EASTERN NILE IRRIGATION AND DRAINAGE STUDY/FEASIBILITY STUDY
DINGER BEREHA IRRIGATION PROJECT

# *ANNEX 10: ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT*

## *Table of contents*


SUMMARY .......... 5

1 INTRODUCTION .......... 10

**1.1 The Project** 10

**1.2 Importance of the project and the need for Environmental and Social Impact Assessment** 11

**1.3 Terms of Reference** 12

**1.4 Comments on the ToR** 13

1.4.1 Field Measurement and Analysis 13

**1.5 Methods** 13

1.5.1 General 13
1.5.2 Screening 14
1.5.3 Scoping 15
1.5.4 Baseline Data Collection 15
1.5.5 Impact Assessments 16
1.5.6 Mitigation Measures 18
1.5.7 Environmental and Social Impact Management Plan 18

**1.6 Environmental Categorization of the Project** 18

2 LEGISLATIVE AND INSTITUTIONAL FRAMEWORK .......... 20

**2.1 Legislation** 20

**2.2 ETHIOPIAN Environmental Institutions** 21

**2.3 EIA Legislation in ETHIOPIA** 21

**2.4 National Policies and International Conventions** 23

**2.5 ADB Environmental Assessment Procedures** 24

3 ENVIRONMENTAL BASE LINE CONDITIONS .......... 25

**3.1 THE PHYSICAL ENVIRONMENT** 25

3.1.1 Introduction 25
3.1.2 Topography 25

3.1.3 Geology 27
3.1.4 Climate 29
3.1.5 Agro-ecology and Land Use 30
3.1.6 Soil and Water Conservation 35
3.1.7 Soils 35
3.1.8 Water Resources 46
3.1.9 The Biotic Environment 50

**3.2 THE SOCIO-ECONOMIC ENVIRONMENT 51**

3.2.1 Population and Settlement 51
3.2.2 Experience in Irrigation 52
3.2.3 Gender Issues 54
3.2.4 Access to Other Services and Infrastructure 54
3.2.5 Environmental Health 55

4 PROJECT DESCRIPTION .......................................................... 56

**4.1 Introduction 56**

**4.2 Headworks 56**

**4.3 Access Road 57**

**4.4 Conveyance and Distribution 57**

**4.5 Operation of the project 57**

**4.6 Agronomic practice 58**

5 POTENTIAL IMPACTS .......................................................... 59

**5.1 Introduction 59**

**5.2 Impacts - External Factors 59**

5.2.1 Positive Impacts 59
5.2.2 Negative Impacts 60

**5.3 Impacts - Internal or Project generated 60**

5.3.1 Positive Impacts 60
5.3.2 Negative Impacts - Biophysical Aspects 61
5.3.3 Socio-Economic Impacts 65

**5.4 Downstream Impacts and Transboundary Effects 67**

**5.5 Discussion on impacts of 'With' and 'without the project' 68**

6 ENHANCEMENT AND MITIGATION MEASURES .................................. 71

**6.1 Introduction 71**

7 ENVIRONMENTAL MANAGEMENT PLAN ........................................ 78

**7.1 General 78**

**7.2 System Management Interventions 79**

**7.3 Irrigation and agronomic practices Interventions 79**

**7.4 Specific 80**

7.4.1 Introduction 80

7.4.2 Design Phase 80
7.4.3 Construction Phase 80
7.4.4 Operation Phase 80

8 ENVIRONMENTAL MONITORING PLAN .......................................... 81

8.1 General Considerations 81

8.2 Specific 81
8.2.1 Introduction 81
8.2.2 Design Phase 82
8.2.3 Construction Phase 82
8.2.4 Operation Phase 83

8.3 Environmental and Social Management Unit (ESMU) Costs 88

BIBLIOGRAPHY AND REFERENCES ................................................................ 90

## List of Tables

1 Checklist for Screening of Environmental Impacts 17
2 Landforms and Land Use at Dinger Bereha 28
3 Mean Monthly Rainfall (mm) 29
4 Chewaka Land use 33
5 Land Use / Land Cover in Dinger Bereha Project Area 33
6 Soil Units and their extent 38
7 Summary of Physical and Chemical Properties of Dinger Bereha Soils 40
8 Summary of Morphological Properties of the Soils of Study Area 41
9 Identified soil types and area coverage 42
10 Land Suitability Limiting Factors 42
11 Suitability class limits for irrigated agriculture at Dinger Bereha 43
12 Suitability of Soil Units for Irrigation 44
13 Area Measurements and Suitability Class, Soil Map Units in LUT 45
14 Summary of Totals by Land Suitability Class 45
15 Monthly dependable flows (MCM) at the weir site 46
16 Water quality results for sites on the Didessa River 47
17 Water quality data of three wells in Dinger Bereha area 48
18 Comparison of water quality data: 3 wells in Dinger Bereha with WHO, European, Ethiopian Standard 49
19 Summary of EC and SAR values for the three wells in Dinger Bereha 49
20 Principal Trees in Dinger Bereha Project Area 50
21 Households in Chewaka Wereda (2009) 53
22 Area of Land Planted with Crops 58
23 Completed ICID Checklist of Impacts 70
24 Summary of Enhancement Measures for Potential Positive (Beneficial) Impacts 72
25 Summary of Mitigation Measures for Potential Negative/Adverse Impacts 73

## List of Figures

1 Location of the Study Area 10
2 Topography 26
3 Slopes 27
4 Trend Analysis of Annual Rainfall at Didessa Station 30
5 Land Use in Dinger Bereha 34
6 Soil Map of Dinger Bereha 39

## List of Appendices


| | | |
|---|---|---|
| Appendix 1A: | List of Contacted Persons | 92 |
| Appendix 1B: | Summary of Discussions with Stakeholders | 94 |
| Appendix 2: | Photographs | 97 |


## Plate Captions (Appendix 2)


| | |
|---|---|
| Plate 1 | Hippopotamus trail and riverine forest, upstream of weir site |
| Plate 2 | Watershed area upslope of Dinger Bereha command. These lands are burnt at end of dry season to allow new grass to emerge, or planted for sorghum. |
| Plate 3 | Gallery forest within Dinger Bereha command area |
| Plate 4 | Grassland of seasonal wetland on Vertisol clays suitable for rice cultivation. These lands are currently grazed and largely dry out by end of dry season. |
| Plate 5 | New bridge under construction on the Didessa River. Will provide much needed link to project area from main road and markets. |
| Plate 6 | Gallery Forest on upper slopes of the catchment. The stream lines on steep slopes have a gallery forest that is usually related to spring lines on the escarpment. |
| Plate 7 | Rudimentary soil and water conservation (SWC) measures on erodible rainfed soils |
| Plate 8 | Eroded lands on edge of gallery forest (behind photographer) |

# SUMMARY

The methods used in the environmental and social impact assessment (ESIA) of the DBIP follow the procedure given in the ToR: namely that the study will make reference to EIA guidelines of the ADB, the World Bank, and Ethiopia. These have been followed.

Prior to the start of the assessment no indication was given of the category of the project. The study has concluded though that the project can be placed as a Category 'A' Project, for which an Environmental and Social Impact Assessment (ESIA) study is required (World Bank EA Sourcebook Update Number 2, 1993).

Base line assessments included using the data collected by the detailed soil survey, and socioeconomic situation in the area. As time allocated for this assessment was limited to a month for an Ethiopian environmentalist and three weeks for an international it was not possible to make detailed assessments of several issues: fauna and flora; archaeological surveys; and the origins and importance of the indigenous Gumuz riverine peoples. These are important issues that will need to be followed up at the start of the detailed design for this proposed project.

While in the field, all relevant institutions at Kebele and Wereda level were visited for data acquisition and discussion purposes. Interviews and discussions with key informants were also made. However, it is worth mentioning here that there is a general lack of organized and well documented data and information at the Woreda office, and less so in the Kebeles/Tabias.

The ESIA has utilised the findings from the land tenure, socio-economic, livestock, soils and land use and topographical baseline surveys.

The Dinger Bereha Irrigation Project would involve large-scale engineering works starting from the abstraction of the required water from the Didessa River by the construction of a mass concrete weir, and relatively long feeder canal (19km) and even lengthy primary and secondary canals.

Whilst positive impacts are indeed likely from the project, it is also probable that negative impacts will occur to the ecology and biodiversity of these ecosystems and to the livelihoods of existing inhabitants; mitigation to minimize such disruptions would need to be put in place. Negative impacts are likely from this proposed development. These include:

- Losses to the existing riverine and gallery forests along the side of the Didessa and other watershed streams that drain the proposed command area, will impact on groundwater availability and biodiversity.

- Seasonal movements of wildlife within to and from a proposed wildlife reserve could be disrupted by canals acting as barriers and other activities related to the development and running of the project.

- The soils are highly erodible under existing rain fed conditions and further deterioration will be likely if appropriate soil and water conservation (SWC) measures are not put in place throughout the project area at an early date.

- There is serious concern that the livelihoods and life style of the indigenous riverine Gumuz people, who live along the right bank of the Didessa River and probably elsewhere, might be disturbed as the result of the activities related to the construction and maintenance of the weir and feeder canal: a detailed socio-anthropological study of the Gumuz is recommended.

The main positive impacts are likely to include:

- Creation of reservoirs and other permanent movement of fresh water in the form of the different canals, which add water to areas where there was none or little before, can create better microclimate in addition to the provision of water that can be utilized for different purposes;
- Creation of opportunities for having recreation areas using the reservoirs that come as part of the irrigation scheme;
- Relatively better vegetation cover on both the command and the hinterland which in turn is responsible for the rich biodiversity can be an asset if properly managed;
- Creation of wet condition on the land surface of the command area which can lower wind and water erosion;
- Increase in agricultural yields and production, generating additional revenues directly from the project output;
- Increased and diversified food supply all year long fulfilling basic local needs and Improvement in quality of life due to new economic opportunities;
- Increase in local development and employment;
- Increase in revenues for the local population due to induced development and complementary activities;
- The possibility of improving the wellbeing of women again due to induced development and complementary activities as well as development of appropriate skills and knowledge;
- Increased income and improved nutrition from irrigated agriculture will benefit women and children in particular;
- A possibility of development of appropriate skills and knowledge;
- Increased opportunities for high value crop productions with access to irrigated water and appropriate irrigation technology;
- Improvement of existing traditional agriculture and skills;
- Increase in land values and price due to irrigation water.

The likely mitigation of impacts that are expected will depend first on acquiring a full understanding of environmental conditions of the project area. Important too will be application of the legal, institutional and policy framework. The suitability of the proposed irrigation scheme and the technological option adopted will require training for local stakeholders in this type of irrigation, SWC measures, and an understanding of watershed management.

Mitigation will be part of an environmental management plan for the Dinger Bereha area. At present this covers the project area but ideally should cover the entire watershed. The basic principles of an environmental management plan are numerous and include that there is an informed decision-making process; that there is accountability of data; that decisions and the approach are participatory; and there are consultations with the public and stakeholders of the development plan. The plan should have considered other alternatives and will aim to mitigate the negative impacts, and enhance the positive ones. At all stages of planning and implementation it will comply with national guidelines and regulatory procedures.

The Environmental management plan should ensure that mitigating measures are implemented, and that monitoring requirements are maintained by the organizations assigned to implement them. The study recommends the organisations that should do this work.

The main objective of any Environmental Management is: to find the best way to implement the project: minimize as much as possible or eliminate negative impacts; enhance benefits; and protect public and individual rights by compensation. Essentially it is an all-embracing land use plan for the area.

As part of an environmental management plan that will be implemented by the Chaweka Wereda staff of the project, it will be essential to initiate a programme of environmental monitoring. The monitoring will commence at start of implementation of the proposed mitigation measures, and may also lead to identification of possibly unforeseen environmental impacts of the project.

It is proposed that an Environmental and Social Management Unit (ESMU) would be established as part of the project's construction supervision office/Project Management Unit. It is recommended that there should be three staff: one land and vegetation specialist; one aquatic biologist; and one social environmentalist professional working in this unit. These would draw on additional specialist staff from Government agencies and also the staff at Chewaka Wereda.

The permanent staff should be recent graduates, but with MSc in these fields, and good experienced in environmental impact assessment and mitigation. They should be willing to devote several years to this project. The ADB could provide additional advanced specialised training and / or short courses in Ethiopia or overseas, for the selected staff.

Environmental monitoring is an essential tool in relation to environmental management as it provides the basis for rational management decisions regarding impact control. The monitoring programme for the present project will be undertaken to meet the following objectives:

- To check on whether mitigation and benefit enhancement measures have actually been adopted, and are proving effective in practice

- To provide a means whereby any impacts which were subject to uncertainty at the time of preparation of the EIA, or which were unforeseen, can be identified, and to provide a basis for formulating appropriate additional impact control measures

- To provide information on the actual nature and extent of key impacts and the effectiveness of mitigation and benefit enhancement measures which, through a feedback mechanism, can improve the planning and execution of future, similar projects.

The overall responsibility for monitoring will mainly be the responsibility of the Regional Water, Agriculture & Rural Development, Health Bureaux, and other pertinent institutions at Zonal and Wereda level as specified for the responsibility for mitigation. It has to be supported by Federal, Regional Zonal as well as Wereda and Kebele institutions with responsibilities as specified in the institutional and legal framework and the recommendations given by the Institutional Study conducted as part of the project. Post-construction phase monitoring will be concerned with identification of the need for routine checking and rectification as required.

For this particular project the proposed environmental and social monitoring indicators, are indicated below.

- Climate (wind, temperature, rainfall, etc.) – a digital climate station is required;
- Stream discharge above the irrigation project and below at various point;
- Nutrient content of discharge water;
- Flow and water levels at critical points in the irrigation system;
- Water table elevations in project area and downstream;
- Water quality of project inflows and return flows;

- Quality of groundwater in project area;
- Physical and chemical properties of soil in irrigation area, erosion data
- Agricultural acreage in production cropping intensity and yields
- Relation between water demand and supply of users (equability of distribution);
- Condition of distribution and drainage canals (siltation, presence of weeds, condition of linings);
- Upstream watershed management (agricultural extent and practices, industrial activity);
- Incidence of disease and presence of disease vectors;
- Health condition of project populations;
- Changes in natural vegetation in the project area especially in the river banks and adjacent slopes of mountains
- Changes in wildlife populations and fish population and species in the project area.

MONITORING COSTS

An Environmental and Social Management Unit (ESMU) would be established as part of the project's construction supervision office/Project Management Unit. It is recommended that there should be three staff: one land and vegetation specialist; one aquatic biologist; and one social environmentalist professional working in this unit, with individual staff cost of USD 8,000 /month. Additional specialists might have to be called in, for example, pesticide management, range management and livestock husbandry: these should be available in line agencies in Oromia State.

Good technical staff, most of whom are graduates and some in natural resources management, are employed at Chewaka Wereda. The permanent staff of the monitoring unit should be, also, should be recent graduates, but with MSc in these fields, and good experienced in environmental impact assessment and mitigation. They should be willing to devote several years to this project. The ADB could provide additional advanced specialised training and / or short courses in Ethiopia or overseas, for the selected staff.

Staff could use the same office locality as the project implementation supervision staff, but must be seen also to be independent and supporting the overall aims of the project to assist the local peoples. They will though have direct link to the resident engineer and will be key participants in all decisions on the construction where mitigation is involved. Realistic costs estimates for the identified mitigation measures are difficult to give at the current stage of planning. This is due to a limited degree of planning, at which the detailed scopes and quantities for mitigation measures have not been identified yet. For these issues, the cost estimates can be updated on a more profound basis during the tender design phase.

Recurrent costs/environmental monitoring during construction and first five years of implementation:

• 20,000 USD / year for bio-physical (soil, vegetation ecosystem) environmental monitoring at weir and pump sites, along the canals, gallery forests, and in wetlands. In addition we would cost for a set of monitoring meters (1: Electrical Conductivity + pH + TDS) for setting up in a small laboratory equipped with bench. Ideally samples are collected din the field and brought to the laboratory. A key acquisition would be for an automatic full climate station for Illu Harer with data logger and laptop - data would be linked to National reporting network). Additional Costs: (1. €1000 for robust instrument and associated glassware equipment; (2: A 50m dipmeter for measuring water table depth is useful. Cost €300 euro; (3. Furniture and start up consumables for the laboratory. Cost €1000 euro; (4. Annual consumable costs of €500, including purchase of distilled water from laboratory in Addis Ababa, and replacement glassware etc. (5. Automatic climate station: Cost €45,000 euro. Total additional cost estimate €47,800 euro equivalent to US$60,763.

• 20,000 USD / year (settlements, health, water) year for monitoring of social issues. These includes transport into the site, laboratory testing for water related diseases in the Didessa and wetland areas, and from hand pumps. No analysis of water for biological test would be made on site, but arrangements to take these to reputable laboratory in Addis Ababa or elsewhere, within normal time-frame allowed between sampling and analysis, needs to be resolved during detailed design. Additional Costs: Allow a further €2000 / year for this. Water quality testing once a month from about 5 selected locations. It may be advisable to acquire a water testing kit (eg Hach or similar) for use at Illu Harer. Cost: allow for €1,000 euro. Total additional cost estimate amounts to € 3,000 euro, equivalent to about US$3,815.

• 10,000 USD / year for public information and meetings in the kebele villages. A permanent display should be set up in Ilullu Harar to advertise the progress of the project.

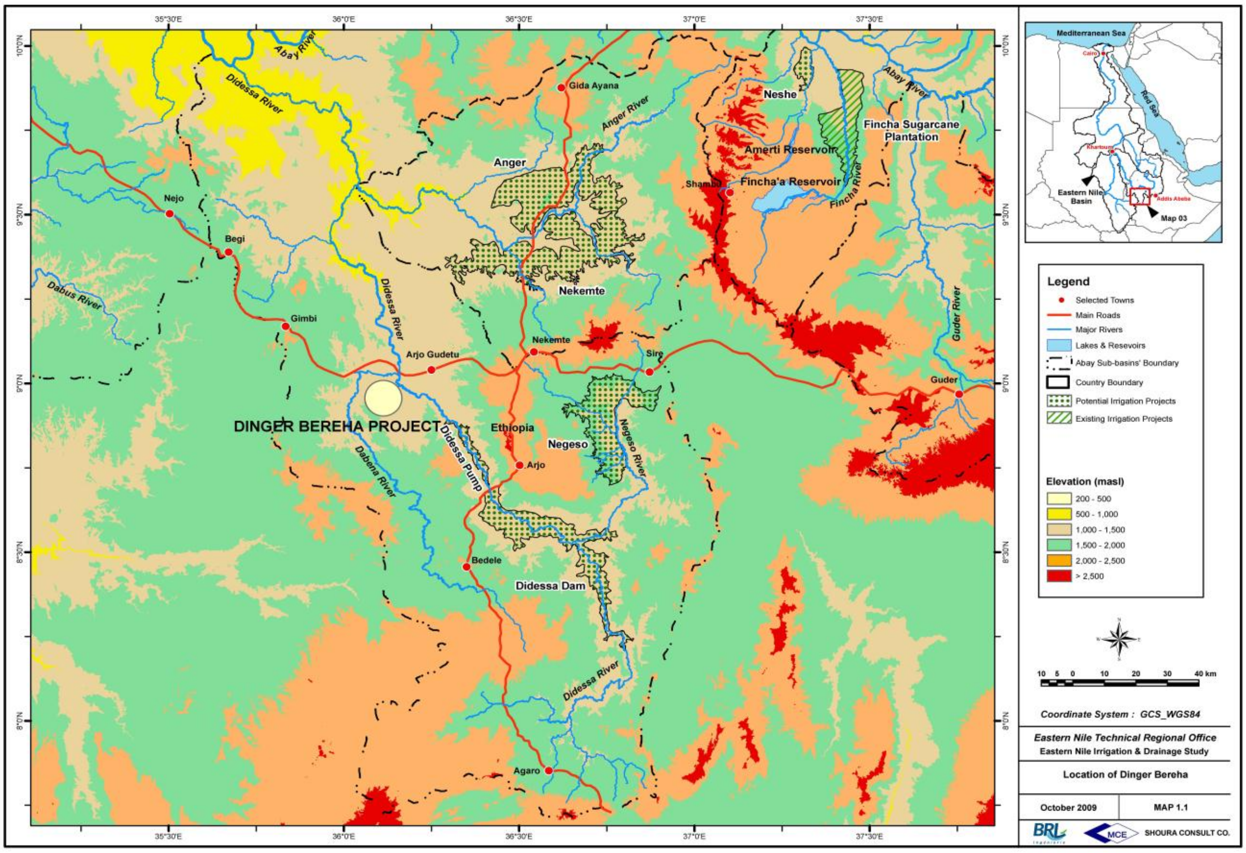
Annual auditing of the ESMU and its output will be essential to demonstrate that the EMP is proceeding as desired. This audit should be made by an independent body selected by Oromia state EPA. In turn the ESMU will report regularly to the wereda, Oromia state EPA agency on progress in its work so that any shortcomings in the design and problems with stakeholders can be identified at an early stage and attempts made to resolve issues.

# 1 INTRODUCTION

## 1.1 THE PROJECT

The proposed Dinger Bereha Irrigation Project is located in the Chewaka Wereda of Illubabor zone in Oromia National Regional State at a distance of about 560 km to West of Addis Ababa (Figure 1, and also refer to Volume Maps, Map LO01 and Volume Drawings, Drawing No. LO01). It is bounded on the east and north by the Didessa and Dabena rivers, and is located upstream of their confluence. Since December 2004, a resettlement programme has already been implemented in the Project area by the Government of Ethiopia. People from Eastern and Western Hararge were resettled in the area under a programme designed to alleviate loss of livelihoods in Hararge due to drought. The number of households resettled when the programme started was estimated at 12,390, whereas the current number of household is some 14,026, with a total population stated to be 78,179 (2004) and 92,027 (now) respectively. These figures came from the 2008 self-wereda population census for the latest size of the population in the wereda.

*Figure 1: Location of the Study Area*



Currently, rainfed agriculture is the mainstay of the economy of the wereda. The people resettled in the area have started producing different types of agricultural crops under rainfed and traditional irrigation during the rainy and dry seasons respectively. Livestock rearing, particularly fattening of bulls and keeping of goats is also part of the agricultural activities that has enabled the settlers to run a mixed farming system. Farm sizes vary from 1.5-2 ha, depending on the size of the family. Such farm sizes are considered to be small and it is highly likely that in the near future intensification and cultivation of cash crops through irrigation during the dry season is required to prevent poverty.

The cardinal objective of the Feasibility Study (FS) for Dinger Bereha Irrigation Project (DBIP) study is to increase crop yields and improve the living standards of the people in the Project area. The objective is planned to be achieved by diverting water from Didessa River, a principal tributary of the Blue Nile, by the construction of a concrete weir upstream of the proposed command area. The study identified a gross command area of about 10,000 ha extending in 6 Kebeles of the Woreda which, for most of its part, is dominated by an undulating terrain incised by streams that add their water to the Didessa River. A net irrigable area of 7,852 ha below contour +1260 is expected to come under the irrigation scheme.

## 1.2 Importance of the project and the need for Environmental and social impact Assessment

The principal purpose of an irrigation project is to increase agricultural food production, usually in an area where rainfed cropping is difficult or impossible as rainfall is deficient, insufficient or irregular, and there is a high risk of crop failure. In the case of Dinger Bereha, though relatively speaking the area is not very much deficient for seasonal crop production, the irregularity of the rainfall and the need for the intensification and expansion of crop production to significantly increase crop yields and improve the living standards of the people in the project area creates the need for the development of irrigated agriculture. The delivery of water to lands previously water-short areas improves human settlement and livestock. Other positive environmental and social impacts resulting from irrigation development include the elevation of farm outputs and higher farm incomes; creation of employment possibilities on the farm, and other infrastructural activities.

However, economic, social and environmental change is inherent to development. Irrigation and drainage projects invariably result in many far-reaching ecological changes. Some benefit human population, while others threaten the long-term productivity of the irrigation and drainage projects themselves as well as the natural resource base. The undesirable changes are not solely restricted to increasing pollution or loss of habitat for native plants and animals; they cover the entire range of environmental components, such as soil, water, energy, and the socio-economic system.

Water abstraction from rivers and agrochemical or industrial waste laden polluted return flows can cause further impacts on water users, biota and habitats, and there are threats also to near surface or deep aquifers, that may be extracted at locations remote from the project. Disease vectors can be enhanced by irrigation infrastructure.

The key tasks of the environmental and social impact assessment studies are, therefore, to assess any potential positive and negative impacts that may arise from the implementation of the Project in a manner that facilitates the comparison between available project alternatives. These involve screening and scoping of impacts, the identification of mitigation measures, and proposals for environmental management.

The ESIA describes the biophysical and social environments of the study area, and relates identified environmental impacts with proposed mitigation measures, where these are necessary, so as to ensure that the project proposals and design plans are compliant, and in accord, with the ADB and The Government of Ethiopia's environmental assessment guidelines, procedures and requirements.

Hence, the function of the ESIA is to analyse all these issues, to identify the associated risks and opportunities, and to point out ways in which negative impacts can be avoided or mitigated, and positive ones can be enhanced.

## 1.3 Terms of Reference

The Terms of Reference for the Environmental and Social Impact Assessment of the Study were given in the ENIDS contract between BRL and ENTRO, and stated that:

"Irrigation and drainage schemes, whether large or small-scale, are likely to generate impacts that can have significant effects on the immediate and off-site environments, and these may range from soil erosion and sedimentation, to an increase in the prevalence of vector-borne diseases, especially malaria, guinea worm. The Consultant will undertake an environmental impact assessment, in line with guidelines of the African Development Bank.

The study will, among other things, include collection and analysis of environmental baseline data, assessment of the technology deployed (Project Technology), identification and evaluation of impacts (both positive and negative) on the existing biophysical and socio-economic situation, design of mitigating measures, and an environmental management and monitoring plan. The particular issues that are to be addressed will include but not be limited to:

Soil erosion and sedimentation in the catchment area of the project;

- Flooding and water-logging;
- Water-borne diseases (malaria, schistosomiasis, etc);
- Fertilizer and pesticide application;
- Effects on quality of water in downstream receptors;
- Re-settlement of affected population;
- Transboundary impacts.

"The Environmental Impact Assessment studies would cover the downstream countries as well as the project areas. The Social value of irrigation development in terms of mitigating the negative effects of drought such as loss of human and animal life would be discussed, and the Consultant will provide a methodology on how to quantify in monitoring terms the social benefits that can be accrued from irrigation development like curtailing movement of refugees around the border areas. The study will identify the relevant natural resources, the eco-system and the population likely to be affected. Direct and indirect impacts will be identified and any particularly vulnerable groups or species highlighted. In some instances views will be subjective and the Consultant will give an indication of the degree of risk or confidence and the assumptions on which conclusions have been drawn.

"The output required will be a report examining the existing environment, the impacts of the proposed project on the environment and the affects of the environment on the project, both positive and negative, the mitigating measures to be taken and any actions needed. Interim reports, for example of baseline studies, will be phased to be of maximum value to parallel technical and economic studies.

"Baseline data collection, if needed, can be time consuming and will have a major impact on the cost and time needed for the study. If considerable data exists, for example a good record of water quality information and hydrological statistics, the EIA may be possible without further primary data collection.

If data are scarce, time must be allowed for field measurement and analysis. In any event, reference would be made to publications such as the ADB guidelines (available at the Bank website) and World Bank Operational Directive 4.01 (1991). The format will be designed to suit the national and transboundary aspects. The Consultant will focus on the major issues and the most serious likely impacts, opportunities for enhancing any positive benefits from the project should also be highlighted."

## 1.4 COMMENTS ON THE TOR

### 1.4.1 Field Measurement and Analysis

The environmental studies, which have involved two environmental specialists - one Ethiopian for 1 mm, and one international for three weeks, have utilised the baseline surveys made for soils, social studies, topography, agriculture, livestock, and geotechnical works. It was not possible to commission any further studies, since there was no provision in the project costs for additional staff and time.

The study area was visited during the dry and wet seasons of 2008-2009, pre- and post-harvest, to gauge the status of the natural vegetation, land use practices and assess the crop calendar. Much of the data and information required for the purpose of the assessment by way of the biophysical base like that of soils, topography, agriculture, geotechnical works, and to some extent that of the socio-economic base was taken from the complementary survey reports conducted by the project and as such no further study was commissioned in this respect.

Where it is not clear that we have the data to close on a particular issue we say so. This is usually because we did not have the personnel or time resources to make detailed assessments of, for example, faunal and floral ecology, archaeology, and Gumuz indigenous peoples. These must all be included in a detailed programme of assessment at the time of detailed design.

All these types of surveys would each take several months work by various specialists. Both dry and wet season surveys are needed, and for fauna night-time surveys are important as much of the smaller mammals are nocturnal. The FS had no budget or time allocation for such surveys, interesting and essential as they might be, and we have made the best of the available data and our own extensive field surveys.

Several visits were made to the project area to examine the status of the natural vegetation, especially the remaining forest vegetation in the area, land use, cropping patterns and some socio-economic aspects which were considered to be not well covered by the complementary surveys.

## 1.5 METHODS

### 1.5.1 General

The methods used in the environmental and social impact assessment (ESIA) of the DBIP follow the procedure given in the ToR, with reference to EIA guidelines of the ADB, the World Bank, and Ethiopia. This study used various methods ranging from the consultation of previous documents to direct observation of the biophysical and socio-economic conditions by crisscrossing the project area. The environmental work has made full use of other annexes in the project. The relevant annexes were reviewed and analyzed, with focus on potential benefits and adverse impacts on the environment following the implementation of the irrigation scheme.

The key tasks of the environmental impact assessment studies are to assess any potential positive and negative impacts that may arise from the implementation of the Project in a manner that facilitates the comparison between available project alternatives. These involve screening and scoping of impacts, baseline surveys to characterise the study area if it is not know already, the likely type of impacts that may occur, the identification of mitigation measures, and proposals for environmental management and monitoring.

### 1.5.2 Screening

The ToR does not state the level of the environmental category of the project, though it can be assumed to have been assessed by the ADB as an ESIA is required. We have started from first principles, as this area appears to have not been studied before, there was little information available. The EIA started with what was known, mainly from the Abbay Master Plan Study, and Upper Didessa studies. In case of the latter, assessments were incomplete and it is possible for example that the ecological studies were never actually published or even made, as we could not find the relevant documents despite a wide search. In the preliminary screening we have examined all that relates to the region from other studies. This has included previous works and assessments made as part of the study: soils, topography, geotechnical studies, hydrology and hydrogeology, land use and land cover, fauna and flora, socio-economic and livelihoods. The initial screening also, is central to categorising the project in terms of the level of environmental assessment required.

A full list of sources is given in the references at the end of this Annex. A key part of the screening and scoping of the ESIA for this project has been the use of the guidelines and checklist prepared by the International Commission for Irrigation and Drainage (ICID). The ICID checklist – Table 1 (Mock and Bolton, 1993; Doughtery and Wall, 1995) provides a very useful template with six categories for classification of impacts:

- A Positive impact very likely
- B Positive impact possible
- C No impact likely
- D Negative impact possible
- E Negative impact very likely
- F No judgement possible at present

The ICID checklist (Table 1) system assists project planners and higher-level decision-makers in trading-off between the different alternatives for an irrigation project.

The criteria used for comparing project alternatives are not limited to the impacts of the project on the physical environment - such as natural resources and biological life - but also include the impacts on socio-economics, as well as economics. The ICID checklist is useful for making systematic basic or in-depth assessments of possible impact issues related to a Project. For Dinger Bereha it has been chosen mainly because the criteria used for comparing project alternatives are not limited to the impacts of the project on the physical environment - such as natural resources and biological life - but also include the impacts on socio-economics, as well as economics.

The ICID checklist in addition to becoming useful for making systematic basic or in-depth assessments of possible impact issues related to a Project, it has also been found to be very comprehensive embracing all environmental issues of concern as indicated in the ADB, WB and the Ethiopian Government guidelines. When applied to the initial screening process it also provides indications of impacts that are clearly not relevant to the project: for example, estuary erosion and operation of large dams, and these can be eliminated from the impacts requiring further consideration.

The environmental assessment at the screening stage identified impacts that required further evaluation and where possible these have been covered by other specialists in the feasibility team, such as impact of diseases on animal production, suitability of the proposed crops, state of wildlife flora and fauna in the vicinity of Dinger Bereha, engineering impacts on hydrology and erosion, and public health considerations resulting from increased irrigation.

At screening and scoping levels, a score indicates the likelihood of an impact, but does not make a conclusion on the significance of the impact. For example a predominant listing in category E might indicate a very likely negative impact for a project, but this may not give an accurate picture as individual impacts cannot readily be compared against each other without making very detailed assessment in an impact analysis. For this reason it is not advisable to list the sum of scores for each level of impact.

### 1.5.3 Scoping

Whilst screening leads to a narrowing down of the key issues, and elimination or marginalising of possible impacts which are found to be of minimal concern or not relevant to the area, the scoping part of this ESIA provides a more detailed assessment. Within the context of the Dinger Bereha Irrigation Project Feasibility Study, made over a few months, a practical approach has to be adopted. This has utilised existing knowledge and data gained during the study, to elaborate on the likely environmental impacts relating to the project, and how mitigation measures could be implemented. The scoping defines the scope of the work that is needed to define, in as precisely as possible, the biophysical and social environmental impacts, and the options for mitigation measures, monitoring as part of an environmental management plan, and the necessary institutional matters.

The scoping for the Dinger Bereha study was made during 2009 by two environmental specialists, Ethiopian and International. Activities included: reviews of existing planning documents of the project; reviews of reports and studies of other irrigation projects in the study area; field trips to the study area before and after the wet season; evaluation of the obtained information; and discussion with other experts of feasibility study team.

The evaluation of the information obtained is aimed at screening out or highlighting those issues of high significance under particular conditions of the project and the local environment. To do this use has been made of the information and analyses undertaken by the technical, social and economic study teams.

### 1.5.4 Baseline Data Collection

The ESIA has utilised the baseline studies made on the soil survey and associated slope and land use surveys, as well as the socio-economic, livestock, land tenure and agricultural field surveys and assessments. These are the main sources of the data for the project area.

The project environmental assessment team are experienced in field assessments of fauna and flora, land and water resources, erosion, indigenous peoples, rural development, and natural heritage. In the time allowed it was not possible to make comprehensive assessments of fauna and flora, nor conduct a detailed archaeological survey. However, initial findings are given, and future assessments will be required at the start of any future tender design stage.

The EIA describes as far as possible therefore, the biophysical and social environments of the study area. It relates identified environmental impacts with proposed mitigation measures, where these are considered necessary, so as to ensure that the project proposals and design plans are compliant and in accord with the ADB and Ethiopian environmental assessment procedures and requirements.

While in the field, all relevant institutions at kebele and wereda level were visited for data acquisition and discussion purposes. Interviews and discussions with key informants were also made. However, it is worth mentioning here that there is a general lack of organized and well documented data and information at the wereda office, and less so in the kebeles/tabias.

### 1.5.5 Impact Assessments

The principal purpose of an irrigation project is to increase agricultural food production, usually in an area where rainfed cropping is difficult or impossible as rainfall is deficient, insufficient or irregular, and there is a high risk of crop failure. The project area has high rainfall but there is a risk of drought and the potential is strong for the proposed project therefore as one providing food security amongst the local population and region.

Other positive environmental and social impacts resulting from irrigation development include higher crop yields; and higher cropping intensities with multiple cropping; poverty reduction and reduction in malnutrition; the elevation of farm outputs and higher farm incomes; creation of employment possibilities on the farm and other infrastructural activities.

Land use changes effected by irrigation development will also impact on the bio-physical environments, and all or part of forests and woodland, rangeland and pasture, flora and fauna can be lost. The social impact from the forced displacement of, for example, indigenous peoples or existing farmers already in an area is one such issue that requires careful assessment of existing land use practices. The land tenure studies of the FS examine the existing land use patterns and rights, so that all potentially project-affected populations are indentified.

Water abstraction from rivers and agrochemical or industrial waste laden polluted return flows can cause further impacts on water users, biota and habitats, and there are threats also to near surface or deep aquifers. Disease vectors can be enhanced by irrigation infrastructure, but the delivery of water to lands previously water-short areas, that improves human settlement and livestock are positive impacts.

Negative impacts of the bio-physical environments though can be common, and have the capability to wreck a project before it is off the ground. Sufficient care must be taken to plan a project, and a successful project plan will need to make a balance of the contrasting impacts: the ICID checklist, with its supporting guidelines, ensures that these issues are thoroughly examined in a step-by-step procedure.

*Table 1: Checklist for Screening of Environmental Impacts*

| For each environmental effect a cross (x) is placed in one of the columns | | Positive impact very likely | Positive impact possible | No impact likely | negative impact possible | Negative impact very likely | No judgment possible at present |
|---|---|---|---|---|---|---|---|
| **Report section** | **Impact Category:** | **A** | **B** | **C** | **D** | **E** | **F** |
| **Hydrology** | **Low flow regime** | | | | | | |
| | **Flood regime** | | | | | | |
| | **Operation of dams** | | | | | | |
| | **Fall of water table** | | | | | | |
| | **Rise of water table** | | | | | | |
| **Organic & Inorganic Pollution** | **Solute dispersion** | | | | | | |
| | **Toxic substances** | | | | | | |
| | **Organic pollution** | | | | | | |
| | **Anaerobic effects** | | | | | | |
| | **Gas emissions** | | | | | | |
| **Soils and Salinity** | **Soil salinity** | | | | | | |
| | **Soil properties** | | | | | | |
| | **Saline groundwater** | | | | | | |
| | **Saline drainage** | | | | | | |
| | **Saline intrusion** | | | | | | |
| **Erosion and Sedimentation** | **Local erosion** | | | | | | |
| | **Hinterland effect** | | | | | | |
| | **River morphology** | | | | | | |
| | **Channel structures** | | | | | | |
| | **Sedimentation** | | | | | | |
| | **Estuary erosion** | | | | | | |
| **Biological & Ecological Change** | **Project lands -a-Land take:** | | | | | | |
| | **-b-Provision of irrigation** | | | | | | |
| | **-c- Settlement development** | | | | | | |
| | **Water bodies** | | | | | | |
| | **Surrounding area** | | | | | | |
| | **Rivers & riverine habitats** | | | | | | |
| | **Rare species** | | | | | | |
| | **Animal migration** | | | | | | |
| | **Natural industry** | | | | | | |
| **Socio-economics** | **Population change** | | | | | | |
| | **Income & amenity** | | | | | | |
| | **Human migration** | | | | | | |
| | **Resettlement** | | | | | | |
| | **Women's role** | | | | | | |
| | **Minority groups** | | | | | | |
| | **Sites of value** | | | | | | |
| | **Regional effects** | | | | | | |
| | **User involvement** | | | | | | |
| | **Recreation** | | | | | | |
| **Health** | **Water & sanitation** | | | | | | |
| | **Habitation** | | | | | | |
| | **Health services** | | | | | | |
| | **Nutrition** | | | | | | |
| | **Relocation effect** | | | | | | |
| | **Disease ecology** | | | | | | |
| | **Disease hosts** | | | | | | |
| | **Disease control** | | | | | | |
| | **Other hazards** | | | | | | |
| **Ecological Imbalances** | **Pests & weeds** | | | | | | |
| | **Animal diseases** | | | | | | |
| | **Aquatic weeds** | | | | | | |
| | **Structural damage** | | | | | | |
| | **Animal imbalances** | | | | | | |

Source: ICID Checklist by Mock and Bolton, 1993.

### 1.5.6 Mitigation Measures

The scoping studies identify the key impacts that will require mitigation measures on the project. These measures are defined in terms of what they are, how serious the issues are; who or what institutions will be responsible for implementing mitigation; how will these be accomplished, in what time frame, and at what cost.

### 1.5.7 Environmental and Social Impact Management Plan

The last section of this ESIA is to present an Environmental Management Plan for the proposed project. This provides an implementation plan for the mitigation measures that aim to minimise or eliminate any negative impacts. It will also suggest the possible indicators for biophysical and socio-economic monitoring on the project, and will review any negative impacts, how they can be mitigated, and lay out the likely institutional arrangements regarding which institutions will implement mitigation monitoring, within a certain time frame and with indicative costs.

The time allowed for the environmental studies has been short and some more comprehensive investigations are recommended to be made during the follow-up detailed design stage to assess, amongst other topics, wildlife biological aspects, and village planning.

## 1.6 Environmental Categorization of the Project

The Dinger Bereha Irrigation Project would involve large-scale engineering works starting from the abstraction of the required water from the Didessa River by the construction of a mass concrete weir, and relatively long feeder canal (19km) and even lengthy primary and secondary canals. This is can resulting in significant negative effects on the existing vegetation of the area especially the gallery forest along the side of the Didessa and other streams that drain the proposed command area. The remaining patches of the forest at both the command area and adjacent slopes can also be affected by the activities of the project. It is also partially within a regionally proposed natural reserve encompassing parts of three Wereda. Seasonal movements of wildlife within to and from the reserve could be disrupted by canals acting as barriers and other activities related to the development and running of the project.

There is also considerable concern that the life style of a population of indigenous Gumuz people, who live along the right bank of the river, might be disturbed as the result of the activities related to the construction and maintenance of the weir, feeder canal as well as the access road and the embankment. Whilst positive impacts are indeed likely from the project, it is also probable that negative impacts will occur to the ecology and biodiversity of these ecosystems and to the livelihoods of existing inhabitants; mitigation to minimize such disruptions would need to be put in place. As can be drawn from the ICID checklist results above in Table 1, all these considerations place the proposed project as a Category 'A' Project, for which an Environmental and Social Impact Assessment (ESIA) study is required (World Bank EA Sourcebook Update Number 2, 1993).

The African Development Bank (ADB) has four categories of environmental assessment (ADB, 2004):

- Category 1 projects will require a full Environmental and Social Impact Assessment (ESIA), including the preparation of an Environmental and Social Management Plan (ESMP). These projects are likely to induce important adverse environmental and/or social impacts that are irreversible, or to significantly affect environmental or social components considered sensitive by the Bank or the borrowing country. The ESIA examines the project's potential beneficial and adverse impacts, compares them with those of feasible alternatives (including the "without project" scenario), and recommends any measures needed to prevent, minimise, mitigate or compensate for adverse impacts and to enhance environmental and social project benefits.

- Category 2 projects require the development of an Environmental and Social Management Plan (ESMP). These projects are likely to have detrimental and site-specific environmental and/or social impacts that are less adverse than those of Category 1 projects and that can be minimized by the application of mitigation measures or the incorporation of internationally recognised design criteria and standards.

- Category 3 projects require no impact assessment. These projects shall involve no adverse physical intervention in the environment and induce no adverse environmental or social impact. Beyond categorisation, no further ESA action is required for this category of project.

- Category 4 projects involve investment of Bank's funds through Financial Intermediaries (FIs) in subprojects that may result in adverse environmental and/or social impacts. FIs include among others banks, insurance and leasing companies, and investment funds that on-lend Bank's funds to small and medium size enterprises.

These considerations made the Consultants conclude that the proposed project should be deemed as a Category 2 Project in the African Development Bank environmental assessment procedures for which an environmental and social assessment is required. In this category, there would be impacts but they would be less diverse than Category I.

Despite this limited time has been allowed for this study (a total of 1.6 mm) and this has meant that detailed surveys and assessments were not possible: baseline studies made by the project have been used to make the environmental and social assessment. Much more could have been possible if resources had been included in the staffing times with surveys over the seasons.

# 2 LEGISLATIVE AND INSTITUTIONAL FRAMEWORK

## 2.1 LEGISLATION

Legislation pertinent to the way overall development should be conducted in general, and environmental protection in particular, emanate from the *Constitution* of the Federal Democratic Republic of Ethiopia (FDRE) adopted on the 21st of August 1995. The concept of sustainable development and environment rights are entrenched in the rights of people in Ethiopia through articles 43 and 44, which states among others the right to development and right to live in clean and healthy environment.

The concept of sustainable development and environmental rights are entrenched in the Rights of Peoples in Ethiopia through Articles 43 and 44 which state the following:

**Article 43:- The Right to Development**

- The Peoples of Ethiopia as a whole, and each Nation, Nationality and People in Ethiopia in particular have the right to improved living standards and to sustainable development.
- Nationals have the right to participate in national development and, in particular, to be consulted with respect to policies and projects affecting their community.
- All international agreements and relations concluded, established or conducted by the State shall protect and ensure Ethiopia’s right to sustainable development.
- The basic aim of development activities shall be to enhance the capacity of citizens for development and to meet their basis needs.

**Article 44:- Environment Rights**

- All persons have the right to live in a clean and healthy environment.
- All persons who have been displaced or whose livelihoods have been adversely affected as a result of State programmes have the right to commensurate monetary or alternative means of compensation, including relocation with adequate State assistance. The government shall pay fair compensation for property found on the land but the amount of compensation shall not take into account the value of land.

**Article 92** of the Constitution states that the design and implementation of any program and development projects shall not damage or destroy the environment, and people have the right to be fully consulted and express their views in planning and implementation of environmental policies and project.

## 2.2 Ethiopian Environmental Institutions

The Constitution as a measure of achieving decentralization provides legislative, executive and judicial powers and responsibilities to the Federal Government and nine Regional States (Article 47 &50). The Environmental Protection Authority (EPA) was established in response to the requirements of the Constitution (Proclamation No 9/1995). The objective of the EPA is to:

*"...ensure that all matters pertaining to the country's social and economic development activities are carried out in a manner that will protect the welfare of human beings as well as sustainably protect, develop and utilise the resource bases on which they depend for survival"* (Federal Negarit Gazeta of the Federal Democratic Republic of Ethiopia - Proclamation No 9/1995)

The Federal Environmental Protection authority (FEPA) was established to harmonize sectoral development plans and implement environmental management programs for the country. Environmental al Protection Proclamation (Procl. 295/2002) is aimed to assign responsibilities of the environmental management activities to separate organizations on the one hand, and environmental protection, regulations and monitoring on the other, in order to ensure sustainable use of environmental resources, thereby avoiding possible conflicts of interest and duplication of efforts. It is also intended to establish a system that fosters coordinated but differentiated responsibilities among environmental protection offices at a federal and regional level.

At the federal level the Environmental Protection Authority is in charge of policies, directives and standards and of enforcing the laws and policies including EIAs and environmental monitoring, for all projects or activities that falls under the control of the Federal Government.

Each of the main federal institutions active in the construction of infrastructure, or economic development is required by law to have its own environmental unit. The Ministry of Water Resource is one of the few federal institutions that indeed have an Environment Unit. According to the Environmental Protection Organs Proclamation, the regional states are required to create their own regional environmental agencies. These institutions are to deal, among others, with EIAs for regionally managed infrastructures or development activities. Recently, environmental units have also been established at the Zonal and Wereda levels including at Chaweka.

## 2.3 EIA Legislation in Ethiopia

EIA Legislation in Ethiopia emanates from the Environmental Impact Assessment Proclamation and Guidelines of the country. The main objective of the above Proclamation is to make the EIA mandatory for specified categories of activities undertaken either by the public or private sectors. Among others, the Proclamation defines the scope of the environmental impact assessment by outlining the contents of EIAs, and determining the duties of the project proponent. The general provision of the Proclamation includes:

- Implementation of any project that requires an EIA is subject to an environmental clearance or authorization from the EPA or Regional Environmental Agency (REA).

- The EPA or the relevant REA, depending on the magnitude of anticipated impacts, may waive the requirement for an EIA.

- Any licensing agency shall, prior to issuing an investment permit or trade or an operating license for any project, ensure that the EPA or the relevant REA has authorized its implementation.

- Licensing agency shall either suspend or cancel a license that has already been issued, in the case that the EPA or the REA suspends or cancels the environmental authorization

- Approval of an Environmental Impact Study Report (EISR) or the granting of authorization by the EPA or the REA does not exonerate the proponent from liability for damage.

To put into effect this Proclamation, the EPA issued EIA Guideline Documents, which provide details of the EIA process and its requirements. The proclamation is based on the principle that each citizen has the right to have a healthy environment, as well as the obligation to protect the environment of the country.

The document provides background to environmental impact assessment and environmental management in Ethiopia. It is also is used as a reference material to ensure effective environmental assessment and management practice in Ethiopia for all parties who are engage in the process. The document details the required procedures for conducting an EIA. In addition, the document specifies tools that may be considered when engaged in the EIA process. Reference is made to the legislation and policies with which potential investors and developers must comply in specific development sectors.

According to this guideline projects are categorized into three schedules:

- Schedule 1: Projects which may have adverse and significant environmental impacts thus requiring a full Environmental Impact Assessment

- Schedule 2: Projects whose type, scale or other relevant characteristics have potential to cause some significant environmental impacts but are not likely to warrant a full EIA study

- Schedule 3: Projects which would have no impact and do not require an EIA

However, projects situated in an environmentally sensitive areas such as land prone to erosion; desertification; areas of historic or archaeological interest; important landscape; religiously important area, etc. will fall under category 1 irrespective of the nature of the project.

According to this guideline all project proponents and executing bodies (agencies) in the country should operate in close cooperation with the EPA to ensure that proper mitigating measures are designed and implemented, especially for projects with an adverse effect on the environment. This in effect means that an Environmental Impact Statement (EIS) should be prepared by project proponents and be examined, commented and approved by the EPA.

*Environmental Pollution Control Proclamation.* The Pollution Control Proclamation was issued in December 2002 and it is mainly based on the principle that each citizen has the right to have a healthy environment, as well as the obligation to protect the environment of the country from pollution. The Proclamation contains provisions for the control of pollution, management of municipal waste, hazardous waste, chemical and radioactive substances. It also encompasses provision for the formulation of practicable environmental standards by the Federal Environmental Protection Authority (FEPA), in consultation with the relevant agencies. Furthermore, it empowers the Federal Environmental Protection Authority or the Regional Environmental Authority to assign environmental inspectors with the duties and responsibilities of controlling environmental pollution.

## 2.4 NATIONAL POLICIES AND INTERNATIONAL CONVENTIONS

Since the early 1990s, the Federal government of Ethiopia has promulgated a wide range of policies and strategies in relation to various sectoral developments and a number of Initiatives that aim at developing regional, national and sectoral strategies to conserve and protect the environment. Paramount amongst these was *the conservation strategy of Ethiopia (CSE, 1996).*

This document provides a strategic framework for integrating environment into new and existing policies, programs and projects. It is also an important policy document, which views environmental management as an important component of development. It recognizes the importance of incorporating environmental factors into development activities from the outset.

*Agricultural Development-Led Industrialization (ADLI) Strategy.* The principal long-term development strategy of the country's development is Agricultural Development-Led Industrialization (ADLI). Based on the ADLI strategy and the new economic direction, a series of supporting strategies and policies have been formulated to encourage equitable sharing of resources by controlling population growth, increasing women participation and improving social services.

*Land Tenure Policy* which makes rural lands the property of the People and Government of Ethiopia, and buying and selling of land is prohibited but leasing rights is allowed. Moreover, it is the right for existing land owner to be compensated fully and satisfactorily if land is expropriated by the state.

The Land Policy of Ethiopia strongly support that projects plans must include attractive and sustainable resettlement strategies to the people who are going to be displaced as a result of the development plan, and they have to be fully convinced, compensated and have to participate in all phases of the project implementation.

*Environmental Policy.* The Environmental Policy of Ethiopia (EPE) was issued in April 1997. The overall policy goal is to improve and enhance the health and quality of life of all Ethiopians and promote sustainable social and economic development through sound management and use of natural, human-made and cultural resources and their environment as a whole, so as to meet the needs of the present generation without compromising the ability of future generations to meet their own needs.

The policy seeks to ensure the empowerment and participation of the people and their organizations at all levels in environmental management activities, raise public awareness and promote understanding of the essential linkage between environment and development. In addition to its guiding principles, the policy addresses sect oral and cross sect oral environmental issues.

Environmental Impact Assessment (EIA) policies are included in the cross sect oral environmental policies. The EIA policy emphasizes the early recognition of environmental issues in project planning at all levels of administration.

*Water Resource Management Policy.* The Ministry of Water Resource prepared water resources management policy of Ethiopia. The overall goal of the policy is to enable and promote all national efforts towards the efficient, equitable and optimum utilization of the available water resources of Ethiopia for significant socio-economic development on sustainable basis. The policy ensures water allocation for water supply and sanitation as the highest priority while apportioning the rest for uses and users that result in highest socio-economic benefits. The policy also recognized the allocation of water for livestock as well as for environment reserve as the highest priority in any water allocation.

## 2.5 ADB Environmental Assessment Procedures

The African Development Bank (ADB) produced Integrated Environmental and Social Impact Assessment (IESIA) Guidelines (ADB, 2003) that merge previous environmental and social guidelines into one set of procedures. Appendix 1 of these guidelines deals with irrigation and states that the major issues that can arise relate to specific problems with the crosscutting of poverty, environment, population, health outcomes, gender and participation. The issues to be examined are defined in a series of components, as follows:

- Poverty issues: assessment of economic activity, employment, incomes, compensation for losses, access to benefits, skills and infrastructure.
- Environment: watershed management, water quality, drainage and sedimentation, water use, soil characteristics, natural heritage, and the protection of vegetation, habitats and specific ecosystems.
- Population: involuntary resettlement and migration, population characteristics and dynamics, land uses, water uses and rights, natural resource management, agricultural practiced and local customs, and quality of life.
- Health Outcomes: vector-borne and water borne diseases, sexually transmitted diseases, food supply and drinking water, accidents and injuries, sanitation and hygiene.
- Gender: women's workload, control over land and land proceeds, income generating activities, access to facilities and services, women's involvement in decision-making processes.
- Participation: participation of affected groups in consultations, organisation of irrigation water management.

The guidelines also specify the potential benefits and adverse impacts that may arise, and provides a list of appropriate enhancement and mitigation measures in relation to each component.

Taking wildlife fauna as an example, a positive impact could be water retention; negative impacts include fragmentation of habitats, creation of habitats suitable for disease vectors, and increase in poaching. The mitigation measures include keeping clear of the area during reproductive periods, preservation of wildlife corridors, and control of hunting, appropriate control of disease vectors. The ADB Guidelines also suggest the types of indicators for environmental and social monitoring that would be included in an environmental management plan.

# 3 ENVIRONMENTAL BASE LINE CONDITIONS

## 3.1 THE PHYSICAL ENVIRONMENT

### 3.1.1 Introduction

The basis for any Environmental and Social Impact Assessment is, first and foremost, a sound understanding of the existing environmental baseline condition of the project area over which the project and its whole array of technology is going to be superimposed or implemented. Below is a summary of the main biophysical and socioeconomic features of the project area. Much of it is based on the complementary surveys of the Dinger Bereha. However, some information and data was also added, especially in relation to the socio-economic aspects, vegetation and deforestation from field observations made in the area by the two environmental specialists.

### 3.1.2 Topography

The project area is characterized by pronounced variation in relief. The surrounding highland plateau elevations reaches up to 1780m or more while the valley floor elevation ranges from 1139 to 1260 meters. In general the landform of the project area is characterized in the central part by gently undulating plain and strongly sloping lands. The slope of the area is dissected towards the Didessa and Dabena Rivers.

The topography of the area is shown in Figure 2 and slopes in Figure 3. These show a series of narrow gently convex interfluves that are bordered by more steeply sloping land in the stream valleys, and that these become increasingly steeper towards the main arterial streams of the Didessa and Dabena.

The relief can be identified as to have three main features being gently undulating plains with convex interfluves (0-6%), valley floor and strongly slopping lands. The area is for most of its part undulating and hilly. It is incised by numerous streams. It is difficult to find a sizeable flat area that we would normally find in the gravity irrigated projects of a similar nature and scale in the country.

In fact this is an important feature of the whole Illu Abababor Zone in which the Chewaka wereda is located. According to the Regional Atlas of the Oromia National Government, the whole zone is regarded as partially suitable for mechanization (8.6%). Below contour level of 1260 m above sea level (asl), the area that has slopes of less than 5% is about 5,900 ha net. This is equivalent to about 80% of the 7,500 ha net that would have to be developed. The remaining 20% is situated in the class of 5-8%.

*Figure 2: Topography* ***(print pdf map on A3 paper)***

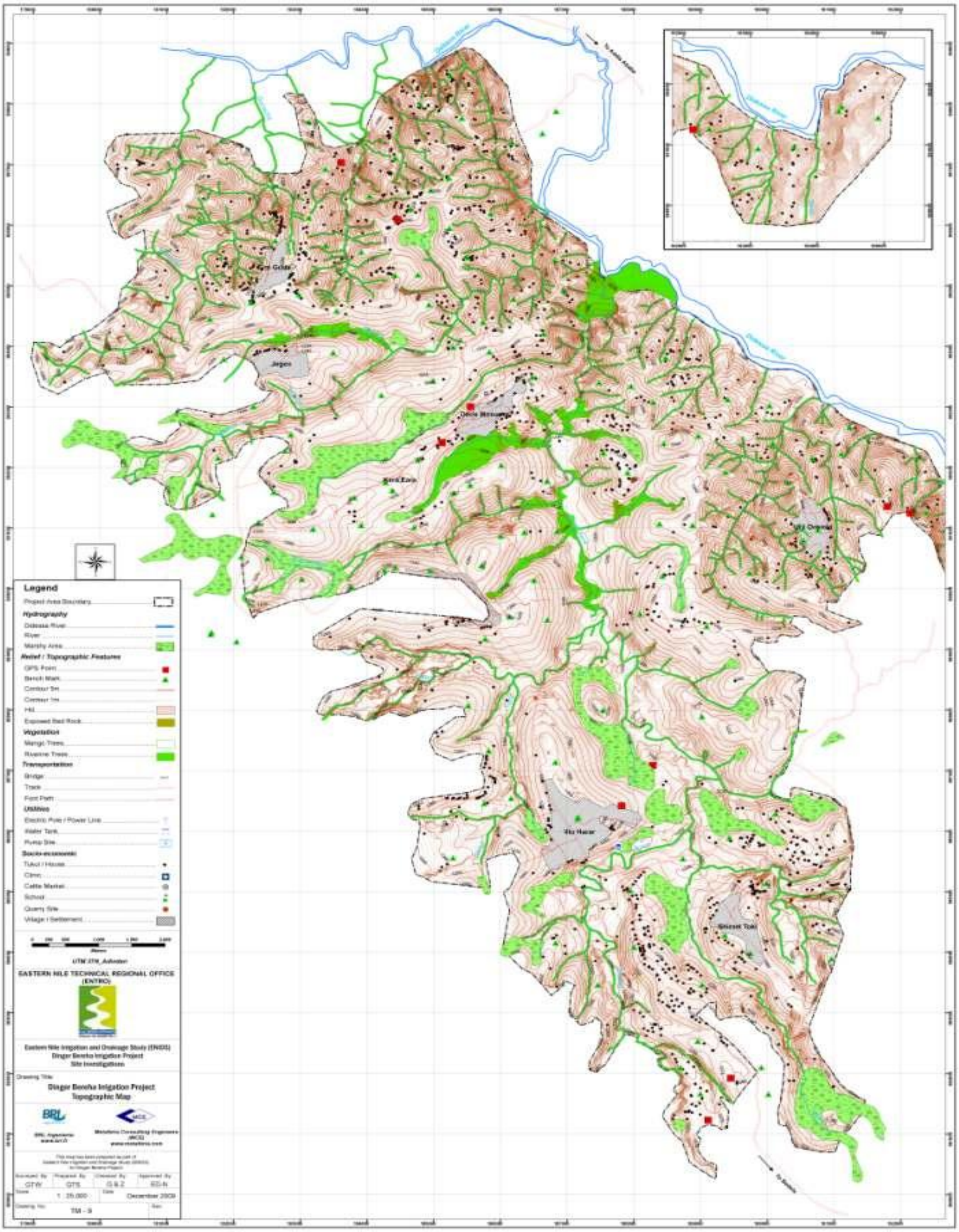
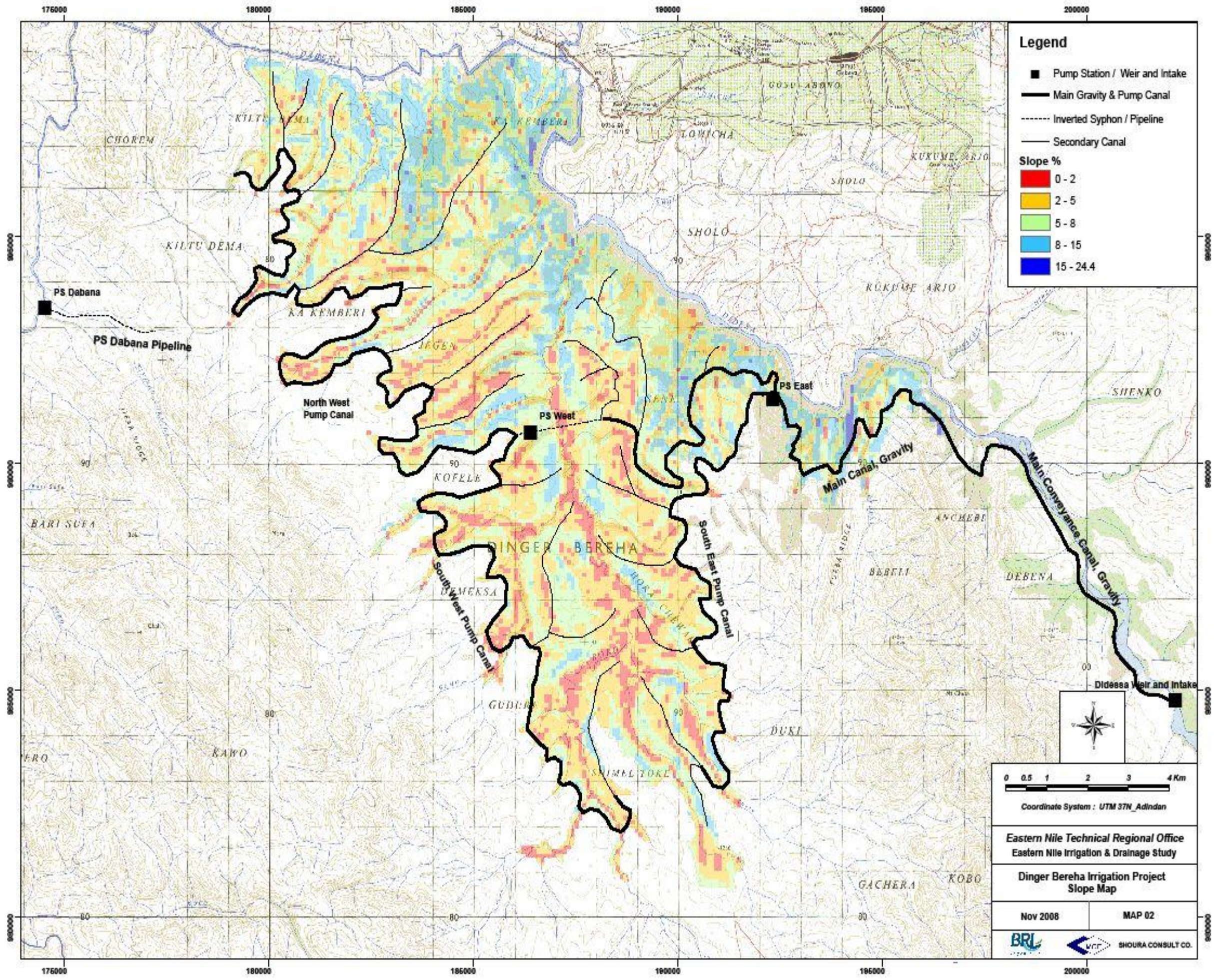


*Figure 3: Slopes*




## 3.1.3 Geology

The study area lies on the western edge of the Ethiopian volcanic escarpment. From the plateau at Bedele, the land drops steeply to the Didessa River valley passing through almost 1000m or so of the Tertiary volcanic succession down into the Pre-Cambrian Basement Complex, here comprising gneisses, schists and granites. There are what appear to be a series of erosion surfaces in the landscape: the high plateau at around 2000 m is one, but this is well outside the area; a prominent surface is at about 1700 m asl on the watershed; the DBIP lies mainly on a lower gently dissected surface, at about 1240 - 1270m, herewith termed the 'Chaweka Plains'. The Basement Complex rocks are exposed in the Didessa River, and also as an elevated fault-bounded horst block which forms a massive ridge along the eastern edge of the study area. The Dinger Bereha area, the subject of this soil survey, lies west of this horst block, mostly on gently to moderately undulating landforms with steeper slopes towards the Didessa and Dabena rivers.

The soil-landforms associations are developed over a thin veneer of highly weathered basalt lava and ash on the interfluves. These weathered volcanics, that appear to be either a downfaulted fragment of the Ethiopian volcanic plateau, or the residue of a lava flow that filled this part of the Didessa valley, passes down into the underlying Basement Complex metamorphic rocks that are exposed mostly on middle and basal slopes and in the rivers at the numerous rapid sites. The actual boundary between these geological formations is obscured by thick colluvial and soil mantles. On the undulating lands of the Chaweka Plains, where slopes range up to 15%, the soils vary from shallow to lithic on convex sedentary soil exposures, down to moderately deep and deep on the colluvial slope deposits of the middle and lower slopes and valley floors: this can be considered to be a catenary association of soils.

These valleys, as noted, become much more incised near the Didessa River due to the downcutting of the main rivers in response to deepening of the Abbay gorge, but there has also been isolation and preservation, to a certain extent, of the Chaweka Plains. It is not clear why this has happened, as the landscape of the wetlands is unusual that they remain as 'perched' above the more incised streams. The same type of landscape occurs on the right bank of the Didessa in the 'Didessa State Farm' area, and beyond. It may be that beds of volcano-lacustrine sediments - of unknown age and remnants of an ash fall blanket preserved only in the wetlands and stream areas- noticed in sections in a few of the streams that dissect the Chaweka Plains have acted as a knick point control on erosion and downcutting in the area. This has preserved the undulating nature of the Chaweka Plains, but it is considered to be fragile: if gallery forests are removed then there is a great risk that this protection, and other contributory aspects that are undoubtedly playing a part also, could be altered and erosion accelerated throughout the DBIP.

Much of the soil study area includes the undulating lands with convex interfluves, some granite tors, deep soils on middle and lower slopes, and passing down into flat, poorly drained uncultivated wetlands where significant parts remain as a dense gallery forest.

A summary of the soils and landforms is given in Table 2**.**

*Table 2: Landforms and Land Use at Dinger Bereha*

| **Landform Group** | **Soil-Landform Association** | **Natural Vegetation** | **Land Use** |
|---|---|---|---|
| Steeply sloping hills and ridges on Basement Complex and volcanic rocks (outside the command area but within catchment protection area); 1200 – 1900 m asl | Upper and middle slopes | Deciduous woodland with perennial grasslands subject to slash and burn and wildfires | Rough grazing, illegal burning and tree felling, wildlife refuges; limited sorghum fields. |
| | Lower slopes | Deciduous woodland with perennial grasslands subject to slash and burn | Rough grazing, illegal burning and tree felling, wildlife refuges; sorghum fields, some irrigation at spring sites |
| | Spring sites | Gallery forest | Includes areas of small scale irrigation or remain as forest |
| Undulating plains with convex interfluves on weathered basic volcanic rocks 1200 to 1400 m asl | Interfluves and ridges | Deciduous wooded savanna and scrub vegetation | Rainfed sorghum. |
| | Middle and lower slopes | Deciduous wooded savanna with emergents; tree cover being burnt; some species remain as parkland | Mostly rainfed crops (sorghum, sesame,); dry season grazing lands, rice on flat lower lands |
| | Floors of the tributary valleys | Gallery forest, including Ficus spp. | Tree nurseries; small scale irrigation for vegetables; forest products; sand extraction |
| Undulating plains with convex interfluves and ridges with tors on Basement complex rocks 1200 to 1300 m asl | Basement Complex ridges and tors | Savanna woodland | Settlements; grazing areas |
| | Basement Complex on middle to lower slopes | Wooded savanna that is regenerating on abandoned lands | Scattered rainfed sorghum; |
| Didessa Alluvial Landforms 1260 to 1200 m asl | Didessa valley floodplain | Riverine and Gallery forest with various species | Generally remains wooded due flood risk; |

Source: field investigations by BRL, 2008-2009

## 3.1.4 Climate

### 3.1.4.1 *Temperature*

The climate of the study area is hot particularly in the months from January to March. The average temperature during the hot season ranges from $35^0$ C to $41^0$ C, and during the rainy season (July –to August) varies from $21^0$ C to $27^0$ C. The climatic features of the area are discussed briefly in the following sections. Air temperature regulates the growth and development of plants by regulating the rate of biochemical processes. The growth of many crops ceases below the critical temperatures of $5^0$C or above $35^0$C and the crop yields are adversely affected. The average annual maximum and minimum temperature are $25.05^0$C in April and $19.99^0$C in December respectively.

### 3.1.4.2 *Rainfall*

The project area is situated within the highest rainfall region of the country. The rainfall in the Dinger Bereha project area is characterized by uni-modal type. The rainy months extend from May to October. The six wettest months cover 88 percent of the total annual rainfall. The dry season, being from November to February (four months) has a total rainfall of about 4.8% of the mean annual rainfall.

Using data from Didessa State farm station (Table 3), a short distance from the northern part of the study area the rainfall distribution of the area shows that the rainy season varies from 158 mm in May to 104 mm in October; the maximum peak month is July, which reaches up to 312 mm. The dry seasons ranges from December to February. Thus, the average mean annual rainfall of the project area is 1454mm. However, according to the metrological data at the bridge on Didessa River below Arjo on Bedele road, the annual precipitation for the period 1963-2008 is 1505 mm (from Hydrology Annex).

The analysis of the Didessa State farm station rainfall is shown in Figure 4, and indicates that over a 25 year period (1970-95) the rainfall did not dip below 1200 mm / per annum: this would appear to indicates the low risk of drought in the area, although no recent data is available.

*Table 3: Mean Monthly Rainfall (mm)*

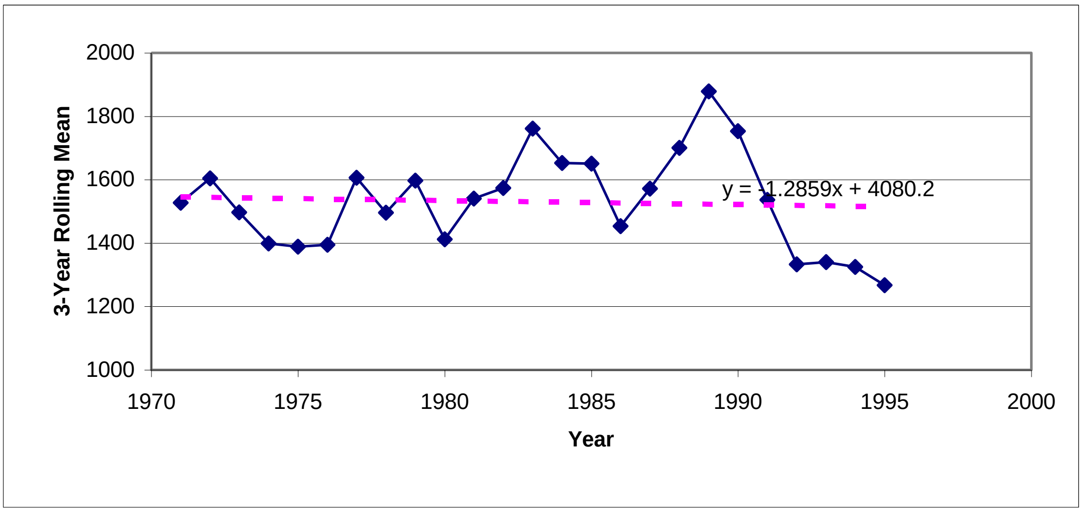
| Description | Jan | Feb | March | April | May | June | July | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Didessa | 3 | 6 | 26 | 49 | 158 | 274 | 312 | 277 | 209 | 104 | 28 | 8 | 1,454 |
| Bedele | 18 | 23 | 65 | 105 | 239 | 291 | 310 | 303 | 302 | 156 | 41 | 12 | 1,864 |
| Jimma | 33 | 49 | 88 | 133 | 172 | 219 | 208 | 210 | 182 | 103 | 68 | 36 | 1,502 |

Source: Hydrology Annex for DB Feasibility Study

### 3.1.4.3 *Relative Humidity*

The average monthly relative humidity of the project area is 75.51% with minimum value 56.63% in March. Therefore, relative humidity of the project area on the average condition can be taken in the range of 56.6% to 88.6%. Relative humidity influences the evaporation, disease prevalence, ripening and maturity of crops.

*Figure 4: Trend Analysis of Annual Rainfall at Didessa Station*




Source: Hydrology Report, Dinger Bereha Feasibility Study

### 3.1.4.4 *Wind Speed*

The mean wind speed of the area ranges from 0.48 m/second in September to 1.08 m/second in April. For the computation of evapo-transpiration, wind speed is the relevant variable climatic element.

### 3.1.4.5 *Sunshine Hours*

Mean sunshine duration determined for the project area is above 8.2 hours in the period November-January and is reduced to 3.7 hours in July.

## 3.1.5 Agro-ecology and Land Use

The agro ecology of the Woreda varies between 1100 m asl at Didessa River to 1800 at the top of the surrounding hills. The study area can be conveniently categorized in the Ethiopian nomenclature as in the moist kola agro-climatic zone.

The natural vegetation of the area includes irregular patches of dense riverine forest along the Didessa River, gallery forest along the tributary valleys that reach up to the a local plateau level at about 1700m asl. In both riverine and gallery forests the vegetation includes a wide mix of species, that include *Ficus spp*., and palms, and both soft and hardwood trees. On the steeply sloping lands of the escarpment there is a mix of *Ficus spp*. and *Acacia abyssinica* (above 1500 m ASL) with a *Combretum spp* dominated woodland at lower elevations.

On the undulating plains that are cultivated for rainfed crops, and the subject of this soil survey, the natural vegetation, dominated by *Combretum*, is being cut or burn by recent settlers and this is leading to substantial erosion on the more sandy soils. A few tall emergent species remain, and suggest that this deciduous savanna woodland was once a very dense and productive wooded savanna, perhaps even almost tropical rainforest. Many of the trees on these undulating slopes, the future DBIP, have been burnt without being harvested first: a very substantial timber resource has been wasted and lost. It is apparent though that many of the burnt trees were destroyed some years ago, prior to the present wave of settlers and relate to a previous settlement phase (Didessa State Farm phase) in the 1980s'.

The area has some residual wildlife. Oribi gazelle have been seen wandering just close to Ilullu Harrar settlement; Pangolin (ant eater) holes are quite common. Elsewhere in the Didessa valley, and upstream of the proposed weir site, it was noticed that there are Warthog in bushlands; Crocodile and Hippopotamus occur along the Didessa River. On the steep slopes of the catchment above the irrigation area Black and White Colobus Monkey, Anubis Baboons, and other small monkeys are common. To the west of the Chaweka area the steeply sloped and well wooded hills are being proposed by the state govt to be a wildlife reserve, and this move is being backed by the Chaweka Woreda administration, as well as by the Consultants.

The DBIP area is settled by families who have been resettled over the past five years from the Harrar area of Ethiopia. The numbers of settlers is increasing.

There are also several hundred indigenous residents of the area, the Gumuz, riverine peoples who now live along the Didessa River, but apparently only on the right bank and outside the proposed irrigation area: the existence of these people was found out late in the FS, and Cheweka Wereda staff appeared to have had little knowledge or interest of them. However these are an important group who are likely to be of very considerable interest with regards to origins, DNA profiling, health and immunity / susceptibility to diseases, and their traditional livelihoods.

Other settlers, whose origins and national affinity are not known at this time though they are thought to have moved across from the Didessa State Farm, used to live within the DBIP area, as witnessed by several stands of mature (10 m high) mango trees. According to the new settlers, the Harar peoples who live in these same locations now, they either died or moved out entirely, partly it is stated due to effects of tsetse fly on their cattle.

The farming system of the Chaweka area, initiated in the past five years as settlers arrived from the Harrar area of south eastern Ethiopia, is based on a single rainfed crop, mostly cereals including sorghum, maize, sesame, and upland rice. Some fruit trees are also grown around farmsteads, and there are several mango groves that date as mentioned from a previous settlement attempt in the valley. Livestock are kept at the home, tied up, and all ploughing is done by the laborious method of using traditional digging sticks, though often in communal efforts.

Agriculture is the main if not the sole contributor to the economy to Chewaka wereda. The area was sparsely populated with a few scattered smallholdings prior to 2004 but the population has expanded to about 14,000 people under a planned resettlement programme with families being allocated 1.5-2.0 ha. Rainfed crops are produced during the long 7-month rainy season. Irrigated crops include maize, rice chilli peppers and a wide variety of vegetables.

Livestock are a small but possibly not unimportant component of the overall system. Oxen have been provided to settlers by the administration in order to complement the crop component in the provision of draught power. Most cattle are "stall fed" using a primitive and low input system that in the main does not include an element of concentrate feeding.

Other cattle are herded in small units as are sheep and goats although the small ruminant species are often allowed to roam freely. Poultry provide a subsidiary source of food and income. Bees are "farmed" in the traditional way and their honey gathered by the simple expedient of setting fire to the tree in which they have built their nest and then robbing them of their honey.

In November 2009 there were estimated to be 11,382 oxen, 799 cows, 41,380 sheep and goats and 41,724 poultry in the wereda. Average number of animals owned by those households actually owning animals is 1.46 oxen, 1.56 cows, 19.58 sheep and goats and 24.83 poultry. About 50 per cent of households, however, own no animals. Cattle, sheep goats and poultry are all of the indigenous type. Livestock production and productivity is low.

The small-scale irrigation in the valleys made by diverting waters from perennial streams and some springs. However, as the woodlands are cut back the Gallery forest disappears it is likely these sources will dry up: therefore, protection of the steep slopes and gallery forested areas is both necessary and essential.

The rainfed farming system, which accounts for most of the food produced in the area, is one of subsistence with low input–low output productivity. The official land use data for Chaweka Woreda is shown in Table 4 below. The land use data for the project area is also shown, as assessed during the detailed soil survey work. It is evident that the estimate for cultivated area is increasing annually, as new settlers clear forest and shrub lands for agricultural use. A map of the land use of the area has been devised from the soil studies and is shown in Figure 5. Area measurements are given in Table 5.

The complementary soil surveys made an interpretation of SPOT 5 Imagery with 5 meter Resolution. This was ortho-rectified and dates from January 2008. The Project area was dominantly occupied by intensively cultivated land. Five major land use/cover mapping units were identified and mapped in the project area. These units were cultivated land, grass land, natural forest, wooded shrub land and marsh/ wet lands.

This cultivated land unit covers around 4,941.93ha (46.86%) of the project area and it is mainly occupied by cereal crops, largely Sorghum, Maize and Sesame. The adaptation and distribution of these crops in the area are highly influenced by rainfall. Grass land unit occupies approximately around 1,053 ha (9.99%) of the total area of the Project. The remaining land units were occupied by natural forest, 1,721ha (16.31%) which is 131ha (1.259) dense forest mainly along streams and 1,589ha (15.07%) riverine forest), wooded shrub land 2,550ha (24.19%), marsh/wet land 26.16 ha (0.26%) and nearly 253ha (2.4%) of the project area is occupied by settlements including Illu Harer, the Chewaka Wereda Town.

Agriculture, clearly, is the main stay of the economy of the wereda. The people resettled in the area have started producing different types of agricultural crops under rainfed and traditional irrigation during the rainy and dry seasons respectively. Sorghum, maize, rice, soybean and sesame are the most important ones. Different types of vegetables are also grown under irrigated agriculture. There is not much of livestock in terms of numbers as the area is very much affected by trypanosomiasis.

However, livestock rearing, particularly fattening of bulls and keeping of goats is also part of the agricultural activities that keeps the settlers to run a mixed farming system. Farm sizes vary from 1.5-2 ha, depending on the size of the family. Such farm sizes are considered to be small and it is highly likely that in the near future the intensification food crop production and cultivation of cash crops through irrigation during the dry season will significantly improve the livelihood of the people.

*Table 4: Chewaka Land use*

| Category | Woreda Area (ha)[1] | Soil Project Area (ha)[2] |
|---|---|---|
| Cultivated land | 19,400 | 4,942 |
| Grassland | 3,500 [3] | 1,053 |
| Natural forest (gallery & riverine forests) | 24,900 | 1,721 |
| Shrubland and wetlands | 5,500 [3] | 2,577 |
| Settlements, farmsteads | 1,100 [3] | 253 |
| **Total** | **54,400** | **10,546** |

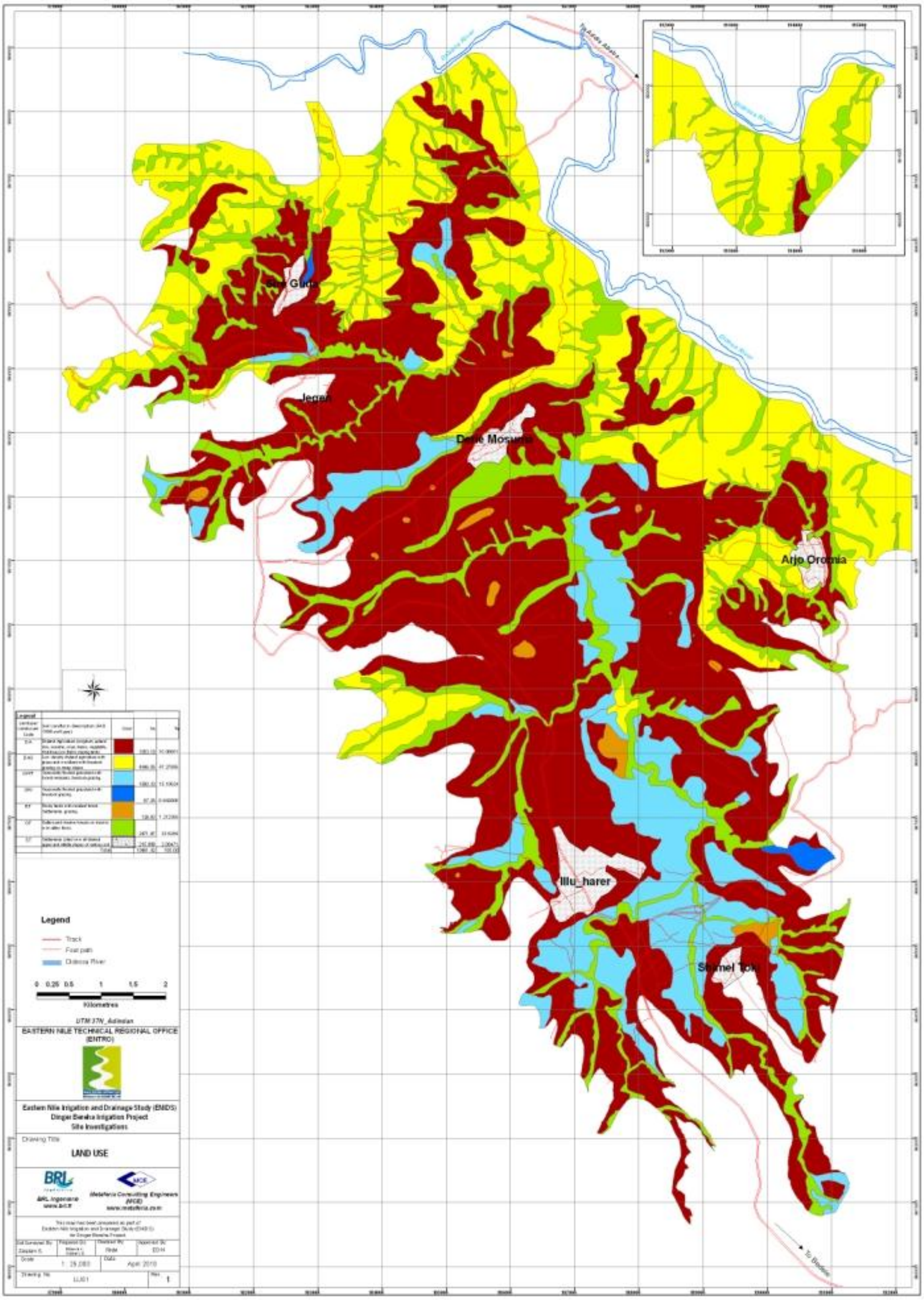
Sources. 1: Chaweka Woreda Agriculture & Rural Development Office; 2: Soil Survey Report, Complementary Surveys, BRL-MCE, 2009; 3: GIS estimated area. Numbers have been rounded off to nearest hectare.

*Table 5: Land Use / Land Cover in Dinger Bereha Project Area*

| Code | Colour on map | Description |
|---|---|---|
| DA | Brown | Dryland (rainfed) agriculture on upper and middle slopes, 0-3 % and 4-8%. Primarily on soil units, 1,2,3,4. Cereals: Sorghum, maize, millet, upland rice, some teff, some barley; sesame; soya; haricot beans; fruit tree crops including mango, papaya; within degraded savanna woodland; livestock grazing on stubble and fallow grass areas. 1053.1 ha. |
| DAG | Yellow | Steeper slopes on margins of area with grassland, woodland fragments, rainfed cropping (extensive in east); abandoned areas under dense 'elephant' grass. Grasslands periodically burnt. Soil units 5,7,8,11 mainly. 4946.05 ha. |
| GWF | Light Blue | Seasonally flooded to permanently waterlogged grasslands of flatter valleys adjacent to stream with gallery forest. Likely former wetland forest cleared since 1970s. Now livestock grazing, and some drainage ditches being cut for probable cultivation in future. Soil unit 9 mainly. 1580.33 ha |
| GW | Dark Blue | Seasonally flooded grassland areas on valley bottoms. Livestock grazing. Some development of sugar cane. Few wetland tolerant trees. Soil unit 10 mainly. 67.25ha. |
| RF | Orange | Rocky boulder land on granite tors and basalt outcrops with variable cover of dryland savanna woodland; some wildlife gazelle seen; livestock grazing; settlements; soil unit 12. 126.83ha. |
| GF | Light Green | Upland Gallery, and Didessa Riverine Forest. Moist to wet lands, flat to steep sided valleys. Mostly gallery forests with secondary forest and shrub growth, along streams, merging with riverine forest at Didessa, and extending upwards to watershed area outside soil survey area. Many rainforest type trees including Ficus spp., Palmae spp. and hardwoods; unauthorised tree felling of hardwoods in places; groundwater sources for settlements; important floral and faunal biodiversity value with wildlife refuges for birds, primates, snakes. Mainly soil unit 13 and 14. 2471.87 ha |
| ST | /////// | Settlements and administrative centres of Chewaka Woreda. |

Source: Complementary Soil Survey, and BRL soils and environmental field studies, 2008-2009.

*Figure 5: Land Use in Dinger Bereha* ***(print pdf map on A3 paper)***



### 3.1.6 Soil and Water Conservation

The settlers have already started to implement some afforestation measures with the aim of having a multi-purpose benefit for food, forrage, and environmental protection. Nursery sites for endegenous and exotic species are being developed for this purpose. It is reported that there is much more focus on the exotic ones for reasons of the longer growth time that it takes for the endegenous species. The use of chemical fertilizers is at a very low stage: for example, only 838 and 615 qt of urea and dap was put in to use respectively for an area of about 2013 ha of agricultural land.

Field observations made by the soils and environmental teams show that water erosion of cuiltivated soils is on the increase. An assessment of this is given in Annex 3: the conclusion is that is most urgent that soil and water conservation (SWC) measures need to be implemented now so as to avoid a continuation of the serious loss of topsoil. If not checked this will lead to further riling, sheet erosion and probably initiation of gullying, and infilling of the valley soils with coarser alluvium.

### 3.1.7 Soils

The soil studies were made using standard field survey methods with application of topographic maps, use of aerial photographic interpretation, reviews of previous studies with production of a soil map of 1:10,000 scale. In the course of the study soil/land mapping units were verified and representative soil samples collected to determine chemical and physical properties of the soils. A total of 1,243 auger holes were described. In addition, 103 profile pits were studied and sampled. Taking on an average 4 samples from each profile pit, 303 samples were collected and analyzed at the Water works Design & Supervision Enterprise Laboratory Serves. In-situ infiltration and hydraulic conductivity tests were also studied on 11 representative model profile pits.

Very little work has been made in the area before: no soil surveys and only exploratory reconnaissance work. The Inception studies for the Feasibility Study determined the broad soil characteristics and formed the basis of the detailed level of soil survey that followed.

According to the *Regional Atlas of the Oromia National Government*, the proposed project area is located within the light zone of degree of degradation with respect the rate of soil erosion. This might be due to the reasonably fair vegetation cover that the area had at the time of the study and before it was used for a settlement area. However, the area has witnessed very significant damages due to erosion in the last six years due to the activities of the resettlement and continuous expansion of agricultural land.

The soil mapping units described for this survey are based on a full assessment of the field data and the accompanying field tests and laboratory analyses. The units that have been chosen relate to a complex mix of landforms, topographic information, parent materials, slopes, soil depths, soil morphology and apparent soil genesis, and assisted by observations on present land use where these are appropriate to soil conditions. Detailed soil maps of the study area have been produced at scales of 1:10,000 and 1:5,000 (and are presented in the Soils Annex). A reduced map is shown here as Figure 6**.** A summary of the soils and their extent is given in Table 6.

Based on the complementary survey, the soil classification for the project area has been made according to FAO-ISSS, ISRIC 1998 Guidelines. Thus ten sub-soil units and six major soil types have been identified, which include, Nitisols (NT), Acrisols (AC), Vertisols (VR), Cambisols (CM), Gleysols (GL) and Leptosols (LP). The most extensive soils of the project area, which have slope less than (8%), are Nitisols (NT) followed by Vertisols (VR), Acrisols (AC) then Cambisols (CM) and Gleysols (GL). Soil chemical and physical properties are shown in Table 7, with morphological properties in Table 8.

A summary of the extent of soil classes is shown in Table 9. Nitisols, Acrisols and Cambisols have relatively deep soil depth, and well drainage good workability. Likewise, Vertisols have deep soil depth, poor drainage and hard workability. The remaining 3,745 ha (35.5%) of the land is occupied by non-potential area.

According to the soils report, the soils are poor in major nutrients - phosphorous, nitrogen and organic carbon. The soils, have over probably a long time, in this higher rainfall area (>1400 mm), formed on highly weathered parent materials and have been leached. The base saturation percentage confirms the same conclusion that the fertility level of the soils is low. In most of the soil samples its value is found to be low, which is found in the range of less than 50 % which indicate that the soils major cations like calcium, magnesium, potassium, and sodium have been leached out. Unquestionably, fertility level of the soil of the study area is found to be so low that it requires optimum agricultural inputs to raise yields in both rainfed and irrigated conditions.

The land suitability evaluation for the area follows the FAO system. The criteria for suitability classes have been based on the particular requirements of the proposed irrigation system, and the surveys identified the following limiting factors: soil drainage, erosion hazard, flooding hazard, potential for mechanization, soil moisture availability, rooting condition, topography, workability, and soil factors. These are given in Table 10.

The land suitability criteria for the Dinger Bereha area are given in Table 11. These follow the FAO system, where five categories are permitted: Highly Suitable (S1); Moderately Suitable (S2) ; Marginally Suitable (S3) ; Currently Not Suitable (N1) ; and Permanently Not Suitable (N2).

The main objective of the land evaluation study has been to select the optimum Land Utilisation Type (LUT) for each soil mapping unit / land unit identified in the study area. Land evaluation defines the suitability of a specific area of land for a specific LUT with particular management and inputs level.

In the Dinger Bereha area the major land use being considered for the evaluation is irrigated agricultural development in the command area, using surface gravity fed from storage reservoirs through buried piped networks to the fields, where farmers will use flexible pipes to irrigate their land. This is an unusual method of irrigation for Ethiopia and will require considerable training of farmers so they can optimise the use of their lands without causing its degradation.

For the final report of the Feasibility Study four land utilization types (LUTs) were identified and defined in terms of their produce. The potential LUTs which have irrigation component and which are considered in the present land suitability assessment for the command are:

A. Irrigated cereals (sorghum, maize, upland rice) and oil crops (sesame) Requirement is for at least moderately deep, well drained soils with appropriate SWC measures to be put in place. These crops are already being grown in the area under rainfed conditions.

B. Irrigated Vegetables and Pulses. Requirement is for well to imperfectly drained soils, with appropriate SWC measures to be put in place. Some of this group are being grown successfully in the area at present.

C. Irrigated Citrus and Fruit Trees. Requirement is for deep well drained soils, with appropriate SWC measures to be put in place. Mango has been grown successfully on the convex slopes of the area on a local basis. There are some problems with termite control. Other fruit trees with deep roots will be suitable for the soils on the plateaux and slopes.

D. Irrigated Wetland Rice. Requirement is for flat lands with heavy clays suitable for puddling. Minor SWC measures to level lands will be required. This is not being grown at present but would appear to be well suited to the flat seasonally flooded areas in the valleys.

Each soil mapping unit has been assessed for its suitability to the different LUTs. In the initial soil Complimentary Survey report on the Dinger Bereha area the land suitability assessments were made on the basis of overheard/ sprinkler and open surface irrigation systems. As such topographic constraints meant that large parts of the study area became unsuitable (N2): the FAO systems and land suitability requirements for Ethiopia required that such decisions be made.

Subsequently, an irrigation system has been devised that will be based neither on overheard nor open surface furrow type irrigations, but on a closed gravity system with irrigation water gravity fed from storage reservoirs through buried piped networks to the fields, where farmers will use flexible pipes to irrigate their land. This is new and unproven in Ethiopia.

The proposed system can utilise much steeper slopes than other methods and thus the land suitability classification has been adopted to accommodate these requirements. This will not be without risk: the potential erodibility of the soils on the steeper slopes will require careful land management. The DBIP extension services will need to provide expert advice to farmers so that they fully understand the techniques that are most appropriate to this unusual (in Africa) type of irrigated farming. The main constraints for each mapping unit are given in Table 12 and the final table for suitability classes for each LUT in Table 13, and for suitability classes in Table 14.

*Table 6: Soil Units and their Extent*

| **Map Unit Code** | **Soil Landform Description** | **Area ha** | **%** |
|---|---|---|---|
| 1 | Deep, well drained, dark reddish brown, loam / clay loam over clay, on colluvial upper convex 0-3 % slopes; no stones or boulders, no flood risk (Orthidystric Nitisols) | 1630.4 | 15.5 |
| 2 | Deep, well drained, reddish brown, clay loams over clays, on colluvial upper convex 0-3% slopes; no stones or boulders, no flood risk (Hyperferric Acrisols) | 675.3 | 6.4 |
| 3 | deep, moderately well drained, dark reddish brown, clay loams over clays, on middle & lower 4-6 % slopes, no stones or boulders, no flood risk (Orthydystric Nitisols) | 2430 | 23.0 |
| 4 | Deep, moderately well drained, dark reddish brown, clay loams / clays on middle & lower 4-6 % slopes, no stones or boulders, no flood risk (Rhodic Nitisols) | 242.4 | 2.3 |
| 5 | Shallow to moderately deep, at least 60 cm deep, dark reddish brown, loams / clay loams on steep slopes >15%, on basaltic materials, stony and rocky in profile below 60 cm (Orthieutric Leptosols) | 787.5 | 7.5 |
| 6 | Deep, well drained, dark reddish brown, loams / sands / sandy clay loams, on middle to upper slopes 5-8 % of rock ridges, stones in profile below 160 (Hyperferric Acrisols) | 387.5 | 3.7 |
| 7 | Moderately deep, well drained, brown, clay loams, of middle to upper 5-8 % slopes on basaltic materials , stony below 70 cm, (Orthidystric Cambisols) | 152.5 | 1.5 |
| 8 | Deep, moderately well drained, dark brown, loams over clays on hillside slopes 8-15 % , stony below 150 cm (Hyperferric Cambisols) | 958.7 | 9.1 |
| 9 | Deep, imperfectly drained, dark grey, clays, on 0-3 % lower slopes of seasonal flooded valleys, no stones (Mesotrophic Vertisols) | 1053.1 | 10.0 |
| 10 | Deep, poorly drained, black, clays on valley floor, 0-2 % slopes, alluvium , no stones (Gelic Gleysols) | 30 | 0.3 |
| 11 | Deep, moderately well drained, dark brown, loams over clay loam / sandy clay loam, on colluvium of 2-4 % lower slopes in dissected valleys, may be gravelly > 1m (Fluvic Cambisols) | 200.2 | 1.9 |
| 12 | Shallow to rocky, reddish brown, sandy and skeletal soils on bedrock granite and basalt outcrops >5 % slopes (Leptosols) | 67.3 | 0.6 |
| 13 | Deep, poorly drained, black, clays and loams on 0-3 % valley floor alluvium with incised central stream channel (Nitisols, Acrisols, Vertisols) | 1585.5 | 15.0 |
| 14 | Deep, dark grey clays to black clay loams on undulating 4-8 % slopes under forest (Nitisols, Vertisols, Acrisols) | 130.4 | 1.2 |
| ST | Settlements (sited on well drained upper and middle slopes of various soil units) | 216 | 2.1 |
| | TOTAL | 10546.8 | 100.0 |

Source: BRL-MCE, 2009

*Figure 6: Soil Map of Dinger Bereha* ***(print pdf map on A3 paper)***

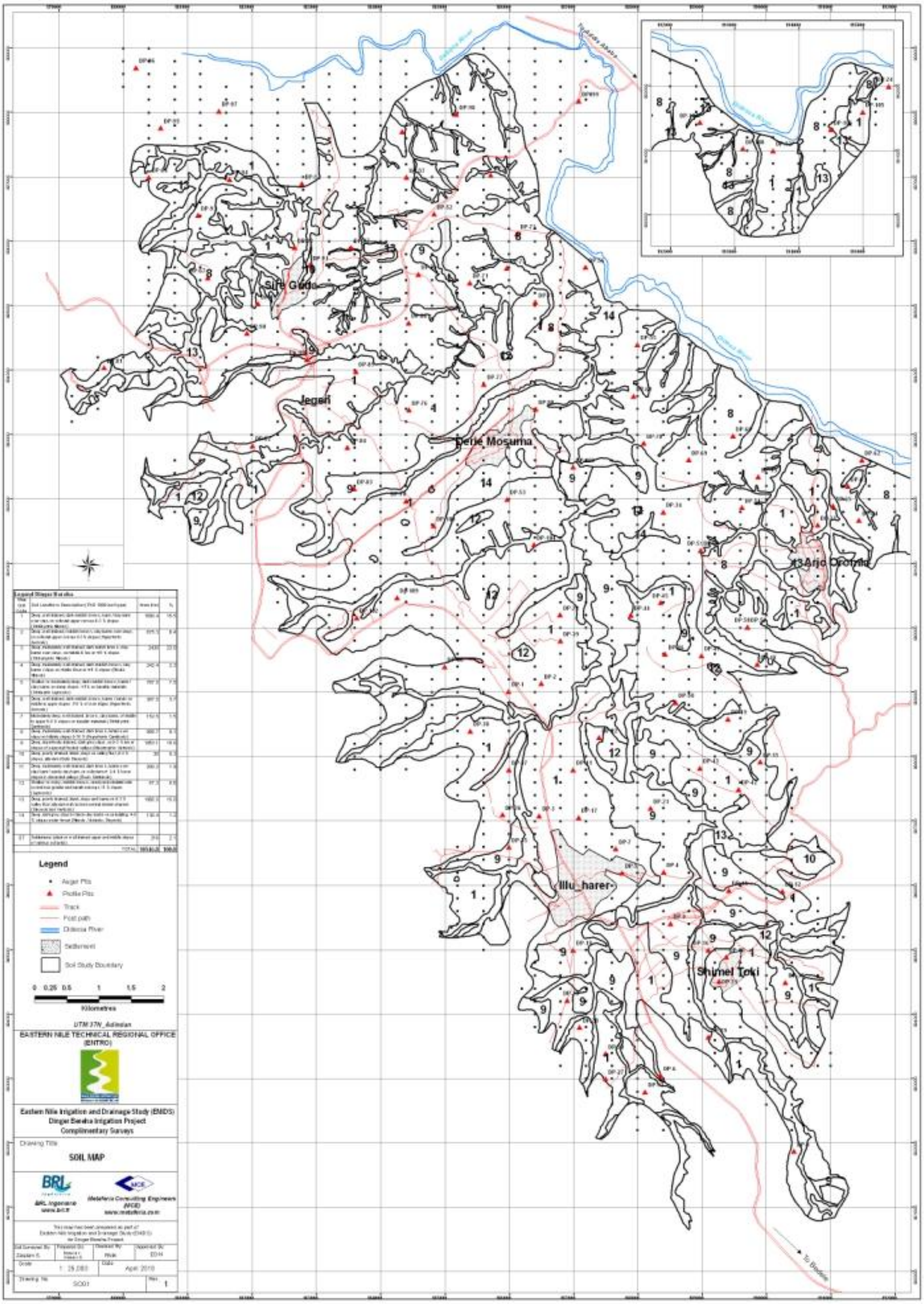


*Table 7: Summary of Physical and Chemical Properties of Dinger Bereha Soils*

| Mapping Symbol | pH | EC dS/m | CEC | TN | O.C | C:N | ESP | P2O5 | $Caco_3$ | B.d | AWC | Infiltration Rates | | Hydraulic Conductivity | | Area | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Av. t op 25cm | Av.Top. 100cm | AV.Top 25cm | Av.top 25cm | Av.top 25cm | Av.Top 100cm. | Av.Top 100cm | Av.Top. 25cm | Av.Top. 100cm | $g/cc^3$ | mm/m | Measured | FAO Stand. | Measured | FAO Stand. | Ha | % |
| 1 (G1b-1) | 5.4 | 0.05 | 24.8 | 0.31 | 3.6 | 13 | 1 | 9.1 | - | 1.4 | 98 | 9.2 | 1.5 | 1.5 | 0.5 | 1630.38 | 15.46 |
| 2 (G1b-4) | 5.3 | 0.06 | 25.8 | 0.28 | 3.2 | 13 | 6.7 | 20.02 | 1.78 | 1.3 | 130.9 | 9.23 | 8 | 2.43 | 0.5 | 675.27 | 6.4 |
| 3 (G2d-1) | 5.2 | 0.05 | 31.1 | 0.26 | 3.2 | 13 | 39.9 | 9.02 | 6.17 | 1.33 | 80.5 | 9.8 | 1.5 | 1.76 | 0.5 | 2429.96 | 23.04 |
| 4 (G2d-2) | 5.3 | 0.1 | 43.2 | 0.3 | 4 | 12 | 0.5 | 10.89 | - | 1.33 | 101.8 | 6.9 | 1.5 | 3.63 | 0.5 | 242.42 | 2.3 |
| 5 (Sg-6) | 5.8 | 0.1 | 29.9 | 0.4 | 4.7 | 12 | 1.3 | 13.6 | - | 1.2 | 102.8 | - | 2 | - | 0.5 | 787.51 | 7.47 |
| 6 (U1e-4) | 5.3 | 0.04 | 28.5 | 0.27 | 3.4 | 11.2 | 0.8 | 3.27 | - | 1.33 | 88.5 | - | 8- | - | 1.5 | 387.45 | 3.67 |
| 7 (U1e-5) | 5.0 | 0.06 | 15.5 | 0.4 | 3 | 9 | 1 | 52.75 | - | 1.3 | 102.8 | - | 8 | - | 0.5 | 152.51 | 1.45 |
| 8 (U2f-9) | 6.3 | 0.09 | 31.4 | 0.4 | 4.4 | 11 | 0.6 | 45.9 | - | 1.2 | 94.5 | - | 2 | - | 0.5 | 958.68 | 9.09 |
| 9 (V1b-3) | 5.1 | 0.09 | 39.1 | 0.2 | 2.5 | 10 | 0.7 | 12.7 | 2.24 | 1.3 | 138.4 | 6.5 | 0.8 | 0.4 | 0.3 | 1053.1 | 9.99 |
| 10 (V2a-7) | 5.2 | 0.03 | 35.6 | 0.3 | 4.59 | 15.6 | 0.6 | 3.36 | - | 1.3 | 130.3 | | 0.8 | | 0.3 | 28.99 | 0.27 |
| 11 V3c_8) | 6.5 | 0.2 | 22.8 | 0.31 | 3.1 | 11.25 | 0.7 | 53.125 | 5.33 | 1.3 | 95.6 | 9.7 | 2 | 1.40 | 0.3 | 200.21 | 1.9 |
| 12 (G3d) | - | - | - | - | - | - | - | - | -- | - | - | - | - | - | - | 67.25 | 0.64 |
| 13 (R) | - | - | - | - | - | - | - | - | -- | - | - | - | - | - | - | 1585.46 | 15.03 |
| 14 (F) | - | - | - | - | - | - | - | - | -- | - | - | - | - | - | - | 130.35 | 1.24 |
| ST | - | - | - | - | - | - | - | - | -- | - | - | - | - | - | - | 216 | 2.05 |
| | | | | | | | | | | | | | | | Total | 10,546 | 100 |

Source: Laboratory analyses result, MCE, 2009

*Table 8: Summary of Morphological Properties of the Soils of Study Area*

| Symbol | Physio/ Geomorphic Land Unit | Slope % | FAO-1998 Soil | Depth cm. | Drainage Class | Texture Class | Munsell Colour | Rock/ Boulders | Flood Class | Erosion hazard | | Water Table Cm. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | sheet | Gully | |
| *1* | Upper Part of Gently Undulating Plain With Convex Interfluves | 0_3 | NTdyo | >200 | WD | C-Cl | Dark reddish br.-Dark Red | None | Fo | Active | Active | >400 |
| 2 | Upper Part of Gently Undulating Plain With Convex Interfluves | 0_3 | ACfrh | >200 | WD | Sacl-SiCl | Dark red-Dar reddish bro. | None | Fo | Active | Active | >400 |
| 3 | Middle & Lower Part of Gently Undulating Plains With Convex Interfluves | 4_6 | NTdyo | >180 | WD | Cl-C | Dark reddish brown- Red | None | Fo | Active | Active | >400 |
| 4 | Middle & Lower Part of Gently Undulating Plains With Convex Interfluves | 4_6 | NTro | >200 | WD | Cl-C | Dark reddish Brown-Red | None | Fo | Active | Active | >500 |
| 5 | Moderately Steep Side of Hill & Ridge | >15 | LPeou | >60 | SWED | L--Cl | Dark red bro. | >60 Stony, Rocky | F2 | High | High | >60 |
| 6 | Strongly Sloping Valley & Hill Side | 5_8 | ACfrh | >160 | WD | L-Sacl | Dark red bro. | >160 stony | Fo | High | High | >160 |
| 7 | Strongly Sloping Upper part of Hill &Ridge | 5_8 | CMdyo | >70 | WD | Sac-Cl | Brown | > 70 stony | Fo | High | High | >70 |
| 8 | Strongly Sloping Hill & Ridge Side | 8_15 | CMeuh | >100 | WD | L-C | Dark brown | >100 stony | Fo | High | High | >100 |
| 9 | Seasonally Wet Valley Floor | 0_3 | VRms | >200 | ID | C | Black -Gray | None | F1 | No | M | >300 |
| 10 | Permanently wet Valley Floor | 0_2 | GLge | >184 | PD | C | Black- Gray | None | F2 | No | M | >184 |
| 11 | Moderately Dissected Valley Side | 4_6 | CMfv | >114 | WD | L-Sacl | Dark brown | > 114 Gravely | Fo | High | M | >114 |
| *12* | Sloppy Basement Ridges & Tors | - | - | - | - | - | - | - | - | - | - | - |
| 13 | Incised Stream Channel | - | - | - | - | - | - | - | - | - | - | - |
| 14 | Forest | - | - | - | - | - | - | - | - | - | - | - |
| ST | Settlement | - | - | - | - | - | - | - | - | - | - | - |

Source : Laboratory analyses result, MCE, 2009

*Table 9:Identified soil types and area coverage*

| No. | Soil Type | Area | |
|---|---|---|---|
| | | Ha | % |
| 1 | Nitisols (NT) | 4,303 | 40.8 |
| 2 | Vertisols (VR) | 1,053 | 10.0 |
| 3 | Acrisols (AC) | 1,063 | 10.1 |
| 4 | Cambisols (CM) | 352 | 3.3 |
| 5 | Gleysols (GL) | 29 | 0.3 |
| Total area | | 6,800 | 64.5 |

*Table 10: Land Suitability Limiting Factors*

| Sub- class/ suffixes | Description |
|---|---|
| d | Soil Drainage: Soil and Land units having soil drainage deficiencies such as poor soil drainage, high ground water table, flooding, slow infiltration, slow permeability, slow surface drainage (low physiographic position) or some combination of these. Sub-soiling, diversion ditches and subsurface drainage may be required. |
| E | Erosion hazard: Land having an increased water erosion risk under irrigation. Conservation practices and surface drainage control are required and must be employed. |
| F | Flooding hazard: Risk of land being flooded at different seasons from upstream or upslope influences. |
| K | Potential for mechanization: Land units having unfavourable slope steepness, rock hindrances, presence of large amount of surface stones and plastic heavy clays, which affects mechanized agricultural operations by any kind of implements. |
| M | Soil moisture availability: Soil and Land units having soil moisture deficiencies. There is a need for an increased amount and frequency of irrigation and/or selection of drought-resistant crop varieties. |
| R | Rooting condition: Soil and Land units with limited effective soil depth defined by occurrence of a high amount of gravels, hard pan, bedrock or toxic layers. |
| T | Topography: Land having topographic limitations ascribed to unfavourable slope angel, micro-relief coupled with excess rock out crops and denser vegetation covers, which needs a higher initial land development cost, requiring land levelling (or short channel lengths and drop structures), grading, terracing, clearances of rock hindrances and vegetation clearances. |
| W | Workability: Land units with poor workability, ascribed to massive clays, poor organic matter content, very firm consistence and occurrence of high amount of stones and gravels in the surface layers. |
| Z | Soil Factors: Soils having a poor capacity to supply crops with nutrients mainly due to CEC, low organic matter, and low or high pH. Input will be required to conserve organic matter and improve soil structure and require fertilizer application. Elsewhere (not DB) soils with high stone content. |

Source: FAO, 1985

*Table 11: Suitability class limits for irrigated agriculture at Dinger Bereha*

| Limitation (*letter code*) | S1 | S2 | S3 | N1 |
|---|---|---|---|---|
| Topography (*t*) | Flat to slightly undulating lands of wetlands and alluvial valleys | | Gently to moderately sloping lands | Undulating middle to upper slopes |
| % Slope (*t*) | 0 – 2 | | 3-8 | 8-20 |
| Flooding (*f*) | No risk | Few events | Common events | Other, if flood protection is feasible |
| Soil depth in metres (*r*) | > 2 | | 1 – 2 | 1-2 |
| Topsoil (0-25 cm) stone, gravel (% vol) *(z)* | < 10 | 10 – 25 | 26 – 40 | |
| Topsoil (0-25 cm) texture *(z)* | clay<br>clay loam | vertic clay<br>sandy clay<br>silty clay<br>silty clay loam | loam<br>sandy clay loam<br>silt loam | |
| Infiltration rate (cm/hr) [3] *(m)* | 1.0 – 3.5 | 0.5 – 1.0<br>3.5 – 6.5 | 0.3 – 0.5<br>6.5 – 9.0 | |
| AWC (mm), top 0.6m. *(m)* | > 100 | 80 – 100 | 60 – 80 | |
| Hydraulic conductivity (permeability) rate (m/day) *(m)* | 1.4 – 1.9 | 0.5 – 1.4 | 0.2 – 0.5<br>2.0 – 3.0 | < 0.2 if drainage is feasible |
| Soil drainage class [3]*(d)* | well<br>moderate | imperfect | poor | very poor, if drainage is feasible |
| Surface waterlogging *(d)* | none | < 4 months | > 4 months | prolonged, if drainage is feasible |
| Water-table depth in wet season *(d)* | > 10 | > 4 | > 2 | < 2.0 if drainage is feasible |
| CEC, top 0.6 m *(z)* | > 25 | 8 – 25 | <8 | |
| pH, top 0.6 m *(z)* | 6.0 – 7.7 | 5.1 – 5.9<br>7.8 – 8.3 | 4.5 – 5.0<br>8.4 – 8.7 | < 4.5 if liming is feasible<br>> 8.7 if not sodic or gypsum can be added |
| Organic C, top 0.6 m (%) *(z)* | > 4 | < 4 | | |
| ECe, top 0.6m (dS/m) *(-)* | < 2 | 2 – 4 | 5 – 8 | > 8 if reclamation is feasible |
| ESP, top 0.6m *(-)* | < 8 | 8 – 15 | 16 – 25 | > 25 if reclamation is feasible |

Notes

1. For ESP and EC the values found are low so these have not been used in the assessment.
2. The suitability classes are based on various assessments being developed on various projects in Ethiopia for irrigated land use within the MOWR and other agencies.

*Table 12: Suitability of Soil Units for Irrigation*

| **Soil Mapping Unit** | **Main Constraints** |
|---|---|
| 1 | Soil drainage and water holding capacity are moderate; for rice soils whilst the soils have high clay content they will not puddle easily and slope requirements too slow. Overall marginally suitable for LUTs A,B, C. |
| 2 | Soil drainage and water holding capacity are moderate; slopes are more unfavourable and SWC measures will be required. For rice soils whilst the soils have high clay content the lack of swelling clays mean they will not puddle properly. Marginally suitable for LUTs A,B,C. |
| 3 | These soils are on moderate steep slopes and are deep clays. They are leached but should react well to inputs and better management that has the potential to raise nutrient levels. Marginally suitable for LUTs A,B,C. |
| 4 | These soils also occur on moderate steep slopes and are deep leached clays. They should react well to inputs and better management that has the potential to raise nutrient levels. Marginally suitable for LUTs A,B,C. |
| 5 | These soils occur on margins of rock outcrops, with slopes > 15% and are shallow to moderately deep. Lands from 15-20% if subjected to SWC can be utilised for LUTs A,B, C as Currently Not Suitable land (N1) with erosion and topographic constraints. Not suitable for D, rice. Those on steeper lands (>20%) are unsuitable for all crops. |
| 6 | These soils also occur on moderate and steep slopes (5-8%) and are deep leached clays. They should react well to inputs and better management that has the potential to raise nutrient levels. Marginally suitable for LUTs A,B,C. |
| 7 | These soils are moderately deep, well drained, clay loams, on middle to upper 5-8 % slopes on basaltic materials , stony below 70 cm. They have depth, soil and slope limitations which makes them marginal for LUTs A,B,C. They are not suitable for rice. |
| 8 | These are deep, moderately well drained, loams with clay sub-soils, on hillside with slopes 8-15 %, and stony below 150 cm. Their limitations are steep slopes and erosion risk, which make them marginal for LUTs A, B, C. Unsuitable for rice. |
| 9 | These are deep, imperfectly drained, Vertisol clays, on 0-3 % lower slopes of seasonal flooded valleys, no stones. They are moderately suitable for rice, LUT D, with slight topographic limitation, and marginally suitable for other LUTs due to flood risks, drainage and workability. |
| 10 | These are deep, poorly drained, clays on valley floor, 0-2 % slopes, alluvium , no stones. They are moderately suitable for rice, LUT D, with and marginally suitable for other LUTs due to drainage and workability. |
| 11 | Includes the deep, moderately well drained, loams over clay loam / sandy clay loam, on colluvium of 2-4 % lower slopes in dissected valleys, may be gravelly > 1m. They are marginally suitable for LUTs A, B, C and unsuitable for rice due slope and soil factors. |
| 12 | Shallow to rocky, reddish brown, sandy and skeletal soils on bedrock granite and basalt outcrops >5 % slopes. These soils are unsuitable (N2) for all LUTs and should not be developed. |
| 13 | The deep, poorly drained, clays and loams on 0-3 % valley floor alluvium are marginally suitable for all LUTs. The central incised stream bed will be demarcated with a 20m wide no-cultivation zone on each bank. |
| 14 | These are deep, clays / clay loams, on undulating , 4-8 % slopes, under forest. They have drainage, workability and topographic limitations that makes them marginally suitable for LUTs A, B, C, and unsuitable for rice. |

*Table 13: Area Measurements and Suitability Class, Soil Map Units in LUT*

| Soil Map Unit | LUT A | LUT B | LUT C | LUT D |
|---|---|---|---|---|
| 1 | 1630.4 (S3) | 1630.4 (S3) | 1630.4 (S3) | 0 (N2) |
| 2 | 675.3 (S3) | 675.3 (S3) | 675.3 (S3) | 0 (N2) |
| 3 | 2430 (S3) | 2430 (S3) | 2430 (S3) | 0 (N2) |
| 4 | 242.4 (S3) | 242.4 (S3) | 242.4 (S3) | 0 (N2) |
| 5 | 787.5 (N1) | 787.5 (N1) | 787.5 (N1) | 0 (N2) |
| 6 | 387.5 (S3) | 387.5 (S3) | 387.5 (S3) | 0 (N2) |
| 7 | 152.5 (S3) | 152.5 (S3) | 152.5 (S3) | 0 (N2) |
| 8 | 958.7 (S3) | 958.7 (S3) | 958.7 (S3) | 0 (N2) |
| 9 | 1053.1 (S3) | 1053.1 (S3) | 1053.1 (S3) | 1053.1 (S2) |
| 10 | 30 (S3) | 30 (S3) | 30 (S3) | 30 (S2) |
| 11 | 200.2 (S3) | 200.2 (S3) | 200.2 (S3) | 0 (N2) |
| 12 | 0 (N2) | 0 (N2) | 0 (N2) | 0 (N2) |
| 13 | 1585.5 (S3) | 1585.5 (S3) | 1585.5 (S3) | 1585.5 (S3) |
| 14 | 130.4 (S3) | 130.4 (S3) | 130.4 (S3) | 0 (N2) |
| Totals | 1263.5 | 9476 | 9476 | 2668.6 |
| Total S2 | 0 | 0 | 0 | 1083.1 |
| Total S3 | 9476 | 9476 | 9476 | 1585.5 |
| Total N1 | 787.5 | 787.5 | 787.5 | 0 |

*Table 14: Summary of Totals by Land Suitability Class*

| Land Suitability Class | Total Area ha (10263.5 ha) | % of total area (10263.5 ha) |
|---|---|---|
| S1. Highly Suitable | 0 | 0 |
| S2. Moderately Suitable | 1083.1 (LUT D - rice) | 10.6 |
| S3. Marginally Suitable | 9476 (LUT A, B, C) | 92.3 |
| S3. Marginally Suitable | 1585.5 (LUT D - rice) | 15.4 |
| N1. Conditionally Suitable | 787.5 (LUT A, B, C) | 7.7 |
| N2. Permanently Unsuitable | 67.3 (mapping units with all LUT) | 0.7 |
| Other - Settlements | 216 | |

## 3.1.8 Water Resources

### 3.1.8.1 *Surface Water*

The Didessa River, which bounds the eastern and north eastern border of the project area, is the major perennial river in the area. Other major perennial left bank tributary rivers are the Dabena, which joins the Didessa to the north of the project area, Boro, Mimite, Guracha, Tefisa and other numerous streams, with deeply incised courses, which cross the proposed command area.

Hydrological data for the project area are attributed from various sources (MoWR, and NMSA). Gauged data are available only for the Didessa River, and the major and minor tributaries within the Didessa catchments are not gauged. The river Didessa has 33 years gauged data records that the project has considered sufficient for analysis. The station for gauging is located on the bridge over the Didessa River on the road linking Bedele and Arjo towns, and is coded as station Nr. 114001. The Hydrology Department of the MoWR is the only organization to supply data and information on river discharge and sediment concentrations. For the un-gauged rivers of particular interest, estimates may be achieved from records of the Didessa River.

Station 114001 with catchment area of 9981 km² is located about 25 km up-stream of the proposed weir site and has become operational since 1960.

In general, as indicated in the hydrology report, the mean annual precipitation of around 1500 mm stretched over 9 months in the year indicates that the area can be regarded as having relatively abundant rainfall.

Surface water is also abundant given the large flow in the Didessa and high runoff witnessed in some of the perennial rivers that join the Didessa below the command area. According to the hydrology report, of this Feasibility Study, the mean annual flow at the weir site is estimated at 3714 $Mm^3$ with an annual 75% dependable flow of 2777.6 $Mm^3$ and 80% dependable 2702 $Mm^3$. In relation to the proposed weir site, the analysis for dependable flows is shown in Table 15. The project proposes to abstract an annula maximum of 50 MCM at 200% cropping intensity.

*Table 15: Monthly dependable flows (MCM) at the weir site.*

| | Jan | Feb | Mar | Mar | May | Jun | July | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 50% Dep. | 38.2 | 20.3 | 18.3 | 16.5 | 38.6 | 170.3 | 568.4 | 836.4 | 827.3 | 355.5 | 127.6 | 76.7 | 3,592 |
| 75% Dep. | 31.7 | 16.04 | 13.9 | 13.7 | 36.6 | 133.2 | 466.7 | 652.2 | 630.7 | 291.6 | 112.4 | 62.7 | 2,738 |
| 80% Dep. | 28.2 | 15.04 | 13.6 | 12.3 | 28.9 | 127.1 | 424 | 624 | 617.2 | 265.2 | 95.8 | 67.7 | 2,650 |
| 85% Dep. | 27.6 | 14.7 | 13.3 | 11.9 | 28 | 123.3 | 411.3 | 605.3 | 598.7 | 257.2 | 92.3 | 65.7 | 2,591 |
| 90% Dep. | 27.1 | 14.4 | 13 | 11.7 | 27.4 | 120.8 | 403.1 | 593.2 | 586.7 | 252.1 | 90.5 | 54.4 | 2,556 |

Water quality data for the Didessa shows that it has a very low SAR and electrical conductivity (Table 16).

*Table 16: Water quality results for sites on the Didessa River*

| Sampling | Near Arjo bridge | at Gimbi bridge |
|---|---|---|
| Sample date | 13/08/96 | 14/08/96 |
| Elevation (m asl) | 1300 | 1200 |
| TDS (gm/l) | 20 | 20 |
| EC (ms/cm) | 60 | 50 |
| PH | 6.74 | 6.97 |
| Na++ | 3.3 | 3.0 |
| K+ | 1.9 | 2.5 |
| Ca++ (mg/l) | 6.4 | 9.6 |
| Mg++ (mg/l) | 2.43 | 1.4 |
| Cl- (mg/l) | 1.0 | 2.0 |
| SAR | 0.29 | 0.25 |

Source: Water Quality Result for Major Rivers (BCEOM, 1996, Cited By BCEOM Abbay River Basin Study, 1998)

### 3.1.8.2 *Groundwater*

According to the hydrogeology report of the project, the major rock units that are expected to store adequate volume of potable water for rural water supply in the project area, are the saprolite and fractured zone and alluvial deposits along major river valleys and inter hill areas. Generally, it is noted that the saprolite and fractured zone at Dinger area is well developed.

The possibility of finding adequate amount of potable subsurface water storage within the weathered basement is thought to be locally adequate, depending on the state of weathering and rock fracturing. More promising though, due to the presence of alluvial and colluvial deposits on river valleys and inter-hill valleys, subsurface storage of water for rural water supply is possible in most places of the project area.

According to the data from wereda water office, 91 springs, 13 shallow wells, one deep well and 2 hand dug wells are developed in the 23 Kebeles of the project area. However, the data does not contain details on the well and aquifer parameters.

Moreover, it is stated in the DBIP groundwater report that rural water supply per capita in Ethiopia is assumed to be 25 l/day/person and taking the service population of each rural water supply scheme and assuming that all the schemes are functioning and all the population designed for the schemes uses these schemes, the annual groundwater abstraction/consumption is estimated to be 30,112 $m^3$. This value has been stated as very small compared to the anticipated annual recharge in the area. The report has determined that the quality of the groundwater is within permissible limits as per the WHO and Ethiopian Ministry of Health standards.

The physico-chemical data of 3 well samples collected from the IIubabore Zone Water Office. The three analyses, from wells at Ilu Harar, Urji and Dabena wells, show slight differences from one another (Table 17). The water sample from Ilu Harar, Urji and Dabena are classified as Ca-HCO3, Ca-Na-HCO3 and Mg-Na-HCO3 type, respectively. The ranges of values of water quality data are compared with WHO and Ethiopian Drinking Water Standards. Generally, the groundwater quality in Dinger Bereha is within acceptable limits compared to these drinking water quality standards. The comparison of concentration values of chemicals and other physical parameters for ground water in Dinger Bereha are shown in Table 18 and summarised in Table 19. In general the quality is satisfactory. The risk will be that these waters become contaminated from agricultural wastes.

*Table 17: Water quality data of three wells in Dinger Bereha area*

| **CLIENTS ID NO.** | **Ilu Harar** | **Urjii** | **Daabana** |
|---|---|---|---|
| SOURCE OF SAMPLE | Well | Well | Well |
| LOCATION | ILUHARAR | URJI | DABANA |
| DATE RECEIVED | 31/05/06 | 26/03/08 | 26/03/08 |
| LAB. ID NO. | 926/98 | 1509/2000 | 1511/2000 |
| Turbidity (NTU) | 5 | 18 | 5 |
| Total Solids 1050C (mg/l) | 292 | 324 | 162 |
| T.Dissolved Solid 1050C (mg/l) | 280 | 292 | 150 |
| Electrical Conductivity (us/cm | 428 | 442 | 229 |
| PH | 6.97 | 7.44 | 6.83 |
| Ammonia (mg/l NH3 | 0.26 | 0.23 | 0.13 |
| Sodium (mg/l Na) | 19.5 | 30 | 13.5 |
| Potassium (mg/l K) | 4.9 | 4.4 | 2.8 |
| Total Hardness (mg/l Ca CO3) | 202.4 | 195.3 | 105 |
| Calcium (mg/l Ca) | 58.7 | 62.16 | 4.2 |
| Magnesium (mg/l Mg) | 10.04 | 9.69 | 22.95 |
| Total Iron (mg/l Fe) | 0.43 | 0.14 | 0.32 |
| Manganese (mg/l Mn) | 0.15 | 0.1 | 0.1 |
| Fluoride (mg/l F) | 0.4 | 1.2 | 0.62 |
| Chloride (mg/l Cl) | 1.9 | 4.97 | 2.98 |
| Nitrite (mg/l NO2) | | 0.02 | 0.015 |
| Nitrate (mg/l NO3) | 0.19 | 5.78 | 6.12 |
| Alkalinity (mg/l CaCO3) | 232.5 | 224 | 122 |
| Carbonate (mg/l CO3) | Trace | Trace | Trace |
| Bicarbonate (mg/l HCO3) | 283.6 | 273.28 | 148.84 |
| Sulphate (mg/l SO4) | 6.1 | 23.3 | 1.52 |
| Phosphate (mg/l PO4) | 0.346 | 0.2 | 0.33 |

Source: DB Draft Feasibility Study, 2009. GPS data not available.

*Table 18: Comparison of water quality data of three wells in Dinger Bereha with WHO, European and Ethiopian Standards*

| Variable | WHO (1984) | European Union | Ethiopian (2002) | Dinger Bereha wells |
|---|---|---|---|---|
| Colour (TCU) | 15 | 20 | 50 | |
| TDS (mg/l) | 1000 | | 1500 | 150 -292 |
| Turbidity (NTU) | 5 | 4 | 25 | 5 - 18 |
| pH | <8.0 | 6.5-8.5 | 7-8.5 | 6.8 – 7.4 |
| Ammonia | | | 0.1 | 0.13 -0.26 |
| Nitrate | 50 | 50 | 50 | 0.19 – 6.12 |
| Phosphorus | | 5 | | |
| Sodium | 200 | 500 | | 13.5 – 30 |
| Chloride | 250 | 25 | 600 | 1.9 – 4.9 |
| Sulfate | 400 | | 483 | 1.52 – 23.3 |
| Fluoride | 1.5 | 1.5 | 1.5 | 0.4 – 1.2 |
| Arsenic | 0.01 | 0.05 | 0.05 | |
| Cadmium | 0.003 | 0.005 | 0.01 | |
| Chromium | 0.05 | 0.05 | 0.05 | |
| Copper | 2 | 0.1-3.0 | 1.5 | |
| Iron | 0.3 | 0.2 | 1 | 0.14 - 0.43 |
| Lead | 0.01 | 0.05 | 0.1 | |
| Manganese | 0.5 | 0.05 | 0.5 | 0.1 - 0.15 |
| Mercury | 0.001 | 0.001 | 0.001 | |
| Nickel | 0.02 | 0.05 | | |
| Zinc | 3 | 0.01-5.0 | 15 | |

Source: DB Draft Feasibility Study, 2009. GPS data not available.

*Table 19: Summary of key parameters for three wells in Dinger Bereha*

| Parameter | Station Code | pH | TDS | El. Conductivity | SAR |
|---|---|---|---|---|---|
| Unit | | | Mg/l | uS/cm | meq/l |
| 1 | Well1 | 6.97 | 280 | 428 | 0.62 |
| 2 | Well3 | 6.83 | 150 | 229 | 0.57 |
| 3 | Well2 | 7.44 | 292 | 442 | 0.93 |

Source: DB Draft Feasibility Study, 2009. GPS data not available.

## 3.1.9 The Biotic Environment

### 3.1.9.1 *Flora*

As explained above, prior to the resettlement, the Chewaka area was reported to have no settlers and widely covered by forests and wild life. Currently, it is dominated by disturbed forest and open woodland near and around the cultivated areas, gallery forest within the command area along the numerous streams that cross the project area and remnants of natural forest on the steep slopes and hills adjacent to the project area. The remaining natural forest is under heavy threat and pressure resulting from expansion of farmlands and settlements. In some parts the gallery forest is as wide as 100m on each side of the river bank. Diversity of tree species has been witnessed.

There is also still a reasonable coverage of shrubs and herbs which are reported by the local communities to be valuable for providing forage cover against erosion, and as a source of some medicinal and culturally important products. Between the wet areas of riverine forest along the left bank of the Didessa River and the hillslopes, there is a preponderance of very tall grass, locally known as *Jejeba* and tentatively identified as a *Hyparrhenia sp*. This land is seasonally wetted by flooding and has heavy clays. The grass is burnt off during the dry season and fires spread into the steep slopes adjacent to the study area where they are allowed to urn uncontrolled for days. A provisional list of the main tree species with their local and identified scientific names is given in **Table 20**. It is recommended that a full botanical survey is made of the forests before or at latest at start of tender design stage.

*Table 20: Principal Trees in Dinger Bereha Project Area*

| Local Name | Scientific Name (note: provisional identifications) |
|---|---|
| Akacha Siligna | Acacia saligna |
| Addessa | Teclea nobilis |
| Ambabessa | Albizia schimperiana |
| Bedessa/Dokma | Syzygium guineense |
| Bisana | Croton macrostachyus |
| Asteraceae | Berkheya spekana Oliv. |
| Birbira | Millettia ferruginea |
| Botoro | Stereospermum kunthianum |
| Buchema | Buddlega polystachya |
| Chewaka | *At present no identification is available* |
| Debacho | Olinia rocchetiana |
| Debeka | Combretum sp. |
| Gerbi/Girar | Acacia bussei |
| Gerbi/Grar | Acacia (feidherbia) albida |
| Goro/Kega | Rossa abyssinica |
| Kerkeha (Bamboo) | Arundinaria alpine |
| Kelo (flowering plant) | Bidens maroptera |
| Kombolcha | Maytenus senegalensis |
| Kosheshila | Cirsium sp. |
| Kosheshila, Shok | Echinops giganteus |
| Meti (Zemababa) | Hyphaene thebaica |
| Oda | Ficus sycomorus |
| Odesa/Wanza | Cordia africana |
| Wachu | Acacia seyal |
| Yekolla Wanza | Piliostigma sp. |
| Zigba | Podocarpus falcatus |

Source: BRL-MCE, 2009

#### 3.1.9.2 *Fauna*

The area has some residual wildlife of interest. Oribi gazelle have been seen close to Ilullu Harrar settlement and Pangolin (ant eater) holes are quite common. Elsewhere in the Didessa valley, upstream of the proposed weir site, it was noticed that there are Warthog in bushlands, and Crocodile and Hippopotamus along the river. On the steep slopes of the catchment above the irrigation area Black and White Colobus Monkey, Anubis Baboons, and other small monkeys are common. Pythons are known to exist in the wetter gallery forest area. Other snakes are reported.

It has been reported by both community members and experts from the wereda office of agriculture that there are a wide range of mammals, reptiles and birds in the proposed project area and its vicinity. Diversity of fauna, which consists of carnivore and herbivore groups, has also been reported as encountered by the settlers. But not much could be seen during the field trip except a number of baboons, monkeys and Oribi antelope. Hippopotamus, python and crocodiles are reported to be found in and around the Didessa. Lion, warthog, and baboon are also reported on the steep slopes and within the proposed Aba Diko wildlife reserve to the west of the DBIP (see next section).

#### 3.1.9.3 *Proposed Nature Reserve*

To the west of the Chaweka area are steeply sloping hills that remain well wooded. This area is being proposed by the National Regional Government of Oromia, the state government, to be a wildlife reserve. This is the mainly because of the existence, it is said, of relatively abundant wildlife in the area. This move is being backed by the Chaweka Woreda administration: it could become a useful source of income for the area to provide guides for the forest zones and their wildlife. We were unable to see the report of this proposal, at the wereda offices at Illu Harer.

The reserve, known as Aba Diko occupies parts of the three weredas: Chewaka and other two adjacent areas of Dabo Hanna and Mekko.

## 3.2 THE SOCIO-ECONOMIC ENVIRONMENT

### 3.2.1 Population and Settlement

The total area of the Chewaka wereda is about 52,000 hectares land and divided into 28 Kebeles, out of which about 25,000 hectares (48 %) of land is now designated as cultivable and of which about 19,400 hectare is already under cultivation by the new settlers. The remaining land is covered with natural forest, which is under heavy threat and pressure. The agro ecology of the Woreda varies between 1100 m asl at Didessa River to 1800. The largest majorities belong to Oromo ethnic group and adhering to Islamic faith.

The project area is located in Chewaka Woreda of Illubabor Zone within Oromia Regional State. Chewaka Woreda was established in 2004 at the time of the resettlement program which moved to the area people coming from densely populated and food-unsecured Woredas of East and West Hararghe Zone of Oromia Region. The total area of the Woreda is about 52,000 ha divided into 28 Kebeles. Prior to the resettlement program the project area was scarcely populated by Gumuz ethnic groups.

It is sometimes reported that prior to the resettlement of the Chewaka area that there were no settlers and the area was forested and inhabited by wild animals only. But it is apparent that there were some inhabitants from the Gumuz ethnic group who were residing along the Didessa river valley. Currently about 200 families from the Gumuz are believed to exist along the banks of the river with the majority of them on the right bank of the river outside of the project area.

The area was also settled by Oromo groups from the adjacent highlands on the undulating lands, who appear to have come across from the Didessa State farm area, but these have moved away.

Now however, almost the entire majority of the people in the Project Area are those settled by the Government resettlement program. People came from several food-insecure Weredas in East and West Harrage Zone of Oromia Region. The resettlement has taken place since December 2004.

Since 2004, the population of the Woreda has been increasing due both to natural growth and influx of people into the area in search of agricultural land as well as other livelihood means.

From information secured from the Woreda Administration, the total number of households which came to the area through the government sponsored resettlement program in 2004 was 12,390 representing a total population of 78,000 people. In September 2009, the number of households censed by the Woreda administration reported is 13,641 and population number is 92,027 people. Data provided by the Cheweka wereda is given in Table 21.

Almost all the population belongs to the Oromo ethnic group and adheres to the Muslim Sunni religion.

For the first three years the settlers have been receiving direct support from the government; they were provided with oxen, cash, grains and other assistance to facilitate their establishment. Each family had also received 1.5 to 2 ha of farming land depending on the family size. Currently the settlers have achieved food self sufficiency and approx 45% of agricultural production is marketed locally.

The resettled population has a previous experience of small scale irrigation in its region of origin and has currently developed a number of traditional irrigation schemes that take water from springs or streams to produce cash crops in the dry season

### 3.2.2 Experience in Irrigation

For the majorities, involvement and water management in small scale irrigation reported to be a long time experience. Many people do recognize the merit of irrigation than mere reliance on rainfed agriculture. They are enthusiastic to have irrigation in their present landholding. Many of the farmers are reported to have long experience in the operation and management of traditional irrigated agriculture and they are very enthusiastic to have the implementation of a modern irrigation scheme in their present landholdings. Traditional irrigation is very important in the kebeles of Chekorsa, Gebina, Shimeltoke, Urgi Oromia, Dersotomusema, Odakebena and Jegen.

Around 300 ha of land are reported to be under irrigation in these areas and there is a plan to increase it to around 600 ha by year 2010. Besides, organized individuals have now start forming cooperatives to be involved in irrigation schemes. About 48 members formed two irrigation cooperatives with an initial 20 hectare of land secured through lease from the Woreda. The trend generally shows that due to past experience and recognition to its merit, the people will not have a problem in involving themselves in the proposed large scale irrigation development in their area.

This experience in irrigation will be useful on the proposed project: as food security is the main objective of the proposed project, the cropping pattern will be dominated by food crops. At full project development, the annual cropping intensity would be close to 175%. Cereals (Sorghum, maize and rice) will command the major part of the area followed by pulses (haricot beans, soybean), sesame and vegetables (onion, pepper and potato).

*Table 21: Households in Chewaka Wereda (2009)*

| Kebele | Male-headed households | Female-headed households | Total |
|---|---|---|---|
| Shimel Toke | 405 | 18 | 423 |
| Gudree | 480 | 6 | 486 |
| Haro Chewaka | 355 | 7 | 362 |
| Urji Oromia | 515 | 5 | 520 |
| Cheffe Megertu | 458 | 6 | 464 |
| Diree Missoma | 622 | 45 | 667 |
| Durssitu Missoma | 417 | 4 | 421 |
| Jegen | 435 | 31 | 466 |
| Siree Gudo | 514 | 21 | 535 |
| Burka Ananai | 455 | 20 | 465 |
| Tarkanfata Missoma | 359 | 11 | 370 |
| Chaman | 291 | 5 | 296 |
| Mirgisa | 404 | 6 | 410 |
| Gabina | 708 | 34 | 742 |
| Kannani Janata | 423 | 17 | 430 |
| Chokorsa | 508 | 18 | 616 |
| Burka Baraka | 455 | 28 | 483 |
| Bahe Biftu | 471 | 11 | 482 |
| Damaksa | 481 | 13 | 494 |
| Dukki | 353 | 7 | 360 |
| Waltassa | 501 | 6 | 507 |
| Tokoma Harar | 565 | 22 | 587 |
| Bonaya | 230 | 10 | 240 |
| Biftu Ayana | 296 | 12 | 308 |
| W jalala | 248 | 28 | 276 |
| Dabena | 571 | 26 | 597 |
| J Belina | 210 | 14 | 224 |
| Kebena | 405 | 19 | 424 |
| | 12,135 | 450 | 12,655 |

Source : Chewaka Woreda Administration Office, 2009

### 3.2.3 Gender Issues

Results from the DBIP socio-economic survey show that women head about 4 % of households. The gender division of labour indicates that women are more responsible for child caring and domestic issues of the household, rather than the physical work in agricultural fields, though their role in marketing of produce is very high. Their responsibility in the household tasks is substantial, and is partly exacerbated by large family sizes. Since polygamy is reported to be quite frequent it is believed this may be one major development constraint in promoting family welfare. Women's health is said to be compromised due to the high fertility rate and a low awareness of primary health care issues. As per the information from the Women's Affairs Office, women are suffering also from a range of harmful traditional practices, such as circumcision and early marriage. The development of the proposed irrigation scheme is expected to have come with some effects on the existing division of labour due to the intensive nature of the job. Naturally, it entails the involvement of more family members. This could well create a greater burden on women.

But the desired condition is that the development intervention should not lead to an exacerbation of women's existing problem; rather it should enable them to have access to benefits that ultimately address their practical as well as strategic needs. Ensuring their participation in all stages of the decision-making is also very important. Hence, there may be a need to introduce labour and time-saving household devices. There will also be a wish to improve access to services like water supply, grinding mill, energy saving devices, and market in order to release women's labour for more productive role under the proposed large scale irrigation project. There is also a need to empower women by enhancing their participation in decision making.

### 3.2.4 Access to Other Services and Infrastructure

From the preliminary socio-economic report, the entire Chewaka Woreda is shown to be under the government-sponsored resettlement operation. Almost all social services (schools, water supply, road, health services and markets) have been established as part of the resettlement programme. Thus, all of the mentioned services are available at Kebele level. All of the 28 Kebeles have one 1st Cycle school, one health post, developed water supply (spring or hand pump), access to road and market. Besides, a higher level school (2nd cycle) is available in seven resettlement sites, serving four Kebeles on average; there are also three health centres and one high school in two resettlement sites and the Wereda capital, Illu Harar.

But because of the more and more influx of people coming there is now more and more pressure on the available water supply schemes and health services. Already serious problem of water scarcity for domestic purposes is creeping in some of the visited Kebeles (as in Jegen and Dabena). The problem is becoming more serious in those localities located in the low-lying parts.

The Project Area is accessible from the Bedele-Nekempte road, which is about 108 km long. The access road departs from this road after 18 km drive from Bedele town and/or after 90 km drive from Nekempte after crossing Arjo town and the Didessa River Bridge. The road that takes to the Wereda capital, Illu Harar, passes via Kone town, which is located 17 km away from Illu Harar. The road is paved as an all weather road but requires intensive maintenance.

Currently, a 22 km road is under construction to link the Woreda with the main Addis Ababa- Assosa highway at Didessa River. With the opening up of this short distance road to the main high way means a lot in changing the demographic and market conditions in the near future. The bridge under construction across the Didessa River to join the project area with Nekempte-Gimbi main road would be an important short cut.

The capital of the Chewaka wereda, Illu Harar, is connected to the hydropower grid system of the country and has 24 hrs electricity services. Most of the settlement centres are also connected by telephone.

The use of compost is being very much encouraged and promoted. The huge amount of biomass available makes compost preparation easy. Each farming household is required to produce about 12 metric cube of compost for the 1.5 to 2 ha of land that it farms.

## 3.2.5 Environmental Health

### 3.2.5.1 *Disease Prevalence*

As per the data received from the Wereda level health office, the entire Cheweka Wereda is malaria endemic. Malaria is the main health complaint reported in all of the health facilities. This is followed by internal parasites and diarrhoea problems. The water quality even in the developed shallow wells and springs is the cause for this water borne disease. With the expansion of irrigated agriculture these health problems could get worse unless accompanied by the proper environmental mitigation measures including the sensitization of the public as well as with the construction of the proper physical works.

### 3.2.5.2 *Health Services*

Each kebele is served by a health post and there are three health centres giving service in the wereda. The existing health infrastructure and manpower are reported to be sufficient as per the standards of the Ministry of Health for weredas. However, the reality is expected to be different under project condition due to the changes expected to come with increased migration and population and prevalence of water borne and communicable diseases.

# 4 PROJECT DESCRIPTION

## 4.1 INTRODUCTION

As part of the base line assessment the prevailing biophysical and socioeconomic situation and setup of the area proposed for the development of irrigated agriculture has already been explained briefly in the preceding chapter. It is against such an environmental setup that one has to see clearly the proposed development intervention and the ways and means of implementing it so as to come with the identification of the potential positive and negative impacts that need to be addressed by way of appropriate environmental management and monitoring system. The salient features of the project are described briefly below, and are derived from the report on hydraulics and irrigation of the project area.

## 4.2 HEADWORKS

Water of an estimated volume of 8.3m$^3$ /s would be abstracted from the Didessa River by means of a headwork which consists of a mass concrete weir, flushing channel, feeder canal off take and a settling basin of a length of 150 meters from which the settled sediment is flushed back to the river. The peak flow over the weir is 1,500 – 1,600 m$^3$/s with a return period of 100 years. The details of the project are as follows:

**Option 1: Pumping, without diversion weir:** a pump station would be located on the left bank of the Didessa River at N 90200, E 98300, where a suitable site was identified. This is where the north-south Basement Complex ridge, named Lebena, abuts against the Didessa River. The riverbed has an altitude in the order of +1220m. Downstream of this site the riverbed drops 40 m over 4 km, thus increasing the required lift rapidly over a short distance and rendering pump irrigation very costly. Water could be lifted to a canal running at +1240m that would command the area located between contour +1240 and the river. The 31 km long main canal, named MC 1240 would end at the Guracha River, a tributary of the Dabena River and would cross a number of valleys by siphon in order to limit its length. The largest valley, named Hora Chewaka, would be irrigated on the eastern side by a 13.3 km secondary canal running from N 93 500 E 87 800 in southern direction. The western side would be irrigated by a 14 km long second secondary taking-off at the d/s end of the siphon. At N 91500, E 92500 a booster station would lift water from MC 1240 to a main canal running at +1260 m. The station would be supplied by a new 10 km long powerline running from Arjo in southern direction.

The area located between +1260 and +1240 on the western side of Hora Chewaka valley would be irrigated by a second booster station located at N 94000, E 85000 and a 5 km long main canal, named Ka Kemberi and commanding the Guracha valley.

**Option 2: Gravity diversion and booster pumping**: about 15 km upstream of the pump station site the riverbed has an altitude of +1240m. At this site, the river has a bed width in the order of 150 m and water could be diverted by a 3-4 m high concrete weir to a feeder canal running on the left bank that would follow the +1244 contour at a gradient of 0,10 m/km to the foot of the Lebena ridge, at the most eastern tip of the irrigation scheme.

The canal would run closely to the river through an area with cross slope between 3 and 10%. The command area between +1240 and +1260 would be irrigated by two booster stations.

Irrigation of land would be possible on the left bank in an area, bounded by contour +1260 to the west, by river Dabena to the north and by Didessa River to the east (see Map 01). Table 1 shows that the gross command area would be in the order of 6,100 ha between rivers and contour +1240 and 5,100 ha between contours +1240 and +1260. Excluding the buffer zone of 661 ha, the net irrigable area under command by gravity and one stage pumping or by two stage pumping is estimated at 7,850 ha or 70% of the total gross area.

In addition, water for the western area could be supplied from Dabena River by a pump station that would be located at N 993 400 and E 174 500, on the right bank of Dabena River at an elevation of +1230. Water would be lifted via pipelines over a length of 2,870 m up to an elevation of +1285 m from where it would run through natural streams until it is diverted to the west pump canal or to the higher lying canal that could command the western zone between +1260 and +1280 as well. The head loss would be about 10 m, so the dynamic head would in the order of 65 m.

## 4.3 ACCESS ROAD

The project also includes the construction of a cut-off drain and 5m access road and an embankment of 2m along the canals.

## 4.4 CONVEYANCE AND DISTRIBUTION

Water is diverted 24 hrs per day from the head works and is discharged into a Night Storage Reservoir, which serves as a night storage for the irrigated area upstream, by a lined feeder canal of about 16.8 km long following the Didessa River very closely for most of its length and again by a lined primary canal of about 30 km long, that crosses numerous deep watercourses in inverted siphons before it reaches the night storage reservoir.

The irrigation water is thereafter pumped from the Pumping Station of the Night Storage Reservoir into 4 other night storages known as Primaries via individual rising mains and these four reservoirs in turn serve as night storages for the secondary pipelines which release water on demand with downstream control. Secondary main pipes from the four reservoirs and tertiary pipelines which serve surrounding command areas via hydrants with flow controllers each serving a group of 2 to 4 farmers with 4 to 5 ha. At last constant flow of 9 to 10 l/s is rotated to farmers via an underground pipeline and private hydrant with scheduled shutoff.

## 4.5 OPERATION OF THE PROJECT

Irrigation will only take place during the 12 hours of day light but the feeder canals, Primary canals and pump stations will operate at a constant flow, appropriate to the irrigation demand, for the whole 24 hour period. During the night, Storage Reservoirs will be filled and during the day these reservoirs will be emptied.

## 4.6 AGRONOMIC PRACTICE

Taking into consideration the climatic and land suitability, subsistence needs, potential markets, as well as farmers' preference the net irrigated area expected to be 7,852 ha is to be planted with various crops in the rainy and dry season as shown in the Table 22, below.

*Table 22: Area of Land Planted with Crops (%)*

| Crop | Rainy Season | Dry Season |
|---|---|---|
| Sorghum | 40 | 0 |
| Maize | 10 | 30 |
| Rice | 5 | 0 |
| Sesame | 20 | 25 |
| Beans | 20 | 25 |
| Vegetables | 0 | 15 |
| Citrus | 5 | 5 |

Source: Woreda office

These crops are rotated in such a way that each cereal is followed by beans and vegetables except in the case of citrus which is perennial.

To summarize, the implementation of the Dinger Bereha Irrigation project is expected to involve the following activities:

- Head work construction of various types (mass concrete weir, flushing channel, feeder canal off take and a settling basin).
- Construction of cut-off drain, access road and embankments
- Construction of irrigation and drainage canals (feeder, primary, secondary and tertiary, siphons, culverts, etc.)
- Construction of reservoirs, pump stations and raising mains
- Construction of approximately 20 km 60 KV power line.
- Farm area development
- Agronomic intervention of different types
- Maintenance of irrigation infrastructures

There is no doubt that properly managed irrigation schemes contribute significantly to agriculture output and food supply thereby improving the economic well-being and quality of life of the target population. However, such projects may also cause serious adverse effects on the environment. If an irrigation project does not function properly, it may result in the disruption of the biophysical and social economic infrastructures. Following is the discussion on potential positive and negative impacts of the project.

# 5 POTENTIAL IMPACTS

## 5.1 INTRODUCTION

The likely positive and negative impacts that can be expected, as well as the environmental mitigation, management and monitoring aspects to be recommended hereafter will largely depend on the nature and characteristics of the project phenomena that have so far been explained in relation to the:

- Environmental base line conditions of the project area i.e. the physical, biotic and socio-economic environment;
- Legal, institutional and policy framework.
- Nature and type of the proposed irrigation scheme and the technological option adopted.

Hence, there was every reason to discuss and elaborate these items at length in order to explore all relevant issues that would enable us to identify the positive and negative environmental impacts. As explained earlier in the screening and scoping process, whatever has been manifested in the form of either positive or negative impacts on the bio-physical and socio-economic aspects as per the assessment made using the ICID checklist (Tables 1 and 23) has been treated accordingly as follows.

## 5.2 IMPACTS - EXTERNAL FACTORS

### 5.2.1 Positive Impacts

Though it may not be conventional, it is also very important at this stage to forward some points in relation to the positive impacts of the environment on the project. These are prevailing factors external to the project that would in one way or the other make the implementation of the project easier and would also serve as factors for its success. In this respect the following need to be considered as the main likely assets that will result from the project:

- Availability of adequate surface water in terms of quantity and quality and thereby satisfying the water needs for the envisaged irrigated agriculture;
- Availability of a relatively better coverage of vegetation cover and diversity of plant and animal species;
- Water quality suitable for irrigation (currently this has a low pollution from upstream activities);
- Highly motivated people who already took the risk of resettlement to improve their livelihood;
- The existence of a relatively fair exercise and experience in irrigated agriculture of the inhabitants in the proposed area for some time now, both at their places of origin in the proposed project area, especially the experience so far gained in the traditional irrigation schemes including agronomic practice and knowledge gained in the process

### 5.2.2 Negative Impacts

In turn the negative impacts that exist at the present time can be stated to include:

- The proposed project area being endemic to water borne diseases such as malaria and cattle diseases including Trypanosomiasis.
- Poor soil nutrient condition
- Low development of development infrastructure (roads, market, etc.)
- High rate of population increase and large family sizes resulting from the tradition of having more than wife
- The possibility of the emergence of development activities at both regional and national level upstream of the irrigation scheme that does not appropriately take into account its resource requirements in terms quantity and quality has to be regarded as a threat to sustainability of the project. This can be manifested in terms of implementing development activities that either compete heavily for resources or release any polluting or hazardous waste can be regarded as a likely external negative impact.

## 5.3 IMPACTS - INTERNAL OR PROJECT GENERATED

The implementation of the proposed Dinger Bereha Irrigation Project will be accompanied by an alteration of the natural conditions of the landscape by extracting water from previously an available source, adding water to fields where there was none or little before, and introducing man-made structures and features to extract, transfer and dispose of water. Furthermore, the irrigated agriculture practices which a) different construction works of the irrigation projects b) water supply and operation of the irrigation projects, and c) the irrigated agriculture management practices can impact bio-physical and socio-economic environment in a variety of ways positively and negatively as shown below. Impacts are shown on the completed ICID checklist (Table 22) shown at the end of this chapter.

### 5.3.1 Positive Impacts

- Creation of reservoirs and other permanent movement of fresh water in the form of the different canals, etc which adds water to areas where there was none or little before can create better microclimate in addition to the provision of water that can be utilized for different purposes.

- Creation of opportunities for having recreation areas using the reservoirs that come as part of the irrigation scheme.

- The relatively better vegetation cover on both the command and the hinterland which in turn is responsible for the rich biodiversity can be an asset if properly managed.

- Creation of wet condition on the land surface of the command area which can lower wind and water erosion.

- Increase in agricultural yields and production, generating additional revenues directly from the project output.

- Increased and diversified food supply all year long fulfilling basic local needs and Improvement in quality of life due to new economic opportunities

- Increase in local development and employment.

- Increase in revenues for the local population due to induced development and complementary activities

- Possibility of improving the wellbeing of women again due to induced development and complementary activities as well as development of appropriate skills and knowledge
- Increased income and improved nutrition from irrigated agriculture will benefit women and children in particular.
- Possibility of development of appropriate skills and knowledge
- Increased opportunities for high value crop productions with access to irrigated water and appropriate irrigation technology.
- Perturbation of existing activities, particularly traditional agriculture.
- Increase in land values and price due to irrigation water.
- Extremely low possibility of disruption of existing settlements which makes project cost lower

The positive impacts identified above are very important and deserve appropriate attention and action since the aim of the whole exercise is to introduce measures which minimize any identified adverse impacts and enhance positive impacts.

## 5.3.2 Negative Impacts - Biophysical Aspects

### 5.3.2.1 *Hydrological Changes*

**Low flow regime/flood regime/operation of dams/fall of water table/rise of water table**

As has been indicated in the base line assessment water an estimated volume of 8.3 $m^3$/s is to be abstracted from the Didessa River at the weir site. The annual flow at the weir site is estimated at 3,714 $Mm^3$ with an annual 75% dependable flow of 2,778 $Mm^3$ and 80% dependable 2,702 $Mm^3$. The project proposes to abstract a total of 50 MCM per annum from the Didessa at 200% cropping intensity. The impact of this amount is minimal on the flow of the Didessa further downstream. Of course in the future if numerous other schemes were to take such amounts the situation would change.

Surface water is also abundant given the huge amount of water in the Didessa and substantial runoff witnessed in some of the perennial rivers that join the Didessa downstream of the weir site. This condition is ideal for the flow recovery immediately downstream of the river.

Hence, in a situation like this project where large abstractions are not contemplated by the project and given the status of other related developments both upstream and downstream, hydrological parameters that are normally assumed to be affected by the irrigation project such as the low flow regime, flood regime, and fall of water table are either very insignificant or irrelevant to be considered under the category of negative impacts. The only aspect of worry would be the case of rise of the water table that can occur under inefficient water management on the flat areas immediately upstream of the confluence of the Dabena and Didessa making a negative impact possible.

### 5.3.2.2 *Organic and Inorganic Pollution*

This covers solute dispersion/toxic substances, organic pollution, anaerobic effects and gas emissions.

The provision of good quality irrigation water, free from harmful levels of soluble salts, introduced toxic substances or pollutants is very essential for the sustainability of an irrigation scheme. Generally polluted sources will result from poor management by upstream users. At the same time where project drainage waters will be passed back into the river system (in this case the many tributaries of the Didessa River) or into the groundwater there is a risk that project generated pollutants will affect downstream users.

In this respect, the water quality of the Didessa upstream the weir site as given by previous studies does not seem to impose any danger of organic and inorganic pollution so far. Any danger of such a pollution is therefore expected to emanate either from the implementation of the proposed irrigation project or other similar activities which seem to be realized very soon upstream to the project if appropriate mitigation measures are not taken accordingly from within and without the project. It is also very likely that a range of organic and inorganic substances and materials will be used and produced in the irrigation scheme.

Hence, as shown in the ICID checklist utilized for this assessment it is possible that concentrations of organic or inorganic solutes that occur in drainage water from expected irrigation schemes upstream and the scheme itself can pollute the numerous streams that cross the command area and downstream in the form of solute dispersion making Negative impact possible.

Given the existing low development of any sort of large scale commercial agriculture, low urbanization and industrialization in the upper and middle catchment area of the Didessa valley, the proliferation of toxic substances in the form of residual effects upstream can be regarded as insignificant. However, as can be gathered from future development plans of the basin, expansion of both agricultural and agro-industrial establishments upstream and the implementation of the Dinger Bereha Irrigation itself there may be an increase in animal waste and sewage from settlements. These will very likely generate more toxic substances and organic pollution due to the use of more and more herbicides, pesticides, chemical fertilizers and other toxic substances discharged from industries. Assessment of Impact Category: Negative impact possible.

The likelihood of the occurrence of the possibility or any likely negative impacts due to anaerobic effects seems to be very insignificant due to the rare possibility of inundation or accumulation of water that gives way to eutrophication given the slope and expected gradient of the streams even at times of over-supply of nutrients. No judgment seems to be possible currently with regards gas emissions to become a cause of negative impact given the current trend of urban and industrial development in and around the project area. However, emission control technology, if properly applied, can minimize possible negative impacts in case of air pollution from possible agro-industry associated developments within the scheme.

#### 5.3.2.3 *Soils, Soil Fertility and Salinity*

- ***Soil Salinity***

The build up of salts in soils under irrigation is a common process where the water quality is poor, or the soils too shallow to allow adequate leaching, and land management inadequate. Given the good water quality of the Didessa River, the intrusion of salty water from without the project is not significant. The soils study of the project has not included soil salinity in the list of constraints resulting from soils. It does not pose any danger in the immediate future. However, there may be slight and slow build-up of salinity over time due to effects of irrigation water bringing the possibility of negative impacts in low lying areas where effective drainage is not implemented, and if water quality in the Didessa deteriorates from upstream effluents. Assessment of Impact Category: Negative impacts are possible.

- ***Soil Properties***

The soils have a low status of fertility. Excessive use of chemical fertilizers to retain productivity under intensification, and use of agro-chemicals, can introduce toxic elements into drainage returns that may pass into the Didessa.

Soil Compaction and soil contamination can arise from mechanical works and spilling of hazardous waste respectively.

#### 5.3.2.4 *Erosion and Sedimentation*

Perhaps the most profound negative effect expected from implementation of the Dinger Bereha Irrigation project would be that of increased soil erosion locally within the command.

- Locally construction activities related to the development of all sorts of irrigation infrastructure and the effect of agricultural practices on soil structure are expected to exacerbate soil erosion.

- The irrigation development will for sure come with a number of environmental impacts especially the significant soil erosion that can arise due to the huge construction of head works, feeder canal, main canal roads, etc as explained earlier in the section on project description. Construction activities such as land clearing, burning, excavation, extracting, filling, compacting, waterways crossing, use of heavy machinery, construction of facilities, etc. will exacerbate soil erosion.

- Soil erosion and sedimentation in the rivers, canals and soils, with degradation of lands and riverbanks.

- Greater use and destruction of the remaining patches of forest on the mountain slopes for fuel wood, construction and expansion of agricultural land will cause deforestation and decrease in the overall vegetative cover thereby enhancing devastation by soil erosion will have detrimental effect on the local fertility and ecology. It will also contribute to sediment related problems.

- It is possible that the irrigation development can attract more and more people into the fringing parts of the scheme bringing a hinterland effect. This can unbalance the existing and long sustained land use practices, causing land degradation, erosion, and conflict.

- The project could attract establishment of more settlers on the land lying upslope of the command where there are few villages at present.

- Again, in relation to the hinterland, the expected increase in intensity of human activity and economic activity in areas surrounding the scheme which can be manifested in the form of more intensive rain fed agriculture, increase in the number of livestock and greater use of forests for different purposes can result in more erosion and sedimentation problems. This is again detrimental to the ecology of the area and such an increase in soil erosion and sedimentation as well as siltation is known to have a profound effect on the functioning of the various irrigation intakes, canals, as well as many other irrigation infrastructures.

#### 5.3.2.5 *Biological and Ecological Changes*

- Though there has not been any adequate base line study of the existing plant and animal species in terms of size and diversity, the land taken by the project will for sure be negatively affected in terms of the strong possibility of losing its existing biodiversity as more and more land is going to be utilized for irrigated agriculture and for settlement development. The trend in the gradual transformation to commercial agriculture and the possibility of monocultures can impact the local flora and fauna reducing biodiversity. This can also result in changing the overall habitat in terms of losing the prevailing plant and animal species through deforestation and clearing resulting in animal migration. The existing riverine forest along the Didessa and Dabena as well as along the numerous streams that pass over the project area will be very much threatened.

- Again, though there is no any nationally designated land for its rare and endangered species within the project area, as has been explained earlier in the base line assessment, the proposed Aba Diko natural reserve which partially falls within the project wereda can be negatively affected due to obstacles that can be created to animal movements.

- Overall, the possibility of introduction of exotic species of plants and animals drive indigenous ones to extinction.

- The main reservoir and the other four reservoirs to be created for night storage can also provide favourable habitats for disease transmitting insects and snails.

- The reduced quality of irrigation drainage return flows due to organic and non-organic pollution can also negatively affect the water and aquatic life of the different streams that pass over the command area.

Hence, these and other factors explained earlier in relation to deforestation, soil erosion, use of agro-chemicals, etc, can have the possibility of creating negative impacts in terms of serious ecological imbalances both at the project site and in adjacent areas that can be manifested the form of proliferation of pests and weeds, animal disease, and aquatic weeds regardless of their size and distribution, unless otherwise adequate and appropriate corrective measures are incorporated.

To summarize one can say the irrigation scheme can be a cause to damages of the ecological resources. The construction activities required to implement the project and the agglomeration of population caused by economic dynamism will exert much more pressure on the natural base of vegetation to fulfil its varied requirements like that of more farmland, and infrastructure, wood for fuel and other purposes creating conducive atmosphere for:

- Encroachment to ecologically sensitive areas such as the gallery forest on the streams and forest remains on the slopes and mountains found in the hinterland.

- Cause reduction of biodiversity,

- Causes damages to trees for different types of construction and fuel wood needs, loss of vegetation due to land clearing, loss of forest products (fuel wood, timber, non timber forest products, medicinal plants),

- Degradation of the landscape by land clearing, construction works, new infrastructures, degradation of wild life, and clearing for new farms by burning of forests and bushes and shrubs.

### 5.3.3 Socio-Economic Impacts

#### 5.3.3.1 *Population Change*

The development of large scale irrigation schemes is normally associated with bringing new trends in the population dynamics of the area which can impact the socio-economic environment negatively. Increased economic activity, prosperity and improvement in livelihood of the population in the Dinger Bereha as the result of the irrigation scheme will give rise to the increase in population density due to population growth encouraged by the irrigation scheme land allocation criteria which can favour large families and uncontrolled influx of migrants attracted by new economic opportunities. The expected human migration during the construction period and during peak periods of agricultural labour demands will create unwanted pressure on existing public services, facilities and socio-economic infrastructures.

This can have far reaching consequences in terms of the provision of accommodations, adequate services in the area of health, water supply, education, as well as problems that can be created by the increased incidence of diseases, especially in relation to sexually transmitted diseases and breakdown in community infrastructure.

#### 5.3.3.2 *Income and Amenity*

Given the current limitations in skill and knowledge in both the public and the private sector and among the farmers in general, ill organized operation and maintenance of the irrigation scheme, reduced farming flexibility, insufficient external supports such as markets, agro-chemical inputs, extension and credit services can result in the reduction of the income generation capacity of the irrigation scheme thereby affecting income and amenity negatively.

#### 5.3.3.3 *Role of Women*

It is possible that the intensive nature of labour expected to come with the irrigation scheme will definitely create the involvement of more family members thereby resulting in more burdens on women unless appropriate labour saving technologies are incorporated with the scheme. There is a danger that the increased work load on women might not be appropriately compensated by commensurate access to resources.

#### 5.3.3.4 *Indigenous People and Minority Groups*

Activities related to the construction of irrigation headwork, the feeder canal, access and maintenance road which will take place over a long distance of the Didessa River and the associated camping and movement of people can be a threat to the around 200 families of Gumuz people living on the right bank of the river. The Gumuz are reported as having the preference of secluded life style, but it was observed they ferry settlers across the river in their dugout canoes at various locations on the Didessa.

#### 5.3.3.5 *Sites of Value & Cultural Heritage*

We were unable to find any reference to any literature on the subject for this area. The base line surveys (soils and topography) and the environmental tours did not show up any presence of historical, religious or cultural heritage sites in the project area, nor of any mention of these. The environmental assessment team made a series of tours cross the area and saw no evidence of remains and heard of no heritage remains from discussions with the wereda administration. That is not to state that such features or remains do not exist. Furthermore, this is a very large area and ancient sites could well be buried on under colluvium on slopes and in valley floors.

During detailed design stage it is recommended that a survey is made along the canal lines. In addition, during construction it is possible that canal lines could cut through ancient settlements that have been buried and these would need to be evaluated by an on-site archaeological inspector who would decide if a rescue dig was necessary.

What is important are the land cover and landscapes that may be negatively affected by the project. It is very likely that areas of aesthetic value in terms of an attractive landscape and vegetation cover can be damaged and destroyed unless effort is made in as much as possible to preserve such areas.

#### 5.3.3.6 *Regional Effects*

It is very likely that the implementation of such a big irrigation scheme with a relatively higher and improved technology will exert pressure and demand on both the regional and national governments for the fulfilment of required public services and facilities, capacity building requirements as well as marketing and other infrastructural requirements. At times, such support can be unattainable at the desired level under existing constraints and due to other commitments of the government. Such a situation may act as a negative impact and setup in efforts made to make the project successful.

#### 5.3.3.7 *User Involvement*

It is possible that the required level of participation on the part of the beneficiaries may not be attained for reasons such as that it may take much more time, lack of commitment and readiness as well as capacity on the part of those responsible resulting in low consultations and in appropriate planning in the whole implementation process finally affecting the sustainability of the scheme.

#### 5.3.3.8 *Human Health*

As explained earlier the agro-ecological characteristics of the project area such as the altitude, temperature and moisture conditions compounded by the creation of even more surface water and wet condition that come with the irrigation scheme will create an ideal condition for the exacerbation of water borne and water related diseases. The diseases that will most directly be linked with the irrigation scheme are malaria, bilharzia (schistosomiasis) and river blindness (onchoceriasis), whose vectors are reported to proliferate in the proposed Didessa irrigation waters.

Other irrigation-related health risks include those associated with increased use of agrochemicals, deterioration of water quality, and increased population pressure in the area. The risk that one or more of the above diseases is introduced or has an increased impact is most likely in the irrigation scheme in and around places where the night storage reservoirs will be constructed; soil drainage is poor, drainage canals are either absent, badly designed and/or maintained; rice or sugar cane is cultivated; and in places where borrow pits are left with stagnant water. This is because such introduction of new wetlands to the landscape will increase the available habitat area for disease vectors over both time and space.

The expected labour migration and agglomeration of population that can be created due to the creation of more settlements can also create a burden on existing water supply and sanitation facilities as well as health services giving rise to the spread of different types of communicable and infectious diseases. Given the expected increase in population density, a significant change in the transmission risk of water related diseases is very likely.

#### 5.3.3.9 *Disease Hosts*

It is certain that when crop production is increased and becomes more variable in the proposed Dinger irrigation scheme there will be a concomitant increase in disease host populations of rats and birds. Livestock numbers can be expected to increase with the project with more feed available and such a trend paralleled with a human population increase is likely to lead to more interaction with disease vectors.

## 5.4 DOWNSTREAM IMPACTS AND TRANSBOUNDARY EFFECTS

The proposed Dinger Bereha Irrigation Project would receive its irrigation water by a weir that diverts water from the Didessa River, a perennial tributary of the Nile, which adds a significant volume of water to Nile (Abbay), which in turn joins the Blue Nile and Main Nile in Sudan. The Didessa originates from the south west highlands of Ethiopia, an area of relatively abundant rainfall. In addition to that of Didessa, the Abbay receives water from other major tributaries on its left and right bank across its long course within Ethiopia. Water from the Didessa River is required to irrigate an irrigation scheme which commands an area of about 7,550 ha.

Irrigation practices elsewhere downstream of the weir site (and within Ethiopia) are considered to be insignificant due to lack of suitable lands.

The impact of a project across a border on another country can have deleterious effects if possible impacts are not examined during project planning. A study on transboundary environmental analysis by NBI et al (2001) identified several issues that relate to the Nile basin:

- Physical or chemical impacts that can cross national boundaries downstream;
- Loss of degradation of wetlands and lakes;
- Need for transboundary cooperation to protect key habitats;
- Lack of early warning systems;
- Spread of exotic and invasive water weeds;
- Waterborne diseases (malaria, diarrhoea, bilharzia).

In the case of the Dinger Bereha area these issues can be dealt with in turn:

- Physical or chemical impacts that can cross national boundaries downstream: reduced flow from the Didessa into the Nile resulting from the Dinger Bereha project is minimal amounting to a small fraction of the annual flow. Of more concern may be influx of fertiliser leachates from soils into the drainage waters and their return to the Didessa. The project will need to look carefully at the use of agrochemicals on the project to minimise such risk.

- Loss of degradation of wetlands and lakes: the wetland areas mentioned in the soil studies, and proposed for rice production are seasonally flooded and already under use for grazing. There are no lakes. There is thus likely no important impact here.

- Need for transboundary cooperation to protect key habitats: the project area is quite remote from the Ethiopian border and this does not apply.

- Lack of early warning systems: with so many plans being prepared for use of the Nile in both Ethiopia and Sudan as well as ongoing requirements in Egypt, this is a priority that is being neglected at present.

- Spread of exotic and invasive water weeds: this is not an issue in the case of Dinger Bereha.

- Waterborne diseases (malaria, diarrhoea, bilharzia): these diseases, and others, are present in the area already. The use of storage reservoirs may lead to increased mosquito larvae habitats and provision will need to be made to reduce impacts. In any case these will not have an impact in Sudan.

Transboundary impacts are, therefore, not considered relevant at this time, but future developments on the Didessa River should be carefully monitored. A potential negative impact downstream and transboundary is likely to be the influx of agro-chemicals coming out of the Dinger Bereha scheme back into the Didessa River unless appropriate mitigation is in place.

## 5.5 DISCUSSION ON IMPACTS OF 'WITH' AND 'WITHOUT THE PROJECT'

Economic analysis for a project traditionally looks at the 'without project' or 'no project' scenario where conditions in the project area are assessed assuming, as in this case, no irrigation development will take place. This section looks at what would be the likely impacts to occur in the Dinger Bereha area if an irrigation supply was not taken from Didessa and the benefits that it may produce.

To gauge the likely trends that would take place in the rural economy without irrigation it is necessary to have a baseline on which to measure subsequent change. In the Dinger Bereha area, both for the proposed irrigation area, the structures on the Didessa, and canals there is now considerable information from the soils, agriculture, livestock, land-tenure and socio-economic studies made for the Feasibility Study. These baseline data have been obtained in the project area during 2008-2009.

The rural economy of the Dinger Bereha is at present dominated by rainfed agriculture for a range of cereals, especially sorghum. The environmental and soils studies have noted that there is a state of fairly serious soil erosion by water on the sloping farmlands. Soil and water conservation (SWC) measures are not being implemented on a large scale. In addition the natural gallery forest is being cut down in streamlines. These negative impacts are already present. Under the project they are quite likely to be accelerated unless a serious attempt is made by the Cheweka wereda administration to reduce them: the agricultural services at Cheweka wereda have qualified technical staff, that are providing extension services to the farming population, and they are aware of these issues.

One important positive impact of the project will be that settlement and resettlement costs will be zero as all the settlements are already in place.

Another positive impact is that, unlike the other ENIDS study area at Wad Meskin in Sudan, the Dinger Bereha area is fortunate that it receives a substantial annual rainfall that is sufficient for rainfed cropping. That is not to say drought years could occur but the risk is much smaller than at Wad Meskin. Thus, the impact of the 'no project' situation would mean that farming would continue to offer moderate returns to the settled population. However, the farmed lands are eroding due to lack of soil and water conservation measures and a complete lack of grass-banked terraces, etc, and here the project has much to offer.

Under the irrigation project there is a better chance for reducing erosion in particular as irrigation water can be used to develop appropriate SWC measures: at present land husbandry is not being well managed and there is serious erosion of soils that will further deplete the fertility state of these soils. At present though, the state of erosion of the lands and destruction of woodlands is serious. These trends represent negative impacts that could be increased more significantly if the irrigation system is not managed in a way to minimise erosion and protect the landscape and its land-cover. This will be the challenge of the project to lessen such negative impacts, but mitigation for improved land husbandry needs to be initiated now not later.

The economic and social analysis has stated that main social impact of the project will be to show that the food security targets are obtained. The suggested annual production of cereals will allow, it is thought, for substantial surpluses that can be sold outside the Project area. The increase of revenue at the household level is shown in the on-farm analyses and these would enhance lifestyles, and also, for example, enable people to gain access to more advanced educational and health services in nearby towns. Here the new road bridge on the Didessa will provide access, and create wealth for households.

The economic and financial analysis has suggested that around 8,000 workers could find permanent activities with an equivalent yearly salary over birr 4,000, and that a further indirect total of some 1,000 jobs could be created in the fields of: water management, market activities (storage, transport, sale of goods), purchase cooperative activities, input providers, spare part distributors, and repair services. The project therefore is likely to have positive social impacts.

*Table 23: Completed ICID Checklist of Impacts*

| For each environmental effect a cross (x) is placed in one of the columns | | Positive impact very likely | Positive impact possible | No impact likely | Negative impact possible | Negative impact very likely | No judgment possible at present |
|---|---|---|---|---|---|---|---|
| **Section** | **Impact Category:** | **A** | **B** | **C** | **D** | **E** | **F** |
| **Hydrology** | **Low flow regime** | | | X | | | |
| | **Flood regime** | | | X | | | |
| | **Operation of dams** | | | NR | | | |
| | **Fall of water table** | | | X | | | |
| | **Rise of water table** | | | | X | | |
| **Organic & Inorganic Pollution** | **Solute dispersion** | | | | X | | |
| | **Toxic substances** | | | | | X | |
| | **Organic pollution** | | | | | X | |
| | **Anaerobic effects** | | | | X | | |
| | **Gas emissions** | | | | X | | |
| **Soils and Salinity** | **Soil salinity** | | | | | X | |
| | **Soil properties** | | | | | X | |
| | **Saline groundwater** | | | | X | | |
| | **Saline drainage** | | | | | X | |
| | **Saline intrusion** | | | X | | | |
| **Erosion and Sedimentation** | **Local erosion** | | | | | X | |
| | **Hinterland effect** | | | | | X | |
| | **River morphology** | | | X | | | |
| | **Channel structures** | | | | X | | |
| | **Sedimentation** | | | | | X | |
| | **Estuary erosion** | | | X | | | |
| **Biological & Ecological Change** | **Project lands -a-Land take:** | | | | X | | |
| | **-b-Provision of irrigation** | | | | X | | |
| | **-c- Settlement development** | | | | | | X |
| | **Water bodies** | | | | | X | |
| | **Surrounding area** | | | | | X | |
| | **Rivers & riverine habitats** | | | | X | | |
| | **Rare species** | | | | | | X |
| | **Animal migration** | | | | | X | |
| | **Natural industry** | | | | | | X |
| **Socio-economics** | **Population change** | | | | | X | |
| | **Income & amenity** | X | | | | | |
| | **Human migration** | | | | X | | |
| | **Resettlement** | | | | | | X |
| | **Women's role** | | X | | X | | |
| | **Minority groups** | | | | X | | |
| | **Sites of value** | | | | X | | |
| | **Regional effects** | | X | | X | | |
| | **User involvement** | | X | | X | | |
| | **Recreation** | | X | | | | |
| **Health** | **Water & sanitation** | | X | | X | | |
| | **Habitation** | | | | | | |
| | **Health services** | | X | | X | | |
| | **Nutrition** | | X | | | | |
| | **Relocation effect** | | | | | | |
| | **Disease ecology** | | | | | X | |
| | **Disease hosts** | | | | | X | |
| | **Disease control** | | X | | | | |
| | **Other hazards** | | | | X | | |
| **Ecological Imbalances** | **Pests & weeds** | | | | | X | |
| | **Animal diseases** | | | | | X | |
| | **Aquatic weeds** | | | | | X | |
| | **Structural damage** | | | | | X | |
| | **Animal imbalances** | | | | | X | |

Source: ICID Checklist by Mock and Bolton, 1993.

# 6 ENHANCEMENT AND MITIGATION MEASURES

## 6.1 INTRODUCTION

The assessment of the baseline biophysical and socio-economic condition of the Dinger Bereha and the interventions and the type of technology to be used to make the proposed irrigation scheme a reality have so far enabled us to identify the most important positive and negative potential impacts associated with the implementation of the project based on the ICID checklist as presented in the preceding chapters.

As explained earlier the implementation and success of the proposed irrigation scheme depends on the ways and means as well as appropriateness of the enhancement measures taken for the sustainability of the beneficial impacts as well as the remedial actions to be taken by way of mitigating measures to avoid or minimize the occurrence of the negative impacts.

The accuracy of the screening, scoping and predictions made depends on a variety of factors most importantly on the availability of data and knowledge regarding the biophysical and socioeconomic phenomena under consideration.

It has to be noted that some of the technological options and the incorporated in implementing the irrigation project have been recommended based on the benefits they can bring to eliminate or reduce the negative impacts that are expected to arise based on the existing biophysical and socioeconomic reality in the project area.

Again, the enhancement and mitigation measures are recommended based on a delicate and appropriate balance of improvements required in both the software and hardware aspects that need to be utilized in the process of implementation. Improvements in the software aspect i.e. education (training and capacity building), institutional building, legal structures and external support services have been found to be much important than the in the hardware aspect i.e. the irrigation technology or required physical structure since much of this has been taken care by the technological options recommended and incorporated already as part of the feasibility study as indicated above.

Tables 24 and 25 provide a summary of enhancement and mitigation measures recommended for the potential positive impacts and negative or adverse impacts respectively as appropriate and as per the identification made in the preceding chapter.

*Table 24: Summary of Enhancement Measures for Potential Positive (Beneficial) Impacts*

| No. | Potential Beneficial Impacts | Enhancement Measures | Responsible body |
|---|---|---|---|
| 1. | ***External - Environment*** | | |
| 1.1 | Adequate surface water in terms of quantity and quality | Implement appropriate watershed management & water resources planning | Natural Resources Office & Kebele |
| 1.2 | Better vegetation cover and diversity of plant and animal species. | Introduce appropriate natural resources management | Natural Resources Office & Kebele |
| 1.3 | Lower pollution from upstream activities | Monitor activities and maintain the health of the watershed | Natural Resources Office & Kebele |
| 1.4 | Highly motivated people | Provide knowledge & skills | Capacity Building Office |
| 1.5 | Existing experience in traditional irrigated agriculture | Enhanced capacity building | Office for Agriculture & Rural Development |
| **2.** | ***Internal (Project Effect)*** | | |
| 2.1 | Increased agricultural productivity | Ensure adequate revenue generation to cover costs | Farmers, Kebele & Wereda Support Offices |
| 2.2 | Increased local development and employment. | Ensure that beneficiaries harvest the fruits of their labour | Kebele, Wereda Administration and Support Offices |
| 2.3 | Development of water management skills | Assure beneficiary participation & sustainability | Agriculture and Water Offices |
| 2.4 | Increased revenue due Induced development and complementary activities | Develop investment opportunities and assure the benefit of disadvantaged groups as well as women & children | Wereda, Zonal & Regional Administration |
| 2.5 | Development of new infrastructures/improvement of existing ones (water supply, health, etc.) | Implement regular maintenance and rehabilitation | Wereda, Zonal & Regional Administration |
| 2.6 | Improved nutrition | Enhance awareness on food and nutrition & assure benefit of women and children | Kebele & Wereda Health Agents |
| 2.7 | High value crop productions | Ensure market & credit facilities | Administration & Cooperatives |
| 2.8 | Development of appropriate irrigation technology & perturbation of existing activities, particularly traditional agriculture | Enhanced capacity building and skill and knowledge programs | Agriculture and Water Offices |
| 2.9 | Increased income and nutrition benefiting women & children | Implement gender based skill trainings and capacity building programs | Wereda Women's Organization & Administration |
| 2.10 | More Freshwater better microclimate & recreation | Promote and provide regulated recreational activities and opportunities, protect resources | Office of Natural Resources & Tourism |
| 2.11 | Low disruption of settlements | Maintain ways and means of reducing settlement disruption. | Wereda Administration |
| 2.12 | Improved Irrigation technology (lined canals and piped irrigation) | Regular maintenance and rehabilitation of system | Consultant, Contractor & Water Users Association |
| 2.13 | Potential use of irrigation drainage to grow trees, orchards, woodlots or forests | Incorporate it in Natural Resources Management plan of the wereda | Farmers, Water Users Association & Wereda Natural resources |

*Table 25: Summary of Mitigation Measures for Potential Negative/Adverse Impacts*

| No. | Potential Negative/Adverse Impacts | Mitigation Measures | Responsible body |
|---|---|---|---|
| **1.** | ***External - Environment*** | | |
| | Endemism to water borne diseases | Improvements in health education and health services | Wereda Health Office |
| | Poor soil nutrient condition | Appropriate and sustainable soil management which includes choice of crops and nutrient | Farmers & Wereda Agriculture Office |
| | Low development of infrastructure (roads, market, etc.) | Enhanced local and regional as well as federal Governments involvement and role of beneficiaries. | Wereda, Zonal and Regional Administrations |
| | Large family sizes | Education and awareness creation | Kebele & Wereda Health Offices, Women Organizations |
| | Implementation of resource competing development activities upstream | Implementation of appropriate basin and regional planning. | Regional and Federal Governments |
| ***2.*** | ***Internal (project generated)*** | | |
| ***2.1*** | ***Biophysical*** | | |
| ***A*** | ***Hydrological Changes*** | | |
| | Rise of water table | Ensure proper water management and irrigation system maintenance by establishing fees | Consultants Design, Contractor & Water Offices |
| ***B*** | ***Water & Air quality*** | | |
| | ***Organic & Inorganic pollution***<br><br>Contamination of surface and ground water during construction | Define and enforce return water quality levels, control effluents and contaminants, minimise gas emissions & noise<br><br>Ensure a safe management of hazardous materials<br><br>Install appropriate sanitary facilities | Consultant's design, Contactor, Water Project office, Wereda Environment and Health Offices Farmers, etc. |
| ***C*** | ***Soil Property*** | | |
| | Soil Salinity | Provide appropriate drainage | Consultants design, Contractor Water Office and Water Users |
| | Soil Workability (Vertisols)<br><br>Soil Compaction (During Construction)<br><br>Soil Waterlogging | Application of appropriate irrigation water & drainage<br><br>Minimize use of heavy machinery and limit their circulation | Consultants design, Contractor Water Office and Water Users,<br><br>Contractor |

*Table 25. Summary of Mitigation Measures for Potential Negative/Adverse Impacts (Cont.)*

| No. | Potential Negative/Adverse Impacts | Mitigation Measures | Responsible body |
|---|---|---|---|
| ***D*** | ***Soil Erosion & Sedimentation*** | | |
| | Local Erosion | Level off the soils and facilitate vegetation generation after construction, avoid steep slopes, implement terracing.<br>Design water canals for reducing sedimentation and facilitating drainage and maintenance<br>Maintain vegetation hedges<br>Avoid clearing vegetation along water bodies | - Contractor<br>- Wereda Office of Natural Resources |
| | Hinterland Effect | Regulate settlement and implement appropriate watershed management programs.<br>Implement land compensation measures in command area to protect the watershed | Wereda and Zonal Administration |
| ***E*** | ***Biological and Ecological Degradation Terrestrial & Aquatic Habitat, Flora and Fauna*** | | |
| | • Deforestation (Loss of trees, forest products, medicinal plants, etc.) | Minimize land clearing and optimize location of structures, Protect trees, Regulate settlements and farm areas, etc. | Consultant's design, Contractor, Wereda Natural resources and Administration |
| | • Changing habitat | Forbid encroachment to ecologically sensitive areas like the gallery and mountain slope forests<br><br>Take care of reproductive habitats | Consultant's design, Contractor, Wereda Natural resources and Administration |
| | • Dominance of Monoculture | Recommend appropriate mix of crops | Consultants Design & Wereda Agriculture Office |
| | • Organic and Inorganic Pollution | Define and enforce return water quality levels, control effluents and contaminants, minimise gas emissions & noise<br><br>Ensure a safe management of hazardous materials<br><br>Install appropriate sanitary facilities<br><br>Reuse waste and drain water, and find alternative ways to dispose drainage effluent. | Wereda Environment and Health Office |
| | • Threat to Nature Reserve | Avoid any measure that would threaten the proposed Aba Diko Nature Reserve | Wereda Natural Resources |

*Table 25: Summary of Mitigation Measures for Potential Negative/Adverse Impacts Cont.*

| No. | Potential Negative/Adverse Impacts | Mitigation Measures | Responsible body |
|---|---|---|---|
| | • Dominance of Exotic Species | Promote endogenous species in as much as possible | Wereda Natural Resources and Agriculture Offices, Farmers. |
| | • Proliferation of pests, diseases and weeds | Implement Integrated Pest Management | Wereda Agriculture & Farmers |
| | • Fragmentation and Degradation of Wildlife | Study wild life type, size, distribution & habitat requirements including fish resources and come with recommendations as a final solution and also implement wildlife protection regulations | Wereda Natural Resources Office |
| ***2.2*** | ***Socio-economic*** | | |
| ***A.*** | ***Population Change Demographic Trends*** | | |
| | Population growth encouraged by irrigation scheme allocation criteria favouring large families | Establish allocation criteria that are not based on family size.<br><br>Provide education on family planning | Wereda, Kebele, and Water Users Association<br><br>Wereda Community Service |
| | Increase in population due to migrants attracted by new economic opportunities giving rise to temporary imbalance between men and women, social conflict, breakdown in community infrastructure, etc, etc. | Plan settlements that prevent promiscuity<br><br>Work closely with host communities to facilitate the acceptance and integration of migrants<br><br>Establish labour camps at a reasonable distance from villages | Wereda Community Service, Administration and Contractor |
| | Increased population density which can generate unwanted pressure on existing public services, facilities and socio-economic infrastructures.<br><br>More incidence of diseases, especially sexually transmitted ones. | Provide adequate settlement areas with housing, water supply, health and sanitation services and facilities<br><br>Provide health education | Contractor and Wereda Administration<br><br>Wereda Health Office |
| ***B.*** | ***Income & Amenity*** | | |
| | The likelihood that limitations in skill and knowledge, poorly organized operation and maintenance, reduced farming flexibility, insufficient external supports, etc can affect income and amenity negatively. | Implement capacity building (training) programs<br><br>Appropriate organizational setup that promotes and provides required input and marketing facilities | Joint effort among Wereda Administration, Water, Agriculture, Water Users Offices; Farmers' Associations and Cooperatives |

*Table 25. Summary of Mitigation Measures for Potential Negative/Adverse Impacts (cont)*

| No. | Potential Negative/Adverse Impacts | Mitigation Measures | Responsible body |
|---|---|---|---|
| **C** | **Women's Status** | | |
| | Increased work load on women not appropriately compensated by commensurate access to resources. | Ensure equitable access to resources for both men and women.<br><br>Provide relevant capacity building trainings to women | Wereda Administration and Community Services |
| **D.** | **Indigenous People** | | |
| | Threat to the around 200 families of Gumuz indigenous people living on the right bank of the river who are reported to prefer secluded life style, but they use dugout canoes and ferry settlers across river. Socio-anthropogenic study needed. | Minimize workers mobility and access and prevent other unwanted encroachments to their villages.<br><br>In the long run give required awareness and training and make them benefit from the scheme for gradual integration | Wereda and Contractors camp administration.<br><br>Wereda Capacity Building Program in collaboration with the adjacent wereda administration |
| **E.** | **Sites of Value** | | |
| | Degradation of the landscape and sites of aesthetic value | Filed survey to assess values during Tender Design; implementation of proposals to preserve put into project master plan | Wereda Administration, State and Federal Govt agencies concerned with heritage (EPA and Antiquities) |
| **F.** | **Regional Effects** | | |
| | Likelihood of lack of support from higher administrative strata regarding issues and development beyond the jurisdiction and capacity of the wereda | Institutions that give desired levels of support to such large development interventions at zonal, regional and national levels shall be identified and given distinct roles for follow-up and support | Initiatives taken by both Regional and National Governments Sectoral Offices. |
| **G.** | **User Involvement** | | |
| | Low capacity and knowledge as well as institutional biases hindering user involvement | A breakthrough in enhancing beneficiaries participation in planning, decision making and implementation | Wereda, Zonal and Regional Administrations and Sectoral Offices. |
| **H.** | **Human Health** | | |
| | Creation of an ideal condition for the exacerbation of water borne and water related diseases by increased surface water in canals and night reservoirs | Promotion and implementation of both preventive and treatment health programs | Wereda, Zonal and Regional Health Offices |
| | Health risks associated with increased population agglomeration and labour migration | Provision of adequate housing, water supply and sanitation services | Wereda Administration |

*Table 25: Summary of Mitigation Measures for Potential Negative/Adverse Impacts (cont)*

| No. | Potential Negative/Adverse Impacts | Mitigation Measures | Responsible body |
|---|---|---|---|
| | Health risks associated with increased use of agrochemicals and pollution | Use pollution control rules and regulations<br><br>Train users in the field of environmental protection<br><br>Promote and implement capacity building for representatives of all stakeholders in environmental protection | Wereda, Zonal and Regional Environment Offices |
| ***I*** | ***Disease Hosts (Vectors)*** | | |
| | Irrigated crop production creates conditions that give rise to increase in disease host populations of such as rats and birds and increase in livestock and in human population is likely to lead to more interaction with disease vectors. | Regular monitoring and promotion and implementation of programs for the prevention of unwanted host populations such as rats.<br><br>Health education to minimize human animal contact<br><br>Adequate Health Services | Wereda Agriculture Office<br><br>Wereda Health Office |

# 7 ENVIRONMENTAL MANAGEMENT PLAN

## 7.1 GENERAL

This section outlines mitigation, monitoring and institutional measure to be taken during further project planning and implementation, in order to ensure that the environmental and social risks identified in the environmental assessment during Feasibility Study are properly addressed, resolved and mitigated in the subsequent project phases as part of an Environmental Management Plan (EMP).

Guidelines for the implementation of an EMP vary from country to country. In Ethiopia for many years land use planning for successful irrigation development project followed the guidelines developed by the FAO (FAO, 1976, 1979, 1989) for land resources evaluation of rainfed or irrigation development. These were all based on best practice for an area and encouraged the users that they must take into account both the bio-physical and social environments. All these had originated in good practices that used to be the norm in development, but had somehow become weakened. Development projects that were externally funded used, as a rule, guidelines, EMPs' in their own way and followed what was and is known as the project cycle. From the early 1980s', due to increasing experience in the external lending and National agencies, and the visible results from undisciplined development and project failure (see for example Hudson, 1991) the project planning cycle procedures became more formalised with environmental and social impact assessment guidelines built into development planning, initially by the World Bank and followed soon after by other lending banks and international development agencies including the African Development Bank.

The basic principles of an environmental management plan are numerous They include that there is an informed decision-making process, and that there is accountability of data and when decisions and the approach is participatory and consultative with public awareness of the development plan. The plan should have considered other alternatives and will aim to mitigate the negative impacts, and enhance the positive ones. At all stages of planning and implementation it will comply with national guidelines and regulatory procedures.

The Environmental management plan gives mitigating measures and monitoring requirements, and identifies the organizations assigned to implement them.

Organizations which are sought to be responsible either by mandate or relevance have already been shown in the summary tables, given above, that show the positive or beneficial impacts that need to be enhanced or further strengthened and the negative or adverse impacts that need to be avoided if possible or minimized in as much as possible given the existing technology available and the socio-economic setup.

Hence, the main objective of any Environmental Management is: to find the best way to implement the project: minimize as much as possible or eliminate negative impacts; enhance benefits; and protect public and individual rights by compensation. Hence, the Environmental Management Plan and work should be designed in such a way that it takes the responsibility of implementing the following two categories of interventions.

## 7.2 SYSTEM MANAGEMENT INTERVENTIONS

- Improve the operation of existing irrigation and drainage infrastructure through introduction of management information systems, etc.
- Enhance farmers' involvement in management and maintenance of irrigation and drainage facilities.
- Evaluate the feasibility of implementing on-demand water delivery to farms.

## 7.3 IRRIGATION AND AGRONOMIC PRACTICES INTERVENTIONS

- Minimize water losses in the on-farm distribution system.
- Improve irrigation systems performance to minimize deep percolation and surface runoff.
- On-farm watercourse improvement and precision land levelling.
- Implement more efficient irrigation methods (e.g. Piped instead of surface irrigation in this case).
- Minimize sediment concentration in runoff water.
- Grow different crops or introduce different crop rotations (i.e., less-water demanding crops, more drought- and salt-tolerant crops).
- Irrigate according to reliable crop water requirement estimates and leaching requirement calculations.
- Manage fertilizer programs so as to minimize nutrients available for detachment and transport.
- Apply soil amendments and reclamation practices.

Institutional factors are often the main cause of failure of large scale irrigation schemes. Operation of all control facilities from the water source to individual farms requires almost constant management. Careful water management is essential to the quantity, timing, controllability, and predictability of water delivered to the users, all of which will determine the success of the project. Training of a cadre of managers to provide the needed services is required if they are not available or lack necessary technical and managerial skills.

## 7.4 SPECIFIC

### 7.4.1 Introduction

Generally, the Ministry of Water Resources via the Oromia Water Bureau will be responsible for the follow up and monitoring of much of the technical works sited in both the enhancement and mitigation measures recommended. However, the tasks and responsibilities that have to be executed in relation to enhancement and mitigation of adverse impacts are presented as follows.

### 7.4.2 Design Phase

As sited above, it is the duty and responsibility of the Ministry of Water Resources (MoWR) to see to it that the *Consultant* makes all that is necessary for preparation of detailed designs which incorporate specific features aimed at minimizing adverse impacts and enhancing beneficial impacts; preparation of tender and construction contract documents which contain appropriate clauses including penalty clauses to allow control of impacts arising from construction activities. The team leader of the consulting firm appointed by the Ministry of Water Resources (MoWR) to finalize detailed designs and tender documents will have primary responsibility for the quality and content of the design and tender documents. This will include ensuring that the adverse impact minimization and benefit enhancement measures set out in this report, which relate to construction impacts, are given due consideration in the finalization of designs and tender documents.

### 7.4.3 Construction Phase

The overall responsibility for construction supervision and contract management, and therefore for environmental management during construction, will lie with the engineer as defined in the construction contract. There will be responsible for establishing procedures and mechanisms for effective environmental management and monitoring and will ensure that these are fully incorporated in, and integrated with, the overall construction supervision and monitoring framework

### 7.4.4 Operation Phase

In this process of environmental management, as indicated earlier, the responsible bodies and institutions for the follow up and implementation of the enhancement and mitigation measures in the operation phase have been given in the tables in association with the type and nature of items that need enhancement and mitigation.

# 8 ENVIRONMENTAL MONITORING PLAN

## 8.1 GENERAL CONSIDERATIONS

Environmental monitoring is very essential part of the project implementation. It helps to follow up the implementation of the proposed mitigation measures and to capture unforeseen environmental impacts of the project. Environmental monitoring is an essential tool in relation to environmental management as it provides the basis for rational management decisions regarding impact control. The monitoring programme for the present project will be undertaken to meet the following objectives:

- to check on whether mitigation and benefit enhancement measures have actually been adopted, and are proving effective in practice
- to provide a means whereby any impacts which were subject to uncertainty at the time of preparation of the EIA, or which were unforeseen, can be identified, and to provide a basis for formulating appropriate additional impact control measures
- to provide information on the actual nature and extent of key impacts and the effectiveness of mitigation and benefit enhancement measures which, through a feedback mechanism, can improve the planning and execution of future, similar projects.

There are two basic forms of monitoring:

1. *Compliance monitoring,* which checks whether prescribed actions have been carried out, usually by means of inspection or enquiries.

2. *Effects monitoring,* which records the consequences of activities on one or more environmental components, and usually involves physical measurement of selected parameters or the execution of surveys to establish the nature and extent of induced changes.

## 8.2 SPECIFIC

### 8.2.1 Introduction

A central part of the EMP is monitoring of the project so that predicted and actual impacts can be compared. On the Dinger Bereha project the key monitoring issues will be made during both construction and implementation. They are recommended to address the following as essential components: monitoring any changes in water quality, changes in soil fertility, status of aquatic ecosystems and biodiversity, changes in water related health issues, impacts on pastoralist routes, changes to traditional livelihoods, demographic trends, changes to crop production and markets.

It is necessary to establish and maintain environmental monitoring system to assess the efficiency of different mitigation measures, to perceive possible environmental hazards or to detect unpredicted impacts in time. Monitoring of environmental parameters will timely signal potential problems and will allow for prompt implementation of effective corrective measures.

The African Development Bank (ADB, 2003) provided a detailed list of monitoring indicators on irrigation projects, under the general headings of poverty, environment, population, health outcomes, gender and participation.

The management of the future Dinger Bereha project would follow these guidelines on a regular basis. Technical and non-technical issues would be the responsibility of the relevant department of the project (administration, engineering, water supply, health and safety, agriculture; transport; settlements etc). Useful data is being collected for some time by the Cheweka Wereda staff.

### 8.2.2 Design Phase

Monitoring during the design phase of the project will be concerned with two aspects:

- Checking that the project designs and specifications incorporate appropriate measures to minimize negative impacts and to enhance beneficial impacts

- Checking that the appropriate environmental protection clauses have been included in the contract documents, so as to allow the contractor to control actions which are potentially damaging to the environment.

These activities will be carried out as part of the preparation of designs and tender documents for the project, and will be mainly the responsibility of the final design and tender documents consultant’s Team Leader.

### 8.2.3 Construction Phase

Environmental monitoring during the construction phase will comprise two principal groups of activities:

- Review of the Contractor’s plans (including the EMP), method statements, temporary works designs, and arrangements relating to obtaining necessary approvals from the Engineer, so as to ensure that environmental protection measures specified in the contract documents will be adopted, and that the Contractor’s proposals will provide an acceptable level of impact control.

- Systematic and regular observation/inspection on a day-to-day basis of all site activities (including environmental mitigation measures) and the Contractor’s offsite facilities, as a check that the contract requirements relating to environmental matters are in fact being complied with, and that no unforeseen impacts are occurring.

These activities will be fully integrated with other construction supervision and monitoring activities carried out by the construction supervision consultant. Primary responsibility for ensuring that an adequate level of environmental monitoring is carried out will lie with the Resident Engineer, as part of his duties concerned with general site supervision. The monitoring activity will be carried out in close co-ordination with Ministry of Water Resources (MoWR) which is also be supported by qualified Environmentalist and Social Scientist of the Consultant. The Environmental Specialist will carry out *check monitoring* on an intermittent basis at intervals. The Environmentalist and Social Scientist from the Ministry should participate in alternate visits, so as to gain first-hand experience of on-site environmental management and monitoring. The Resident Engineer (RE), or whoever is delegated by the Consultant will still retain overall responsibility for environmental matters, and this should be reflected in his Terms of Reference.

Monthly Progress Reports prepared by the Engineer should contain a section referring exclusively to environmental matters, which summarizes the results of site monitoring, remedial actions that have been initiated, and whether or not the resultant action is having the desired result. The Report will also identify any unforeseen environmental problems occurred and will recommend suitable additional actions. Monthly progress meetings with the Contractor will and should also include a review of environmental aspects.

As described earlier, environmental inspection checklists for use on site should be developed by the RE, Environmental Specialist/Sociologist and the Assistant RE, prior to the commencement of construction, so as to facilitate systematic monitoring and recording. These may require modification in the light of site experience, and it is recommended that a review of their adequacy and ease of use should be carried out, and submitted for review and comment, approximately 3 months after the commencement of works. Further reviews as to their suitability should be carried out whenever a new activity commences. The RE will mainly be responsible for the review for the effectiveness of environmental management and monitoring plan and will introduce improved procedures as required by the project-specific circumstances.

### 8.2.4 Operation Phase

At this phase though the overall responsibility for monitoring will mainly be the responsibility of the Regional Water, Agriculture & Rural Development, Health Bureaux and other pertinent institutions at Zonal and Wereda level as specified for the responsibility for mitigation. It has to be supported by Federal, Regional Zonal as well as Wereda and Kebele pertinent institutions with responsibilities as specified in the institutional and legal framework and the recommendations given by the Institutional Study conducted as part of the project. Post-construction phase monitoring will be concerned with identification of the need for routine checking and rectification as required. However, due to capacity and resource limitations, monitoring of the post construction and implementation of the irrigation scheme should be scoped to those indicators that are most relevant for evaluation of the performance of the environmental mitigating measures. The selection of the issues to be monitored must be based on the severity, extent and intensity of the impacts. The key issues can be listed as follows:

- Climate (wind, temperature, rainfall, etc.);
- Stream discharge above the irrigation project and below at various point;
- Nutrient content of discharge water;
- Flow and water levels at critical points in the irrigation system;
- Water table elevations in project area and downstream;
- Water quality of project inflows and return flows;
- Quality of groundwater in project area;

- Water salinity levels
- Physical and chemical properties of soil in irrigation area
- Agricultural acreage in production cropping intensity
- Crop yield per unit of land and water;
- Erosion /sedimentation rates in project area;
- Relation between water demand and supply of users (equability of distribution);
- Condition of distribution and drainage canals (siltation, presence of weeds, condition of linings);
- Upstream watershed management (agricultural extent and practices, industrial activity);
- Incidence of disease and presence of disease vectors;
- Health condition of project populations;
- Changes in natural vegetation in the project area especially in the river banks and adjacent slopes of mountains
- Changes in wildlife populations and fish population and species in the project area

We have made estimates of the frequency of monitoring activities within each section, as follows:

**Poverty Indicators - Economy**
- Number of jobs created (directly and indirectly) and occupied by men and women; *Frequency: monthly.*
- Level of satisfaction of adversely affected men and women toward compensations and offered alternatives (survey). *Frequency: annual*

**Information, Education and Communication**
- Acquired irrigation systems management skills by trained men & women. *Frequency: annual*

**Access to Infrastructures and services**
- volume of sedimentation in irrigation canals to evaluate soil degradation; *Frequency: monthly*
- maintenance expenses on irrigation canals; *Frequency: monthly*
- number of breakdowns of the irrigation systems; *Frequency: daily in the flood season*
- number of water points as a function of the population; *Frequency: monthly*
- number of domestic water supply breakdowns. *Frequency: daily reporting*

**Environment – Water**
- Groundwater static level and refilling capacity. *Frequency: weekly at key sites*
- Parameters of *WHO Guidelines for Drinking-water Quality* for evaluating the physical-chemical characteristics of underground and surface water quality (upstream, on the site and downstream). *Frequency: weekly to monthly.*
- Coliforms and viable intestinal nematode eggs per litre for evaluating wastewater quality for irrigation purposes (*WHO Guidelines for the Safe Use of Wastewater and Excreta in Agriculture and Aquaculture*). *Frequency: weekly to monthly.*
- Quantity of water used compared to initial estimates. *Frequency: weekly.*

**Environment – Soils**
- Volume of sedimentation downstream of irrigated area. *Frequency: weekly in flood season*
- Changes in soil physical and chemical parameters (e.g.: pH, salinity, water retention, etc.). *Frequency: weekly to monthly, with annual checks at bench mark sites*

**Environment –Ecosystems**

- Surface of sensitive areas affected by the irrigation project. *Frequency: monthly.*

**Environment – Flora:**

- Area covered by aquatic plants in canals. *Frequency: monthly.*
- Biomass per inhabitant nearby the project area. *Frequency: annual.*

**Environment -Natural and cultural heritage:**

- Natural and cultural sites affected by the project. *Frequency: daily checks during construction.*

**Population - Demographic trends**

- Population growth and ethnic composition. *Frequency: annual*

**Population - Migration and Resettlement**

- Type of house and accessible services to displaced men and women before and after project implementation. *Frequency: monthly.*
- Integration level of migrants in host communities (survey). *Frequency: monthly consultations to annual.*
- Number of informal settlements built by migrants. *Frequency: monthly.*

**Natural Resources and Land Management**

- Subsistence production in calories per inhabitant. *Frequency: annual.*
- Presence of a water user organisation, including men and women. *Frequency: monthly checks on status, higher in flood season.*
- Revenues from irrigation water fee collection and allocation. *Frequency: monthly.*

**Quality of life**

- Level of satisfaction of displaced men and women (survey). *Frequency: annual.*

**Health Outcomes - Communicable Diseases**

- Prevalence rates of diseases such as malaria, schistosomiasis, diarrhoea and HIV. *Frequency: monthly liaison with health centres.*
- Number of vector breeding sites and vector density. *Frequency: annual surveys.*
- Availability of condoms, impregnated bed nets, mosquito repellents. *Frequency: weekly status.*
- Outpatient attendance records. *Frequency: monthly.*
- Quantities of drug supplied/used from health services & local shops. *Frequency: monthly*

**Health Outcomes - Non-Communicable Diseases**

- Inventory of exposure sites including wastewater drainage. *Frequency: monthly.*
- Water quality analysis results. *Frequency: monthly to bi-weekly.*

**Health Outcomes - Malnutrition**

- Number of people affected by seasonal hunger (evolution over time). *Frequency: annual.*
- Height/weight monitoring of children. *Frequency: annual.*

**Health Outcomes - Injuries**

- Number of violent events reported by the police & social services. *Frequency: annual.*
- Construction site occupational health and safety records. *Frequency: daily checks.*

**Gender - Division of labour**

- Time allocation of women before and after the irrigation project. *Frequency: annual*
- School attendance of girls / boys before & after the irrigation project. *Frequency: monthly.*

- Number of children working on a regular basis in irrigated schemes. *Frequency: monthly.*

**Gender - Income-Generating Activities**

- Proportion of family income received and managed by men and women before and after the project. *Frequency: monthly.*

**Gender - Access to and Control over Productive Factors**

- Proportion of men and women being owners or tenants of irrigated schemes. *Frequency: annual.*
- Level of satisfaction of women toward project investment decisions & management methods (survey). *Frequency: annual.*

**Gender - Involvement in Societal Organisations**

- Number of women and men involved in user organisations. *Frequency: annual.*

**Participation - Civil Society Strengthening**

- Level of participation of user organisations in the water management decision-making processes. *Frequency: monthly.*

All these have to be judged in relation to a baseline established before the project starts. It is known there are gaps in the baseline data and the sections below suggest how these might be filled. As such the first task of the EMP, in the run up to the start of construction, and probably best initiated at the start of the Tender Design stage, will be to:

- Provide an update to the local population and other stakeholders in the area of the final project plan- what impacts it might have that effect their environments and their livelihoods, and what mitigations are necessary if these are negative. The positive aspects too will be discussed and the economic advantages as such outlined. It will be essential to enlist their support in all these issues. This will be made by the ESMU and MIWR project staff in cooperation with wereda staff.

- Limitations of the exiting agencies, for example for livestock management given Annex 6 will require serious decisions to ensure that they modernise and improve. It will be necessary to provide some form of budgetary upgrade to these agencies first, so their participation in the project and to others will be useful.

- Bring up to date any and all existing environmental, agricultural cropping and livestock, forestry, and social datasets, from sources in Illu Harar, the administrative town. If none then such data collection must be initiated by special surveys, such as for fisheries and aquatic ecosystems.

- It will be very advantageous to establish a full automatic climate station in Hawata, ideally at the same location where rainfall used to be collected. This should be achieved at an early stage, preferably during the detailed design stage, and will involve establishing modern climate station at site of old defunct station. This will take digital data readings every hour of a wide range of parameters including: rainfall, rainfall intensity, maximum and minimum temperatures, dry and wet bulb temperatures, soil temperatures, wind speed and direction, sunshine hours, solar radiation, evaporation, soil moisture.

- Initiate regular testing of waters in the principal sources The Ministry of Irrigation and Water Resources should be responsible for this. Any shortfall in equipment and staff capability will be identified during the initial stage of Tender Design. A budget for this section will be required. The testing will need to be made on site.

- Ensure that hydrologic flows in the Didessa River are measured at all times in the flood season. The MIWR will be responsible for this, as noted above.

- Make a series of sediment measurements in the Didessa River during the floods and at low water flows.

- Make a survey of fish in the Didessa River, and examine the role of fish migrating up these rivers into the catchments during the floods.

- Gaseous emissions from livestock. The review of the draft report mentioned this as a possible impact in the area, presumably, though not stated, from increased methane production. The project does not see a substantial increase in livestock in the area and this is not seen as serious negative possibility. Some air quality monitoring should be included, but there is no baseline on this.

- Soil Fertility. This needs to be raised in the study area. The soil survey shows it is low and present farming methods are resulting in a high rate of erosion. Good land husbandry within a programme of soil and water conservation must be a part of this. Progress needs to be monitored by the agricultural officers in the Woreda.

- The project could and should play a very useful role here with routine monitoring of bench mark soils, where there is now up-to-date analysis including trace elements from several soil profiles whose location is known exactly. Re-sampling should be made every few years. At the same time sites should be sampled for soil moisture measurements at depth down profiles throughout the year. Associated monitoring would include climate, farming practices and agricultural inputs.

- Pests. Agricultural pests and diseases are widespread and the Cheweka wereda agricultural extension staff provide guidance to farmers on prevention measures. These need to be maintained and advice sought from the State Ministry of Agriculture on best practices.

To summarise on the key issues where monitoring needs to be started soon and this should in reality be not just for the proposed project but for the Cheweka wereda as a whole. In any case the key issue will incorporate some of the proposal above and make provisions for, and commence funding of, programmes to fill the gaps in the baseline data situation. We have identified that information is needed on: fishing, fauna and flora, climate data, decline in soil fertility, hydrologic flows on the river, sediment loads on the river, and water quality testing.

Executive responsibility for project management and monitoring commonly involves several organizations, each with specific responsibilities for particular aspects, and this project is no exception. The above responsibilities will therefore be split between several organizations, depending on the mandates and institutional setup, especially the institutional and organizational setup specific to this project.

## 8.3 ENVIRONMENTAL AND SOCIAL MANAGEMENT UNIT (ESMU) COSTS

An Environmental and Social Management Unit (ESMU) would be established as part of the project's construction supervision office/Project Management Unit. It is recommended that there should be three staff: one land and vegetation specialist; one aquatic biologist; and one social environmentalist professional working in this unit, with individual staff cost of USD 8,000 /month. Additional specialists might have to be called in, for example, pesticide management, range management and livestock husbandry: these should be available in line agencies in Oromia State.

Good technical staff, most of whom are graduates, are employed at Chewaka Wereda. The permanent staff of the monitoring unit should be recent graduates also, but with MSc in these fields, and good experienced in environmental impact assessment and mitigation. They should be willing to devote several years to this project. The ADB could provide additional advanced specialised training and / or short courses in Ethiopia or overseas, for the selected staff.

Staff could use the same office locality as the project implementation supervision staff, but must be seen also to be independent and supporting the overall aims of the project to assist the local peoples. They will though have direct link to the resident engineer and will be key participants in all decisions on the construction where mitigation is involved. Realistic costs estimates for the identified mitigation measures are difficult to give at the current stage of planning. This is due to a limited degree of planning, at which the detailed scopes and quantities for mitigation measures have not been identified yet. For these issues, the cost estimates can be updated on a more profound basis during the tender design phase.

Recurrent costs/environmental monitoring during construction and first five years of implementation:

- 20,000 USD / year for bio-physical (soil, vegetation ecosystem) environmental monitoring at weir and pump sites, along the canals, gallery forests, and in wetlands. In addition we would cost for a set of monitoring meters (1: Electrical Conductivity + pH + TDS) for setting up in a small laboratory equipped with bench. Ideally samples are collected din the field and brought to the laboratory. A key acquisition would be for an automatic full climate station for Illu Harer with data logger and laptop - data would be linked to National reporting network). Additional Costs: (1. €1000 for robust instrument and associated glassware equipment; (2: A 50m dipmeter for measuring water table depth is useful. Cost €300 euro; (3. Furniture and start up consumables for the laboratory. Cost €1000 euro; (4. Annual consumable costs of €500, including purchase of distilled water from laboratory in Addis Ababa, and replacement glassware etc. (5. Automatic climate station: Cost €45,000 euro. Total additional cost estimate €47,800 euro equivalent to US$60,763.

- 20,000 USD / year (settlements, health, water) year for monitoring of social issues. These includes transport into the site, laboratory testing for water related diseases in the Didessa and wetland areas, and from hand pumps. No analysis of water for biological test would be made on site, but arrangements to take these to reputable laboratory in Addis Ababa or elsewhere, within normal time-frame allowed between sampling and analysis, needs to be resolved during detailed design. Allow a further €2000 / year for this. Water quality testing once a month from about 5 selected locations. It may be advisable to acquire a water testing kit (eg Hach or similar) for use at Illu Harer. Cost: allow for €1,000 euro. Total additional cost estimate amounts to € 3,000 euro, equivalent to about US$3,815.

- 10,000 USD / year for public information and meetings in the kebele villages. A permanent display should be set up in Ilullu Harar to advertise the progress of the project.

Annual auditing of the ESMU and its output will be essential to demonstrate that the EMP is proceeding as desired. This audit should be made by an independent body selected by Oromia state EPA. In turn the ESMU will report regularly to the wereda, Oromia state EPA agency on progress in its work so that any shortcomings in the design and problems with stakeholders can be identified at an early stage and attempts made to resolve issues.

# BIBLIOGRAPHY AND REFERENCES

ADB, 2003. Integrated Environmental and Social Impact Assessment Guidelines. African Development Bank.

ADB, 2004. African Development Bank Group's Policy on the Environment. PSDU

Azeme Bekele Tesema , 1993. Useful trees and shrubs of Ethiopia. Reissued in 2007 by World Agroforestry Centre ICRAR.

BCEOM, 1998. Abbay Basin Master Plan. Ministry of Irrigation and Water Resources. Addis Ababa.

Boulenger, G.A., 1909-1916. Catalogue of the Freshwater Fishes of Africa in the British Museum (Natural History). 4 vols. London : BM (NH).
Vol. 1, 1909 at http://www.biodiversitylibrary.org/item/36773#9
Vol. 2, 1909 at http://www.biodiversitylibrary.org/item/91114#5
Vol. 3, 1915 at http://www.biodiversitylibrary.org/item/90544#5
Vol. 4, 1916 at http://www.biodiversitylibrary.org/item/57864#5

Breitenbach, F.W., 1963. The indigenous trees of Ethiopia.

De Data, S.K. 1981. Principles and practice of rice production. p618. Wiley, Chichester.

Dent, D and Young, A., 1981. Soil survey and land evaluation. George Allen and Unwin Ltd., London.

Doughtery, T.C. and Wall, A.W., 1995 : Environmental impact assessment of irrigation and drainage projects. *FAO Irrigation and Drainage Paper*, 53. Rome: Food and Agricultural Organization.

FAO, 1972. Trace Elements in soils and agriculture. FAO Soil Bulletin No. 17. FAO, Rome.

FAO, 1976 (reprinted 1981). A framework for land evaluation. Soils Bulletin 32. Food and Agricultural Organization (FAO), Rome.

FAO, 1979. Soil survey investigations for irrigation. Soils Bulletin 42, Food and Agricultural Organization (FAO), Rome.

FAO, 1985. Guidelines: land evaluation for irrigated agriculture. Soils Bulletin 55, Food and Agricultural Organization (FAO), Rome.

FAO, 1990. Guidelines for Soil Description. 3rd edition. Rome.

FAO, 2006. Guidelines for Soil Description. 4th edition. Rome.

FAO, ISRIC and ISSS. 1998. World Reference Base for Soil Resources (WRB) –World Soil Report No. 84. Editors: J.A. Deckers, O.C. Spaargaren, F. O. Nachtergaele (ISSS), L.R. Oldeman, R (ISRIC), Brinkman (FAO). FAO, Rome.

FAO, ISSS and ISRIC, 1998. World Reference Base for Soil Resources, Rome.

Fichtl, R. and Adkmasu Adi, 1994. Honey Bee Flora of Ethiopia.

Grist, D.H. 1983. Rice. 5th edition. Longman, London.

Hudson, N.W., 1991. A study of the reasons for success or failure of soil conservation projects. FAO soils bulletin 64. Rome: FAO. (available online from WAICENT, FAO)

ICID – WB, 1998. Planning the Management, Operation and Maintenance of Irrigation and Drainage Systems. A guide for Preparation of Strategies and Manuals. World Bank Tech. Paper No. 389. International Commission for Irrigation and Drainage and World Bank. Washington , DC.

Landon J.R, 1991. Booker Tropical Soil Manual, a Handbook for Soil Survey and Agricultural Land Evaluation in the Tropics and Sub-Tropics. Longman, London.

LUPRD, 1984. Geomorphology and soil Map of Ethiopia. FAO, Rome.

Mock, J.F. and Bolton, P., 1993. The ICID Environmental Checklist, International Commission on Irrigation and Drainage. Oxfordshire.

Nile Basin Initiative, GEF, UNDP, WB, 2001. Transboundary Environmental Analysis. 120 p. Nile Basin Initiative. Shared Vision Programme.

Nile Basin Initiative, 2005. National Nile Basin Water Quality Monitoring Baseline Report for Sudan. Nile Initiative, Transboundary Environmental Action Project. March 2005.

Sogreah, 1979. Lower Didessa Project. Ministry of Irrigation and Water Resources.

TAMS, 1975. Upper Didessa Project. Part I Resources.

TAMS, 1975. Upper Didessa Project. Part I Resources. Annex A.(not seen despite wide searches and may not have been published).

Tedla, S. 1973. Freshwater fishes of Ethiopia. Department of Biology, Addis Ababa University, Addis Ababa, Ethiopia, 101 pp.

USBR, 1964. Land and Water Resources Study of the Blue Nile Basin. Addis Ababa.

World Bank Group, 2004. Involuntary Resettlement. Operational Policy 4.12. Washington DC: The World Bank.

WWD&SE and ITC of India , 2007 (May). Arjo-Didessa Irrigation Project, Feasibility Study.

# APPENDIX 1A: LIST OF CONTACTED PERSONS

| Name | Organization | Position |
|---|---|---|
| Ato Kedir | Chewaka Wereda administration | Head |
| Ato Abdu | Chewaka Wereda administration | Deputy Head |
| Ato Nura Ahmed | Wereda Agriculture & Rural Development | Head |
| Ato Negussie Bulbula | Wereda Nat.Res. Office | Head |
| Ato Weyessa Bekelle | Wereda Environment. & Land Adm. Office | Head |
| Ato Dugassa Gumoro | Wereda Environment & Land Adm. Office | Expert |
| Ato Wendo Safo | Wereda Plant Protection | Expert |
| Ato Taju Abdu | Wereda Soil & Water Conservation | Expert |
| Ato Legesse Gabissa | ” Livestock | Expert |
| Ato Abdulhakim Ahmed | ” Health Office | Head |
| Ato Mohammed Seid | ” | Deputy |
| Ato Hassen Yuyo | Burka Bereka Kenelle | Chairman |
| Ato Mohammed Abdella | Illu Harar Wereda | Farmer |
| Ato Ahmed Mohamed | ” | ” |
| Ato Jemal Abdurahman | ” | ” |
| Ato Mohamed Amin | Shemel Toke | ” |
| Ato Jemal Mohamed | ” | ” |
| Ato Tewfik Ahmed | ” | ” |

Note that discussions were held also with large group of farmers in Shemel Toke, Illu Harar and Burka Bereka by the Socio-Economic team.

# APPENDIX 1B: SUMMARY OF DISCUSSIONS

**Summary of Discussions with Stakeholders and the Environmental, Land Tenure, Livestock and Social Specialists.**

**General**

The initial contacts made to date during the environmental study preparations, include discussions with key stakeholders, as well as interviews held with farmers. These have shown that officials and the people in the project area are largely supportive of the project.

During the feasibility study a number of useful discussions have been made with stakeholders by numerous specialists involved in the study. The results of these have been very favourable and the sedentary rainfed farming communities in particular look forward to this project being implemented. The social studies found that inhabitants agree on the project and are expecting benefits from irrigation and good agricultural services.

The final design though is not yet established and if the project goes to Tender Design then the process of participation and involvement with the stakeholders at all levels will be developed more strongly and positively.

The project is expected by all to bring improvement to the way of life, particularly provision of services and improved infrastructure. The inhabitants perceive that the project will bring with it more services to the area.

The project is expected to provide capacity building at village level to maximize the willingness to participate in the project. Such institution building may be through formation of farmers unions to enable farmers participate effectively and to help solving problems of land tenure and to organize the presence of nomads during the dry season. Capacity building may also extend to formation of village development communities to take care of village development needs and to be the link between the villagers, project management and the locality. It is expected that in the project management there must be a social mobilize to take care of these issue. Capacity building may extend to the formation of water users associations (WUA) to help in organizing irrigation of different fields.

<u>Feb. 5$^{th}$ 2009. Meeting at Illu Harar, Cheweka Woreda Administration.</u>

Met Ato Dugasa, agricultural deputy to Nurra Ahmad Simaa.

Agriculture: He stated there are 19,200 ha of rainfed agriculture in the Cheweka Woreda. Potential area is 25,000 ha and plan to put more settlers in remaining area. Holding size: about 1.5 ha each, 2 ha max. Tree planting. Last year 500,000 seedlings given out for neem, gravillea, sesbania, mango, avocado.

Burning:He was asked about continued burning of trees. If they are going to be destroyed, then why not cut them instead and use the timber? Stated that most farmers don't wish to burn bit some do and it gets out of control. How are they started: cigarettes often. Fires then spread onto steep areas and are uncontrolled. Fires spread from lower slopes but farmers are also expanding into the steeper slopes and burning is widespread. We suggested that they encourage people to burn grass off early in dry season so that damage to trees is reduced.

Pests and Diseases: Typical crop pests are African Bollworm (Catworm) and Late Blight on sweet potato and maize. They are introducing IPM measures rather than pesticides.

Animal diseases. Some strange disease is affecting goats: they start to cry and then die! Some medicines for this have now arrived. Tsetse a problem here, and malaria is worst in rainy season.

Feb. 6th 2009. National Tsetse and Trypanosomiasis Investigation & Control Centre, Bedele.

Met Ato Abere Worku. Tsetse Officer.

There are two species found here, along river and in savanna woodland. Whole of Didessa valley is infested by both. Considered it is a very great problem. Clearing of woodlands for irrigation also clears areas of tsetse. They are using traps of several types (mono conical, biconical, and Ngu) and use sheets sprayed with insecticides (Deltamethrin). The baits are a mix of acetone, octenol, and cows urine.

Nov. 5th 2009. Meeting at Illu Harar, Cheweka Woreda Administration.

Met with Ato Abdu Nuressa, Chief Administrator; Ato Kadir Abdulle, agricultural administrator.

Irrigation: There was none when they first came here but farmers soon started to abstract from streams. In 2009 there has been some 299 ha of traditional irrigation. Small canals are taken along slope to fields from springs and also from rivers in the gallery forested stream valleys. They grow tomatoes, some sugarcane, rice, red beans, sweet potato, and carrots.

Domestic Water from Streams: Streams become drier after May. We asked if the water in streams was less now due to cutting down of the gallery forests. Answer was that in 2007 there was a low flow but last year 2008 it was flowing all year.

Fertilisers: Have not been used as they do not seem to increase sorghum yield. At moment less fertiliser is entering the aquatic system.

Compost: This is widespread and success story. Each homestead is recommended to make a $6m^3$ pit. (Later we were shown some of these).

Deforestation:We asked what are the causes of loss of forests? Expansion of agricultural lands; fuel wood; construction materials; fences to protect croplands from animal pests eating crops.

Pesticides in Use: They will use IPM measures but nothing in place yet.

Diseases: Bilharzia is present ‘to some extent’. 1 person infected ; River Blindness is not seen in area they said ; Malaria is a significant problem ; Tsetse fly is a significant problem. They have traps, not spraying.

# APPENDIX 2: PHOTOGRAPHS

Plate 1. Hippopotamus trail and riverine forest, upstream of weir site.

Plate 2. Watershed area upslope of Dinger Bereha command. These lands are burnt at end of dry season to allow new grass to emerge, or planted for sorghum,

Plate 3. Gallery forest within Dinger Bereha command area

Plate 4. Grassland of seasonal wetland on Vertisol clays suitable for rice cultivation These lands are currently grazed and largely dry out by end of dry season.

Plate 5. New bridge under construction on the Didessa River. Will provide much needed link to project area from main road and markets.

Plate 6. Gallery Forest on upper slopes of the catchment. The stream lines on steep slopes have a gallery forest that is usually related to spring lines on the escarpment.

Plate 7. Rudimentary soil and water conservation (SWC) measures on erodible rainfed soils

Plate 8. Eroded lands on edge of gallery forest (behind photographer).