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

# *MAIN REPORT*

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The Feasibility Study (FS) report for the Dinger Bereha Irrigation Project (herein after named 'the Project') comprises one main report and six volumes of annexes, maps and drawings and has been prepared in accordance with the requirements of the contract for the Feasibility Study Phase 2 of the Engineering Component of the Eastern Nile Irrigation and Drainage Study (ENIDS), concluded between the Eastern Nile Technical Regional Office (ENTRO), the Client and BRLi, Metaferia Consultants and Shoraconsult, respectively for the Dinger Bereha project site in Ethiopia and the Wad Meskin project site in Sudan.

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# 2. INTRODUCTION

## 2.1 STUDY CONTEXT

The Nile Basin Initiative (NBI) was established in 1999 by the ten Nile Riparian States[1] as a co-operative programme to address poverty, environmental degradation and instability in the Nile Basin while promoting socio-economic development. The African Development Bank was represented at the launching of the International Consortium for Co-operation on the Nile (ICCON) which took place in Geneva, 26-28 June 2001, and on that occasion, committed itself to support the Nile countries in their effort "to achieve sustainable socio-economic development through equitable utilization of, and benefit from, the common Nile Basin water resources"[2]. In order to transform their Vision to action, the Nile Riparian countries developed a Strategic Action Programme which is being implemented through two complementary programmes: (i) the Shared Vision Programme (SVP) and (ii) the Subsidiary Action Programme (SAP). The SVP seeks to build trust among the states, improve implementation capacity and lay the foundations for cooperative investment and development. The SAP is oriented towards investment projects at the sub-basin level, involving all potentially affected states.

Two sub-basin Subsidiary Action Programmes (SAP) have been initiated, covering respectively the Eastern Nile and the Nile Equatorial Lakes regions. Egypt, Ethiopia and Sudan form part of the Eastern Nile Subsidiary Action Programme (ENSAP) under the Eastern Nile Council of Ministers of Water Affairs (ENCOM) while Burundi, Democratic Republic of Congo, Egypt, Kenya, Rwanda, Sudan, Tanzania and Uganda form part of the Equatorial Lakes Subsidiary Action Programme (NELSAP). The goal of the ENSAP and the NELSAP are to develop the water resources of the Eastern Nile Basin and of the Equatorial lakes Basin respectively in a sustainable and equitable way to ensure prosperity, security, and peace for the whole Nile basin. The Eastern Nile Irrigation and Drainage Study (ENIDS) project, hereinafter named 'the Study' aims at contributing to the enhancement of food security, reduction of rural poverty, and reduction of population pressures in the region, with all associated beneficial effects on the environment. The study will contribute to attaining the agricultural sector goals of the participating countries (Egypt, Ethiopia and Sudan), towards an integrated approach to irrigation and drainage development in the Eastern Nile sub-basin as a means for enhancing food security, poverty reduction, improved welfare of the rural population and sustainable natural resource management.

The Study has two components:

- Engineering Sub-component that has identified a total of 15,000 ha (net) in Ethiopia and Sudan from among the proposed potential sites and has undertaken a feasibility study for irrigation development.
- The Cooperative Regional Assessment (CRA) that has:
  - prepared guidelines for the identification and selection of irrigation and drainage projects presenting regional benefits;
  - undertaken assessment of the need for institutional and legislative reforms; and
  - proposed a cooperative framework and a common agenda on irrigation development in the Eastern Nile Basin (Egypt, Ethiopia and Sudan) for the medium and long term.

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[1] The ten Nile countries are Burundi, Democratic Republic of Congo, Egypt, Ethiopia, Eritrea, Kenya, Rwanda, Sudan, Tanzania and Uganda. Eritrea currently holds an observer position.

[2] Vision of the NBI

The Inception Phase of the Study commenced in September 2007. The findings of this phase indicated that there was a need to undertake detailed field surveys related to soils, topography and geotechnical investigations that would be a critical input to the Phase 2 Feasibility study under the Engineering sub-component. However, the sites would have to be selected first during Phase 1 of the Engineering Study.

## 2.2 Phase 1 Diagnosis of Engineering Study and Identification of Potential Site

BRLi of France and Metaferia Consulting Engineers of Ethiopia have been working on the Eastern Nile Irrigation and Drainage Study (ENIDS) since September 2007. During the Diagnosis Phase a large number of project sites were described, compared and ranked on basis of a number of criteria. The results have been presented in the respective reports. The analysis showed that many projects identified and ranked were already under study at feasibility level, apart from projects that were ranked low in the Abbay, Tekeze and Baro-Akobo Masterplans. Moreover, many sites not yet under study such as Galegu, Rahad and Lower Beles covered areas that were much larger than 7,500 ha net.

The smaller sites included the Didessa Pumping Project and the Dabana Project in the Didessa Valley, as outlined during the Abbay Masterplan Studies. The site for the Didessa Pumping Project was preselected for further study as it was located in a populous zone, near a major town and near good infrastructure and services. The Consultant carried out a brief study on this site and quickly came to the conclusion that is was not suitable at all for the development as proposed in the Masterplan.

Subsequently, the Didessa State Farm on the right bank of Didessa River and adjacent to the main road between Nekempte and Assossa was found to be a good site for irrigated agriculture, but further studies showed that the investment and recurrent costs for delivery of water either by gravity or by pumping would be prohibitive. During these studies, it appeared that the left bank of the river opposite the Didessa State Farm, upstream of the confluence with Dabana River presented better opportunities. This area was part of the Dabana Project, as formulated by the Abbay Masterplan. This project was ranked very low at the time because of many reasons that are not relevant to this study. A preliminary study was carried out for the new project site and the indicators were so positive that the Consultants strongly recommended to select this site for feasibility study.

In the Phase 1 Engineering Report, the Consultant’s findings indicated that the sites proposed for feasibility study were the Dinger Bereha area in Ethiopia and the Wad Miskeen project, in Rahad II area in Sudan. The preliminary boundaries were determined during the Inception Phase of the Field Investigations.

## 2.3 Preliminary Analysis of Dinger Bereha Project Site and Comparison with Nekempte Project Site

It was, however, late in October 2008 that a preliminary go-ahead for Dinger Bereha was approved for the intended studies. In view of the approval, the Consultants made a field trip between 3 and 8 November for verification, delineation and first hand observation of the Project area so as to plan and program for subsequent surveys and sectoral studies. The team was led by the BRLi Project Director and on Nov. 5, Ato Ayalew Nigussie of ENTRO and Ato Hayalsew Yilma, the National Coordinator at MoWR joined the team for the same purpose. The team’s first visit was the Woreda Administration Office at Ilu Harar, administrative town of Chewaka Woreda in the Didessa Valley near the confluence of Dabana River with Didessa River.

The main findings of this visit were:

- The Project area is located about 54 km from the junction of Nekemte – Bedele road. The junction is at the 18 km mark from Bedele on the way to Nekemte, at the site of village 77. The project site (Woreda town) is accessible via an all-weather road, which is in poor condition over at least 50% of its length.
- The area is a newly settled area, where resettlement of farmers from Harar started in the beginning 2004. According to the information gathered from the Woreda, about 12,000 households with about 92,000 persons were settled on this area. The total area that is under cultivation/has been cultivated in 2008 is about 20,000 ha. Crops grown included sorghum, maize, sesame, soybean and upland rice. There are 27 peasant associations formed throughout the Woreda.
- The Project area is undulating and criss-crossed by large and small gullies. Vegetation cover is sparse with the exception of trees and bushes along streams and dense vegetation along Didessa River. The intended irrigable area of 7,500 ha could be easily attained. However, the length of the Main Canal, as proposed in the option with gravity supply and/or pumping from Didessa River together with the topography of the command area may pose some limitations regarding investment and O&M costs.

In view of the topographic features of the Project area, the Client requested the Consultants to justify the technical and financial feasibility of the area for further studies. In association with the findings during the visit the Client requested the Consultants to investigate the technical feasibility of the Nekempte Project area as well, as the topography of the area located south of the Angar River was reported to be more suitable than the topography at Dinger Bereha.

In November 2008, the Consultant prepared a technical note that would enable the Client to make a final decision. The note presented the first details and indicators on Dinger Bereha that were not available at the time of the preparation of the ENID First phase Diagnosis Study and a comparison of the description of the Nekempte project according to the USBR and Masterplan studies with the description of the ENIDS option for Nekempte, as formulated by the Consultants. The note recommended against the selection of Nekemte project in favour of the Dinger Bereha site for further feasibility level studies and concluded, after comparison with the Nekemte project that:

- Dinger Bereha will be dependent on Didessa River, the base flow of which is not sufficient to irrigate substantial areas. Moreover, a sugarcane project was and is still being developed upstream of the potential diversion/pump site and therefore the proposed scheme, like any other project would be dependent on flow regulated by irrigation/hydropower/multipurpose dams in the upstream catchment area. The Arjo-Didessa multi-purpose dam is now under study.
- Both Dinger Bereha and Nekemte schemes will be dependent on dams for regulated flows and therefore selection has to be based on other indicators such as investment costs, O&M costs, IRR (all for irrigation only), proximity to major roads and market centres, population density and environmental impact.
- The updated investment and O&M cost estimates and the subsequent IRR calculations have clearly shown that Dinger Bereha has a good score, whereas Nekemte is not feasible. Dinger Bereha is also located very close to a major highway that is now being upgraded.

Other advantages that were highlighted include:

- A bridge would soon be constructed to link the woreda with the major highway Assossa-Nekempte-Addis highway;
- Settlement and resettlement costs would be relatively small because the site was already settled by a farming population and the proposed water distribution system would require minimal land take;
- The settlers are experienced farmers and have experience with irrigated agriculture;

- Land suitability is good for many irrigated cash crops.

The Consultants therefore strongly recommended selecting Dinger Bereha for further studies, during which gravity and pump options would be compared. Following a review of the technical note the MoWR decided on 24th December 2008 to endorse the selection of the Dinger Bereha site for feasibility study (see MoWR letter in Appendix A).

## 2.4 FIELD INVESTIGATIONS

ENTRO made arrangements, intended to prepare soil and topographic maps as well as to undertake geotechnical investigations of the sites selected for feasibility study. The terms of reference of the surveys were prepared during the beginning of 2008, and after funding was committed by the AfDB, a RFP was issued in March 2008. Proposals were submitted in July 2008 and after evaluation, selection and negotiations a contract was signed in January 2009 by ENTRO, the Client, and the Joint Venture BRLi, Shoraconsult and Metaferia Consulting Engineers (MCE). The identification of sites with a total area of 15,000 ha (net) for feasibility study among the proposed potential sites was finalized in September 2008, after the locations of the sites were determined. As per the Phase 1 Engineering Report, the Consultant’s findings indicated that the sites proposed for feasibility study were the Dinger Bereha area, in Ethiopia and the Wad Miskeen project, in Rahad II area in Sudan. The precise boundaries were to be determined during the Inception Phase of the additional investigations.

Inception Reports were prepared and the final version of these reports was approved in May 2009. The surveys, laboratory work, mapping and reporting were carried out between the end of April and the end of October. Part of the toposurvey work and geotechnical investigations could not be completed because fieldwork had to be suspended due to inaccessibility of part of the Study area during the rainy season. In spite of the best efforts of the Consultants this could not be avoided, as the start of the fieldwork was delayed due to circumstances beyond the control of the Consultant. Fieldwork would be continued as soon as the area would become accessible again, which was expected to be in the beginning of November 2009. However, toposurvey work could not be restarted before the end of January 2010 because of very tall wet elephant grass in swampy conditions.

## 2.5 ANALYSIS OF THE PROJECT SITE BEFORE DETAILED STUDIES

### 2.5.1 General Description

The Project site is located in the Chewaka Woreda of Illuababora zone in Oromia National Regional State at a distance of about 560 km to West of Addis Ababa. (see Map 2.1). The command area, marked by undulating terrain covers fully or partly 11 Kebeles of the Woreda, and is about 10,000 ha in gross. It is bounded by Didessa and Dabana rivers, and is located upstream of their confluence. The Project area was settled by the Government resettlement programme as of December 2004. People from the eastern and western Hararge were resettled in the area under the programme. The number of households resettled was estimated at 12,390 when the programme started whereas the current house hold number is 14,026, with a total population of 78,179 and 92,027 respectively (source: 2008 self-woreda population census for the latest size of the population in the Woreda). 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. Agriculture is the main stay of the economy of the Woreda. 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 keeps the resettled population to run a mixed farming system. Irrigation of land would be possible on the left bank bounded by contour +1260 to the west, by Dabana river to the north and by Didessa River to the east.

The gross command area was estimated at 6,100 ha between rivers and contour +1240 and 5,500 ha between contours 1240m and contour 1260m. The net irrigable area under command by two stage pumping was estimated at 8,100 or 70% of the total gross area. The pump station would be located at N 090200, E 098300. As alternative, the water could be supplied by a weir, located 15 km upstream of the pump station site at N 083500 E 003800. Pumping would then be limited to the area of between +1240 and +1260.

View on Project area (November 2008)

Didessa River near Dabana River (Nov 2008)

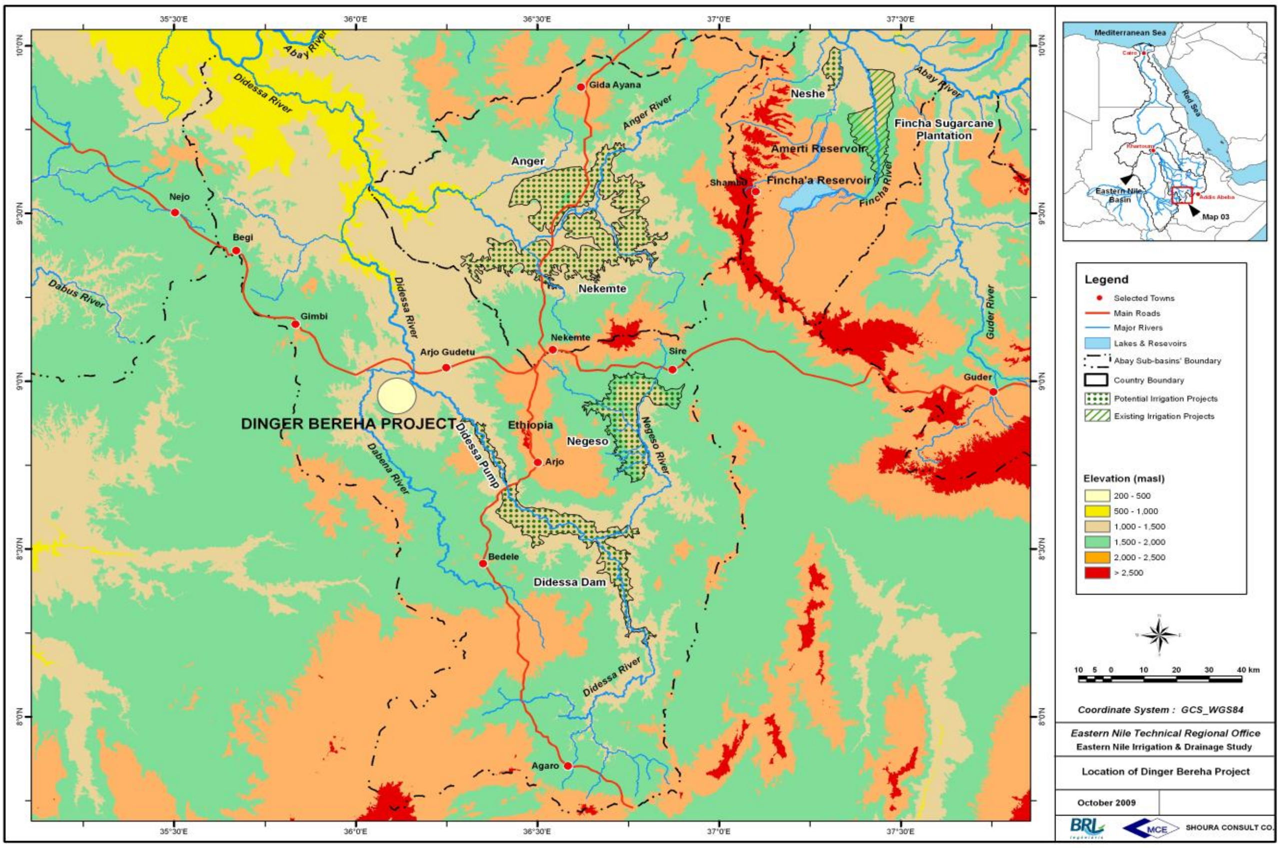
Because of the different development options the command area was divided in two parts:

- the western part, bounded by Didessa River, Dabana River, Chekorsa/Boro River and contour +1260 m; and
- the eastern part, bounded by Chekorsa/Boro River, Didessa River and contour +1260 m.

With GIS software and the Consultant's 1:50,000 georeferenced map database the gross areas between the physical boundaries and contours +1240, +1260, and +1280 were determined. A forested buffer zone of 200 m wide along Didessa and Dabana Rivers was excluded from irrigation development. The results of this analysis are presented in Table 2.1. To allow for villages, roads, topographically unsuitable areas, and areas to be set aside for woodlots and bufferzones along streams the net irrigable area is assumed to be 70% of the gross area. In addition, with the Spatial Analist software a slope analysis was prepared of the potential command areas below contour +1260, using a SRTM digital elevation model with 90 m spatial resolution. It could be concluded that:

- 7,852 ha net can be irrigated below contour +1260;
- In the western area, close to the Dabana River there is more than 2,300 ha net available between contours +1260 and +1280. In the eastern zone the area enclosed by these contours is less than 600 ha. The difference is attributed to the fact that the eastern area is smaller and steeper than the western area;
- As in the eastern area the difference between +1260 and +1280 is small, it does not make much sense to lift water higher than an elevation of +1260 m. Therefore the eastern main canal will follow the contour +1260;
- Below contour + 1260, the area with slopes 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%.

The western area can be commanded by a canal following contour +1260 to be supplied either from the eastern canal and/or by a pumping station at the Dabana River.




*Map 2.1: Location of the Dinger Bereha Irrigation Project*

*Table 2.1: Areas (ha) for different zones, Dinger Bereha*

| Name | Eastern area | | Western area | | Total | |
|---|---|---|---|---|---|---|
| | Gross | Net | Gross | Net | Gross | Net |
| Bufferzone | 333 | 333 | 328 | 328 | 661 | 661 |
| Below 1240 | 2,242 | 1,569 | 3,846 | 2,692 | 6,088 | 4,261 |
| Below 1260 | 3,949 | 2,764 | 7,268 | 5,088 | 11,217 | 7,852 |
| Below 1280 | 4,700 | 3,290 | 10,584 | 7,409 | 15,284 | 10,699 |

Note: The 'below' figures do not include the bufferzone areas

*Table 2.2: Areas (ha) according to slope class, Dinger Bereha*

| Slope class (%) | Eastern area below +1260 | | Western area below +1260 | | Total below +1260 | |
|---|---|---|---|---|---|---|
| | Gross | Net | Gross | Net | Gross | Net |
| 0-2 | 504 | 353 | 996 | 697 | 1,500 | 1,050 |
| 2-5 | 1,940 | 1,358 | 4,994 | 3,496 | 6,935 | 4,854 |
| 5-8 | 1,724 | 1,207 | 3,179 | 2,226 | 3,904 | 2,433 |
| Over 8 | 980 | 686 | 1,645 | 1,151 | 2,625 | 1,837 |

Note: The areas do not include the bufferzone area

## 2.5.2 Previous studies

The command area is part of the Dabana command area. There were no previous studies for the Dinger Bereha Project, but the irrigable part of the area has been described under the Dabana Project (USBR 1964).

Although a site visit to west Wellega zone of Oromia National Regional State was made earlier, and a discussion with the zone's officials was undertaken, no additional documents for review could be made available. Prior to the second site visit (in September 2008), additional documents were searched for review at the Ministry of Water Resources and at the Oromia Regional Water Resources Bureau, but it was not possible to get any additional document that describes the Project area, and/or study on the potential resources of the area.

### 2.5.3 Identified Development Options and Project Outline

The objective of the Project is to increase crop yields and improve the living standards of the people in the Project area. This objective would be achieved by diverting irrigation water from Didessa River, one of the potential tributaries of Blue Nile, at d/s of the bridge on the road Nekemte via Arjo to Bedele. During the first phase of the ENIDS two alternatives for irrigation were identified:

**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 where the north-south ridge, named Lebena is joining 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 Dabana 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. Details on capacity, dynamic head, and power requirement are presented in the project cost sheet in Appendix A of the Main Report of the Phase 1 Component 1 study. 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 boosterpumping**: about 15 km upstream of the pumpstation 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 main 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 boosterstations.

Irrigation of land would be possible on the left bank in an area, bounded by contour +1260 to the west, by river Dabana 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 bufferzone of 661 ha, the net irrigable area under command by gravity&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 Dabana River by a pumpstation that would be located at N 993 400 and E 174 500, on the right bank of Dabana River at an elevation of +1230. Water would be lifted via pipelines over a length of 2,870 m upto 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 headloss will be about 10 m, so the dynamic head would be in the order of 65 m.


*Plate 2.1: Potential site for weir and intake, Didessa River*

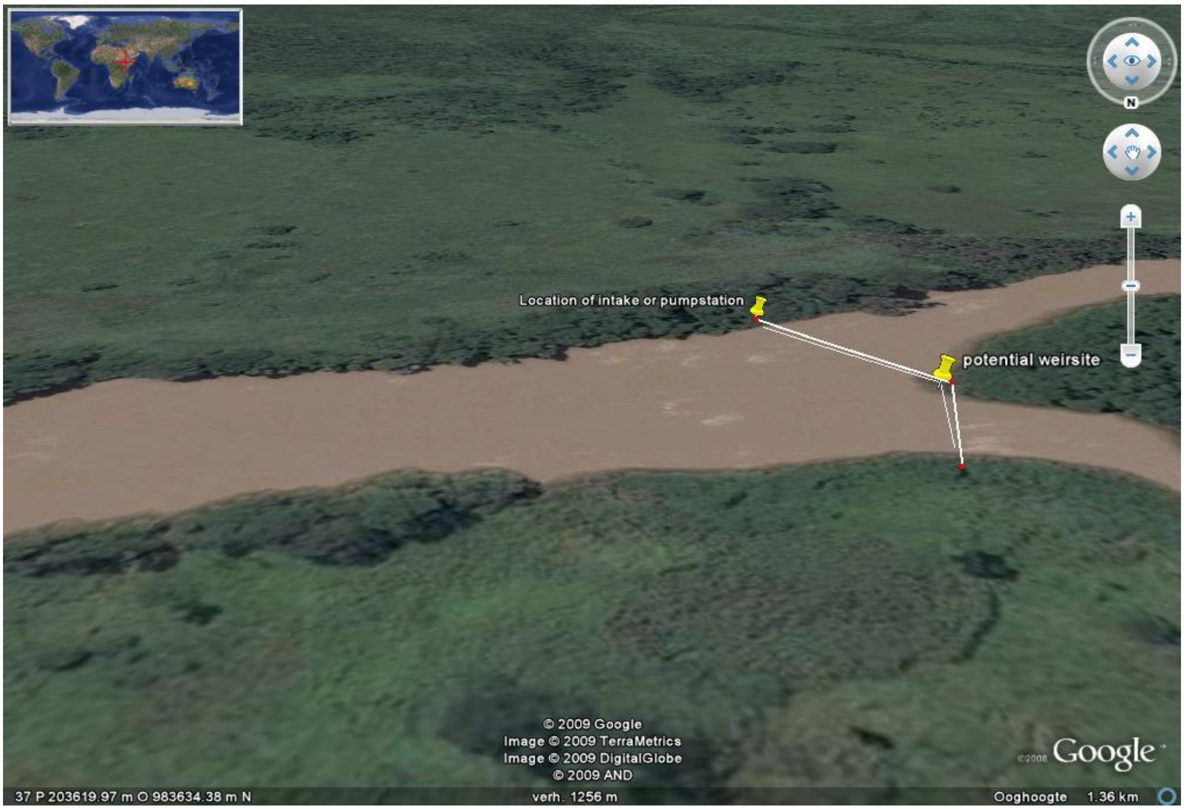



*Plate 2.2: Birds eye view of weir and intake in western direction*

*Plate 2.3: View on bifurcation downstream of diversion site*

# 3. BACKGROUND

## 3.1 ETHIOPIAN ECONOMY

### 3.1.1 Geography and population of Ethiopia

Ethiopia is a landlocked country of 1,100,000 $km^2$ in the Horn of Africa having international borders with Eritrea to the North, Djibouti and Somalia to the East and the South East, Kenya to the South and Sudan to the West. Ethiopia's physical and socio-economic geography is marked by its huge relief variation. Altitude ranges from 110 below sea level in the Danakil depression to over 4,600 meters above sea level in the Northern Simien mountains.

The **highlands** (altitude above 1,500 m) are composed of rugged mountains and flat topped plateaus and amount to 58% of the country land mass. Here, communication and transport is very difficult and population density can reach 150 inhabitants per $km^2$ making Ethiopia "the most populated mountain in the world" as some geographers put it. It strongly contrasts with the **lowlands** plains (altitude below 1,500 m) generally hot, arid and little populated (see map 3.1).

Ethiopia has a tropical monsoon **climate** with wide altitude-induced variation. Three climatic zones can be distinguished: a cool zone consisting of the central parts of the western and eastern section of the high plateaus, a temperate zone between 1,500 m and 2,400 m above sea level, and the hot lowlands below 1,500 m. Mean annual temperature varies from less than 7-12ºC in the cool zone to over 25 ºC in the hot lowlands. Mean annual potential evapotranspiration varies between 1,700-2,600 mm in arid and semi-arid areas and 1,600-2,100 mm in dry sub-humid areas. Average annual rainfall for the country is 848 mm, varying from about 2,000 mm over some pocket areas in South-West Ethiopia to less than 100 mm over the Afar Lowlands in the North-East. Rainfall in Ethiopia is highly erratic, and most rain falls intensively, often as convective storms, with very high rainfall intensity and extreme spatial and temporal variability. The result is that there is a very high risk of annual droughts and intra-seasonal dry spells. Considering the water balance and the length of the growing period, Ethiopia can be divided into three major agro-climatic zones:

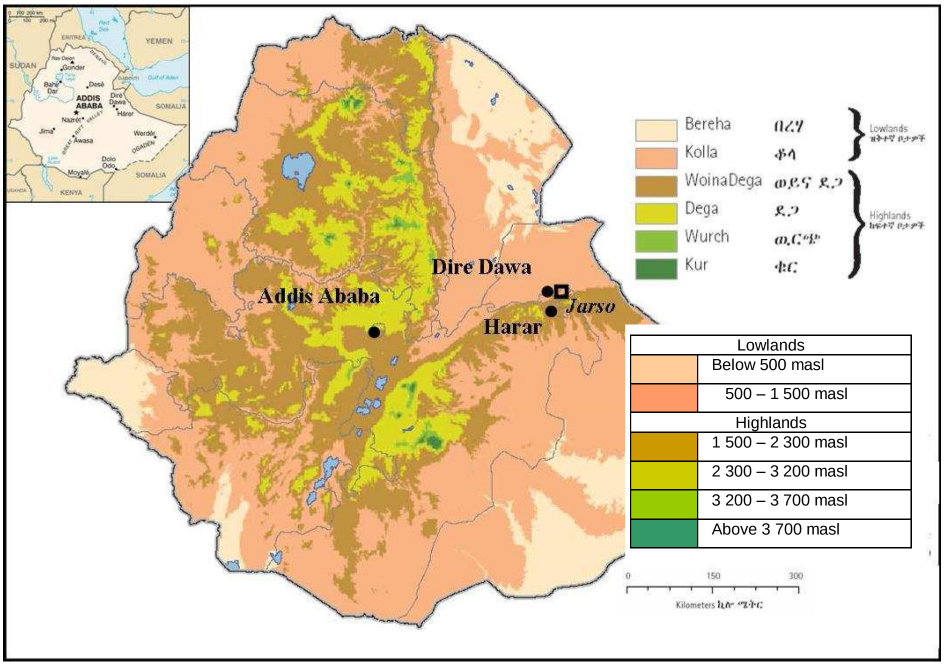
- Areas without a significant growing period, with little or no rainfall (eastern, north-eastern, south-eastern, southern and northern lowlands);

- Areas with a single growing period and one rainy season from February/March to October/November, covering the western half of the country, with the duration of the wet period decreasing from south to north;

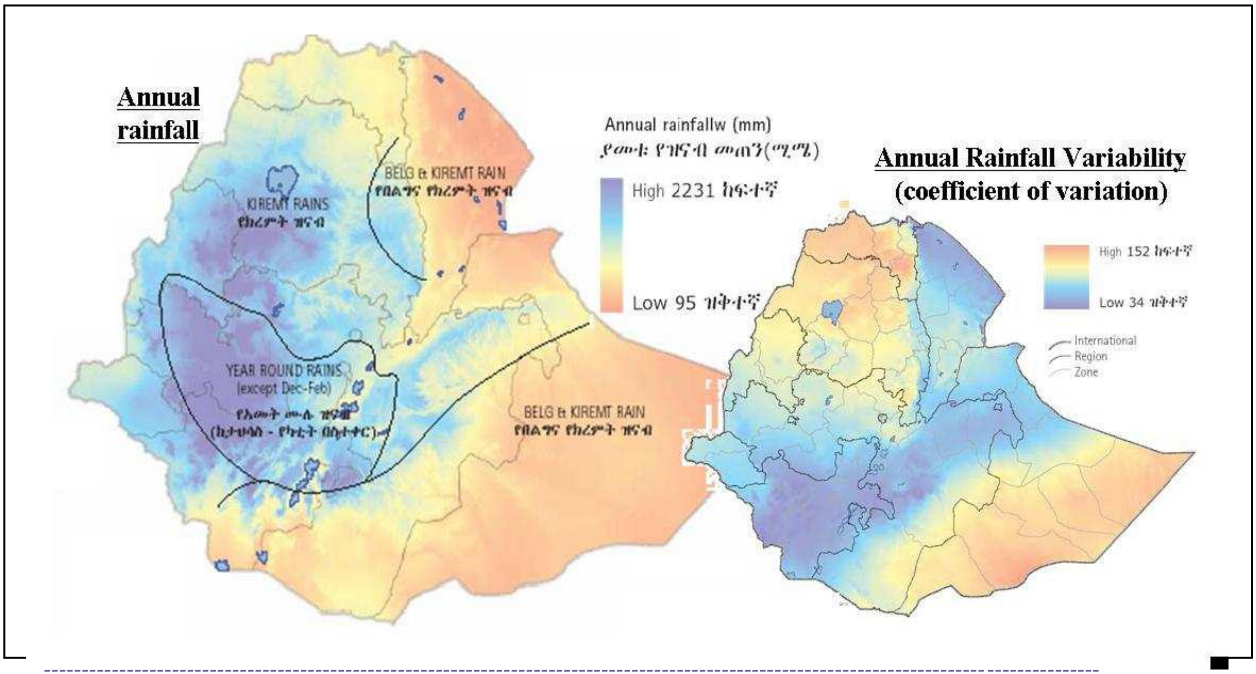
- Areas with a double growing period and two rainy seasons (Belg and Meher) which are of two types: bimodal type 1 and bimodal type 2. The region of type 1 in the East of the country has a small rainfall peak in April and a major one in August. The region of type 2, covering most of the lowlands of the south and southeast, has two distinct wet periods, February-April and June-September, interrupted by two clear-cut dry periods. The peak rainfall months are April and September.

According to the Population Census (2007), **the total population is 73.9 million** of which 12 million (16%) are urban and 61.9 million (84%) are rural and mainly dependant on agriculture as their primary source of livelihood. The average annual population growth was 2.6% over the period 1994-2007. Ethiopia's population ranks as the second largest in Sub-Saharan Africa (after Nigeria). Composed of 83 ethnic groups, Ethiopia's population is highly multiethnic. The main groups are the Oromo (34.5% of population), the Amhara (26.9%), the Somali (6.2%), the Tigrie (6.1%) the Sidama (4%). Though the country's history is strongly marked by Christianity, around 34% of the population is Muslim (Sunnite), 62% Christian (predominantly Orthodox) and 4% have kept Animist cults. The population of the Project area is Muslim Oromo people which were resettled from the highly populated Hararghe highlands.

*Map 3.1: Relief of Ethiopia*




*Map 3.2: Rainfall spatial distribution and variability.*



### 3.1.2 Structure and performance of the Ethiopian economy

**Structure:** Agriculture still accounts today for 47% of GDP (down from 75% in the 1960's) agriculture contribution to the GDP can be disaggregated between crop and livestock production in Ethiopian highland and lowlands (table 3.1). Manufacturing only contributes to approx 5% as does the construction sector. Services account for about 40%. In addition, agriculture accounts for 90% of exports and 85% of employment. Agriculture is the primary source of income for 87% of the rural population (or 73% of the total population). **In short, Ethiopian economy is based on the labour of the millions of Ethiopian small scale farmers.**

*Table 3.1: Disaggregation of agriculture contribution to GDP in % (in year 2000)*

| | |
|---|---|
| Peasant crop production highlands | **25.0** |
| Peasant crop production lowlands | **7.6** |
| Total crops | 32.6 |
| Peasant livestock | **13.6** |
| Commercial farming | **2.3** |
| Total agriculture | 48.5 |

Source: Alemayehu Seyoum and Tadele Ferede, The structure of Ethiopian Economy (2004**)**

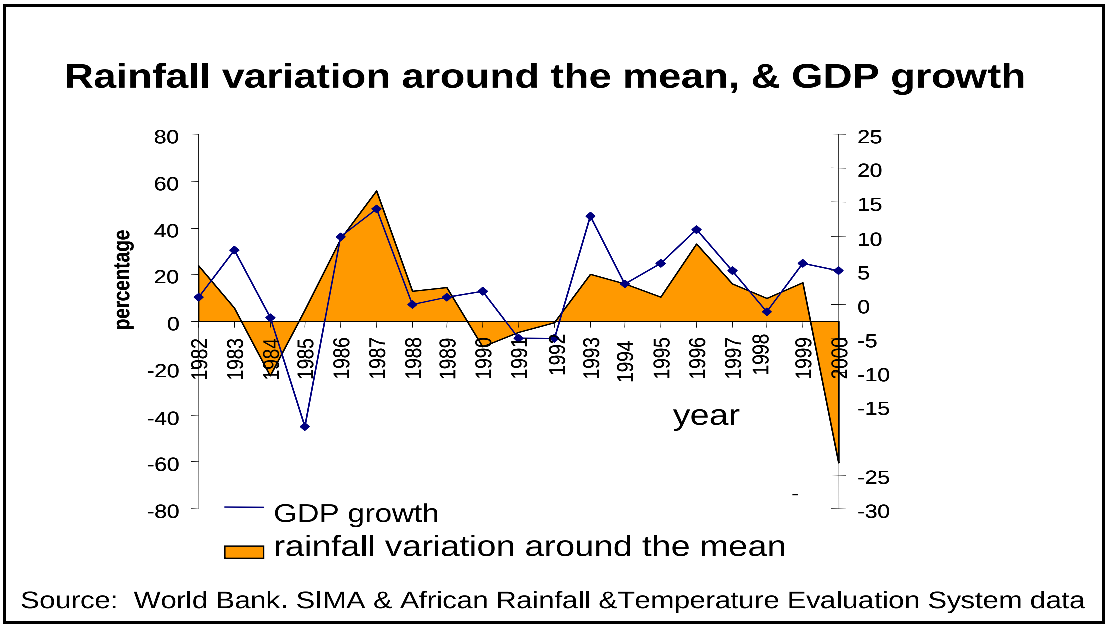
**Recent trends:** Per capita GDP was about US$180 in 2006. There was a declining trend during the Derg regime, 1974 - 1991, as well as in the years just after but since 1994/95 there has been a positive upwards trend. Since the drought of 2002/03, there has been a two digit GDP growth rate (table 3.1). However, the GDP growth of a few years should be interpreted with caution because agriculture has a heavy weight in Ethiopia's GDP and is subject to recurrent droughts. The correlation between GDP and rainfall is strong as shown in figure 3.1. 2008-09 is a drought year in which agriculture production and GDP might significantly drop as in 2002-03.

*Table 3.2: Recent trends in key economic indicators (%)*

| | **2001/2** | **2002/3** | **2003/4** | **2004/5** |
|---|---|---|---|---|
| GDP | 1.0 | -3.3 | 11.9 | 10.6 |
| Agriculture | -2.1 | -11.4 | 17.3 | 13.4 |
| Industry | 8.3 | 3.0 | 10.0 | 8.1 |
| Distributive Services | 3.3 | 2.9 | 8.2 | 7.6 |
| Other Services | 0.3 | 6.1 | 6.4 | 9.1 |
| Inflation | -8.5 | 15.1 | 8.6 | 6.8 |
| Gross Domestic Investment | 10.9 | 4.5 | 17.3 | 15.5 |
| Total Government Expenditure | -1.4 | 24.1 | 0.0 | 20.9 |
| Pro-poor sectors expenditure | 37.1 | 13.8 | 18.4 | 37.6 |

Source PASDEP, 2006.

*Figure 3.1: Correlation between GDP and rainfall variations*




**Exports.** Exports of goods and services only account for about 15% of GDP. In 2005/06, Ethiopia's total exports of goods amounted to about US$1 billion, primarily comprised of agricultural commodities. Coffee is the major export item accounting for 35-40%, followed by oilseeds (about 20%) and khat (9-12%). The value of oilseed exports has increased from US$33 million in 2001/02 to US$211 million in 2005/06. Also cut-flower exports are increasing rapidly; from a negligible base of less than US$1 million in 2001 to US$23 million in 2005/06. Ethiopia has the highest number of livestock heads in Africa (comprising an estimated 29 million cattle, 24 million sheeps, 18 million goats, 1 million camels, 7 million equines, 53 million poultry). However, the export value of live animals and livestock products (meat and leather) is modest (US$121 million in 2005/06).

**Privatisation and state owned enterprises.** Since 1992, market liberalisation and major privatisations have been undertaken to make the economy private-sector-led. As a consequence of privatisation as well as private sector growth, the share of State Owned Enterprises (SOEs) in industrial output declined from 86% in 1996 to 51% in 2005. According to the World Bank, while pursuing privatisation, GoE continues to establish and develop new enterprises, and as a consequence the (net) number of medium and large industrial SOEs has increased since 2002. Foundations linked to political parties own enterprises (i.e. endowment companies), which often engage in areas that according to the World Bank judgment[3] are not adequately covered by the private sector, e.g. agricultural inputs, storage and processing, and transport, banking and rural microfinance. Information on reasons for inadequate coverage is available in the WB reports. The largest endowment companies are region-based and focus on rehabilitation and development of a particular region.

**The financial sector.** Government of Ethiopia has allowed private *local* ownership of banks, and private banks now hold 24% of total commercial bank assets, a share that is rapidly increasing. However, the financial sector is still dominated by large public financial institutions such as the Commercial Bank of Ethiopia (CBE) and the Development Bank of Ethiopia (DBE). In recent years, the state and regional governments have made a major push to increase financial services for agriculture, micro and small enterprises and low-income households.

[3] Country Economic Memorandum; the World Bank (2007).

**Social development.** When the EPRDF formed the transitional government in 1991, the human resource base was in very poor state. Since then, massive investments have been made in education at all levels. The primary school gross enrolment rate has increased from 20% in 1993 to 79% in 2004 and universities are being established in all regions, with the enrolment capacity of universities increasing from a few thousand in the early 1990s to about 50,000 today. Similarly, there have been rapid improvements in health sector services and water supply.

**Poverty.** Based on three household income, consumption and expenditure surveys, it appears that national poverty prevalence declined during 1999/2000 – 2004/05. The reduction has been significant in rural areas, due to the very high rates of agricultural growth during 2003/04 and 2004/05, but also to the National Food Security Programme (see section 3.3.1). However, in urban areas poverty has increased. Data also show that the poverty gap (distance up to the poverty line) has declined. However, due to population growth the absolute number of poor people has only declined by 2% or half a million, from 28 million in 1999/00 to 27.5 million, in 2004/05; and about 60 million Ethiopians live with less than two dollars per day.

## 3.2 Agriculture Development and Food Security

### 3.2.1 The Ethiopian farming systems

**Ethiopian agriculture is a rain-fed peasant agriculture**; commercial farming and irrigated agriculture represent so far an insignificant part in term of contribution to the national production. Ethiopian peasant agriculture is often termed as "subsistence agriculture" since common characteristics of peasant farming systems are low inputs- low outputs production systems, small land holding due to lack of farming equipment and population pressure on arable land in the highlands. Another characteristic is the concentration of farming activity in the highly populated and now saturated highlands while some of the lowlands offer considerable and little developed potential for both rain-fed and irrigated farming. The total cultivated area in the country is approx 13 million ha.

**The peasant highland mixed farming system** is based on cereal production; it is practised on about 45 percent of the country land mass in areas at more than 1 500 m above sea level. Livestock production is an integral part of the system, but is increasingly being restricted to stall feeding of animals due to scarcity of land. Animal traction (oxen) is used for land preparation to produce mainly cereals: barley (only above 2500 masl), teff, sorghum, wheat and maize; pulses (chick peas and lentils) and oil crops (Niger seeds). Land holding size is generally small, between1 and 2 ha. Saturation of the system due to high population density, deteriorating soil fertility and rainfall volatility are the biggest challenges facing this production system that is largely dominant in Ethiopia both in term of area and population. Agriculture productivity is low (1.4 ton/ha for cereals in average).

**The peasant highland maize-sorghum and perennial crops farming system** is located in the highlands of the Southern and Western part of the Nile basin that are sparsely populated and highly forested compared to highland mixed farming systems. The system area benefits of year round rains except from December to February. It encompasses various cropping patterns such as maize-wheat; sorghum-teff-wheat; maize-enset and maize-teff-coffee[4]. Although livestock is typically integrated in this system, hoe culture is reported in some areas for enset and tuber cultivation. It is also practiced in khat and coffee fields with intercropping. The major production constraint is the fluctuation of the international market prices of coffee. Seasonal labour shortages are frequently reported during coffee harvest.

[4] Source : Bourn, D 2002. Farming systems and natural resource management. Ministry of Agriculture, Addis Ababa, Ethiopia

Thus farmers hire casual labour, mostly landless farmers and farmers who move from other areas (Highland mixed farming system) for this purpose.

**The peasant lowland crop-livestock production system** is located in low-lying plains, valleys and mountain foothills, which include the northern parts of the Awash and the rift valley with elevations of less than 1 500 m. These areas mainly produce drought-tolerant varieties of maize, sorghum, wheat and teff, along with some oil crops and lowland pulses. Oxen are used for providing traction power and communal grazing lands and crop residues are used for livestock rearing. Off-farm activities such as sale of firewood and charcoal are widely practised.

**The peasant lowland shifting cultivation system** is located in the Western and southern lowlands of the country. The major crops are sorghum, maize and millet, sorghum becoming dominant when rainfall declines toward the Sudanese border. The population in this farming system is sparse (less than 10 persons / $km^2$). Slash and burn is the main soil fertility management practice and plots are cultivated for one or two years then the farmer moves to another plot. The yield in this system is low (0.6 – 1 ton/ha for cereals). Despite surplus feed, livestock is little integrated in the system; this could be accounted to the prevalence of the tsetse fly in some areas. In response to the rapid population growth due to the government resettlement program and spontaneous population migration from the saturated highland mixed farming system, this system is likely to evolve into a crop-livestock production system. **The Project area is located in this farming system and resettled population from the Hararghe highlands have started using oxen for draft power and fattening livestock as part of their livelihood strategies.** There is significant irrigation potential in the system area particularly in the western part of Abbay basin. The major agriculture development constraint is the low accessibility of the Region.

**The pastoral system** supports the livelihood of approx 10 percent of the total population living in the Afar, Somali and Borena regions. Livestock is the major source of livelihood of these populations that are highly mobile in search of water and grazing. Camels are the most important animals serving as both food and means of transport. Some lowland varieties of maize, sorghum and other cereals are also cultivated on flood plains or as rain-fed crops.

**Commercial farming** is very limited in Ethiopia. It mostly consists of public or recently privatized **irrigated farms** producing the country's bulk of industrial crops (sugar, cotton, tobacco) and horticulture crops; **State owned rain-fed farms** mostly in the region of the highland maize-sorghum and perennial crops farming system and the rapidly growing private **cut-flower business** located in the vicinity of Addis Ababa and the rift Valley. There are also a number of large scale farm projects at various stages of advancement recently initiated by **foreign investors** from Brazil, China, India, Pakistan, Saudi Arabia for production of food crops, industrial crops (sugar cane) and bio-fuel.

**Peasant irrigated farming** is usually operated on a small scale. Small scale irrigation of fruits and vegetables (onion, potato, cabbage, etc) complements the livelihoods of rain-fed peasant farmers by providing cash incomes. Small scale traditional or modern irrigation is integrated into the farming systems (e.g.: highland mixed system, lowland crop-livestock system) and cannot be considered as a separate farming system. There are also a number of large scale irrigation schemes under construction (Koga in Lake Tana watershed) and under study: Megech, Ribb and Anger in the Nile basin and Humera in the Tekeze basin.

Note: Figures of small scale modern and traditional are rough estimates since it is difficult to account for the small-scale irrigation development, particularly, the traditional irrigation development. The privately developed household-based irrigation schemes which use traditional diversions, water harvesting and ground water development are not included in table 3.3.

*Table 3.3: Categories of irrigation schemes in Ethiopia.*

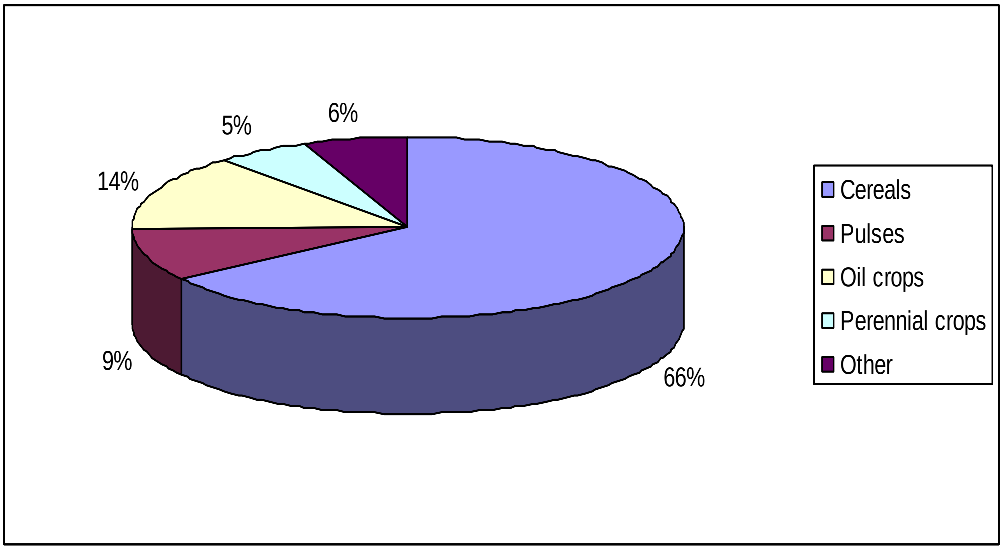
| | Peasant irrigation | | Commercial irrigation | |
|---|---|---|---|---|
| | Traditional irrigation | Modern irrigation with smallholder farmers | Irrigated state farms | Transferred or privatizes schemes |
| Total area in country | 200,000 ha | 80,000 ha | 60,000 ha | 10,000 ha |
| Size of individual scheme | 10 -200 ha | 30 – 200 ha | above 3,000 ha | 200 – 3000 ha |
| Average size of farms within scheme | 0.1 – 0.5 ha | 0.25 ha | N.A | N.A |
| Design & construction by | Communities | Regional bureaus of water or former regional irrigation development authorities | Government after 1975, private enterprises before 1975. | Government after 1975, private enterprises before 1975. |
| Management by | Irrigation Water Users communities | Irrigation cooperatives | Public enterprises | Private enterprise |

Source: "Water resources and irrigation development in Ethiopia"
IWMI Working Paper 123 (2007).

## 3.2.2 Agriculture production and food self-sufficiency

The cultivated area covers about 13 million ha and cereals are the largely dominant crops and cover 66% of the cropped area, food crops (cereals, pulses and oil crops) cover 88% of the cultivated area (figure 3.2).

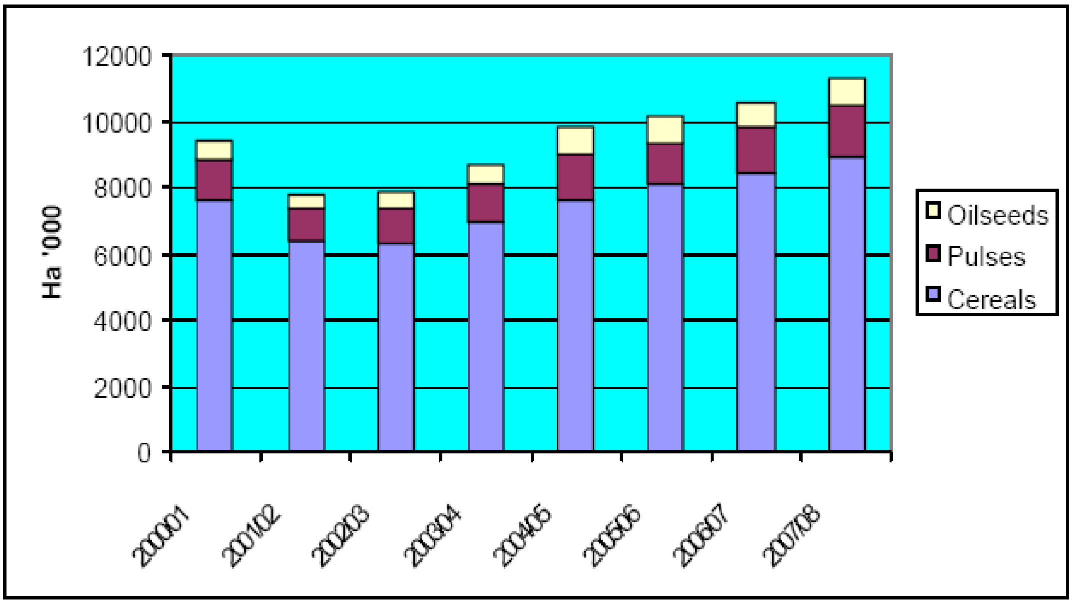
*Figure 3.2: Area by categories of crops in 2007 (% total cultivated area)*




Source CSA Estimates

Figure 3.3 below shows changes in the area under cultivation for food crops. The scale of cereal production masks a significant increase in the areas sown to pulses and oil crops over the last 7 years of 31% and 39% respectively. The figure also shows a consistent increase in overall cultivated area since 2001/02. The overall cultivated area has increased by 20% between 2001 and 2007. Over the same period of time, the production increased of approx 40% (table 3.4). **In other words half of the production increase came from expansion of cultivated area and half from productivity gains.** Ethiopia experienced a drought year in 2002/03, cereal production dropped by 33% compared to the previous year. Ethiopia is a large country and different regions can experience very different weather conditions (drought or flood) leading to crop failures in some areas even in "good years".

*Figure 3.3: Cultivated area for food crops ('000 ha)*




Source: CSA Estimates

*Table 3.4: Ethiopia's food crops production for years 2001 - 2008 ( '000 tons)*

| Crops | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|
| Cereals | 9 046 | 9 146 | 6 102 | 10 427 | 10 734 | 12 532 | 12 866 | 12 270 |
| Pulses | 1 014 | 1 004 | 723 | 1 036 | 1 361 | 1 307 | 1 579 | 1 418 |
| Oil crops | 199 | 219 | 195 | 298 | 510 | 494 | 497 | 583 |

Source CSA.

At a national level Ethiopia does not reach food sufficiency even in years with good rainfalls.

*Table 3.5: Food availability for the years 2001 - 2008 ( '000 tons)*

(Assuming 17% for waste and seeds and 30% oil extraction rate)

| Crops | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|
| Cereals | 7 508 | 7 591 | 5 065 | 8 654 | 8 909 | 10 402 | 10 679 | 10 184 |
| Pulses | 842 | 833 | 600 | 860 | 1 130 | 1 085 | 1 311 | 1 177 |
| Oil | 50 | 55 | 49 | 74 | 127 | 123 | 124 | 145 |

Source: FY 2008 Bellmon analysis for Title II monetization and distribution commodities for Ethiopia (AGRIDEV Consult; 2008).

Based on a total population of 73.9 millions in 2007 a growth rate of 2.6 % and FAO minimal nutritional requirements of 147 Kg/pers/year for cereals; 26 kg/pers/year for pulses and 9 kg/pers/year for oil, annual food requirements are given in table 3.6 below.

*Table 3.6: Food requirements for the years 2001- 2008 ( '000 tons)*

| | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|
| Cereals | 9 320 | 9 555 | 9 805 | 10 055 | 10 319 | 10 584 | 10 863 | 11 143 |
| Pulses | 1 648 | 1 690 | 1 734 | 1 778 | 1 825 | 1 872 | 1 921 | 1 971 |
| Oil | 571 | 585 | 600 | 616 | 632 | 648 | 665 | 682 |

Source: FY 2008 Bellmon analysis for Title II monetization and distribution commodities for Ethiopia (AGRIDEV Consult; 2008).

*Table 3.7: Food balance for the years 2001 – 2008 (' 000 tons)*

Food availability minus food requirements.

| | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|
| Cereals | - 1 812 | - 1 964 | - 4 740 | - 1 400 | - 1 410 | - 182 | - 185 | - 958 |
| Pulses | - 807 | - 857 | - 1 134 | - 919 | - 696 | - 787 | - 611 | - 794 |
| Oil | - 521 | - 530 | - 552 | - 541 | - 505 | - 525 | - 541 | - 537 |

Source: FY 2008 Bellmon analysis for Title II monetization and distribution commodities for Ethiopia (AGRIDEV Consult; 2008).

### 3.2.3 Food insecurity

Food insecurity is pervasive and persistent in Ethiopia because (i) the country is not self sufficient in food and its overall economy is too weak to purchase food on the international market to meet its needs beside of essential imports such as oil, manufactured equipments and fertilizers; (ii) many Ethiopians are too poor to buy food even when it is available; and (iii) dependency of Ethiopia's rain-fed agriculture to highly variable and increasingly unpredictable weather condition. The country has been chronically receiving food aid for many years.

**Four to six million people are chronically food insecure** and depend on food aid for survival. These are people who have no capacity to produce or to buy food even under satisfactory weather and market conditions. **If agriculture production would ensure food self-sufficiency and availability through markets at national level, the main food security issue would be access to food arising from lack income.**

**Another ten million people are vulnerable**, with a weak resilience to any shock. Under any adverse circumstances, these people are very likely to be dependent on food aid for survival; most of these people live in the area of the densely populated highland mixed farming system. There were also reported cases of "green famine" in the coffee growing areas near Jimma due to dramatic drop in coffee price on the international markets. The administrative units (Woredas) are categorized according to their vulnerability (see map 3.3 on following page).

The highly and very highly vulnerable areas are also referred as drought prone areas. In such zones, agriculture production varies considerably from year to year depending on rainfall pattern. Recurrent drought years or dry spells during the rainy season cause crop failure and subsequent famine if food aid is not delivered in time.

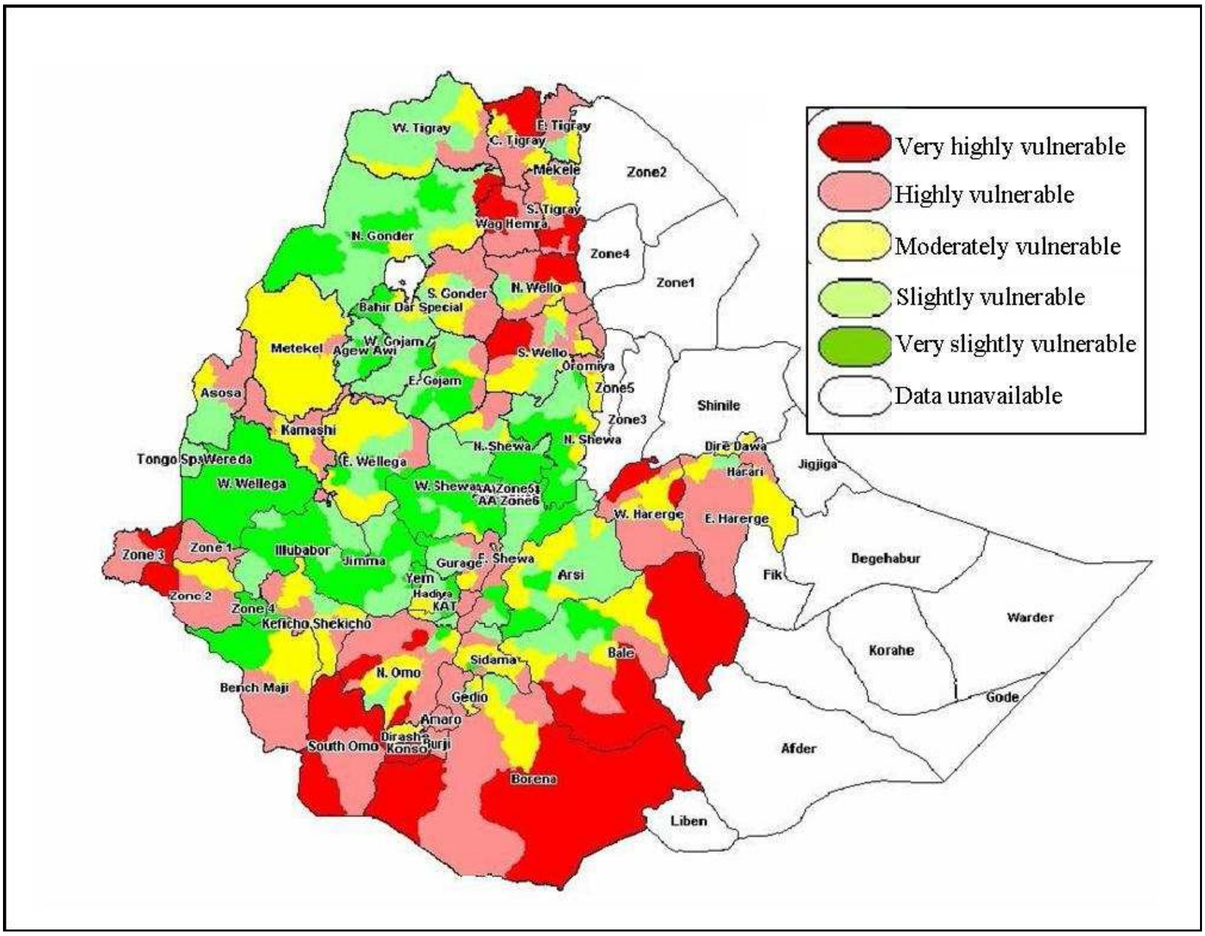
The Welfare Monitoring Survey (WMS) of 2006 (World Bank, 2006) shows a global prevalence of 37% undernourished. Malnutrition prevalence is higher in rural areas than in urban areas. This reflects the **difficulty of many subsistence farming households to satisfy their food needs with their own production**.

*Table 3.8: Food aid shipment and food commercial import for the years 2001 -2008 ( '000 tons)*

| | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|
| **Food aid** | | | | | | | | |
| Cereals | 623 | 284 | 1 633 | 532 | 887 | 323 | 479 | 370 |
| Pulses | 5 | 9 | 7 | 43 | 40 | 41 | 33 | 37 |
| Oil | 18 | 6 | 29 | 44 | 37 | 18 | 16 | 15 |
| **Commercial import** | | | | | | | | |
| Cereals | 10 | 12 | 22 | 19 | 12 | 22 | 17 | 18 |
| Pulses | - | 51 | 50 | 34 | 45 | 4 | 20 | NA |
| Oil | 12 | 3 | 52 | 11 | 22 | 40 | 51 | 60 |

Source CSA.

*Map 3.3: Food insecurity mapping*




Source: World Food Program (2006)

## 3.3 GOVERNMENT SUB-SECTORAL POLICIES

### 3.3.1 Agriculture and rural development policy

During the past two decades, Ethiopia's approach to promoting development and improving the lives of the country's rural population has been driven by a government strategy called Agricultural Development–Led Industrialization (ADLI). This strategy's main goal is to encourage broad-based development within the agricultural sector in order to power overall economic growth. While ADLI considers, human capacity and market to be key engines of agricultural growth, it also focuses on increasing public expenditure in road infrastructure, as well as in social sectors that are perceived as contributing to agricultural productivity.

The main pillars of ADLI are:

- **Public investments in the agriculture sector:** introduction of modern agricultural technology packages, inputs supply system and research and extension services. So far the return of public investments in agriculture has been limited because (i) application of standard packages to very diverse and risky environments; and (ii) the state dominated input supply and credit systems which negatively impacted on the timeliness and quality of input supply (seed and fertilizers). The PASDEP (2006) advocates for the development and introduction of agricultural technology packages adapted to the various agro-ecological of the country.

- **Diversification and commercialisation:** Promotion of diversification out of low-value cereals, mainly for the households' own consumption, and into higher value crops such as horticultural crops, oilseeds and various cash crops, both for the domestic and export market. This option has received priority in recent GoE policy which emphasises commercialisation of smallholder agriculture and improvements of agricultural marketing systems. The recent impressive increase in agricultural exports may be an indication that this is a viable strategy.

- A number of Growth Corridors were identified to serve as economic growth centres in the long run: Tana Beles; West and East Hararghe; Rift Valley; South and South-West Wollega; Addis Ababa and surrounding zone and resettlement areas. In each of these zones an integrated rural development approach and strategy is being implemented. **The Project area is a resettlement area included in the South and South-West Wollega Growth Corridor.**

- **Public investments in roads and social services:** Various studies show that investments in road infrastructure had a considerable positive impact on rural household production and consumption. Investments in the education and health sectors have widespread positive effects on rural welfare.

The **Food Security Program** included in the PASDEP (2005 – 2010) has three components: direct food production interventions through household asset building, a productive safety net program, and a voluntary resettlement program. Since 2003, the food security program has been under implementation in most of the chronically food insecure districts (*Woreda)*. The Safety Net Program (SNP) is designed to address the needs of about **4.8 million chronically food-insecure people** in almost 300 *Woredas*, by direct food aid or cash aid in exchange of beneficiaries' participation to labour intensive public works. The overall development objective is to improve efficiency and productivity of public spending for food insecure households, reduce household vulnerability, improve resilience to shocks, and to provide them with multi-annual and predictable sources of livelihood.

### 3.3.2 Water Resources Management Policy

The overall objective of Ethiopia's Water Resources Policy is "to enhance 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 a sustainable basis."

The general water resource development and management policies are to enhance integrated water resources management at basin level. For doing so and as river basins are to be used as the unit for water development and management, water resources development and management activities will be guided by the overall socio-economic development objectives at the Federal level and by those of concerned Regional states in the various basins for consistency between the hydraulic units and the administrative boundaries.

Integrated management means that fragmented approach should be avoided by recognizing that water resources development, utilization and conservation go hand in hand and by ensuring that all water-related activities such as water supply and sanitation, irrigation and drainage, watershed management are addressed in unison. Furthermore water management should also be integrated with other natural resources development (i.e. land, forestry) and other sector development goals such as hydropower, health, mining, agriculture, transportation through basin development plans.

The main supporting strategies are:

- Give priority to identification and implementation of multipurpose water development projects for maximizing benefits and reducing costs.
- Update and take follow-up action on completed Integrated River Basin Master Plans, including the master plans for Abay, Tekeze and Baro-Akobo, the three river basins that constitute the Eastern Nile basin in Ethiopia. Complete master plan studies so that they cover all river basins of the country.
- Establish effective institutions for water management, in particular river basin management institutions and water users associations.
- Co-ordinate the development and enforcement of appropriate mechanisms and standards to prevent pollution of water resources.
- Promote appropriate watershed management practices.
- Develop and implement capacity building programs at all levels in all the relevant areas of water resources management and water-related technologies.

Formulate appropriate and essential water legislation required to expedite water resources development and management.

### 3.3.3 Irrigation Sector Policy

The overall objective of the irrigation policy is "to develop the huge irrigated agriculture potential for the production of food crops and raw materials for agro industries, on efficient and sustainable basis and without degrading the fertility of the production fields and water resources base". The policy is based on a two-pronged approach. The first pillar is centralisation (and top-down) driven by the logic of integrated water resources management whereby irrigation development has to be integrated within the overall framework of the country's socio-economic development goals, more particularly the Agricultural Development Led Industrialization (ADLI), and shall be based on projections of the country's needs for food and the requirements of raw materials for agro-industries.

The second pillar is decentralization (and bottom-up) through involvement of regional governments, NGOs and the private sector in irrigation development as well as farmers' participation in all phases in planning, studies, implementation, and operation and maintenance of irrigation schemes. It can be argued that the main challenge of successful implementation of the irrigation policy is to harmonise these two opposite and, at first sight, contradictory approaches. As for all water development and management activities, funding for irrigation projects will come from the government budget, external support agencies, the private sector and payments of water fees by irrigation water users. Ethiopia's irrigation sector is little developed whereas the supporting strategies deal with the four major issues for successful irrigation expansion:

- Initiate the planning and implementation of a comprehensive, well coordinated and targeted irrigation development program,
- Improving the preparation and design of irrigation projects including environmental and social impact assessment,
- The formation and capacity building of the institutions needed to ensure long term productivity and sustainability of irrigation systems, and
- Economic aspects: increase of government's budget allocation for irrigation development, establishment of norms and procedures for financial viability of irrigation schemes, promotion of credit facilities and bank loans for irrigation development and definition of appropriate cost recovery mechanisms for all irrigation schemes.

### 3.3.4 Water Sector Development Programme 2002-2016

The Water Sector Development Programme 2002-2016 developed by the Ministry of Water Resources in 2002, divides the 15 year planning period in five year periods, described as short, medium and long term. The targets for the irrigation component are shown in the table 3.9 whereas table 3.10 presents the targets for the development of small-scale irrigation in the Oromiya region. The actual total number of schemes developed in Oromiya region is 149 with a total area of 12,548. This includes a small number of medium scale irrigation schemes. Oromiya developed 1,872 ha during 2003-2004, which represents nearly 20% of the area to be developed under the plan. It is not known, whether this rate of developed will be maintained. The total nr of schemes and total area included in the programme are 17 and 118,000 ha respectively.

*Table 3.9: Targets for the irrigation component of the Programme*

| Description | | Small scale | Medium and large scale | Total area |
|---|---|---|---|---|
| Short term | 2002-2006 | 40,319 | 13,044 | 53,363 |
| Medium Term | 2007-2011 | 40,348 | 39,701 | 80,049 |
| Long Term | 2012-2016 | 46,471 | 94,729 | 141,200 |
| Total area to be developed | 2002-2016 | 127,138 | 147,474 | 274,612 |
| Currently developed | | 98,625 | 98,625 | 197,250 |
| Grand total irrigated area by 2016 | | 225,763 | 246,099 | 471,862 |

Source: MoWR

*Table 3.10: Oromiya targets for IDP Small scale projects*

| Description | | Schemes | Area (ha) | No of beneficiaries |
|---|---|---|---|---|
| Short term | 2002-2006 | 122 | 9,422 | 35,900 |
| Medium Term | 2007-2011 | 121 | 9,400 | 37,600 |
| Long Term | 2012-2016 | 133 | 11,250 | 16,100 |

The priorities of the National Level Investment Plan were set as follows:

- The Federal Government attaches the highest priority to the regional Small Scale Irrigation Development programme (SSIDP) projects, given the importance of the current Poverty Reduction Strategy for the country. The region based SSIDP aims to provided irrigation over 127,138 ha for an investment of 600 million USD.
- Second priority for investment consideration reflecting the Federal Government s international commitments are the Nile Basin Initiative (NBI) irrigation projects (of the ENSAP) with an area of 82,112 ha for an investment of 687 million USD.
- Three suspended national schemes have third place in priority, covering 34,400 ha for an investment of 220 million USD.
- Fourth priority goes to other LMSIDP schemes that will be developed over 29,000 ha for an investment of 167 million USD.
- Last priority has been given to the study of two multipurpose schemes that will cover 124,626 ha to be undertaken at a cost of 10.2 million USD.

The 5-year development plan for Oromiya has scheduled new irrigation investment worth 262 million Birr that included work on 100 new small scale schemes with a combined area of 7,865 ha. Under the new plan Oromiya will also undertake:

- 348 reconnaissance studies.
- 224 feasibility studies, covering 17,440 ha.
- 182 engineering design studies.
- 88 rehabilitation studies.
- 84 rehabilitation works.
- establishment of 45 forestry and horticultural nurseries.
- training of about 136,000 beneficiary farmers in project study construction and watershed management.
- mobilisation of about 66,000 beneficiary farmers for participatory development, including irrigation construction and watershed management.
- establishment of about 700 water committees.
- training of about 1,600 water committee members.
- establishment of 100 WUA's.
- coordination of O&M of 204 communal irrigation schemes.

# 4. DESCRIPTION OF THE PROJECT AREA

## 4.1 Location and Natural Resources

### 4.1.1 Location

The Project area is located in Chewaka Woreda of Illuababor zone, Oromia National Regional State (ONRS). The Woreda is bounded by Didessa and Dabana rivers, and is located upstream of the confluence of the two rivers (see Map 1). Neighbouring Zones and Woredas include Dabo Hanna in the south, West Wollega Zone in the north, East Wollega Zone in the east, and Meko Woreda in the west. The Woreda is a newly established settlement scheme (2004) whereby people from drought stricken Eastern and Western Hararge Zones of ONRS were resettled in the area on free will basis. In the beginning, the number of households resettled was estimated at 12,390. However, the current households are estimated at 14,026, with a total population of 92,027 (Woreda population census, 2008). Agriculture is the main occupation of the settlers and various crops are grown under rainfed and traditional irrigation during the rainy and dry seasons, respectively. Livestock rearing is also part of the agricultural activities. The total area of the Woreda is about 55,400ha. The potentially irrigable land, estimated at about +7,500ha, is located between UTM 98669m-998979m North and 19098-195294 East. The number of Kebeles in the Woreda is 28. Eleven of these Kebeles benefit from the implementation of the irrigation scheme. While four of the Kebeles are fully covered by the command area, the remaining seven Kebeles have partial coverage, ranging from 25 to 75%.

### 4.1.2 Topography

The altitude variations, which range from less than 1,100 masl in the low lying valley bottoms to about 1,800 masl in the nearby mountain ranges, have little effect on variation in temperature and rainfall patterns in the Woreda. According to the engineering study, the command area would be bounded by contours +1240 and +1260. However, these areas are characterized by undulating plains and strongly sloping terrains, with slopes ranging from 0 to 8%. A large portion of this area is currently under rainfed cultivation.

### 4.1.3 Population, Local Economy and Land Tenure

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 programme that 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 52,000ha divided into 28 Kebeles. Prior to the resettlement program the Project area was scarcely populated by Gumuz ethnic groups. 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. As per 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. Almost all the population belongs to the Oromo ethnic group and adheres to the Muslim Sunnite religion.

*Table 4.1: Households in Chewaka Woreda ( 2009)*

| Kebele | Male headed HH | Female headed HH | 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 |
| Dabana | 571 | 26 | 597 |
| J Belina | 210 | 14 | 224 |
| Kebena | 405 | 19 | 424 |
| **TOTAL** | **12 135** | **450** | **12 655** |

Source : Chewaka Woreda Administration Office

The resettled population has a previous experience of irrigation in its region of origin and has currently developed a number of traditional irrigation schemes tapping water from springs or streams to produce cash crops in the dry season. Agriculture is the main occupation in the Woreda. The farming system is cereal dominant, single cropping and mixed farming, where livestock production, though at a smaller scale, is undertaken complementary to crop production. The farming system, which accounts for the bulk of the food produced in the area, is characterized by subsistence farming with its typical feature of low input–low output productivity. Crop production is predominantly carried out under rainfed condition though irrigation, using small streams diversions, is being practised in very few areas. When the settlement scheme was first initiated, allocation of land was determined to be 2ha per household. Currently, the program has been, more or less, implemented as planned and cultivated land per household ranges from 1.5 to 2.0ha, averaging about 1.75ha. The tenure system is based on the Country's policy that farmers have the right for long-term usufruct rights to their holdings. Compared to the national average land holding size, which is less than 1ha, farmers in the Project area are relatively better off than their contemporaries elsewhere in the country.

### 4.1.4 Food security

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 a surplus of food production (table 4.2) and approx 45% of agricultural production is marketed locally.

*Table 4.2: Food balance in the Woreda (year 2008)*

| Crop production | Cultivated land | | Average yield | Production |
|---|---|---|---|---|
| | Ha | % | qt/ha | qt |
| **Cereals** | **10 981** | **56.6%** | | **315 151** |
| Sorghum | 6 480 | 33.4% | 29.3 | 189 852 |
| Maize | 3 337 | 17.2% | 23.0 | 76 751 |
| Rice | 1 145 | 5.9% | 42.4 | 48 548 |
| *Other cereals | 19 | 0.1% | | |
| | | | | |
| **Pulses** | **4 345** | **22.4%** | | **78 917** |
| Haricot bean | 543 | 2.8% | 10.9 | 5 919 |
| Soya bean | 3 802 | 19.6% | 19.2 | 72 998 |
| | | | | |
| **Oil Seeds** | **4 074** | **21.0%** | | **23 887** |
| Sesame | 3 841 | 19.8% | 5.4 | 20 741 |
| Groundnut | 233 | 1.2% | 13.5 | 3 146 |
| | | | | |
| | **Food requirement** | | **Food surplus** | |
| | Per capita | **Total Woreda | | |
| | qt | qt | qt | % production |
| **Cereals** | 1.80 | 165 649 | 149 502 | 47.4% |
| **Pulses** | 0.45 | 41 412 | 37 505 | 47.5% |
| **Oil seeds** | 0.14 | 12 884 | 11 003 | 46.1% |

Source: Woreda administration for figures on crop production. *teff, barley, millet.**population = 92 027. Total cropped area in 2008 was 19,400 ha.

The calculation of local food requirement is made on the base of MoWR annual survey of the family consumption. The calculation is made in calories, with a conversion table indicating the equivalent cereals consumption. At the current agricultural productivity level and with a total of 25,000 ha of arable land (source Office of Agriculture and rural Development), the woreda crop production system can support a total population of approx 220,000 (or a population density of 420 pers/km$^2$) before becoming food insecure. However environment degradation factors such deforestation, soil erosion and depletion of drinking water may prevent to reach this population number.

### 4.1.5 Asset building

As mentioned above, the resettlers had been under government support for the first three years. Apart from the crop land (1.5-2 hectare), a number of other supports had been extended to them to stand on their own. Now it is believed that all are at the self sustaining stage. Resettlers are buying assets like oxen, sheep and goats for fattening purpose and donkeys which are used for transporting people and goods. The data collected by the Woreda Agriculture and Rural Development Office (table 4.3) indicate that asset ownership at household level is still very low and that people are currently at asset building stage.

*Table 4.3: Household level oxen ownership in the Woreda (year 2008)*

| | Number | Percent |
|---|---|---|
| Number of Households with no oxen | 5,935 | 45% |
| Households with one ox | 6,579 | 50% |
| Households with two oxen | 695 | 5% |
| Households with more than two oxen | 0 | |
| Total number of oxen in the Woreda | 7,274 | 100% |
| Average oxen ownership per household | 0.5 | |

Source: Woreda Agriculture and Rural Development Office

In the current situation, the need for support in the form of availing credit is very much required to enabling the resettlers to diversify their source of income from on-farm and off-farm activities. With the development of the proposed irrigation project, the needs for investment credit will greatly increase in order to acquire farming and irrigation equipments, credit for facilitating the planting of perennial crops (fruit crops), transportation equipments for the flow of production, etc. Credit requirements can be filled by both commercial banks and the promotion of new credit system such as leasing for farm equipment. Agricultural inputs use should also increase dramatically with irrigation development. This would lead to an increased need for seasonal credit.

### 4.1.6 Gender issues

The Ethiopian National Policy on Women enacted in 1993 with the main objective of “facilitating conditions conducive to the speeding of equality between men and women so that women can participate in the political, social and economic life of their country on equal terms with men and ensuring that their right to own property as well as their other human rights are respected” (TGE, 1993b: 25).

Unleashing the potential of Ethiopian women is one of the eight strategic pillars of the Plan for Accelerated sustainable Development and Eradication of Poverty (PASDEP 2005/06 – 2009/10). As per the data secured from Chewaka Woreda Women’s Affair Office, women headed households represent four percent of the total. The gender division of labour, as reported by the Woreda Women’s Affairs Office, indicate that unlike in other places, women participate less on agricultural fields, though their role in marketing is very high. Their responsibility in household management is quite immense, partly exacerbated by large family size. Polygamy is also quite frequent. Women’s health is quite compromised due to frequent pregnancy, low awareness of primary health care issues and harmful traditional practices such as circumcisions. The school data shows a significant lesser number of girl’s enrolment and higher dropout rate than boys, mainly because of early marriage.

The decline in domestic water availability disproportionately affects women’s welfare than men. Similarly, the increase in deforestation rate greatly affects women, as it simply entails more travel time to collect firewood from farther places. The development of the proposed irrigation project is expected to have some implications on the existing division of labour because irrigation is a labour intensive activity that entails the involvement of more family members. In order to harmonize labour requirement on the one hand and women’s welfare on the other, there is a need to introduce labour and time saving household devises. Access to services like water supply, grinding mill and market need to be improved so as to release the burden of women’s labour.

This briefly meant to indicate the need to envisage and prepare sub projects addressing women needs. The sub projects could include rehabilitation and expansion of the existing basic services like water supply health and family planning, promotion of fuel and labour efficient devises at the household level, support for credit services in the area to start new small scale ventures such as processing, transportation and marketing of products, and other off farm business.

### 4.1.7 Access

Present access into the Project area is reasonable. However, access from the administrative centre to the villages and their surroundings is only possible during the dry season, because of a complete lack of stream crossings. More details are presented in section 4.6.

## 4.2 Soils and Land Suitability

### 4.2.1 Vegetation, Fauna and Land Use

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 1700 masl. 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 show that this deciduous savanna woodland was once a very dense and productive wooded savanna. Many of the trees on these undulating slopes, the future DBIP, have been burn without being harvested first: a very substantial timber resource has been wasted and lost.  A fuller account of the vegetation is given in the Environmental Annex.

The area has some residual wildlife. 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. 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. This move is being backed by the Chaweka Woreda administration.

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 older residents of the area, Gumuz, who now live along the Didessa River, but on the right bank and outside the proposed irrigation area. These people used to live within the DBIP area, as witnessed by several stands of mature (10 m high) mango trees, but have moved out; 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 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.

There is some irrigation in the valleys made by diverting waters from perennial streams. 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 1. 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.

*Table 4.4: 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, Field Investigations, BRL-MCE, 2009; 3: GIS estimated area. Numbers have been rounded off to nearest hectare.

### 4.2.2 Landforms and Soils

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. The DBIP lies on a gently dissected erosion 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 into wetlands- 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.

### 4.2.3 Summary of Soil and Land Suitability Studies

The soils study of the proposed Dinger Bereha Irrigation Project was carried out at a detailed level of soil survey over 10,546ha of land. The survey has showed that out of the total surveyed area, about 6,260ha (59%) of land is characterized by gently undulating plains and valley floor landforms with a slope range of 0-5%, which are expected to be a potential area for irrigation development. Using survey methods of topographic maps, study of erial photographic interpretation, reviewing previous studies and conducting field survey, a soil map of 1:10,000 scale and a narrative soil report were produced. 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.

The data from soil sites pertaining to the profiles and auger holes including their location coordinates have been recorded with the help of GPS. Slope percentages were recorded with clinometer. Land forms, land use/cover, presence of stoniness, soils drainage, and erosion hazards have also been studied in the field. Internal soil characteristics such as soil depth, texture, structure, mineral nodules and depth to ground water were noted on each auger hole description.

Based on the investigation results, most of the gently undulating plain with convex interfluve area soils have loam to clay loam on surface and clay texture in subsurface.  The Vertisols, which are situated in the valley floor area, have clay to clay loam soil texture, and the infiltration rate and hydraulic conductivity measurements are found to be at moderate level. Due to relatively low topographic features and high clay contents of the area, the soils have imperfect to poor drainage characteristics. This makes some soils well suited to rice cultivation. Cation Exchange Capacity (CEC) and the derived base saturation percentage (BS %) that are important for soil classification and that can be used as indicator for ranking soil fertility assessment are low to medium. Regarding the total nitrogen percentages the value ranges from medium to very high. On the other hand comparing the organic carbon content with nitrogen content it is found constantly higher for almost all soils.

Subsequently, based on significant information, soils of the Project area were classified based on FAO-ISSS, ISRIC 1998 Guidelines. Six major soil types were identified, which include, Nitisols (NT), Acrisols (AC), Vertisols (VR), Cambisols (CM), Gleysols (GL) and Leptosols (LP). The most extensive soils of the Project area are found to be Nitisols which is followed by Acrisols and Cambisols. In area wise Nitisols occupy around 4,303ha, which is about 41% of the Study area. Whereas, 1,311ha (12.4%) and 1,063ha (10.1%) are occupied by Acrisols and Cambisols respectively. The remaining area is occupied by Vertisols 1,053ha (10.0%), Leptosols 788ha (7.5%) and Gleysols 29ha (0.3%) correspondingly. With regard to fertility status based on the laboratory test results detailed assessment has been carried out. Accordingly, fertility status of most of the soils of the Study area is found to be low to medium for major nutrients like Phosphorous, Nitrogen and Organic Carbon.

The base saturation percentage of the Study area is also confirms the same conclusion that the fertility level of the soils is found to be low to medium. For most of the soils samples its value is observed to be low to medium with an average value of 50 % which indicate that the soils major cations like calcium, magnesium, potassium, and sodium have been leached down and the sizable portion of the soil colloid is covered by Aluminum cation. In addition to that, most of the analyzed soil samples for acidity test fall in high acidic category based on pH tests. However, when it is tested for aluminum toxicity only six samples out of the suspected 40 samples confirm aluminum toxicity. The laboratory results for electrical conductivity (EC) of all soils of the Study area have an average value of 0.1 dS/m, which is very low. It is far below the threshold critical values and therefore, salinity will not be causing any restriction on plant growth of soil of the Study area. Similarly, the average value of the exchangeable sodium percentage (ESP) within the 100cm depth of the soils is also low (2). These levels of exchangeable sodium of the soils do not cause any adverse effect for both plant nutrition and physical properties of the soils.

### 4.2.4 Conclusions and Recommendations

#### *4.2.4.1 Soils*

- The main constraint for agriculture production in the Project area is believed to be acidity. Yields of any crops are limited mainly as a result of root damage because of aluminium toxicity. Such damage can be observed on maize. As soon as the plant root is damaged the plant's ability to extract water and nutrients such as phosphorous is severely reduced. As the result plants are very susceptible to drought and are prone to nutrient deficiencies.

- The sampled area has an acidity potential that will hinder crop production unless or else, immediate remedial action is taken to improve the situation. One of the actions to be taken is the use of agricultural lime to neutralize the soil acidity and to suppress the negative effect of aluminum toxicity in the area.

- The average available phosphorous for most of the soils of the Study area is found to be at a moderate level. The response of soil to phosphorus fertilizer for the time being is not required but, in the near future applications of phosphorous fertilizer is likely to be required.

- The valley floor of the Study area is covered with Vertisols and they have area coverage of 1,053ha. During the wet season the clays of these soils swell and cause pressure in the sub-soil. Therefore, to use these soils properly for future agricultural development, Vertisols management technologies like, broad bed-maker (BBM) should be considered or practiced.

- During the survey time high deforestation action has been observed in the Project area. This kind of misuse of natural vegetations will have brought high ecological disparity. Therefore, to develop these areas properly and sustainably the prevailing deforestation action has to be stopped and proper management will have to be undertaken especially along the incised stream channels and gully areas.

- Laboratory results indicated very low of organic carbon having over all an average value of 3.7%. Therefore, to increase the organic matter of the soils of the Study area mulching activity has to be. The positive effect of high organic matter content in the soil is, at the same time, increasing the cation exchange capacity of the soils. Therefore, ploughing back of the crop residues and mulching should be encouraged to raise the very low carbon levels and to improve the structure of the top soils.

- The amount of lime needed to neutralize soil acidity mostly depends on the crop type, soils, and the effective calcium carbonate equivalent (ECCE) or effective neutralizing value (ENE) of the liming materials. In view of that, when magnesium deficiencies is occur in the acidic soil dolomitic lime that, containing $MgCO_3$ is particularly advantageous for liming.

- In the case of soils of the Study area as it is learned from laboratory results the Ca: Mg ratio for all identified soil types found to be between 3:1 to 4.1, which is optimum for most of the crops and deficiencies of Mg is not observed. Therefore, with this value ranges to correct soil acidity of the Project area calcitic lime ($CaCO_3$) or dolomitic lime ($MgCO_3$) materials can be used. For that matter both agricultural limes are available from lime crushers at Guder and Degen area.

#### *4.2.4.2 Land Suitability Classification*

Following the TOR, Land evaluation assessment for irrigation development has been conducted based on the methodology outlined in the FAO Soil Bulletin No. 55, Guideline for Land Evaluation for Irrigated Agriculture (FAO, 1985) and FAO, Soil Bulletin No. 32, Land Evaluation Framework.

As part of land resources study the land evaluation assessment aims to translate land resources data into an expression of suitability of land units (land units map) for a defined use. The soil report and map are the main land resource database for the anticipated land evaluation assessment. The main objective of the land evaluation is to select possible relevant land use types for which kinds of development land should be classified. The land evaluation assessments of the irrigation area identified a number of land utilization types (LUTs) and defined in terms of their climatic adaptability, economic viability and food preferences.

The Field Investigations selected 5 land utilization types for onions, beans, citrus, maize and sesame. The Feasibility Study, which followed the FI work decided to broaden this into a series of land utilization types which reflect more the types of crops that the Project had decided to concentrate on. These included cereals and sesame (oil crops) as LUT-A; Vegetables and Pulses as LUT-B; Citrus and Fruit Crops as LUT-C; and wetland rice as LUT-D.

For all of these the overall suitability of the land units were then determined on the basis of the suitability ratings. The evaluation assessments were made assuming moderately to high inputs of management, and high labour intensity.

To undertake the land evaluation assessment the land use requirements of these LUTs were determined. The Land use requirements are described by the land characteristics grouped to land qualities needed for the required sustained irrigated agriculture production for the LUTs considered. Based on land characteristics 15 land mapping units have been identified for the Study area. After considering various factors namely: agronomic, environmental requirements and conservation, the relevant class determining factors were defined as variables that affect the performance of LUTs on a land unit. Subsequently, individual class determining factor of each land use requirement has been combined (matching) with each land unit and a tentative land suitability classification has been obtained.

The Field Investigations made land suitability maps for selected crops with surface and overhead irrigation as part of the report. The Feasibility Study did not consider overhead irrigation as the chosen method for the project will be based on subsurface pipes.

In general, most soils that have been identified in the Dinger Bereha irrigation project found to be marginally suitable for surface (and overhead) irrigated agriculture. The limitations are moisture and oxygen unavailability, workability and unsuitability for mechanization. It should also be emphasized that the present land suitability evaluation results are guidelines for future agricultural developments activities.

### *4.2.4.3 Soil and Water Conservation*

The proposed DBIP will adopt and implement a novel type of irrigation system, using buried pipes that supply water directly to small fields. We have developed the land suitability classification to cover the steeper and more erodible lands, so that the irrigation system can cover the command area. It must be stressed that this is a tremendous risk, as the technology is unproven in Ethiopia and especially amongst these farmers.

Although the farming community have some experience of irrigation, most are rainfed farmers. In addition, the Study area is being eroded by lack of soil and water conservation (SWC) practices. The introduction of a new irrigation system will require an immense effort to train the new irrigators so that the project can be sustained. This is the risk and the challenge

It must be stressed therefore that the DBIP will be as much a soil conservation project as an irrigation project, for several reasons:

- The watershed above the command area must be protected. It will require protection so that the gallery forests continue to exist and supply waters to the downstream users in the community as good drinking water supply, and the forest ecosystems in the gallery forests, and that the / any excess water discharge will continue to pass into the Didessa and hence to the Abbay. Unless these basic rules of watershed management are heeded then there will be an unsatisfactory degradation of this area. The Chaweka community should not assume that they can continue to deforest the catchment and utilise every drop of water, and still hope to be able to continue to utilise the valley soils for forest products and obtain a water supply that is currently being recharged and runs throughout the year.

- The continued destruction of gallery forest within and upslope of the command area will lead to an infilling with coarser materials of the wetlands schedule to become rice lands and lead to unsuitable soils in these areas. This is not wanted.

- The soils in the development area on the sloping lands already show very considerable susceptibility to water erosion. During rain events, rills and sheet erosion deposit coarser materials in the valley floors - the wetlands and stream beds. There is no control over this by farmers and almost no SWC measures to reduce water erosion. A few attempts, though very feeble, are lines of crop sorghum stalk residues that are placed along the contour in some of the more sandy areas. But, despite good intentions, these have minimal impact. Without improvements put in place soon, and whilst the lands remain as rainfed, the soils of the Project area will become more degraded. This could change the land suitability classification as it is now assessed, but in a downwards spiral of degradation.

Much of the work to make this successful will fall on the agricultural services of the Chewaka Woreda to implement SWC measures in the coming seasons, in the rainfed lands and also in the catchment. It has good well qualified staff, who can take on these tasks, but they will need support. It is recommended that mitigation to protect the catchment and command areas from erosion and ecosystem degradation are now implemented with the greatest speed and determination.

The lessons provided by Hudson (1991) on the success or failure of soil and water conservation projects provide a sober reading for all interested in these matters, and should be examined very carefully by all concerned with final planning for this potentially useful project.

## 4.3 CLIMATE

### 4.3.1 Climatic Stations and Data Availability

For the climatological study of Dinger Bereha irrigation Project, four meteorological observation stations, which are located in and around the Dinger Bereha Irrigation Project area, were selected for further analysis and use in the determination of different parameters to calculate crop water requirements for the project. These meteorological data were obtained from the NMSA. Out of these stations, Jimma station is Class 1 station that included observations of rainfall, temperature, relative humidity, sunshine duration, wind speed and evaporation. Bedele and Didessa stations are also Class 1 stations but do not include sunshine duration. Jimma station is located at approximately 10 km from the divide of Didessa catchments. Bedele station is located up-stream of the proposed irrigation command area of the project. Didessa station is located very close and nearby to the command area. The details like location, altitude, year of establishment along with their class for three of the four stations are presented in Table 4.5.

*Table 4.5: Location of Stations*

| S.Nr | Station Name | Latitude North | | Longitude East | | Altitude (m) |
|---|---|---|---|---|---|---|
| | | Deg | Min | Deg | Min | |
| 1 | Arjo | 08 | 27 | 36 | 20 | 2565 |
| 2 | Bedele | 08 | 16 | 36 | 14 | 2090 |
| 3 | Didessa | 09 | 03 | 36 | 04 | 1312 |

Furthermore, the data availability and record conditions are shown on table 4.6 for the three stations, which are nearby the project site. Whereas, Bedele and Arjo stations are far from the project site and are located at highlands relatively.

*Table 4.6: Climatic Data Availability*

| No | Station name | RF | | Tm | | RH | | WS | | SD | | 1 day | | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Yrs | Avl | Yrs | Avl | Yrs | Avl | Yrs | Avl | Yrs | Avl | Yrs | Avl | |
| 1 | Didessa | 38 | X | 47 | X | 37 | X | 37 | X | 37 | X | 15 | X | 1 |
| 2 | Bedele | 28 | X | | X | 13 | X | | | 18 | X | | | 1 |
| 3 | Arjo | 20 | X | | X | 37 | X | 37 | X | 37 | X | | | 1 |

Note: Yrs =refers to rainfall series; RF=monthly rainfall; Tm=average temperature; WS=wind speed; SD=sunshine duration; RH=relative humidity; and Avl=Availability

### 4.3.2 Rainfall

The climatic data that are collected from the above stations included rainfall, air temperature, air humidity, sunshine hours, and wind speeds.

The rainfall data obtained from the three stations of Bedele, Didessa and Arjo were found to be the most reliable and relevant for use in the rainfall analysis of Dinger Bereha irrigation project. Didessa station is geographically located very close to the command area and has the longest recorded rainfall data of the stations identified for the purpose of rainfall analysis of the Project area. The rainfall in the Project area and its surroundings is of uni-modal type. Most of the rainfall is concentrated for almost six months which is from May through October. The six wettest months cover 88% of the total annual rainfall. The dry season, being from November to February (four months) has a total rainfall of about 5% of the mean annual rainfall. The Didessa and Bedele stations provide more relevant rainfall data that can be adopted for the command area in computing of the total runoff of the Didessa River since Didessa is very close to the Project area and Bedele station is located outside the project, but it is within the same catchments area.

According to the Woreda report, the rainfall pattern in the Project area is uni-modal and the amount ranges between 900 to 1,100mm, annually. However, the long-term records at Didessa indicate a much higher amount, averaging 1,500mm over a twenty years period. The onset of the rainy season begins around mid-May and lasts for approximately 4 to 5 months. The highest rainfall occurs during July and the dry spell stretches from November to April. The amount of rainfall in the area does not constrain rainfed cropping although abnormal on set and cessation of the rains can impact on crop yields.

On the basis of Agro-Ecological Zones of Ethiopia (MoRAD, 2005), the project Woreda is basically classified as moist sub-humid indicating a fair distribution and adequacy of moisture in the area. There would be very little or no need for supplementary irrigation for any rainfed cropping so long planting takes place at the correct time. Irrigation development would only be necessary for the provision of water during the dry season cropping. A summary of the average monthly rainfall at Didessa station is presented in the following table.

*Table 4.7: Monthly rainfall characteristics at Didessa (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 |

### 4.3.3 Other Climatological Characteristics

Long-term records of temperature, relative humidity, wind speed, sunshine hour and potential evapotranspiration have also been analyzed by the hydrology study. The monthly mean temperature data at the station shows relatively small fluctuations; the range being from 22.1°C in August to 26.6°C in March. Temperature regime is generally suitable for normal growth of major crops adapted to low to medium altitudes. Relative humidity values are highest during the rainy season (88%, August & September) and lowest during March (46 percent).

*Table 4.8: Other Climatic Factors*

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean Temp (°C) | 23.1 | 24.4 | 26.6 | 26.3 | 24.8 | 23.3 | 22.2 | 22.1 | 22.9 | 23.5 | 23.1 | 22.3 | 23.7 |
| RH (%) | 65 | 59 | 57 | 68 | 76 | 81 | 88 | 89 | 89 | 85 | 79 | 72 | 76 |
| Wind speed (m/s) | 0.62 | 0.80 | 1.00 | 1.08 | 1.04 | 0.86 | 0.62 | 0.51 | 0.5 | 0.51 | 0.48 | 0.51 | 0.71 |
| Sun (hrs) | 8.2 | 7.6 | 7.5 | 7.3 | 7.6 | 6.1 | 3.7 | 4.1 | 6.2 | 7.9 | 8.3 | 8.3 | 6.9 |
| PET (mm) | 115 | 115 | 143 | 135 | 134 | 107 | 92 | 97 | 114 | 125 | 114 | 107 | 1,398 |

The mean monthly wind speed varies from 0.5 m/s in September to 1.08 m/s in April. The relatively higher wind speed values stretch from February to June. On the other hand, mean sunshine hour per day ranges from 3.7 hours in July to 8.3 hours in November and December. The annual potential evapotranspiration is about 1,390mm. The peak monthly potential evapotranspiration occurs in March and the lowest in July.

## 4.4 Surface Water Resources

### 4.4.1 Available Data and Data Resources

In the Project area apart from the Didessa River, there are no data gauged implying that all the major and minor tributaries are remained ungauged. The data from the gauging station of Didessa river is old enough for the purpose of this study. There are 33 years of records in total.

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.

### 4.4.2 Stream Flow Analysis

Station 114001 with a catchment area of 9,981 km² is located about 25 km up-stream of the proposed weir site and has become operational since 1960. The catchment area between the station and the weir site of the Dinger Bereha irrigation project is estimated as 625 km². Before the stream flow analysis, missing data were infilled and then checked for their consistency prior to different analysis. The recorded available flow data at the gauged site shows discontinuity and starting from 1963 up to 2003 there are data missing, which hampers proper statistical analysis; hence, for every missed flow, the "all the years monthly ratio" method is applied and infillings are performed. The station year method of data infilling technique was used for verification, but due to the non-availability of long year records of the Didessa River, it was rejected.

Mean monthly discharges, coefficient of variation of monthly flows, summary of regional monthly flow characteristics, statistics of monthly flows at the weir site are presented in Annex.

### 4.4.3 Flow at the Weir Site

Transposing method has been selected to estimate the flow at the weir site. Since the weir site is located on the Didessa River at some 25 km down-stream of the gauging site at the bridge near Arjo (114001), then it is wise and appropriate to estimate the flow at the weir site by considering area proportionality.

The selected regionalization approach has considered the following characteristics of the catchments:

- The only recorded one is Didessa River and the weir site also is on the same river, which is nearby station 114001;
- The two sites have similar climatological and hydrological characteristics;
- They have similar geological setup;
- There are adequate rainfall records corresponding and longer reliable station for rainfall-runoff regression.

Based on the above final relationship, the mean annual and monthly flows at the weir sites are estimated and the results are displayed as follows.

- Mean dependable flow = 3,232 $Mm^3$
- 75 % dependable flow = 2,415 $Mm^3$
- 80 % dependable flow = 2,351$Mm^3$

### 4.4.4 Peak Floods at the Weir site

In the hydrologic analysis of dams, weirs, bridges and drainage structures, there are many factors that affect floods. Some of the factors that need to be recognized and considered on site-by-site basis are:

- rainfall amount and storm distribution;
- catchment area size, shape and orientation;
- ground cover;
- type of soil;
- slopes of terrain and stream(S);
- antecedent moisture condition;
- storage potential (overbank, ponds, wetlands, reservoirs, channel, etc.); and
- Catchments area

Data were checked for their consistency before use for different analyses. The investigation concentrated mainly on the outliers of the monthly and daily data series. Extremely high or low values that occurred at a given time were checked against records of other nearby rivers (such as Dabana). If the outliers are found to be inconsistent with others, then they were replaced by new values that were generated regionally from data set obtained from other stations.

In the flood frequency analysis, the objective is to estimate a flood magnitude corresponding to any required return period of occurrence. Nowadays, the regionalization approach to flood frequency analysis (particularly the index-flood method) is becoming more popular. An essential prerequisite for the index-flood method is the standardization of the flood data from sites with different flood magnitudes. The most common practice, used also in this study, is to standardize data by division by an estimate of the at-site mean, thus:

$Xi = Qi/Qm$

Where, Xi is the i^th standardized flow, Qi is the i^th annual maximum flow, Qm is the average value of at-site annual maximum flow series. Then the quantile QT is estimated as

$QT = Qm.XT$

Thus, the mean annual flood is the index-flood. The parameters of the distribution of X are obtained from the combined set of regional data. In this study, two distributions have been used for flood frequency analysis. These distributions are:

- Generalized Extreme Value (GEV) distribution (Jenkinson, 1969)
- Log-Logistic (LLG) distribution (Ahmed et al., 1988)

*Table 4.9: Monthly peak flow at the weir site*

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean | 25 | 17 | 19 | 28 | 52 | 166 | 400 | 568 | 555 | 536 | 137 | 59 |

### 4.4.5 Maximum Flow Frequency Analysis

The peak floods at the weir site at different return periods are:

25 years = 1,083 $m^3/s$
50 years = 1,143 $m^3/s$
75 years = 1,187 $m^3/s$
100 years = 1,192 $m^3/s$
1,000 years = 1,335 $m^3/s$

### 4.4.6 Low Flows and Water Availability

Since the Didessa River is gauged at the station near Arjo Bridge and has more than 30 years of recorded flow data, the availability of surface water at the proposed weir site is assessed and analyzed. The frequency analysis of the mean monthly flow of the Didessa River at the proposed weir site is performed and presented in the following table. In the Project area, the dry season starts in the month of November and extends up to the end of May.

*Table 4.10: Dry season dependable flow (MCM)*

| | Jan | Feb | Mar | Mar | May | Nov | Dec | Total | % to the Annual |
|---|---|---|---|---|---|---|---|---|---|
| 50% Dep. | 38.2 | 20.3 | 18.3 | 16.5 | 38.6 | 127.6 | 76.7 | 336.2 | 9.4 % |
| 75% Dep. | 31.7 | 16.04 | 13.9 | 13.7 | 36.6 | 112.4 | 62.7 | 287.1 | 10.5 % |
| 80% Dep. | 28.2 | 15.04 | 13.6 | 12.3 | 28.9 | 95.8 | 67.7 | 261.5 | 10 % |
| 85% Dep. | 27.6 | 14.7 | 13.3 | 11.9 | 28 | 92.3 | 65.7 | 253.5 | 9.8 % |
| 90% Dep. | 27.1 | 14.4 | 13 | 11.7 | 27.4 | 90.5 | 54.4 | 238.5 | 9.3 % |

The monthly minimum flows for the period 1961-2004 are presented in the table here below. In the case of irrigation by diversion scheme, the water availability depends on the design minimum flow, which should be equal to the scheme irrigation demand.

*Table 4.11: Probability of minimum flows (m3/s)*

| Year | Minimum Flow ($m^3$/sec) | Rank | P |
|---|---|---|---|
| 1961 | 13.1 | 1 | 0.03 |
| 1962 | 13.1 | 2 | 0.07 |
| 1963 | 13 | 3 | 0.1 |
| 1964 | 11.8 | 4 | 0.13 |
| 1965 | 11.3 | 5 | 0.16 |
| 1966 | 9.2 | 6 | 0.19 |
| 1967 | 7.23 | 7 | 0.23 |
| 1969 | 7.2 | 8 | 0.26 |
| 1971 | 7.2 | 9 | 0.29 |
| 1972 | 6.9 | 10 | 0.33 |
| 1973 | 5.1 | 11 | 0.36 |
| 1979 | 4.4 | 12 | 0.39 |
| 1982 | 4.4 | 13 | 0.42 |
| 1983 | 4.4 | 14 | 0.45 |
| 1984 | 4.4 | 15 | 0.48 |
| 1985 | 3.1 | 16 | 0.51 |
| 1986 | 3.1 | 17 | 0.54 |
| 1987 | 2.7 | 18 | 0.57 |
| 1988 | 2.3 | 19 | 0.6 |
| 1989 | 2.2 | 20 | 0.63 |
| 1990 | 2.2 | 21 | 0.66 |
| 1992 | 2.1 | 22 | 0.69 |
| 1993 | 1.9 | 23 | 0.72 |
| 1994 | 1.8 | 24 | 0.75 |
| 1995 | 1.7 | 25 | 0.79 |
| 2001 | 1.1 | 26 | 0.81 |
| 2002 | 0.73 | 27 | 0.84 |
| 2003 | 0.6 | 28 | 0.87 |
| 2004 | 0.44 | 29 | 0.91 |

The 75% excess probability year, which is 1994 has been adopted as the critical period to be sufficient to analyse the degree of reliability of flows for the proposed irrigation scheme.

### 4.4.7 Conclusions regarding Surface Water Availability

From the preceding analysis it can be concluded that shortages could occur during the peak period when 6 $m^3/s$ is required. Therefore, cropping patterns would have to be adjusted in such a way that peak demands fall inside periods with higher river discharges. With the ongoing development in the upstream catchments it is highly likely that more water will be diverted in the future thus constraining water availability at the diversion point. This can only be counteracted by the construction of the Arjo-Didessa Dam or the Negeso Dam.

### 4.4.8 Sediment Loads and Water Quality

#### *4.4.8.1 Sediment Loads*

Suspended sediment data from Station 14001 is obtained to see the sediment status of the weir site. Suspended concentration rates varying between 162 mg/l at a depth of 3.3 feet to 1,740 mg/l at a depth of 9 feet were observed from Didessa River at station 114001. Relationships between water discharge and sediment loads at various sites were established. Annex 1 concludes that the total annual sediment concentration at the weir site is 1.197 million cubic meters, which is 113 $kg/km^2/year$. Out of the total annual sediment load, 15 percent is assumed as bed load, which is 17 $kg/km^2/year$ the remaining 98 $kg/km^2/year$ is the estimated of suspended load at the proposed weir site.

#### *4.4.8.2 Water Quality*

The water quality status of the Didessa River is evaluated using the data collected from MoWR, Abbay River Basin Master Plan Study Report (1998). The samples were taken as part of the supporting measurement for the aquatic study, and appear to represent the only available data on water quality within the catchment.

Samples were taken after the start of the rainy season and presumably, all tributaries of the river exhibited adequate water quality at the time of sampling. Total dissolved solids characterized mainly by major anions and cations are directly related to the electrical conductivity of the water. The low Electrical Conductivity (EC) and TDS value in general shows that the water is soft in nature and has low salinity. Moreover, the low conductivity is a sign of low fertility of the water with regard to aquatic life.

Electrical conductivity (EC) measurements were very low at all the sampled sites. EC is the ability of the water to conduct electric current and directly related to the amount of cations and anions in the water. The pH value is the measure of the concentration of hydrogen ($H^+$) and hydroxyl ($OH^-$) ions in the water. It is to determine the acidity or alkalinity of the substance. The $Na^+$ and $K^+$ reading expressed in terms of Sodium Adsorption Ratio (SAR) is the useful parameter for the evaluation of the water body for irrigation purpose. The maximum computed SAR value among the readings is 0.29, which is less than 10. This illustrates that the water is very much suitable for irrigation purpose in terms of SAR. The chloride concentration of the rivers stipulated in is very low (1.0 to 2.0 mg/l), at times of sampling. Hence, the parameter was in conformity with the standard set by EPA (250 mg/l for aquatic species). From the analyses presented in Annex 1 it can be concluded that the Didessa River water is fit and can be used without harm for irrigation in the Dinger Bereha Project area.

### 4.4.9 Peak Flows from the Sub Catchments in and near the Project area

In the hydrologic analysis the following factors have been considered:

- rainfall amount and storm distribution;
- catchments area size, shape and orientation;
- ground cover;
- type of soil;
- slopes of terrain and stream;
- antecedent moisture condition;
- storage potential (overbank, ponds, wetlands, reservoirs, channel, etc.);
- the size of the catchments area.

In general, three types of estimation of floods magnitudes; namely the Rational Method, SCS method and Transferring Gauged Data method can be applied for the Project area. These methods are described as follows.

The Rational Method has been applied to small catchments if they do not exceed 12.8 $km^2$ (or 5 square mile) at the most (Gray, 1971). The consequences of applying the Rational Method to larger catchments is to produce an over estimate of discharge and a conservative design. The coefficient of runoff C is given by many soil and water conservation texts. Information on rainfall intensity I in a time of concentration (time period required for flow to reach the outlet from the most remote point in the catchment) is required and can be estimated (refer to Annex 1). The selection of the correct value of 'C' presents some difficulty. It represents a parameter that can influence runoff including: soils type, antecedent soil conditions, land use, vegetation and seasonal growth. Therefore, the value of 'C' can vary from one moment to another according to changes, especially soil moisture conditions.

The time of concentration was calculated according the Kirpich equation (refer to Annex 1) and an area reduction factor (Fr) introduced to account for the spatial variability of point rainfall over the catchment. This is not significant for small catchments but becomes so as catchment size increases. The relationship adopted for 'Fr' is based on that developed for the East African condition (Fiddes, 1997).

The relationship can be expressed as:

$$Fr = 1 - 0.02\ D^{-0.33}\ A^{0.50}$$

where:

D = duration in hours;
A = drainage area in $km^2$;

This equation applies for storms of up to 8 hours duration. For longer durations on large catchments the value of D can be taken as 8 for use in the above formula.

A relationship between accumulated rainfall and accumulated runoff is derived by SCS (Soil Conservation Service). The SCS runoff equation is a method of estimating direct runoff from 24-hour or 1-day storm rainfall (refer to Annex 1). The relationship between Ia and S was developed from experimental catchment area data. It removes the necessity for estimating Ia for common usage.

Gauged data may be transferred to an un-gauged site of interest provided such data are nearby (i.e., within the same hydrologic region, and there are no major tributaries or diversions between the gage and the site of interest). These procedures make use of the constants obtained in developing the regression equations. These procedures are adopted from the work of Admasu (1989) as follows:

$$Qu = Qg \times (Au/Ag)^{0.70}$$

where:

Qu = mean annual daily maximum flow at ungauged site ($m^3/s$),
Qg = mean annual daily maximum flow at nearby gauged site ($m^3/s$),

Au = ungauged site catchment area ($km^2$),
Ag = gauged site catchment area ($km^2$),

The estimate daily (or the 24-hr) annual maximum flood could be converted into a momentary peak as:

Qp = Cf x Qu

Here, Cf is a factor estimated as Cf = 1 + 0.5/Tc where Tc is time of concentration.

#### 4.4.9.1 Conclusions regarding peakflows for cross drainage structures

In general, the command area peak flow (QP) at different return periods can be generalized as peak flow per area, so that in case there is a change in the locations of cross drainage works, easily the peak flow can be determined. Then, command area peak flow QP at different return periods are:

| | |
|---|---|
| Qp at 25 year return period | = 0.28 $m^3/s/km^2$ |
| Qp at 50 years return period | = 0.3 $m^3/s/km^2$ |
| Qp at 75 years return period | = 0.315 $m^3/s/km^2$ |
| Qp at 100 years return period | = 0.32 $m^3/s/km^2$ |

The calculation of weighted average using the rational, SCS and transferring data from gauged catchments is not a considered to be a good practice, since the rational and SCS methods are much more precise than the method involving the transfer of a very large catchment to very small catchment. There, the peak flows as calculated in Annex 1 (Appendix B) have been retained for dimensioning the cross drainage structures.

## 4.5 GROUNDWATER RESOURCES

The Project area is characterised by metamorphic rock basement overlain by different volcanic flows and basaltic dikes through the regional faults on the metamorphic basement and localised fissures for recent alkaline dikes and the command area is an undulating landform. The aquifer system is associated with two major units, which are expected to store an exploitable amount of groundwater in and adjacent to the command area of the Project. The flat and depression areas have relatively thicker saprolite zones than the rugged terrain areas in the valley. The localized riverbank and inter-hill valley deposits are also considered to have a high deposition of granular material, which can serve as localized groundwater storage and transmission reservoirs. The lower part of the saprolite/ weathered zone forms the primary water bearing strata and groundwater storage.

Recharge in the area is mainly from direct infiltration of part of the water from precipitation. According to the meteorological data at Didessa Bridge, the annual precipitation for the period 1963-2008 is 1,505 mm. Therefore, the annual recharge to groundwater is 256 mm. The water quality data from Ilu Harar, Urji and Dabana are classified as Ca-HCO3, Ca-Na-HCO3 and Mg-Na-HCO3 type, respectively. Further, 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 when compared to the drinking water quality standards. The most damaging effects of poor-quality irrigation water are excessive accumulation of soluble salts and/or sodium in soil. The water quality data from 3 wells that were collected in the Ilubabor Zone water Office were analysed using a Wilcox Diagram in order to classify irrigation waters and showed that the Dabana well water sample analysis lie in the C1-S1 Type and those from Ilu Harar and Urji Oromiya lie in C2-S1 type.

Currently there are a number of drilled shallow and hand dug wells for community water supply source. In addition to wells springs are also the main water supply sources for the community in Dinger Bereha. The groundwater potential for augmenting surface water irrigation was assessed. The aquifer system in such metamorphic rocks is dependent on fracturing and mainly weathering and development of saprolite zone which is usually localized. The texture of the weathered zone of the basement complex depends largely on the parent rock composition and the crystal type and size. The weathered basement can be broadly considered as one aquifer regardless of parent lithology as the final weathering products for gneissic and granite is always clay minerals with residual quartz fragments.

Moreover, the lateral extent, depth and weathering products in the saprolite zone determine the storage and movement of groundwater. In the particular area under consideration, the aquifer is found to be localized in different pocket weathered zones. This means that as such no high quantity of groundwater exists to be abstracted using wells for irrigation. For very small irrigation schemes at household level it may be possible to use hand pumps to irrigate horticultural crops in at micro scale. Conclusively, the quantity of groundwater per well is not promising to install motorized systems for augmenting the watersupply for surface irrigation intended at Dinger Bereha. With respect to springs, it was observed in the field that many springs have been protected for the rural water supply sources in the Woreda. There are still unprotected springs in the area but these are very small and thus there is no scope to use groundwater in conjunction with surface water for irrigation. However, the unprotected springs and over flows, and night flows of protected springs can be used for micro irrigation at household level.

## 4.6 INFRASTRUCTURE

### 4.6.1 General

The current Project woreda, Chewaka, was administratively under Dabo district in the pre Derg regime. A settlement program that created conducive environment for shifting Chewaka district from part of Bedele-Dabo district to an independent district has happened in 2003 where the area was selected to resettle people from East and West Hararge zones of Oromia National Regional State. Since December 2003 to April 2004 about 76882 people from West Hararge and East Hararge zones were resettled in the Project district. The district capital is Illu-Harar and is named after the resettlement of the people from the mentioned areas.

In the Project area, thus, a system of modern roads that linked the district with the zonal towns of Bedele and Illuababora are maintained and the district is connected via this road with other parts of the country. The district, Chewaka is located geographically between latitudes 8° 46’-8° 56’N and longitudes 36° 01’-36° 15’E. The woreda is bordered by Dega district of Illuababora and Dega Leka district of East Wellega zone in the west, Gimbi District of West Wellega and Dega Leka of East Wellega zone in the north, Dega Leka zone of East Wellega in the east and Bedele-Dabo district in the south. The larger of the district’s boundaries are demarcated by the rivers Didessa and Dabana from the east and west respectively. The total area of the district is estimated to be about 33.34 km2, that puts the district to be the largest and shares about 11.37% of the zonal surface area.

### 4.6.2 Existing Road Network

Chewaka district is accessible by rural all-weather road via Dabo district to Bedele town and Nekempte town using a 74km long and a 142km long road respectively. The district is also linked with other parts of the country using this all-weather road, which after every rainy season requires intensive maintenance as most reaches of the road are aligned on undulating terrain that is susceptible for erosion by the high rainfall flood of the area.

The district's capital, Illu-Harar is distanced 552km from Addis Ababa, 72km from Bedele and 192 km from Metu, the capital of Illuababora zone in which the district, Chewaka is located. As road availability is one of the variables for considering the extent and efficiency of road distribution over land. Thus the district has a road density of 47km per 1,000 km$^2$. The road network within the district is fairly interlinked and seasonal tracks link each settlement site with Illu-Harar. There is a 19km long dry season road that joins site nr 1 to site nr 8 (Burka Bereka) where the Project weir site is located. Furthermore, there are other offside roads joining the capital town, Illu-Harar with other sites, like site Nr. 3, 4, 5, 6, and 7 with distance ranging between 5 to 10 km from the centre. Currently an all-weather road is under construction with a bridge to cross the Didessa River which will join the district with the Asossa-Gimbi-Nekempte-Addis main highway road. Part of this bridge and most reaches of the road construction are completed and it is expected that it becomes operational in 2010.

## 4.7 Existing Agriculture, Land Use and Forestry

The farming system in the Woreda is cereal dominant, single cropping and mixed farming, where livestock production, though at a smaller scale, is undertaken complementary to crop production. The farming system, accounting for the bulk of the food produced in the area, is characterized by subsistence farming with its typical feature of low input–low output productivity. Crop production is predominantly carried out under rainfed conditions though irrigation, using small stream diversion, is being practised in few areas. The land use pattern of the Woreda is shown in the table below. The land use data for the Project area is also shown, in parallel, as estimated by the detailed soil survey work. It has to be noted here that the estimate for cultivated area increases, annually, as new settlers clear forest and shrub lands for agricultural use.

*Table 4.12: Woreda land use*

| Category | * Woreda (ha) | ** Project Area (ha) |
|---|---|---|
| Cultivated land | 19,400 | 4,942 |
| Grassland | 3,500 [1] | 1,053 |
| Natural forest | 24,900 | 1,721 |
| Shrubs and Marshs | 5,500 [1] | 2,577 |
| Towns and farmsteads | 1,100 [1] | 253 |
| **Total** | **54,400** | **10,546** |

Source: *Woreda Agriculture and Rural development Office
**Soil Survey Report, MCE, 2009
[1] Estimated area

### 4.7.1 Crop Production and Livestock

The major crops of the Woreda include cereals (sorghum and maize,); pulses (soybean); oil crops (sesame); fruits (mango); and vegetables (onion, tomato and pepper); almost all are grown during the rainy season. Since the last two years rice is a new addition to the cropping pattern. As depicted in the table below, sorghum commands the largest area coverage, which signifies its importance as staple crop for the population of the Woreda. There are few locally selected crop varieties currently cultivated by the farmers. Most crops grown are registered varieties and distributed through the Woreda Agriculture Office or through cooperatives and NGOs.

Irrigated crops are mostly vegetables (tomatoes, carrots) and fruits (mango, banana and papaya). Banana and papaya are newly introduced fruit crops and seem to be readily taken by the farmers. Last cropping season, rice was grown under irrigation on 12 ha for seed multiplication purposes. Information gathered from the Woreda Agriculture records indicates that the yield performance was more than satisfactory, averaging 54q/ha. According to the Woreda Agricultural Office, crop yields are satisfactory by national standards. In fact, present cropping pattern and production levels are reported to produce more than enough to cover the basic food requirements of the Woreda population.

Although well-compiled and documented, data are hardly available. A two-year trend of area, production and yield in the Woreda is shown in the following table.

*Table 4.13: Area, production and yield/ha in Chewaka Woreda*

| Crop Type | 1999/2000 | | | 2000/01 | | |
|---|---|---|---|---|---|---|
| | Area (ha) | Prod. (qt) | Yield (qt/ha) | Area (ha) | Prod. (qt) | Yield (qt/ha) |
| Sorghum | 6,800 | 173,400 | 25.5 | 5,356 | 183,006 | 34 |
| Maize | 2,788 | 66,277 | 24.0 | 3469 | 77,578 | 22 |
| Tef | - | - | - | 12 | 63 | 5.5 |
| Barley | - | - | - | 9 | 70 | 8 |
| Millet | 10 | 70 | 7 | 19 | 152 | 8 |
| Rice | 623 | 23,695 | 38 | 1,528 | 67,516 | 44 |
| H. Beans | 580 | 7,540 | 13 | 430 | 3,472 | 8 |
| Soybean | 3,074 | 58,481 | 19 | 4,082 | 79,089 | 19 |
| Sesame | 3,400 | 20,440 | 6 | 3,827 | 18,775 | 5 |
| G.Nut | 240 | 4,080 | 17 | 180 | 1,584 | 9 |
| Total | 17,515 | 353,983 | 20.1 | 18,912 | 431,305 | 22.8 |

Source: Chewaka Woreda Agricultural Office

The two-year trend indicates that there is a marked improvement in crop performance in the given time frame. The increment in production may be attributed to expansion of cultivated land. But, the productivity per unit area has also been greatly improved: by about 15% over a one-year period. This fact indicates that there is room for improving the performance of crop production through improved support services.

Moreover, the Woreda agricultural experts revealed that at times of good rains, yields are far better than indicated for the former two years. In fact, they estimate yields to range between 50 to 60qt/ha for sorghum, 40 to 50qt/ha for maize, and more than 50qt/ha for rice. From the collected data at the Woreda level it is possible to compose the situation before the Project and to calculate the production volume as shown in following table. This base will be used to identify the Project benefits in the economic comparison between situations 'without' and 'with project'.

*Table 4.14: Present situation in the Project area*

| DINGER BEREHA | | | | |
|---|---|---|---|---|
| PROJECT AREA - ESTIMATED SITUATION IN 2009 | | | | |
| | Total cultivated Land | | Yield Average | Total Production |
| | ha | % | qt/ha | qt |
| Sorghum | 1 649 | 33.4% | 29.3 | 48 353 |
| Maize | 849 | 17.2% | 23.0 | 19 517 |
| Tef | 2 | 0.0% | 5.3 | 9 |
| Barley | 1 | 0.0% | 7.8 | 9 |
| Millet | 4 | 0.1% | 7.7 | 30 |
| Rice | 292 | 5.9% | 42.4 | 12 374 |
| Har.bean | 137 | 2.8% | 10.9 | 1 494 |
| Soya bean | 971 | 19.6% | 19.2 | 18 664 |
| Sesame | 980 | 19.8% | 5.4 | 5 320 |
| Groundnut | 57 | 1.2% | 13.5 | 768 |
| Total | 4 942 | 100.0% | | |

### 4.7.2 Production Constraints and Sustainability of Land Use

The main constraints are the following:

**Deforestation:** Due to the relative success of the settlement program, there is an influx of people coming into the Woreda. Almost ninety percent of these migrants are farmers whose basic need is to access land for their livelihood. As a result large tracts of forest land are being burned down for cultivation of crops. The Woreda Administration seems powerless to control the influx and the destruction of the dwindling forest resources.

The current land holding size per household is on the average 1.75 ha. This is more than adequate for a family size of 4 to 6 members. However, if the current influx of migrants continues, land redistribution may be inevitable. The result would a diminishing crop area and this will have a catastrophic effect on the livelihood of the settlers.

**Poor farming practices:** Farming operations are generally labour intensive and animal power is rarely employed for farming purposes. Current use of production inputs (fertilizers, improved seeds and agro-chemicals) is encouraging. Nevertheless, the ever escalating prices of these inputs and the limited access to credit facilities are important factors that determine the productivity of the Woreda in general and the Project in particular.

**Crop pest problems:** Termites, rats and other wild animals are reported to inflict heavy losses to agricultural production. Measures, so far, taken are not satisfactory. For the control of termites, there is a need for a concerted effort among all stakeholders including researchers, NGOs, extension people and authorities. As the Project cropping program is intensified, termite infestation might increase.

**Soil Acidity:** Fertility status is poor mainly due to strong acidity of most parts of the Project area. The soils study confirmed that major cations like calcium, magnesium, potassium and sodium have been leached down and the sizable portion of the soil colloid is covered by aluminum cation. The effect of acidity on crop yield may be enormous and there is a need for cautious application of fertilizers as currently used types may further exacerbate the problem of acidity.

## 4.8 Marketing Infrastructure and Support Services

### 4.8.1 Marketing and Agro-processing

The Project is located in a new resettlement area with poor but soon to be improved accessibility. Currently, market organisation is nonexistent, agricultural production is mainly oriented toward home consumption. The lack of roads and local motorised transports restrict the marketing of products outside the Project area. Within the seven resettlement villages, trade is limited to traditional low value exchanges, sometimes in kind, between the families almost totally involved in farming activities. The farmers met in the villages say they sell approx 45% of their production on local markets, mainly at Illu-Harrar.

In the context of this Project and since food security is considered the main target, the opportunity to develop an additional source of income through a more market-oriented agricultural production should be addressed. Introducing cash crops in the cropping pattern is certainly the best way to provide farmers with increased monetary income. For the farming households, this is also an opportunity to shift from subsistence to market oriented agriculture and to increase their capacity to pay for irrigation management, operation and maintenance costs.

To meet this objective, access to market sites must be developed through considerable investments in infrastructure such as roads and transport facilities. A first phase of investment is now currently implemented with the construction of a bridge across the Didessa River providing a new connexion between the Project area and the main road linking Nekemte to Asosa and Sudan. In the future a network of rural roads will be constructed within the Project area.

Establishing an adequate marketing organization is a key of the success of the Project. It is a too early to tell whether or not farmers have the willingness and the capacity to decide on agro-processing options. For the time being, it is more important to emphasize on the need for storage of crop products in order to better value the production and ensure a regular supply of grains, vegetables and other fresh products to markets and to match the market demand with respect to prices and quantities. For doing so, it will be important to determine the adequate size of storage and processing facilities. One should keep in mind that the Project area is very fragmented in terms of settlement villages and that communication means are minimal; this is a major constraint for good market information that can be alleviated by developing a cellular phone network.

On the other hand, the resettled population is very committed to the success of this irrigation Project and may adopt the right attitudes to win a strong position on the markets. Nevertheless, the large size of the proposed irrigation scheme and the expected huge production of agricultural commodities call for specific action to encourage farmers toward comprehensive marketing approach. To help farmers to achieve their market goals it will be important to consider the following main points:

- Facilitate the **access to information** relating to the market prices, the existing demand, the main products exchanged and the level of intra-regional trade.
- Diffuse the knowledge of **Ethiopian standards and regulations**: in particular standardisation of weights and measures, to have access to storage management and specifically to the warehouse receipt system initiated by EGTE[5].
- Identify the features of the market and the various **buyers**: assemblers, traders, retailer outlets, merchants, brokers.
- Analyse and integrate the marketing components such as:
  - the **form of products**: farm gate products are processed, packaged, bulked or sub-divided into different products or quantities
  - the **transaction spot**: local market place or delivery point, each with its own characteristics
  - the **duration of storage** between production and delivery to market.
- **Increase productivity by irrigation, both in rainy and dry season.**
- **Diversification of cropping pattern**, in order to obtain a more regular flow of cash income to the farm household.
- Reinforce **education and training** of traders and market agents.
- **Increase local value added** through local initiatives such as:
  - Incentive measures to develop local agro-processing
  - Help to organise collective action to increase **local storage** and to regular supplies toward the market
  - Diffusion of agricultural technology packages to **increase yields**
  - Organization of inputs purchasing groups.
- **Reduce transport costs** from farms to markets:
  - Encouraging local groups to pool transport and share costs.
  - Training schemes on truck maintenance and responsible driving.

[5] EGTE Ethiopian Grain Trade Enterprise

Moreover, if export markets are to be targeted, marketing information service would play a crucial role in identifying the crops that can meet the international demand and in taking into account the various costs related to quality control, negotiation fees, transport and taxes. In the past three years Ethiopia's exports of pulses and oil seeds have significantly increased. However Ethiopia overall agricultural production is lower than the domestic demand hence targeting the national market is likely to be the best option.

### 4.8.2 Input Supply and Other Support Services

The voluntary resettlement program in the Project area was given particular attention by the Government of Ethiopia. For the first three years after resettlement, the population had been receiving, free of charge farming, inputs and food. Afterwards, farmers had to form informal groups or cooperatives to purchase inputs in bulk with the assistance of the Woreda administration. The process for establishing cooperatives, among them two irrigation cooperatives, did not allow enough time to consider and analyze farmers' needs. Cooperatives were given insufficient assistance and follow-up, as a result there is some confusion amongst farmers about the roles of cooperatives and the advantages they can get in joining them. In other irrigation projects in Ethiopia, irrigation cooperatives have generally performed poorly.

The rapidly increasing number of farmers due to continuous influx of new settlers calls for reinforcing or establishing support services such as inputs supply and agricultural extension. For the proposed Project, it is important to enhance the capacity of farmers to form groups, to exchange their experience and knowledge and to reinforce support services to help farmers establishing cooperatives or other forms of organization. However, it is recommended to avoid integrating marketing and water management activities in one organization, a cooperative for instance. Water management requires a specific form of organization. WUAs are well suited to take charge of operation and maintenance and collecting water fee from users. In Ethiopia there is a large consensus on establishing water user associations as legal entities to perform the irrigation management thanks to efforts of the Ministry of Water Resources. Reports of former studies on marketing cooperatives underline their financial difficulties and the lack of competitive edge that drives commercial traders. When they are engaged in commercial activities, the cooperatives have not enough bargaining power to negotiate prices either with traders or farmers. In the end, farmers consider cooperatives as the buyer of last resort, and indeed the cooperative share of the market is decreasing.

The situation is completely different for input supply cooperatives. In general, this category of cooperatives has provided significant benefits to farmers by making good seeds and fertilizers available; however their impacts have been so far relatively limited. This confirms the need to help farmers to reinforce their skills in cooperative management and the need to give them enough information to identify what cooperatives can do and what they cannot do. The Government of Ethiopia is strongly committed to reform and expand the cooperative sector. The financial capacity of the cooperative sector has been strengthened through provision of collaterals by regional governments to facilitate cooperatives access to credit. Recently, EGTE has established a Warehouse Receipt System (WRS) throughout the country.

Only grain production is concerned by this system which also involves standardisation: control of quality and colour, weights, moisture and trash contents, investment in cleaning equipments and handling facilities and so on. This system is not yet established in the Project area. Agricultural extension services in the Project area are provided by the Woreda Agricultural Development Office. Extension services, which are based on a participatory approach, aim at a better adoption rate of technological packages, providing proper feedback mechanism and ensuring successful implementation of programs and projects. The Woreda has 28 Kebeles and to fully implement the extension program, each Kebele should have three experts dealing with natural resources management, crop production and livestock development.

Farmers Training Centres (FTCs) are being established in the area and these centres provide farmers with new technologies for agriculture and livestock production including irrigated agriculture and liaising farmers with technology providers. The extension workers work in close contact with the farmers. They are expected to play an important role in the adoption and implementation of more efficient and environment friendly agricultural practices both for rain-fed and irrigated crops. Non-governmental organizations (NGOs) play an additional role in providing specific extension services to the Woreda population. Sasakawa Global 2000 (SG2000) has been operating for the last two years and is credited for the introduction of adapted rice varieties in the Project area. Rice seeds are now multiplied in selected farmers' fields with support provided by SG2000. This NGO has also distributed seeds and fertilizers to more than 250 farmers. The United Nations Development Program (UNDP) is also involved in providing assistance in equipping FTCs with basic facilities. It also provides seeds and watering cans for farmers including women to grow horticultural crops. The Ethiopian Institute of Agricultural Research has two main centres at Jimma and Bako, which are relatively close to the Project area. The Jimma Research Centre, in addition to its main task as a research centre on coffee, also works on cereals, horticultural and spice crops. Bako is the centre for the National Maize Research Project. Bako centre also deals with other crops including sorghum, rice, soybean, haricots, groundnut and sesame. The Project would greatly benefit from these two research centres for cereals, pulses, oil seeds and horticultural crops. On farm testing and application of new techniques would be readily adapted to the conditions in the area.

### 4.8.3 Credit Facilities

After a long period of time during which credit to farmers was almost inexistent in Ethiopia, The Government of Ethiopia has taken action to develop rural finance institutions. One main achievement is the strengthening of the cooperative sector, regional governments acting as collaterals to facilitate cooperatives access to credit. Another incentive for the cooperative sector is the exemption from income tax. With the availability of rural credit has increased substantially and is better that at any time in the past; traders also have a much better access to credit for financing their commercial activities. Experiences from other countries stress the important role that micro-finance schemes can play for small scale farmers. Most of the time loans are meant for the construction of local storage and agro-processing facilities or seasonal credit for purchasing agricultural inputs. At farm level, it is important to consider all these elements as an integrated financial package in order to adopt a financial plan and then seek the best suited financial resources. Indeed, the financial needs of a farming business are very often closely linked to the needs for working capital and it is usual that cash flow problems occur often because of the seasonal nature of agricultural production. Once these problems are overcome, it becomes possible for farmers to finance long term investments such as storage facilities or farming equipments or irrigation equipment. Therefore it is recommended to pay the greatest attention to the availability of seasonal credit, at least for the first five years of the Project.

# 5. THE PROJECT WORKS

## 5.1 PROJECT RATIONALE

The Project area and its surroundings are characterised by a high population density, a fast growing population, rapid destruction of the environment, small farm sizes, an almost fully cultivated hilly area with gradients upto 30% and declining crop yields. The recently settled families are largely dependent on agriculture with no other resources and although rainfall is reasonably reliable there is little scope for improving yields. Therefore, it can be expected that poverty will increase rapidly and food security will decline quickly if no countermeasures are taken. In order to achieve its goal of reducing and preventing poverty, improving rural incomes and enhancing food security the Government has placed high priority on increasing food production through the expansion of irrigated agriculture. The Dinger Bereha Irrigation Project will address the risks of non-intervention. The Project was selected from a range of projects that were identified by the Government. In addition to the development of an irrigation infrastructure the most effective means of improving farm income and preventing poverty is through increased agricultural productivity and improving marketing conditions. An integrated approach will be adopted that combines irrigation infrastructure, land and water management, crop diversification and intensification with emphasis on high value crops, improved agricultural practices and improvement of accessibility. As the Project area is almost fully under cultivation and is marked by significant slopes, the length of open canals crossing the cultivated area must be minimal.

## 5.2 PROJECT OBJECTIVES

The overall goals of the Project are to increase rural income, reduce poverty and improve health in the Project area and surroundings on a sustainable basis. In order to achieve these goals the main purposes have been defined as follows:

- Mitigate and reverse the adverse impact of periodic drought;
- Develop 7,500 hectares of land for irrigation and irrigate dry season crops as well as supplement wet season crops during times of late onset or early withdrawal of the rains;
- Improve existing wet season cropping systems, supported by crop diversification and introduce appropriate cropping patterns for dry season irrigated farming so as to improve crop productivity;
- Sustain crop productivity through better management of soil and water resources; and
- Introduce high value food and industrial crops and agro-processing facilities.

Regarding the introduction of irrigation the rationale will be to establish a cropping system that will change gradually so that subsistence cropping will be dominant during the wet season in the first few years, but will decrease steadily with increasing yields of the staple crops and increasing revenues of cash crops. The cropping intensities during the dry season will increase depending on the development of marketing opportunities and better returns. The objectives are in accordance with the Government's Agricultural Development Led Industrialisation (ADLI) Strategy which is a key component of the Sustainable Development and Poverty Reduction Programme (SDPRP).

The Government's ongoing institutional and policy reforms which aim to decentralise decision making and management to the Woreda level, as well as to improve the capacity of the local authorities to manage rural development programmes, will also help to ensure that proposed irrigation development is sustainable in the long term through active participation by the local community.

## 5.3 Characteristics and Size of the Irrigable Area

The command area lies on the left bank of the Didessa River upstream of the confluence of the Dabana River with the Didessa River and is divided by a large number of streams that flow to the Didessa, dividing the command area into a number of interfluves. In addition, the area is divided into an east and a west part by the Duna Sere stream that flows from south to north. Gradients in the Project area range from around 4% in the upper part of the Project area to 30% in the steepest places close to the Didessa and Dabana Rivers. The steep gradients along the river indicate that the area is under rejuvenation, i.e. the bed of the river has fallen and the land is eroding close to the river. Similar conditions are found in the valley of the Finchaa River, which is also a tributary of the Abbay. According to the soils and land suitability studies 6,800 ha are suitable for irrigated agriculture. This amount does not include the area covered by incised streams and riverine forest along banks of rivers and streams. This area was calculated at 1,721 ha gross. The length of rivers and streams in the command area is 265 km. Assuming an average width of streambed of 3m and a 10m wide reserve on each bank the area to be set aside for reforestation is 610 ha. Hence, an additional 1,111 ha would be available for irrigated agriculture, bringing the total to 7,911 ha. Assuming about 5% of the area to be taken for tracks and roads, the total net irrigable area would be about 7,500 ha. For calculation purposes this figure will represent the net irrigable area that will be commanded by the system.

## 5.4 Irrigation Infrastructure

### 5.4.1 Options studied

#### *5.4.1.1 Gravity, combined with booster pumping*

The following options comprising gravity and booster pumping have been studied:

1) Option 1: gravity diversion at a waterlevel of +1245 via 15 km main canal to the boundary of the command area of 7,500 ha net, followed by a primary canal to a low lift pumping station. Water would be lifted from +1240 to +1263, with gravity irrigation for about 550 ha.

2) Option 2: gravity diversion at a waterlevel of +1245 via 15 km main canal to the boundary of a command area of 7,500 ha net, followed by a primary canal to the site of PS. Conveyance continues by 15 km extended primary canal, that follows contour 1240 northwards, turns sharply after 5 km to the south (just west of village Desle Mosuma) and continues another 10 km to finish at a waterlevel of +1235. Gravity irrigation would be possible on about 3,000 ha.

Disadvantages of option 2 are: a) much more landtake for canals, b) scattered areas for low lift pumping which requires multiple small stations, longer powerlines, smaller distribution systems, and much less area that can be irrigated by low to medium pressure systems. Therefore this option was not studied further.

#### 5.4.1.2 Booster pumping and two stage pumping

The following options have been studied:

1) Option 1: gravity diversion at a waterlevel of +1245 via 15 km main canal to boundary of command area of 7,500 ha and primary canal to low lift pumping station. Pumping would be from +1240 to +1263 and gravity irrigation would be possible on 550 ha.

2) Option 3: pumping from the river from a waterlevel of +1220 to +1242 for 7,500 ha into a 3 km long main canal to command area. Booster pumping from +1240 to +1263 as in option 1.

The table below shows that the investment costs for option 3 are higher than for option 1. Combined with the additional pumping and maintenance costs, option 3 is much less economical than option 1.

*Table 5.1: Comparison between options 1 and 3*

| **Description** | **Costs ('000 Birr)** |
|---|---|
| **Extra costs Option 3** | |
| Pumping station | |
| Civil Engineering, 100% of pumping station costs | 881 |
| HM and electrical equipment+powerline etc | 91,050 |
| Intake works at river, 20% of headworks costs | 4,135 |
| GRP Rising mains, 2 x 200 m, diameter 1.4 m | 7,040 |
| *Subtotal* | 103,106 |
| **Savings Option 3** | |
| Headworks | 20,673 |
| 12 km maincanal | 54,194 |
| 8 cross drainage structures, | 5,000 |
| *Subtotal* | 79,867 |
| *difference in favour of adopted option 1* | 23,238 |

### 5.4.2 Overall Concept and Lay-out of the Selected Option

**Diversion**. A gravity diversion has been selected for the proposed project because comparison of costs of options has shown that the partly gravity-partly pump option is more cost effective than the alternative of full pumping from a point on the Didessa nearer to the command area. Water is taken from the Didessa River by a headworks made up of a mass concrete weir with a flushing channel with sediment excluder and Main Canal offtake on the left bank. Immediately downstream of the Main Canal offtake there is a settling basin, from which the settled sediment can be flushed back to the river.

**Main System for Conveyance.** Trapezoidal concrete lined canals with a gradient of 0.20m/km have been chosen for all canals because of the high permeability of the soils. A steeper canal gradient was examined but the additional pumping costs together with the loss of production exceeded the saving in canal construction cost. The Main Canal between the gauging weir and the boundary of the command area is 15 km long and follows the Didessa River closely for most of its length. At the south eastern extremity of the Project area, the Main Canal has gained sufficient command to irrigate the area between the canal and the river.

Once the Main Canal reaches the command area it is designated Primary Canal. This canal reaches up to the pump station and balance/night storage reservoir. From this reservoir water will be pumped to four night storage reservoirs at an elevation of approximately 1263 m designated NW, SW, NE and SE. For all of the night storage reservoirs except NE, there will be an outlet to a high level Primary Canal. From the night storage reservoir NE the offtakes will be secondary pipelines with downstream control.

The Primary Canals will traverse the deeper valleys in inverted siphons which will have GRP barrels and will either be buried or installed above ground, according to the pipe size and geotechnical conditions. Although most of the scheme will be irrigated by secondary pipelines feeding directly from the reservoirs or Primary Canal, contour secondary canals are required in a number of locations. The high level Primary Canals will operate with upstream control, i.e. the required amount of water will be released from the night storage reservoirs

**Siphons and side weirs.** Inverted siphons are used to cross deep valleys along the canal route for reasons of cost; an inverted siphon will cost less than a long section of canal with a cross-drainage culvert. Side weirs are used to control the water levels in the Primary Canals so that outflows from the canal can be accurately controlled. Side weirs are found to be both less costly and less subject to mechanical failure than mechanical devices such as an AMIL gate. These are very robust devices so there is also less opportunity for interference and vandalism.

**Reservoirs.** Since irrigation will only take place during the 12 daylight hours, it is necessary to store the night time flow in the canals at a location close to the irrigated area. The provision of night storage reservoirs simplifies the management of the scheme and enables the scheme to make efficient use of the diverted irrigation water. Each of the larger irrigation blocks supplied from the high level Primary Canals will have its own night storage reservoir. These reservoirs will be supplied with a constant 24-hour inflow from the Primary Canals.

**Secondary and Tertiary Distribution System.** Because of the terrain, conveyance and distribution of water perpendicular to the contours has to be mainly through piped networks, because a system with open lined canals coupled to a huge number of large drop structures would be very expensive and would require large land take in a densely populated and cultivated area. From the primary network, including the canals and the night storage reservoirs, water is conveyed to the head of standard blocks by a secondary canal and/or a buried pipe network. The Project area is divided into 15 Command Areas corresponding to the main interfluves. For each command area, blocks are demarcated. taking into account the site geomorphology, slope, streams and gullies. The tertiary system comprises buried pipe networks connected to the secondary pipes or canals. The tertiary systems feed flow control hydrants each serving an area of about 6 ha. The flow from the hydrant is controlled by a flowlimiter and distributed by a permanently buried PVC or PE pipes to a number of field outlets. Each farmer has its own field outlet and the full flow from the hydrant is rotated amongst the farmers united around the hydrant. The tertiary network and the hydrants are operated at maximum 12 hours/day when water requirements peak. Additional advantages of piped systems are increased distribution efficiency, large reduction in water theft, better control of quantities delivered to users and the possibility to use highly efficient localised irrigation systems with full and transparent control of water quantities delivered.

**On Farm Distribution.** The on-field irrigation system is connected to the individual outlets and comprises gated pipes or other improved surface irrigation equipment such as hoses or simple HDPE pipe that can be dragged from farm to farm. Where sufficient pressure is available at the hydrant, farmers can install localised irrigation systems such as drip and sprinkler (draghose system).

## 5.4.3 Technical Description of Components

### 5.4.3.1 Headworks

A suitable site for a diversion weir has been identified some 16 km upstream of the Project area. At the selected diversion site the riverbed is weathered rock which, after removal of the most weathered rock, provides good foundation conditions for the weir. The weir will be of mass concrete with an ogee section and a crest length of 110 m. Embankments will be constructed at each end of the weir section to prevent the flow by-passing the weir. At the left hand end of the weir there will be a flushing channel to prevent the build up of sediment upstream of the weir. The offtake to the main canal will be at right angles to the flushing channel and the flow into the canal and through the flushing channel will be controlled by vertical slide gates. Downstream of the canal offtake there will be a settling basin 150 m long to remove suspended sediment from the irrigation water. The settling basin will be angled towards the river with a gate at its downstream end such that, at appropriate intervals of time, the sediment that has accumulated in the settling basin can be flushed back into the river. The conveyor canal will take off from the downstream end of the settling basin and will flow in a rectangular reinforced concrete channel for 50 m where there will be a gauging weir to ISO 4360. This gauging weir will allow the flow in the main canal to be set to the value appropriate to the irrigation demand.

### 5.4.3.2 Canals

**General**. Since the soils of the Project area are permeable, all canals will be trapezoidal with side slopes of 1.5:1 (H:V) and lined with a geomembrane and a geotextile protected by a 65 mm thick layer of mass concrete. The geomembrane will prevent leakage from the canal and the geotextile will allow the concrete lining to be placed on the sloping sides of the canal without sliding. This combination has been found to give the most cost effective and durable method of construction a water tight canal lining. The gradient of all canals has been taken as 0.0002 and the Manning "n" as 0.016. A canal gradient of 0.0003 was examined but this was found to be economically less favourable than the 0.0002 gradient; the value of the agricultural production forgone because of loss of command and the additional pumping cost exceeded the savings in canal construction by a considerable margin.

**Main Canal.** The length of the Main Canal between the gauging weir and the boundary of the command area where it connects to the Primary Canal is 15 km long. The canal will be lined and its capacity will be 6 $m^3/s$, whereas bedwith, section depth and water depth will be 1.75, 2.15, and 2.00 m respectively. Freeboard will be 0.35m. The Main Canal will cross a number of watercourses. These will be carried underneath in reinforced concrete box culverts 2.5 m wide and 2.0 m high. This size of culvert barrel will allow people, animals and vehicles to pass under the canal. Depending on the estimated flow in the watercourse there will be between one and three barrels of this size.

**Primary Canals.** The Primary Canals will be constructed in the same way as the Main canal. There will be four Primary Canals; the Primary Canal, which is supplied by gravity and runs upto the pump station and the NW, SW and SE Primary Canals which are supplied by pumping from the reservoir at the end of the Primary Canal. Table 5.2 presents relevant data on the Main Canal sections. Irrigation water will be taken directly from the canal to the piped secondary and tertiary systems which will supply a net area of about 550 ha. The water level in the Primary Canals is controlled side weirs which will ensure the submergence of the secondary offtakes. The Primary Canal section between Main Canal and pumpstation is 11.72 km long and supplies water directly to 550 ha under gravity. Where watercourses are not crossed by siphons these will be carried under the canal in reinforced concrete box culverts 2.5 m wide and 2.0 m high. This size of culvert barrel will allow people, animals and vehicles to pass under the canal. Depending on the estimated flow in the watercourse there will be between one and three barrels of this size. Table 5.3 presents data on these culverts.

*Table 5.2: Primary Canal Dimensions at a gradient of 0.2 m/km*

| Section Reference | Max Flow $m^3/sec$ | Length m | Canal Section | Bed width m | Section depth m | Water depth m | Freeboard m |
|---|---|---|---|---|---|---|---|
| PC 1+1a | 6.00 | 7,628 | C02 | 1.75 | 2.15 | 2.00 | 0.35 |
| PC 2 | 6.00 | 1,016 | C02 | 1.75 | 2.15 | 2.00 | 0.30 |
| PC 3 | 6.00 | 3,845 | C03 | 1.75 | 1.95 | 1.93 | 0.35 |
| PC 4 | 6.00 | 1,854 | C03 | 1.75 | 1.95 | 1.90 | 0.30 |
| PC 5 | 0.40 | 2,675 | C12 | 0.75 | 0.80 | 0.60 | 0.20 |
| PC5a | 0.20 | 4,509 | C12 | 0.75 | 0.80 | 0.45 | 0.20 |
| PC 6 | 0.19 | 1,614 | C12 | 0.75 | 0.80 | 0.45 | 0.15 |
| PC 7 | 0.45 | 2,360 | C12 | 0. 75 | 0.80 | 0.65 | 0.20 |
| PC 8 | 1.04 | 4,784 | C10 | 0.75 | 1.10 | 0.90 | 0.20 |
| PC 9 | 2.35 | 3,034 | C07 | 1.25 | 1.45 | 0.92 | 0.23 |
| PC 10 | 1.80 | 1,240 | C08 | 0.75 | 1.45 | 1.15 | 0.25 |
| PC 10a | 1.80 | 2,622 | C08 | 0.75 | 1.45 | 1.15 | 0.25 |
| PC 10b | 1.80 | 0,266 | C08 | 0.75 | 1.45 | 1.14 | 0.25 |
| PC 11 | 1.16 | 1.868 | C09 | 0.75 | 1.25 | 0.65 | 0.20 |
| PC 11a | 1.16 | 1,060 | C09 | 0.75 | 1.25 | 0.65 | 0.20 |
| PC 12 | 0.33 | 0.883 | C10 | 0.75 | 0.75 | 0.60 | 0.20 |

*Table 5.3: Data on Cross-Drainage Culverts*

| Culvert Number | Flow T = 25 ($m^3/s$) | Number of cells 2.00x2.50 m |
|---|---|---|
| 1 | 13 | 2 |
| 2 | 25 | 3 |
| 3 | 13 | 2 |
| 4 | 22 | 3 |
| 5 | 14 | 2 |
| 6 | 28 | 3 |
| 7 | 24 | 3 |
| 8 | 16 | 2 |
| 9 | 9 | 1 |
| 10 | 17 | 2 |
| 11 | 18 | 2 |
| 12 | 12 | 2 |
| 13 | 9 | 1 |
| 14 | 4 | 1 |
| 15 | 8 | 1 |
| 16 | 7 | 1 |
| 17 | 26 | 3 |
| 18 | 5 | 1 |
| 19 | 6 | 1 |

#### 5.4.3.3 Inverted Siphons

Within the Project area the Primary Canals will cross watercourses in inverted siphons; the inverted siphons are found to be more economical than a long contour canal following the valley and a culvert to carry the watercourse under the canal. The inverted siphons will have reinforced concrete transitions at the up- and downstream ends and a GRP barrel, which may be buried or installed above ground on concrete cradles, depending on the size of the barrel and the geotechnical conditions. Table 5.4 presents salient data.

*Table 5.4: Schedule of Inverted Siphons (q = 0.8 l/s/ha)*

| Designation | Pipe Length (m) | Q (m3/s) | Pipe Diameter (m) | Velocity (m/s) | Head Loss (m) |
|---|---|---|---|---|---|
| S1 | 237 | 6.00 | 2.0 | 1.88 | 0.55 |
| S2 | 185 | 6.00 | 2.0 | 1.88 | 0.50 |
| S3 | 240 | 6.00 | 2.0 | 1.88 | 0.56 |
| S4 | 441 | 6.00 | 2.0 | 1.88 | 0.77 |
| S5 | 372 | 0.45 | 0.6 | 1.59 | 1.42 |
| S6 | 116 | 1.04 | 0.9 | 1.64 | 0.48 |
| S7 | 386 | 1.80 | 1.1 | 1.89 | 1.16 |
| S8 | 253 | 1.16 | 0.9 | 1.82 | 0.95 |
| S9 | 110 | 0.33 | 0.5 | 1.68 | 0.75 |
| S10 | 267 | 0.66 | 0.8 | 1.31 | 0.57 |
| S11 | 128 | 0.66 | 0.8 | 1.31 | 0.35 |

#### 5.4.3.4 Night Storage Reservoirs

Two basic types of Night Storage Reservoir will be used a so called "on-stream" night storage reservoir, which is supplied directly by a rising main or a Primary Canal and an "off-stream" night storage reservoir, which is constructed alongside the Primary Canal. The off-stream night storage reservoirs will be supplied from the Primary Canal with an accurately controlled continuous flow which is set by a baffle distributor. The water level in the Primary Canal will be controlled to within the tolerance limits of the baffle distributor by a side weir immediately downstream of the offtake to the reservoir. An additional 15% in the capacity of the night storage reservoirs has been allowed over calculated reservoir volume for operational convenience. The volumes of the night storage reservoirs are given in Table 5.5. The reservoir serving the NE part of the command area has no canals downstream but instead feeds directly to the secondary pipelines which serve surrounding command area. Certain of the secondary pipelines for this area will be taken directly off the P1 rising main. Each one of the pumped Primary Canals (SE, NW and SW) has a reservoir at the downstream end to provide night storage and to provide operational flexibility. The larger command areas served by these three Primary Canals will have their own off-stream Night Storage Reservoir. The flow from the Primary to the off-stream reservoirs will be accurately regulated by a Baffle Distributor with close control of the canal water level by a side weir. Water will be taken from these night storage reservoirs by the secondary pipe system "on-demand", i.e. with downstream control. The farmers will open their hydrants at the proper time and a regulated flow will be delivered to their fields.

*Table 5.5: Volumes of Night Storage Reservoirs*

| Canal | Designation | Flow $m^3/s$ | Net vol. $m^3$ | Gross vol. (+15%) $m^3$ | Reservoir Type |
|---|---|---|---|---|---|
| Primary | R1 | 0.49 | 21,315 | 24,512 | On-stream |
| NE | R2 | 0.86 | 37,092 | 42,656 | On-stream |
| SE | R3 | 0.81 | 35,054 | 25,309 | On-stream |
| | R4 | 0.20 | 8,513 | 9,790 | Off-stream |
| | R5 | 0.10 | 4,480 | 5153 | On-stream |
| NW | R6 | 0.46 | 19,635 | 22,580 | On-stream |
| | R7 | 0.55 | 23,809 | 27,380 | Off-stream |
| | R8 | 0.64 | 27,632 | 31,777 | Off-stream |
| | R9 | 0.83 | 35,662 | 41,012 | Off-stream |
| | R10 | 0.33 | 14,350 | 16,502 | On-stream |
| SW | R11 | 1.04 | 44,751 | 38,528 | On-stream |
| | R12 | 0.26 | 11,249 | 12,936 | On-stream |

#### 5.4.3.5 Side Weirs

Side weirs have a number of advantages over other methods of controlling upstream water levels. Compared to mechanical devices such as the AMIL gate, a side weir has the following advantages:

1) No moving parts, not subject to mechanical failure.
2) Not subject to interference and vandalism.
3) Low cost
4) Simple to construct and repair; similar to canal lining.
5) Low foreign exchange component.

The simple side weir is cheaper to construct than a duckbill weir, which requires more reinforced concrete. Table 5.6 presents a schedule of the 10 side weirs required.

### 5.4.4 Pump Station and Rising Mains

The pump station to supply the remainder of the command area will pump from the balance/night storage reservoir. The pump station will have a total of 10 pumps, two to pump to the SE Primary Canal, two to pump to the NE command area (CA13) and the remaining 6-7 pumps to pump to NW and SW command areas. The pumps station will be constructed as one or two reinforced concrete structures with the sets of pumps discharging, via butterfly and non-return valves, to separate buried manifolds. The possibility of interconnecting the manifolds to provide a degree of stand-by capacity may be investigated during the detailed design. The pumps will be mixed-flow vertical turbine pumps with close-coupled motors. Each pump will discharge about 500-600 l/s against a total head of 36-37.5 m. The pumps will be weatherproof and installed in the open. A building will be provided for the switchgear that will be housed in a common switchboard and supplied by common transformers. The rising mains will, like the inverted siphons, be of GRP, albeit of a suitable class to withstand the operating and surge pressures that will occur in the rising mains.

*Table 5.6: Schedule of Side Weirs*

| Reference | Canal bed width B (m) | Canal section depth Y (m) | Head on weir H (m) | Height of weir crest H (m) | Length of weir crest L (m) |
|---|---|---|---|---|---|
| SW1 | 1.75 | 2.15 | 0.25 | 1.90 | 28 |
| SW2 | 1.75 | 2.15 | 0.25 | 1.90 | 28 |
| SW3 | 1.75 | 1.95 | 0.25 | 1.70 | 28 |
| SW4 | 0.75 | 1.45 | 0.20 | 1.25 | 12 |
| SW5 | 0.75 | 1.45 | 0.15 | 1.30 | 105 |
| SW6 | 0.75 | 1.25 | 0.10 | 1.10 | 7.5 |
| SW7 | 0.75 | 0.80 | 0.10 | 0.70 | 7.5 |
| SW8 | 0.75 | 1.10 | 0.10 | 1.00 | 12.5 |
| SW9 | 0.75 | 0.80 | 0.10 | 0.70 | 7.5 |
| SW10 | 0.75 | 0.80 | 0.10 | 0.70 | 7.5 |

The rising main serving the SW Primary Canal will branch off rising main P3. Rising mains up to one metre diameter will be buried and over one metre diameter will be installed on cradles above ground. Particular attention will be paid the anchoring the pipeline to withstand the thrust at changes of direction. Table 5.7 presents details on the 4 rising mains.

*Table 5.7: Rising Main and Pump Characteristics*

| Rising Main | Pipe D (m) | Length of Rising Main | Pipe Class | Total Head (m) | Flow ($m^3/s$) | Number Pumps |
|---|---|---|---|---|---|---|
| P1 | 0.70 | 2,376 | PN16 | 37.4 | 0.86 | 1.5 |
| P2 | 0.60 | 1,016 | PN16 | 35.7 | 0.81 | 1.5 |
| P3 | 1.40 | 3,847 | PN20 | 36.6 | 3.84 | 7 |
| P4 | 0.90 | 1,854 | PN10 | - | 1.04 | - |

### 5.4.5 Electricity supply

Along the main road Nekempte-Gimbi there is a 32 kV powerline. However, stepping down to 11 kV would cost 33 million ETB and is not allowed according to EEPCO regulations. The nearest transformer station where power is stepped down from the national 132 kV grid to 11 kV is in Nekempte, about 70 km away from the pumpstation site. According to EEPCO the unit cost of an 11 kV powerline, including stepdown transformers from 11kV to 415 V would be 160,000 ETB/km. Therefore the costs of electrification would be in the order of 11.2 million ETB. To allow for some contingencies the amount is rounded-off to 12 million ETB.

### 5.4.6 Secondary Systems

**Canals.** The secondary canals will take their water from the night storage reservoirs. The flow from the reservoir will be controlled by a constant downstream water level gate (AVIO type). The shorter secondary canals will be constructed with horizontal banks so that they can operate with downstream control. The longer and more complex secondary canal will operate with upstream control, the AVIO gate being supplemented by a modular baffle distributor to regulate the flow.

**Pipe distribution networks.** From the primary network, including the canal and the night storage reservoirs, water is conveyed to the head of each standard block by a buried pipe network. The Project command area is divided into 15 Command Areas corresponding to the main interfluves. For a small CA, or part of CA located near the primary canal, pipes are directly connected to the canal, without reservoir.

For large CAs, two networks are designed:

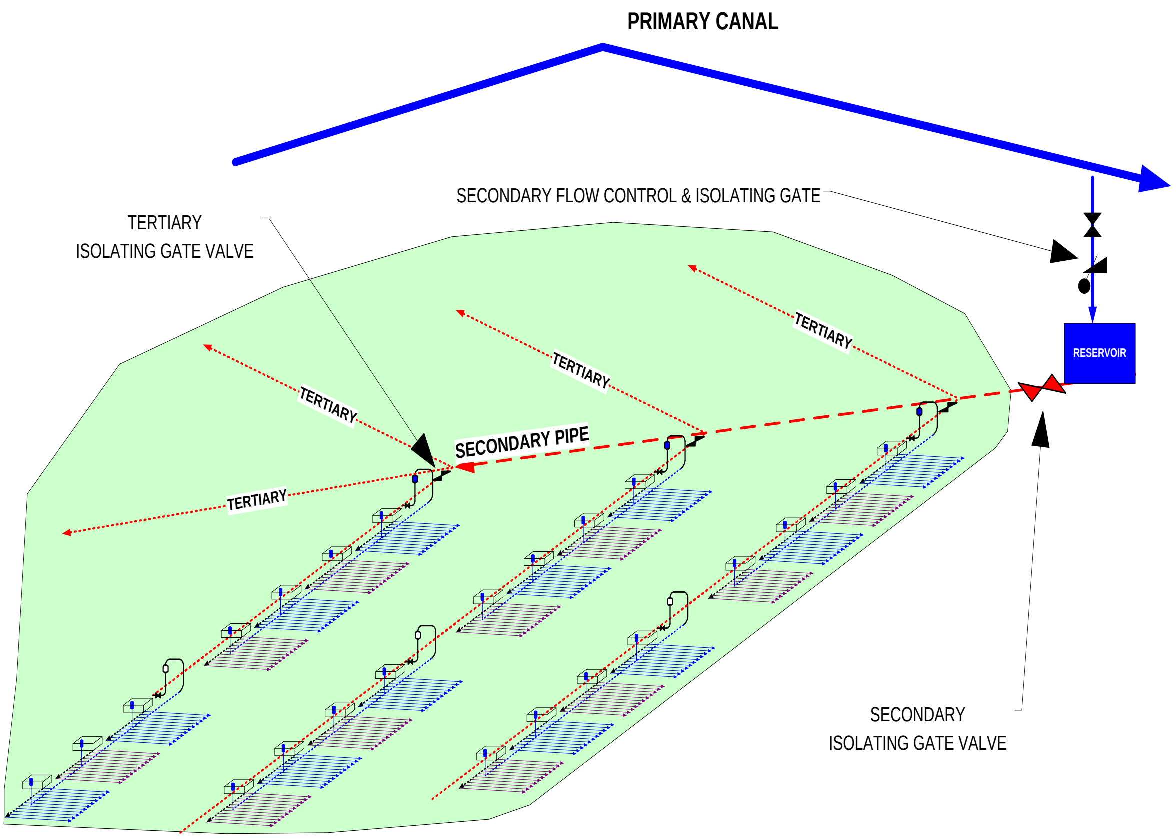
- The secondary network, located at the ridges of the CA
- The tertiary network, watering the blocks from the secondary network

Two kinds of pipes are selected for the present project:

- GRP pipes (Glass Reinforced Pipes), for all diameters ≥ 400mm
- Stiffness class SN 5000 / NWP 6 bar
- PCV pipes for all diameters < 400mm.
- NWP 6 bar

Networks are installed with the necessary fittings and air valves. Appropriate valves are installed at the head of each network branch, to allow proper maintenance and management of water distribution.  Figure 5.1 presents a schematic lay-out.

*Figure 5.1: Schematic lay-out of secondary and tertiary pipe networks*



**Selection of Command Areas for Hydraulic Calculations**

In order to obtain a good approach of the network sizing and cost, blocks, tertiary and secondary networks were designed for 8 CAs, covering a total gross area of 4,357ha i.e. approximately half of the gross irrigable Project area. For each command area the following criteria were used:

- Blocks are demarcated for an approximate 6 ha net area, taking into account the site geomorphology, slope, streams and gullies. Figure 5.2 presents a representative lay-out.
- Maximum land slope is around 20%, and maximum furrows length around 200m.
- Inventory of all blocks is established for all the tertiary and secondary branches and project discharges are defined considering that ALL BLOCKS are watered simultaneously with a nominal discharge of 9.6 l/s/block.

In order to select the secondary and tertiary networks pipes diameters a mathematical model was established using HAZEN-WILLIAMS formula on Microsoft Excel software. Details on automatic selection of hydrant type, based on a number of conditions are presented in Annex 7.

## 5.4.7 Tertiary Systems

**General Concept.** During the design of the on-farm equipment and organisation that determines the capacity and operation of the secondary and tertiary systems the following factors have been taken into account:

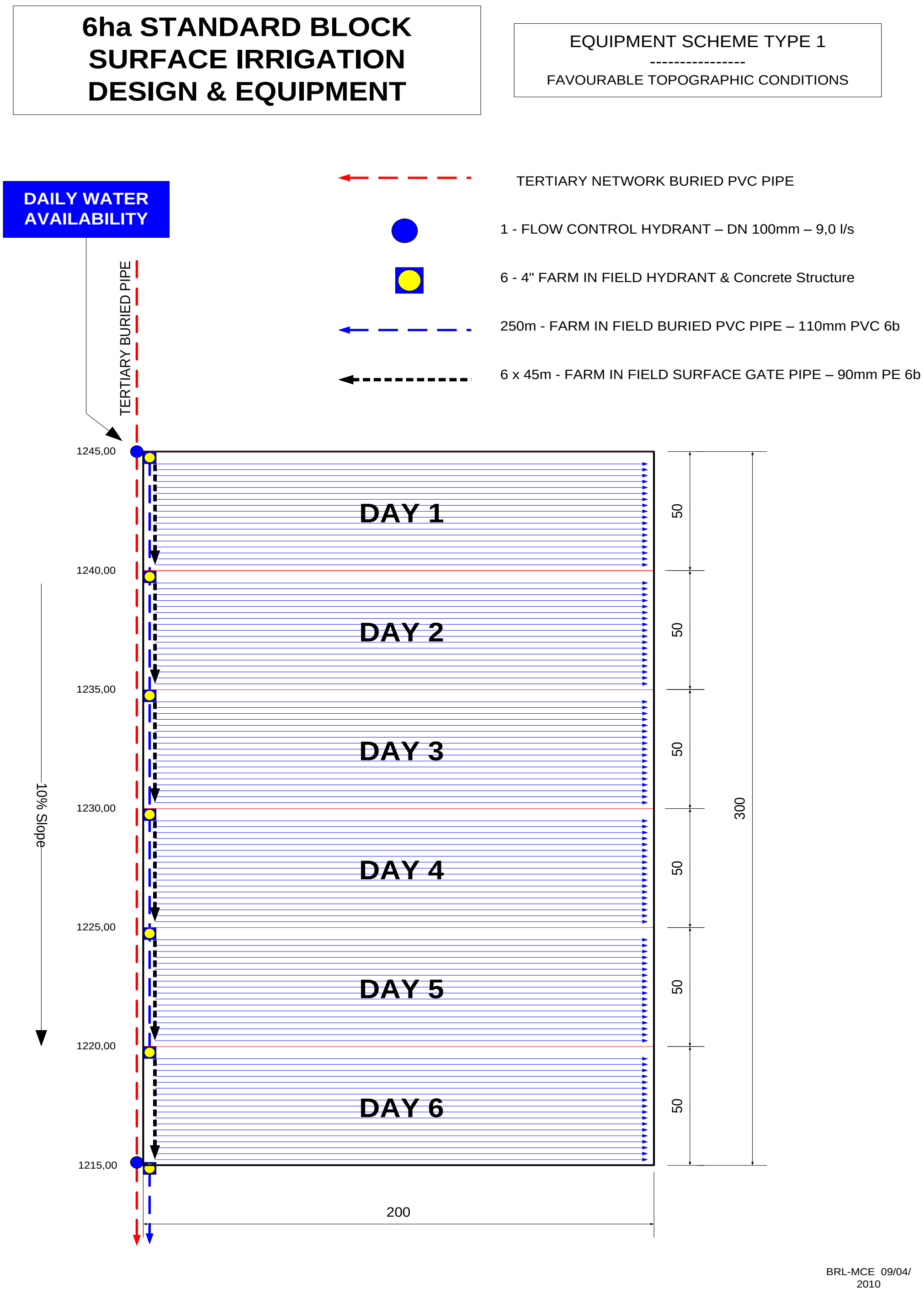
- The topographical conditions show a general slope > 2% for 90% of the area.
- The numerous gullies and streams cutting the Project area into several main interfluves whereas each interfluve comprises numerous small plateaus.
- The need to minimise the energy requirements by reducing pumping.
- The present social structure and land organisation based on a small farms, and family labour without mechanization.
- The actual farmer's knowledge of water use and management of surface irrigation, when water is available.
- The possibility of future improvement of irrigation efficiencies, with progressive development of modern field irrigation systems without modification of the conveyance and distribution networks and associated water management.

Thus, the design has been based on the principle of permanent water availability during 12 hours of irrigation per day at the head of standard command bloc. The corresponding water discharge is automatically controlled by a flow control device calibrated for $Q = S \times q0 \times 12/24$, with $q0 = 0.8$ l/s/ha and S the surface of the standard command bloc. The discharge is suitable with the practice of surface irrigation by furrows, with a minimum of 5 l/s per furrow. The area of the bloc can be divided into several family farms with a daily rotation of the water availability for each farm and a maximum farm watering frequency of 6 days during the peak water requirements period, in order to allow the use of sprinkler or localised irrigation systems. Due to topographical conditions and associated development costs, the only solution for the water conveyance from upstream the primary canal to downstream the head of the standard block is by buried pipes networks.

**The Standard Block.** Considering the topographical conditions of the zone, the surface of the standard bloc is small and reduced to 6 ha (200 x 300). Thus, the length of the contour lines furrows remains feasible (#200m), without excessive earthworks, so they can be dug by the farmers. When the slope of the bloc is very important, (>8/10%), land should be terraced in order to allow a good watering of the furrows or the basins, and to avoid erosion. Inside the standard bloc, land is organized with 6 farms of 1ha (50 x 200). Due to the difficult topographic and geomorphologic conditions, the digging of the contour lines furrows and terraces remains the key point of the present project.

The lay-out of the standard bloc with its different equipment is presented in Figure 5.2.

*Figure 5.2: Lay-out of 6 ha standard bloc*

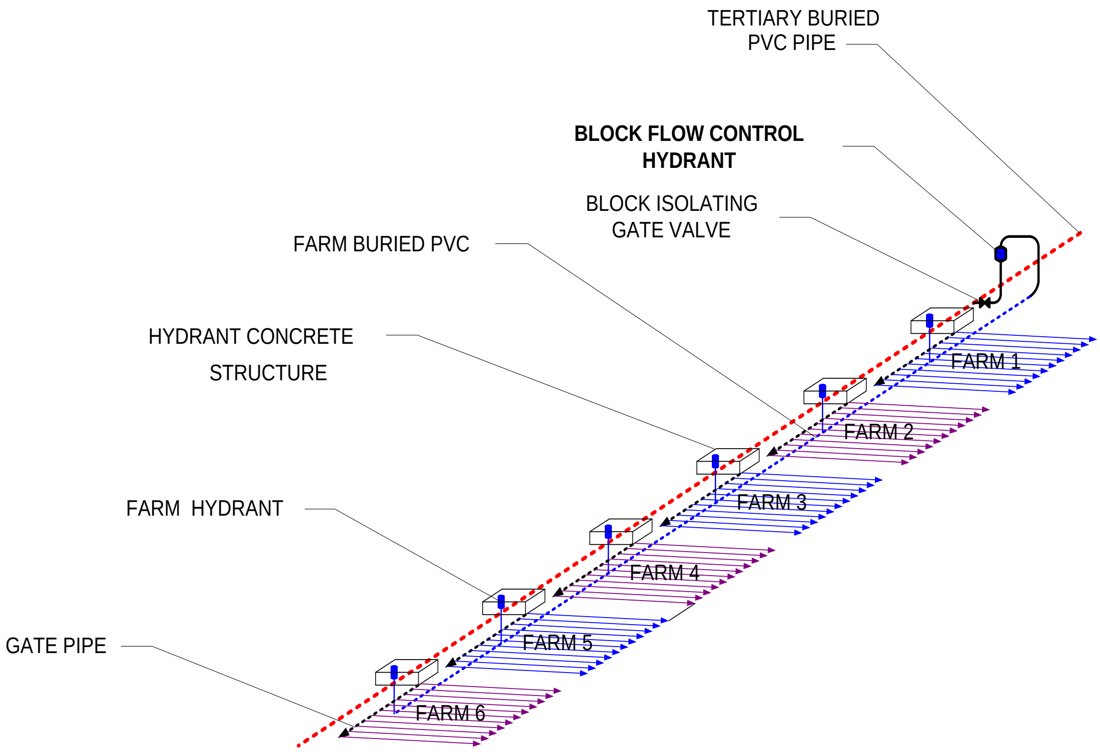


**Discharge and flow limitation.** From a 0.8 l/s/ha specific hydro module designed for the project, the theoretical discharge to be delivered during 12 hours out of 24 hours at the head of the standard bloc is: 0.8 x 6 x 2 = 9.6 l/s. Two types of flow limiters are presently available from manufacturers of hydraulic equipment.

**Flow control hydrants.** Using a constant flow valve, such as EQUIVAR or BOCAR, the A Type flow control hydrant will be used in case of low pressure conditions, when 0.6 mwc < P < 7m. The standard lower discharge of such device is 10 l/s. Nevertheless, and due to the big quantity required for the project, a special manufacture with 9.6 l/s regulated flow is possible. Regulation flow range remains within the ±5% limits when pressure working range is considered. The device should be installed inside an impregnable shelter with an isolating valve. The isolating valve will only be closed by agents of the water management agency under certain conditions. When the available pressure is higher than 7 m of water column, standard water flow limiters used for pressurized irrigation networks will be installed at the head of the bloc. As the accuracy of that kind of device is in a range of 0/+20%, a 30m³/h ND 100mm flow limiter is selected with a flow range limits between 8.3 l/s and 10 l/s, i.e. an average flow of 9.2 l/s.

**Water delivery from hydrant to farms.** From the flow control hydrant located at the head of the block, water is delivered to the 6 farms of the standard block by a buried PVC pipe network. (see Figure 5.3). Farms are watered by one hydrant located at the head of each field. When surface irrigation is practiced, only one hydrant is open per standard block and 3 or 6 days rotation is practiced during the peak water requirements period. The same hydrant is installed at all farms. In case of different farm surfaces, the watering time is adjusted to obtain the project ratio of 60-65 m³/ha/ watering. The hydrant can be opened using a suited elbow key. In order to simplify water management procedures, only one key is allotted per standard block. Consequently, only one farm can be watered in the same standard block, following the water rotation program. Farm hydrants are protected by a concrete structure, which incorporates the stilling basin. The stilling basin is also used as pressure head breaker.

*Figure 5.3: Schematic lay-out of flow-control hydrant, buried pipes and individual hydrants*

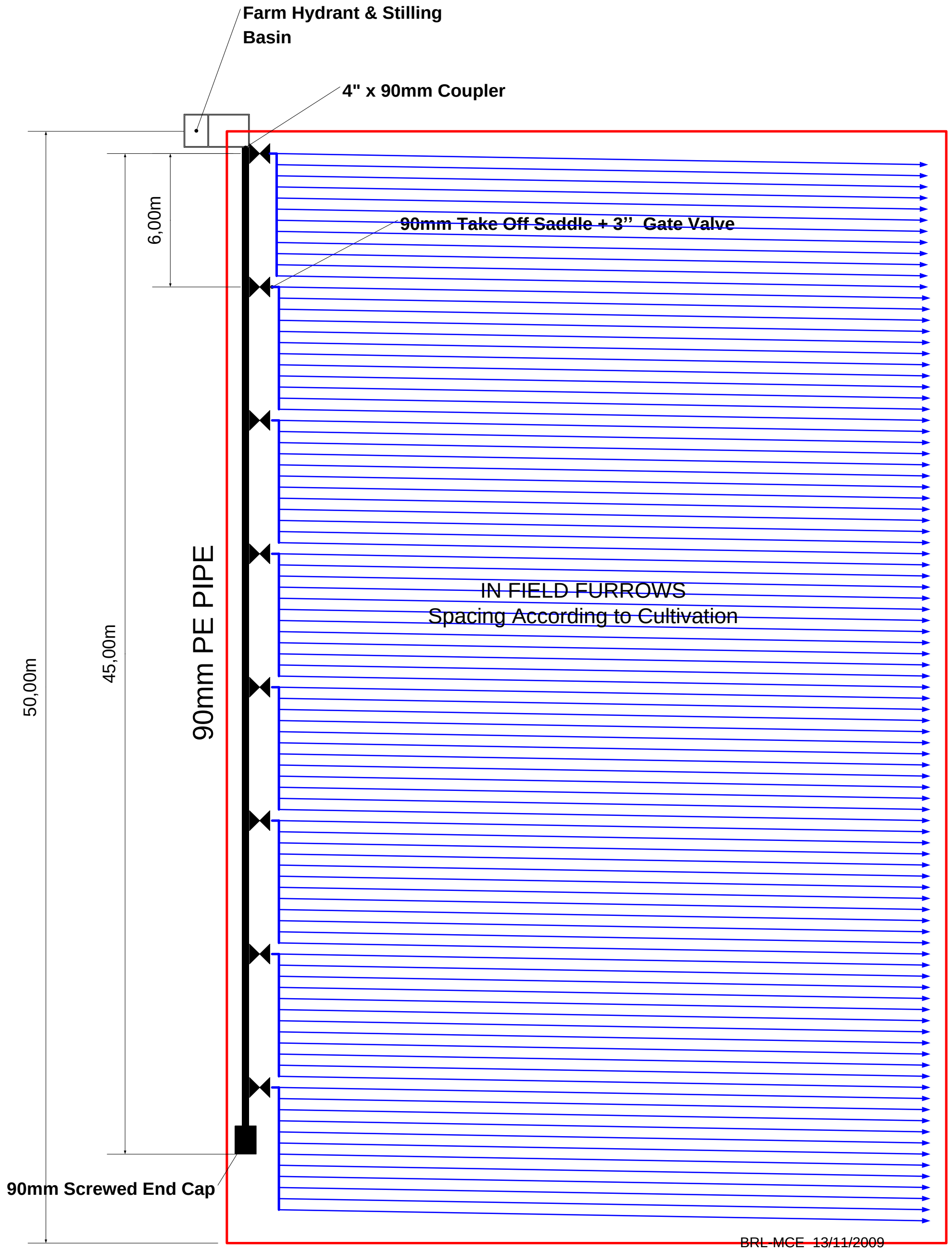


## 5.4.8 Field Irrigation System and On-Farm Water Management

**Improved Surface Irrigation Equipment in favourable conditions**

In case of favourable topographic conditions and very good irrigation practices by farmers, furrows can be constructed directly from the stilling basin, and specific equipment is not necessary. Nevertheless in order to maximise water efficiency, gated pipes systems are particularly advised for this project when surface irrigation is practiced. Flume hose pipes with adjustable gate outlets are available on the world market (USA, Australia, EU, Iran…). A local solution is possible, using local PE black pipe, is shown in Figure 5.4.

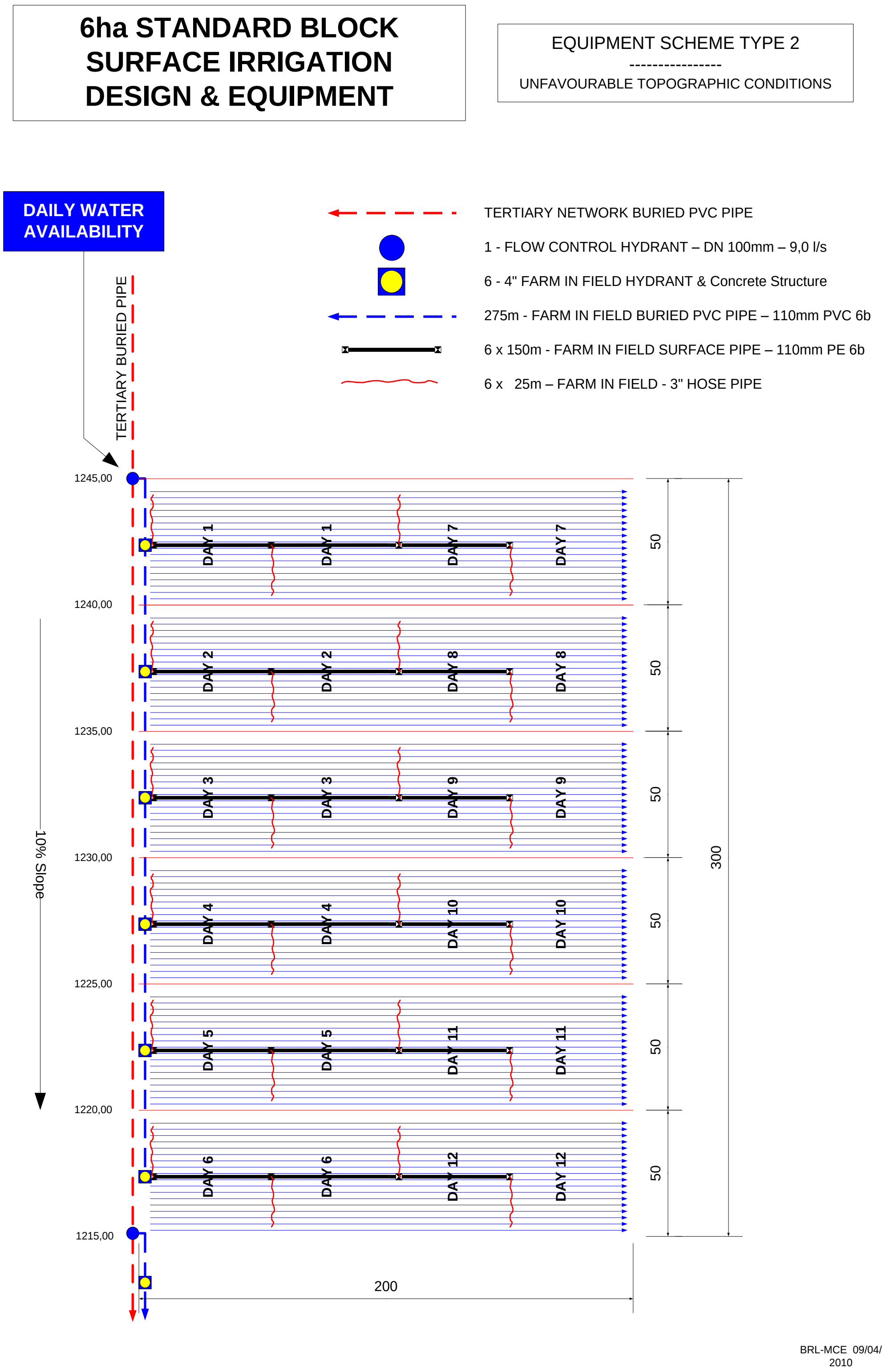
*Figure 5.4: Lay-out on a one ha farm using 90 mm PE gated pipe*



**Surface Irrigation Equipment in unfavourable conditions**

In case of unfavourable conditions, important slopes (>10%), soils with high permeability and presence of numerous gullies, the furrow length must be reduced and therefore special arrangements have to be adopted as shown in Figure 5.5.

*Figure 5.5: Lay-out of a block with 6 farms and rotation under difficult topographic conditions*



**Sprinkler Irrigation.** When pressure is available at the head of the block, (P>2.5 bar) sprinkler irrigation can be used. Dragline systems with small spacing are very suitable for small farms and different crops under difficult topographic conditions. A screen filtering unit is installed at the head of the block, downstream of the flow control device. Block farmers are responsible for cleaning the filter when necessary. The total block discharge (9.6 l/s) is distributed to the farms in the block. The discharge to each farm is limited by the number of sprinklers. Surface pipe networks are connected directly to the farm hydrant. When sprinkler irrigation is working on one farm of a block, all the farms of the same block have to irrigate with the same system. (see figure 5.6).

**Localized Irrigation.** Localized irrigation systems as drip, micro sprinklers, etc. are well suited to fruit trees cultivation. Furthermore these systems require a good technological level mainly for operation and maintenance of the filtration equipment. The only possible system that could be developed is localised irrigation using calibrated nozzles mounted on PE pipelines, a quite simple irrigation system. Basins are constructed and levelled around the trees. Pipes are laid along fruit tree rows and calibrated nozzles are fixed to the PE pipe. For citrus trees like orange, lemon, grapefruit trees… with 6m x 6m spacing, 2 nozzles are required to provide water to each basin. The size of the nozzles is adjusted in order to reach a constant 60 l/h flow ±10% for all the emitters. The total discharge for a complete 1 ha farm planted with 256 citrus trees is 31 $m^3/h$ per hydrant controlled discharge. As designed here above, the farm irrigation equipment scheme can be easily inserted in one standard block, without disturbing the overall water management of the block. Figure 5.7 presents the lay-out for this type of system.

### 5.4.9 Drainage

Apart from important earthworks requirements and hard labour for irrigation by furrows, surface irrigation requires also the digging of a ditches network in order to drain the possible overflow at the end of the furrows. Spoon drains located downstream of the furrows are generally dug by the farmers when tertiary and secondary drains are dug by contractor and maintained by the organization responsible for project management. Due to the particular site geomorphology, marked by sufficient ground slopes, free draining soils and a dense network of existing streams drainage works have not been considered for the present project.

*Figure 5.6: Lay-out of farm with sprinkler irrigation equipment*

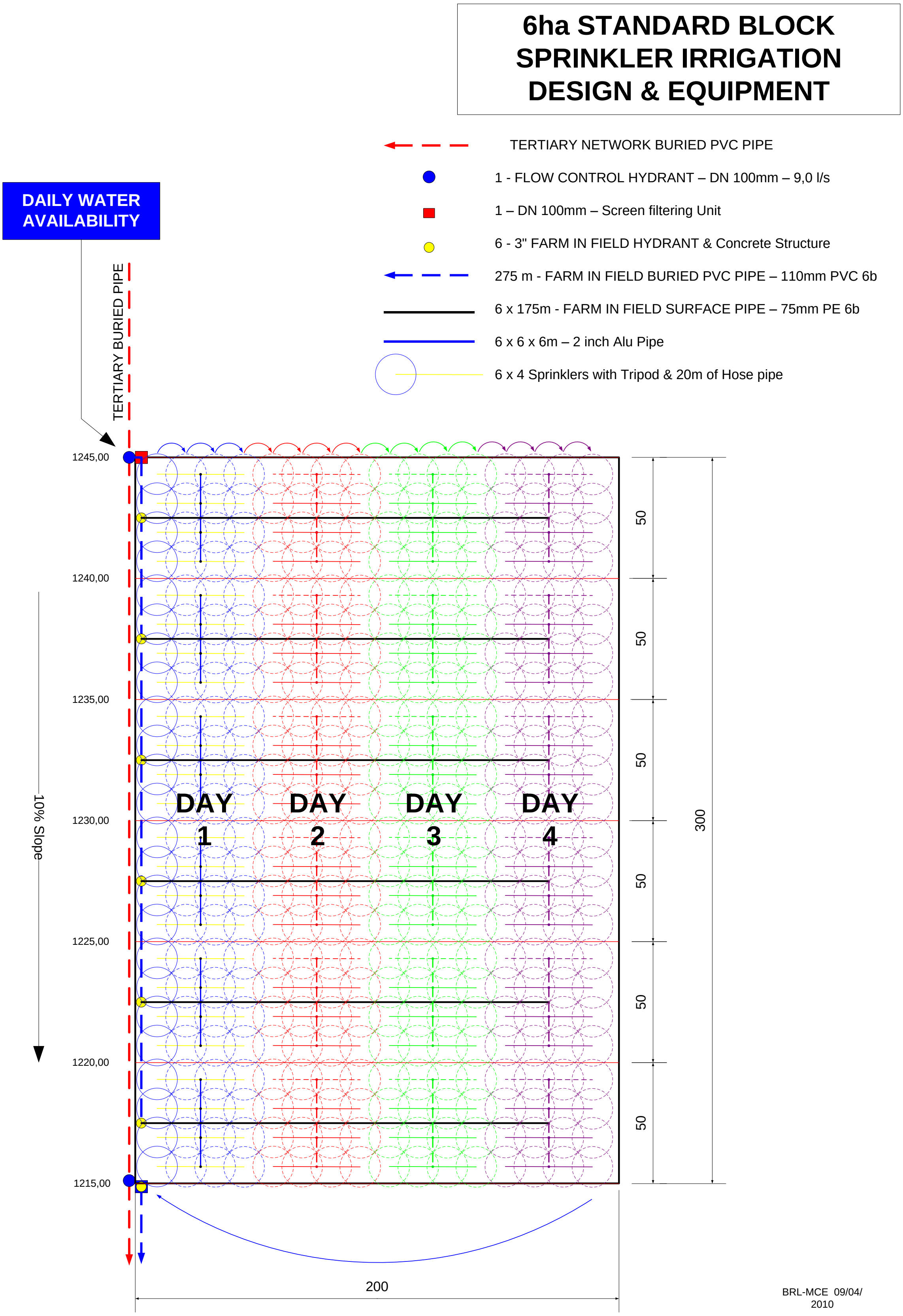
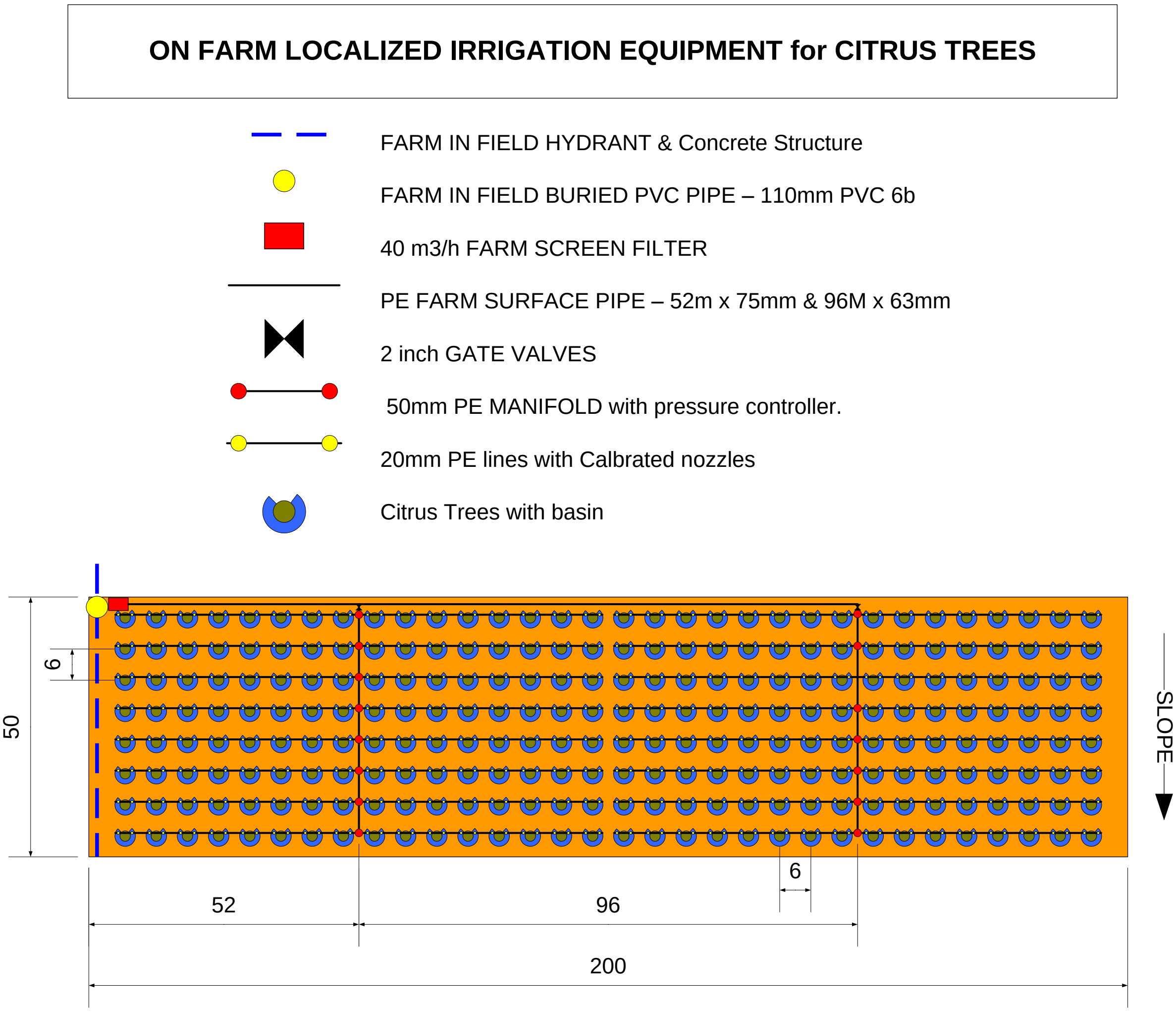


*Figure 5.7: Layout of a one ha citrus farm with localized irrigation*




## 5.5 INFRASTRUCTURE DEVELOPMENT

**Road Network upgrading within the Project area.** Apart from the new access roads to be constructed along canals and drains, a total length of 46 km road network with about 14 river/stream crossing structures are planned to be upgraded in the Project area in order to connect the production centres with each village or the main all-weather road. Details are presented in the respective annex.

**Communications.** The District is currently linked to other areas using a direct line telephone system. In the centre of the district there is a telecommunications tower that enables the district to receive telephone network systems. The rural area centres have wireless telephone systems that enable communication with the district centres or the rest of the country and the world.

**Water Supply.**The district is endowed with surface and groundwater resources. The community of the district use springs and streams as main sources of drinking water supply. Water supply schemes were constructed in the year 1996 in different parts of the district. In this year and other previous times, a total of 74 springs and eight hand dug wells are developed. There is also one deep borehole serving the capital of the district for water supply, and a network of water supply system from this borehole is made and most of the town's households have got a pipe water supply system in their compounds. Under the WASH programme, the district is benefiting in getting more water supply facilities as discussed with the office of water resources development experts of the district.

**Energy Supply.** The electric power system has been extended towards the district during the resettlement program and the district is facilitated with electric power supply. Not only the centre of the district, Illu-Harar, gets electric power, but also site nr 1 /village 1/ is also getting the hydroelectric power supply as the main grid passes via this village to the capital of the district.

**Education.** As the district is newly established after the resettlement, most of the schools are under construction. Initially, for temporary purposes through community participation, 4 (1-4) grade levels of schools, and 3 (1-8) grade levels of schools were built to start with. In the academic year of 2004-2005, a total of 11,318 school children were registered in the district to attend their education. Currently, all the settlement sites do have at least 1-4 primary schools, and there are 4-8 secondary schools well distributed within the district. There is one preparatory school in Illu-Harar.

**Health.** Regional health policy emphasizes on the provision of a comprehensive primary health care by integrating the decentralized health facilities, health personnel and provision of equitable health resources. In the year 2004 the numbers of the health centres in the district serving the people were about 6 health posts. Currently many more health posts at different places and one big health centre is under construction in Illu-Harar. The ratio of the medical personnel, and health facilities to the district's population were far below the standards recommended by the World Health Organization (WHO). Moreover, a large number of the district's population lacks access to safe drinking water and sanitation facilities causing in wide spread of water-borne diseases. The prevailing common disease in the district is malaria.

## 5.6 Project Organisation, Management and Coordination

The operation and maintenance requirements of the Project call for a sound organised structure to ensure a proper distribution of the irrigation water and an efficient and effective operation of the projects infrastructure. Such an organisation should have:

1) a well established standard of technical procedures
2) an adequate financial basis
3) an appropriate administrative system

The Main system management entity (agency, company, government department), which may be a Government body established specifically for the purpose will be responsible for operation and maintenance of the headworks, the Main canal, Primary Canals, pumping station(s) and reservoirs. The entity will supply water to the secondary systems according to agreed quantities of water and a delivery schedule drawn up with the WUA's. Supply to the reservoirs will be on 24 hour per day basis. In general the interface will be the reservoir that supplies water during 12 hours/day to its command area. The duties of the management entity will include:

- Determining and agreeing the secondary offtake flows with the WUA's.
- Adjusting flows from the headwork's to give the required constant flow in the Main and Primary Canals
- Maintaining the headwork's, Main and Primary Canals, as well as the secondary canals and collecting the water fees from the WUA's
- Providing extension services to irrigated agriculture, irrigation management, WUA organisation and management and accounting.

Works will be by direct labour or by subcontracting to local and national contractors. Maintenance and operation of vital elements like diversion complex, Main canal and pumpstation will be subcontracted to supplier/contractor.

Regarding private investment opportunities it can be concluded that all land in the command areas has been issued to smallholder farmers and that there is no scope for private investors to lease irrigable land at medium or large scale. On the other hand traders in the agricultural sector could make contracts with individual and groups of farmers for crop production using inputs and services provided by the traders.

The Project costs amount to 985 million Birr. A summary is presented in Chapter 8. Detailed breakdowns are presented in Annex 13.

# 6. AGRICULTURAL PRODUCTION AND MARKETING OPPORTUNITIES

## 6.1 AGRICULTURAL DEVELOPMENT

### 6.1.1 Choice of crops

Crop selection for the Project is based on the following important factors:

- Suitability of the soils (physical and chemical characteristics);
- Adaptability to the prevailing climate (rainfall, temperature, altitude and other climatic factors);
- Food and economic value;
- Farmers' preference and experience in the production of the crop in question;
- Suitability of the crop for the envisaged irrigation system; and
- Marketability and potentiality for agro-processing.

On the basis of the above mentioned factors, suitable crops were selected for both seasons (wet and dry). Farmers of the area are well acquainted with most of these crops. This was confirmed during the focus group discussions where farmers' preferences include almost all of these crops. The following are the main crop types recommended for the scheme.

- Cereals: Maize, Sorghum & Rice
- Pulses: Haricot beans & Soya bean
- Oil-crops: Groundnuts, Sunflower & Sesame
- Vegetables: Onion, Pepper, Sweet-potato & Potatoes, tomatoes
- Fruits: Citrus & Mango

Table 6.1 shows the cropping systems that would be representative for the Project

Though new crops have just begun to be grown, production of cereals, notably sorghum and maize, has been the primary crops of the Project area. New inclusions of other crops in the cropping pattern, both for use in rotation with cereals or as an alternative crop under certain circumstances, would be necessary.  Crops like pulses, oil seeds, and horticultural crops have been considered as alternative crops with cereals. Most of these crops, apart from their agronomic benefits, have readily available markets, locally as well as for export. The envisaged crop mix should, therefore, create the opportunity for diversification. The objective of diversification is basically to maximize marketing opportunities and production economics. In addition, production factors including land, oxen/equipment and labour will be profitably employed thereby widening the economic base of the Project as well as the farm community.

The prospect for crop intensification, through double or more intensive cropping per year is highly likely. The crops for irrigation should be as much as possible high value crops both for local and export markets. The types and extent of high value crops that will be grown under irrigation will depend on further studies and applicable, gradually. However, for the short-term period, certain types of pulses, oil seeds, fruits, and vegetables are identified for a cropping intensity of 175%, which may be attainable through time as farmers gain knowledge and experience in irrigation practices.

*Table 6.1: Cropping system (Wet and Dry Season Cropping)*

| DINGER BEREHA IRRIGATION PROJECT | | | | |
|---|---|---|---|---|
| Global Cropping System | | Total coverage | Wet Season | Dry Season |
| | | % | May-June / October | Nov. / April-May |
| | | | | |
| | Cereals | 40% | Maize | Maize |
| | | | Sorghum | Rice |
| | | | | |
| | Root Crops | 5% | Sweet Potato | Potato |
| | Pulses | 25% | Groundnut | Haricot bean |
| | | | Soya bean | |
| | Oil seeds | 15% | Sunflower | Sunflower |
| | | | Sesame | Groundnut |
| | Vegetables | 10% | Pepper | Onion |
| | | | Cabbage | Tomato |
| | | | Lettuce | |
| | Perennial Fruits | 5% | Mango | Mango |
| | | | Citrus | Citrus |

*Note that the pattern is based on farmers' current practices

*The total suitable area identified by the soils study is about 7 500ha

*The pattern is tentative and would be adjusted in due course

*The choice of irrigated crops is based on food and cash value mix

### 6.1.2 Cropping Pattern

As indicated above, the change in the present cropping pattern would be gradual until most prerequisites are fulfilled. The prerequisites include availability of suitable crop varieties, farmer's knowledge on cultural practices of the various crops and access to market information develops to a satisfactory level.

On the basis of crop mix and area coverage, three options of cropping patterns are proposed. Various crop types have been considered to establish the crop mix and area coverage. The introduction of various crops into the cropping pattern is assumed to provide a wider economic base of the Project that would minimize the risks associated with the growing of a single or a few number of crops. The pattern shall be kept under continuous review so as to include new crops that serve the rotational requirements as well as alternative crops under certain circumstances.

As food security is the main objective of the project, the cropping pattern will be dominated by food crops. At full Project development, the annual cropping intensity would be close to 200%. 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). Generally, the cropping pattern shown in Table 6.2 is based on the needs of the population of the area and will have the following main features:

- It increases the volume of production (through successful cropping in the two seasons) and thereby improving food security of the area;
- The production of high value crops, especially pulses, oil crops and vegetables improves cash income and dietary requirements of the households;
- It employs household labour throughout the year; and
- Increases availability of livestock feed (crop residue) all year round.

*Table 6.2: Annual cropping pattern*

| DINGER BEREHA IRRIGATION PROJECT | | | | |
|---|---|---|---|---|
| Global Cropping Pattern | | Main crops | " The Basket" | |
| | | % | | % |
| | | | | |
| Rainy season | Cereals | 65% | Maize | 10% |
| | | | Sorghum | 35% |
| | | | Rice | 20% |
| | Pulses | 20% | Har.bean * | 5% |
| | | | Soya bean * | 15% |
| | Oil seeds | 10% | Sesame * | 10% |
| | Fruits | 5% | Mango | 1% |
| | | | Citrus | 4% |
| | | | | |
| | | | | |
| Dry season | Cereals | 20% | Maize irrig. | 30% |
| | Pulses | 20% | Har.bean irrig. | 15% |
| | | | Soya bean irrig. | 10% |
| | Oil seeds | 17% | Sesame irrig. | 25% |
| | Vegetables | 13% | Potato irrig. | 5% |
| | | | Cabbage irrig. | 3% |
| | | | Pepper irrig. | 3% |
| | | | Onion irrig. | 4% |
| | Fruits | 5% | Mango | 1% |
| | | | Citrus | 4% |
| | | | | |
| | Total | 175% | | 200% |

In the final analysis, it is the choice of the individual farmer that prevails. The cropping pattern presented here only serves as a guide that eventually aids the project's cost/benefit analysis. Area and percent of coverage of the crops to be grown, annually, in wet and dry seasons, is shown in the Annex 6, Appendix 5.

On the other hand it is good to keep in mind the possibility to increase the revenue with ancillary tasks as selling activities, transport management, workshop founding, and agro industrial production, which generally are developed in the production context. In order to practice the complementary activities a too high intensity or a too big dispersion in the cropping pattern is not favourable to obtain good management of the farm.

To conduct a realistic feasibility analysis a basket of products was kept based on consumption needs (during rainy season) and cash crops (planted during dry season, with irrigation facilities). The final choice shown in the following table is based on:

- The need to develop cereals, at least 40% of the cultivated area, to respect the food requirement of farmer's family;
- Taking advantage of the high market success for vegetables, citrus and mango and develop these crops in a well balanced cropping pattern;
- The development of crops able to yield high value results, as maize and rice in the cereals group, onions and potatoes in the vegetables basket;
- The necessary development of oil seeds to produce oil, and at the same time to develop a milling system and to reinforce the local agro-industry;
- Integrating the geographical and technical constraints of irrigation in the crop calendar limiting the crop intensity around 200%, at least during the first years;

- Increasing the value of crops with irrigation: in the future calendar vegetables are essentially produced in dry season;
- Well understanding the water and soil constraints and also terrace management to concentrate cultivation of rice during the wet season;
- Developing activities based on an intensive agriculture along the year to keep population in active employment in the Project area.

## 6.2 Agricultural Production

### 6.2.1 Crop Production

Various crop types have been considered to establish the crop mix and area coverage. The introduction of various crops into the cropping pattern is assumed to provide a wider economic base of the Project that would minimize the risks associated with the growing of a single or a few number of crops. The pattern shall be kept under continuous review so as to include new crops that serve the rotational requirements as well as alternative crops under certain circumstances. As food security is the main objective of the project, the cropping pattern will be dominated by food crops. At full Project development, the annual cropping intensity would be close to 200%. Cereals (Sorghum, maize and rice) will command the major part of the area followed by pulses (haricot beans, soybean) and vegetables (onion, pepper and sweet potato). Yield estimates for individual crops are based on current yields in the Project area, yields potentials of each crop and yields obtained in research stations and on-farm demonstrations; as well as on assumptions that improved farming practices will be introduced. Current yields in the Project area have been taken as base lines and yields obtained in research stations of the Ethiopian Institute of Agriculture, EIAR, have been considered for making future projections. Yields would increase steadily during the first four years as a result of improvements in farming techniques as well as through the introduction of improved crop varieties. The forecasted yields for annual rain-fed crops in the first year are equal during to the yields currently obtained by farmers in the Project area. At full development, the envisaged irrigated crop yield levels in quintals/ha are 56 for maize, 25 for haricots and sunflower, 28 for groundnut, 148 for various types of fruits and 220 for onion.

*Table 6.3: Yields (qt/ha)*

| DINGER BEREHA IRRIGATION PROJECT | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Global Cropping Pattern & Yields | | Yield 1 | Yield 2 | Yield 3 | Yield 4 | Yield 5 | Yield 6 | Yield 7 to 25 |
| | | qt/ha | qt/ha | qt/ha | qt/ha | qt/ha | qt/ha | qt/ha |
| Rainy season | Maize * | 28.0 | 34.0 | 41.0 | 49.0 | 49.0 | 49.0 | 49.0 |
| | Sorghum * | 24.0 | 28.0 | 34.0 | 43.0 | 43.0 | 43.0 | 43.0 |
| | Rice * | 30.0 | 35.0 | 40.0 | 45.0 | 45.0 | 45.0 | 45.0 |
| | Har.bean * | 12.0 | 14.0 | 17.0 | 22.0 | 22.0 | 22.0 | 22.0 |
| | Soya bean * | 12.0 | 18.0 | 23.0 | 25.0 | 25.0 | 25.0 | 25.0 |
| | Sesame * | 5.5 | 6.0 | 6.5 | 7.5 | 7.5 | 7.5 | 7.5 |
| Dry season | Maize irrig. | 30.0 | 36.0 | 45.0 | 56.0 | 56.0 | 56.0 | 56.0 |
| | Har.bean irrig. | 20.0 | 25.0 | 30.0 | 25.0 | 25.0 | 25.0 | 25.0 |
| | Soya bean irrig. | 19.0 | 22.0 | 25.0 | 31.0 | 31.0 | 31.0 | 31.0 |
| | Sesame irrig. | 6.0 | 7.0 | 8.0 | 9.0 | 9.0 | 9.0 | 9.0 |
| | Potato irrig. | 130.0 | 140.0 | 180.0 | 240.0 | 240.0 | 240.0 | 240.0 |
| | Cabbage irrig. | 80.0 | 110.0 | 150.0 | 180.0 | 180.0 | 180.0 | 180.0 |
| | Pepper irrig. | 40.0 | 60.0 | 70.0 | 80.0 | 80.0 | 80.0 | 80.0 |
| | Onion irrig. | 120.0 | 150.0 | 170.0 | 220.0 | 220.0 | 220.0 | 220.0 |
| | Mango | | | | | 40.0 | 80.0 | 150.0 |
| | Citrus | | | | 30.0 | 60.0 | 120.0 | 180.0 |

From year 7 onward, the forecasted irrigated crop yields reach a satisfactory and realistic level; provided that all production factors are present, for instance: an adequate soil preparation, terrace levelling, a sufficient provision of certified improved seeds, adequate supply of organic fertilizers and amendments, adequate and fully completed irrigation infrastructures, etc. Extension services should play a major role in supporting farmers obtaining good yields. Similarly, it is also important to stress the need for strengthening seasonal credit institutions and/or establishing new ones. Once the farmers will have reached the "cruising speed", with a good income from cash crops, credit services should progressively re-orient their activities from seasonal credit toward investment credit for mechanisation, milling facilities, sprinklers, packaging facilities, or again storage facilities.

Moreover, it must be noted here that the full production period of fruit trees will begin on the fourth year (for citrus) and the fifth year (for mango) after planting.

## 6.2.2 Production costs

Annual production costs for the first years and subsequent years of the Project are presented in the next table. Inputs (seeds fertilizers and pesticides, machinery/draft power and labour) have been estimated for individual crops (cost estimates at market prices are presented in appendix 6-3). For most crops, seeds, fertilizers and pesticides represent the highest share of the production costs. However, for fruits and vegetables production, labour costs represent the highest share as indicated in the synthesis of labour requirements in appendix 6-4. It should be noted, that the level of inputs use, namely fertilizers, chemicals and handling equipments, estimated in this schedule is likely to increase with the adoption of improved technology packages.

*Table 6.4: Annual production costs*

| DINGER BEREHA IRRIGATION PROJECT | | financial values | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Production Costs | | Prod Costs Y1 | Prod Costs Y2 | Prod Costs Y3 | Prod Costs Y4 | Prod Costs Y5 | Prod Costs Y6 | Prod Costs Y7 - 25 |
| | | Birr/ha | Birr/ha | Birr/ha | Birr/ha | Birr/ha | Birr/ha | Birr/ha |
| Rainy season | Maize * | 3 380.0 | 3 430.0 | 3 480.0 | 3 530.0 | 3 530.0 | 3 530.0 | 3 530.0 |
| | Sorghum * | 2 720.0 | 2 970.0 | 3 020.0 | 3 070.0 | 3 070.0 | 3 070.0 | 3 070.0 |
| | Rice * | 2 775.5 | 3 172.0 | 3 568.5 | 3 965.0 | 3 965.0 | 3 965.0 | 3 965.0 |
| | Har.bean * | 2 762.0 | 2 812.0 | 2 862.0 | 2 912.0 | 2 912.0 | 2 912.0 | 2 912.0 |
| | Soya bean * | 3 105.0 | 3 255.0 | 3 405.0 | 3 555.0 | 3 555.0 | 3 555.0 | 3 555.0 |
| | Sesame * | 2 136.0 | 2 286.0 | 2 436.0 | 2 586.0 | 2 586.0 | 2 586.0 | 2 586.0 |
| | Mango | | | | | | | |
| | Citrus | | | | | | | |
| Dry season | Maize irrig. | 4 020.0 | 4 070.0 | 4 120.0 | 4 170.0 | 4 170.0 | 4 170.0 | 4 170.0 |
| | Har.bean irrig. | 4 162.0 | 4 212.0 | 4 262.0 | 4 312.0 | 4 312.0 | 4 312.0 | 4 312.0 |
| | Soya bean irrig. | 4 805.0 | 4 855.0 | 4 905.0 | 4 955.0 | 4 955.0 | 4 955.0 | 4 955.0 |
| | Sesame irrig. | 3 836.0 | 3 886.0 | 3 936.0 | 3 986.0 | 3 986.0 | 3 986.0 | 3 986.0 |
| | Potato irrig. | 6 379.0 | 6 479.0 | 6 579.0 | 6 679.0 | 6 679.0 | 6 679.0 | 6 679.0 |
| | Cabbage irrig. | 5 712.0 | 5 887.0 | 6 062.0 | 6 237.0 | 6 237.0 | 6 237.0 | 6 237.0 |
| | Pepper irrig. | 6 485.0 | 6 655.0 | 6 825.0 | 6 995.0 | 6 995.0 | 6 995.0 | 6 995.0 |
| | Onion irrig. | 7 031.0 | 7 206.0 | 7 381.0 | 7 556.0 | 7 556.0 | 7 556.0 | 7 556.0 |
| | Mango | 6 157.0 | 3 049.0 | 3 049.0 | 3 049.0 | 3 199.0 | 3 349.0 | 4 739.0 |
| | Citrus | 7 024.0 | 3 204.0 | 3 204.0 | 3 204.0 | 3 404.0 | 3 604.0 | 5 004.0 |

For practical purposes and according to current practices in the area, the cost for land preparation is based on oxen/draft power although estimation for machinery operation has also been indicated (see annexed tables, in appendix 6-3). This indication may be useful as references when the need arises.

### 6.2.3 Livestock Production

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 Woreda. 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 natural vegetation is broad-leaved woodland savanna with an understory of usually coarse grasses. Because settlement is recent the vegetation has not yet been degraded. Natural vegetation provides most of the feed consumed by livestock: at present it is more than adequate in quantity but is low in quality for much of the year. Crop residues provide a smaller proportion of total livestock feed but these also are generally of low nutritive value. Extension advice to farmers is provided in only limited amounts. Animal health services include three clinics and eight animal health assistants that provide little more than rudimentary support. There is no private provision of veterinary service of drug supplies. Marketing is in the private sector although few animals are marketed.

There are clear opportunities to add value to the livestock subsector. These include assistance towards the transparent sale, safe and easy movement of healthy animals to local and export markets, increased production of standard and high quality feed, human resources development across the whole of the subsector from producer to policy maker, better provision and use of information, strengthening of public health and inspection capabilities and development of enhanced lines of input supply and credit. Animal nutrition and health are major constraints. Even in the Project area where the quantity of feed at present is not limiting there are still likely to be nutritional problems. Because of the nature of the sex and age composition, especially of cattle, most feed is used for maintenance and probably less than 15 per cent of the total is used for production. In spite of the distribution of oxen to new settlers most farmers have only one draught animal whereas two are needed for adequate performance. In the absence of sufficient draught power food security is diminished.

## 6.3 MARKETING OPPORTUNITIES

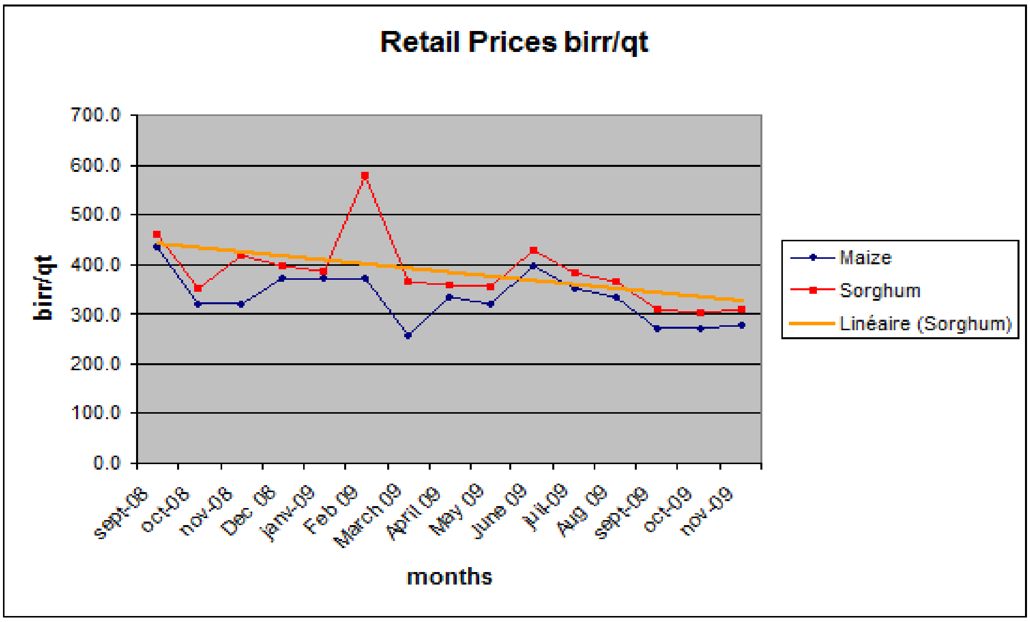
### 6.3.1 Crops and marketing options

In the Ethiopian context where the domestic production does not match the national demand, the domestic market is obviously the primary market opportunity. Since many years, the demand reaches high level, namely for cereals, pulses and oil seeds and the demand growth has even been accelerating these past few years. At the same time, crop prices remained high reflecting high demand and withholding of grains (farmers have learned holding back their products to get better prices). Due to the geography of Ethiopia, the various production areas do not have the same opportunity for selling the agricultural commodities they produce to the major marketing sites.

At this stage, the export market cannot be considered as a relevant option. However it cannot be excluded that new road construction will offer opportunities to create market linkages with Addis Ababa and other distant cities in Ethiopia and even with Sudan. Market potential of the Project area is indeed high, with a good development prospect for the next 10-20 years.

The description of the possible cropping patterns in this study underlines the willingness of farmers to grow rice and crops they are already familiar with, namely sorghum, maize, soya beans, sesame, potatoes, and fruits. Such cropping patterns are in line with the food needs of the local population, and moreover they would allow farming households to get high return since the market prospect for these crops are very good both in terms of size and prices; the two main conditions to tackle the market. The level of the projected prices is reasonably optimistic and certainly not over estimated in a long term prospect. Cereals prices witnessed during the shock price in the first half of 2008 were not considered although cereal prices still remain higher than in the pre-crisis period.

*Figure 6.1 : Average Oromiya retail prices for main cereals*




All indicated prices are farm gate prices. The figures used come from field investigations in December 2009, data from CSA and EGTE, and from Oromiya AMDA. The values kept are one year average values from November 2008. Details are given in Appendix 9-1, 9-2, 9-3. The average prices shown in table 6.7 can be used around the year including for the dry season in the case of double cropping. More generally, average prices are more significant than monthly prices that may unexpectedly vary along with market fluctuations. Knowing the food requirements for the local population, quantities to be sold on the local (first level) market can be estimated as well as the surplus that will have to be sold on the wider domestic market (second level).

The estimates of local food requirement are based on the MoWR surveys monitoring the annual consumption of rural households. The computation is made in calories using a conversion table indicating the equivalent cereals consumption. The need per capita per day is about 270 kg equivalent cereals. The precise break-down figures are 180 kg for cereals, 45 kg for pulses, and 14 kg for oil seeds. It's possible to consider these needs as a strict minimum. These figures match the present situation in the Project area where farmers sell about 45% of their productions.

*Table 6.5: Farm gate prices*

| DINGER BEREHA IRRIGATION PROJECT | |
|---|---|
| Farm gate prices<br>birr/qt - nov.2009 | |
| Maize | 307 |
| Sorghum | 325 |
| Rice | 450 |
| Har.bean | 365 |
| Soya bean | 584 |
| Sesame | 1 127 |
| Potato irrig. | 334 |
| Cabbage irrig. | 197 |
| Pepper irrig. | 597 |
| Onion irrig. | 436 |
| Mango | 271 |
| Citrus | 371 |

*Table 6.6: Share of Output Production*

| Local consumption and Output destinations | Project area Production<br>T | Food Requirements<br>/ C / Year | Project area needs: 31 000 people in 2015<br>T | Woreda needs: 31 000 + 45 000 people in 2015<br>T | Gross tradable production to Woreda Markets<br>T | Gross tradable production to other national Market Places<br>T |
|---|---|---|---|---|---|---|
| | | | | | | |
| Cereals | 44 213 | 180 kg | 5 580 | 13 680 | 8 100 | 30 533 |
| Pulses | 21 338 | 45 kg | 1 395 | 3 420 | 2 025 | 17 918 |
| Oil seeds | 3 750 | 14 kg | 434 | 1 064 | 630 | 2 686 |
| Fruits | 6 525 | 10 kg | 310 | 760 | 450 | 5 765 |

The assumption of local population inside the command area of the proposed irrigation Project is based on:

- 25,000 inhabitants in 2009,
- natural annual growth rate 2.5%, (USAID 2008 Population Reference Bureau for Ethiopia), and
- annual immigration rate 1.15% (higher than the one for the whole woreda).

The assumption of Woreda requirements is based on:

- 100,000 inhabitants in 2009 (including Project area: 75,000 + 25,000)
- annual growth rate 3.11% (natural rate 2.5% + immigration rate outside the command area of 0.61%)

Within the Project area, the quantities marketable at the national (second) level, are about 30,000 tonnes of cereals. That means less than 1% of the national production. For pulses the marketable production represents 2.1% of the national production and for oil seeds 2.5%. In other words, the Project will have a very limited, if any, impact on Ethiopia's domestic market.

### 6.3.2 Livestock and Livestock Products

Possible projects to improve livestock output include nutritional interventions and development of apiculture. A number of interventions are possible to improve the feed base both under rainfed and irrigated conditions.

### 6.3.3 Credit Facilities

Farmers, through their cooperatives will mainly require small loans for purchasing inputs: seeds and fertilisers as well as for storage facilities to limit post-harvest losses and to increase their market bargaining power. The loans will be repaid within 12 months. The interest rate for 12 months is 8.5%, which is relatively high despite the recent efforts made by the regional government to act as collaterals. The current conditions are certainly unsatisfactory for the farmers and many of them may be reluctant to take a credit at such an interest rate. A set of accompanying measures including quality control of inputs, efficient extension services and market information will be needed to overcome farmers' reluctance to take credit.

# 7. ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

## 7.1 Environmental Aspects

### 7.1.1 Environmental Impact Assessment

#### *7.1.1.1 Objectives*

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 AfDB 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.

#### *7.1.1.2 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".

#### *7.1.1.3 Screening and Scoping Methods*

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 and ADB requirements). 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. Due to budgetary limits it was not possible to make many of these studies during the Feasibility Study: it is strongly recommended that ENTRO ensures that such assessments are initiated during the Tender Design Stage.

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. While in the field, all relevant institutions at Kebele and Woreda 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 EIA has been initiated with the collection of all known previous baseline studies in the area, and the database assembled in the screening 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 key part of the screening and scoping of the EIA 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 (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

## 7.1.2 Mitigation Planning

### *7.1.2.1 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 Main canal (19km) and even lengthy primary and secondary canals. This can result in 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 Woredas. 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 doubt that the life style of some endogenous 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, Main 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).

#### 7.1.2.2 Enhancement and Mitigation Measures

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 in Annex 10 present 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.

The results of the application of the ICID checklist are given in Table 8.1. The ICID checklist 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 AfDB, WB and the Ethiopian Government guidelines. When applied to screening process it also provides indications of impacts that are clearly not relevant to the project: for example, estuary erosion and operation of 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.

#### 7.1.2.3 Environmental Monitoring

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.

There are two basic forms of monitoring:

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

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 ; and
- 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.

#### *7.1.2.4 Factors to be Monitored*

There is a large number of factors to be monitored. These are mentioned in Annex 10. 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 woreda 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 benchmark 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 Chewaka Woreda 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 Woreda 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.

### 7.1.3 Public Consultation

To ensure that the Dinger Bereha Project a success, it will be necessary that all available institutional capacity is utilized in a concerted action, and to help develop the social and economical conditions that will enable the population to seize those opportunities the Project can offer. 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. A central recommendation is therefore to establish a stakeholder participation and a public information campaign in the Project area, once the Tender Design stage has been initiated and the Project design is agreed. Although a very useful series of discussions have been made to date with stakeholders these must be regarded as preliminary. There should be a unit responsible for environmental and social issues within the Dinger Bereha Project management unit, and this unit would be the main mechanism to ensure that the environmental and social safeguarding measures identified in this report, and those further specified during the future tender design phase, and those that may come to light during implementation, will actually be carried out. 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 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.

### 7.1.4 Environmental Management during Implementation

#### *7.1.4.1 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; and
- Checking that the appropriate environmental protection clauses have been included in the contract documents, so as to allow control of any actions by the contractor 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.

#### *7.1.4.2 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.

#### 7.1.4.3 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 Woreda level as specified for the responsibility for mitigation.

It has to be supported by Federal, Regional Zonal as well as Woreda 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.

### 7.1.5 Indicative 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. 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 Woreda. 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 people. 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 and 41,000 USD for equipment.
- 23,800 USD/year (settlements, health, water) year for monitoring of social issues.

- 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 Woreda, 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.

### 7.1.6 Alternative Sites and Proposals

The choice of the irrigation scheme, with subsurface pipes is specifically designed to ensure that surface erosion is minimised: the soil survey baseline reported that erosion by water is a serious issue at present. The alternative to the irrigation project is one without irrigation. Erosion by rainfall runoff is already a very serious affair and the Chewaka Woreda authorities are acutely aware that soil and water conservation measures are needed at this time. These need to be in place and being utilised by the farming community therefore well in advance of any conversion to irrigation. In the areas both where there will be irrigation and those that will lie out of command of the scheme. The key issue remains that soil erosion must be tackled by the Chewaka Woreda regardless of whether an area of land is going to be irrigated or remain as rain-fed. The location of the main weir site and main canals were examined with regards to their impact on forest and erosion. During the detailed design an additional assessment, of the indigenous Gumuz people, will be required. The existence of these people, who live on the right bank of the Didessa and are primarily riverine users, will need careful assessment and discussion. They are important stakeholders of the project. Alternatives sites for the weir were examined and were all downstream of the proposed site. In these areas the river is more deeply incised, and these reaches of the Didessa were rejected by the engineering design for location of weirs and pump stations, as they would involve a much greater elevation for pumping up to the reservoirs areas.

## 7.2 Public Participation and Social Implications

### 7.2.1 Target Groups

11 Kebeles out 28 in the Chewaka Woreda fall within the command area of the proposed irrigation Project and people living in them are expected to be direct beneficiaries of the irrigation scheme. While in some Kebeles the command area represents a small part (15-25 %) of the Kebele area, in others it covers the entire Kebele. The potential beneficiaries are also expected to vary accordingly. The following table summarizes the estimated land portion within the command area and the households. The Land Administration and Use Proclamation of Oromia Regional state (130/2007) allows for land redistribution for irrigation projects. Hence the target group may be extended to population form other kebeles upon a decision from the regional government.

### 7.2.2 Gender Aspects

As per the data secured from Chewaka Woreda Agriculture Office, women headed households constitute four percent of the total. The gender division of labour, as reported by the Woreda Women’s Affairs Office, indicate that women are more responsible for the reproductive role than the productive ones.

*Table 7.1: 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** |
| **3.1 Hydrology** | **Low flow régime** | | | X | | | |
| | **Flood régime** | | | X | | | |
| | **Operation of dams** | | | NR | | | |
| | **Fall of water table** | | | X | | | |
| | **Rise of water table** | | | | X | | |
| **3.2 Organic & Inorganic Pollution** | **Solute dispersion** | | | | X | | |
| | **Toxic substances** | | | | | X | |
| | **Organic pollution** | | | | | X | |
| | **Anaerobic effects** | | | | X | | |
| | **Gas émissions** | | | | X | | |
| **3.3 Soils and Salinity** | **Soil salinity** | | | | | X | |
| | **Soil properties** | | | | | X | |
| | **Saline groundwater** | | | | X | | |
| | **Saline drainage** | | | | | X | |
| | **Saline intrusion** | | | X | | | |
| **3.4 Erosion and Sedimentation** | **Local érosion** | | | | | X | |
| | **Hinterland effect** | | | | | X | |
| | **River morphology** | | | X | | | |
| | **Channel structures** | | | | X | | |
| | **Sedimentation** | | | | | X | |
| | **Estuary érosion** | | | X | | | |
| **3.5 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 |
| **3.6 Socio-economics** | **Population change** | | | | | X | |
| | **Income & amenity** | X | | | | | |
| | **Human migration** | | | | X | | |
| | **Resettlement** | | | | | | X |
| | **Women's rôle** | | X | | X | | |
| | **Minority groups** | | | | X | | |
| | **Sites of value** | | | | X | | |
| | **Regional effects** | | X | | X | | |
| | **User involvement** | | X | | X | | |
| | **Recreation** | | X | | | | |
| **3.7 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 | | |
| **3.8 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.

*Table 7.2: Estimated Household Numbers in the Proposed Command area*

| Kebele | Estimated Portion within the Command Area (in %) | Household Number | | |
|---|---|---|---|---|
| | | Male | Female | Total |
| Shimel Tokee | 100 | 405 | 18 | 423 |
| Gudree | 75 | 480 | 6 | 486 |
| Haro Chewaka | 75 | 355 | 7 | 362 |
| Urji Oromia | 100 | 515 | 5 | 520 |
| Cheffe Megertu | 25 | 458 | 6 | 464 |

Unlike other places, women participate less on agricultural fields, though their role in marketing is very high. Their responsibility in household tasks is quite immense, partly exacerbated by big family size. Polygamy is quite frequent and believed to be one major development constraint in promoting the family welfare. Women's health is quite compromised due to high fertility and low awareness on primary health care issues. As per the information from the Women's Affairs Office, women are suffering from a range of harmful traditional practices like circumcisions, early marriage, etc. The school data also shows quite lesser number of girl's enrolment and higher dropout rate than boys, mainly due to the early marriage problem.

The development of the proposed irrigation scheme expected to have some implications on the existing division of labour due to the fact that irrigation is a labour intensive activity that entails the involvement of more family members. In order to harmonize labour requirement on the one hand and women's welfare on the other, there is a need to introduce labour and time saving household devises. Access to services like water supply, grinding mill and market need to be improved so as to release women's labour for more productive role under the proposed large scale irrigation project. This briefly meant to indicate the need to envisage and prepare sub-projects, under the proposed large scale irrigation project, that will ultimately address women's practical needs as well as gives them opportunities to be involved in new activities that will follow the irrigation development (like in processing and marketing new products). The sub projects could include rehabilitation and expansion of the existing basic services like water supply and health, promotion of fuel and labour efficient devises at the household level, support for credit services in the area to start new small scale ventures related to the irrigation activities and marketing of products, and other off farm business**.**

### 7.2.3 Land Tenure Aspects

There are a number of issues concerning land tenure and land use that will need to be resolved for the successful implementation of the irrigation project.

1. Land Redistribution and Plot Size

Article 14.4a of the amended Oromiya Rural Land Use Proclamation 130/2007 states that the maximum plot size of irrigation land per household shall be 0.5ha. Article 14.4e states that anyone who loses land through redistribution shall be given compensation rain-fed land but if this is not possible they should get a further 0.5ha of irrigation land. The recently developed Fantale irrigation scheme (also in Oromiya) set out plots of 0.75ha for each household but this was on previously uncultivated land without redistribution. In the Project area the land is cultivated by resettlers and average landholding size is 1.75 ha; above the maximum plot size stated in the Proclamation.

There are also considerable and increasing numbers of landless young adults in and around the Project area. Therefore it is conceivable that the stipulations of the proclamation could be adhered to by redistributing land within family groups. On the other hand, resettlers are used to irrigation and they consider they have enough labour to farm their land efficiently even under irrigation and therefore it could also be proposed that there is no land redistribution associated with irrigation development. Article 14.4c of the Proclamation states that any redistribution of irrigation land shall take place with the participation and decision of the community using the land. In any case this issue will need to be resolved prior to irrigation development.

2. Land Expropriation for Irrigation Infrastructure

Any land expropriation for irrigation infrastructure should follow appropriate guidelines such as the World Bank Guidelines for Involuntary Resettlement (WB OP 4.12, 2001) and be in accordance with existing legislation.

3. Use of Communal Grazing Land

At present there are small areas of communal grazing land within the Study area. It is proposed that these may be used for rice under irrigation. There will therefore be a need to either keep them as communal land with defined use rights or to allocate them to an individual.

4. Land Management of Surrounding Hills

There are already a large number of spontaneous resettlers in the area. With the completion of the bridge to link with the Asosa-Nekempt main road and the development of irrigation it is likely that this will attract more people. At present the land use of the surrounding hills is confined largely to cut and carry fodder, fuelwood collection and illegal charcoal making. To ensure the sustainability of the irrigation scheme the future land management must be tightly controlled and enforcement of any land use rights must be carried out.

### 7.2.4 Resettlement Aspects

For the first three years the settlers were receiving direct support from the government like oxen, cash, grains and other assistance needed to kick off their own livelihood means. Each family had also received a crop land with the size ranging from 1.5 to 2 hectare. Currently the settlers have achieved a self sustaining stage and their agricultural products are also beyond the family consumption and being marketed locally. Social services (schools, water supply, road, health services, market and others) were established as part of the resettlement program. 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 in the Woreda capital, Ilu Harar.

*Table 7.3: Total numbers of enrolled students*

| Grade | Total number of Enrolled Students | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1997 EC | | | 1998 EC | | | 1999 EC | | | 2000 EC | | |
| | Male | Female | Total | Male | Female | Total | Male | Female | Total | Male | Female | Total |
| 1 - 4 | 5351 | 3248 | 8599 | 5568 | 3335 | 8903 | 6276 | 4154 | 10430 | 6840 | 4212 | 11052 |
| 5 - 8 | 671 | 49 | 720 | 656 | 109 | 765 | 735 | 207 | 942 | 951 | 161 | 1112 |
| 9 - 10 | - | - | - | - | - | - | - | - | - | 170 | 22 | 192 |

Source : 'Woreda Profile', compiled by the Woreda Finance and Economic Development Office

As the above data shows girls enrolment at the first cycle (grade 1-4) is good but get much lesser in the higher grades. High adult illiteracy rate is one major bottleneck in building human capital and continue to be a major blocking factor in disseminating information related to such critical areas like family planning, new technology uses, primary health care up keeping, etc. A small number of people are enlisted for adult literacy programme, of which 99 % are male. Though the general social service coverage can be considered as good in comparison to other rural areas in Ethiopia, some of the services (mainly water supply) are now weakening due to the increase in population and lack of proper sustainability mechanism. Additional water and school facilities will be required to cope with population increase.

# 8. FINANCIAL AND ECONOMIC ANALYSIS

## 8.1 MAIN ASSUMPTIONS, PARAMETERS AND METHODOLOGY

The analyses have been carried out at three levels.

- Assess the return on investments, at short and medium term, on the basis of financial analysis, with components as debt service and cash flow status. Prepare financial elements available either for farm analysis, or for identifying shadow prices.
- Forecast the situation at farming household level using data on the household food needs and monetary income, and check whether or not farmers will have the capacity to pay for the irrigation water fee.
- Quantify the benefits of the Project for the national economy through an economical analysis.

Detailed are presented in Annex 12. For the proposed irrigation project, the financial and economic analyses are built on Cost-Benefits Analysis and the return on investment. Specific attention is given to the estimates of all costs and prices. In both analyses, the actualization technique is used for cost and benefits occurring along the Project years. A discounting rate of 10% is currently used in Ethiopia (MoFED).

For the proposed irrigation project, the financial and economic analyses are built on Cost-Benefits Analysis and the return on investment. Specific attention is given to the estimates of all costs and prices. In both analyses, the actualization technique is used for cost and benefits occurring along the Project years. A discounting rate of 10% is currently used in Ethiopia (MoFED). The financial analysis tells whether or not the Project is feasible from an investor's perspective, the financial return on investment being the main criterion. The economic analysis determines the added value of the Project for the national economy (contribution to GDP growth). Therefore, the financial analysis uses market prices while the economic uses shadow prices. Shadow prices are meant to actually reflect the opportunity costs of foregone resources to ensure that the Project impact on national welfare is well accounted for. Since information on market prices is usually more readily available than data on shadow prices, market prices are generally used as a basis for estimating shadow prices. The analysis at household (or farm) level is done for one model farm using market prices (financial analysis) to estimate cost, benefits and farmers' income and food self-sufficiency status. In addition, the analysis takes in due account the financial contribution of farmers to the management, operation and maintenance costs of the proposed irrigation project.

### 8.1.1 Components of Costs-Benefits analyses (CBA)

In financial & economic studies for projects results usually depend on the baseline data used and the level of precision in the description of project features. Before running a cost-benefit model, extensive work is required to prepare accurate data, i.e. identifying the amount of investments and the production costs and benefits of the farming system. Details on data are presented in Annex 12.

### 8.1.2 Developing the model

In a CBA a Project consists of a series of costs and benefits occurring over a number of years. The figures materialise in a positive or negative cash flow balance throughout the project. The number of years considered for the proposed Project is 50 years for determining the financial and economic IRR; and 20 years for the detailed cash flow status. A discount rate is applied to enable comparison over the years; here a 10% rate is used in line with the recommendations from MoFED. It is important to remind that this actualization method is totally independent from inflation or monetary erosion. The main expected results will be the F-IRR, E-IRR, NPV, and B/C analysis. All these indicators will be produced by financial and economic models, and completed by the sensitivity analysis. Market and shadow prices are in constant Birr (ETB), at the date of November 2009. Further details are presented in Annex 12.

## 8.2 Financial Analysis

### 8.2.1 Investment and recurrent costs

Total investments costs amount to 985 million ETB. The breakdown of these costs is presented in Table 8.1. The amount is distributed over a period of six years as shown in Table 8.2. The investments costs are estimated at market prices in November 2009. The total amount includes the Project study and design costs. These figures include 10% for contingencies. The renewal of main equipment such as gates on the canals, pumps, and on farm equipment is positioned along the time of analysis, according to their normal service life:

- 10 years for steel gate, 500,000 birr initial value
- 20 years for pumps, 30,000,000 birr initial value
- 10 years for farm equipments, for 40,000,000 value birr

The renewal expenses are shown in Table 8.3.

### 8.2.2 Recurrent costs

The recurrent costs include maintenance costs, energy costs, and management costs:

- Maintenance costs are usually estimated as a percentage of the investment cost. The percentage varies between 0.5% for civil engineering works and 3.5% for pumping station.
- Energy costs are assessed based on the amount of pumped cubic meters of water using an efficiency rate of 60%. The unit price per hectare is 483 birr.
- The management costs are operation costs of the management agency including salaries and contingencies costs and to the IWUA including costs of monitoring irrigation water distribution water. The amount per hectare is 250 birr.

*Table 8.1: Summary of investment costs*

SUMMARY OF BILL OF QUANTITIES

| No | Description | Total of BOQ (Birr) |
|---|---|---|
| | Preliminaries and general (Contractors establishment etc) | 28,000,000 |
| 1 | Headworks | 20,672,774 |
| 2 | Gauging weir | 184,300 |
| 3 | Main Canal | 67,743,430 |
| 4 | Primary canal | 97,486,160 |
| 5 | GRP rising mains | 60,690,804 |
| 6 | Secondary canals | 15,427,078 |
| 7 | Reservoirs | 35,407,539 |
| 8 | Secondary&tertiary pipe distribution system | 395,012,500 |
| 9 | Cross drainage structures type 1 | 2,907,236 |
| 10 | Cross drainage structures type 2 | 3,718,274 |
| 11 | Cross drainage structures type 3 | 2,896,482 |
| 12 | GRP Syphons | 36,193,668 |
| 13 | Main Canal Offtakes | 1,616,600 |
| 14 | Side Weirs | 1,736,564 |
| 15 | Civil Engineering Works Pump station | 880,957 |
| 16 | P&HM&E&MI pump station | 91,050,300 |
| 17 | Road bridges&culverts, footbridges | 15,550,002 |
| 18 | Engineers requirements and additional studies 2% | 17,000,000 |
| | | |
| | SUB-TOTAL | 894,174,667 |
| | contingencies items 1-15 and 17 , 12% | 90,974,924 |
| | TOTAL | 985,149,591 |
| | | |

*Table 8.2: Implementation program*

| DINGER BEREHA IRRIGATION PROJECT | | | | | | |
|---|---|---|---|---|---|---|
| Implementation program | | | | | | |
| | Equipments | Area with equipement ha | Area in operation ha | Investments birrs | Unforseen elements 10% | Total investments birrs |
| program years | | | | | | |
| 1 * | Main Infrastructures : diversion weir, main canal | | | 249 289 651 | 24 928 965 | 274 218 616 |
| 2 ** | Main Infrastructures : canal, pumping stations | | | 148 802 041 | 14 880 204 | 163 682 246 |
| 3 ** | Sec. & Tert. network + On farm equipement | 1 700 | | 151 214 222 | 15 121 422 | 166 335 644 |
| 4 | Sec. & Tert. network + On farm equipement | 2 000 | 1 700 | 145 367 634 | 14 536 763 | 159 904 397 |
| 5 | Sec. & Tert. network + On farm equipement | 2 000 | 3 700 | 105 674 209 | 10 567 421 | 116 241 630 |
| 6 | Sec. & Tert. network + On farm equipement | 1 800 | 5 700 | 95 106 788 | 9 510 679 | 104 617 467 |
| 7 | Full use of equipement | | 7 500 | | | |
| | | | | | | |
| Total | in financial values | | | 895 454 545 | 89 545 455 | 985 000 000 |
| | | | | | | |
| * | including preliminary surveys | | | | | |
| ** | including ingeneer requirements | | | | | |

*Table 8.3: Renewal expenses*

| DINGER BEREHA IRRIGATION PROJECT | | | | | | | |
|---|---|---|---|---|---|---|---|
| Renewal | | Headworks Steel Gate | Main canal Offtakes | S&Tdistribution system Farm Equipment | Pumping station | Total Renewal |
| Initial value | Birrs | 500 000 | 500 000 | 40 000 000 | 30 000 000 | |
| Times of renewal in the project period | | 4 | 4 | 4 | 2 | |
| Total value for Renewal | Birrs | 2 000 000 | 2 000 000 | 160 000 000 | 60 000 000 | 224 000 000 |

In the financial analysis, recurrent costs shall be taken in charge by farmers. The calculation process is using the actualization technique to insure a right balance along the 50 years of the project.

## 8.2.3 Project benefits

The only source of benefit for the Project is the profit resulting of agricultural production. It is the difference between the gross value of the agricultural production and agricultural production costs. To calculate the benefits, the following data must be considered:

**The yields of each crop.** They increase during the first years of the Project as a result of adoption of improved technology packages by farmers. They stabilized from the 4th year onward for cereals, oil seeds and vegetables and from the 7th year onward for citrus and mango. Yields are higher for irrigated crops than rain-fed crops. Harvest and post harvest losses are estimated at 10% of agronomic yields.

**The farm gate prices.** They were considered as constant all along the number of years considered for analysis. It is well known that market prices fluctuations happen all the time, therefore it is best using the annual average price for a long term analysis. Only 90% of the market price was used to take into account transaction and marketing costs.

**The commercial income.** In a financial analysis, only the income from marketed commodities has to be considered as a benefit. The agricultural production kept for home consumption has no financial value. Therefore, to assess the part of the production sold on the market, a specific ratio (Production sold/total production) is applied to each crop reflecting its importance in the daily diet of farming households. The commercial income is assessed for scenario 1 of the cropping pattern and based on the respective proportion of food crops and cash crops (see annex 12, Appendix 12-7).

**The production costs.** They increase with irrigation development (more labour), and also with the yields (more inputs, and more handling and packaging equipments). The water cost is assessed based on energy consumption for pumping water.

Table 8.4 shows the **profit per ha** of the various crops in Project cruising years (year 7 and onward). It is no surprise that cash crops, namely onions and potatoes, provide the highest profit. High market demand and good ability to be stored for a relatively long period of time explain their high profit. Sesame has a high farm gate price but a relatively poor profit because sesame yields are low reflecting the yields obtained by Ethiopian farmers. Sorghum and rice have both a satisfactory profit; the analysis confirms that farmers are right to make them their preferred crops.

Table 8.5 shows the total profit for the whole command area (7,500 ha).

*Table 8.4: Agricultural gross margin ha, in full regime situation*

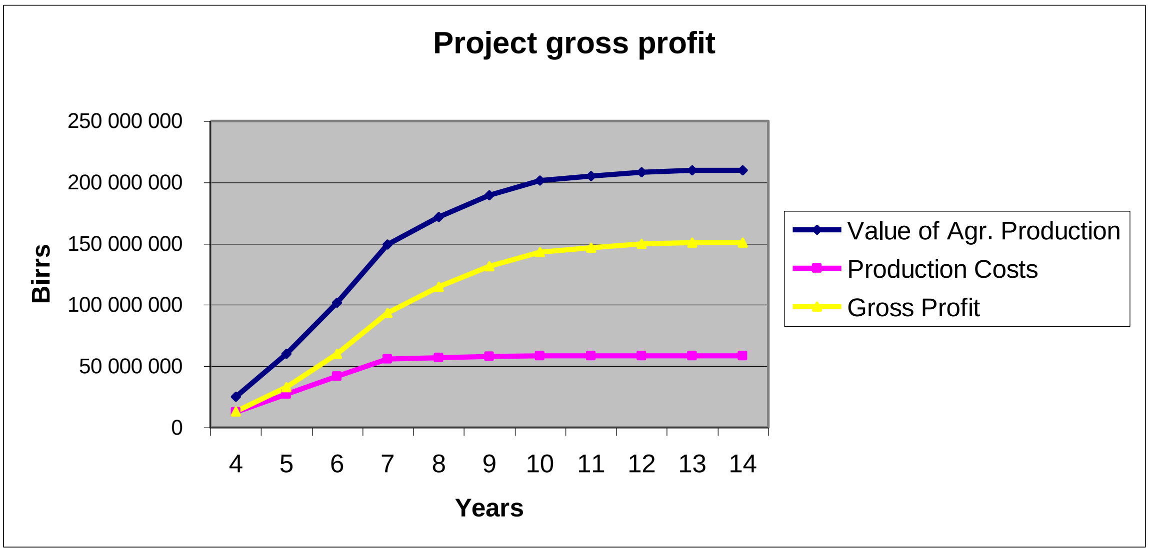
| DINGER BEREHA IRRIGATION PROJECT | | | | Financial Analysis | | |
|---|---|---|---|---|---|---|
| Results for 1 ha | | YIELDS tradable | Farm gate price | Gross value of agricultural production | Production costs | Gross profits |
| | | qt/ha | Birr/qt | Birr/ha | Birr/ha | Birr/ha |
| | | | | | | |
| Rainy season | Maize * | 22.5 | 307.0 | 6 907.5 | 3 530.0 | 3 377.5 |
| | Sorghum * | 30.5 | 325.0 | 9 903.2 | 3 070.0 | 6 833.2 |
| | Rice * | 36.9 | 450.0 | 16 605.0 | 3 965.0 | 12 640.0 |
| | Har.bean * | 12.6 | 364.6 | 4 593.5 | 2 912.0 | 1 681.5 |
| | Soya bean * | 18.9 | 584.3 | 11 043.6 | 3 555.0 | 7 488.6 |
| | Sesame * | 4.0 | 1 127.0 | 4 451.7 | 2 586.0 | 1 865.7 |
| | Mango | | | | | |
| | Citrus | | | | | |
| | | | | | | |
| Dry season | Maize irrig. | 45.6 | 307.0 | 13 999.2 | 4 170.0 | 9 829.2 |
| | Har.bean irrig. | 22.5 | 364.6 | 8 202.6 | 4 312.0 | 3 890.6 |
| | Soya bean irrig. | 27.9 | 584.3 | 16 302.5 | 4 955.0 | 11 347.5 |
| | Sesame irrig. | 8.1 | 1 127.0 | 9 128.7 | 3 986.0 | 5 142.7 |
| | Potato irrig. | 215.6 | 334.4 | 72 085.9 | 6 679.0 | 65 406.9 |
| | Cabbage irrig. | 161.7 | 197.1 | 31 869.6 | 6 237.0 | 25 632.6 |
| | Pepper irrig. | 71.9 | 596.6 | 42 872.2 | 6 995.0 | 35 877.2 |
| | Onion irrig. | 197.6 | 436.0 | 86 155.3 | 7 556.0 | 78 599.3 |
| | Mango | 123.0 | 271.0 | 33 337.9 | 4 739.0 | 28 598.9 |
| | Citrus | 155.0 | 371.4 | 57 560.8 | 5 004.0 | 52 556.8 |

*Table 8.5: Total profit for 7,500 ha*

| DINGER BEREHA IRRIGATION PROJECT | | | | |
|---|---|---|---|---|
| Project gross profit | | Total values of agricultural production | Total Production costs | Gross Profit |
| | | Birrs | Birrs | Birrs |
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | 25 160 972 | 12 309 666 | 12 851 306 |
| 5 | | 60 013 903 | 26 945 085 | 33 068 818 |
| 6 | | 101 857 397 | 41 954 640 | 59 902 757 |
| 7 | | 149 441 678 | 55 924 299 | 93 517 379 |
| 8 | | 171 836 826 | 56 919 535 | 114 917 291 |
| 9 | | 189 395 746 | 57 730 455 | 131 665 291 |
| 10 | | 201 279 946 | 58 254 755 | 143 025 191 |
| 11 | | 205 248 601 | 58 430 655 | 146 817 946 |
| 12 | | 208 297 432 | 58 587 555 | 149 709 877 |
| 13 | | 209 792 780 | 58 713 375 | 151 079 405 |
| & following years | | 209 792 780 | 58 713 375 | 151 079 405 |

Figure 8.1 shows a rapid increase for the value of production. The costs increase sharply during the first four years and then stabilize. The annual profit for 7,500 ha reaches 151 million birr, equivalent to 20,144 birr/.

*Figure 8.1: Revenues and costs comparison during first years*




## 8.2.4 Current production

The current situation is described in the preceding chapter. It enlightens farmers' capacity to ensure food self-sufficiency at household levels and to produce a surplus sold on the local market. An average gross margin of 1,167 birr/ha was calculated, taking into account the market prices in 2009 (local survey made during the field visits). The profit of agricultural production in the current situation in the Project area (4,942ha currently cultivated) is gradually considered as a foregone production.

*Table 8.6: Profit in without project situation*

| DINGER BEREHA IRRIGATION PROJECT | | | | | |
|---|---|---|---|---|---|
| Basic items | | Cultivated land without project | Present profit /ha | Total profit of production | Value of lost production |
| | | ha | Birrs / ha | Birrs | Birrs |
| | | | | | |
| | | | | | |
| 1 | | 4 942 | 1 167 | 5 768 308 | |
| 2 | | 4 942 | 1 167 | 5 768 308 | |
| 3 | | 4 942 | 1 167 | 5 768 308 | 0 |
| 4 | | 3 242 | 1 167 | 3 784 066 | 1 984 242 |
| 5 | | 1 242 | 1 167 | 1 449 664 | 4 318 644 |
| 6 | | 0 | | | 5 768 308 |
| 7 | | 0 | | | 5 768 308 |
| 8 | | 0 | | | 5 768 308 |
| 9 | | 0 | | | 5 768 308 |
| 10 | | 0 | | | 5 768 308 |
| 11 | | 0 | | | 5 768 308 |
| 12 | | | | | 5 768 308 |
| 13 | | | | | 5 768 308 |
| & following | | | | | 5 768 308 |

## 8.2.5 Cash flow

The cash flow is the difference between the benefits and all costs of the project. Agricultural production in the without project situation is considered as lost. The 30 years analysis shows that cash flow level is quickly stabilized from the 13th year onward, when fruit trees are in full production. Operation and maintenance costs are stabilized from the 5th year onward when the whole irrigation system is fully operational. For renewal costs for equipment the rhythm is different because of differences in lifetime.

*Figure 8.2: Cash flow*

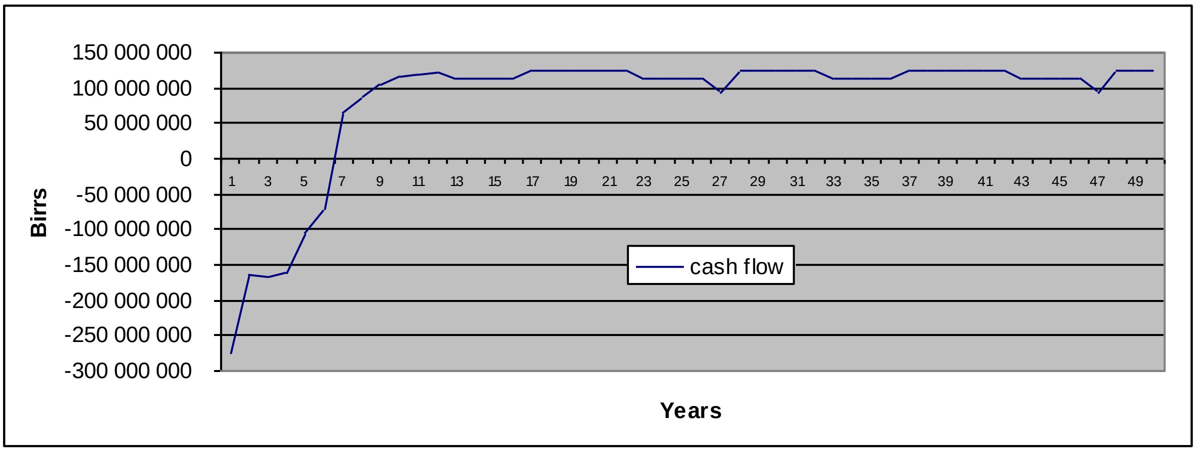



*Table 8.7: Cash flow*

| DINGER BEREHA IRRIGATION PROJECT | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CASH FLOW Values: | | | | | | | | | | | | |
| | Y | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| | | | | | | | | | | | | |
| Gross value of production | | | | | 25.2 | 60.0 | 101.9 | 149.4 | 171.8 | 189.4 | 201.3 | 205.2 |
| Gross value of foregone production | | | | | 2.0 | 4.3 | 5.8 | 5.8 | 5.8 | 5.8 | 5.8 | 5.8 |
| Total Production Costs | | | | | 12.3 | 26.9 | 42.0 | 55.9 | 56.9 | 57.7 | 58.3 | 58.4 |
| Total Project Profit | | | | | 10.9 | 28.8 | 54.1 | 87.7 | 109.1 | 125.9 | 137.3 | 141.0 |
| | | | | | | | | | | | | |
| Investments | | 274.2 | 163.7 | 166.3 | 159.9 | 116.2 | 104.6 | | | | | |
| O&M costs | | | | | 11.0 | 13.6 | 15.9 | 15.9 | 15.9 | 15.9 | 15.9 | 15.9 |
| Management costs | | | | 0.24 | 0.49 | 1.06 | 1.64 | 2.16 | 2.16 | 2.16 | 2.16 | 2.16 |
| Renewal costs | | | | | | | | | | | | |
| Energy costs | | | | | 0.82 | 1.79 | 2.75 | 3.62 | 3.62 | 3.62 | 3.62 | 3.62 |
| Total Costs | | 274.2 | 163.7 | 166.6 | 172.2 | 132.7 | 124.9 | 21.7 | 21.7 | 21.7 | 21.7 | 21.7 |
| | | | | | | | | | | | | |
| Cash Flow | | -274.2 | -163.7 | -166.6 | -161.4 | -103.9 | -70.8 | 66.1 | 87.5 | 104.2 | 115.6 | 119.4 |
| FIRR | 8.72% | | | | | | | | | | | |

*Table 8.7: Cash flow (ctd)*

| CASH FLOW Values: Million birrs | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Y | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
| | | | | | | | | | | | | |
| Gross value of production | | 208.3 | 209.8 | 209.8 | 209.8 | 209.8 | 209.8 | 209.8 | 209.8 | 209.8 | 209.8 | 209.8 |
| Gross value of foregone productio | | 5.8 | 5.8 | 5.8 | 5.8 | 5.8 | 5.8 | 5.8 | 5.8 | 5.8 | 5.8 | 5.8 |
| Total Production Costs | | 58.6 | 58.7 | 58.7 | 58.7 | 58.7 | 58.7 | 58.7 | 58.7 | 58.7 | 58.7 | 58.7 |
| Total Project Profit | | 143.9 | 145.3 | 145.3 | 145.3 | 145.3 | 145.3 | 145.3 | 145.3 | 145.3 | 145.3 | 145.3 |
| | | | | | | | | | | | | |
| Investments | | | | | | | | | | | | |
| O&M costs | | 15.9 | 15.9 | 15.9 | 15.9 | 15.9 | 15.9 | 15.9 | 15.9 | 15.9 | 15.9 | 15.9 |
| Management costs | | 2.16 | 2.16 | 2.16 | 2.16 | 2.16 | 2.16 | 2.16 | 2.16 | 2.16 | 2.16 | 2.16 |
| Renewal costs | | 0.5 | 9.1 | 11.2 | 10.7 | 9.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 |
| Energy costs | | 3.62 | 3.62 | 3.62 | 3.62 | 3.62 | 3.62 | 3.62 | 3.62 | 3.62 | 3.62 | 3.62 |
| Total Costs | | 22.2 | 30.7 | 32.8 | 32.3 | 31.3 | 21.7 | 21.7 | 21.7 | 21.7 | 21.7 | 22.2 |
| | | | | | | | | | | | | |
| Cash Flow | | 121.8 | 114.6 | 112.5 | 113.0 | 114.0 | 123.6 | 123.6 | 123.6 | 123.6 | 123.6 | 123.1 |

| CASH FLOW Values: Million birrs | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Y | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 |
| | | | | | | | | | | | | |
| Gross value of production | | 209.8 | 209.8 | 209.8 | 209.8 | 209.8 | 209.8 | 209.8 | 209.8 | 209.8 | 209.8 | 209.8 |
| Gross value of foregone productio | | 5.8 | 5.8 | 5.8 | 5.8 | 5.8 | 5.8 | 5.8 | 5.8 | 5.8 | 5.8 | 5.8 |
| Total Production Costs | | 58.7 | 58.7 | 58.7 | 58.7 | 58.7 | 58.7 | 58.7 | 58.7 | 58.7 | 58.7 | 58.7 |
| Total Project Profit | | 145.3 | 145.3 | 145.3 | 145.3 | 145.3 | 145.3 | 145.3 | 145.3 | 145.3 | 145.3 | 145.3 |
| | | | | | | | | | | | | |
| Investments | | | | | | | | | | | | |
| O&M costs | | 15.9 | 15.9 | 15.9 | 15.9 | 15.9 | 15.9 | 15.9 | 15.9 | 15.9 | 15.9 | 15.9 |
| Management costs | | 2.16 | 2.16 | 2.16 | 2.16 | 2.16 | 2.16 | 2.16 | 2.16 | 2.16 | 2.16 | 2.16 |
| Renewal costs | | 9.1 | 11.2 | 10.7 | 9.6 | 30.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 9.1 |
| Energy costs | | 3.62 | 3.62 | 3.62 | 3.62 | 3.62 | 3.62 | 3.62 | 3.62 | 3.62 | 3.62 | 3.62 |
| Total Costs | | 30.7 | 32.8 | 32.3 | 31.3 | 51.7 | 21.7 | 21.7 | 21.7 | 21.7 | 22.2 | 30.7 |
| | | | | | | | | | | | | |
| Cash Flow | | 114.6 | 112.5 | 113.0 | 114.0 | 93.6 | 123.6 | 123.6 | 123.6 | 123.6 | 123.1 | 114.6 |

The cash flow in the first 6 years is negative, corresponding to the investment phase without an agricultural stabilized benefit. Starting from the seventh year of the Project after all investments have been made, the cash flow becomes positive. A more detailed cash flow analysis is presented in the Annex 12, Appendix 8-9.

### 8.2.6 Principal results

The first expected result is the Financial Internal Rate of Return F-IRR. It was computed for a 50 years long period in line with the amount of investments. The value obtained is 8.72% which is a good figure for this project dealing with a resettled population and for food security purpose. With a shorter and more usual period of 30 years for assessing the profitability of an investment, the F-IRR would be 7.64%. This confirms that the Project is financially viable.

The most widely used measurement of the cash flow of a project is the Net Present Value (NPV). The NPV is a conventional indicator for project financial analysis. It is closely linked to project performance. When the discount rate is equal to the IRR, the NPV is zero; it is positive when the IRR is superior to the discount rate, negative when the IRR is inferior to the discount rate.

The selection of a project discount rate usually results of discussions amongst experts about financing rules (loan interest rates, bank risk and availability of self-owned funds). To keep the discussion to a minimum, International Development Partners generally require performing sensitivity tests within a range of 8% to 12%.

The discount rate used for the Dinger Bereha Project is 10%, consistent with the usual practices in Ethiopia; this would also permit comparisons with other projects in the country. The NPV value is negative: -115.8 million birr. This does not reflect the distribution of costs and benefits amongst the main stakeholders: the government of Ethiopia (or the investor), the management agency, farmers, inputs suppliers, traders and IWUAs. With a 12% discount rate the NPV becomes more negative: -237.8 million birr. The B/C ratio is computed using the same discount rate of 10%. The financial analysis indicates that costs are higher than benefits; the B/C ratio is 0.9. The general rule is to go ahead with a Project when the B/C ratio is above 1. The signification of a B/C ratio below 1 is that benefits do not compensate investments and recurrent cost. For this particular project, investments will come from public funds exclusively. Regarding the recurrent costs they should be compensated for by beneficiaries.

The recurrent costs of the Project could be shared between the farmers and the public entity in charge of irrigation management, operation and maintenance. For doing so, farmers’ capacity to pay for recurrent costs must be assessed.

The opportunity cost of water is the average dynamic (real-time) cost per cubic metre or the equilibrium price of water for the considered period of 50 years. The value obtained is 2.8 birr/m$^3$ if all investments and current costs are taken into account, and 0.46 birr/m$^3$ if only recurrent costs are taken into account. The latter figure represents the actualized current costs, using 10% discount rate, per consumed m$^3$ of water.

## 8.2.7 Financial results and Project management

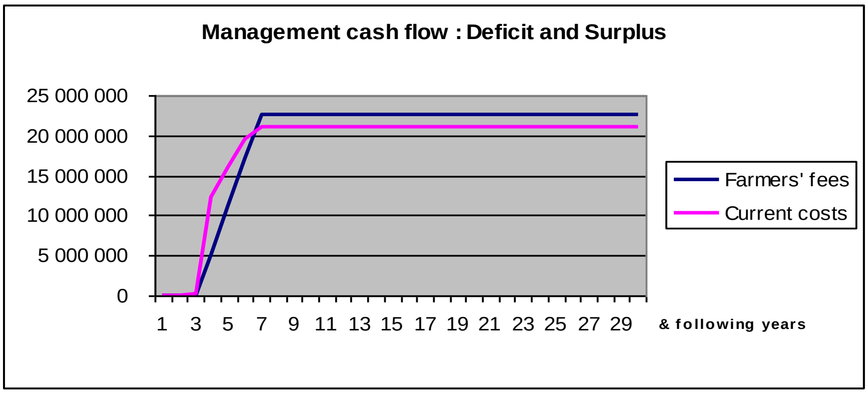
Having identified the main results, it is possible then to consider the management style of the project and address its cash flow status. If the recurrent costs are taken in charge by the farmers, the value of 0.46 birr/m$^3$ becomes a source of funding for Project management.

*Table 8.8: Share of current expenses*

| DINGER BEREHA IRRIGATION PROJECT | | 1000 birrs | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CASHFLOW Management of irrigated perimeter | birrs/m3 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 | following Y.... | Total for 50 Y | NPV |
| | | | | | | | | | | | | |
| Application of funds | | | | | | | | | | | | |
| Total recurrent expenses | | 244.4 | 12 333.6 | 16 432.5 | 20 275.8 | 21 663.2 | 21 663.2 | 21 663.2 | 21 663.2 | 21 663.2 | 1 002 468.2 | 150 693.9 |
| Source of funds | | | | | | | | | | | | |
| Farmers' fees | 0.458 | 0.0 | 5 296.0 | 11 526.5 | 17 757.0 | 23 364.5 | 23 364.5 | 23 364.5 | 23 364.5 | 23 364.5 | 1 062 618.1 | 150 693.9 |
| | | | | | | | | | | | | |
| Needs of working capital | | 244.4 | 7 037.6 | 4 906.0 | 2 518.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 |
| Necessary surplus paid by the farmers | | 0.0 | 0.0 | 0.0 | 0.0 | 1 701.3 | 1 701.3 | 1 701.3 | 1 701.3 | 1 701.3 | | |

Generally, investments in productive activities must be financially supported during the first operation years. The Dinger Bereha irrigation Project will need support in working capital for the first four years, the necessary period of time for the Project to become fully operational. It can be considered that during the first four years of operation the need and working capital would be taken in charge by the management agency. From year five and onward, irrigation fees paid by farmers would be higher than the recurrent cost provided the recovery rate is good. The working capital surplus could be transferred back to the agency. The NPV of recurrent expenses is nil at the end of the considered 50 years period. This indicates that a supplementary loan would not be necessary. There is a need for working capital for the first four years only.

*Figure 8.3: Comparison between sources and needs of funds*




The chart illustrates that there is a deficit in the first four years, while the following years the farmers' fees will match the recurrent costs. Using a 10% discounting rate for a 50 years period, the difference between the respective values of the source and the needs of funds is nil. In the technical jargon, the deficit during the first years is known as intermediary charges, they result of the very nature of an investment project, and they are generally supported by the investor. Here the intermediary charges amount to a total of 14.7 million birr for the first four years. This gap is compensated by the surplus paid by farmers the following years.

## 8.2.8 Sensitivity tests

The model also enables carrying out sensitivity tests to take into account possible change in the value of costs and benefits. Generally, sensitivity tests consider variations within a range of -10 % to + 10%, and combine several scenarios with variations of the costs and benefits to forecast the project situation for the most optimistic and the most pessimistic scenarios.

*Table 8.9: Results of sensitivity tests*

| DINGER BEREHA IRRIGATION PROJECT | | | | | |
|---|---|---|---|---|---|
| Sensitivity Analysis | | | | | |
| | F-IRR | NPV discount rate 10% | B/C discount rate 10% | Opportunity Cost m³ All costs | Opportunity Cost m³ Currents Costs |
| | % | million birrs | | birr/m³ | birr/m³ |
| Results | 8.7% | -115.8 | 0.90 | 2.80 | 0.46 |
| 10% investment increase | 8.0% | -192.7 | 0.80 | 3.00 | 0.46 |
| 10% Energie increase | 8.7% | -118.1 | 0.87 | 2.80 | 0.47 |
| 10% Total cost increase | 7.8% | -207.8 | 0.79 | 3.10 | 0.46 |
| 10% Yield decrease | 7.3% | -237.4 | 0.74 | 2.80 | 0.46 |
| 10% Farm gate price decrease | 7.3% | -237.4 | 0.74 | 2.80 | 0.46 |
| 10% Yield & Farm gate price decrease | 5.9% | -346.7 | 0.62 | 2.80 | 0.46 |

The figures show the strong impact of negative variations in farm gate prices and yields; the worst situation occurs when they are combined. Success is therefore strongly linked to the profit generated by the agricultural production.

This result emphasizes the crucial role of good market organisation and efficient extension services to support farmers for production and marketing activities. Without accompanying measures related to both market organization and extension services, the Project would not be viable. The impact of variation in the level of investments is relatively limited while the impact of energy cost variations is almost negligible. It is important to underline that the F-IRR is negative if investments are doubled or if farm gate prices or yields are only 65% of their levels in the current situation. The sensitivity analysis confirms the Project is viable from a financial perspective; a F-IRR of 8.7% is acceptable for a Project dealing with a resettled population and primary targeting food security. Using a discount rate of 10%, higher than the F-IRR, the net present value becomes negative. The B/C ratio (0.9) is satisfactory. A more specific sensibility test was conducted to test the impact of a 175% cropping intensity instead of 200%. In this case de F-IRR becomes 7.7% instead of 8.7%. Even if the difference is relatively small, **it shows the interest for having a cropping intensity as high as possible.**

## 8.3 Economic Analysis

### 8.3.1 The economic values methodology

The economic analysis assesses the contribution of an investment project to the economic growth (or GDP growth) of a country. The economic analysis uses shadow prices to the maximum possible extent. Shadow prices are the market prices that would prevail without taxes, subsidies or policy restrictions on market activity. Project should not go ahead if its economic value added depends on taxes or subsidies. The estimation of shadow prices was carried out using a conversion factor applied to the financial (market) prices excluding VAT. The conversion factors are useful to take into account the marketing costs (transportation, handling costs and commercial margins) on the basis of CIF/FOB prices to integrate export and import parity prices for each commodity. For this Project shadow prices are estimated on the basis of the data given by MoARD (Ministry of Agriculture and Rural Development) and were discussed with the Oromiya BoARD (Bureau of Agriculture and Rural Development) and Oromya BoFED (Bureau of Finance and Economy Development). Conversion factors were used for agricultural commodities and inputs.

For labour costs (20 birr/day for unskilled labour, and 30 birr/day for skilled labour), the conversion factor is based on the World Bank methodology, whereby daily wage rates are reduced by a conversion factor corresponding to the rate of unemployment among the active population living in a specific Project area. In the case of the proposed Project area where there is a continuous influx of new settlers, the unemployment rate is very high, about 50%. Cost estimates are expressed in economic prices. The labour costs are considered as opportunity costs to enlighten the change in the employment situation, and to assess the overall wealth creation at country’s level. The investments are corrected on the basis of the respective share of local and imported equipment. Locally made equipment represents 20% of the total amount of investment expressed in constant birr (value of November 2009). The conversion factor applied to the investments is 0.9.

### 8.3.2 Project costs at economic level

Total investment costs amount to 886.5 million Birr. Investments are made over a period of six years. The investment economic costs and the implementation program are indicated in table 8.11 in constant birr (November 2009). Estimates of investment costs include the costs of local labour. The computation of the E-IRR is made according to the same methodology as for the financial analysis

*Table 8.10: Conversion factors applied in the economic model*

| Farm Gate Price | Financial value | Economic value | Conversion factor |
|---|---|---|---|
| | | | |
| Crops | birr/qt | birr/qt | |
| Maize | 307.0 | 233.3 | 0.76 |
| Sorghum | 325.0 | 371.5 | 1.14 |
| Rice | 450.0 | 379.8 | 0.84 |
| Haricot bean | 364.6 | 291.6 | 0.80 |
| Soya bean | 584.3 | 467.5 | 0.80 |
| Sesame | 1 127.0 | 1 329.9 | 1.18 |
| Potato | 334.4 | 267.5 | 0.80 |
| Cabbage | 197.1 | 197.1 | 1.00 |
| Pepper (fresh) | 596.6 | 596.6 | 1.00 |
| Onion | 436.0 | 436.0 | 1.00 |
| Mango | 271.0 | 271.0 | 1.00 |
| Citrus | 371.4 | 371.4 | 1.00 |
| | | | |
| Inputs | Crops | birr/qt | birr/qt |
| D.A.P | 410.0 | 512.5 | 1.25 |
| Urea | 360.0 | 479.9 | 1.33 |
| Agrochemicals | 85.0 | 85.0 | 1.00 |
| | | | |
| Labour | birr/day | birr/day | |
| Skill worker | 30.0 | 15.0 | 0.50 |
| Unskill worker | 20.0 | 10.0 | 0.50 |

*Table 8.11: Implementation program at economic costs*

| DINGER BEREHA IRRIGATION PROJECT | | | | | | |
|---|---|---|---|---|---|---|
| Implementation program | | Economic analysis | | | | |
| | Equipments | Area with equipement ha | Area in operation ha | Investments birrs | Unforseen elements 10% | Total investments birrs |
| program years | | | | | | |
| 1 * | Main Infrastructures : diversion weir, main canal | | | 224 360 686 | 22 436 069 | 246 796 755 |
| 2 ** | Main Infrastructures : canal, pumping stations | | | 133 921 837 | 13 392 184 | 147 314 021 |
| 3 ** | Sec. & Tert. network + On farm equipement | 1 700 | | 136 092 800 | 13 609 280 | 149 702 080 |
| 4 | Sec. & Tert. network + On farm equipement | 2 000 | 1 700 | 130 830 871 | 13 083 087 | 143 913 958 |
| 5 | Sec. & Tert. network + On farm equipement | 2 000 | 3 700 | 95 106 788 | 9 510 679 | 104 617 467 |
| 6 | Sec. & Tert. network + On farm equipement | 1 800 | 5 700 | 85 596 109 | 8 559 611 | 94 155 720 |
| 7 | Full use of equipement | | 7 500 | | | |
| | | | | | | |
| Total | in economical values | | | 805 909 091 | 80 590 909 | 886 500 000 |
| | | | | | | |
| * | including preliminary surveys | | | | | |
| ** | including ingeneer requirements | | | | | |

- The renewal of main equipment is positioned along the time of analysis according to their normal service life.
- Operation and maintenance costs are estimated using a percentage applied to the initial value of the equipments used.
- Energy costs are computed based on the amount of pumped m3 and using an efficiency of 60%. The unit economic price is birr 483 per ha.
- The management costs relate to the operation of the management agency including salaries and contingencies costs and to the IWUA operation including supervision of water distribution to the farms. The unit economic cost is 250 birr/ha.

### 8.3.3 Project Benefits

The benefits are the value of agricultural production minus agricultural production costs. In the economic analysis, all produced agricultural commodities, either sold or consumed by the farming households are considered as economic goods. In the economic analysis, the estimates of benefits are carried out on the same principle as for the financial analysis, taking into account:

- Yields increase during the first years when farmers adopt improved agricultural practices. Yields of irrigated crops are higher than yields for rain-fed crops. The economic yields are 90% of the agronomic yields to take into account losses occurring during harvest or a later stage (post harvest). The losses during harvesting and handling activities represent 10% of agronomic production.
- The shadow or economic prices at farm gate;
- The shadow or economic production costs;
- A 200% cropping intensity.

Table 8.12 shows the results per ha for each crop, when the irrigation scheme is fully operational. The results are similar to those of the financial analysis: high for vegetables and relatively low for sesame and haricot beans which nevertheless remain important commodities of the diet of farming households. Table 8.13 shows the gross annual profit of the whole Project which amount to 189 million Birr. This corresponds to 25,212 Birr/ha.

*Table 8.12: Annual gross margin per ha, in full regime situation*

| DINGER BEREHA IRRIGATION PROJECT | | Economic values | | | | |
|---|---|---|---|---|---|---|
| Results for 1 ha | | YIELDS usable=90% | Farm gate price | Gross value of agricultural production | Production costs | Gross profit |
| | | qt/ha | Birr/qt | Birr/ha | Birr/ha | Birr/ha |
| Rainy season | Maize * | 44.1 | 233.3 | 10 289.4 | 3 037.3 | 7 252.1 |
| | Sorghum * | 38.7 | 371.5 | 14 376.1 | 2 636.3 | 11 739.8 |
| | Rice * | 40.5 | 379.8 | 15 381.9 | 3 107.0 | 12 275.0 |
| | Har.bean * | 19.8 | 404.7 | 8 012.3 | 2 260.9 | 5 751.4 |
| | Soya bean * | 22.5 | 467.5 | 10 517.8 | 2 847.9 | 7 669.9 |
| | Sesame * | 6.8 | 1 329.9 | 8 976.6 | 2 075.5 | 6 901.1 |
| | Mango | 0.0 | | | | |
| | Citrus | 0.0 | | | | |
| Dry season | Maize irrig. | 50.4 | 233.3 | 11 759.3 | 3 507.3 | 8 252.0 |
| | Har.bean irrig. | 22.5 | 404.7 | 9 104.9 | 3 460.9 | 5 644.0 |
| | Soya bean irrig. | 27.9 | 467.5 | 13 042.0 | 4 047.9 | 8 994.1 |
| | Sesame irrig. | 8.1 | 1 329.9 | 10 771.9 | 3 275.5 | 7 496.4 |
| | Potato irrig. | 216.0 | 267.5 | 57 784.3 | 4 761.5 | 53 022.8 |
| | Cabbage irrig. | 162.0 | 197.1 | 31 933.4 | 4 529.8 | 27 403.7 |
| | Pepper irrig. | 72.0 | 596.6 | 42 958.1 | 5 527.0 | 37 431.1 |
| | Onion irrig. | 198.0 | 348.8 | 69 062.4 | 5 532.3 | 63 530.1 |
| | Mango | 135.0 | 271.0 | 36 590.4 | 4 082.6 | 32 507.8 |
| | Citrus | 162.0 | 371.4 | 60 160.3 | 4 255.2 | 55 905.1 |

*Table 8.13: Total annual gross profit for 7,500 ha*

| DINGER BEREHA IRRIGATION PROJECT | | | | |
|---|---|---|---|---|
| Project gross profit | | Total value of agricultural production | Total Production costs | Gross Profit |
| | | Birrs | Birrs | Birrs |
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | 28 560 700 | 9 967 463 | 18 593 236 |
| 5 | | 68 054 184 | 21 818 176 | 46 236 008 |
| 6 | | 115 375 829 | 34 008 703 | 81 367 126 |
| 7 | | 168 938 972 | 45 367 658 | 123 571 314 |
| 8 | | 193 898 810 | 46 224 646 | 147 674 163 |
| 9 | | 213 499 842 | 46 931 641 | 166 568 201 |
| 10 | | 226 848 451 | 47 361 038 | 179 487 413 |
| 11 | | 231 491 218 | 47 502 620 | 183 988 598 |
| 12 | | 235 056 485 | 47 625 202 | 187 431 284 |
| 13 | | 236 807 692 | 47 720 136 | 189 087 557 |
| and following years | | 236 807 692 | 47 720 136 | 189 087 557 |

## 8.3.4 Cash flow for economic analysis

The cash flow is the difference between project benefits and project costs. The value of agricultural benefits in the current situation (4,942 ha currently cultivated) is gradually lost for the Project area (foregone production).

*Table 8.14: Cash flow*

| DINGER BEREHA IRRIGATION PROJECT | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CASH FLOW<br>Values: Million birrs | | Economic Analysis | | | | | | | | | | | | | |
| | Y | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| Gross value of production | | | | | 28.6 | 68.1 | 115.4 | 168.9 | 193.9 | 213.5 | 226.8 | 231.5 | 235.1 | 236.8 | 236.8 |
| Gross value of foregone production | | | | | 3.1 | 6.7 | 8.9 | 8.9 | 8.9 | 8.9 | 8.9 | 8.9 | 8.9 | 8.9 | 8.9 |
| Total Production Costs | | | | | 10.0 | 21.8 | 34.0 | 45.4 | 46.2 | 46.9 | 47.4 | 47.5 | 47.6 | 47.6 | 47.6 |
| Total Project Profit | | | | | 15.5 | 39.6 | 72.5 | 114.7 | 138.8 | 157.7 | 170.6 | 175.1 | 178.5 | 180.3 | 180.3 |
| | | | | | | | | | | | | | | | |
| Investments | | 246.8 | 147.3 | 149.7 | 143.9 | 104.6 | 94.2 | | | | | | | | |
| O&M costs | | | | | 9.9 | 12.2 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 |
| Management costs | | | | 0.2 | 0.4 | 0.9 | 1.4 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 |
| Renewal costs | | | | | | | | | | | | | 0.5 | 9.1 | 11.1 |
| Energy costs | | | | | 0.8 | 1.8 | 2.8 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 |
| Total Costs | | 246.797 | 147.314 | 149.915 | 155.081 | 119.553 | 112.630 | 19.794 | 19.794 | 19.794 | 19.794 | 19.794 | 20.244 | 28.860 | 30.910 |
| | | | | | | | | | | | | | | | |
| Cash Flow | | -246.797 | -147.314 | -149.915 | -139.545 | -79.969 | -40.147 | 94.892 | 118.995 | 137.889 | 150.809 | 155.310 | 158.302 | 151.437 | 149.387 |
| EIRR | 12.02% | | | | | | | | | | | | | | |

The cash flow is negative during the first six years 6 years corresponding to the project implementation phase. In the fourth year of production (project seventh year) when the Project becomes fully operational, the cash flow becomes positive and then increase with production growth. The model also enables to carry out sensitivity tests to take into account possible change in the value of project costs and benefits. Generally, sensitivity tests consider variations within a range of -10 % to + 10%, and combine several scenarios with variations of the costs and benefits to forecast the Project situation for both the most optimistic and the most pessimistic scenarios.

*Table 8.15: Results of sensitivity tests*

| DINGER BEREHA IRRIGATION PROJECT<br>Sensitivity Analysis | EIRR | VAN discount rate 10% | B/C discount rate 10% | Opportunity Cost m³ All costs | Opportunity Cost m³ Currents Costs |
|---|---|---|---|---|---|
| | % | million birrs | | birr/m³ | birr/m³ |
| Results | 12.0% | 178.1 | 1.21 | 1.90 | 0.42 |
| 10% investment increase | 11.2% | 108.7 | 1.12 | 2.06 | 0.42 |
| 10% Energie increase | 12.0% | 175.7 | 1.21 | 1.90 | 0.42 |
| 10% Total cost increase | 11.0% | 94.9 | 1.10 | 2.09 | 0.42 |
| 10% Yield decrease | 10.5% | 40.8 | 1.05 | 1.90 | 0.42 |
| 10% Farm gate price decrease | 10.5% | 40.8 | 1.05 | 1.90 | 0.42 |
| 10% Yield & Farm gate price decrease | 9.0% | -82.6 | 0.90 | 1.90 | 0.42 |

At this level the sensitivity test confirms the results obtained in the financial analysis. The figures show the strong impact of negative variations in farm gate prices and yields; the worst situation occurs when they are combined. The success of the Project is therefore strongly linked to the profit generated by the agricultural production. This result emphasizes the crucial role of good market organisation and efficient extension services to support farmers for production and marketing activities. Without accompanying measures related to both market organization and extension services, the Project would not be viable.

The impact of variation in the level of investments is relatively limited while the impact of energy cost variations is almost negligible. It is important to underline that the E-IRR is negative if investments are doubled, or if farm gate prices or yields are only 50% of their levels in the current situation. The sensitivity analysis confirms that the Project is viable from a financial perspective; an E-IRR of 12% is acceptable for a project dealing with a resettled population and primary targeting food security. Using a discount rate of 10%, below than the E-IRR, the net present value is naturally positive. The B/C ratio of 1.2 is good.

### 8.3.5 Results of the economic analysis

All indicators are good, encouraging going ahead with the project. The E-IRR is 12.02%, higher than the 10% discounting rate. Thus, the NPV is positive, amounting 178 million birr. The B/C is more than 1, with a good value of 1.21. These results indicate the Project is economically viable. It can offer employment opportunities for the current population and newcomers to the area through the development of processing, marketing and service activities. The Project will strongly contribute to ensure social peace by ensuring food security and reducing unemployment rate (Detailed results are given in Annex 12, Appendix 10&11).

## 8.4 Financial Analysis at Farm Level

### 8.4.1 Objectives and components

The objectives of the financial analysis at farm level are:

- To verify the food security status;
- To indicate the financial income of farming households;

- To identify the capacity of farming households for making investments;
- To estimate an acceptable level of farmers' financial participation to recover investment costs and at least the recurrent costs of the project, especially the costs related to pumping.
- To verify labour availability for actually implement the proposed cropping patterns.

The financial analysis is built on a "pilot irrigated farm" of 1.75 ha, the average farm acreage since land was attributed to farmers at sizes ranging from 1.5 to 2.0 ha. The simulation shown below assumes a cropping intensity of 200% as for the economic and financial analysis. The cropping pattern is the typical cropping pattern used for the analysis. Identification of household's food requirements is based on the average household size of seven persons. According to information made available by the Ministry of Agriculture, the average annual food requirement per capita is 180 kg of cereals, 45 kg of pulses and 14 kg of oil seeds. The habit of consuming fruits in the Project area led to adding at least 10 kg of fruits (mango and citrus) per capita per year. Vegetables requirements were also added in a higher proportion than fruits and based on the regular households' diet in the Project area. Computations were made using a labour cost of 20 birr/day. The cost of water was not included in this analysis since one objective of the analysis is to assess farmers' capacity to pay for water. Marketing costs were estimated at 10% of farm gate prices.

The net marketable production volume is estimated by deducing food requirements from the net production. The net production is estimated to 90% of the agricultural production in the field to take into account an estimated 10% lost at harvest and in the post harvest processes. The net marketable production is presented in the table below.

*Table 8.16: Food requirement and tradable production for one 1.75 ha family farm reference scenario*

| DINGER BEREHA IRRIGATION PROJECT | | | | | | |
|---|---|---|---|---|---|---|
| Household Production | | Cropping Pattern | YIELDS usable=90% | Total Production | Household food requirements | Net tradable production |
| Area : | 1.75 ha | % | qt/ha | qt for 1.75 ha | qt | qt |
| | | | | | | |
| R S | Maize * | 10% | 44 | 7.72 | 3.78 | 3.94 |
| | Sorghum * | 35% | 39 | 23.70 | 5.04 | 18.66 |
| | Rice *. | 20% | 41 | 14.18 | 1.26 | 12.92 |
| | Har.beans * | 5% | 20 | 1.73 | 0.63 | 1.10 |
| | Soya bean | 15% | 23 | 5.91 | 0.95 | 4.96 |
| | Sesame * | 10% | 7 | 1.18 | 0.49 | 0.69 |
| | Mango | 1% | 0 | 0.00 | | |
| | Citrus | 4% | 0 | | | |
| | | | | | | |
| Dry S | Maize irrig. | 30% | 50 | 26.46 | 2.52 | 23.94 |
| | Har.bean irrig. | 15% | 23 | 5.91 | 0.95 | 4.96 |
| | Soya bean irrig. | 10% | 28 | 4.88 | 0.63 | 4.25 |
| | Sesame irrig. | 25% | 8 | 3.54 | 0.49 | 3.05 |
| | Potato irrig. | 5% | 216 | 18.90 | 0.04 | 18.86 |
| | Cabbage irrig. | 3% | 162 | 8.51 | 0.02 | 8.49 |
| | Pepper irrig. | 3% | 72 | 3.78 | 0.01 | 3.77 |
| | Onion irrig. | 4% | 198 | 13.86 | 0.03 | 13.83 |
| | Mango | 1% | 135 | 2.36 | 0.21 | 2.15 |
| | Citrus | 4% | 162 | 11.34 | 0.49 | 10.85 |
| | | | | | | |
| | Total | 200% | | 153.96 | 17.52 | 136.44 |

With respect to the components of the financial farm analysis, it is useful reminding that computations are made using a labour cost of 20 birr/day. The labour requirements are assessed on the basis of the technical crop description (Annex 12, Appendix 12.1 and Annex 6, Appendix 6-4). The cost of water was not included in this analysis since one objective of the analysis is to assess farmers' capacity to pay for water. The marketing costs were estimated at 10% of farm gate prices.

### 8.4.2 Three Cropping Pattern Scenarios

In order to take into account land suitability constraints and farmers' preferences, three distinct cropping patterns are considered (Details are given in Annex 12, Appendix 12-12). The first scenario (or reference scenario) is the one used for the financial and economic analysis with a relatively large number of crops and a well balanced proportion of food and cash crops. Cereals are predominant to insure food security. Rice, one of farmers' preferred crops, is introduced. The cropping intensity is 200%, therefore the annual cultivated area is 3.50 ha: 1.75 ha in the dry season (rain-fed crops) and 1.75 ha in the dry season (irrigated crops). The second scenario was designed for farms with shallow soils and/or located in hilly areas; rice and fruits trees were discarded and substituted by pulses, sesame and to a lesser extent by vegetables. The cropping intensity remains 175%. The third scenario introduces a cropping pattern for more market-oriented farmers. In the dry season (irrigated crops), the area under maize is reduced and pulses are discarded to the profit of vegetables. The area of irrigated crops in the dry season is reduced due to labour constraints (vegetables). The cropping intensity is reduced to 160% and the annual cultivated area is 2.80 ha.

### 8.4.3 Results at Farm Level

The financial results are good for the three scenarios and very satisfactory with regard to food security status. For each scenario, the volume of marketable crops is higher than the food requirements. The details are given in Annex 12, Appendix 12-13. With an emphasis on cash crops, the net profit under the third scenario is approx twice the profit under the two other scenarios. The net profit in scenario 2 is lower than for scenario 1 as increase of area under cereals does not fully compensate the discarding of rice and fruit trees. The labour requirements are all well suited to a typical farming household with at least one or two persons working full time for agricultural production. With a maximum of 300 man-days, the labour calendar is almost full around the year. The labour requirements exceed one the capacity of one full time farm worker. In the computation some options are considered, for instance income taxes are estimated as a reduction by 5% of the gross profit. The cooperative registration fees were arbitrary fixed at 500 birr/year. This contribution is determined by the cooperative general assembly. This amount could vary between cooperatives and with time. Estimates of the debt service are based on the amount of working capital (for inputs) borrowed every year and with an interest rate of 8.5%[6].

All results are good. This base case can now be used to assess the level of farmers' financial participation to the project. Applying the discounting of 10% used in the financial analysis system the total annual farmer participation is 5,451 birr for 1.75 ha or 3,115 birr for 1 ha. This amount reflects all recurrent costs of the project.

The estimated annual gross financial profit before payment of water charges of farming households shows that this cost can be supported by farmers; however in that case farmer's financial contribution to the Project would amount to approx 14% for scenarios 1 & 2; 10% for scenario 3. From international experience, the level of farmers' contribution should not excess 5% of the gross financial profit. Moreover irrigation development will not benefit to farming households only. A significant portion of the overall benefits will go to the off-farm sector, in particular to those who will benefit from expanded opportunities flowing from the irrigation Project (the so-called multiplier effects).Therefore it is useful to assess the indirect and induced benefits of the Project in order to seek how it would be possible to alleviate the financial contribution of farmers.

[6] In Oromiya Region the rate is fixed at 8,5% for one year.

*Table 8.17: Main results for family farm*

| DINGER BEREHA IRRIGATION PROJECT | | | | |
|---|---|---|---|---|
| Farm RESULTS | | Scenario 1 | Scenario 2 | Scenario 3 |
| | | | | |
| Farm superficie | ha | 1.75 | 1.75 | 1.75 |
| Annual harvested area | ha | 3.50 | 3.27 | 2.80 |
| Crop intensity | coef | 2.00 | 1.87 | 1.60 |
| Production volumes | qt | 154.0 | 145.6 | 221.8 |
| Food Requirements | qt | 17.5 | 17.5 | 17.5 |
| Tradable volumes | qt | 136.4 | 128.8 | 204.3 |
| Gross profit | birrs | 33 250 | 30 246 | 55 252 |
| | | | | |
| Labor man day | md | 302 | 288 | 299 |
| Wages amount | birrs | 6 040 | 5 760 | 5 980 |
| Gross household revenue | birrs | 39 290 | 36 006 | 61 232 |
| | | | | |
| Income tax | birrs | 1 662 | 1 512 | 2 763 |
| Coop registration fees | birrs | 500 | 500 | 500 |
| Debt service | birrs | 582 | 539 | 459 |
| | | | | |
| Estimated gross profit before project investing | birrs | 36 545 | 33 455 | 57 510 |
| | | | | |
| Gross financial profit | | 30 505 | 27 695 | 51 530 |
| Recurent costs | | 5 452 | 5 452 | 5 452 |
| Net Profit | | 25 053 | 22 243 | 46 078 |
| | | | | |
| | | | | |
| Scenario 1 | Balance between food requirements and cash crops | | | |
| Scenario 2 | No rice nor fruit trees | | | |
| Scenario 3 | Intensive cash crops with irrigation during dry season | | | |

## 8.4.4 Benefit Distribution, Poverty Impact and Employment

The first important indicators are the F-IRR and the E-IRR. A F-IRR close to 9% means a significant impact of the Project on the off-farm sector, in particular on economic agents involved in marketing and transportation. Thus, the primarily concerned economic agents are traders, transportation companies, inputs suppliers and service providers. A number of farmers would also develop off-farm profit making activities. An E-IRR of 12% guarantees, for a Project of this nature, that the risks taken for investing in off-farm activities will be limited. The main social impact of the Project is ensuring food security in the Project area and the whole woreda. The cereals production exceed 44,000 tons per year and projected estimates of food requirements of 13,700 tons in the year 2016 indicate that the Project will ensure food security and will allow farmers to market the major part of their products. In other words, the Project will create jobs at farmlevel and in the off-farm sectors and will create wealth for the households. Approx 8,000 workers can find around the year on-farm employment earning an annual salary of 4,000 birr or more. In the off-farm sector, approx 1,000 jobs would be created for water management (through IWUAs), marketing activities (storage, transport, sale of goods), input providers of the private or cooperative sector, spare part retailers, and repair services. The figure indicates that more than 142 million Birr is gained by the farming households, which would serve to pay taxes, to increase their livelihood standards and to have a better access to health care. At least, the Project will redistribute about 3.2 million birr/year corresponding to VAT calculated on input needs, and more than 8 million birr as income taxes. The total 23.3 million birr that farmers would pay for recurrent expenses (on the base of 0.46 birr per m3) must be added to the impacts of the Project.

# 9. PROJECT IMPLEMENTATION

## 9.1 ORGANISATION

The organisation of the implementation will be the responsibility of the MoWR and the Oromiya Bureau of Water Resources. It is proposed that a special Project Implementation Unit (PMU) is created in or nearby the Project site (possibly Nekempte) and that this PMU is receiving support from international consultants.

## 9.2 TRAINING AND MANPOWER DEVELOPMENT

### 9.2.1 Training of staff for Main System Operator

The training requirements will have to be defined during the detailed design phase and after the modalities regarding the identification and selection of the main system operator have been formulated by the MoWR and the Oromiya Bureau of Water Resources.

### 9.2.2 Training on formation and capacity building of IWUAs

The objective is to develop the capacities of the staff that will be involved in establishment and capacity building activities of the IWUAs in the Project area.

**The capacity building activities** should aim to provide WUAs with information and knowledge for carrying-out, monitoring and assessing their activities. This knowledge and information should materialize under the form of a series of *management tools* such as, by-laws, performance indicators, worksheets for maintenance, irrigation schedule, mechanisms for assessing and collecting the water supply charge, bookkeeping system, communication and conflict resolution mechanisms and so on.

Proposed supporting activities are:

- Preparation of guidelines for the formation of IWUAs and training of staff of the "supervising body"
- Preparation of a series of practical manuals on all aspects of operation and maintenance of irrigation systems (or adaptation of existing ones) and training of staff of the "supervising body" and members of IWUAs management and control committees;
- Preparation of a manual / guidelines for monitoring and evaluation of IWUAs performance supported by indicators;
- Organization of study tours to countries more advanced in the irrigation management transfer process for staff of "supervising body".

*Capacity building of irrigating farmers and agricultural extension staff*

The capacity building activities should address:

- On-farm water management: crop water requirements, irrigation scheduling (amount and frequency of water applications) and on-farm irrigation methods;
- Selection of cropping patterns, promotion of technology packages for irrigated agriculture, determination of farm budgets and compatibility with an irrigation cost recovery approach;
- Assessment and monitoring of the performance of irrigated agriculture: land productivity, labour productivity, water productivity and farmers' income and capacity to pay for O&M.

A set of supporting materials and training curricula should be developed accordingly.

- Arranging staffing for Project implementation, including recruiting or redeploying staff with the required skills and experience, and training staff for new functions that they will have to perform;
- Organizing farmers for their participation to the project.

## 9.3 Detailed Design and Procurement

Terms of references for detailed design and associated studies, as well as procurement requirements and modalities have to be defined after acceptance of the final feasibility report by all stakeholders.

## 9.4 Overall Implementation Plan

The overall implementation has to be drawn up after acceptance of the preliminary seven year implementation plan. This requires the participation of all stakeholders, who have at this stage very little knowledge of the proposed developments.

# 10. RISKS AND UNCERTAINTIES

The following risks and uncertainties have been identified:

1) Shortages of river water during the months of March and April might occur at the peak demand of 6m3/s. Therefore, cropping patterns would have to be adjusted in such a way that peaks fall inside periods with higher flows in the river. With the ongoing development in the upstream catchments it is highly likely that more water will be diverted in the future thus constraining water availability at the diversion point. This can only be counteracted by the construction of the Arjo-Didessa Dam or the Negeso Dam.

2) Although the beneficiaries are keen to accept the Project their preparedness and willingness to accept reallocation of land for development of irrigated agriculture is an unknown factor. The land take for the irrigation system is kept to a minimum.

3) The preparedness of the farmers to carry out soil and water conservation works on the steep land to mitigate any negative impact of surface irrigation.

4) The availability of sufficient labour for irrigated agriculture over the full 7,500 ha during two seasons, each at 100% cropping intensity.

5) The availability and reliability of electric power supply. Investment in standby capacity for the pumping station is too costly.

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# APPENDIX 1:

# TERMS OF REFERENCE OF THE REVIEW OF THE FEASIBILITY STUDY AND THE PREPARATION OF DETAILED DESIGNS AND TENDER DOCUMENTS FOR THE DINGER BEREHA IRRIGATION PROJECT

# 1. TERMS OF REFERENCE

## 1.1 INTRODUCTION AND OBJECTIVE

During the period 2007 to 2010 feasibility studies were prepared for the Dinger Bereha Irrigation Project in Ethiopia and the Wad Meskin Irrigation Project in Sudan. Final reports were completed by in June 2010 and submitted to the Client ENTRO who had received a grant from AfdB to finance these studies. The Client has received (applied for) a loan (or grant) from the African Development Bank Group in various currencies towards the costs of the implementing detailed design studies (hereinafter named 'the Study') for the above mentioned projects and intends to apply the proceeds to procure consultancy services for this assignment.

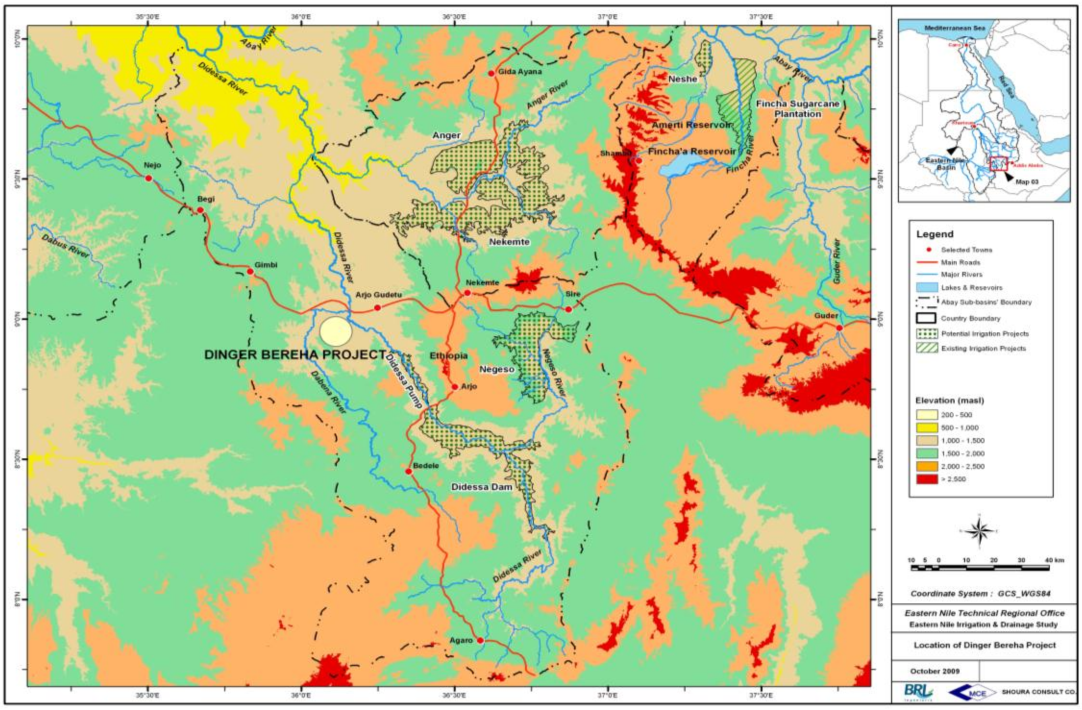
The TOR presented below concerns only the Dinger Bereha Irrigation Project. The objective of the Study is to review the 2010 Feasibility Study (FS) of the Dinger Bereha Irrigation Project (DBIP) of 7,500 ha net in Ethiopia and to provide detailed designs and specification, costs, and bid documents in accordance with the scope of works presented in the following chapters.

## 1.2 THE PROJECT

### 1.2.1 General

The Project area is located in Chewaka Woreda of Illuababora zone, Oromia National Regional State (ONRS) (see map 1). Distances between Bedele and Addis Ababa are 74 and 560 km respectively. Access is currently difficult, but will be greatly improved by a bridge under construction linking the Woreda to the main road between Nekempte and Assossa.

*Map 1: Location of the Dinger Bereha Project*



The Woreda is a newly established settlement scheme (2004) when people from drought stricken Eastern and Western Hararge Zones of ONRS were resettled in the area on free will basis. The original number of households resettled was estimated at 12,390. However, the current number of households is estimated at 14,026, with a total population of 92,027 (Woreda population census, 2008). Agriculture is the main occupation of the settlers and various crops are grown under rainfed and traditional irrigation during the rainy and dry seasons, respectively.

Livestock rearing is also part of the agricultural activities. The total area of the Woreda is about 55,400ha. The altitude variations from less than 1,100 masl in the low lying valley bottoms to about 1,800 masl in the nearby mountain ranges have little effect on variation in temperature and rainfall patterns in the Woreda. The command area is bounded by contours +1240 and +1260. However, these areas are characterized by undulating plains and strongly sloping terrains, with slopes ranging from 0 to 8%. A large portion of this area is currently under rainfed cultivation. The resettled population has previous experience of irrigation in its region of origin and has developed a number of traditional irrigation schemes tapping water from springs or streams to produce cash crops in the dry season. When the settlement scheme was initiated, allocation of land was determined to be 2 ha per household.

Currently, the program has been implemented as planned and cultivated land per household ranges from 1.5 to 2.0ha, averaging about 1.75ha. The tenure system is based on the Country's policy that farmers have the right for long-term usufruct rights to their holdings. Compared to the national average land holding size, which is less than 1ha, farmers in the Project area are relatively better off than their contemporaries elsewhere in the country. As per the data secured from Chewaka Woreda Women's Affair Office, women headed households represent 4% of the total. The gender division of labour indicates that unlike in other places, women participate less on agricultural fields, though their role in marketing is very high. Their responsibility in household management is quite immense, partly exacerbated by a large family size. Polygamy is also quite frequent. Women's health is quite compromised due to frequent pregnancy, low awareness of primary health care issues and harmful traditional practices such as circumcisions. The school data shows a significant lesser number of girl's enrolment and higher dropout rate than boys, mainly because of early marriage. Chewaka district is accessible by rural all-weather road via Dabo district to Bedele town and Nekempte town using a 74km long and a 142km long road respectively. Currently an all-weather road is under construction with a bridge to cross the Didessa River and to join the area with the Asossa-Gimbi-Nekempte-Addis main highway. This bridge is expected to be completed by the end of 2010. The distance of the district from Addis will be significantly shortened from about 560 km to about 430 km, thus impoving marketing opportunities significantly.

## 1.2.2 Proposed Irrigation Infrastructure

### *1.2.2.1 Diversion*

A gravity diversion has been selected for the proposed Project because comparison of costs of various options has shown that the partly gravity-partly pump option is more cost effective than the alternative of full pumping from a point on the Didessa nearer to the command area. Water is taken from the Didessa River by a headworks made up of a mass concrete weir with a flushing channel with sediment excluder and Main Canal offtake on the left bank. Immediately downstream of the Main Canal offtake there is a settling basin, from which the settled sediment can be flushed back to the river. At the head of the Main Canal there will be a sediment removal reach and a flow measurement structure to ensure that the flow released to the canal is equal to the irrigation water requirements.

### *1.2.2.2 Main System for Conveyance*

**Main and Primary Canals.** Trapezoidal concrete lined canals with a gradient of 0.20 m/km have been chosen for all canals because of the high permeability of the soils. A steeper canal gradient was examined but the additional pumping costs together with the loss of production exceeded the savings in canal construction cost.

A 15 km long Main Canal conveys water from the gauging weir near the intake to the boundary of the command area, following the Didessa River closely for most of its length. It is crossed by watercourses that are passing underneath via reinforced concrete drainage structures. Once the Main Canal reaches the command area it is designated Primary Canal. This canal conveys water to a balance reservoir at a pumpstation and has a number of downstream control gravity offtakes directly to the irrigation blocks. To ensure that these offtakes are always submerged there will be three sideweirs along this canal. The canal will cross four watercourses in inverted siphons consisting of Glass Reinforced Polyester (GRP) barrels. These will either be buried or installed above ground, according to the pipe size and geotechnical conditions.

Since irrigation will only take place during maximum 12 daylight hours, it is necessary to store the night time flow at a location close to the irrigated area. The provision of night storage reservoirs simplifies the management of the scheme and enables the scheme to make efficient use of the diverted irrigation water. At the pump station water will be lifted from the reservoir to four night storage reservoirs designated NW, SW, NE and SE. These are located at an elevation of approximately 1263 m asl. From night storage reservoir NE the offtakes will feed secondary pipelines with downstream control.

Although most of the scheme will be irrigated by secondary pipelines feeding directly from the reservoirs or Primary Canal, contour secondary canals are required in a number of locations. These will be supplied with irrigation water from the reservoirs using an "AVIO" type gate and a modular baffle distributor to ensure that the correct flow is delivered. The high level Primary Canals will operate with upstream control, i.e. the required amount of water will be released from the night storage reservoirs. Side weirs are used to control the water levels in the Primary Canals so that outflows from the canal can be accurately controlled. The weirs are found to be both less costly and less subject to mechanical failure than mechanical devices. They are very robust so there is also less opportunity for interference and vandalism. Each of the larger irrigation blocks supplied by gravity from the high level Primary Canals will have its own night storage reservoir. The offtakes from the night storage reservoirs will be either pipes or secondary canals, both with downstream control. The reservoir serving the NE part of the command area has no canals downstream but instead feeds directly to the secondary pipe networks which serve the surrounding command area.

Some of the secondary pipelines for this area will be taken directly off one of the rising mains. The flow from the Primary to the off-stream reservoirs will be accurately regulated by a Baffle Distributor and close control of the canal water level by a side weir. Water will be taken by the pipe systems "on-demand", i.e. with downstream control.

#### *1.2.2.3 Pump Station and Rising Mains*

The pump station will pump from the night storage reservoir. The station has a maximum capacity of 5 $m^3$/s and will have a total of 10 pumps, with three pumps supplying the SE Primary Canal and the NE command area and the remaining 7 pumps the NW and SW command areas. It will be constructed as one or two reinforced concrete structures with the sets of pumps discharging, via butterfly and non-return valves, to separate buried manifolds. The possibility of interconnecting the manifolds to provide a degree of stand-by capacity may be investigated during the detailed design. The pumps will be of the mixed-flow vertical turbine type with close-coupled motors. Each pump will discharge about 500-600 l/s against a dynamic head of 36-37.5 m. The pumps will be weatherproof and installed in the open. A building will be provided for the switchgear that will be housed in a common switchboard and supplied by common transformers. The rising mains will, like the inverted siphons, be of GRP, albeit of a suitable class to withstand the operating and surge pressures that will occur in the rising mains. Along the main road Nekempte-Gimbi there is a 32 kV powerline. However, stepping down to 11 kV would cost 33 million ETB and is not allowed according to EEPCO regulations. The nearest transformer station where power is stepped down from the national 132 kV grid to 11 kV is in Nekempte, about 70 km away. Costs of electrification would be 12 million ETB.

#### 1.2.2.4 Distribution Systems

Because of the terrain, conveyance and distribution of water perpendicular to the contours has to be mainly through piped networks, because a system with open lined canals coupled to a huge number of large drop structures would be very expensive and would require a large land take in a densely populated and cultivated area. The Project area is divided into 15 Command Areas corresponding to the main interfluves. For each command area, blocks are demarcated, taking into account the site geomorphology, slope, streams and gullies. The tertiary system comprises buried pipe networks connected to the secondary pipes or canals.

The tertiary systems feed flow control hydrants each serving a block of 6 ha with a nominal discharge of 9.6 l/s/block.

The flow from the hydrant is controlled by a flowlimiter and distributed by permanently buried PVC or PE pipes to a number of field outlets. Each farmer has its own field outlet and the full flow from the hydrant is rotated amongst the farmers united around the hydrant. The tertiary network and the hydrants are operated at maximum 12 hours/day when water requirements peak. Additional advantages of piped systems are increased distribution efficiency, large reduction in water theft, better control of quantities delivered to users and the possibility to use highly efficient localised irrigation systems with full and transparent control of water quantities delivered. The on-field irrigation system is connected to the individual outlets and comprises gated pipes or other improved surface irrigation equipment such as hoses or simple HDPE pipe that can be dragged from farm to farm. Where sufficient pressure is available at the hydrant, farmers can install localised irrigation systems such as drip and sprinkler (draghose system).

#### 1.2.2.5 Drainage

Sufficient ground slopes, well draining soils and a dense network of existing streams that will be used as drainage network, mark the particular site geomorphology. Therefore, additional drainage works are not considered to be required for the Project.

### 1.2.3 Environmental and Social Impact Assessment Issues

#### 1.2.3.1 Methods used and definitions of impacts

The methods used in the environmental and social impact assessment (ESIA) of the Project 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 and AfDB requirements). 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 consultant 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. Due to budgetary limits it was not possible to make many of these studies during the Feasibility Study. It is strongly recommended that ENTRO ensures that such assessments are initiated during the Tender Design Stage. While in the field, all relevant institutions at Kebele and Woreda 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 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, a 15 km long main canal and 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 area 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 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, skills, and in land values and price due to irrigation water.

The likely mitigation of negative impacts that are expected will depend first on acquiring a full understanding of environmental conditions. Therefore, mitigation has to be part of an environmental management plan. At present this covers the Project area but ideally should cover the entire watershed. Whilst there are numerous positive impacts resulting from the Project, the likely main negative impacts that will require mitigation include possible spread of water borne diseases in the irrigation system and changes to disease ecology, spread of crop and animal pests and diseases and increased soil erosion.

Moreover, pollution of ground and surface waters from agrochemicals, destruction of gallery forests and loss of associated water resources and reduction in plant biodiversity may occur. These will be tackled as part of an environmental management plan that will implement mitigation measures to minimise these impacts.

#### *1.2.3.2 Environmental Monitoring*

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 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 Woreda 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 15 environmental and social monitoring indicators have been defined.

## 1.3 Phase 1: Review of Feasibility Study and Implementation of Additional Studies

### 1.3.1 Irrigation System Development

Based on the information obtained from the feasibility study regarding the lay-out of the conveyance and piped distribution systems, the following design aspects shall be addressed in close consultation with the DB farmers, Woreda staff and technical staff:

- Review the advantages and disadvantages of the proposed irrigation system and compare with alternative systems, calculate the investment and recurrent cost of each alternative. Based on the initial investment, operation and maintenance costs and also the simplicity of operational management, recommend the most appropriate irrigation system.

- Taking into account the detailed recommendations of the FS, identify the most appropriate in-field irrigation application system(s) with respect to topography, soil type, water use efficiency, irrigation management, reliability and cost of the material supply, as well as farmers' acceptance and management capacity, The FS recommended to adopt a distribution system comprising hydrants and surface and sub-surface pipes.

- Prepare lists and specifications of irrigation materials and calculate their associated costs.

- Minimize investment costs and O&M costs of the buried pipe distribution networks by optimizing diameters and length of pipelines.

### 1.3.2 Agricultural Land Development

Based on the information obtained from the feasibility study of soils, topography and also data from the existing cropping patterns, the following agricultural issues shall be addressed in close consultation with DB farmers and Woreda staff:

- Prepare detailed cropping patterns, crop husbandry and other factors affecting yields, irrigation practice and land use efficiency.

- Work out irrigation calendars per growth stage, soil type and season in conformity with the selected irrigation system.

- Define agricultural practices to be adopted in light of the soil, topographic and climatic data.

- Define the equipment required for land development and calculate associated costs.

- Prepare lists and specifications of agricultural machinery, implements and workshop tools necessary for the development and determine associated costs.
- Estimate the total investment cost of the agricultural development and the annual operation costs including fixed costs and variable costs,

### 1.3.3 Mapping

- Carry out surveys to establish current boundaries of landholdings of individual farming families.
- Prepare cadastral maps that indicate these boundaries and compile data on GIS system, using the topomaps prepared during the FS.
- Using the cadastral and topomaps, determine exact canal and pipeline routes and locations of pumpstation, reservoirs and structures on basis of these maps.

### 1.3.4 Infrastructure

- Determine detailed infrastructure requirements for project management organization, power supply, communications, roads and drainage structures, with all necessary facilities. These shall be worked out and an implementation schedule would be made available.
- Present engineering estimates of costs for the infrastructure.
- Prepare implementation and cost allocation schedules.

### 1.3.5 Manpower Requirement

Present the detailed manpower needs to manage, operate and maintain the irrigation scheme and to provide support to the farmers and give a breakdown into skilled (specify), semi-skilled, and unskilled personnel.

### 1.3.6 Creation of Water User Organizations

Using the recommendations of the FS and in close cooperation with farmers leaders and woreda staff the Consultant will start organizing farmers in Water Users Organizations and will prepare detailed training programmes to ensure capacity building at all levels.

### 1.3.7 Environmental and Social Impact Assessment (ESIA)

During the feasibility study in 2008 and 2009 a preliminary ESIA was carried out that included a broad assessment of the environmental effects of the proposed Project. This study identified specific environmental control measures in and around the proposed facilities but identified a host of other issues that could not be studied in detail. The additional ESIA during the detailed design phase shall include land use, soil conservation, forestry, environmental pollution and control requirements, as well as other issues identified in chapter 1.2.3 of these ToR. Moreover, a detailed environmental management plan (EMP) and resettlement action plan (RAP), if necessary, will have to be formulated as soon as designs have become more detailed and consultations with stakeholders have been carried out. Associated costs will be incorporated into the overall project costs to ensure compliance with all statutory guidelines.

## 1.4 PHASE 2: DETAILED ENGINEERING DESIGNS AND PREPARATION OF TENDER DOCUMENTS

### 1.4.1 General

The Consultant shall prepare detailed designs including all required drawings on the basis of the results of the review and on the detailed design criteria. The drawings shall be based on engineering investigations and calculations and the results of EIA, EMP, and any required RAP carried out during Phase 1.

The drawings will be prepared with sufficient degree of detail, including required information allowing for performance of good quality construction and accurate definition of quantities of the works. On the basis of the detailed design a list of drawings, including site plans (in scale to be defined with ENTRO and technical Ministry) shall be prepared and presented in the a Detailed Design Report. The required detailed data on presentation, kind, number and scale of drawings will have to be identified during Phase 1, in close consultation with ENTRO and the technical Ministry. The work content and quantities shall not consider attendant measures, connected with organization of construction and technological schemes of works performance, testing, and putting into operation works of electro-mechanical and hydro-mechanical equipment besides those specified in the design as obligatory. All construction design drawings and quantity tables for equipment testing must be submitted with the Confidential Engineering Estimates.

In general, the following principles must be taken into account during the design of the headworks, lined canals, pumpstation, reservoirs, structures and buried pipe distribution networks:

- Hydraulic and structural design must be transparent and must meet internationally accepted standards.
- Structures must be designed according acceptable safety standards, ensuring their stability under all circumstances and preventing harm and damage to living creatures.
- The design of the headworks must be based on maximum flood estimates and subsurface hydraulic analysis, using the hydrological, the geological and geo-technical information presented in the FS.
- Pipeline systems and siphons must be equipped with safety devices to prevent damage caused by sudden changes in pressure.
- Operation and maintenance of the components in the system must be as simple as possible, durable and not prone to interference by non-authorised persons.

### 1.4.2 Technical Specifications

The Consultant shall develop the construction technical specifications in close coordination with the technical Ministry. The technical specifications shall contain detailed descriptions of regulations and terms of works performance, as well as standards of materials and quality of goods and services. Standard technical specifications of the technical Ministry will include all main types of civil works. These shall form the basis for preparation of the construction technical specifications. They do not exclude occurrence of new issues or types of works or use of materials in the process of construction, which were not included in the Standard Technical Specifications, but should be defined in technical terms. In case of such issues they shall be prepared by the Consultant. Technical Specifications shall be adjusted individually to each construction package. It means that for each contract some items can be added or excluded. At the end the Technical Specifications include as "Attachment" documents providing continuity of construction process as: Bill of Benchmarks, appropriate environmental clauses from design/scheme level EIAs, agreements with and permits from appropriate organizations (Ministries, Environmental Protection Agency, Energy etc.), with institutional organizations on electricity transmission lines, crossings with highways; location of reserve and spoil banks, land alienation and other agreements.

### 1.4.3 Bill of Quantities and Planning of Civil Works

Planning of civil works shall include all works of the selected option considering the duration of the cultivation season, rainy season conditions and actual estimation of time and methods of construction. In conformity with planning of civil works, the Consultant shall prepare the Engineering Estimates of Quantities. These quantities shall be filled in a table, hereafter called the Bill of Quantities (BOQ), which is to be included in the Bidding Documents.

Consultant shall prepare a simplified BOQ with reduced but sufficient number of "descriptions" (items) of work and reasonable working out of quantities in details. BOQ shall consist of Summary BOQ and separate parts of BOQ (earth works, concrete works, metal works etc.), submitted on separate sheets and agreed with ENTRO and the technical Ministry. The Consultant shall submit the table of conformity of BOQ with items of quantities on drawings in "General Attachments". The BOQ shall not include quantities associated with organization of construction, with technological schemes and putting into operation, except those specified in the design as obligatory. In the bidding documents will be included the final EIA, EMP and RAP (if any) as well as any required technical, environmental and social permits and approvals. According to this TOR the Consultant is responsible for technical aspects of the bidding document, including the Bills of Quantities, Technical Specifications, Confidential Cost Estimate, inputs relating to the environment and economic analysis. ENTRO and the technical Ministry will be responsible for issuing the complete Invitation for Bid.

### 1.4.4 Preparation of Confidential Engineering Estimates and General Attachments

The Consultant shall develop Confidential Engineering Estimates of the construction costs (including mitigation measures costs) and submit them separately to the Client. The Consultant shall not disclose these estimates to others, particularly to potential contractors and/or suppliers. The Confidential Engineering Estimates of Construction Costs shall provide the Client with a point of reference for financial planning and control. Confidential Engineering Costs shall be prepared according to real market prices, which shall include subtotals according to relevant sections of summary BOQ. The General attachments shall include materials not connected directly with the construction process, such as:

- Terms of Reference;
- Defect Lists;
- Minutes of Meetings;
- Conclusions (on tests of materials, structures etc.);
- Letters;
- Table of conformity of BOQ items to items of quantities on drawings;
- Table of conformity of BOQ items to items of market prices;
- Other materials worked out in the process of designing.

### 1.4.5 Completion of Phase II

Phase II shall be completed with the preparation and the subsequent approval by ENTRO and technical Ministry of the Bidding Documents and Confidential Engineering Estimates. The period for the review and approval of the Bidding Documents by an independent Expertise shall be included in the overall duration of design. The Expertise services costs are covered by Consultant and shall be provided for in the Financial Proposal. It is assumed that the entire expertise process will last about 30 days, i.e. Consultant shall submit 10 copies of the above documentation to ENTRO for review, making corrections and approval 30 days before the design deadline.

The Consultant shall submit to ENTRO the following:

- Bidding Documents consisting of:
  - Technical Specifications - 10 copies.
  - Drawings (in 2 separate files for each canal) - 10 copies
  - Final EIA, EMP and RAP (if any) - 10 copies.
  - Any required technical, environmental and social permits and approvals (10 copies).
  - Bill of Quantities – 10 copies.
- Attachments
  - Confidential Engineering Estimates - 2 copies.
  - General Attachments - 2 copies.

### 1.4.6 Detailed design criteria

Design criteria need to be formulated and agreed upon BEFORE proceeding to the detail design task, so this will have to be carried during the latter part of Phase 1. They will be presented in a Design Criteria Report to be submitted not later than the Phase 1 Report.

### 1.4.7 Terms of reference for support to Client during bid evaluation and supervision of construction

The Consultant will be responsible to prepare detailed Terms of Reference for support to the Client during evaluation of the bids for construction and for supervision of construction.

# 1.5 EXPERTISE REQUIREMENTS

## 1.5.1 General

To undertake the Study ENTRO will engage the services of a consulting firm or firms through requirement procedures as stipulated in AfDB's guidelines on selection of consultants. It is anticipated that a total of 90 person-months of professional staff will be required comprising 40 person-months of International professional staff and 50 person-months of National professional staff. Further, about 15 person-months of sub-professional staff and technical staff and 15 person-months of supporting staff will be required. The review and design studies will be undertaken by a team of experts comprising International and National professional staff. In general, preference will be given to International staff that has work experience in Ethiopia and/or in the region. The expected requirements for professional staff and qualifications are shown in the next chapter.

## 1.5.2 Required Number of Man-months

The following table shows the approximate number of personnel and total manmonths for each position of international and national Professional staff.

| | Designation | nr | Mm/ person | Total nr of mm |
|---|---|---|---|---|
| | International Professional Staff | | | |
| 1 | Team leader/Irrigation Engineer | 1 | 10 | 10 |
| 2 | Geotechnical Engineer | 1 | 2 | 2 |
| 3 | Irrigation and Drainage Engineer | 1 | 2 | 2 |
| 4 | Hydraulic Engineer | 1 | 10 | 10 |
| 5 | O&M specialist | 1 | 1 | 1 |
| 6 | Structural Design Engineer | 1 | 10 | 10 |
| 7 | HM&E Engineer | 1 | 2 | 2 |
| 8 | Water User Association Specialist | 1 | 2 | 2 |
| 9 | Environment Specialist | 1 | 1 | 1 |
| | *subtotal* | | | *40* |
| | National Professional Staff | | | |
| 1 | Deputy Team leader/Irrigation Engineer | 1 | 10 | 10 |
| 2 | Topographical Engineer | 1 | 4 | 4 |
| 3 | Geotechnical Engineer | 1 | 2 | 2 |
| 4 | Irrigation Design Engineer | 1 | 2 | 2 |
| 5 | Hydraulic Design Engineer | 1 | 4 | 4 |
| 6 | Irrigation and O&M Engineer | 1 | 2 | 2 |
| 7 | Structural Engineer | 1 | 10 | 10 |
| 8 | HM&E Engineer | 1 | 4 | 4 |
| 9 | Contract Engineer | 1 | 6 | 6 |
| 10 | Environment Specialist | 1 | 2 | 2 |
| 11 | Sociologist/Public Participation Specialist | 1 | 4 | 4 |
| | *subtotal* | | | *50* |

The total number of manmonths amounts to 90. The Professional staff will be supported by technical staff (CAD and GIS technicians, secretaries), which require about 30 manmonths.

### 1.5.3 International Professional Staff

(1) **Team Leader/Irrigation Engineer**: should be a university graduate civil engineer with about 20 years experience in the field of preparing feasibility studies and detailed designs of irrigation projects. He/she should also have experience in operation and design of irrigation systems, and maintenance of infra-structure projects. He/she should have preferably worked in Ethiopia and/or in the region in the field of water resources planning, operation and design of major irrigation systems. Further he/she should have experience in management of a multi-disciplinary team for a minimum period of 10 years and be capable of concise reporting. His/her duties will include all duties normally assigned to a team leader such as liaison with ENTRO and the executing Ministry and other Ethiopian institutions, liaison with and reporting to his/her home office, coordination of the feasibility, design and investigation work, overall responsibility for administrative, financial, and technical reporting, progress planning and overall guidance to the professional and supporting staff.

(2) **Geotechnical Engineer**: should be a university graduate with about 15 years experience in planning of geotechnical investigations, collection and analysis of geotechnical data for design and construction of embankments, lined canals, foundations for weirs, siphons and other water related structures. His/her duties will also include preparation of a subcontract for geotechnical field investigations and soil laboratory testing, supervision of such investigations and testing and interpreting borelogs and soil parameter and supervising the geotechnical works conducted by the contractor.

(3) **Irrigation Engineer**: should be a university graduate with about 15 years experience in water resources planning. He/she should have experience in planning of water availability, water demand for irrigation, distribution schedules and in designing localised irrigation systems. Preferably, he/she should have worked in Ethiopia and/or in the region in the field of water resources planning.

(4) **Senior Hydraulic Engineer**: should be a university graduate with about 15 years experience in planning and hydraulic design of large conveyance systems such as irrigation canals and pipe lines including appurtenant hydraulic structures as weirs, siphons, water level control and measuring structures, culverts, etc. Further, he/she should have experience in preparation and running of hydraulic canal models.

(5) **O&M Expert**: should be a university graduate with about 15 years experience in the O&M of irrigation and drainage systems. He/she should have experience in the planning of O&M, improvement of irrigation and drainage system operation and its management.

(6) **Senior Structural Design Engineer**: should be a university graduate with about 15 years experience in planning, detailed design, and construction of structures in diversion, conveyance and distribution systems such as weirs, siphons, intake and outlet works, regulators, retaining walls, modular offtakes, bridges, etc. He/she should have profound knowledge of detail design of water retaining structures and construction planning, including preparation of design and tender drawings. His/her duties will be to plan and prepare detailed designs of the major structures, execute design calculations, prepare the relevant specifications and guide the National structural and civil engineers in their design work, preparation of the bill of quantities, cost estimate and design and tender drawings.

(7) **Hydro-Mechanical and Electrical Specialist**: should be a university graduate with about 15 years experience in planning, design, installation and operation of hydro-mechanical and electrical (HM&E) equipment used in water resources infrastructures, such as pumping plants, trash racks, hydraulic gates, measuring gates, spillway and flushing gates, etc. Further, he/she should also have experience in preparation of specifications for procurement and testing of HM&E equipment.

(8) **Water User Association Specialist**: should be a university graduate with about 10 years experience in agriculture water management and organizing farmers in water management projects. He/she should have experience. He/she should preferably have experience in Ethiopia and/or in the region.

(9) **Environment Specialist**: should be a university graduate with environmental background and not less than 15 years experience in environmental impact assessment (EIA), and Environmental Management Planning (EMP) of water resources development and related projects. This shall include experience in environment impact and in the assessment of resettlement and compensation. He/she must have experience in the preparation of Environment Impact Assessment reports according to the national guidelines. He/she shall be assisted by the national Sociologist/Public Participation Specialist.

### 1.5.4 National Professional Staff

(1) **Deputy Team Leader/Irrigation Engineer:** should be a university graduate civil engineer with about 15 years experience in the field of water resources planning, feasibility studies, design and construction of irrigation and drainage systems and related structures and raw water supply. Further he/she should have ample experience in managing project teams for design studies. His/her duties will include liaison with the Team Leader as well as his own home office, preparation of coordination with various local authorities and survey and investigations contractors, overall guidance to the National staff members, reporting on special subjects to the Client and participation in feasibility, design and construction work.

(2) **Topographical Engineer**: should be a university graduate with about 10 years experience in collection and review of topographical data, measurement of cross sections and levelling, preparation of contracts for topographical surveys and supervision of field work. He/she will be responsible for planning of the survey work, its supervision and preparation of survey data and maps for detailed design. His/her duties will further include quantity estimation of canal and reservoir excavation, cadastral mapping and determination of the location and dimensions of cross regulators, irrigation offtakes and other important canal structures.

(3) **Geotechnical Engineer**: should be a university graduate with about 10 years experience in geotechnical aspects of foundation design and construction of hydraulic structures and siphons as well as in the design of canal banks and in unstable soil. Further, he/she should have ample experience in analysis of materials used for fill and foundation of hydraulic structures and supervision of geotechnical field investigations and laboratory testing.

(4) **Irrigation Design Engineer**: should be a university graduate with not less than 10 years experience in planning and design of surface irrigation and drainage and pipe distribution systems. He/she should also have knowledge of operation and maintenance of irrigation canals, reservoirs, pumpstations and related control and measuring structures.

(5) **Hydraulic Design Engineer**: should be a university graduate with about 10 years experience in hydraulic design of irrigation and drainage canals and appurtenant structures such as weirs, siphons, irrigation offtakes, etc. He/she should also have experience in dimensioning of low and medium pressure pipe systems for irrigation purposes.

(6) **Irrigation and O&M Engineer**: should be a university graduate with not less than 10 years experience in planning of O&M requirements (equipment, manpower, maintenance intervals) for irrigation and drainage systems.

(7) **Structural Engineer**: should be a university graduate with not less than 10 years experience in structural design and construction of hydraulic structures such as weirs, siphons, spillways, culverts, and irrigation offtakes as well as in the design of roads and bridges. His/her duties will be preparation of detailed designs of canal structures and improvement works, relevant specifications and structural design and tender drawings.

(8) **Hydro-Mechanical and Electrical Specialist**: should be a university graduate with about 15 years experience in planning, design, installation and operation of HM&E equipment used in water resources infrastructures, such as pumping plants, trash racks, hydraulic gates, measuring gates, flushing gates, etc. Further, he/she should also have experience in preparation of specifications for procurement and testing of HM&E equipment.

(9) **Contract Engineer**: should be a university graduate with about 10 years experience in preparation of prequalification documents, tender documents and schedules for construction works. He/she should also have experience in preparation of tenders and contracts for International Competitive Bidding (ICB) and National Competitive Bidding (NCB).

(10) **Environment Specialist**: should be a university graduate with environmental background and not less than 8 years experience in environmental impact assessment (EIA) of water resources development and related projects. This shall include experience in environmental impact and in the assessment of resettlement and compensation. He/she must have experience in the preparation of Environment Impact Assessment reports according to national guidelines. He/she will assist the international Environmental Specialist.

(11) **Sociologist/Public Participation Specialist:** should be a university graduate in social geography or spatial planning with not less than 8 years experience in the field of regional development planning, assessment of social impacts of water resources development and related projects and in public participation activities. Further he/she should have experience in identification of socio-economic problems related to settlement, preparation of resettlement plans and compensation arrangements. He/she will assist the international Environmental and WUA specialists.

## APPENDIX 2: ENDORSEMENT OF THE SELECTION OF THE DINGER BEREHA IRRIGATION PROJECT FOR FEASIBILITY STUDY

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The Federal Democratic Republic of Ethiopia
**Ministry of Water Resources**

ቁጥር MWR237/15/32
Ref. No.

ቀን 24 DEC 2008
Date

**BRL Ingenierie**
**Addis Ababa**

**Subject: Endorsement of the Selection of Dinger Bereha Irrigation Project for Feasibility Study**

It is to be recalled, as part of Eastern Nile Irrigation and Drainage Study Project that you had conducted preliminary study on Dinger Bereha and Nekemte Irrigation Projects and submitted the preliminary study results of these two projects to the Ministry.

Accordingly, the Ministry of Water Resource has thoroughly looked at the preliminary study report and accepted your recommendation based on the study you conducted and have decided that the feasibility study for Dinger Bereha irrigation project should be conducted.

With regards

Hayalsew Yilma
World Bank Financed Ethiopian-Nile Irrigation & Drainage Project Coordinator

**CC:**

- **Irrigation and Drainage Development Study Department**
- **Ethiopian Nile Irrigation and Drainage Project Coordination Office**
  **Ministry of Water Resource**
- **Eastern Nile Technical Regional Office (ENTRO)**
  **Addis Ababa**

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Please Quote our Ref. No. When Replying

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