues of environmental training are divided into 3 groupings:

- General environmental issues
- Semi- professional issues
- Professional issues

Similarly, the execution of training programs can be conducted in two manners directly and indirectly.

By monitoring and supervision the environmental training programs, its capacities and short comings are specified and likewise, the special requirements shall be made apparent. This monitoring shall be the basis for transformations and corrective measures in the training program. The trainers must also be from amongst the professional group in concern with (EIA) environmental assessment study and or informed individuals and experts should be selected. If in the case that in the region, authentic persons for training can be defined, individuals requiring training will even further welcome this program.

Environmental training program for different groups is given in the Table 10.12.

Table 10.12: Environmental Training for Different Groups

Groups	Training Program
Executive Managers	1- Steps of the project implementation 2- Environmental legal structures related to the project 3- Abatement of environmental impacts 4- Environmental monitoring 5- Environmental impacts of the project
Environmental Monitoring Group	1- Methods of sampling, transportation, maintenance and analysis of samples 2- Methods of data analysis and reporting 3- Health, safety and environment 4- Steps of the project implementation 5- Environmental impacts of the project 6- Mitigation measures 7- Environmental monitoring
Group of Reparation & Maintenance	Safety and occupational hygiene
Supervisors of Project Implementation	1- Steps of the project implementation 2- Environmental impacts of the project 3- Abatement of environmental impacts 4- Environmental monitoring 5- Health, safety and environment
Inhabitants	1- Environmental impacts of the project 2- Simple mitigation measures 3- Health and disease

11. Conclusion and Recommendations

11.1 Conclusions

The Project will reliably meet the rapidly increasing water supply demands of the Elgeyo-Marakwet county. The Project will directly contribute in achieving vision 2030 through increased power and water supply. It will improve the economic development in Kenya through the availability of a good quality water supply, power supply, increased agricultural food production and creation of employment.

The Project's impact on the physical environment will be manageable, mostly short term construction-related impacts, which will be mitigated. The report has outlined mitigation measures in the EMP matrix in chapter 9 to be implemented during the various project phases.

Given that the Environmental Assessment undertaken under this Project, and considering the Project's strong economic justification, the Project satisfactorily meets environmental protection requirements provided that the mitigation, monitoring, and reporting programs are carried out.

Based on field work and consultations with local community, administration, and other stakeholders, it was concluded that:

- It is unlikely that the Project will have significant adverse social and environmental impacts. Most adverse impacts will be of a temporary nature during the construction phase and can be managed to acceptable levels with implementation of the recommended mitigation measures for the Project such that the overall benefits from the Project will greatly outweigh the few adverse impacts.
- All the negative impacts will either be moderate or lesser in rating and could be easily mitigated.

11.2 Recommendations

The consultant recommended that the proposed project be implemented in compliance with all the relevant legislation and planning requirements of Kenya at all times. In line with this, the proponent and the contractor must take the legislative framework provided in this report into consideration, during and after the implementation of the project, as will be appropriate.

Also, KVDA should implement RAP report to the latter so as to mitigate the loss of land, fixed assets and other private properties by timely compensation and restoration of livelihoods.

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Appendix

Appendix A: Water quality analysis

Appendix B: Questionnaire of Pollution Study

Appendix C: List of potential mammalian fauna

Appendix D: List of potential bird fauna

Appendix E: List of potential reptile fauna

Appendix F. List of potential amphibian fauna

Appendix G: List of potential fish fauna

Appendix H: Minutes, Photos, attendance list and Questionnaire of Social Study

Appendix A: Arror River Water Quality Analysis - Near Arror Dam Site (2C5 Station)

Parameter	Unit	Date of Sampling - Year 1987							
		26 Aug.	27 Aug.	28 Aug.	3 Sep.	5 Sep.	8 Sep.	21 Sep.	29 Sep.
pH	pH Sclae	7.5	7.9	7.4	7.5	7.7	7.3	7	7.9
Color	mg pt/l	10	15	30	30	15	< 5	10	15
Turbidity	N.T.U	3.4	1.5	7	29	17	1.5	4.3	5.2
Conductivity (25 °C)	micro S/cm	420	364	156	351	176	228	390	345
Iron	mg Fe/l	1.1	0.4	3.5	0.6	1.87	0.3	1	0.2
Manganese	mg Mn/l	0.2	< 0.1	0.3	0.2	0.1	0.1	< 0.1	0.1
Calcium	mg Ca/l	21	10.4	6.6	30	10.2	38	10	24
Magnesium	mg Mg/l	8.8	9.7	4.5	10	5.4	11	5.1	9.4
Sodium	mg Na/l	12	13	4	13	4	17	5	12
Potassium	mg K/l	-	-	-	-	-	-	-	-
Total Hardness	mg $CaCO_3$/l	131	148	59	69	69	158	72	143
Total alkalinity	mg $CaCO_3$/l	119	150	62	142	64	148	68	142
Chloride	mg Cl/l	8	9	6	5	6	11	6	9
Fluoride	mg F/l	0.3	0.23	0.12	0.12	< 0.1	0.42	0.18	0.25
Nitrate	mg N/l	-	-	-	-	-	-	-	-
Nitrite	mg N/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.02	< 0.01	< 0.01
Sulphate	mg SO_4/l	6.5	5.4	1.5	< 0.03	0.58	5.4	2.1	4.6
Orthophosphate	mg P/l	< 0.01	0.02	0.02	0.02	< 0.01	0.02	0.01	0.01
Total Suspended Solids	mg/l	-	-	-	-	-	-	-	-
Free Carbon Dioxide	mg/l	6	6	8	12	4	8	4	8
Dissolved Oxygen	mg/l	-	-	-	-	-	-	-	-
TDS	mg/l	252	218	94	210	105	137	234	207
SAR		-	-	-	-	-	-	-	-

Ref: B & B Consulting Engineers, Feasibility Study on the Integrated Development of the Arror River Basin, Vol 1Basic Studies of the Hydroelectric Scheme-Annex C, 1988.

Arror River Water Quality Analysis - Near Arror Dam Site (2C5 Station)

Parameter	Unit	Date of sampling (Year)								
		1987					1988			2011
		23 Oct.	25 Nov.	27 Nov.	28 Nov.	30 Nov.	26 Jan.	15 Feb.	29 Feb.	Feb.
pH	pH Scale	7	7.4	7.4	7.2	7.1	6.9	7.5	7.8	7.85
Color	mg pt/l	70	20	5	20	20	< 5	< 5	< 5	-
Turbidity	N.T.U	24	26	19	29	15	3.7	25	17	-
Conductivity (25°C)	micro S/cm	189	132	156	132	138	195	220	208	160
Iron	mg Fe/l	4.6	855	8	1	1.5	0.45	0.5	0.4	-
Manganese	mg Mn/l	0.4	0.2	0.1	0.1	0.2	< 0.1	< 0.1	< 0.1	-
Calcium	mg Ca/l	9.7	13	17	14	19	18	17	23	22
Magnesium	mg Mg/l	7.7	3.4	3.4	3.4	0.4	5.5	8.6	8.9	3.6
Sodium	mg Na/l	6	4.5	4.9	4.9	-	11	13	6.2	5.75
Potassium	mg K/l	-	-	-	-	-	-	2.3	2.4	2
Total Hardness	mg $CaCO_3$/l	71	48	56	50	50	68	78	94	160
Total alkalinity	mg $CaCO_3$/l	68	52	60	52	54	62	76	80	90
Chloride	mg Cl/l	6	6	4	2	4	5	5	4	14
Fluoride	mg F/l	0.17	0.1	0.1	< 0.1	0.12	0.15	0.13	0.12	-
Nitrate	mg N/l	-	-	-	-	-	-	-	-	-
Nitrite	mg N/l	0.01	0.01	< 0.01	< 0.01	0.09	< 0.01	< 0.01	< 0.01	-
Sulphate	mg SO_4/l	2.1	0.28	0.28	3	0.28	1.9	0.31	0.99	-
Orthophosphate	mg P/l	< 0.01	< 0.01	< 0.02	< 0.01	< 0.01	0.01	0.01	< 0.01	-
Total Suspended Solids	mg/l	-	-	-	-	-	-	41	27	75
Free Carbon Dioxide	mg/l	4	5	4	4	7	10	4	4	-
TDS	mg/l	113	79	92	79	82	117	132	124	141
SAR		-	0.29	0.28	0.3	-	0.58	-	-	0.3

Ref: - B & B Consulting Engineers, Feasibility Study on the Integrated Development of the Arror River Basin, Vol 1-Basic Studies of the Hydroelectric Scheme-Annex C, 1988.

- NTM Consulting Engineers, Feasibility Study and Detailed Design of the Arror Multipurpose Dam Development Project on River Arror, Hydrology Report, 2011.

Kerio River water Quality Analysis (2C17 Station)

Parameters	Unit	Date of sampling-Year 1987	
		4 Aug.	6 Aug.
pH	pH Scale	7.8	7.6
Colour	mg pt./l	Cloudy white	Cloudy white
Turbidity	N.T.U	110	170
Conductivity (25 °C)	micro S/cm	245	217
Iron	mg Fe/l	11	19
Manganese	mg Mn/l	0.2	0.4
Calcium	mg Ca/l	9.6	4.6
Magnesium	mg Mg/l	6.3	3.8
Sodium	mg Na/l	20	19
Potassium	mg K/l	-	-
Aluminium	mg Al/l	-	-
Total Hardness	mg $CaCO_3$/l	85	57
Total alkalinity	mg $CaCO_3$/l	112	88
Chloride	mg Cl/l	6.48	4.3
Fluoride	mg F/l	0.32	0.7
Nitrate	mg N/l	-	-
Nitrite	mg N/l	0.09	-
Ammonia	mg N/l	-	-
Total Nitrogen	mg N/l	-	-
Sulphate	mg SO_4/l	2.9	< 0.3
Orthophosphate	mg P/l	0.06	0.06
Total Suspended Solids	mg/l	195	203
Free Carbon Dioxide	mg/l	2	9
Dissolved Oxygen	mg/l	-	-
TDS	mg/l	147	130
SAR		-	-

Ref: B & B Consulting Engineers, Feasibility Study on the Integrated Development of the Arror River Basin, Vol 1-Basic Studies of the Hydroelectric Scheme(Annex C), 1987.

Appendix B: Questionnaire of Pollution Study

Kenya-Arror Dam Project

Environmental Impact Assessment (EIA) of Arror Dam Project

Questionnaire of Pollution Study

Date:	**Name of Village:**
Province:	**District:**

1. Location of Village toward the project area:

Catchment area ☐ Reservoir area ☐ Downstream of Dam-Arror river ☐

Route of tunnel ☐ Irrigated and Drainage Area ☐

2. Population of Village:

3. Main occupation of inhabitants:

4. Main source of water supply (drinking water) in the village:

River ☐ well ☐ spring ☐ Other ☐

5. Way of garbage and rubbish disposal:

Burying ☐ Burning ☐ Dumping ☐ Other ☐

6. Way of sewage disposal :

Discharge to river ☐ Absorbing well ☐ Septic tank (pit) ☐ Other ☐

7. Number of livestock in the village:

Cow ☐ Sheep ☐ Goat ☐ Other ☐

8. Type of agricultural lands:

Dry-farming ☐	Irrigated ☐	Orchard ☐
Area: --------- (ha)	Area: ----------- (ha)	Area: ----------- (ha)

9. Type of agricultural crops:

Corn ☐ Grain ☐ Rice ☐ vegetable ☐ Fruitage ☐ Other:

10. Type & amount of usual fertilizers used in agricultural lands (per hectare):

- Type of fertilizer:
- Amount of fertilizer:

11. Type & amount of usual pesticides used in agricultural lands (per hectare):

- Type of pesticides:
- Amount of pesticides:

12. Are there any common diseases (contagious or non-contagious) in the village?

Appendix C: List of potential mammalian fauna

Occurrence in the 5 macrohabitat types and IUCN Red List status (updated to 30/Jan/2017) are also given

Order	Family	Scientific	Forest	Agricultural landscape	Evergreen bushland	Acacia-Commiphora	Riverine	IUCN
Primates	Cercopithecidae	*Cercopithecus mitis*	x	x				LC
Primates	Cercopithecidae	*Chlorocebus pygerythrus*	x	x	x	x	x	LC
Primates	Cercopithecidae	*Colobus guereza*	x					LC
Primates	Cercopithecidae	*Papio anubis*	x	x	x	x	x	LC
Primates	Galagidae	*Galago senegalensis*		x	x	x	x	LC
Primates	Galagidae	*Otolemur crassicaudatus*		x	x	x	x	LC
Primates	Galagidae	*Otolemur garnettii*	x	x	x	x	x	LC
Chiroptera	Emballonuridae	*Coleura afra*		x	x	x	x	LC
Chiroptera	Emballonuridae	*Taphozous mauritianus*		x	x	x	x	LC
Chiroptera	Hipposideridae	*Hipposideros caffer*		x	x	x	x	LC
Chiroptera	Hipposideridae	*Triaenops persicus*		x	x	x	x	LC
Chiroptera	Megadermatidae	*Lavia frons*				x	x	LC
Chiroptera	Miniopteridae	*Miniopterus natalensis*			x	x	x	LC
Chiroptera	Molossidae	*Chaerephon bivittatus*		x	x	x	x	LC
Chiroptera	Molossidae	*Chaerephon chapini*		x	x	x	x	LC
Chiroptera	Molossidae	*Chaerephon pumilus*		x	x	x	x	LC
Chiroptera	Molossidae	*Mops nanulus*	x	x	x			LC
Chiroptera	Molossidae	*Otomops martiensseni*	x	x	x	x	x	NT
Chiroptera	Molossidae	*Platymops setiger*			x	x	x	LC
Chiroptera	Molossidae	*Tadarida fulminans*			x	x	x	LC
Chiroptera	Nycteridae	*Nycteris hispida*	x	x	x	x	x	LC
Chiroptera	Pteropodidae	*Epomophorus minor*			x	x	x	LC
Chiroptera	Pteropodidae	*Epomophorus wahlbergi*	x	x	x	x	x	LC
Chiroptera	Pteropodidae	*Rousettus aegyptiacus*	x	x	x	x	x	LC
Chiroptera	Pteropodidae	*Rousettus lanosus*	x	x				LC
Chiroptera	Rhinolophidae	*Rhinolophus clivosus*	x	x	x	x	x	LC
Chiroptera	Rhinolophidae	*Rhinolophus eloquens*			x	x	x	LC
Chiroptera	Rhinolophidae	*Rhinolophus fumigatus*			x	x	x	LC
Chiroptera	Rhinolophidae	*Rhinolophus hildebrandtii*			x	x	x	LC
Chiroptera	Rhinolophidae	*Rhinolophus landeri*			x	x	x	LC
Chiroptera	Vespertilionidae	*Kerivoula lanosa*	x	x	x	x	x	LC

Order	Family	Scientific	Forest	Agricultural landscape	Evergreen bushland	Acacia-Commiphora	Riverine	IUCN
Chiroptera	Vespertilionidae	*Mimetillus moloneyi*	x	x				LC
Chiroptera	Vespertilionidae	*Myotis bocagii*					x	LC
Chiroptera	Vespertilionidae	*Myotis tricolor*	x	x				LC
Chiroptera	Vespertilionidae	*Neoromicia capensis*	x	x	x	x	x	LC
Chiroptera	Vespertilionidae	*Neoromicia tenuipinnis*	x	x	x	x	x	LC
Chiroptera	Vespertilionidae	*Neoromicia zuluensis*			x	x	x	LC
Chiroptera	Vespertilionidae	*Nycticeinops schlieffeni*				x	x	LC
Chiroptera	Vespertilionidae	*Pipistrellus hesperidus*	x	x	x	x	x	LC
Chiroptera	Vespertilionidae	*Scotoecus hirundo*		x	x	x	x	LC
Chiroptera	Vespertilionidae	*Scotophilus dinganii*	x	x	x	x	x	LC
Eulipotyphla	Erinaceidae	*Atelerix albiventris*		x	x	x	x	LC
Eulipotyphla	Soricidae	*Crocidura elgonius*	x					LC
Eulipotyphla	Soricidae	*Crocidura fuscomurina*		x	x	x	x	LC
Eulipotyphla	Soricidae	*Crocidura hildegardeae*	x					LC
Eulipotyphla	Soricidae	*Crocidura jacksoni*	x	x				LC
Eulipotyphla	Soricidae	*Crocidura nigrofusca*	x	x	x			LC
Eulipotyphla	Soricidae	*Crocidura olivieri*	x	x	x			LC
Eulipotyphla	Soricidae	*Crocidura parvipes*			x	x	x	LC
Eulipotyphla	Soricidae	*Crocidura turba*	x	x	x			LC
Eulipotyphla	Soricidae	*Crocidura viaria*		x	x			LC
Macroscelidea	Macroscelididae	*Elephantulus brachyrhynchus*			x	x	x	LC
Macroscelidea	Macroscelididae	*Elephantulus rufescens*				x	x	LC
Lagomorpha	Leporidae	*Lepus capensis*		x	x	x	x	LC
Rodentia	Cricetidae	*Lophiomys imhausi*	x	x	x			LC
Rodentia	Gliridae	*Graphiurus murinus*	x	x	x			LC
Rodentia	Hystricidae	*Hystrix cristata*	x	x	x	x	x	LC
Rodentia	Muridae	*Acomys kempi*			x	x	x	LC
Rodentia	Muridae	*Acomys percivali*			x	x		LC
Rodentia	Muridae	*Acomys wilsoni*			x	x		LC
Rodentia	Muridae	*Aethomys hindei*		x	x			LC
Rodentia	Muridae	*Arvicanthis niloticus*		x	x	x	x	LC
Rodentia	Muridae	*Colomys goslingi*	x					LC
Rodentia	Muridae	*Dasymys incomtus*					x	LC
Rodentia	Muridae	*Gerbilliscus robustus*				x	x	LC

Order	Family	Scientific	Forest	Agricultural landscape	Evergreen bushland	Acacia-Commiphora	Riverine	IUCN
Rodentia	Muridae	*Grammomys dolichurus*	x	x	x	x	x	LC
Rodentia	Muridae	*Hylomyscus denniae*	x	x				LC
Rodentia	Muridae	*Lemniscomys striatus*		x	x			LC
Rodentia	Muridae	*Mastomys natalensis*		x	x			LC
Rodentia	Muridae	*Mus triton*	x	x	x			LC
Rodentia	Muridae	*Myomyscus brockmani*			x	x	x	LC
Rodentia	Muridae	*Otomys tropicalis*	x	x				LC
Rodentia	Muridae	*Praomys jacksoni*	x	x				LC
Rodentia	Muridae	*Rhabdomys pumilio*		x	x	x	x	LC
Rodentia	Muridae	*Taterillus emini*				x	x	LC
Rodentia	Muridae	*Zelotomys hildegardeae*	x	x	x			LC
Rodentia	Nesomyidae	*Cricetomys gambianus*				x	x	LC
Rodentia	Nesomyidae	*Saccostomus mearnsi*		x	x	x	x	LC
Rodentia	Sciuridae	*Paraxerus ochraceus*	x	x	x			LC
Rodentia	Sciuridae	*Xerus erythropus*		x	x	x	x	LC
Rodentia	Sciuridae	*Xerus rutilus*			x	x	x	LC
Rodentia	Spalacidae	*Tachyoryctes splendens*	x	x	x			LC
Carnivora	Canidae	*Canis adustus*			x	x	x	LC
Carnivora	Canidae	*Canis mesomelas*			x	x	x	LC
Carnivora	Canidae	*Otocyon megalotis*			x	x	x	LC
Carnivora	Felidae	*Caracal caracal*			x	x	x	LC
Carnivora	Felidae	*Felis silvestris*		x	x	x	x	LC
Carnivora	Felidae	*Leptailurus serval*			x	x	x	LC
Carnivora	Felidae	*Panthera pardus*	x	x	x	x	x	VU
Carnivora	Herpestidae	*Helogale parvula*				x	x	LC
Carnivora	Herpestidae	*Herpestes ichneumon*		x	x	x	x	LC
Carnivora	Herpestidae	*Herpestes sanguineus*		x	x	x	x	LC
Carnivora	Herpestidae	*Ichneumia albicauda*		x	x	x	x	LC
Carnivora	Herpestidae	*Mungos mungo*		x	x	x	x	LC
Carnivora	Hyaenidae	*Crocuta crocuta*			x	x	x	LC
Carnivora	Hyaenidae	*Hyaena hyaena*				x	x	NT
Carnivora	Mustelidae	*Aonyx capensis*					x	NT
Carnivora	Mustelidae	*Ictonyx striatus*		x	x	x	x	LC
Carnivora	Mustelidae	*Mellivora capensis*	x	x	x	x	x	LC

Order	Family	Scientific	Forest	Agricultural landscape	Evergreen bushland	Acacia-Commiphora	Riverine	IUCN
Carnivora	Nandiniidae	*Nandinia binotata*	x	x				LC
Carnivora	Viverridae	*Civettictis civetta*	x	x	x		x	LC
Carnivora	Viverridae	*Genetta genetta*		x	x	x	x	LC
Carnivora	Viverridae	*Genetta maculata*	x	x	x			LC
Pholidota	Manidae	*Smutsia temminckii*		x	x	x	x	VU
Tubulidentata	Orycteropodidae	*Orycteropus afer*	x	x	x	x	x	LC
Hyracoidea	Procaviidae	*Dendrohyrax arboreus*	x					LC
Hyracoidea	Procaviidae	*Heterohyrax brucei*		x	x	x		LC
Hyracoidea	Procaviidae	*Procavia capensis*		x	x	x	x	LC
Proboscidea	Elephantidae	*Loxodonta africana*				x	x	VU
Cetartiodactyla	Bovidae	*Aepyceros melampus*				x	x	LC
Cetartiodactyla	Bovidae	*Kobus ellipsiprymnus*				x	x	LC
Cetartiodactyla	Bovidae	*Madoqua kirkii*			x	x	x	LC
Cetartiodactyla	Bovidae	*Oreotragus oreotragus*			x	x	x	LC
Cetartiodactyla	Bovidae	*Raphicerus campestris*			x	x	x	LC
Cetartiodactyla	Bovidae	*Sylvicapra grimmia*			x	x	x	LC
Cetartiodactyla	Bovidae	*Syncerus caffer*				x	x	LC
Cetartiodactyla	Bovidae	*Tragelaphus eurycerus*	x					NT
Cetartiodactyla	Bovidae	*Tragelaphus scriptus*	x		x	x	x	LC
Cetartiodactyla	Bovidae	*Tragelaphus strepsiceros*	x					LC
Cetartiodactyla	Suidae	*Hylochoerus meinertzhageni*	x					LC
Cetartiodactyla	Suidae	*Phacochoerus africanus*			x	x	x	LC
Cetartiodactyla	Suidae	*Potamochoerus larvatus*	x					LC

Appendix D: List of potential bird fauna

Family	Scientific	Forest	Agricultural landscape	Evergreen bushland	Acacia-Commiphora	Riverine	Endemic	IUCN
Podicipedidae	*Tachybaptus ruficollis*					x		
Pelecanidae	*Pelecanus rufescens*					x		
Ardeidae	*Nycticorax nycticorax*					x		
Ardeidae	*Bubulcus ibis*					x		
Ardeidae	*Egretta garzetta*					x		
Ardeidae	*Ardeola ralloides*					x		
Ardeidae	*Butorides striatus*					x		
Ardeidae	*Mesophoyx intermedia*					x		
Ardeidae	*Casmerodius alba*					x		
Ardeidae	*Ardea cinerea*					x		
Ardeidae	*Ardea purpurea*					x		
Ardeidae	*Ardea goliath*					x		
Ardeidae	*Ardea melanocephala*					x		
Scopidae	*Scopus umbretta*					x		
Ciconiidae	*Ciconia ciconia*					x		
Ciconiidae	*Ciconia nigra*	x						
Ciconiidae	*Ciconia abdimii*					x		
Ciconiidae	*Ephippiorhynchus senegalensis*					x		
Ciconiidae	*Leptoptilos crumeniferus*		x			x		
Ciconiidae	*Mycteria ibis*					x		
Threskiornitidae	*Threskiornis aethiopicus*		x			x		
Threskiornitidae	*Bostrychia hagedash*		x			x		
Threskiornitidae	*Platalea alba*					x		
Anatidae	*Dendrocygna bicolor*					x		
Anatidae	*Dendrocygna viduata*					x		
Anatidae	*Thalassornis leuconotus*					x		
Anatidae	*Plectopterus gambensis*					x		
Anatidae	*Alopochen aegyptiacus*					x		
Anatidae	*Sarkidiornis melanotos*					x		
Anatidae	*Anas sparsa*					x		
Anatidae	*Anas crecca*					x		
Anatidae	*Anas querquedula*					x		
Anatidae	*Anas undulata*					x		
Anatidae	*Anas acuta*					x		
Anatidae	*Anas erythrorhynchos*					x		
Anatidae	*Anas hottentota*					x		
Anatidae	*Anas clypeata*					x		
Anatidae	*Netta erythrophthalma*					x		
Sagittaridae	*Sagittarius serpentarius*		x	x	x	x		VU
Accipitridae	*Aviceda cuculoides*	x	x					
Accipitridae	*Pernis apivorus*	x	x	x	x	x		
Accipitridae	*Macheiramphus alcinus*	x	x					
Accipitridae	*Elanus caeruleus*		x	x	x	x		
Accipitridae	*Milvus migrans*		x	x	x	x		
Accipitridae	*Neophron percnopterus*		x	x	x	x		EN

Family	Scientific	Forest	Agricultural landscape	Evergreen bushland	Acacia-Commiphora	Riverine	Endemic	IUCN
Accipitridae	*Necrosyrtes monachus*	x	x	x	x	x		CR
Accipitridae	*Gyps africanus*		x	x	x	x		CR
Accipitridae	*Gyps rueppellii*		x	x	x	x		CR
Accipitridae	*Torgos tracheliotus*		x	x	x	x		EN
Accipitridae	*Trigonoceps occipitalis*		x	x	x	x		CR
Accipitridae	*Circaetus pectoralis*	x	x	x	x	x		
Accipitridae	*Circaetus cinereus*		x	x	x	x		
Accipitridae	*Circaetus cinerascens*		x	x	x	x		
Accipitridae	*Terathopius ecaudatus*		x	x	x	x		NT
Accipitridae	*Polyboroides typus*	x	x	x	x	x		
Accipitridae	*Circus macrourus*		x	x	x	x		NT
Accipitridae	*Circus pygargus*		x	x	x	x		
Accipitridae	*Circus aeruginosus*					x		
Accipitridae	*Micronisus gabar*	x	x	x	x	x		
Accipitridae	*Melierax metabates*		x	x	x	x		
Accipitridae	*Accipiter tachiro*	x	x	x	x	x		
Accipitridae	*Accipiter badius*		x	x	x	x		
Accipitridae	*Accipiter minullus*	x	x	x	x	x		
Accipitridae	*Accipiter melanoleucus*	x	x					
Accipitridae	*Buteo buteo*		x	x	x	x		
Accipitridae	*Buteo oreophilus*	x	x					NT
Accipitridae	*Buteo augur*	x	x	x	x	x		
Accipitridae	*Haliaeetus vocifer*					x		
Accipitridae	*Aquila pomarina*		x	x	x	x		
Accipitridae	*Aquila rapax*		x	x	x	x		
Accipitridae	*Aquila nipalensis*		x	x	x	x		EN
Accipitridae	*Aquila wahlbergi*		x	x	x	x		
Accipitridae	*Hieraaetus spilogaster*		x	x	x	x		
Accipitridae	*Hieraaetus pennatus*	x	x	x	x	x		
Accipitridae	*Hieraaetus ayresii*	x						
Accipitridae	*Lophaetus occipitalis*	x	x	x	x	x		
Accipitridae	*Stephanoaetus coronatus*	x						NT
Accipitridae	*Polemaetus bellicosus*			x	x	x		VU
Accipitridae	*Polihierax semitorquatus*		x	x	x	x		
Falconidae	*Falco biarmicus*	x	x	x	x	x		
Falconidae	*Falco peregrinus*	x	x	x	x	x		
Falconidae	*Falco subbuteo*		x	x	x	x		
Falconidae	*Falco cuvieri*		x	x	x	x		
Falconidae	*Falco rupicoloides*		x	x	x	x		
Falconidae	*Falco alopex*		x	x	x	x		
Falconidae	*Falco ardosiaceus*		x	x	x	x		
Falconidae	*Falco naumanni*		x	x	x	x		
Falconidae	*Falco tinnunculus*		x	x	x	x		
Phasianidae	*Coturnix coturnix*		x	x				
Phasianidae	*Coturnix delegorguei*		x	x				
Phasianidae	*Francolinus sephaena*		x	x	x	x		

Family	Scientific	Forest	Agricultural landscape	Evergreen bushland	Acacia-Commiphora	Riverine	Endemic	IUCN
Phasianidae	*Francolinus squamatus*	x	x					
Phasianidae	*Francolinus jacksoni*	x	x					
Phasianidae	*Francolinus leucoscepus*			x	x	x		
Numididae	*Guttera edouardi*	x						
Numididae	*Numida meleagris*		x	x	x	x		
Rallidae	*Sarothrura elegans*	x						
Rallidae	*Crex egregia*					x		
Rallidae	*Crex crex*		x					
Rallidae	*Rallus caerulescens*					x		
Rallidae	*Amaurornis flavirostra*					x		
Rallidae	*Gallinula chloropus*					x		
Gruidae	*Balearica regulorum*		x					EN
Jacanidae	*Actophilornis africanus*					x		
Rostratulidae	*Rostratula benghalensis*					x		
Himantopidae	*Himantopus himantopus*					x		
Burhinidae	*Burhinus vermiculatus*					x		
Burhinidae	*Burhinus capensis*					x		
Charadriidae	*Charadrius hiaticula*					x		
Charadriidae	*Charadrius tricollaris*					x		
Charadriidae	*Vanellus spinosus*					x		
Charadriidae	*Vanellus tectus*					x		
Charadriidae	*Vanellus lugubris*		x			x		
Charadriidae	*Vanellus melanopterus*		x					
Scolopacidae	*Calidris minuta*					x		
Scolopacidae	*Calidris ferruginea*					x		NT
Scolopacidae	*Philomachus pugnax*					x		
Scolopacidae	*Gallinago gallinago*					x		
Scolopacidae	*Gallinago nigripennis*					x		
Scolopacidae	*Gallinago media*					x		NT
Scolopacidae	*Tringa stagnatilis*					x		
Scolopacidae	*Tringa nebularia*					x		
Scolopacidae	*Tringa ochropus*					x		
Scolopacidae	*Tringa glareola*					x		
Scolopacidae	*Actitis hypoleucos*					x		
Columbidae	*Treron calva*					x		
Columbidae	*Turtur tympanistria*	x						
Columbidae	*Turtur chalcospilos*		x	x	x	x		
Columbidae	*Oena capensis*		x	x	x	x		
Columbidae	*Columba delegorguei*	x						
Columbidae	*Columba arquatrix*	x						
Columbidae	*Columba guinea*		x	x	x	x		
Columbidae	*Aplopelia larvata*	x						
Columbidae	*Streptopelia semitorquata*	x	x	x	x	x		
Columbidae	*Streptopelia capicola*		x	x	x	x		
Columbidae	*Streptopelia lugens*	x	x					
Columbidae	*Streptopelia senegalensis*		x	x	x	x		

Family	Scientific	Forest	Agricultural landscape	Evergreen bushland	Acacia-Commiphora	Riverine	Endemic	IUCN
Psittacidae	*Poicephalus gulielmi*	x						
Psittacidae	*Poicephalus meyeri*		x	x	x	x		
Muisophagidae	*Musophaga rossae*					x		
Muisophagidae	*Tauraco hartlaubi*	x						
Muisophagidae	*Corythaixoides leucogaster*		x	x	x	x		
Cuculidae	*Clamator jacobinus*		x	x	x	x		
Cuculidae	*Clamator levaillantii*		x	x	x	x		
Cuculidae	*Clamator glandarius*		x	x	x	x		
Cuculidae	*Cuculus clamosus*	x	x	x	x	x		
Cuculidae	*Cuculus solitarius*	x	x	x	x	x		
Cuculidae	*Cuculus canorus*	x	x	x	x	x		
Cuculidae	*Cuculus gularis*	x	x	x	x	x		
Cuculidae	*Chrysococcyx cupreus*	x						
Cuculidae	*Chrysococcyx klaas*		x	x				
Cuculidae	*Chrysococcyx caprius*			x	x	x		
Cuculidae	*Ceuthmochares aereus*	x						
Cuculidae	*Centropus superciliosus*	x	x					
Tytonidae	*Tyto alba*		x					
Strigidae	*Otus senegalensis*		x	x	x	x		
Strigidae	*Bubo africanus*		x	x	x	x		
Strigidae	*Bubo lacteus*		x	x	x	x		
Strigidae	*Glaucidium perlatum*		x	x	x	x		
Strigidae	*Ciccaba woodfordii*	x	x					
Strigidae	*Asio capensis*					x		
Caprimulgidae	*Caprimulqus poliocephalus*	x	x					
Caprimulgidae	*Caprimulqus tristigma*	x	x					
Caprimulgidae	*Caprimulqus inornatus*		x	x	x	x		
Caprimulgidae	*Caprimulgus europaeus*		x	x	x	x		
Caprimulgidae	*Caprimulqus clarus*		x	x	x	x		
Caprimulgidae	*Macrodipteryx vexillarius*		x	x				
Apodidae	*Schoutedenapus myoptilus*	x	x	x				
Apodidae	*Apus barbatus*	x	x					
Apodidae	*Apus niansae*	x	x	x				
Apodidae	*Apus aequatorialis*	x	x	x				
Apodidae	*Apus melba*	x	x					
Apodidae	*Apus caffer*	x	x	x				
Apodidae	*Apus horus*	x	x	x				
Apodidae	*Apus affinis*	x	x	x	x	x		
Coliidae	*Colius striatus*		x	x				
Coliidae	*Urocolius macrourus*		x	x	x	x		
Trogonidae	*Apaloderma narina*	x						
Trogonidae	*Apaloderma vittatum*	x						
Alcedinidae	*Halcyon leucocephala*					x		
Alcedinidae	*Halcyon chelicuti*					x		
Alcedinidae	*Alcedo cristata*					x		
Alcedinidae	*Ispidina picta*		x	x	x	x		

Family	Scientific	Forest	Agricultural landscape	Evergreen bushland	Acacia-Commiphora	Riverine	Endemic	IUCN
Alcedinidae	*Ceryle maxima*					x		
Alcedinidae	*Ceryle rudis*					x		
Meropidae	*Merops apiaster*		x	x	x	x		
Meropidae	*Merops albicollis*		x		x	x		
Meropidae	*Merops pusillus*		x	x				
Meropidae	*Merops oreobates*	x	x					
Coraciidae	*Coracias garrulus*		x	x	x	x		
Coliidae	*Coracias abyssinica*				x	x		
Coliidae	*Coracias caudata*				x	x		
Ciconiidae	*Coracias naevia*				x	x		
Coraciidae	*Eurystomus glaucurus*				x	x		
Upupidae	*Upupa epops*		x	x	x	x		
Phoeniculidae	*Phoeniculus bollei*	x						
Phoeniculidae	*Phoeniculus purpureus*		x	x	x	x		
Phoeniculidae	*Rhinopomastus cyanomelas*		x	x	x	x		
Phoeniculidae	*Rhinopomastus minor*		x	x	x	x		
Bucerotidae	*Bucorvus leadbeateri*		x	x	x	x		VU
Bucerotidae	*Bucorvus abyssinicus*		x	x	x	x		
Bucerotidae	*Tockus erythrorhynchus*				x	x		
Bucerotidae	*Tockus flavirostris*				x	x		
Bucerotidae	*Tockus jacksoni*				x	x		
Bucerotidae	*Tockus hemprichii*				x	x		
Bucerotidae	*Tockus alboterminatus*	x	x					
Bucerotidae	*Tockus nasutus*		x	x	x	x		
Bucerotidae	*Bycanistes subcylindricus*	x	x					
Capitonidae	*Gymnobucco bonapartei*	x						
Capitonidae	*Pogoniulus leucomystax*	x	x					
Capitonidae	*Pogoniulus bilineatus*	x	x					
Capitonidae	*Pogoniulus pusillus*		x	x	x	x		
Capitonidae	*Buccanodon duchaillui*	x						
Capitonidae	*Tricholaema lacrymosa*		x	x				
Capitonidae	*Tricholaema melanocephala*				x	x		
Capitonidae	*Trachylaemus purpuratus*	x						
Capitonidae	*Trachylaemus erythrocephalus*				x	x		
Capitonidae	*Trachylaemus darnaudii*				x	x		
Indicatoridae	*Indicator variegatus*	x	x	x	x	x		
Indicatoridae	*Indicator indicator*		x	x	x	x		
Indicatoridae	*Indicator minor*		x	x	x	x		
Indicatoridae	*Indicator conirostris*	x						
Indicatoridae	*Indicator exilis*	x						
Indicatoridae	*Prodotiscus regulus*			x	x	x		
Picidae	*Jynx ruficollis*	x	x	x	x			
Picidae	*Campethera nubica*	x	x	x	x	x		
Picidae	*Campethera nivosa*	x						
Picidae	*Campethera caroli*	x						
Picidae	*Denropicos fuscescens*	x	x	x	x	x		

Family	Scientific	Forest	Agricultural landscape	Evergreen bushland	Acacia-Commiphora	Riverine	Endemic	IUCN
Picidae	*Thripias namaquus*	x	x	x				
Picidae	*Mesopicos goertae*	x	x	x	x	x		
Pittidae	*Pitta angolensis*	x						
Alaudidae	*Mirafra africana*		x					
Alaudidae	*Calandrella cinerea*		x					
Alaudidae	*Eremopteryx leucopareia*		x					
Hirundinidae	*Riparia cincta*					x		
Hirundinidae	*Riparia riparia*					x		
Hirundinidae	*Hirundo smithii*		x	x	x	x		
Hirundinidae	*Hirundo rustica*		x	x	x	x		
Hirundinidae	*Hirundo abyssinica*		x	x	x	x		
Hirundinidae	*Hirundo fuligula*	x	x	x				
Hirundinidae	*Delichon urbica*	x	x	x	x	x		
Hirundinidae	*Psalidoprocne holomelas*	x						
Motacillidae	*Motacilla aguimp*		x			x		
Motacillidae	*Motacilla alba*		x			x		
Motacillidae	*Motacilla cinerea*		x			x		
Motacillidae	*Motacilla clara*	x	x					
Motacillidae	*Motacilla flava*		x			x		
Motacillidae	*Anthus cinnamomeus*		x					
Motacillidae	*Anthus similis*		x					
Motacillidae	*Anthus leucophrys*		x					
Motacillidae	*Anthus trivialis*	x	x					
Motacillidae	*Anthus cervinus*		x					
Motacillidae	*Macronyx sharpei*						x	EN
Motacillidae	*Macronyx croceus*		x	x	x			
Andropadidae	*Andropadus latirostris*	x						
Andropadidae	*Andropadus gracilirostris*	x						
Andropadidae	*Andropadus nigriceps*	x						
Andropadidae	*Phyllastrephus cabanisi*	x						
Andropadidae	*Phyllastrephus strepitans*			x	x	x		
Andropadidae	*Pycnonotus barbatus*	x	x	x	x	x		
Accipitridae	*Bleda syndactyla*	x						
Timaliidae	*Pseudoalcippe abyssinica*	x						
Timaliidae	*Turdoides plebejus*		x	x	x	x		
Timaliidae	*Turdoides rubiginosus*		x	x	x	x		
Timaliidae	*Illadopsis pyrrhopterum*	x						
Timaliidae	*Illadopsis rufipennis*	x						
Turdidae	*Pogonocichla stellata*	x						
Turdidae	*Sheppardia aequatorialis*	x						
Turdidae	*Sheppardia polioptera*	x						
Turdidae	*Cossypha caffra*		x	x				
Turdidae	*Cossypha natalensis*	x						
Turdidae	*Cossypha heuglini*	x	x					
Turdidae	*Cossypha niveicapilla*	x						
Turdidae	*Alethe poliocephala*	x						

Family	Scientific	Forest	Agricultural landscape	Evergreen bushland	Acacia-Commiphora	Riverine	Endemic	IUCN
Turdidae	*Cichladusa guttata*			x	x	x		
Turdidae	*Cercotrichas leucophrys*			x	x	x		
Turdidae	*Phoenicurus phoenicurus*		x					
Turdidae	*Saxicola torquata*		x					
Turdidae	*Saxicola rubetra*		x					
Turdidae	*Oenanthe oenanthe*		x					
Turdidae	*Oenanthe pleschanka*		x					
Turdidae	*Oenanthe isabellina*		x					
Turdidae	*Monticola saxatilis*		x	x				
Turdidae	*Monticola rufocinerea*		x	x				
Turdidae	*Turdus olivaceus*	x	x	x				
Turdidae	*Zoothera piaggiae*	x						
Muscicapidae	*Muscicapa striata*		x	x				
Muscicapidae	*Muscicapa adusta*	x	x					
Muscicapidae	*Melaenornis fischeri*	x	x					
Muscicapidae	*Bradornis microrhynchus*		x	x	x	x		
Muscicapidae	*Bradornis pallidus*		x	x	x	x		
Muisophagidae	*Empidornis semipartitus*		x	x	x	x		
Syilviidae	*Acrocephalus schoenobaenus*					x		
Syilviidae	*Acrocephalus scirpaceus*					x		
Syilviidae	*Hippolais pallida*		x	x				
Syilviidae	*Sylvia nisoria*		x	x				
Syilviidae	*Sylvia communis*		x	x				
Syilviidae	*Sylvia borin*		x	x				
Syilviidae	*Sylvia atricapilla*	x	x					
Syilviidae	*Phylloscopus collybita*	x						
Syilviidae	*Phylloscopus trochilus*	x	x	x				
Syilviidae	*Phylloscopus umbrovirens*	x						
Syilviidae	*Bradypterus baboecala*					x		
Syilviidae	*Bradypterus lopezi*	x						
Syilviidae	*Bradypterus cinnamomeus*	x						
Syilviidae	*Chloropeta natalensis*	x	x					
Syilviidae	*Chloropeta similis*	x						
Syilviidae	*Cisticola hunteri*	x						
Syilviidae	*Cisticola chubbi*	x	x					
Syilviidae	*Cisticola galactotes*					x		
Syilviidae	*Cisticola chiniana*		x	x	x	x		
Syilviidae	*Cisticola brachypterus*		x	x	x	x		
Syilviidae	*Cisticola juncidis*				x	x		
Syilviidae	*Prinia subflava*		x					
Syilviidae	*Prinia leucopogon*	x	x					
Syilviidae	*Calamonastes simplex*			x	x	x		
Syilviidae	*Camaroptera brachyura*	x	x					
Syilviidae	*Apalis flavida*		x	x				
Syilviidae	*Apalis porphyrolaema*	x						
Syilviidae	*Apalis cinerea*	x						

Family	Scientific	Forest	Agricultural landscape	Evergreen bushland	Acacia-Commiphora	Riverine	Endemic	IUCN
Syilviidae	*Apalis jacksoni*	x						
Syilviidae	*Apalis pulchra*	x						
Syilviidae	*Spiloptila rufifrons*			x	x	x		
Syilviidae	*Sylvietta brachyura*		x	x	x	x		
Syilviidae	*Sylvietta whytii*		x	x	x	x		
Syilviidae	*Sylvietta leucophrys*	x						
Syilviidae	*Eremomela icteropygialis*			x	x	x		
Syilviidae	*Phyllolais pulchella*			x	x	x		
Zosteropidae	*Zosterops senegalensis*	x	x					
Paridae	*Parus thruppi*		x	x	x	x		
Paridae	*Parus albiventris*	x	x					
Remizidae	*Anthoscopus musculus*			x	x	x		
Remizidae	*Anthoscopus caroli*	x	x					
Syilviidae	*Elminia longicauda*	x						
Monarchidae	*Trochocercus albonotatus*	x						
Monarchidae	*Terpsiphone viridis*	x	x			x		
Platysteiridae	*Batis molitor*	x	x	x				
Platysteiridae	*Batis perkeo*		x	x	x	x		
Platysteiridae	*Platysteira cyanea*	x						
Platysteiridae	*Platysteira peltata*	x						
Platysteiridae	*Dyaphorophyia castanea*	x						
Prionopidae	*Prionops plumatus*		x	x	x	x		
Laniidae	*Eurocephalus rueppelli*		x	x	x	x		
Laniidae	*Lanius collurio*		x	x	x	x		
Laniidae	*Lanius minor*		x	x	x	x		
Laniidae	*Lanius excubitoroides*		x	x	x	x		
Laniidae	*Lanius collaris*		x	x				
Malaconotidae	*Nilaus afer*			x	x	x		
Malaconotidae	*Tchagra senegala*		x	x				
Malaconotidae	*Tchagra australis*		x	x				
Malaconotidae	*Tchagra jamesi*			x	x	x		
Malaconotidae	*Malaconotus sulfureopectus*		x	x	x	x		
Malaconotidae	*Malaconotus nigrifrons*	x						
Malaconotidae	*Malaconotus blanchoti*	x	x	x				
Malaconotidae	*Laniarius luehderi*	x						
Malaconotidae	*Laniarius aethiopicus*	x	x	x				
Malaconotidae	*Laniarius funebris*			x	x			
Malaconotidae	*Dryoscopus gambensis*	x	x					
Campephagidae	*Campephaga flava*	x						
Campephagidae	*Campephaga quisqualina*	x						
Campephagidae	*Coracina caesia*	x						
Dicruridae	*Dicrurus adsimilis*	x	x	x	x	x		
Oriolidae	*Oriolus oriolus*		x	x	x	x		
Oriolidae	*Oriolus auratus*		x	x	x	x		
Oriolidae	*Oriolus larvatus*	x	x	x	x	x		
Oriolidae	*Oriolus percivali*	x						

Family	Scientific	Forest	Agricultural landscape	Evergreen bushland	Acacia-Commiphora	Riverine	Endemic	IUCN
Corvidae	*Corvus albus*		x	x	x	x		
Corvidae	*Corvus albicollis*		x	x	x	x		
Corvidae	*Corvus rhipidurus*		x	x	x	x		
Corvidae	*Corvus capensis*		x					
Sturnidae	*Poeoptera stuhlmanni*	x						
Sturnidae	*Onychognathus walleri*	x						
Sturnidae	*Onychognathus morio*	x	x					
Sturnidae	*Onychognathus tenuirostris*	x	x					
Sturnidae	*Lamprotornis chalybaeus*		x	x	x	x		
Sturnidae	*Lamprotornis purpuropterus*		x	x	x	x		
Sturnidae	*Lamprotornis superbus*		x	x	x	x		
Sturnidae	*Cinnyricinclus leucogaster*	x	x	x	x	x		
Sturnidae	*Cinnyricinclus sharpii*	x						
Sturnidae	*Creatophora cinerea*		x	x	x	x		
Sturnidae	*Buphagus erythrorhynchus*		x	x	x	x		
Nectariniidae	*Anthreptes orientalis*				x	x		
Nectariniidae	*Anthreptes collaris*	x	x	x				
Nectariniidae	*Nectarinia olivacea*	x						
Nectariniidae	*Nectarinia verticalis*	x						
Nectariniidae	*Nectarinia amethystina*	x	x	x				
Nectariniidae	*Nectarinia senegalensis*		x	x	x	x		
Nectariniidae	*Nectarinia hunteri*				x	x		
Nectariniidae	*Nectarinia venusta*		x	x				
Nectariniidae	*Nectarinia chloropygia*	x						
Nectariniidae	*Nectarinia preussi*	x						
Nectariniidae	*Nectarinia mediocris*	x						
Nectariniidae	*Nectarinia mariquensis*			x	x	x		
Nectariniidae	*Nectarinia pulchella*			x	x	x		
Nectariniidae	*Nectarinia tacazze*	x	x					
Nectariniidae	*Nectarinia kilimensis*	x	x					
Nectariniidae	*Nectarinia reichenowi*	x	x					
Nectariniidae	*Nectarinia famosa*	x						
Ploceidae	*Passer motitensis*		x	x				
Ploceidae	*Passer griseus*		x	x				
Ploceidae	*Passer eminibey*		x	x				
Ploceidae	*Petronia pyrgita*		x	x	x	x		
Ploceidae	*Dinemellia dinemelli*				x	x		
Ploceidae	*Bubalornis albirostris*				x	x		
Ploceidae	*Plocepasser mahali*				x	x		
Ploceidae	*Pseudonigrita arnaudi*				x	x		
Ploceidae	*Sporopipes frontalis*				x	x		
Ploceidae	*Amblyospiza albifrons*					x		
Ploceidae	*Ploceus baglafect*	x	x	x				
Ploceidae	*Ploceus luteolus*				x	x		
Ploceidae	*Ploceus nigricollis*	x						
Ploceidae	*Ploceus ocularis*	x	x	x				

Family	Scientific	Forest	Agricultural landscape	Evergreen bushland	Acacia-Commiphora	Riverine	Endemic	IUCN
Ploceidae	*Ploceus melanogaster*	x						
Ploceidae	*Ploceus xanthops*		x	x				
Ploceidae	*Ploceus jacksoni*					x		
Ploceidae	*Ploceus velatus*		x	x	x	x		
Ploceidae	*Ploceus intermedius*		x	x	x	x		
Ploceidae	*Ploceus cucullatus*		x	x	x	x		
Ploceidae	*Ploceus rubiginosus*				x	x		
Ploceidae	*Ploceus bicolor*	x						
Ploceidae	*Ploceus insignis*	x						
Ploceidae	*Anaplectes rubriceps*		x	x				
Ploceidae	*Quelea quelea*		x	x	x	x		
Ploceidae	*Quelea cardinalis*		x	x	x	x		
Ploceidae	*Euplectes afer*		x	x				
Ploceidae	*Euplectes capensis*		x	x				
Ploceidae	*Euplectes jacksoni*		x					NT
Estrildidae	*Nigrita canicapilla*	x						
Estrildidae	*Pytilia melba*				x	x		
Estrildidae	*Cryptospiza salvadorii*	x	x					
Estrildidae	*Spermophaga ruficapilla*	x	x					
Estrildidae	*Mandingoa nitidula*	x						
Estrildidae	*Lagonosticta senegala*		x	x	x			
Estrildidae	*Lagonosticta rubricata*	x	x					
Estrildidae	*Estrilda quartinia*	x	x					
Estrildidae	*Estrilda rhodopyga*		x	x				
Estrildidae	*Estrilda astrild*		x	x				
Estrildidae	*Estrilda nonnula*	x						
Estrildidae	*Estrilda charmosyna*			x	x	x		
Estrildidae	*Uraeginthus bengalus*		x	x	x	x		
Estrildidae	*Uraeginthus cyanocephalus*				x	x		
Estrildidae	*Uraeginthus ianthinogaster*		x	x	x			
Estrildidae	*Lonchura cantans*				x	x		
Estrildidae	*Lonchura griseicapilla*			x	x	x		
Estrildidae	*Lonchura cucullata*	x	x	x				
Estrildidae	*Lonchura bicolor*	x	x					
Estrildidae	*Amadina fasciata*		x	x				
Estrildidae	*Vidua chalybeata*		x	x	x	x		
Estrildidae	*Vidua macroura*		x	x	x	x		
Estrildidae	*Vidua fischeri*				x	x		
Estrildidae	*Vidua paradisaea*				x	x		
Fringillidae	*Serinus canicollis*	x	x	x				
Fringillidae	*Serinus citrinelloides*		x	x				
Fringillidae	*Serinus dorsostriatus*			x	x	x		
Fringillidae	*Serinus sulphuratus*		x	x				
Fringillidae	*Serinus striolatus*	x	x					
Fringillidae	*Serinus burtoni*	x						
Fringillidae	*Serinus reichenowi*		x	x				

Family	Scientific	Forest	Agricultural landscape	Evergreen bushland	Acacia-Commiphora	Riverine	Endemic	IUCN
Fringillidae	*Linurgus olivaceus*	x						
Emberizidae	*Emberiza tahapisi*		x	x	x			
Emberizidae	*Emberiza flaviventris*			x	x	x		
Emberizidae	*Emberiza poliopleura*			x	x	x		

Appendix E: List of potential reptile fauna

In the IUCN Status “NE” means not evaluated under the IUCN Red List Criteria

Order	Family	Scientific	Forest	Agricultural landscape	Evergreen bushland	Acacia-Commiphora	Riverine	Endemic	IUCN
Crocodylia	Crocodylidae	*Crocodylus niloticus*					x		LC
Squamata	Agamidae	*Acanthocercus atricollis*		x	x	x	x		LC
Squamata	Agamidae	*Agama agama*				x	x		NE
Squamata	Agamidae	*Agama caudospinosa*			x	x		x	LC
Squamata	Atractaspididae	*Amblyodpsas unicolor*			x	x	x		NE
Squamata	Atractaspididae	*Aparallactus lunulatus*			x	x	x		NE
Squamata	Atractaspididae	*Atractaspis irregularis*			x	x	x		NE
Squamata	Boidae	*Eryx colubrinus*				x	x		NE
Squamata	Boidae	*Python sebae*					x		NE
Squamata	Chamaeleonidae	*Chamaeleo dilepis*				x	x		LC
Squamata	Chamaeleonidae	*Chamaeleo gracilis*				x	x		LC
Squamata	Chamaeleonidae	*Trioceros bitaeniatus*	x	x	x				LC
Squamata	Chamaeleonidae	*Trioceros ellioti*		x	x	x			LC
Squamata	Chamaeleonidae	*Trioceros hoehnelii*	x	x	x				LC
Squamata	Colubridae	*Coluber florulentis*			x	x	x		NE
Squamata	Colubridae	*Crotaphopeltis hotamboeia*	x	x	x				NE
Squamata	Colubridae	*Dasypeltis atra*			x				NE
Squamata	Colubridae	*Dasypeltis scabra*		x	x	x	x	x	LC
Squamata	Colubridae	*Dispholidus typus*			x	x	x		NE
Squamata	Colubridae	*Duberria lutrix*		x	x	x			NE
Squamata	Colubridae	*Lamprophis fuliginosus*		x	x	x	x		NE
Squamata	Colubridae	*Lycophidion capense*		x	x	x	x		NE
Squamata	Colubridae	*Lycophidion depressirostre*		x	x	x	x		NE
Squamata	Colubridae	*Mehelya capensis*			x	x	x		NE
Squamata	Colubridae	*Meizodon semiornatus*			x	x	x		NE
Squamata	Colubridae	*Philothamnus battersbyi*			x	x	x		NE
Squamata	Colubridae	*Psammophis mossambicus*			x	x	x		NE
Squamata	Colubridae	*Psammophis sudanensis*			x	x	x		NE
Squamata	Colubridae	*Psammphylax multisquamis*		x	x				NE
Squamata	Colubridae	*Pseudaspis cana*		x	x				NE
Squamata	Colubridae	*Rhamphiophis rubropunctatus*				x	x		NE
Squamata	Colubridae	*Scaphiopis raffreyi*				x	x		NE
Squamata	Colubridae	*Telescopus dhara*				x	x		NE
Squamata	Cordylidae	*Chamaesaura anguina*		x					NE
Squamata	Cordylidae	*Gerrhosaurus flavigularis*			x	x	x		NE
Squamata	Cordylidae	*Gerrhosaurus major*			x	x	x		NE
Squamata	Elapidae	*Dendroaspis polylepis*			x	x	x		LC
Squamata	Elapidae	*Elapsoidea loveridgei*			x	x	x		NE
Squamata	Elapidae	*Naja melanoleuca*	x	x					NE

Order	Family	Scientific	Forest	Agricultural landscape	Evergreen bushland	Acacia-Commiphora	Riverine	Endemic	IUCN
Squamata	Elapidae	*Naja nigricollis*			x	x	x		NE
Squamata	Gekkonidae	*Cnemaspis dickersoni*	x						NE
Squamata	Gekkonidae	*Hedmidactylus mabouia*		x					NE
Squamata	Gekkonidae	*Hemidactylus brooki*		x					NE
Squamata	Gekkonidae	*Holodactylus africanus*				x	x		NE
Squamata	Gekkonidae	*Lygodactylus keniensis*				x	x	x	LC
Squamata	Gekkonidae	*Lygodactylus manni*			x	x	x		LC
Squamata	Lacertidae	*Adolfus jacksoni*	x	x					NE
Squamata	Lacertidae	*Heliobolus spekii*				x	x		NE
Squamata	Lacertidae	*Latastia longicaudata*				x	x		NE
Squamata	Scincidae	*Lygosoma afrum*		x	x	x	x		NE
Squamata	Scincidae	*Lygosoma sundevalli*		x	x	x	x		NE
Squamata	Scincidae	*Mabuya quinqueaeniata*				x	x		NE
Squamata	Scincidae	*Mabuya striata*		x	x	x	x		NE
Squamata	Scincidae	*Mabuya varia*		x	x	x	x		NE
Squamata	Scincidae	*Trachylepis bayonii*	x	x					DD
Squamata	Scincidae	*Trachylepis dichroma*				x	x		LC
Squamata	Typhlopidae	*Typhlops lineolatus*		x	x	x	x		NE
Squamata	Varanidae	*Varanus albigularis*				x	x		NE
Squamata	Varanidae	*Varanus niloticus*				x	x		NE
Squamata	Viperidae	*Bitis arietans*			x	x	x		NE
Squamata	Viperidae	*Bitis worthingtoni*	x	x	x			x	NE
Squamata	Viperidae	*Causus resimus*			x	x	x		NE
Squamata	Viperidae	*Causus rhombeatus*			x	x	x		NE
Testudines	Pelomedusidae	*Pelomedusa subrufa*				x	x		NE
Testudines	Testudinidae	*Kikixys belliana*			x	x	x		NE
Testudines	Testudinidae	*Kinixys spekii*			x	x	x		NE
Testudines	Testudinidae	*Stigmochelys pardalis*		x	x	x	x		LC

Appendix F: List of potential amphibian fauna

With habitat associations and IUCN status (updated 1st Feb 2017)

Family	IUCN	Scientific	Forest	Agricultural landscape	Evergreen bushland	Acacia-Commiphora	Riverine	Endemic
Bufonidae	LC	*Poyntonophrynus lughensis*			x	x	x	
Bufonidae	LC	*Sclerophrys garmani*		x	x	x	x	
Bufonidae	LC	*Sclerophrys kerinyagae*	x	x				
Bufonidae	LC	*Sclerophrys kisoloensis*	x					
Bufonidae	LC	*Sclerophrys pusilla*		x	x	x	x	
Bufonidae	LC	*Sclerophrys regularis*		x	x	x	x	
Bufonidae	LC	*Sclerophrys xeros*				x	x	
Dicroglossidae	LC	*Hoplobatrachus occipitalis*						
Hemisotidae	LC	*Hemisus guineensis*		x	x	x	x	
Hemisotidae	LC	*Hemisus marmoratus*		x		x	x	
Hyperoliidae	LC	*Afrixalus osorioi*	x	x				
Hyperoliidae	LC	*Hyperolius glandicolor*		x	x	x	x	
Hyperoliidae	LC	*Hyperolius montanus*	x	x	x			x
Hyperoliidae	LC	*Hyperolius viridiflavus*		x	x	x	x	
Hyperoliidae	LC	*Kassina senegalensis*		x	x	x	x	
Microhylidae	LC	*Phrynomantis bifasciatus*				x	x	
Phrynobatrachidae	LC	*Phrynobatrachus acridoides*		x	x	x	x	
Phrynobatrachidae	LC	*Phrynobatrachus keniensis*	x	x	x			x
Phrynobatrachidae	LC	*Phrynobatrachus natalensis*		x	x	x	x	
Phrynobatrachidae	LC	*Phrynobatrachus scheffleri*		x		x	x	
Pipidae	LC	*Xenopus borealis*		x	x			
Pipidae	LC	*Xenopus victorianus*	x	x	x	x	x	
Ptychadenidae	LC	*Hildebrandtia ornata*				x	x	
Ptychadenidae	LC	*Ptychadena anchietae*		x	x	x	x	
Ptychadenidae	LC	*Ptychadena mahnerti*	x	x	x			
Ptychadenidae	LC	*Ptychadena nilotica*		x	x	x	x	
Ptychadenidae	LC	*Ptychadena oxyrhynchus*		x	x	x	x	
Pyxicephalidae	LC	*Amietia angolensis*	x	x	x			
Pyxicephalidae	LC	*Amietia wittei*	x	x	x			x
Pyxicephalidae	LC	*Pyxicephalus adspersus*				x	x	
Pyxicephalidae	LC	*Tomopterna tandyi*		x	x	x	x	
Ranidae	LC	*Amnirana albolabris*	x	x	x			
Ranidae	LC	*Amnirana galamensis*			x	x	x	
Rhacophoridae	LC	*Chiromantis kelleri*			x	x	x	
Rhacophoridae	LC	*Chiromantis petersii*			x	x	x	

Appendix G: List of potential fish fauna

IUCN Red List status (updated to 30/Jan/2017) is also given. All the species of fishes occur exclusively in Riverine habitats.

Family	Scientific name	Author	Occurrence	IUCN
Alestidae	*Hydrocynus vittatus*	Castelnau, 1861	native	LC
Bagridae	*Bagrus docmak*	(Forsskål, 1775)	native	LC
Cichlidae	*Coptodon zillii*	(Gervais, 1848)	native	Not evaluated
Cichlidae	*Oreochromis niloticus*	(Linnaeus, 1758)	native	LC
Clariidae	*Clarias gariepinus*	(Burchell, 1822)	native	LC
Claroteidae	*Auchenoglanis occidentalis*	(Valenciennes, 1840)	native	LC
Cyprinidae	*Enteromius neumayeri*	(Fischer, 1884)	native	Not evaluated
Cyprinidae	*Enteromius paludinosus*	(Peters, 1852)	native	Not evaluated
Cyprinidae	*Enteromius stigmatopygus*	(Boulenger, 1903)	native	Not evaluated
Cyprinidae	*Labeo cylindricus*	Peters, 1852	native	LC
Cyprinidae	*Labeo horie*	Heckel, 1847	native	Not evaluated
Cyprinidae	*Labeo niloticus*	(Linnaeus, 1758)	native	LC
Cyprinidae	*Labeobarbus intermedius*	(Rüppell, 1835)	native	LC
Cyprinidae	*Leptocypris niloticus*	(Joannis, 1835)	native	LC
Cyprinidae	*Neobola bottegoi*	Vinciguerra, 1895	native	DD
Latidae	*Lates niloticus*	(Linnaeus, 1758)	native	LC
Mochokidae	*Chiloglanis kerioensis*	Schmidt, Bart & Ny., 2015	endemic	DD
Mochokidae	*Synodontis frontosus*	Vaillant, 1895	native	LC
Mormyridae	*Mormyrus kannume*	Forsskål, 1775	native	LC
Poeciliidae	*Aplocheilichthys jeanneli*	(Pellegrin, 1935)	native	LC
Salmonidae	*Oncorhynchus mykiss*	(Walbaum, 1792)	introduced	LC

Appendix H: Minutes, Photos, attendance list and HH questionnaires used in public consultation and participation

MINUTES OF CONSULTATIVE MEETING ON ARROR MULTIPURPOSE DAM DEVELOPMENT PROJECT HELD ON 7TH DECEMBER, 2016 AT KIPSAIYA/HOSSEN LOCATION BETWEEN KVDA, MAIER CONSULTANTS AND THE COMMUNITY

PRESENT.

See the attached list.

AGENDA

1. Introduction
2. Project Introduction
3. Sensitization
4. Discussion, concerns and address
5. Way forward
6. Adjournment

Minute 01: Introduction.

The Deputy County Commissioner one (ACC 1); Erick Wamulevu called the meeting to order at 3:00pm and after word of prayer, he welcomed everyone to the meeting and had the Leaders, KVDA team, the Consultants and the research assistants introduce themselves.

Mr Erick Wamulevu promised the members present in the meeting that, the government will make sure that the project runs well and all necessary laws will be adhered to.

The Deputy County Commissioner one welcomed views from all attending community members and promised them that their views will be aired to the relevant authorities.

Minute 02: Project Introduction by KVDA

The KVDA deputy managing director, Mr Francis Kipkech gave a brief of the project to the local community members present in the meeting and apologized for not have involved and engaged them fully before explaining to them that the KVDA team was still trying to source for funds.

Mr Francis Kipkech emphasized that the project is very friendly to the environment since it will promote food security due to the irrigation component, create employment in all phases of construction and increase domestic water supply. He also insisted that catchment conservation and cooperate social responsibilities will be done as part of the project to empower the locals.

Mr Francis Kipkech also explained to the locals that the project will help connect the county to the national power grid since the hydroelectric power produced will be connected to the national power grid hence power availability will be consistence.

Mr Francis Kipkech urged the locals to embrace the project and promised them that they will be involved in all phases of the project. The locals will be given the first priority when it comes to jobs in the implementation phase.

Minute 03: Sensitization by the Consultant Representative

The team leader, Prof. Elijah K. Biamah explained that the purpose of the meeting was to engage the community using the bottom up approach and have the community members express their views and grievances. He explained broadly on the importance of local community involvement at all stages of the project namely:

- Planning phase
- Implementation phase
- Operational phase

Prof. Biamah gave a brief of the project and the area the project will cover and tackled the issue of land acquisition and compensation whereby he explained in details the modes of compensation highlighting;

- Land for land whereby the project affected person is compensated for the land acquired for project purpose with another piece of land.
- Land for money whereby the project affected person is compensated for land acquired for project purpose with money depending current market rates.
- Voluntary donation whereby project affected persons voluntarily donates their land for the project use.

Prof. K. Biamah also briefed on the benefits the community members will get from the project which are:

- Domestic water supply
- Hydro-electric power
- Irrigation
- Employment for both skilled and non-skilled labour

Professor Biamah also pointed out to the community the negative impacts of the project that include loss of biodiversity and relocation of people who are within the dam site but promised that there will be conservation of the catchment area and relocated people will be well compensated. He reassured the locals that mitigation measures will be put in place and strictly adhered to.

Prof. Biamah then urged the community members to accept the project since its more beneficial to them and the country at large.

Minute 04: Sensitization by the Community Representative

Mr Benjamin Cheboi and Samuel K. Tanui addressed the meeting representing the community and aired the community grievances to the consultant and KVDA team with main issue being that they were never involved in the past planning of the project by the KVDA. Being the community representative, they promised that they are ready to accept the project since by now they are well sensitized and aware of the project benefits to them.

Samuel Tanui requested for apologies from KVDA for some rumours that have been circulating that the local communities will be forcefully evicted with no compensation like those in Chebara dam and also requested that the land acquisition and compensation process be carried according to the law.

Minute 05: Comments, Concerns and Address.

The locals raised some issues that required clarification on the following.

Name	Area	Concerns	Responses
Moses Yator	Hossen Village; Kipsaiya Location	The community still needs further consultations	Prof. Biamah promised the community of more consultation and involvement as the project progresses.
		The community is not aware of the boundaries of the dam	Prof. Biamah said that there are recent maps and as the project progresses they will be informed who is affected directly or indirectly as per the recent map
		The mode and way of compensation is not clear to the community	The three modes of land acquisition and compensation were made clear to them. They were requested to form a CBO which will be their channel of communication with KVDA and contractor for negotiations of compensations
		The community feels that their leaders are	Prof. Biamah explained that the top down approach which was used initially was

		not fully representing them in project	a wrong approach and therefore at that is why the team agreed to come and consult the community alone with the bottom up approach
		The community would wish to be given a chance to value their own land instead of the government valuer	Prof. requested the members to form a CBO which they can use to negotiate for their own valuation
Danson Suter	Kipsaiya location	Land ownership in the area is mostly ancestral land with more than one dependent. The community wanted to know how such will be compensated	Prof. Biamah explained that in time of compensation, the owner of the land appears first but lists all the household members and dependents and any household member property affected by project is compensated to the relevant owner.
Leah jebet	Hossen village	Clarification on the resettlement and compensation.	Prof. Biamah clarified that when that stage comes after the community accepts the project, RAP experts will come and engage the community fully through their representatives and everything about compensation and resettlement will be agreed upon
Susan Christopher	Hossen village	Requested that mothers be compensated as well since mostly compensation is done to men	Prof. assured that everyone affected by the project is fully compensated and in a transparent way
Elias Korir	Kipsaiya location	Concern on compensation of graves and shrines	Prof. assured the community that everything will be considered and since with the culture of kalenjins, one cannot be compensated for graves hence the community will need to agree on what they want as

			a mode of compensation of the graves
Paul Cherop	Kipsaiya location	Concern on where the affected persons will be relocated to	Prof. told the locals that for now it is not clear on where they will be relocated to but assured them that they will be relocated and well compensated
General community concern	Kipsaiya location	Compensation Further consultative meetings	Professor Biamah promised the locals that the compensation process will be fair and transparent a and more consultative meetings will be done as the project progresses

Minute 06: Way forward.

Professor Biamah requested the local community members not to dispose their land in the affected dam area to avoid land speculators reaping from land buying during compensation and the expected hiking of land prices

The local community members were urged to make sure they have the legal documents to show land ownership for easier compensation process.

Professor Biamah promised the local community members that there will be other consultative meetings for proper sensitization as the project progresses.

All members in attendance agreed that the project is more beneficial to them for social and economic transformation through creation of sustainable livelihoods and thus a decision was made on a public consultation forum at Hossen ward, Kapsaiya location in Marakwet West sub county to continue with the project implementation but the local community members requested for more public consultation and sensitization.

Therefore, it was agreed that another consultative meeting to be done on Tuesday, 13th December, 2016.

Minute 07: Adjournment.

There being no other business, the meeting was adjourned at 5:00 pm with a word of prayer.

MINUTES OF CONSULTATIVE MEETING ON ARROR MULTIPURPOSE DAM DEVELOPMENT PROJECT HELD ON 8TH DECEMBER, 2016 AT MAINA SUB LOCATION BETWEEN KVDA, MAIER CONSULTANTS AND THE COMMUNITY

PRESENT.

See the attached list.

AGENDA

1. Introduction
2. Project Introduction
3. Sensitization
4. Discussion, concerns and address
5. Way forward
6. Adjournment

Minute 01: Introduction

The Assistant County Commissioner one (ACC 1); Mr George Kubai called the meeting to order at 2:00pm and after word of prayer, he welcomed everyone to the meeting and had the Leaders, KVDA team, the Consultants and the research assistants introduce themselves.

Mr Kubai welcomed views from all attending community members and promised them that their views will be aired to the relevant authorities.

The assistant county commissioner then introduced and welcomed the KVDA and consultant team to address the meeting.

Minute 02: Project Introduction by KVDA

The KVDA deputy managing director, Mr Francis Kipkech gave a brief of the project to the local community members present in the meeting and apologized for not have involved and engaged them fully before explaining to them that the KVDA team was still trying to source for funds.

Mr Francis Kipkech emphasized that the project is very friendly to the environment since it will promote food security due to the irrigation component, create employment in all phases of construction and increase domestic water supply. He also insisted that catchment conservation and cooperate social responsibilities will be done as part of the project to empower the locals.

Mr Francis Kipkech explained to the locals that the project will help connect the county to the national power grid since the hydroelectric power produced will be connected to the national power grid hence power availability will be consistence.

Mr Francis Kipkech urged the locals to embrace the project and promised them that they will be involved in all phases of the project. The locals will be given the first priority when it comes to jobs in the implementation phase.

Minute 03: Sensitization by the Consultant Representative.

The team leader, Prof. Elijah K. Biamah explained that the purpose of the meeting was to engage the community using the bottom up approach and have the community members express their views and grievances. He explained broadly on the importance of local community involvement at all stages of the project namely:

- Planning phase
- Implementation phase
- Operational phase

Prof. Elijah K. Biamah also gave a brief of the project and the area the project will cover and tackled the issue of land acquisition and compensation whereby he explained in details the modes of compensation highlighting;

- Land for land whereby the project affected person is compensated for the land acquired for project purpose with another piece of land.
- Land for money whereby the project affected person is compensated for land acquired for project purpose with money depending current market rates.
- Voluntary donation whereby project affected persons voluntarily donates their land for the project use.

Prof. K. Biamah also briefed on the benefits the community members will get from the project which are:

- Domestic water supply
- Hydro-electric power
- Irrigation
- Employment for both skilled and non-skilled labour

Professor Biamah also pointed out to the community the negative impacts of the project that include loss of biodiversity and relocation of people who are within the dam site but promised that there will be conservation of the catchment area and relocated people will be well compensated. He reassured the locals that mitigation measures will be put in place and strictly adhered to.

Prof. Elijah K. Biamah then urged the community members to accept the project since its more beneficial to them and the country at large.

Minute 04: Sensitization by the Community Representative

Mr Benjamin Cheboi and Samuel K. Tanui addressed the meeting representing the community and aired the community grievances to the consultant and KVDA team with main issue being that they were never involved in the past planning of the project by the KVDA. Being the community representative, they promised that they are ready to accept the project since by now they are well sensitized and aware of the project benefits to them.

Samuel Tanui requested for apologies from KVDA for some rumours that have been circulating that the local communities will be forcefully evicted with no compensation like those in Chebara dam and also requested that the land acquisition and compensation process be carried according to the law. The KVDA team apologized and assured the community that proper sensitization is to be done with fairness.

Minute 05: Comments, Concerns and Address.

The locals however raised some issues that required clarification on the following.

Name	Area	Concerns	Responses
Samuel Kiptanui	Chemworor village	Previous poor compensation	Prof. Biamah requested the members to treat the project solely and assured them that they will be well compensation without such challenges
		The community requested for water supply from the project	Prof. Biamah promised them that there will be domestic water supply from the dam to the community.
		The mode and way of compensation is not clear to the community	The three modes of land acquisition and compensation were made clear to them. They were requested to form a CBO which will be their channel of communication with KVDA and contractor for negotiations of compensations
		Land ownership in the area is mostly ancestral land with more than one dependent. The community wanted to	Prof. Biamah explained that in time of compensation, the owner of the land appears first but lists all the household members and dependents and any household member

		know how such will be compensated	property affected by project is compensated to the relevant owner.
Samuel Kipchumba	Maina sub location	For further sensitization the community requested for a benchmarking trip to Ndakaini dam	The KVDA team clarified to the community that it's only possible if they form a CBO with all people represented. Such arrangement should be made through the CBO
		Job opportunities to community members	Prof. Biamah promised the community that the first priority will be given to the local community in terms of skilled and unskilled labourers
		Scholarships as one of the CSR projects	Prof. Biamah told them that they can negotiate the projects they want as CRS through the CBO they will form.
Ben Chesir	Maina sub location	The community was not involved in initial stages	Prof. apologized for late involvement and clarified to them that for any project to kick off, the community must sensitized and involved and that is why the team came back for the public consultation and participation
		The community is not aware of the long term benefit of the project to them	Prof. clarified to the community that the benefits includes continuous flow of water throughout the year for both domestic use and irrigation and power availability
Tula Bowen	Maina sub location	Land ownership in the area is mostly ancestral land with more than one dependent. The community wanted to know how such will be compensated	Prof. Biamah explained that in time of compensation, the owner of the land appears first but lists all the household members and dependents and any household member property affected by project is compensated to the relevant owner.

		Further consultation meetings	Prof. Biamah assured the community that they will be fully consulted as the project progresses
General community concern	Maina sub location	Compensation Further consultative meetings	Professor Biamah promised the locals that the compensation process will be fair and transparent a and more consultative meetings will be done as the project progresses

Minute 06: Way forward.

Professor Biamah requested the local community members not to dispose their land in the affected dam area to avoid land speculators reaping from land buying during compensation and the expected hiking of land prices

The local community members were urged to make sure they have the legal documents to show land ownership for easier compensation process.

Professor Biamah promised the local community members that there will be other consultative meetings for proper sensitization as the project progresses.

The community appreciated the presences of professor and his team and appreciated their involvement in the project at this stage.

All members in attendance agreed that the project is more beneficial to them for social and economic transformation through creation of sustainable livelihoods and thus a decision was made on a public consultation forum at Maina location in Marakwet East sub County to continue with the project implementation.

Minute 07: Adjournment.

There being no other business, the meeting was adjourned at 6:00 pm with a word of prayer.

MINUTES OF CONSULTATIVE MEETING ON ARROR MULTIPURPOSE DAM DEVELOPMENT PROJECT HELD ON 9TH DECEMBER, 2016 AT ARROR LOCATION BETWEEN KVDA, MAIER CONSULTANTS AND THE COMMUNITY

PRESENT.

See the attached list.

AGENDA

1. Introduction
2. Project Introduction
3. Sensitization
4. Discussion, concerns and address
5. Way forward
6. Adjournment

Minute 01: Introduction

The Assistant County Commissioner one; Mr George Kubai representing Marakwet West Deputy County Commissioner (DCC) called the meeting to order at 2:00pm and after word of prayer, he welcomed everyone to the meeting and had the Leaders, KVDA team, the Consultants and the research assistants introduce themselves.

Mr George Kubai welcomed views from all attending community members and promised them that their views will be aired to the relevant authorities.

The Assistant County Commissioner one introduced and welcomed the KVDA and consultant team to address the meeting.

Minute 02: Project Introduction by KVDA

The KVDA deputy managing director, Mr Francis Kipkech gave a brief of the project to the local community members present in the meeting and apologized for not have involved and engaged them fully before explaining to them that the KVDA team was still trying to source for funds.

Mr Francis Kipkech emphasized that the project is very friendly to the environment since it will promote food security due to the irrigation component, create employment in all phases of construction and increase domestic water supply. He also insisted that catchment conservation and cooperate social responsibilities will be done as part of the project to empower the locals.

Mr Francis Kipkech also explained to the locals that the project will help connect the county to the national power grid since the hydroelectric power produced will be connected to the national power grid hence power availability will be consistence.

Mr Francis Kipkech urged the locals to embrace the project and promised them that they will be involved in all phases of the project. The locals will be given the first priority when it comes to jobs in the implementation phase.

Minute 03: Sensitization by the Consultant Representative.

The team leader, Prof. Elijah K. Biamah explained that the purpose of the meeting was to engage the community using the bottom up approach and have the community members express their views and grievances. He explained broadly on the importance of local community involvement at all stages of the project namely:

- Planning phase
- Implementation phase
- Operational phase

Prof. Elijah K. Biamah also gave a brief of the project and the area the project will cover and tackled the issue of land acquisition and compensation whereby he explained in details the modes of compensation highlighting;

- Land for land whereby the project affected person is compensated for the land acquired for project purpose with another piece of land.
- Land for money whereby the project affected person is compensated for land acquired for project purpose with money depending current market rates.
- Voluntary donation whereby project affected persons voluntarily donates their land for the project use.

Prof. K. Biamah briefed on the benefits the community members will get from the project which are:

- Domestic water supply
- Hydro-electric power
- Irrigation
- Employment for both skilled and non-skilled labour

Professor Biamah also pointed out to the community the negative impacts of the project that include loss of biodiversity and relocation of people who are within the dam site but promised that there will be conservation of the catchment area and relocated people will be well compensated. He reassured the locals that mitigation measures will be put in place and strictly adhered to.

Prof. Elijah K. Biamah then urged the community members to accept the project since its more beneficial to them and the country at large.

Minute 04: Sensitization by the Community Representative

Mr Samuel K. Tanui addressed the meeting representing the community and aired the community grievances to the consultant and KVDA team with main issue being that they were never involved in the past planning of the project by the KVDA. Being the community representative, they promised that they are ready to accept the project since by now they are well sensitized and aware of the project benefits to them.
Samuel Tanui requested for apologies from KVDA for some rumours that have been circulating that the local communities will be forcefully evicted with no compensation like those in Chebara dam and also requested that the land acquisition and compensation process be carried according to the law. The KVDA team apologized and assured the community that proper sensitization is to be done with fairness.

Minute 05: Comments, Concerns and Address.

The locals however raised some issues that required clarification on the following.

Name	Area	Concerns	Responses
Bor Cheserek	Resim village	The land is not subdivided and no legal documents to show ownership such as titles deeds, allotment letters and plot numbers. How will such land be compensated?	Prof. Biamah requested the members to leas with their county government to oversee on how they can be helped with the land ownership legal documents.
		During and after dam construction, will the river still be flowing downstream?	Prof assured the community members that the design of the dam allows for the river to continue flowing downstream.
		Land ownership in the area is mostly ancestral land with more than one dependent. The community wanted to know how such will be compensated	Prof. Biamah explained that in time of compensation, the owner of the land appears first but lists all the household members and dependents and any household member property affected by project is compensated to the relevant owner.
Paul Kiplagat Ruto	Arror	Job opportunities to community members	Prof. Biamah promised the community that the first priority will be given to the local community in terms of

			skilled and unskilled labourers
John Cheruon	Arror	Education scholarships as CRS project	Prof. Biamah told them that they can negotiate the projects they want as CRS through the CBO they will form.
Joseph Keino	Arror	The community is concerned on where the project affected persons will be relocated to	Prof. told the locals that for now it is not clear on where they will be relocated to but assured them that they will be relocated and well compensated
Johnson Kairo	Arror	Land ownership in the area is mostly ancestral land with more than one dependent. The community wanted to know how such will be compensated	Prof. Biamah explained that in time of compensation, the owner of the land appears first but lists all the household members and dependents and any household member property affected by project is compensated to the relevant owner.
		The community is not aware of the long term benefit of the project to them	Prof. clarified to the community that the benefits includes continuous flow of water throughout the year for both domestic use and irrigation and power availability
		The mode and way of compensation is not clear to the community	The three modes of land acquisition and compensation were made clear to them. They were requested to form a CBO which will be their channel of communication with KVDA and contractor for negotiations of compensations
Chepkwony Kipsalem	Arror sub location	Compensation of herbs that will be cleared to give room for dam	Prof assured the community that the herbs will be valued by a valuer and compensated accordingly.

		Long term benefits of the project to the community	Prof. clarified to the community that the benefits includes continuous flow of water throughout the year for both domestic use and irrigation and power availability as well as job opportunities to the community members.
		Compensation for land acquired for the dam and power house.	Prof. Biamah promised the local community members that proper compensation for any land acquired will be done.
General community concern	Arror location	Compensation	Professor Biamah promised the locals that the compensation process will be fair and transparent a and more consultative meetings will be done as the project progresses
		Further consultative meetings	

Minute 06: Way forward.

Professor Biamah requested the local community members not to dispose their land in the affected dam area to avoid land speculators reaping from land buying during compensation and the expected hiking of land prices

The local community members were urged to make sure they have the legal documents to show land ownership for easier compensation process.

Professor Biamah promised the local community members that there will be other consultative meetings for proper sensitization as the project progresses.

All members in attendance agreed that the project is more beneficial to them for social and economic transformation through creation of sustainable livelihoods and thus a decision was made on a public consultation and participation forum at Arror location in Marakwet West Sub County that the project implementation should go on.

Minute 07: Adjournment.

There being no other business, the meeting was adjourned at 5:00 pm with a word of prayer.

PHOTOS OF THE PUBLIC CONSULTATION AND PARTICIPATION MEETINGS

Fig.A1: Prof. Elijah K. Biamah addressing a public consultation meeting at Hossen, Kipsaiya, Marakwet West Sub County. (Dec. 2016)

Fig.A2: Public consultation meeting at Hossen, Kipsaiya, Marakwet West Sub County. (Dec. 2016)

Fig.A3: KVDA, Maier Consultancy Team and Sub County officials at a public consultation meeting at Maina, Marakwet East Sub County. (Dec. 2016)

Fig.A4: Public consultation meeting at Maina, Marakwet East Sub County. (Dec. 2016)

Fig.A5: Public consultation meeting at Arror, Marakwet West Sub County. (Dec. 2016)

Fig.A6: Public consultation meeting at Arror, Marakwet West Sub County. (Dec. 2016)

Fig. A7: County Commissioner, Elgeyo Marakwet County (Dec. 2016)

Fig.A8: Prof Biamah of Maier Consulting Limited, Francis Kipkech-DMD of KVDA at a Courtesy call meeting with County Commissioner (Fredrick K. Ndambuki) of Elgeyo Marakwet County.

(Dec. 2016)

Fig.A9: Prof Biamah of Maier Consulting Limited, Francis Kipkech-DMD of KVDA at a Courtesy call meeting with Assistant County Commissioner One (George Kubai) of Marakwet West Sub County. (Dec. 2016)

Fig. A10: Marakwet Professionals at the County Commissioners Office, Iten, Elgeyo Marakwet County. (Dec. 2016)

Fig. A11: Maier Consultancy Team at the County Commissioners Office, Iten, Elgeyo Marakwet County. (Dec. 2016)

Fig.A12: Assistant County Commissioner One (George Kubai) , Prof Biamah of Maier Consulting Limited and Francis Kipkech-DMD of KVDA at a Courtesy call meeting with Deputy County Commissioner(Erick Wamulevu) of Marakwet East Sub County. (Dec. 2016)

Fig.A13: Marakwet Professionals at a Courtesy call meeting with Deputy County Commissioner (Erick Wamulevu) of Marakwet East Sub County. (Dec. 2016)

Fig. A14: Meeting at KVDA-Eldoret
July 2010

Fig. A15: KVDA-Eldoret
Jan. 2011

Fig. A16: NEMA-Eldoret
July 2010

Fig. A17: NEMA-Eldoret
Jan. 2011

Fig. A18: Public Health Office-Nakuru Authority Jan. 2011

Fig. A19: Water Resources Management Office-Nakuru- Jan. 2011

Fig. A20: Ministry of Forestry- Nairobi July 2010

Fig. A21: Kenya Wildlife Service (Head GIS Office) Nairobi -Jan. 2011

Fig. A22: NEMA-Nairobi Jan. 2011

Fig. A23: Water Resources Management Authority Nairobi- Jan. 2011

THE QUESTIONNAIRE USED TO COLLECT THE LOCAL COMMUNITY MEMBERS' VIEW ON THE PROJECT

ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT (ESIA) FOR ARROR MULTIPURPOSE DAM IN ELGEIYO MARAKWET COUNTY

Household Socio-Economic Survey

1. Identification Information

Date:
Location:
Sub location:
Village name:
Location of the village towards the project area: a. Catchment area b. Reservoir area c. Downstream of Dam-Arror river d. Route of tunnel e. Irrigated and Drainage Area
Full names:
Age:
Identification Card Number:
Phone number:

2. Number of the household members you have ______________

3. Number of livestock possessed.

Row	Type of Animal		Quantity (Numbers)
1	Cattle		
2	Goats		
3	Sheep		
4	Donkey		
5	Chicken		
6	Other:	Dog	
7	Other:	Cat	

4. Respondent's Land ownership status.

a. Type of ownership:	a. Owned ☐ b. Rent ☐ c. Other☐ :
b. period of occupation:	
c. Size of land (acre):	

5. Main occupation of inhabitants:

____

6. Social structure of inhabitants:

Language ☐ Religion ☐

Tribe ☐

7. Infrastructure:

Electricity ☐ Pipe drinking water ☐ Asphalt road ☐

Distance (km) to:

Health Centre _________ Primary: _______

8. Main source of livelihood: ____________________

9. Employment and income:

Is implementation (construction and operation) of the project effective on employment in the area?

Yes ☐ Not clear ☐ No ☐

If yes, how much? Very much ☐ Not much ☐

-Does the implementation of the project increase your income?

Yes, ☐ very much ☐ Not much ☐ Not clear No ☐

- Approximate income of a farmer per month: ___________________
- Approximate income of a worker per month: ___________________

10. What crops do you grow and how much of it do you harvest in a season and in how much land?

____

11. Natural disasters in the past 10 years

Flood ☐ Drought ☐ Earthquake ☐ Storm ☐ Others☐

12. Cultural Characteristics:

Is there any cultural heritage or historic monument near the village?

Yes ☐ No ☐

13. What is your opinion about implementation of the project?

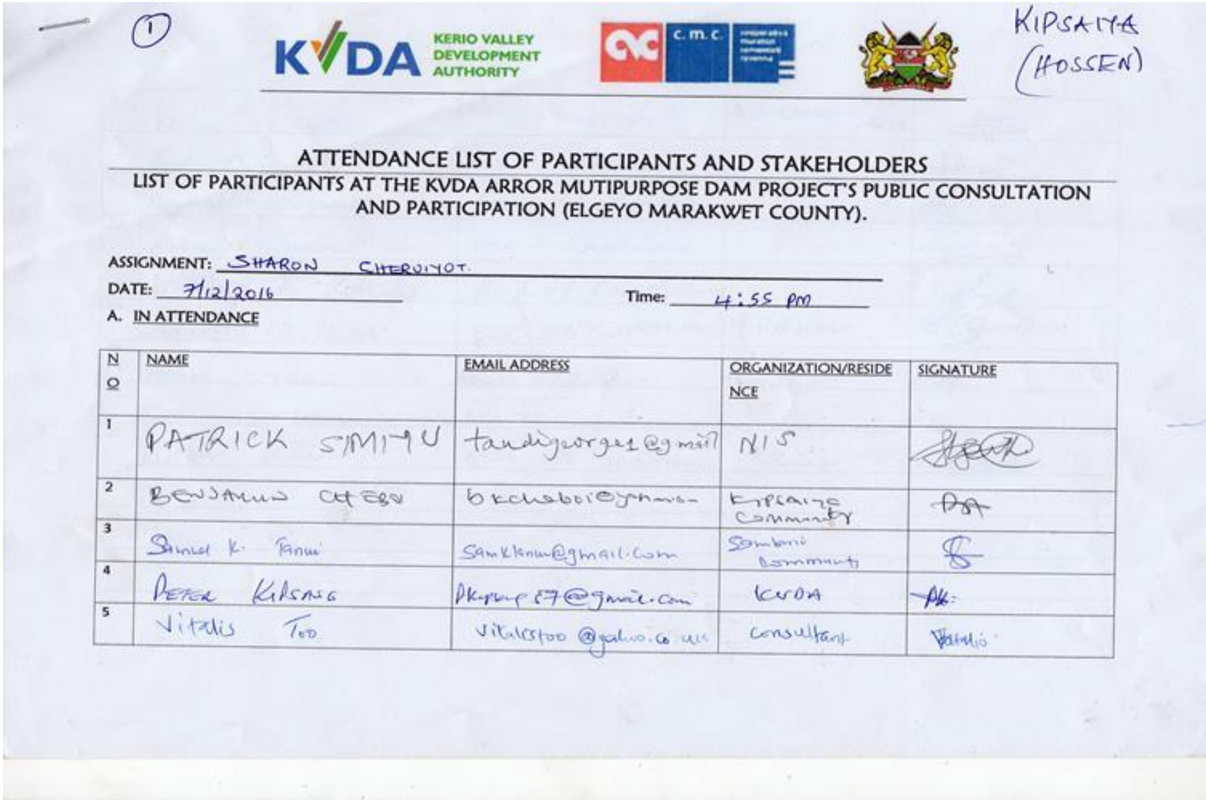
Agree☐ Disagree ☐ No comment ☐

14. What do you think of advantages and disadvantages of the project for your village?

Advantages: More ☐ Average ☐ Less ☐ Can't Tell ☐

Disadvantages: More ☐ Average ☐ Less ☐ Can't Tell ☐

ATTENDANCE LISTS OF THE PUBLIC CONSULTATION AND PARTICIPATION MEETINGS



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KVDA KERIO VALLEY DEVELOPMENT AUTHORITY

c. m. c.

KIPSAIYA
(HOSSEN)

ATTENDANCE LIST OF PARTICIPANTS AND STAKEHOLDERS

LIST OF PARTICIPANTS AT THE KVDA ARROR MUTIPURPOSE DAM PROJECT'S PUBLIC CONSULTATION AND PARTICIPATION (ELGEYO MARAKWET COUNTY).

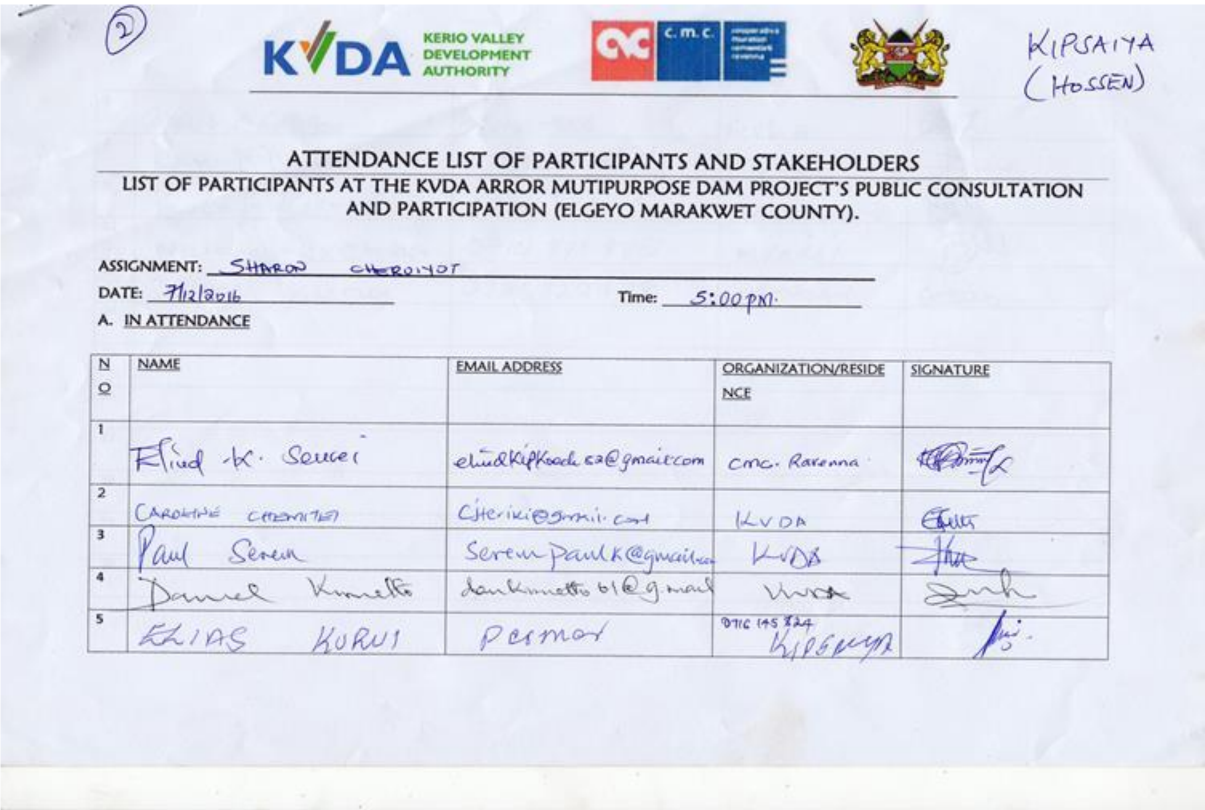
ASSIGNMENT: SHARON CHERUIYOT.

DATE: 7/12/2016 Time: 4:55 pm

A. IN ATTENDANCE

NO	NAME	EMAIL ADDRESS	ORGANIZATION/RESIDENCE	SIGNATURE
1	PATRICK SIMIYU	tandigeorge1@gmail	NIS	
2	BENJAMIN CHEBOI	bkcheboi@yahoo	Kipsaiya Community	
3	Samuel K. Tanui	samktanui@gmail.com	Sambirir community	
4	Peter Kipsang	Pkipsang57@gmail.com	KVDA	
5	Vitalis Too	vitalistoo@yahoo.co.uk	consultant	Vitalis

6	PERIS J. CHEBOI	BOX 55 – KAPSOWAR	ASS. CHIEF, SISIYA	
7	Paul Cherop	Box 136 KAPSOWAR		
8	Barnabbe Cheserem	Box 71 KAPSOWAR		
22	Charles Kurui	Box 71 Kapsowar		
23	Wilson K Ruto	BOX 71 Kapsowar		
24	JAMES ROTICH	BOX 136 Kapsowar	Franer	
25	Thomas C Yano	Box 11 Kapsowar	Farmer	
26	Salina J. Cherutich	Box 71 Kapsowar	farmer	
27	Moses Kitum	Box 55 Kapsowar	Chief	
28				
29				
30				



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KIPSAIYA
(HOSSEN)

ATTENDANCE LIST OF PARTICIPANTS AND STAKEHOLDERS

LIST OF PARTICIPANTS AT THE KVDA ARROR MUTIPURPOSE DAM PROJECT'S PUBLIC CONSULTATION AND PARTICIPATION (ELGEYO MARAKWET COUNTY).

ASSIGNMENT: SHARON CHEROIYOT

DATE: 7/12/2016 Time: 5:00pm.

A. IN ATTENDANCE

NO	NAME	EMAIL ADDRESS	ORGANIZATION/RESIDENCE	SIGNATURE
1	Elind K. Serrei	elindkipkorir.sa@gmail.com	CMC. Ravenna	
2	CAROLINE CHEMITEI	Cheriki@gmail.com	KVDA	
3	Paul Serem	Serempaulk@gmail.com	KVDA	
4	Daniel Kimetto	dankimetto61@gmail	KVDA	
5	ELIAS KURUI	Permar	0716 145 824 Kipsaiya	

KVDA KERIO VALLEY DEVELOPMENT AUTHORITY

c.m.c.

6	CHARLES .C. KIPSOGOM.	0701460858	K.V.D.A	
7	Ben Mwale	0737617 866	Member	
8	PAULO K KIPNGETUNY	0724520145	Member	
22	Mathew . K . Chebor	0714 971 980	mKaasi	
23	Salome Kurui	0725729478	member	
24				
25				
26				
27				
28				
29				
30				

③

MAINA

KERIO VALLEY DEVELOPMENT AUTHORITY

ATTENDANCE LIST OF PARTICIPANTS AND STAKEHOLDERS

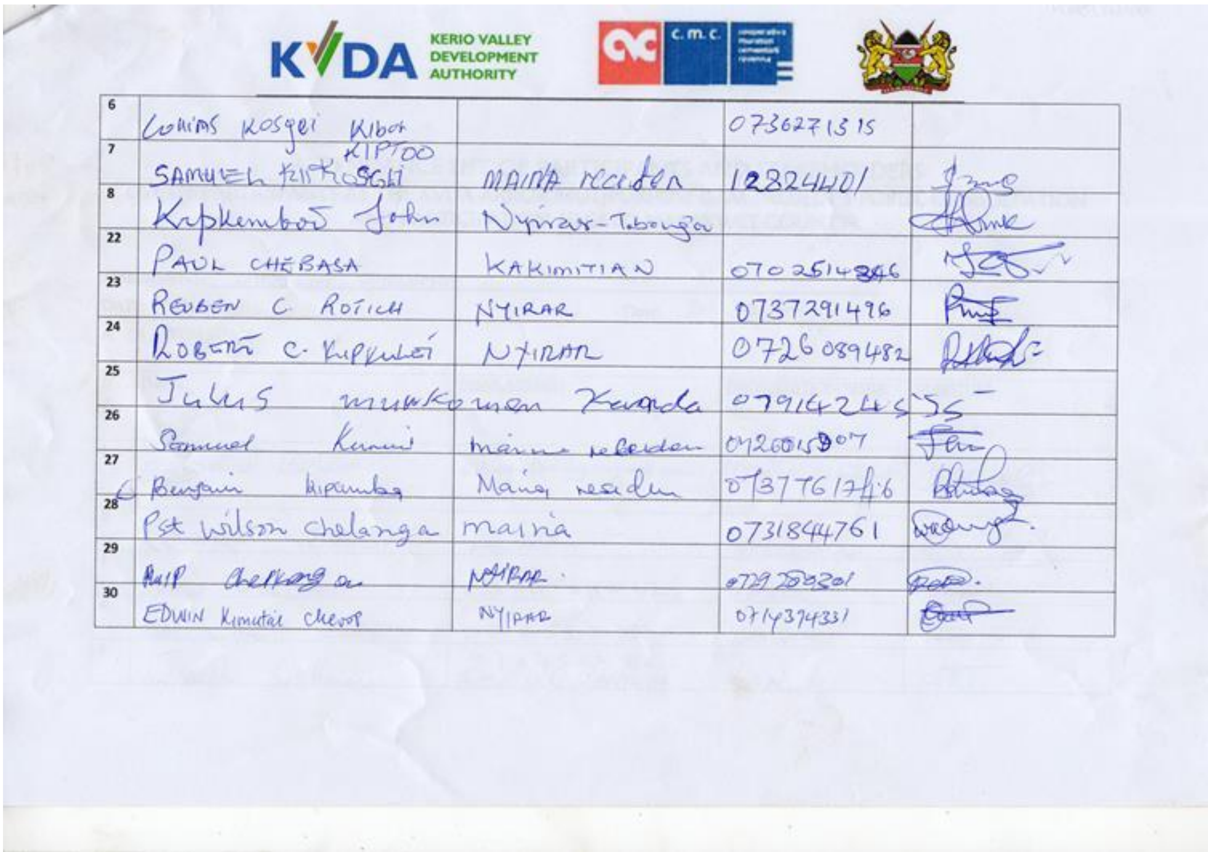
LIST OF PARTICIPANTS AT THE KVDA ARROR MUTIPURPOSE DAM PROJECT'S PUBLIC CONSULTATION AND PARTICIPATION (ELGEYO MARAKWET COUNTY).

ASSIGNMENT: SHARON CHEROIYOT.

DATE: 8/12/2016 Time: 3:30 Pm

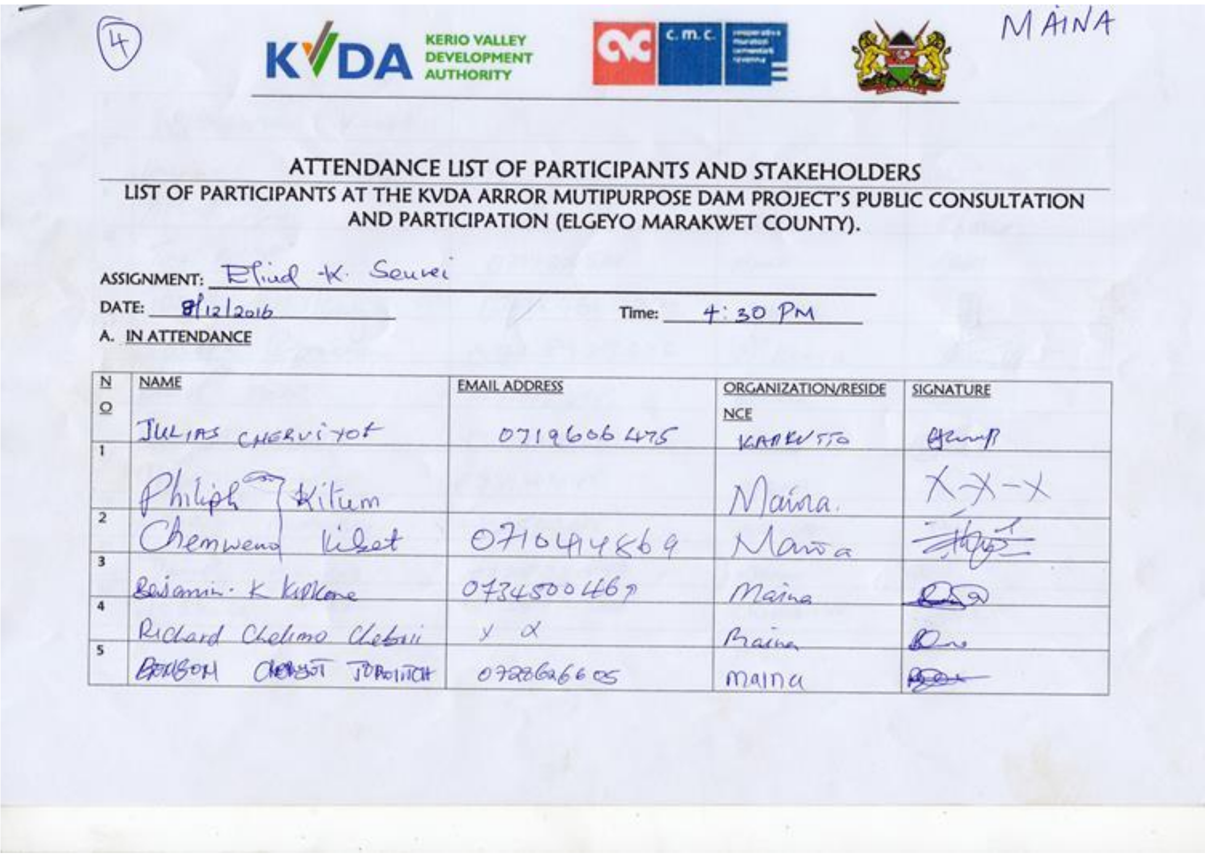
A. IN ATTENDANCE

NO	NAME	EMAIL ADDRESS	ORGANIZATION/RESIDENCE	SIGNATURE
1	Edward Belio	edwardkangogogmail.com	Maina resident	
2	Kbowi Kosgei	[illegible]	Maina	
3	Musa cheptoo	0796968442	Kobil	
4	Kiplagat Kiptoo	0708877978	Kobil	
5	Joseph K. Kuui	0704522822 Box 45 Kapsowar	Kapkuto	



KERIO VALLEY DEVELOPMENT AUTHORITY

6	Lomas Kosgei Kibor		0736271315	
7	SAMUEL KIPKOSGEI KIPTOO	MAINA resident	12824401	
8	Kipkemboi John	Nyirar-Tabonga		
22	PAUL CHEBASA	KAKIMITIAN	0702514846	
23	REUBEN C ROTICH	NYIRAR	0737291496	
24	ROBERT C. KIPKULEI	NYIRAR	0726089482	
25	Julius murkomen	Kaanda	0791424555	
26	Samuel Kuui	maina resident	0726015907	
27	Benjamin kipamba	Maina resident	0737761746	
28	Pst wilson chelanga	maina	0731844761	
29	[illegible]	NYIRAR	0729288201	
30	EDWIN Kimutai Chesot	NYIRAR	0714374331	



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MAINA

KERIO VALLEY DEVELOPMENT AUTHORITY

ATTENDANCE LIST OF PARTICIPANTS AND STAKEHOLDERS

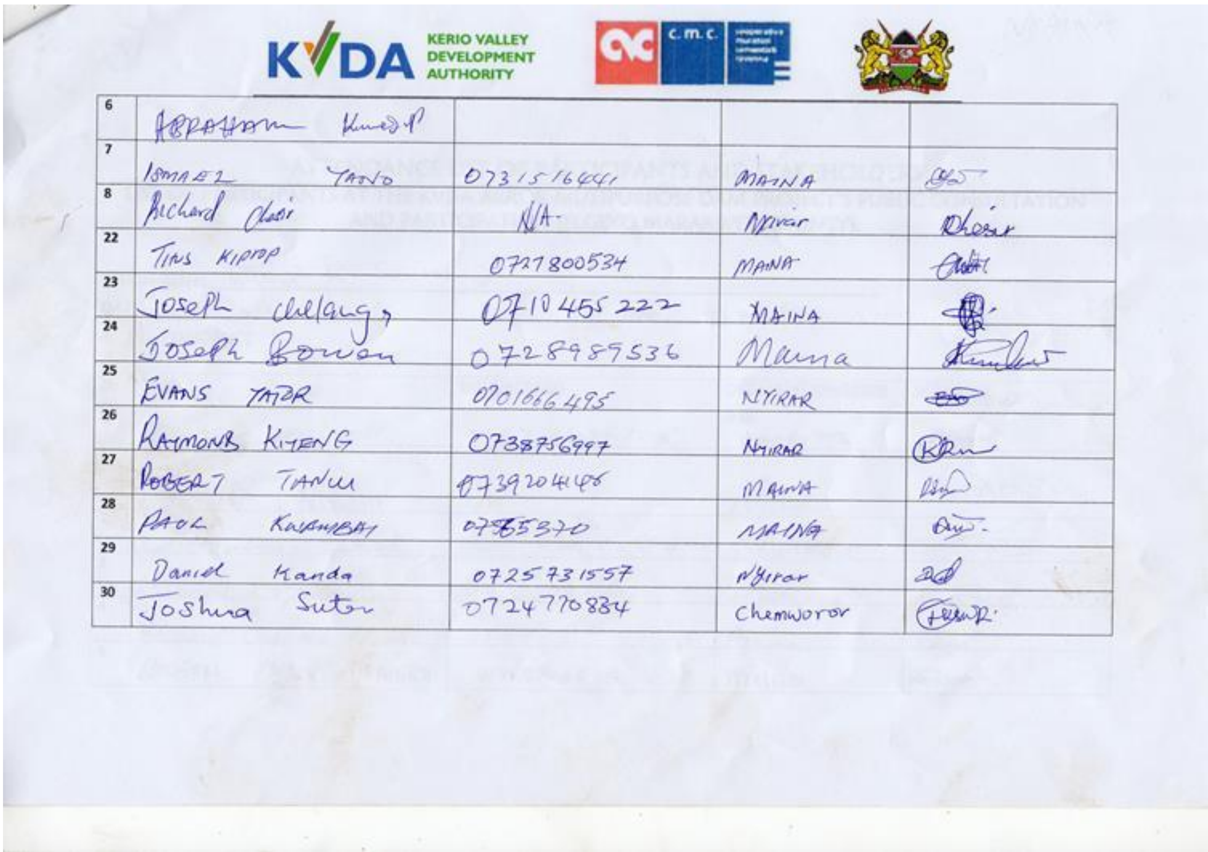
LIST OF PARTICIPANTS AT THE KVDA ARROR MUTIPURPOSE DAM PROJECT'S PUBLIC CONSULTATION AND PARTICIPATION (ELGEYO MARAKWET COUNTY).

ASSIGNMENT: Eliud K. Seurei

DATE: 8/12/2016 Time: 4:30 PM

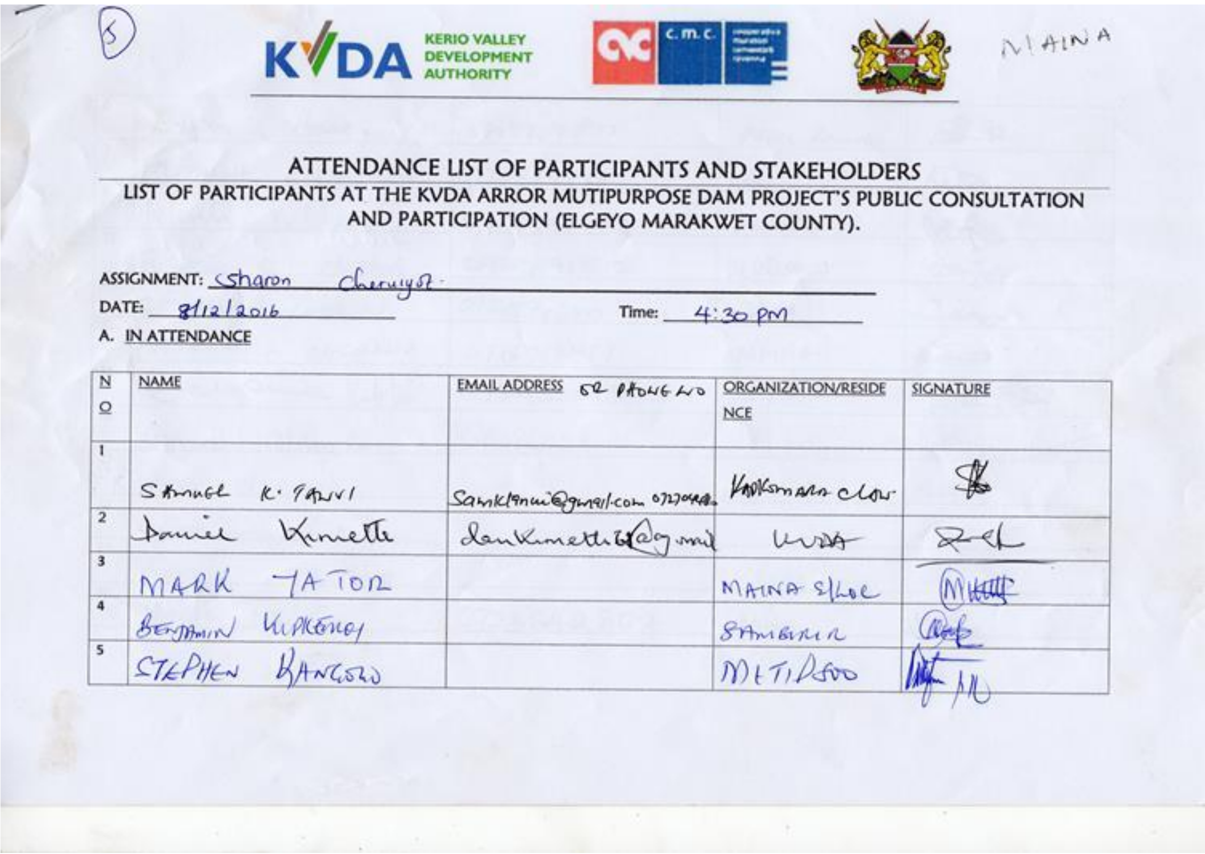
A. IN ATTENDANCE

NO	NAME	EMAIL ADDRESS	ORGANIZATION/RESIDENCE	SIGNATURE
	JULIAS CHERUIYOT	0719606475	KAPKUSTO	
1	Philip Kitum		Maina.	X-X-X
2	Chemweno Kibet	0710494869	Maina	
3	Benjamin. K Kipkore	073450046?	Maina	
4	Richard Chelimo Chebii	x x	Maina	
5	BENSON CHERUIYOT JOROITICH	0728626605	maina	



KERIO VALLEY DEVELOPMENT AUTHORITY

6	ABRAHAM Kimeto P			
7	ISMAEL YANO	073151644	MAINA	
8	Richard Chesir	N/A	Nyirar	
22	TINS KIPROP	0727800534	MAINA	
23	Joseph Chelagat	0710455222	MAINA	
24	Joseph Bowen	0728989536	Maina	
25	EVANS YATOR	0701666495	NYIRAR	
26	RAYMOND KITENG	0738756997	NYIRAR	
27	ROBERT TANUI	0739204148	MAINA	
28	PAUL KWAMBAI	07565370	MAINA	
29	Daniel Kanda	0725731557	Nyirar	
30	Joshua Suter	0724770884	Chemworor	



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KERIO VALLEY DEVELOPMENT AUTHORITY

c.m.c.

MAINA

ATTENDANCE LIST OF PARTICIPANTS AND STAKEHOLDERS

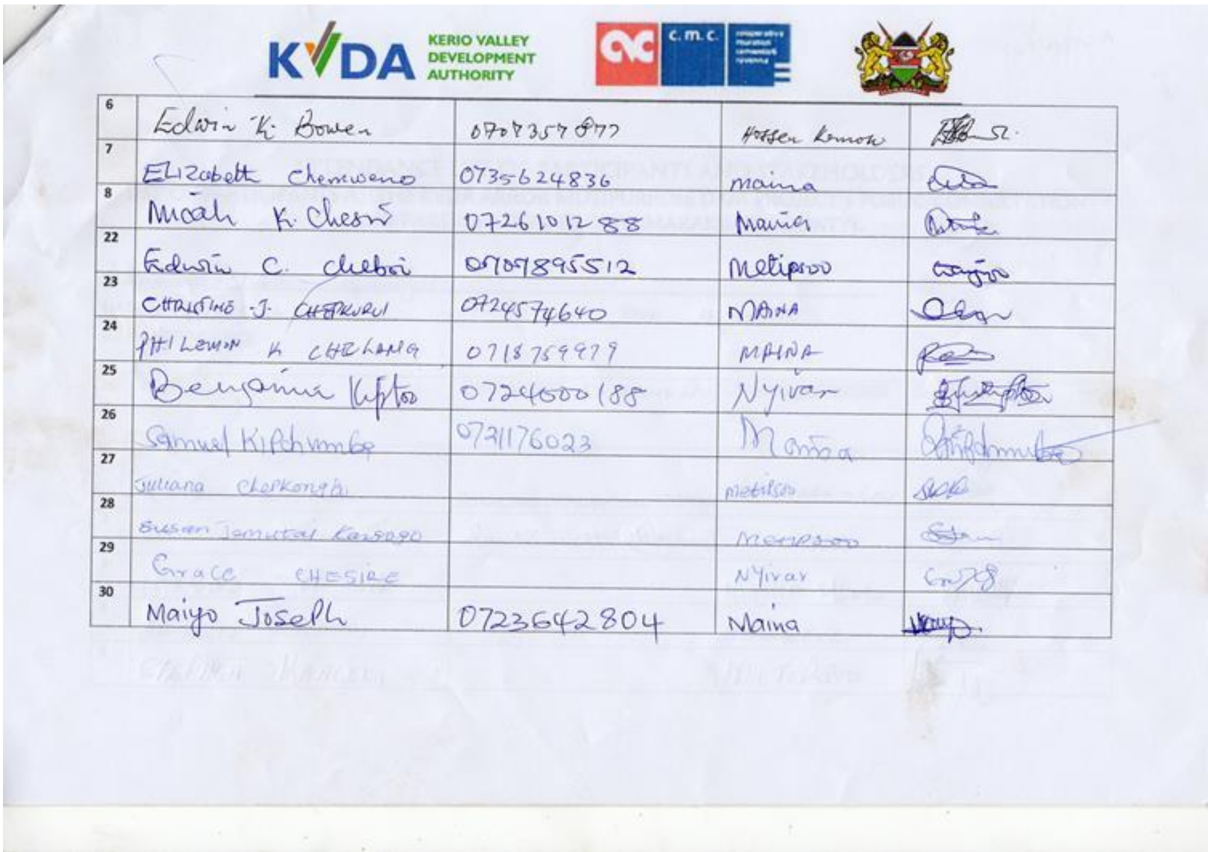
LIST OF PARTICIPANTS AT THE KVDA ARROR MUTIPURPOSE DAM PROJECT'S PUBLIC CONSULTATION AND PARTICIPATION (ELGEYO MARAKWET COUNTY).

ASSIGNMENT: Sharon Cheruiyot

DATE: 8/12/2016 Time: 4:30 PM

A. IN ATTENDANCE

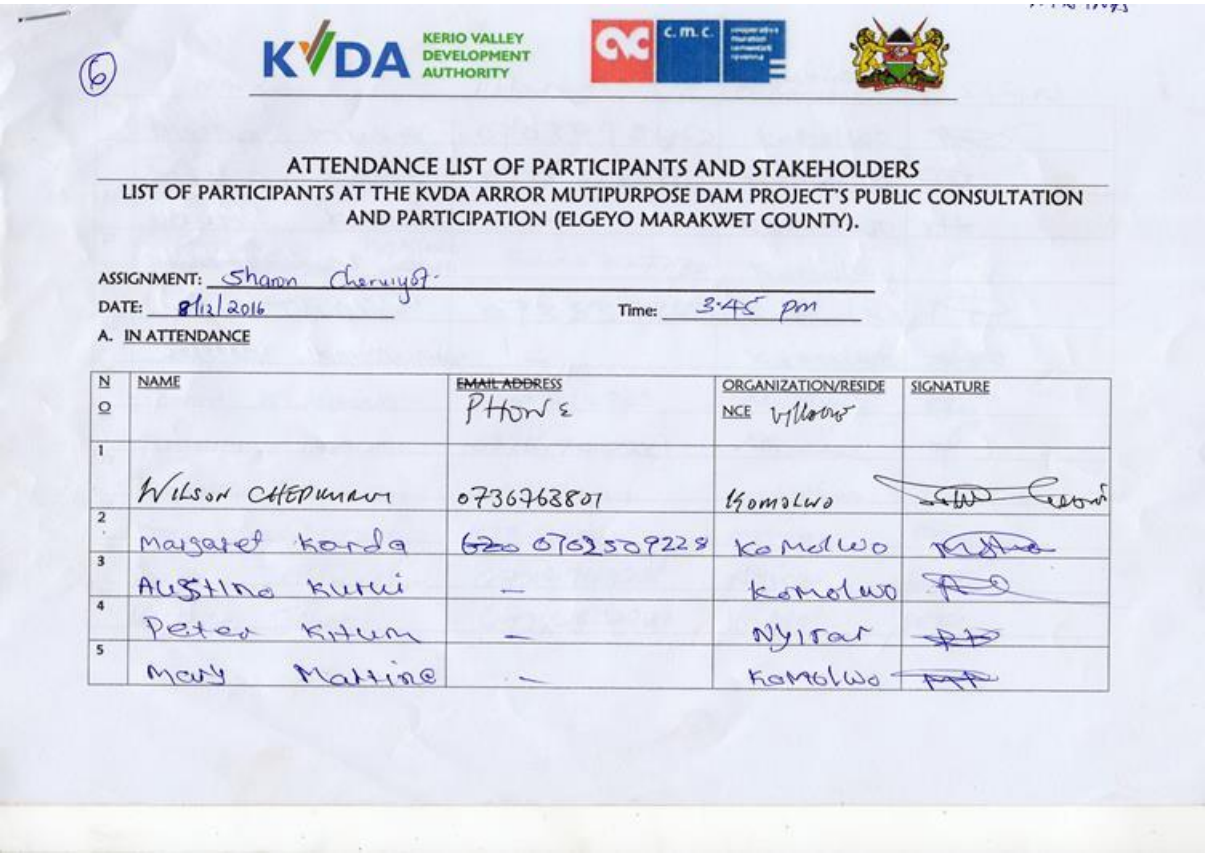
NO	NAME	EMAIL ADDRESS OR PHONE NO	ORGANIZATION/RESIDENCE	SIGNATURE
1	SAMUEL K. TANUI	Samkltanui@gmail.com 0727044	Kapkomara clow	
2	Daniel Kimetto	dankimetto6@gmail	KVDA	
3	MARK YATOR		MAINA S/LOC	
4	BENJAMIN KIPKENEI		SAMBIRIR	
5	STEPHEN KANGOGO		METIPSOO	



KERIO VALLEY DEVELOPMENT AUTHORITY

c.m.c.

6	Edwin K. Bowen	0708357877	Hosser Kamok	
7	Elizabeth Chemweno	0735624836	maina	
8	Micah K. Chesoi	0726101288	Maina	
22	Edwin C. Chebii	0707895512	Metipsoo	
23	CHRISTINE J. CHEPKURUI	0724574640	MAINA	
24	PHILEMON K CHERLANG	0718759979	MAINA	
25	Benjamin Kiptoo	0724600188	Nyivar	
26	Samuel Kipchumba	0721176023	Maina	
27	Juliana Chepkongai		metipsoo	
28	Susan Jemutai Kasogo		Mompsoo	
29	Grace CHESIRE		Nyivar	
30	Maiyo Joseph	0723642804	Maina	



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KERIO VALLEY DEVELOPMENT AUTHORITY

C.M.C.

ATTENDANCE LIST OF PARTICIPANTS AND STAKEHOLDERS

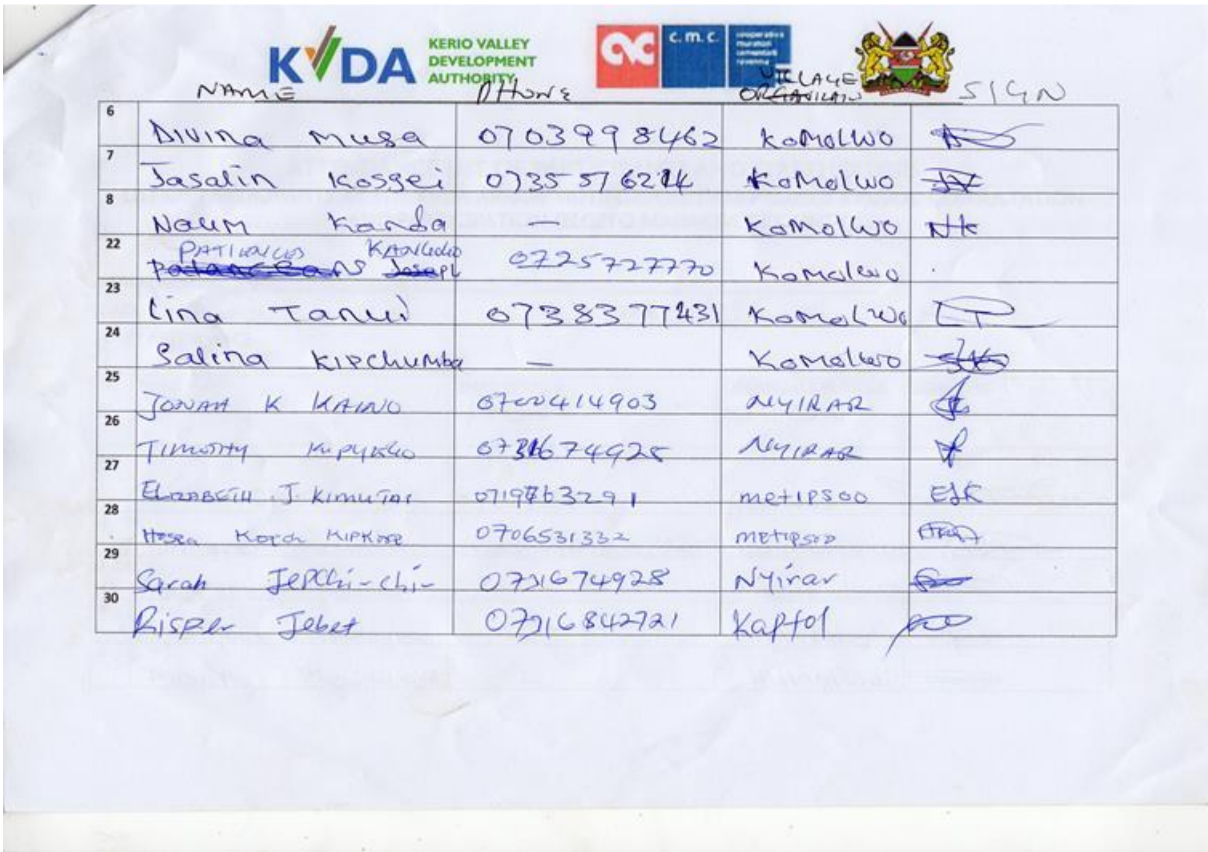
LIST OF PARTICIPANTS AT THE KVDA ARROR MUTIPURPOSE DAM PROJECT'S PUBLIC CONSULTATION AND PARTICIPATION (ELGEYO MARAKWET COUNTY).

ASSIGNMENT: Sharon Cheruiyot.

DATE: 8/12/2016 Time: 3:45 pm

A. IN ATTENDANCE

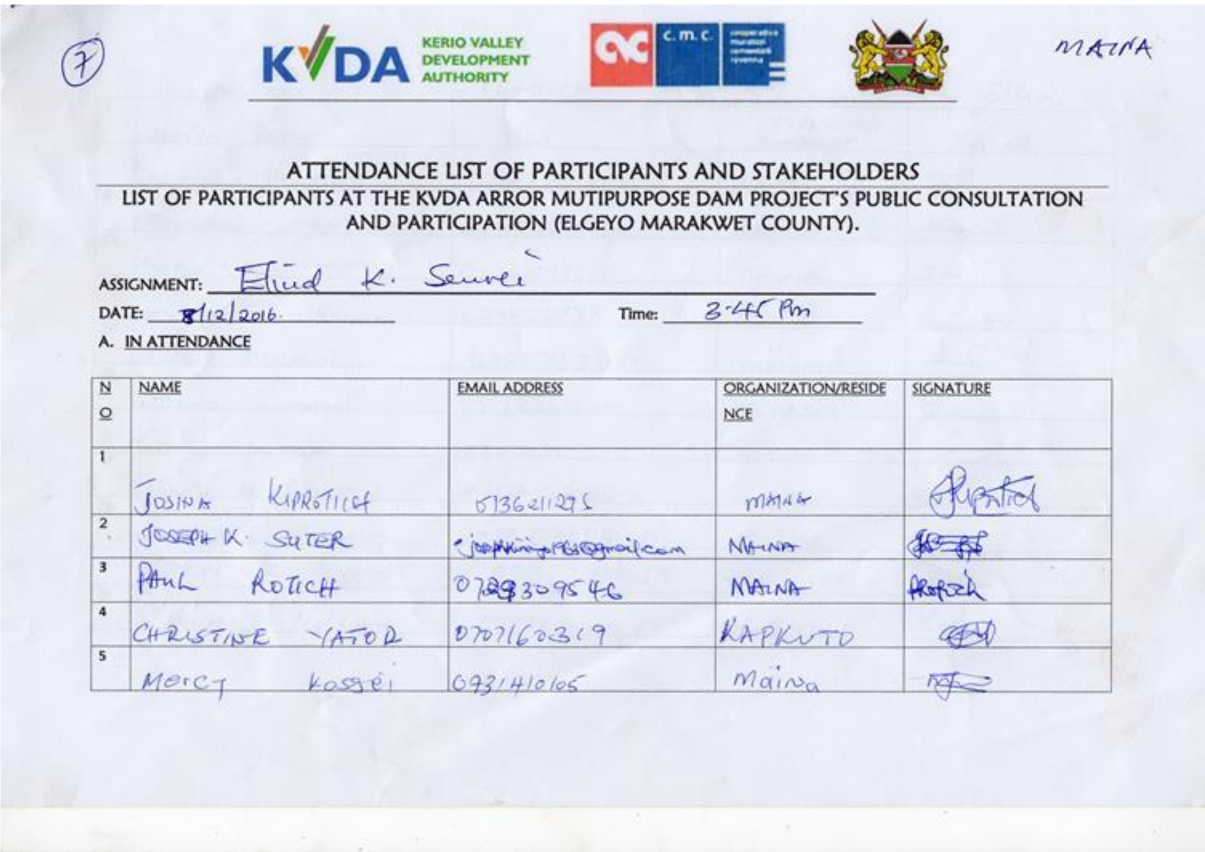
NO	NAME	~~EMAIL ADD~~RESS Phone	ORGANIZATION/RESIDENCE Village	SIGNATURE
1	Wilson CHEPKURUI	0736763801	Komolwo	
2	Margaret Korda	~~620~~ 0702509228	Komolwo	
3	Augstino Kurui	–	Komolwo	
4	Peter Kitum	–	Nyirar	
5	Mary Martine	–	Komolwo	



KERIO VALLEY DEVELOPMENT AUTHORITY

c.m.c.

	NAME	PHONE	VILLAGE ORGANISATION	SIGN
6	Divina Musa	0703998462	Komolwo	
7	Jasalin Kossei	0735 576214	Komolwo	
8	Naum Kanda	—	Komolwo	NK
22	PATIENCUS KANGOGO ~~[illegible]~~ ~~Joseph~~	0725727770	Komolwo	
23	Lina Tanui	0738377431	Komolwo	LT
24	Salina Kipchumba	—	Komolwo	
25	JONAH K KAINO	0700414903	NYIRAR	
26	TIMOTHY Kipyego	0736674925	NYIRAR	
27	ELIZABETH J KIMUTAI	0719763291	metipsoo	EJK
28	Hosea Koech Kipkore	0706531332	metipsoo	
29	Sarah Jepchi-chi-	0721674928	Nyirar	
30	Risper Jebet	07216842721	Kaptol	



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MAINA

KERIO VALLEY DEVELOPMENT AUTHORITY

c. m. c.

ATTENDANCE LIST OF PARTICIPANTS AND STAKEHOLDERS

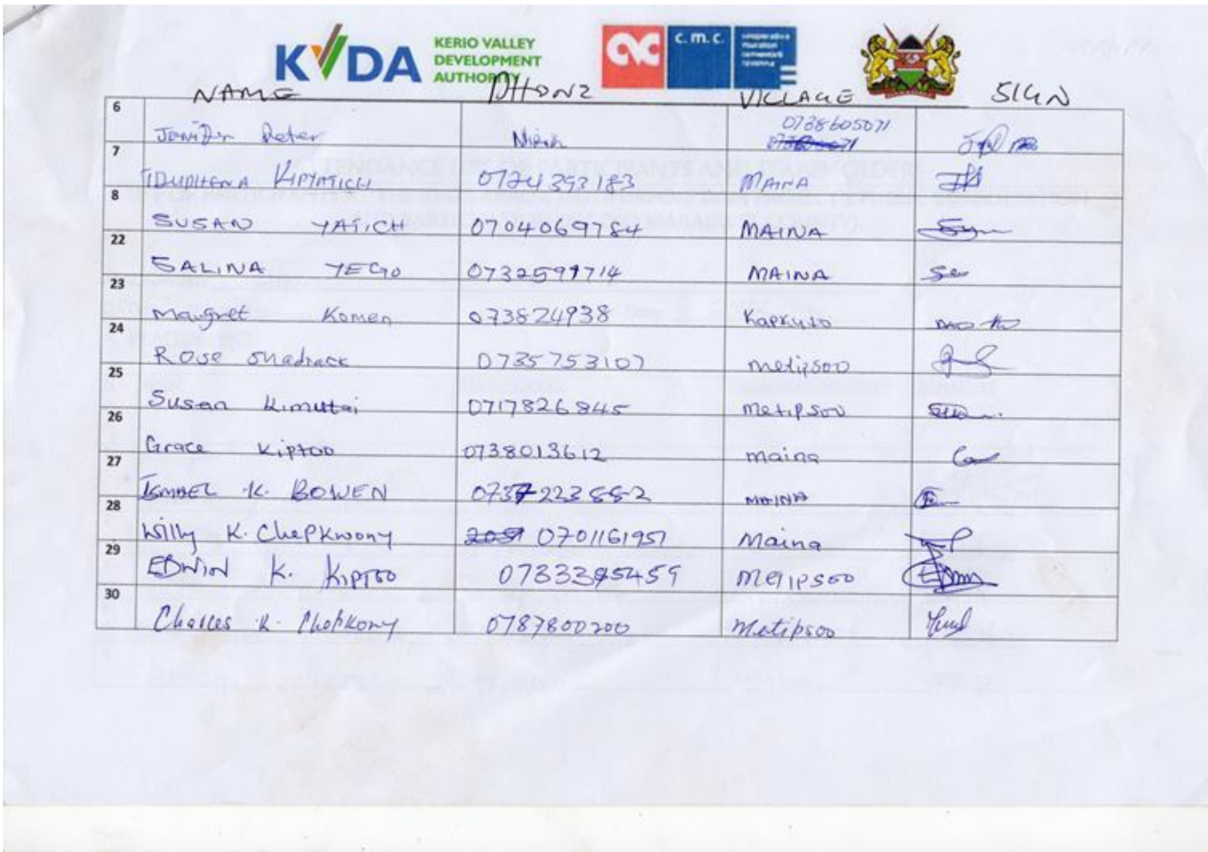
LIST OF PARTICIPANTS AT THE KVDA ARROR MUTIPURPOSE DAM PROJECT'S PUBLIC CONSULTATION AND PARTICIPATION (ELGEYO MARAKWET COUNTY).

ASSIGNMENT: Eliud K. Seurei

DATE: 8/12/2016. Time: 3.45 Pm

A. IN ATTENDANCE

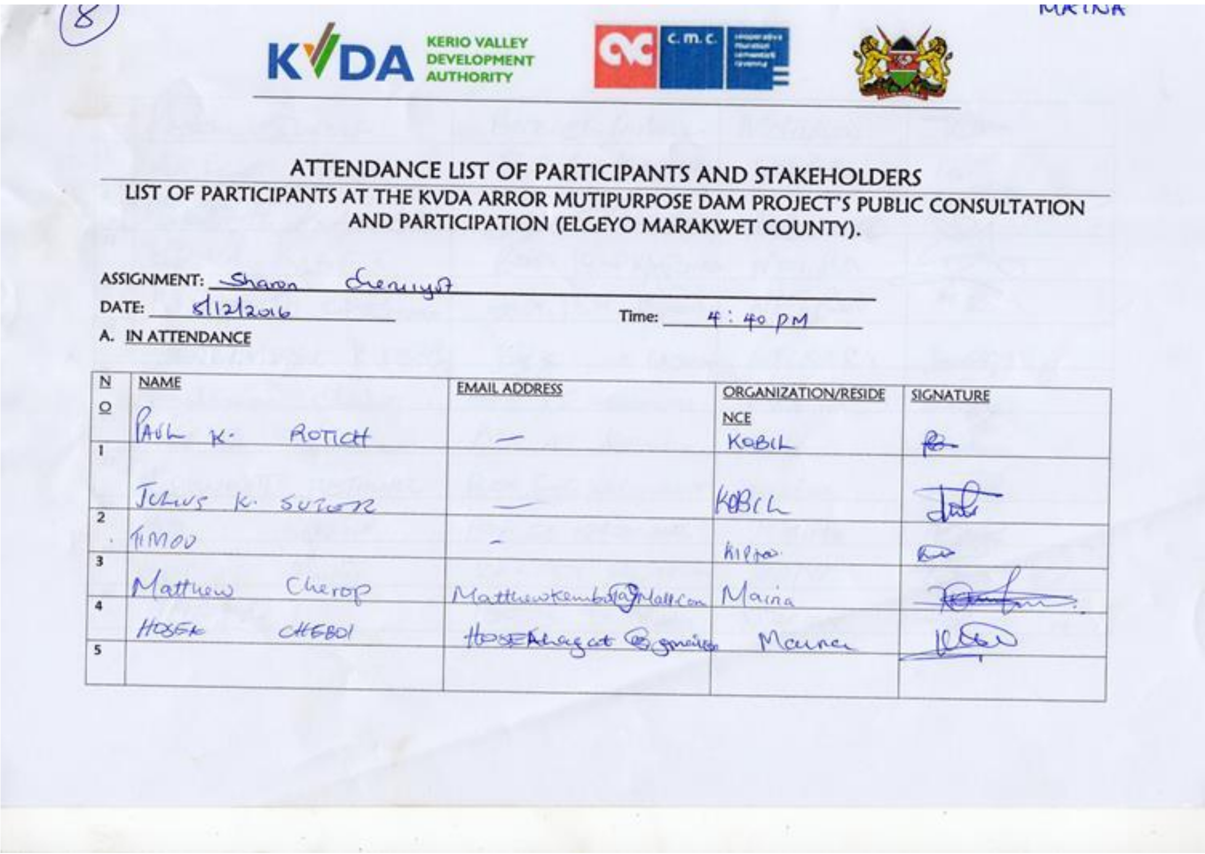
NO	NAME	EMAIL ADDRESS	ORGANIZATION/RESIDENCE	SIGNATURE
1	JOSINA KIPROTICH	0736211295	MAINA	Kiprotich
2	JOSEPH K. SUTER	[illegible]@gmail.com	MAINA	
3	PAUL ROTICH	0728309546	MAINA	
4	CHRISTINE YATOR	0707160319	KAPKUTO	
5	MERCY KOSGEI	0731410105	Maina	



KERIO VALLEY DEVELOPMENT AUTHORITY

c. m. c.

	NAME	PHONE	VILLAGE	SIGN
6	Jennifer Peter	Mirah	0788605071 ~~[illegible]~~	
7	TIDUPHENA KIPYATICH	0724393183	MAINA	
8	SUSAN YATICH	0704069784	MAINA	
22	SALINA YEGO	0732599714	MAINA	
23	Maugret Komen	073824938	Kapkuto	
24	Rose Shadrack	0735753107	metipsoo	
25	Susan Kimutai	0717826845	Metipsoo	
26	Grace Kiptoo	0738013612	maina	
27	ISMAEL K. BOWEN	0737223882	MAINA	
28	Willy K. Chepkwony	~~2059~~ 0701161957	Maina	
29	EDWIN K. KIPTOO	0733345459	Metipsoo	
30	Charles K. Chepkony	0787800200	Metipsoo	



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MAINA

KERIO VALLEY DEVELOPMENT AUTHORITY

ATTENDANCE LIST OF PARTICIPANTS AND STAKEHOLDERS

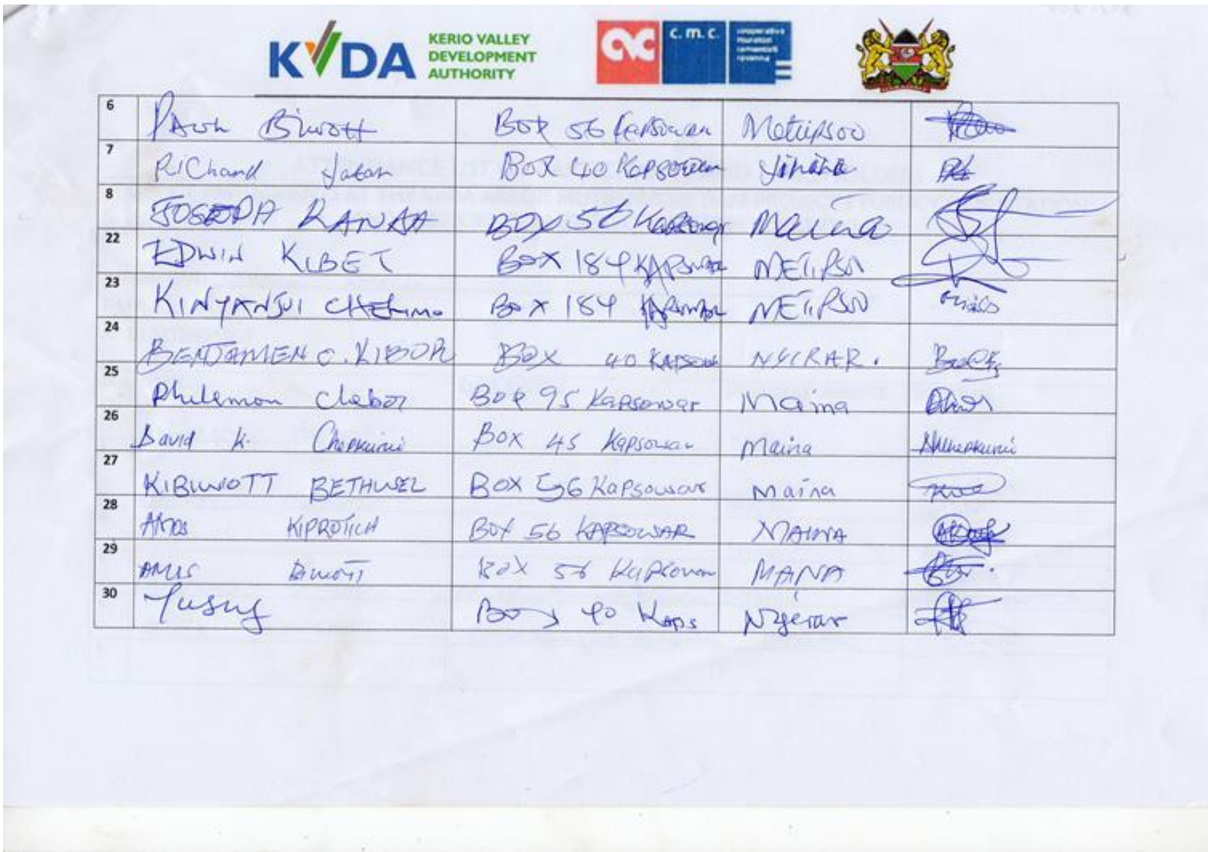
LIST OF PARTICIPANTS AT THE KVDA ARROR MUTIPURPOSE DAM PROJECT'S PUBLIC CONSULTATION AND PARTICIPATION (ELGEYO MARAKWET COUNTY).

ASSIGNMENT: Sharon Cheruiyot

DATE: 8/12/2016 Time: 4 : 40 PM

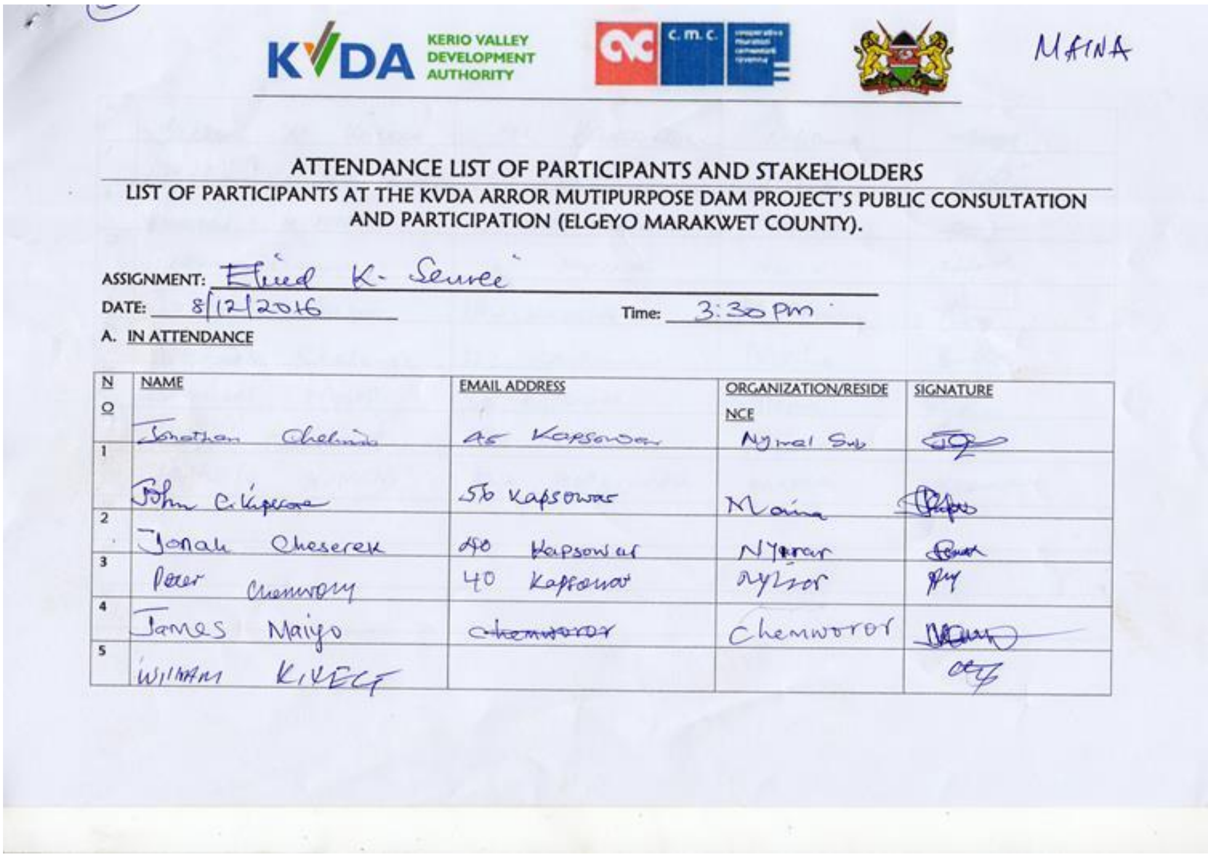
A. IN ATTENDANCE

NO	NAME	EMAIL ADDRESS	ORGANIZATION/RESIDENCE	SIGNATURE
1	PAUL K. ROTICH	—	KOBIL	
2	JULIUS K. SUTER	—	KOBIL	
3	TIMOO	–	Kipto	
4	Matthew Cherop	Matthewkemboi@gMall.Com	Maina	
5	HOSEA CHEBOI	HoseAKagat @gmail	Maina	



KERIO VALLEY DEVELOPMENT AUTHORITY

6	Paul Biwott	Box 56 Kapsowar	Motirsoo	
7	RIChard Jatan	Box 40 Kapsowar	Jiriana	
8	Joseph Ranam	Box 56 Kapsowar	Maina	
22	EDWIN KIBET	Box 184 KAPSOWAR	METIPSO	
23	KINYANJUI Chelimo	Box 184 Kapsowar	METIPSO	
24	BENJAMEN C. KIBOR	Box 40 KAPSOWAR	NYCRAR.	
25	Philemon Chebor	Box 95 Kapsowar	Maina	
26	David K. Chepkurui	Box 45 Kapsowar	Maina	
27	KIBIWOTT BETHWEL	Box 56 Kapsowar	Maina	
28	Amos KIPROTICH	Box 56 KAPSOWAR	MAINA	
29	Amos Biwott	Box 56 Kapsowar	MAINA	
30	Yusuf	Box 40 Kaps	Nyeiyar	



KERIO VALLEY DEVELOPMENT AUTHORITY

MAINA

ATTENDANCE LIST OF PARTICIPANTS AND STAKEHOLDERS

LIST OF PARTICIPANTS AT THE KVDA ARROR MUTIPURPOSE DAM PROJECT'S PUBLIC CONSULTATION AND PARTICIPATION (ELGEYO MARAKWET COUNTY).

ASSIGNMENT: Elied K- Seuree

DATE: 8/12/2016 Time: 3:30 pm

A. IN ATTENDANCE

NO	NAME	EMAIL ADDRESS	ORGANIZATION/RESIDENCE	SIGNATURE
1	Jonathan Chelimo	45 Kapsowar	Nyinal Sub	
2	John C. Kipcore	56 Kapsowar	Maina	
3	Jonah Cheserek	40 Kapsowar	Nyarar	
4	Peter Chemwory	40 Kapsowar	Nyisor	
5	James Maiyo	~~Chemworor~~	Chemworor	
	William Kiveg			

KERIO VALLEY DEVELOPMENT AUTHORITY

6	Jackson K. Kitum	40 Kapsowar	Nyiena	
7	Abraham Kemboi Chelagat	184 Kapsowar	Naltipsoo	
8	PHILEMON K. KITANA	56-30705 KAPSOWAR	MAINA	
22	Geoffrey Cheserek	56 Kapsowar	Maina	
23	John C. Chebor	184 Kapsowar	Metipsoo	
24	Daniel Chelangat	152, Kapsowar	Maina	
25	Samweas Masop	56 Kapsowar	Maina	
26	James Cheserek	184 Kapsowar	Nyirar	
27	KIPRUTO KOMEN	122 KAPSOWAR	maina	
28				
29				
30				

(10)

MAINA

KERIO VALLEY DEVELOPMENT AUTHORITY

c. m. c.

ATTENDANCE LIST OF PARTICIPANTS AND STAKEHOLDERS

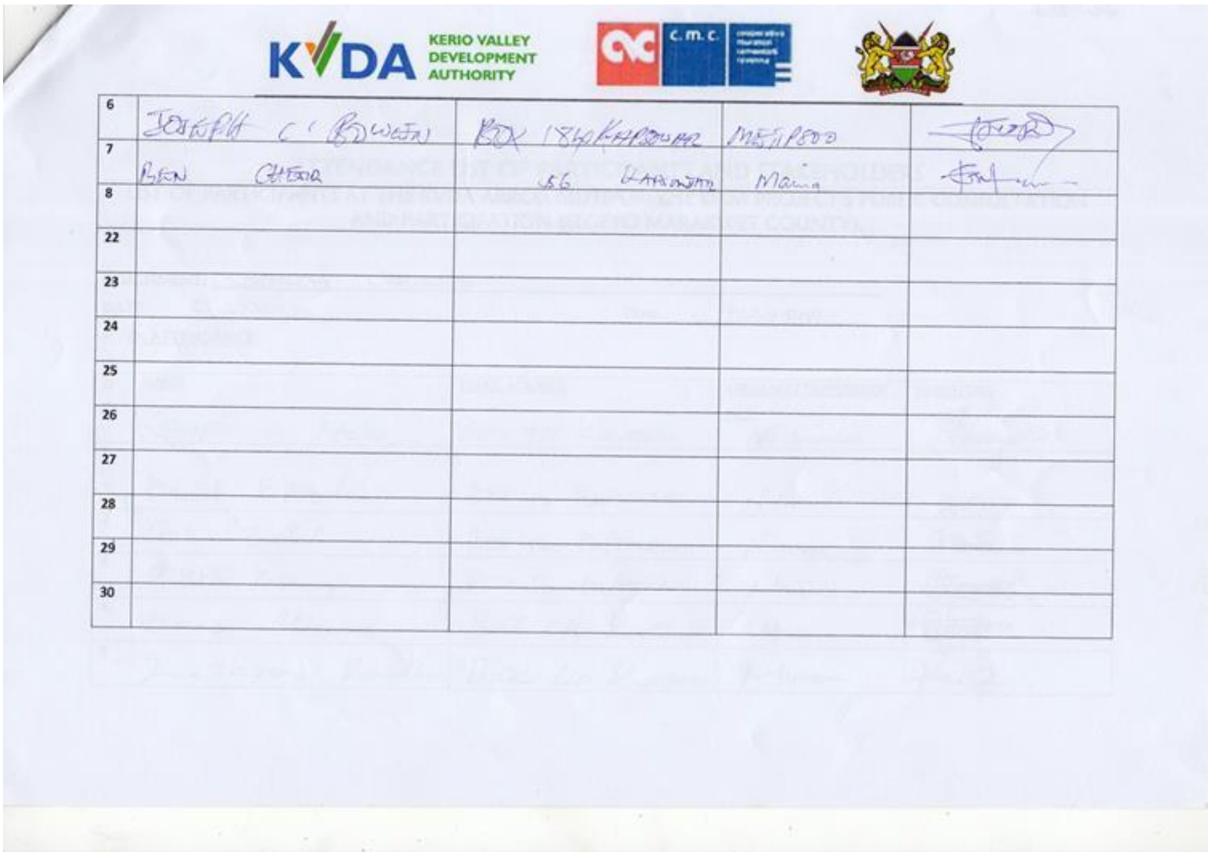
LIST OF PARTICIPANTS AT THE KVDA ARROR MUTIPURPOSE DAM PROJECT'S PUBLIC CONSULTATION AND PARTICIPATION (ELGEYO MARAKWET COUNTY).

ASSIGNMENT: SHARON CHERUIYOT

DATE: 8/12/2016. Time: 4:30 PM

A. IN ATTENDANCE

NO	NAME	EMAIL ADDRESS	ORGANIZATION/RESIDENCE	SIGNATURE
	Joseph C. Itok	Box 95 Kapsow	Maina	
1	David Kipendo	BOX 40 KAPSOWAR	Nyiwa	
2	John Torotich	Box 40 Kapsowar	Nyiwa	
3	Joseph Kisang	BOX 56 Kapsowar	Maina	
4	Evans Chelimo	Box 40 Kapsowa	Myiren	
5	Lazarus Koech	Box 40 Kapsowa	Myiren	



KERIO VALLEY DEVELOPMENT AUTHORITY

c.m.c.

6	JOSEPH C' BOWEN	BOX 1840 KAPSOWAR	MESIPE00	
7	BEN CHEBOR	56 KAPSOWAR	Maina	
8				
22				
23				
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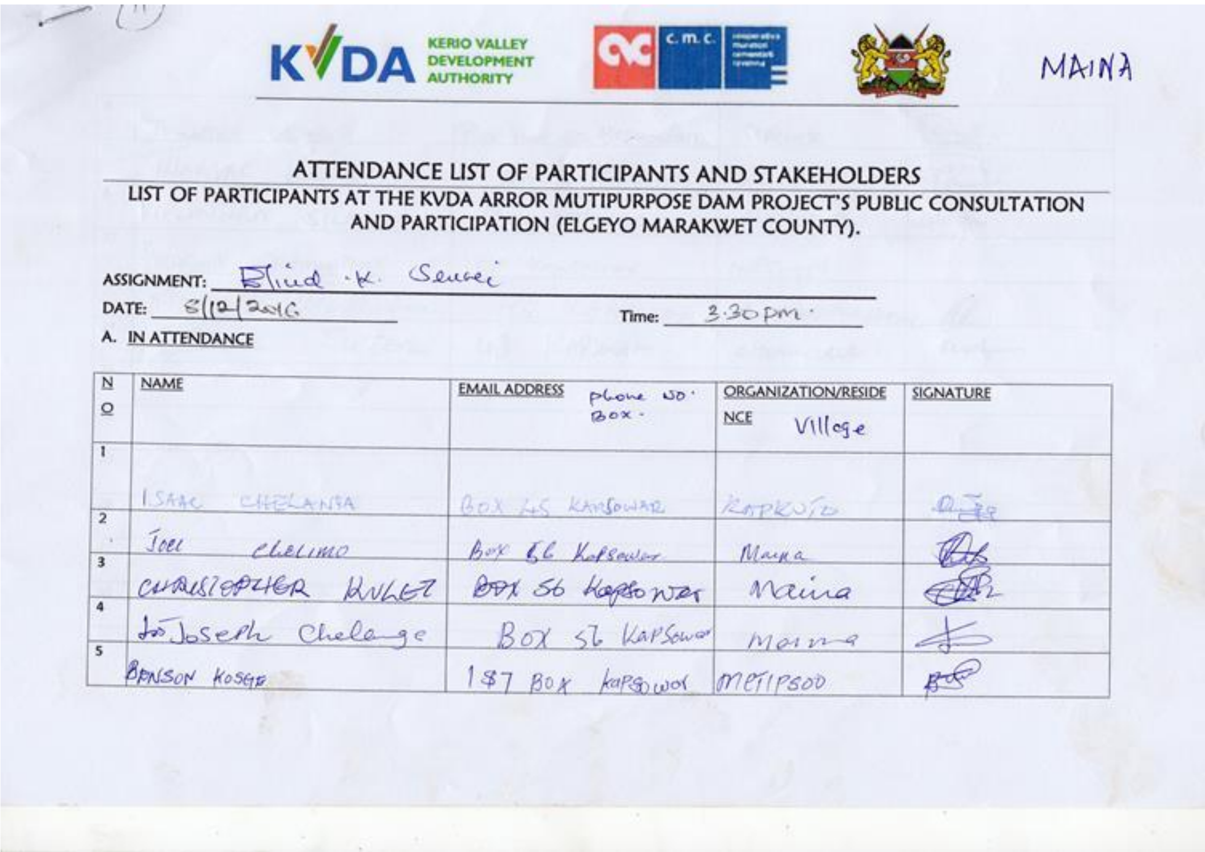

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MAINA

ATTENDANCE LIST OF PARTICIPANTS AND STAKEHOLDERS

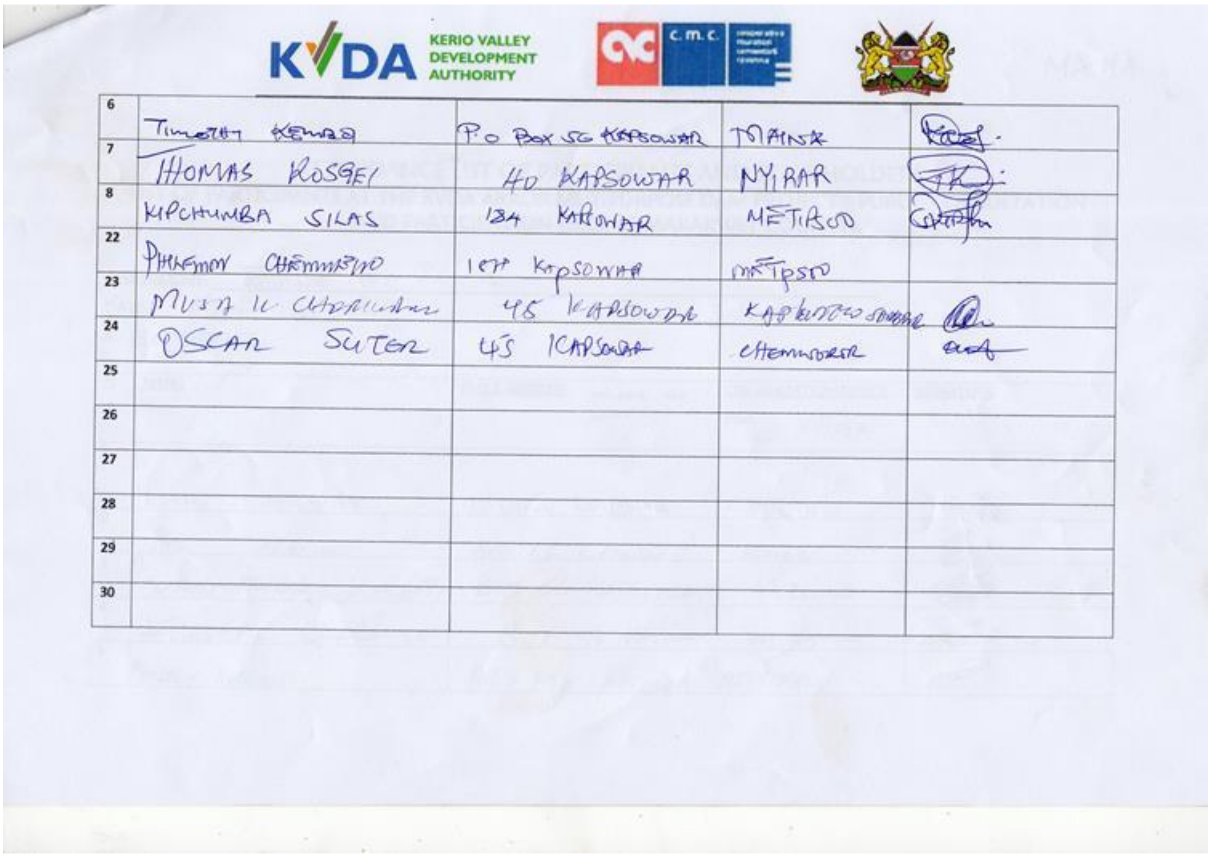
LIST OF PARTICIPANTS AT THE KVDA ARROR MUTIPURPOSE DAM PROJECT'S PUBLIC CONSULTATION AND PARTICIPATION (ELGEYO MARAKWET COUNTY).

ASSIGNMENT: Eliud ·K· Senei

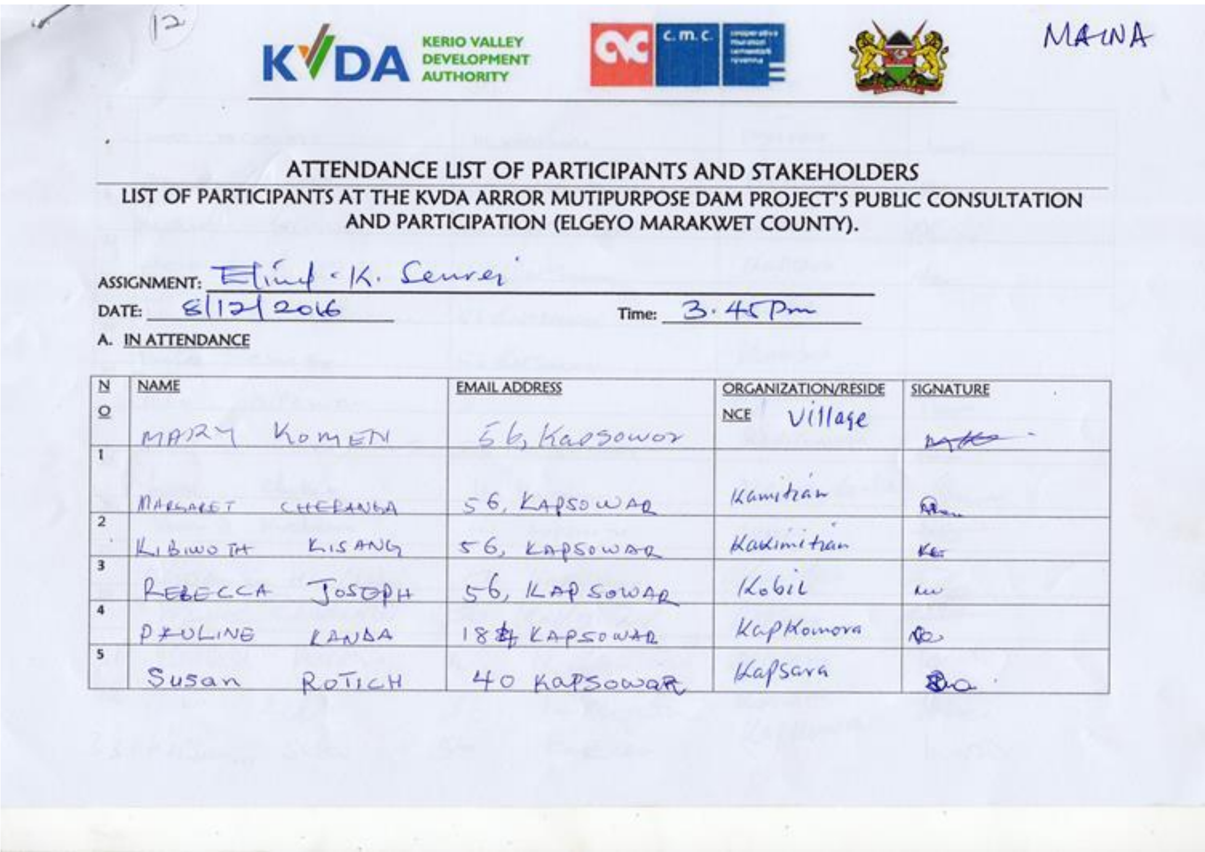
DATE: 8/12/2016 Time: 3.30 pm·

A. IN ATTENDANCE

NO	NAME	EMAIL ADDRESS phone no. Box.	ORGANIZATION/RESIDENCE Village	SIGNATURE
1	ISAAC CHELANGA	BOX 45 KAPSOWAR	KAPKWTO	
2	Joel Chelimo	Box 56 Kapsowar	Maina	
3	CHRISTOPHER KWLET	BOX 56 Kapsowar	Maina	
4	~~Jo~~ Joseph Chelange	Box 56 Kapsowar	Maina	
5	BENSON KOSGE	187 BOX kapsowar	METIPSOO	



6	Timothy Kemboi	P.O Box 56 Kapsowar	MAINA	
7	THOMAS KOSGEI	40 KAPSOWAR	NYIRAR	
8	KIPCHUMBA SILAS	184 KAPSOWAR	METIPSOO	
22	PHILEMON CHEMWENO	187 Kapsowar	METIPSOO	
23	MUSA K CHEMWOLAN	45 KAPSOWAR	KAPKWTO SAMBAE	
24	OSCAR SUTER	45 KAPSOWAR	CHEMWORER	
25				
26				
27				
28				
29				
30				



12

MAINA

KERIO VALLEY DEVELOPMENT AUTHORITY

c.m.c.

ATTENDANCE LIST OF PARTICIPANTS AND STAKEHOLDERS

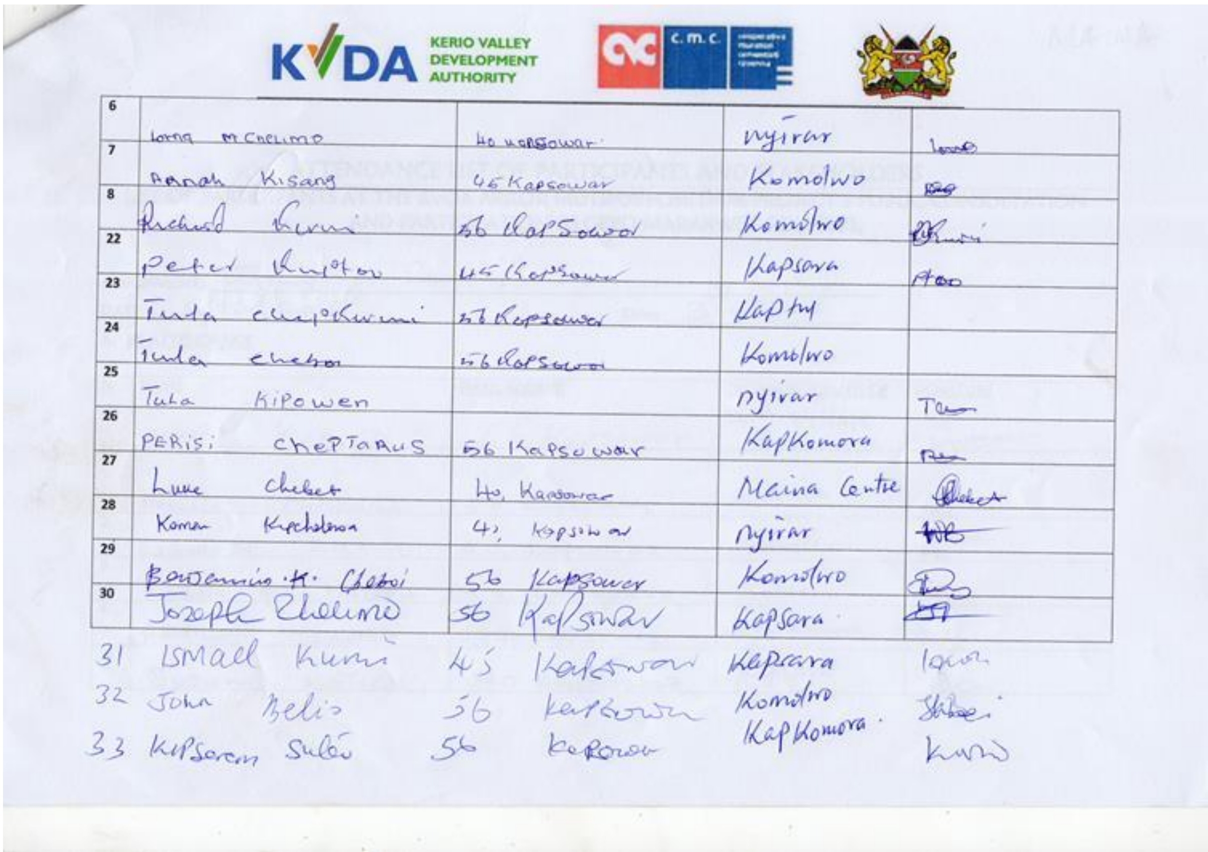
LIST OF PARTICIPANTS AT THE KVDA ARROR MUTIPURPOSE DAM PROJECT'S PUBLIC CONSULTATION AND PARTICIPATION (ELGEYO MARAKWET COUNTY).

ASSIGNMENT: Elind. K. Senrei

DATE: 8/12/2016 Time: 3.45Pm

A. IN ATTENDANCE

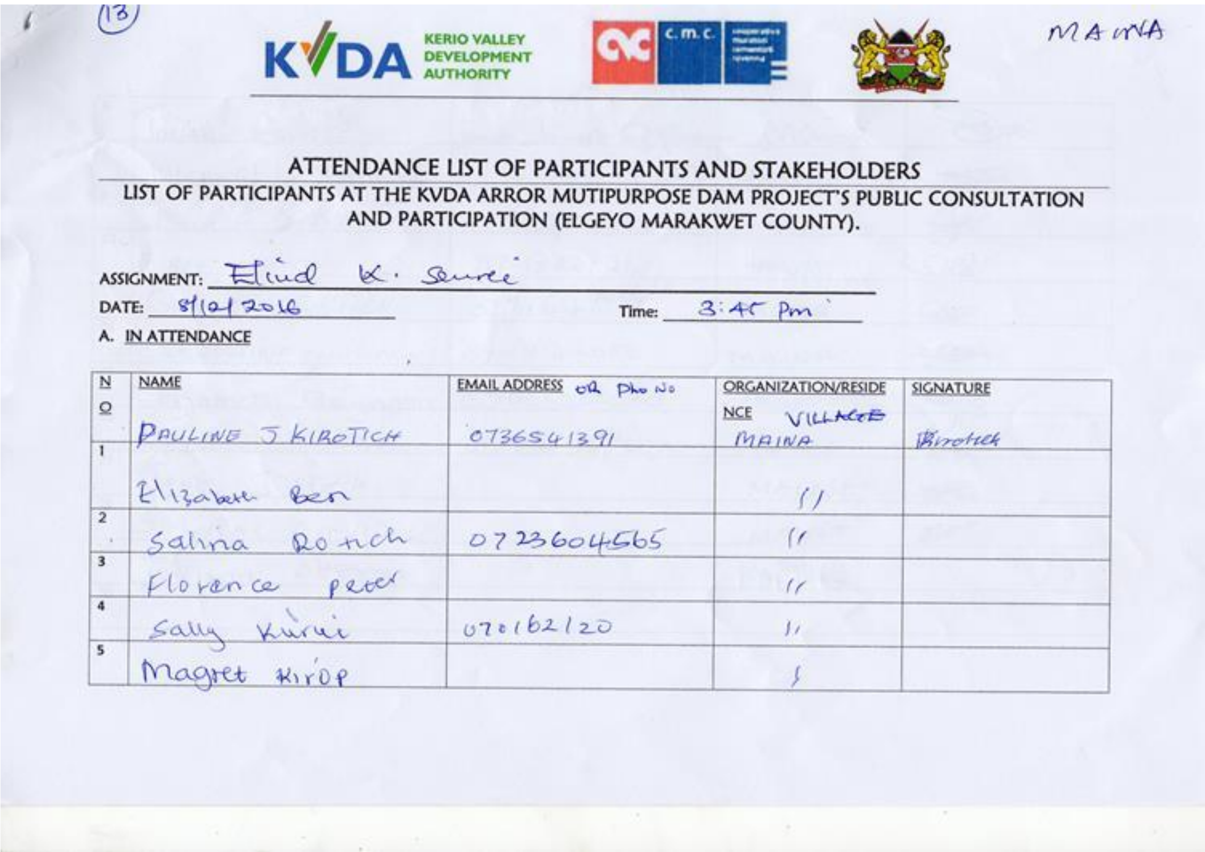
NO	NAME	EMAIL ADDRESS	ORGANIZATION/RESIDENCE	SIGNATURE
	MARY KOMEN	56, Kapsowor	Village	
1	MARGARET CHERANGA	56, KAPSOWAR	Kamitran	
2	KIBIWOTT KISANG	56, KAPSOWAR	Kakimitran	
3	REBECCA JOSEPH	56, KAPSOWAR	Kobil	
4	PAULINE KANDA	18, KAPSOWAR	Kapkomora	
5	Susan ROTICH	40 KAPSOWAR	Kapsara	



KERIO VALLEY DEVELOPMENT AUTHORITY

c.m.c.

6	Lorna M Chelimo	40 Kapsowar	Nyirar	
7	Annah Kisang	45 Kapsowar	Komolwo	
8	Richard Kurui	56 Kapsowar	Komolwo	
22	Peter Kiptoo	45 Kapsowar	Kapsara	
23	Tula Chepkurui	56 Kapsowar	Kaptuy	
24	Tula Chebon	56 Kapsowar	Komolwo	
25	Tula Kipowen		Nyirar	
26	PERIS: CHEPTARUS	56 Kapsowar	Kapkomora	
27	Luke Chebet	40, Kapsowar	Maina Centre	Chebet
28	Koman Kipchalwon	4, Kapsowar	Nyirar	
29	Benjamin K. Cheboi	56 Kapsowar	Komolwo	
30	Joseph Chelimo	56 Kapsowar	Kapsara	
31	ISMAEL Kurui	45 Kapsowar	Kapsara	
32	John Belis	56 Kapsowar	Komolwo	
33	Kipsorom Sulei	56 Kapsowar	Kapkomora	



(13)

MAINA

KVDA KERIO VALLEY DEVELOPMENT AUTHORITY

ATTENDANCE LIST OF PARTICIPANTS AND STAKEHOLDERS

LIST OF PARTICIPANTS AT THE KVDA ARROR MUTIPURPOSE DAM PROJECT'S PUBLIC CONSULTATION AND PARTICIPATION (ELGEYO MARAKWET COUNTY).

ASSIGNMENT: Eliud K. Senei

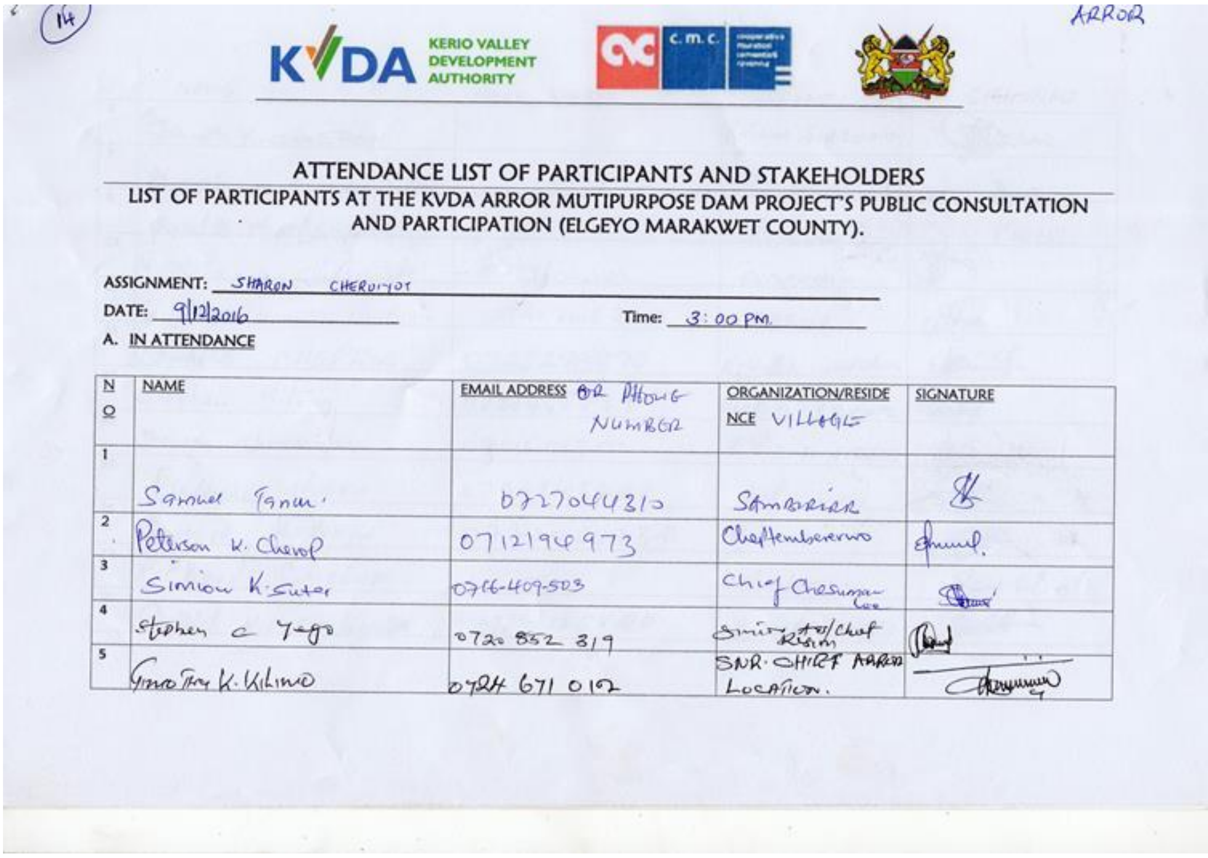
DATE: 8/12/2016 Time: 3:45 pm

A. IN ATTENDANCE

NO	NAME	EMAIL ADDRESS or Pho No	ORGANIZATION/RESIDENCE VILLAGE	SIGNATURE
	PAULINE J KIROTICH	0736541391	MAINA	Birotich
1	Elizabeth Ben		〃	
2	Salina Rotich	0723604565	〃	
3	Florence peter		〃	
4	Sally Kurui	070162120	〃	
5	Magret Kirop		〃	

KVDA KERIO VALLEY DEVELOPMENT AUTHORITY

6	JONAH BIWOTT	jonah_biwott@yahoo.com	Maina	
7	MICHAEL K. CHUMBA	0704674202	maina	
8	JUSTINE K. KIMUTAI	0724953656	//	
22	EUNICE KIMOI	0713221241	KAPKUTO	
23	GRACE ROTICH	0731649991	MAINA	
24	JOSEPHINA CHELIMO	070413 0032	MAINA	
25	Elizabeth Benjamin	0796542030	Kaptul	
26	SAMSON KONIBAI	0708150947	MAINA	
27	JANE JOSEPH		MAINA	
28	SALINA DAVID		MAINA	
29	JULIANA CHEBET		KAPTUL	
30				



(14)

ARROR

KERIO VALLEY DEVELOPMENT AUTHORITY

c.m.c.

ATTENDANCE LIST OF PARTICIPANTS AND STAKEHOLDERS

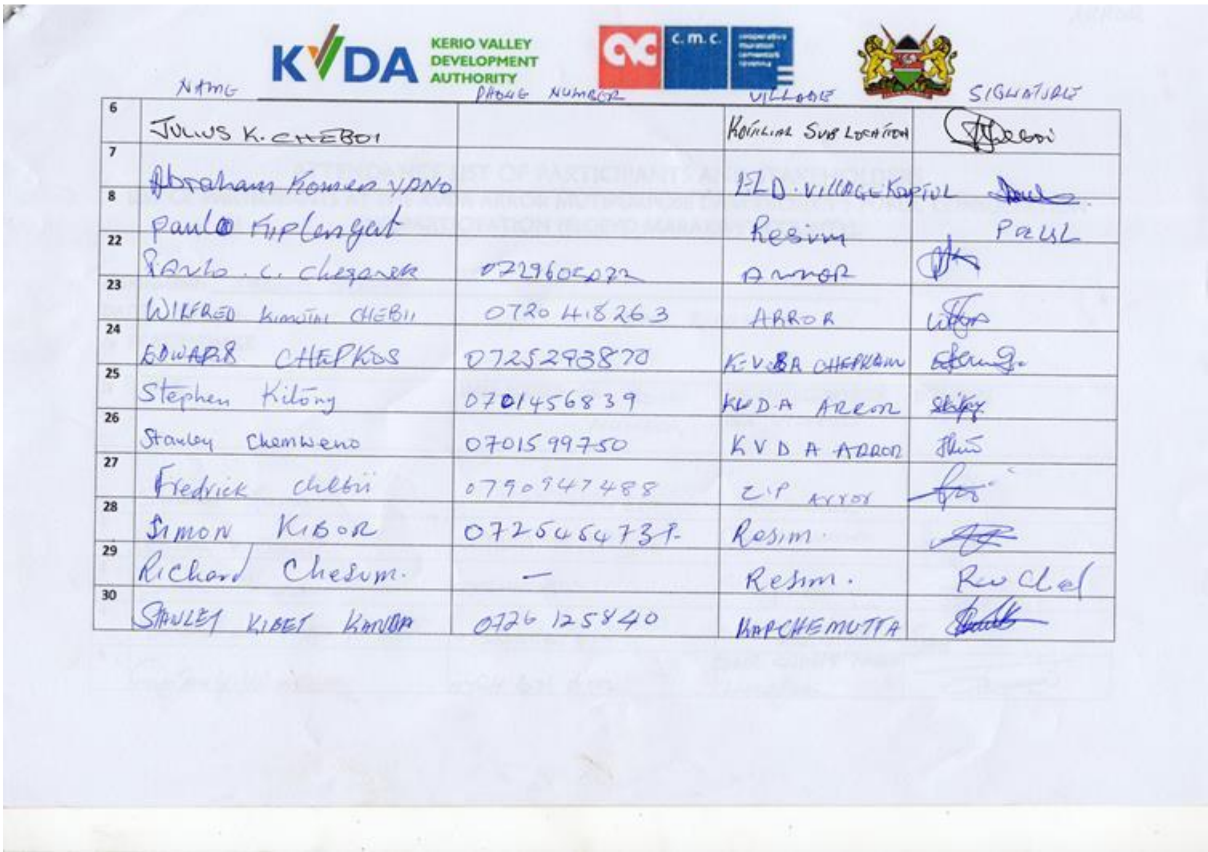
LIST OF PARTICIPANTS AT THE KVDA ARROR MUTIPURPOSE DAM PROJECT'S PUBLIC CONSULTATION AND PARTICIPATION (ELGEYO MARAKWET COUNTY).

ASSIGNMENT: SHARON CHERUIYOT

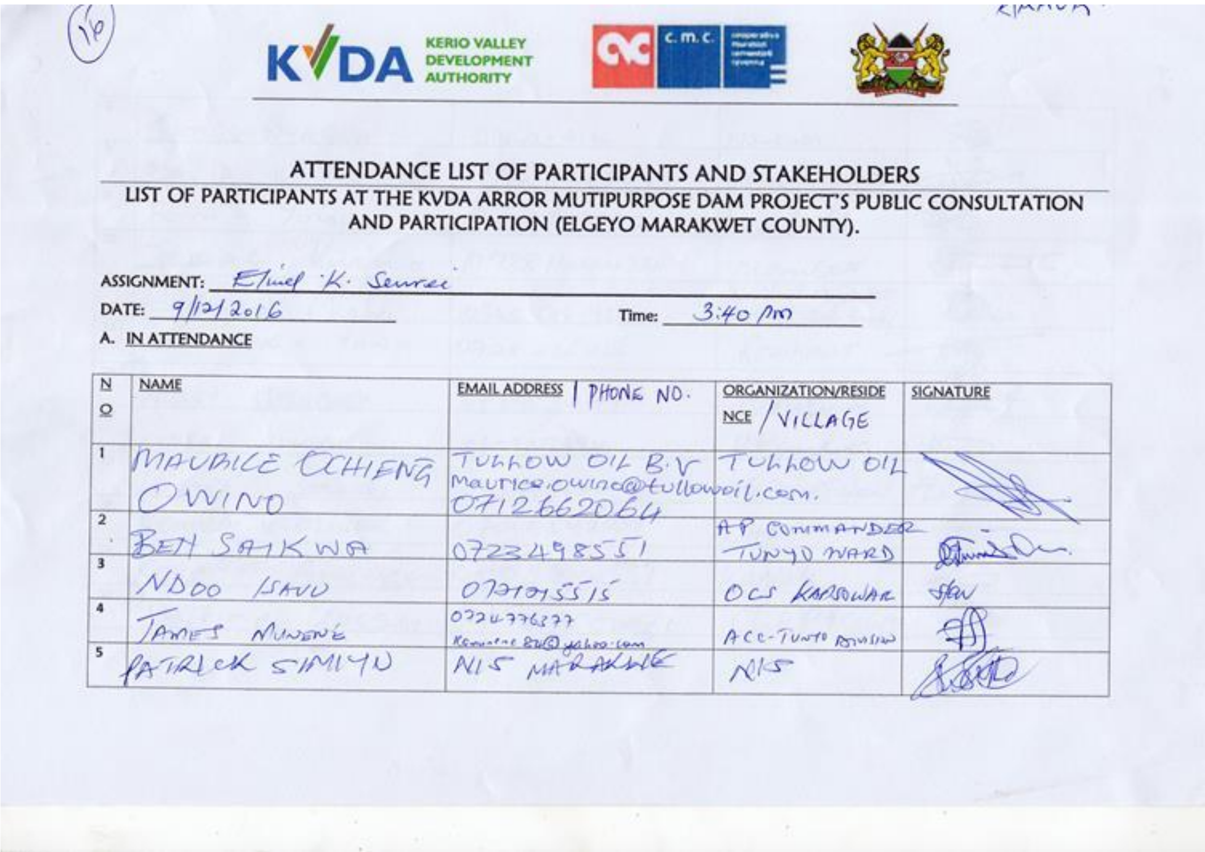
DATE: 9/12/2016 Time: 3:00 PM.

A. IN ATTENDANCE

NO	NAME	EMAIL ADDRESS OR PHONE NUMBER	ORGANIZATION/RESIDENCE VILLAGE	SIGNATURE
1	Samuel Tanui.	0727044310	Sambirir	
2	Peterson K. Cherop	0712194973	Cheptembererwo	
3	Simion K. Suter	0716-409-503	Chief Chesuman Loc	
4	Stephen C Yego	0720 852 319	Snior Ass/Chief Kisim	
5	Timothy K. Kilimo	0724 671 012	SNR. CHIEF ARROR LOCATION.	



	NAME	PHONE NUMBER	VILLAGE	SIGNATURE
6	JULIUS K. CHEBOI		Koitilial Sub Location	
7	Abraham Komen YANO		ELD. Village Kaptul	
8	Paulo Kiplangat		Resim	PaUL
22	Pavlo. C. Chegaren	0729605022	Arror	
23	WILFRED Kimutai CHEBII	0720 418263	ARROR	
24	EDWARD CHEPKOS	0725293870	K.V.D.A CHEPKAM	
25	Stephen Kilong	0701456839	KVDA ARROR	
26	Stanley Chemweno	0701599750	KVDA ARROR	
27	Fredrick Chebii	0790947488	CIP Arror	
28	SIMON KIBOR	0725464731	Resim.	
29	Richard Chesum.	—	Resim.	
30	STANLEY KIBET KANDA	0726 125840	KAPCHEMUTTA	



16

KERIO VALLEY DEVELOPMENT AUTHORITY

c. m. c.

ATTENDANCE LIST OF PARTICIPANTS AND STAKEHOLDERS

LIST OF PARTICIPANTS AT THE KVDA ARROR MUTIPURPOSE DAM PROJECT'S PUBLIC CONSULTATION AND PARTICIPATION (ELGEYO MARAKWET COUNTY).

ASSIGNMENT: Eliud K. Senrei

DATE: 9/12/2016 Time: 3:40 pm

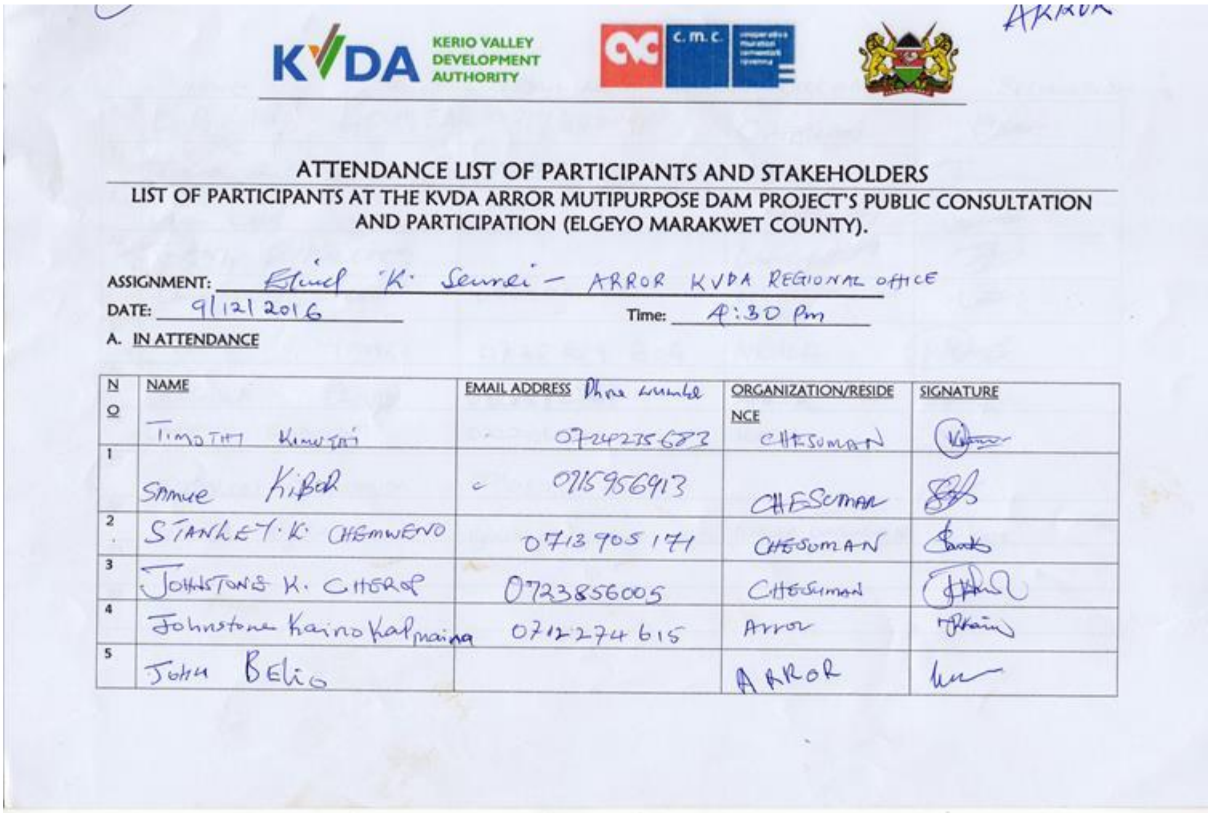
A. IN ATTENDANCE

NO	NAME	EMAIL ADDRESS / PHONE NO.	ORGANIZATION/RESIDENCE / VILLAGE	SIGNATURE
1	MAURICE OCHIENG OWINO	TULLOW OIL B.V maurice.owino@tullowoil.com. 0712662064	TULLOW OIL	
2	BEN SAIKWA	0723498551	AP COMMANDER TUNYO WARD	
3	NDOO ISAVU	0721015515	OCS KAPSOWAR	
4	JAMES MUNENE	0724776377 Kemunene84@yahoo.com	ACC-TUNYO DIVISION	
5	PATRICK SIMIYU	NIS MARAKWET	NIS	

KERIO VALLEY DEVELOPMENT AUTHORITY

c. m. c.

6	JAMES NYAKIYA	0720259146	D/SUBCOM	
7	DAVID K. ROTICH	0728845051	SOCIAL WORKER	
8	PETER K YEGO	0710953102	Resident	
22	Joseph Kaino	0738144424	member	
23	Erick K. Chebii	0725 531 958	Driver Marakwet West Sub County	
24	CHRISTOPHER.C. YANO	0728 235453	RESIDENT	
25	WISLEY CHESEREK	0710534472	Resident	
26	HOSEA BOWEN	0702251244	Resident	
27	LEONARD SERONEI	0713 498090	KAPCHEPTUREN	
28	KEMBOI K. OLIVER	0701654229	CHEPKUM	
29	KIPLAGAT BONIFACE	0705844551	Kapkata	
30	Justine Kosgei	0796955891	Cheppkum	



ARROR

KERIO VALLEY DEVELOPMENT AUTHORITY

c.m.c.

ATTENDANCE LIST OF PARTICIPANTS AND STAKEHOLDERS

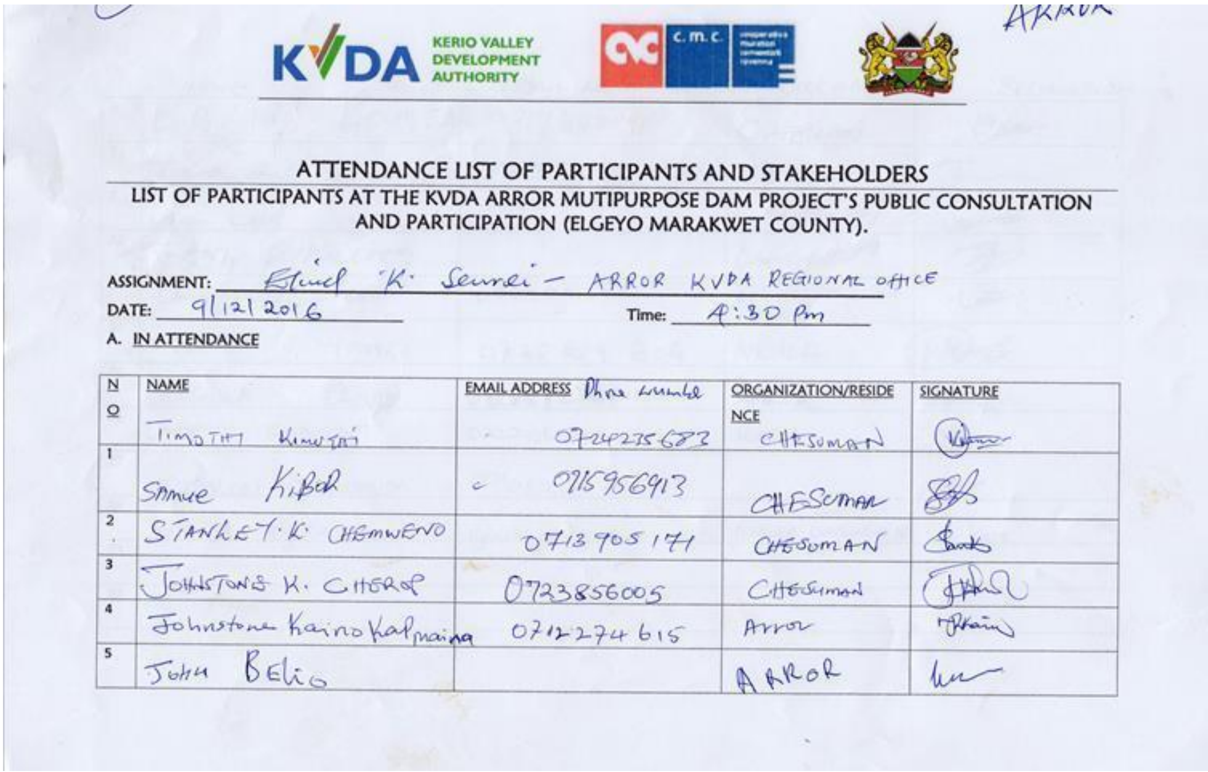
LIST OF PARTICIPANTS AT THE KVDA ARROR MUTIPURPOSE DAM PROJECT'S PUBLIC CONSULTATION AND PARTICIPATION (ELGEYO MARAKWET COUNTY).

ASSIGNMENT: Elkud K. Seurei – ARROR KVDA REGIONAL office

DATE: 9/12/2016 Time: 4:30 Pm

A. IN ATTENDANCE

NO	NAME	EMAIL ADDRESS Phone number	ORGANIZATION/RESIDENCE	SIGNATURE
	TIMOTHY KIMUTAI	0724235683	CHESUMAN	
1	Samue Kibor	0715956913	CHESUMAN	
2.	STANLEY. K. CHEMWENO	0713905171	CHESUMAN	
3	JOHNSTONE K. CHEROP	0723856005	CHESUMAN	
4	Johnstone Kaino Kalmaina	0712274615	Arror	
5	JOHN BELIO		ARROR	



ARROR

KERIO VALLEY DEVELOPMENT AUTHORITY

c.m.c.

ATTENDANCE LIST OF PARTICIPANTS AND STAKEHOLDERS

LIST OF PARTICIPANTS AT THE KVDA ARROR MUTIPURPOSE DAM PROJECT'S PUBLIC CONSULTATION AND PARTICIPATION (ELGEYO MARAKWET COUNTY).

ASSIGNMENT: Elkud K. Seurei – ARROR KVDA REGIONAL office

DATE: 9/12/2016 Time: 4:30 Pm

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NO	NAME	EMAIL ADDRESS Phone number	ORGANIZATION/RESIDENCE	SIGNATURE
	TIMOTHY KIMUTAI	0724235683	CHESUMAN	
1	Samue Kibor	0715956913	CHESUMAN	
2.	STANLEY. K. CHEMWENO	0713905171	CHESUMAN	
3	JOHNSTONE K. CHEROP	0723856005	CHESUMAN	
4	Johnstone Kaino Kalmaina	0712274615	Arror	
5	JOHN BELIO		ARROR	