Nile Basin Initiative

Eastern Nile Subsidiary Action Program (ENSAP)

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Eastern Nile Irrigation and Drainage Studies (ENIDS)

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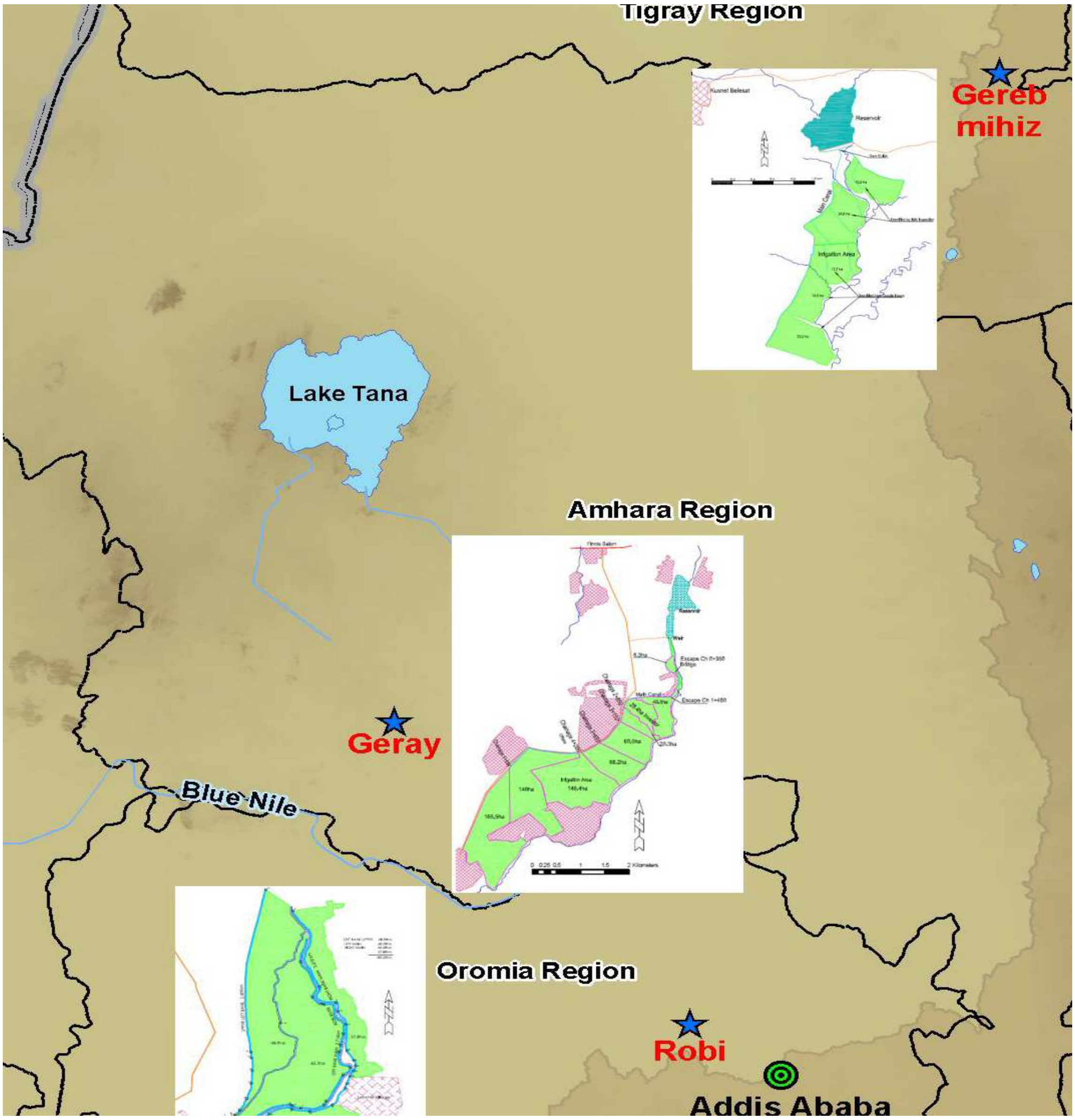
FINAL REPORT

Pilot Study on Improving Water Use Efficiency and Productivity on Selected Small Scale Irrigation Schemes in Ethiopia

September 2010



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EXECUTIVE SUMMARY

This pilot study, for improving water use efficiency and productivity on selected irrigation schemes in Ethiopia and Sudan is the outcome of the ENIDS Cooperative Regional Assessment Sub-study, which was tasked with enhancing the understanding of benefits and costs accruing to irrigation and drainage projects across the sub-basins countries. The study aimed to select a small sample of irrigation schemes throughout the Ethiopian sector of the sub-basin, study their peculiar problems and make cost effective recommendations for improving their performance. This report derives productivity indicators for three selected schemes in Amhara, Oromiya and Tigray Regions which were recommended by the regional Bureaux of Irrigation as poor performers, suffering from typical problems encountered by irrigation schemes in their region, and prepares an action plan for the rehabilitation and modernisation of each.

A summary of performance indicators were determined for each scheme. The overall average for Robi Scheme is 3.5, considered a good performer. Geray Scheme has a value of 2.23, considered fair and Gereb Mihiz a value of 2.15, also fair.

The Robi River Irrigation Scheme is a small (186 ha) run of river scheme in the humid highlands of Oromiya Region which was constructed in the late 1990s. It is situated on a fertile flood plain and has an intensive winter irrigated cropping pattern of maize, potatoes and vegetables. Management is carried out by farmers, organised by three WUSC at kebele level under the direction of wereda ARD water and agriculture staff. The headworks and main canals remain under the ownership and responsibility of the Bureau of Irrigation. The main problem of the scheme is water control. A diversion weir has control gates on both banks, but these are barely operational and need replacement. The main canals have little in the way of control structures and banks are eroded. One of the main problems is flood control as the summer flows flood the area and no cropping is achieved in summer. The upper left bank canal has been cut, eliminating 48.9 ha from irrigation. Present maintenance costs are high, as the scheme requires reconstruction of canals and drains each year. A combination of lack of technical expertise and lack of a wereda budget line for repair and maintenance means that the headworks and main canals are deteriorating and the scheme will return to an informal irrigation scheme once these are out of service. It will have difficulty competing for water with other informal irrigation schemes upstream. Solutions to the problems include building three dyke embankments, one left bank for 154 m, one right bank for 227 m, plus the repair of the upper left bank canal. The main weir abutments will be raised by 2.0 m to meet the height of the embankments. The entire length of the Robi River through the scheme, for 3.0 km. will be de-silted. With the canal repair, cropping intensity will increase and the scheme will return to its original design area. There will be a strengthening of the existing WUA to manage the O&M of the headworks and canal system. Fee collection will also be strengthened. The total costs of these works is US$ 378,002. This gives an FIRR of 40% and a CB ratio of 5.2.

The Geray Irrigation Scheme is the largest studied (618 ha) scheme representative of mid altitude humid climatic conditions in Amhara Region. It also represents the scheme with the greatest potential for improvement. It was built in 1983, and is also a run of river scheme with a masonry weir providing water to a right bank canal, running for about 5.3 km. There is a problem with headworks seepage. Cropping includes a high proportion of perennial crops including coffee and fruit, as well as maize and vegetables. The problems of this scheme are quite different from Robi River: there are sociological problems and a non-functioning WUC, caused by insecurity of rights to both land and water and difficulties between smallholder farmers and an investor who has recently opened a 28 ha farm in the command. There is evidence of inequity in water distribution. A large proportion of the scheme command has either never been irrigated or has gone out of irrigation. The proposed improvements included complete modernisation of structures by the introduction of downstream control regulation which will allow tail farmers to receive equitable supply of water. This is done by the use of an automatic diaphragm valve (ADV). The leak at the headworks will be repaired and all canal embankments will be rehabilitated. The existing organisations, the irrigation cooperative (IC) and the tertiary farmers groups (TFG) will be strengthened and handed responsibility for MOM of headworks and canal system. The total cost of these works is US$ 618,970 with an FIRR of 30% and CB ratio of 4.0.

The Gereb Mihaz scheme is very small (80 ha) and is representative of irrigation schemes operating in small semi-arid catchments in Tigray. Its problems are predominantly technical and concerned with the management of the catchment to reduce erosion and therefore the reduction of live storage in the dam, and the problem of managing the dam itself which is subject to aggressive sedimentation. The dam outlet is completely blocked with sediment and no longer works, and farmers are resorting to siphoning water over the dam wall to feed the main canal. Only about 18 ha of the scheme command is now being irrigated, and in this area winter maize and vegetables are grown. The rest of the area is under rainfed cropping of wheat, teff and barley in roughly equal proportions. There appear to be no serious problems will scheme management or supporting services, the local Farmers Association supports input supply through annual credit. Solutions proposed include constructing a formal well engineered siphon over the embankment capable of handling the full flow for the 80 ha. An HDPE pipe of 10" with a floating intake and valve on the outlet will suffice. For the sediment it is proposed to share a floating dredger with 7 other dams in the area, to pump the sediment over the dam wall and spread it over the farmers fields as fresh fertile soil in a level field to enhance productivity and irrigation performance. Dredging is the cheapest method of moving sediment. The catchment conservation efforts are to be maintained and increased, but major efforts are required to introduce conservation tillage farming techniques that will greatly reduce the erosion at source. Costs of these proposals are US$ 175,387 with an FIRR of 24% and CB ratio of 2.13.

Each of these three schemes was studied in some depth, through on-the-ground engineering studies, a Household Survey and institutional analysis through FGD. As a result, the team has been able to prepare performance indicators which are described in section 3 of this report. The performance indicators are helpful as an objective description of aspects of scheme functionality, and are sometimes useful to compare relative performance between schemes. As such they have value in scheme benchmarking and macro (regional) level performance assessment. But indicators are seldom diagnostic – they do not lead to an action plan for performance improvement. The action plan has to be prepared in the context of the local situation and make maximum use of local knowledge and the objectives of technical staff, irrigation managers and irrigators. The action plans for each of the schemes are described in section 5 (Robi River), 6 (Geray) and 7 (Gereb Mihiz). Each action plan descries the works necessary to enure the short term technical security of the scheme – flood control works in Robi, head works improvement and canal rehabilitation in Geray and dam de-sedimentation in Gereb Mihiz. The present cropping pattern and production are assessed and compared with potential production under maximum irrigation supply. Model farm budgets were prepared on the basis of a Household Survey of randomly selected farms in the scheme, and this assisted in the preparation of a cost benefit analysis for each scheme. A full institutional analysis was carried out. Modernisation – giving more control to downstream farmers – is only appropriate in the largest scheme, Geray, where little control at the water source exists. Instead, institutional studies focussed on identifying ways of establishing ownership and improving management of scheme resources.

The ultimate objective of each action plan for each scheme is to establish a sound irrigation infrastructure for which MOM can be met from water charges levied by a management organisation which is representative of both the interests of irrigators and long term scheme sustainability.

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ABBREVIATIONS

A_a	Cropped area
A_i	Initial cropped area
ADV	Automatic Diaphragm Valve
ARD	Agriculture & Rural Development
BCM	Billion Cubic Metes
BCR	Benefit Cost Ratio
BPI	Biomass productivity Index

BWR	Bureau of Water Resources
CAR	Cropped Area Ratio
CB	Cost Benefit
CBA	Cost Benefit Analysis
CBR	Cost Benefit Ratio
CRA	Cooperative Regional Assessment
CROPWAT	An FAO software program for irrigation design and monitoring
CWC	Crop water Consumption
CWD	Crop water Deficit
CWR	Crop Water Requirements
C_w	Cost of Irrigation Water
C_{tc}	Total Cost of Crop Production
$C_{o\&m}$	Cost of operation and maintenance
df	degrees of freedom
DA	Development Advisor
DPR	Delivery Performance Ratio
DR11	Dimension Ratio 11 (for PVC pipe classification)
^oC	degree Centigrade
EIRR	Economic Internal Rate of Return
EI	Efficiency of Infrastructure
ENIDS	Eastern Nile Irrigation and Drainage Studies
ENSAP	Eastern Nile Subsidiary Action Program
ENTRO	Eastern Nile Technical Regional Office
ETB	Ethiopian Birr
ETo	Reference Crop Evapotranspiration
EWUAP	Efficient Water Use for Agricultural Production
F	F statistic
F/C	Foreign Component
FGD	Focus Group Discussion
FIRR	Financial Internal Rate of Return
GDP	Gross Domestic Product
GPS	Global Positioning System
HDPE	High Density Poly Ethylene
ha	hectares
HP	Horse Power
I_c	Budget for Sustainable MOM
I_a	Actual budget income
I_s	Sustainable budget income
IAR	Irrigated Area Ratio
IC	Irrigation Cooperative
IRR	Internal Rate of Return
IWR	Irrigation Water Requirement
kcal	kilocalorie
km	Kilometer
km^2	Square Kilometer
l/s/m	liters per second per meter
L/C	Local Component
LP	Land productivity Index
LSI	Large Scale Irrigation
m^3	cubic meter
m^3/s	Cubic meters per second
MCM	Million Cubic Meters
$MJ/m^2/day$	million joules per square meter per day
mkcal	million kilo calories
mm	millimeter
MoWR	Ministry of Water Resources (Ethiopia)
MOM	Management Operation and Maintenance

MOM_FR	Management Operation and Maintenance Funding Ratio
NBI	Nile Basin Initiative
NELSAP	Nile Equatorial Lakes Subsidiary Action Program
O&M	Operation and Maintenance
OER	Official Exchange rate
pH	measure of acidity/alkalinity
ppm	parts per million
PN10	Nominal Pressure 10 bars
PIM	Participatory Irrigation Management
R^2	R square value used in regression
RWC	Relative Water Cost Indicator
SAP	Subsidiary Action Program
SCF	Standard Conversion Factor
SER	Shadow Exchange Rate
SERF	Shadow Foreign Exchange Factor
SVP	Shared Vision Programme
t	t statistic
t/ha	tons per hectare
TFG	Tertiary Farmers Group
TLU	Tropical Livestock Unit
V_a	Volume of Applied Water
WP	Water Productivity Index
WRM	Water Resource Management
WUA	Water User Association
WUE	Water use efficiency
WUO	Water User Organization
WUS	Water User School
WUSC	Water User Steering Committee
Y_c	Crop Yield

1 INTRODUCTION

1.1 Context of the Pilot Study

For the last decade, most countries in the Nile Basin had been classified as food insecure. All riparian countries have a limited capacity to absorb shocks such as drought and floods and high external prices. Production levels in all countries are lower than are needed to sustain their populations. Population growth is tending to outrun agricultural production, gains in which are based on crop area expansion rather than intensification though improved use of inputs. Water shortages remain in spite of efforts to recycle drainage water and reuse of treated wastewater. To meet these challenges, the Nile Basin Initiative (NBI) was established in 1999 by the ten Nile Riparian States[1] as a co-operative programme. A strategic action programme was developed to transform NBI's vision to action. This programme is being implemented through the Shared Vision Programme (SVP) and the Subsidiary Action Programme (SAP). As shown in Figure 1-1 Context of the Pilot Study, two sub-basin Subsidiary Action Programmes (SAP) have been initiated, covering respectively the Eastern Nile and the Nile Equatorial Lakes regions. One is Eastern Nile Subsidiary Action Programme (ENSAP) formed by Egypt, Ethiopia and Sudan and the other one is Nile Equatorial Lakes Subsidiary Action Programme (NELSAP) formed by Burundi, Democratic Republic of Congo, Egypt, Kenya, Rwanda, Sudan, Tanzania and Uganda. Eastern Nile Irrigation and Drainage Study (ENIDS) is one of the eight ENSAP projects that aims at contributing to the enhancement of food security, reduction of rural poverty, and more efficient water use in the region, with all associated beneficial effects on the environment. ENIDS has two components; i) An Engineering Sub-study; and ii) A Cooperative Regional Assessment Sub-study The Cooperative Regional Assessment (CRA) is geared at enhancing the understanding of benefits and costs accruing to irrigation and drainage projects across the sub-basins countries. The CRA will propose guidelines for the selection of such projects having regional interest or implications and will develop a methodology to render explicit, using actual data, the incremental benefits of cooperation and the distribution of the costs and benefits of those projects.

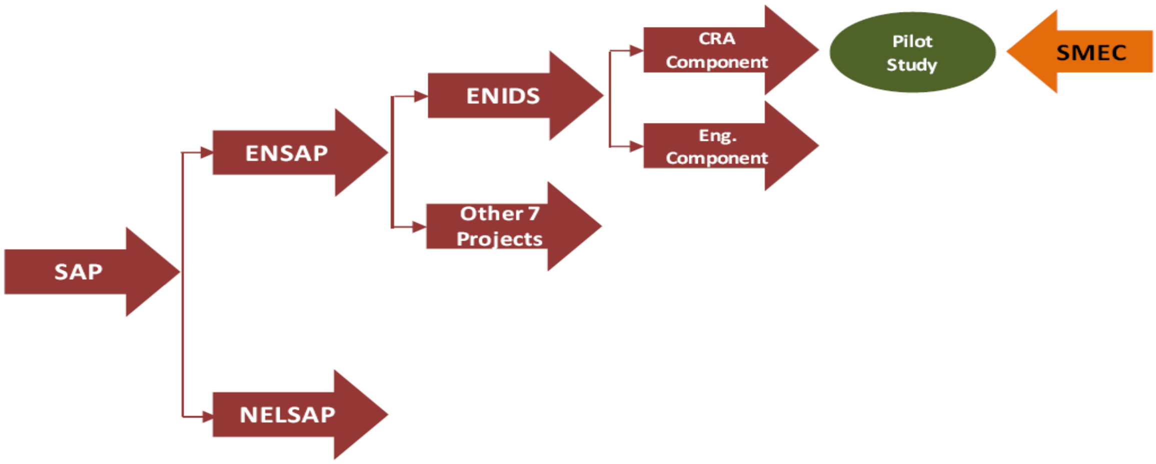


Figure 1-1 Context of the Pilot Study

This pilot study, for improving water use efficiency and productivity on selected irrigation schemes in Ethiopia and Sudan is the outcome of the CRA study.

One of the projects under the SVP is the Efficient Water Use for Agricultural Production (EWUAP) which studied Large Scale Irrigation (LSI) schemes in the Nile Basin. This study derived performance indicators based on remote sensing and evaluated them across large scale irrigation schemes in the basin. Unfortunately the project was unable to obtain much in the way of actual field data and had to rely on remote

[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.

sensing technology to perform their analysis. The performance indicators derived need to be supplemented and compared with more conventional performance indicators based on detailed study at field level.

1.2 Pilot Study Description

Agriculture plays a major role in the lives and livelihoods of most households in the Nile Basin countries and contributes significantly to overall economic growth and Gross Domestic Product (GDP). Irrigation is considered an effective vehicle to boost rural development and provide jobs to disadvantaged people. There are now approximately 180 million people living in the Nile Basin, and food security is an issue of growing concern.

There is approximately 5 million ha of irrigated land in the Nile basin. The inflow of water from the many tributaries and main rivers of the Nile system (Kagera, White Nile, Sobat, Blue Nile, Atbara) is highly variable. Streamflow by default increases from the upperstream catchments to the central part of the basin. The longer term average discharge at the confluence of Khartoum is approximately 100 BCM/yr. Due to river abstractions, riparian vegetation water use, seepage losses and evaporation losses, the river looses water on its downstream course. The mean annual discharge of the main Nile measured at Dongola in Northern Sudan is 87 BCM (Conway, 2005). The longer term inflow into Lake Nasser is estimated to be 84 BCM/yr. An amount of 10 BCM/yr is evaporated from Lake Nasser and the remaining 74 BCM is shared among Egypt (55.5 BCM) and Sudan (18.5 BCM).

Policies of Egypt and Sudan combined massive irrigation investments (including the construction of the Aswan dam), promotion of Green Revolution technology packages (selected seeds, fertilizers and pesticides) and accompanying measures aiming at facilitating farmers' adoption of these technologies. In addition Egypt went through two successive agrarian reforms in 1952 and 1961 that expropriated the large estates in various ways and redistributed the land to smallholder farmers.

These policies were strongly sustained by the Nile Water Agreement that Egypt and Sudan signed on 8th November 1959. According to the Agreement, out of the average annual flow of the Nile at Aswan of 84 BCM, Egypt has an annual guarantee of 55.5 BCM and Sudan 18.5 BCM. The remaining 10 BCM are the estimated water losses through evaporation in the reservoir of the High Aswan dam. The 1959 Agreement made possible the immediate construction of the High Aswan Dam (1962-1970), the construction of the Roseires dam (1961 – 1966) on the Blue Nile in Sudan, the Managil extension of the Gezira irrigation scheme. The Construction of the Aswan dam also led to the construction of Khashm El Girba dam and the New Halfa irrigation scheme (180,000 ha) located on the upper Atbara River in Eastern Sudan where the inhabitants of the Sudanese Nubia were resettled after the inundation of their land. In Egypt, the completion of Aswan dam provided over-years storage and flood control, which supplied agriculture with steady and until recently plentiful irrigation water. Thus the High Aswan dam offered the possibility of irrigation expansion and substantial rise in the productivity of irrigated agriculture in Egypt and Sudan.

1.3 Constraints to Irrigation Productivity in Ethiopia

Ethiopian irrigation schemes are gravity fed and involve either river diversions or dams. Water is distributed in earthen canals. Most of the schemes are poorly equipped with water control and measurement structures. Manually operated gates are used for water partition. Most traditional irrigation schemes have to be re-built each year after the rains and flood that destroy intakes and canal networks. Field irrigation methods are un-levelled basins or short furrows in small scale irrigation scheme. Large estates use long furrows or basin irrigation; some of them are equipped with sprinkler irrigation (i.e. Finchaa Sugar Estate). Generally, no drainage system is built on small scale irrigation schemes that have to rely on natural drainage.

Yields obtained by farmers in small scale irrigation schemes are low, for instance less than 2 tons/ha for maize versus a reasonable benchmark of 6 tons/ha. Yields vary considerably between irrigation schemes and between farmers within one irrigation scheme. Main factors affecting yields are:

- Absence of extension service for providing support for managing small scale irrigation systems;
- Poor maintenance and degradation of irrigation canals

- Difficulty in sourcing inputs: high cost of inputs, absence of credit, lack or shortage of inputs in due time for planting;
- High maintenance labour requirement and difficulty in water distribution due to sedimentation in canals and, for traditional schemes, to repair locally made scheme intakes.
- Low selling prices of products at peak supply period;
- Poor market access due to distance and poor road status.

Traditional irrigation schemes are managed by community-based committees often led by elected leaders, “The Water Fathers”; traditional committees are in charge of operation and maintenance activities and conflict resolution. Modern irrigation schemes are managed by irrigation cooperatives, which are meant to combine O&M and marketing activities. There is also a growing consensus among irrigation stakeholders in Ethiopia on the fact that mixing up O&M and marketing activities in one organization (an irrigation cooperative) increases the difficulty of irrigation management and creates confusion amongst irrigating farmers. It is more and more widely agreed that organizations such as Water Users Associations (WUAs) are the most appropriate institutions to deal with the “forced cooperation” that O&M implies, and cooperatives should remain voluntary-based farmers’ organizations. Ethiopia Irrigation Policy wants “to promote the establishment of appropriate institutions and develop human capacity in irrigation engineering and management”; however there is currently no legal status for Water Users Associations in Ethiopia.

2 OROMIYA REGION – ROBI RIVER SCHEME

2.1 OROMIYA REGION – ROBI RIVER SCHEME

2.1.1 Background – Brief History

Robi River Scheme is constructed in the Met Robi Wareda, in West Shoa Zone. It is located at 38^{o} 18.1' E and 9^{o} 21.8' N.

Constructed in1997, this scheme irrigates 180 ha. A diversion weir has control gates on both banks, but these are barely operational and need replacement. The main canals have little control structures and banks are eroded. One of the main problems is flood control as the summer flows flood the area and no cropping is achieved in summer. During construction of the weir, a coffer dam was constructed and the river diverted around the construction site. When the diversion course was re-filled, the quality of compaction was insufficient and this was breached during floods some years later. The breach of the coffer dam caused the river to find a new course, which broke the upper left bank main canal, isolating the entire area of 46.9 ha.

The villages with assistance from the Kabele have made attempts to repair these breaches, but they lack the technical expertise to complete the work. Their repairs are holding during the dry season, but will be washed away during the next floods. The main problem with the system is there are no flood control dykes on either side of the diversion weir and the main river course looks silted up. So when the river floods, it overtops the banks and easily enters the new river course.

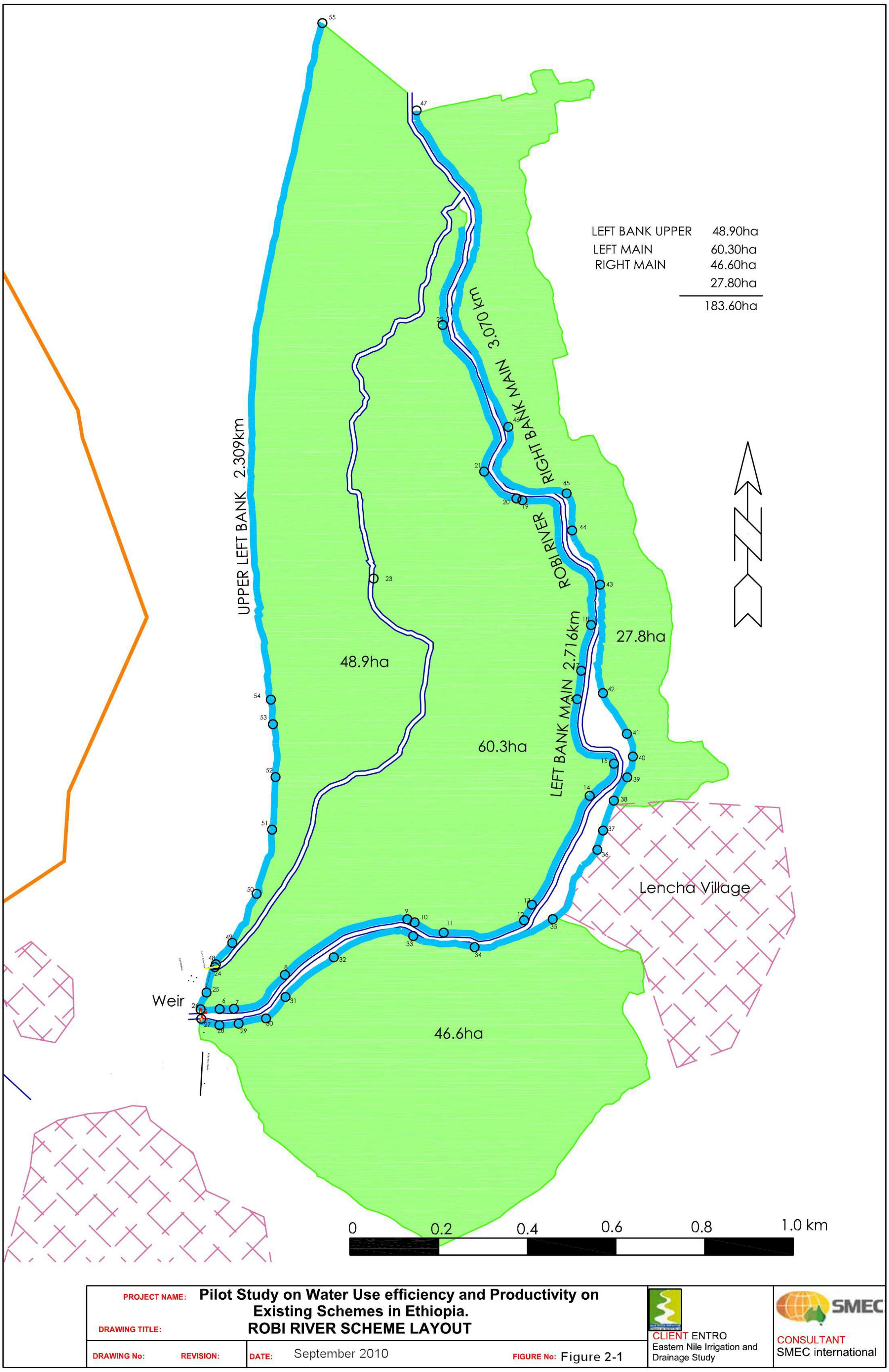
The scheme has three canals, upper left, left main and right main canals. The total gross area commanded is 181.6 ha. The Left main canal serves an island created by the new river course. The upper left and right main canals run for 2.3 km and 3.0 km respectively, but both run for much longer and are used when sufficient water is available. Table 2-1 gives the data for canals and command areas. The right bank canal is split by Lencha village.

Table 2-1 Robi River Irrigation Infrastructure Data

Canal	Length km	Command Gross area ha
Upper Left	2.309	46.9
Main Left	2.716	60.3
Main Right	3.070	46.6
		27.8
	Total	181.6

The layout of the scheme is shown in Figure 2-1.

Figure 2-1 Layout of Robi River Scheme



2.1.2 Climate of Robi River

Table 2-2 Climate Data for Robi River Scheme

Country	**ETHIOPIA**		Station	**AMBO**	Altitude	**2080m**	
Month	Min Temp	Max Temp	Humidity	Wind	Sunshine	Radiation	ETo
	°C	°C	%	km/day	hours	MJ/m²/day	mm/day
January	11.2	26	51	192	8.7	20.4	4.26
February	12.3	25.9	50	207	7.9	20.5	4.55
March	12.8	26.2	46	194	7.7	21.2	4.82
April	12.8	25.7	54	175	7	20.3	4.45
May	12.1	25.5	55	141	7.5	20.5	4.27
June	11.6	22.9	69	99	5.4	17	3.31
July	12.1	21.2	73	82	3.6	14.5	2.82
August	11.8	21.8	77	73	3.7	14.9	2.84
September	11	22.9	74	77	5.3	17.4	3.2
October	10.4	24.5	59	126	9	22.3	4.09
November	10.2	24.9	56	170	9.2	21.3	4.07
December	10.7	25.2	51	201	8.6	19.8	4.12
Average	11.6	24.4	60	145	7	19.2	3.9

2.2 PERFORMANCE INDICATORS

2.2.1 Water and Engineering Indicators

In Robi River no records of flows or other irrigation factors are taken. However, some assessment has been made on the basis of the inspections in the field. A structural indicator, Effectivity of Infrastructure (EI) can be calculated from the inspection made. There are 14 structure observed in the scheme, of which 8 are operational and in working order. This gives an EI of 0.57.

The Irrigated Area Ratio is calculated from the actual are irrigated compared to the measured irrigated area from GPS measurements. There measurements are gross so have been reduced by 5% to obtain a net irrigated area. The irrigated area is different to the cropped are, which can be higher when double cropping is practised, like in Robi River. Below is the estimated IAR:

Scheme	Gross Area	Net Area	Irrigated Area	IAR
	ha	ha	ha	
Robi River	183.6	174.4	134.7	0.77
Geray	674.4	640.7	238.0	0.37
Gereb Mihiz	94.7	90.0	18.0	0.20

In two of the schemes, irrigation was taking place and flows could be estimated. No flows were observed in Robi River, as irrigation was not taking place as rain had recently fallen. The flow is used in a Delivery Performance Ratio calculation, but this is rather crude. The intended flow is taken as the future water requirement, as an indicator. Below is the estimated DPR:

Scheme	Measured Flow	Intended Flow	DPR
	l/s	ha	
Robi River			
Geray	150	585	0.26
Gereb Mihiz	10	68.0	0.15

2.2.2 Institutional Indicators

Performance indicators for institutional aspects of the three irrigation schemes, namely: Robi; Geray; and Gereb Mihiz are focused on institutions involved in the: management and operation and maintenance of the irrigation scheme; fee collection and extension services provided to the water users of the irrigation scheme.

In assessing the performance of the institutions involved, the following variables and methodology for data gathering were used:

Variables

a. Mandate/Functions of the institution

b. Organization, System and Procedures for MOM, O&M and extension services

c. Fee Collection (components, amount and efficiency)

d. Perception on efficiency of the organization, system and procedures

Methodology and Data Gathering

a. Household Survey

b. Direct on-site observation

c. Semi-Structured Interviews with water users and relevant officials and staff at regional, zonal, woreda and kebele levels.

In line with the objectives of the pilot study on improving Water Use Efficiency, the institutional performance indicators used in the study are presented in the following Table 2-3. It shows the performance indicators with the corresponding performance assessment for the three irrigation schemes.

Table 2-3: Robi Irrigation Scheme Performance Indicators

No.	Performance Indicators	Performance Assessment
1.	Functionality of Government Institutions e.g. BWR and ARD	• Performance assessment of BWR at Woreda level is satisfactory (3). BWR is perceived helpful by the Kebele and WUA Chairman in the repair and maintenance needs of the scheme. However, there seems to be weak guidance to the WUA on MOM, O&M planning and budgeting. In addition, collection of water charge has not been introduced yet. • Performance assessment of ARD staff at Woreda level and the DAs is perceived as satisfactory. They work closely with BWR and Kebele Chairman in maintenance activities.
2.	Functionality of Farmers' Institutions e.g. WUA and Savings and Credit Company	• Performance assessment of WUA is fair (2). It has no legal personality yet and does not collect water charge. At present, there is weak implementation of its by-laws and lack of cohesiveness among members. The WUA bookkeeping is poor. • The Oromia Savings and Credit Company at the Woreda level is performing well. It has excellent repayment rate. It provides credit to small low-income farmers.
No.	**Performance Indicators**	**Performance Assessment**
3.	Adequacy and effectiveness of Extension Services	The conclusion reached in the household survey conducted is that the extension and training offered by ARD in the area had reached the sampled households and was appreciated. The subject matter offered is generally appropriate, but there are some notable gaps – for example horticulture extension and training was confined to improved potato varieties. Irrigation techniques are barely touched. Performance assessment is satisfactory (3).

Note: Scale of 1-5 with 1= Poor 2= Fair=; 3=Satisfactory; 4= Good; 5= Very Good

Key Institutional Issues in Robi Scheme

- One of the 3 WUSCs is at present inactive and not participating actively in the WUA's operation and maintenance activities due to internal conflict (not related to WUA) within the sub-kebele. This greatly jeopardized the overall WUA functionality rendering the WUA officers weak in implementing its policies and regulations on water distribution and maintenance.
- The diversion of the river from its natural course resulting to two river courses which affected water availability in the irrigated area. Majority of the farmers have complained on the water shortage brought about by this situation but some farmers benefited more from this. This somehow contributed also in the difficulties of the WUA officers to implement its rules and regulations with regard to water distribution.
- There is no annual O&M plan and budget prepared for Robi River Scheme by BWR and WUA. According to the acting Head of BWR, he prepares bill of quantity whenever a major repair and/or maintenance work is required in the scheme. It can be concluded from this information that preventive maintenance is not performed in the scheme. Consequently, no annual budget is allocated for the operation and maintenance. Only routine canal and drain maintenance done by the WUA once a year is undertaken with no monetary compensation.

2.2.3 Economic Indicators

2.2.3.1 Relative Water Cost

The relative water cost indicator (*RWC*) is calculated using the formula:

$$RWC = \frac{C_w}{C_{tc}}$$

where C_w is the total cost of irrigation water and C_{tc} is the total cost of production of crops. RWC is the cost of providing water as percentage of the total cost of crop production.

RWC for Robi River has been calculated as 0.40. This is a relatively high ratio: water is expensive relative to other inputs because the scheme infrastructure is damaged each year during aggressive floods, so farmers must spend valuable time re-excavating and cleaning canals and drains.

Table 2-4 The Relative Water Cost Indicator

Scheme	Key Parameters		Relative Water Cost Indicator
	Total Scheme Production Cost ETB	Scheme MOM and field irrigation cost, ETB	
Robi River	1,286,724	519,223	0.40
Geray	1,193,062	162,045	0.14
Gereb Mihiz	344,423	28,879	0.08

2.2.3.2 Operation and Maintenance Fraction

The operation and maintenance fraction (O&M) is calculated using the formula:

$$O\&M = \frac{C_{o\&m}}{I_S}$$

where $C_{o\&m}$ is the cost of operation and maintenance and I_s is the budget for sustainable MOM. The O&M fraction is the cost of O&M proportional to the total cost MOM cost.

One of the indicators of a well run business is low management overhead costs, and an efficient water user association would be expected to have a fraction of about 0.90, depending on its size. For Robi River the O&M fraction has been calculated as 0.98. This is a strikingly high value, but suggests that farmers are working virtually without management, which is likely to be inefficient. Inefficiency is most obvious in the necessity to re-excavate canals and drains each year after flooding. The future expected O&M fraction is also shown in Table 2-5, taking into account full maintenance costs on the structures proposed, and the irrigation management structure expected.

Table 2-5 The O&M Fraction

Scheme	Key Parameters			O&M Fraction	Future Expected O&M Fraction
	Scheme MOM ETB/ha	Scheme Management ETB/ha	Scheme O&M ETB/ha		
Robi River	564	11	553	0.98	0.93
Geray	255	65	190	0.75	0.87
Gereb Mihiz	181	48	133	0.73	0.96

2.2.3.3 MOM Funding Ratio

The MOM funding ratio (*MOM_FR*) is calculated using the formula:

$$MOM\_FR = \frac{I_a}{I_S}$$

where I_a is actual annual income and I_s is the budget for sustainable MOM. The ratio measures the impact of the cost of water on farmer's incomes. It is calculated first using present MOM. The method used was to compare the estimated net household income with the sample of the Household Survey for each scheme and calculate the MOM payment at current rates that would be required on the irrigated area of each – assuming MOM costs were distributed pro rata to irrigated area. The ratio is also calculated for future expected MOM against the future expected farm budget.

For Robi River the present MOM funding ratio has been calculated as 0.05, implying that if the farmer paid cash to the WUA for irrigation services then the average farm must allocate 5% of its net annual income to irrigation charges for the next year. This is a reasonable proportion. However, the cost of irrigation is mostly incurred in voluntary labour. As a proportion of estimated future net farm income the MOM ratio is expected to be about the same. This is also a reasonable ratio, but especially as it includes flood protection, the irrigation delivery would be about eight times greater, and the area served would be 11% greater. Future MOM would be a cash payment, payable according to the area of different crops irrigated.

Table 2-6 The MOM Funding Ratio

Scheme	Key Parameters			Present MOM Funding Ratio	Future Expected MOM funding Ratio
	Total Net Income of HHS sample, ETB pa	Net irrigable area of HHS sample, ha	MOM Requirement of HHS sample, ETB		
Robi River	264,319	23	12,904	5%	5%
Geray	78,783	79	20,111	26%	5%
Gereb Mihiz	73,001	7	1,204	2%	10%

2.2.4 Environmental Indicators

Sustainability indicators are classified under environmental indicators in Bos et al (2005) and are intended to indicate trends in the proportion of the command irrigated, and the tonnage of biomass produced per unit volume of water and area of land.

2.2.4.1 Cropped Area Ratio

The cropped area ratio (*CAR*) is calculated using the formula:

$$CAR = \frac{A_a}{A_I}$$

where A_a is average cropped area and A_I is the initial total irrigable area. CAR is a measure of the intensity of use of the command area. Table 2-7 summarises the calculation for each of the three schemes. For Robi River the gross cropped area of the scheme in 2009/10 was about 232 ha and the designed net irrigable command is 175 ha, so the CAR in 2009/10 = 1.32. In 2002 however, gross cropped area of the scheme in 2009/10 was only about 182 ha, a CAR of 1.04. During the period the CAR increased consistently because of the increased proportion of double cropped vegetables in the cropping pattern.

Table 2-7 The Cropped Area Ratio

Scheme	Key Parameters		Cropped Area Ratio
	Gross cropped ha 2009/10	Designed net irrigable ha	
Robi River	232	175	1.32
Geray	238	618	0.39
Gereb Mihiz	18	80	0.22

2.2.4.2 Water Productivity Indicator

The water productivity indicator (*WP*) is calculated using the formula:

$$WP = \frac{Y_c(kg)}{V_a(m^3)}$$

where Y_c is the crop yield in kilograms and V_a is the application of water in m^3.

The land productivity indicator (*LP*) is similar, and calculated using the formula:

$$LP = \frac{Y_c}{A_a}$$

where Y_c is the crop yield in kilograms and A_a is the net scheme area in hectares. The indicator is simply aggregated tons of crop production divided by scheme area.

The water productivity indicator requires an estimate of present irrigation practice. The Household Survey requested farmers to report the frequency, depth and duration of irrigation for each plot and crop they irrigated. The weakness of this approach is that the information is based on recall – though farmers generally have good memories. The strength of the method is that data is compiled on a large number of plots (Robi 224 plots of which about 180 were irrigated); Geray 158 plots of which about 40 were irrigated and Gereb Mihiz 106 plots of which 32 were irrigated). The variance of the data reduces with the size of the sample. Also the data is not only plot specific but also crop specific, as land use was recorded for each plot, including planting and harvest dates. CROPWAT8 was then used to estimate the impact of the reported applications on the reported crops, and build up a scheme level estimate of use based on the reported cropping pattern.

Water and land productivity indicators are shown for Robi River, Geray and Gereb Mihiz Irrigation schemes in Table 2-8. In Robi River the land productivity indicator is 10,570 kg/ha which is high, and attributed to a present high cropping intensity dominated by moderately high yielding potato and vegetables. The Water Productivity index is also high, 14 kg per m^3. However, as well as high yields, the scheme apparently has low present water deliveries. It does have the advantage of a lower irrigation requirement due to the short dry season, and may also benefit from capillary rise from groundwater table within two or three metres in the winter months.

Table 2-8 Water and Land Productivity Indicators

Scheme	Key Parameters				Land productivity kg/ha	Water Productivity kg/m³
	Irrigated gross ha	Non irrigated ha	Total crop production, quintals	Water application, m³		
Robi River	231	0	19,558	140,101	10,572	13.96
Geray	156	82	4,506	535,249	2,359	0.84
Gereb Mihiz	18	62	1,278	19,419	1,598	6.58

2.2.4.3 Biomass Productivity Indicator

Biomass productivity is calculated in a similar way to the land and water productivity indices, but includes the weight of crop residues as well as main crop in the calculation. There are measurement difficulties here, because crop and residue yields may be measured with different water contents. Also residue yields are not well known; they vary considerably depending on crop yield and management and really need to be measured directly. With this in mind, the estimates given in Table 2-9 should be considered indicative only.

Biomass production per ha has risen steadily in the Robi scheme from about 3,250 kg/ha in 2002 to around 15,600 kg/ha in 2009, partly because of increasing crop intensification, but also because of the increasing proportion of higher yielding vegetable and potato crops. The proportion of main crop in the total biomass has also risen for the same reason. The biomass production per unit of water in 2009 is estimated as 25.7 kg per m^3. This is very high. The scheme is located on a flood plain and although water table is apparently at a depth of several metres in the dry season, plants may benefit from capillary rise. Further, the scheme is situated at a high altitude and rainfall is both higher and more frequent than at the other sites investigated in this study.

Table 2-9 Biomass Productivity Indicators

Scheme	Key Parameters				Biomass Productivity, kg/ha	Biomass Productivity, kg/m³
	Main crop quintals/ha	Residues quintals/ha	Net scheme area, ha	Water application, m³		
Robi River	120	35	89	140,101	15,556	25.70
Geray	7,553	3,762	191	535,249	5,924	2.11
Gereb Mihiz	1,249	647	80	19,419	2,370	9.76

2.2.5 Summary of Performance Indicators

A summary of the performance indicators for all schemes is given in Table 2-10.

Table 2-10 Summary of Performance Indicators

Performance Indicators		Robi		Geray		Gereb Mihiz	
		Value	Rate	Value	Rate	Value	Rate
Irrigated Area Ratio	IAR	0.77	3	0.37	1	0.20	1
Delivery Performance Ratio	DPR	-		0.26	1	0.15	1
Function BWR/ARD			3		3		2
Function FU/WUA			2		4		2
Function Extension			3		3		2
Relative Water Cost	RWC	0.40	1	0.14	2	0.08	3
O&M Fraction	O&M F	0.98	5	0.75	3	0.73	3
MOM Funding Ratio	MOM R	0.05	1	0.26	4	0.02	1
Crop Area Ratio	CAR	1.32	4	0.39	1	0.22	1
Land Productivity	BIO kg/ha	10,572	5	2,359	1	1,598	1
Water Productivity	BWP kg/m³	13.92	5	0.84	2	6.58	5
Biomass Land Productivity	BIO kg/ha	15,556	5	5,924	2	2,370	2
Biomass Water Productivity	BWP kg/m³	25.70	5	2.11	2	9.76	4
Scheme Average Score			3.50		2.23		2.15

The average overall indicator for Robi is 3.5, which is considered a good indicator.

For the details of the performance rating for the indicators, see Table 5-2.

2.3 DETAILED ACTION PLAN

2.3.1 Weir Raising

Robi River Scheme is in a position that part of the irrigation command is cut off, and this needs to be repaired. This can be done by building a closure dyke across the gully cut by the new channel of the river. But this would not be sufficient to maintain its sustainability as the main river course still overtops its banks. This overtopping is reducing the summer command area considerably, so an integrated approach is required for the flooding solution. The weir crest level is built only 0.77 m below the surrounding ground level, and this is not sufficient to contain the flood flows. So the abutments of the weir need to be raised on both banks, left and right, and this higher level must be carried right up to the adjacent ground, 154 m on left bank and 227 m on the right bank. To maintain this level, embankments will be built for these lengths and height. Once the flood is not controlled, all the water will pass over the weir crest. The Robi River section downstream of the weir has silted up over the years and needs to be de-silted to contain the flood flows. These are described below.

In order to construct the embankment training works, the present weir abutment will have to be raised by 2.0 m and the embankment filled in behind to contain the river. The new height of the weir abutment will mean the 4 gates will have to be replaced, which are damaged anyway. The new gates must be strong and the gate leaf should be reinforced to stop buckling. The left and right canals will be buried for the start reach, so culverts will be constructed before earth filling. This work is shown in Appendix C, Figures C1 to C3.

2.3.2 Dyke Embankment Training Works

The exact extent of floods was indicated by farmers at the weir site. This indicated the a flood dyke should be in the order of 2,465 m amsl, but this needed to be checked. Flood data was obtained for an adjacent catchment 50 km to the south east, at Chancho. Here 28 years of daily flows are available. These were analysed and the 1:25 year flood computed. This was then transposed to the Robi catchment to give an estimated flood of 38 m^3/s. These details are given in Appendix C. The calculations show that this 1:25 year flood would reach a height of 2,464 m. So the designed bank level of 2,465 m would give a 1.0 m freeboard during this flood.

Three separate dykes will be built, one on the left bank, one on the right bank and one to repair the breached canal The location of each dyke is shown in Figure C1. Where the embankment crosses the new river course, special attention is required to create an effective closure. The design across this reach will be made wider and deeper, to a depth of 2.0 m and width of 7.0 m. This should be backfilled with a clay material. The crest elevation of the training dykes is 2,465 m amsl. The height of the upper left canal repair is 2,462.5 m amsl. The left bank is 154 m long and right one 227 m. The average height of embankment is 3.6 m with the maximum being 5.0 m in the new incised river section.

2.3.3 River De-silting Works

The Robi River annually overtops its banks and floods much of the irrigated area. By de-silting the river for its length of the scheme, this flooding can be alleviated.

The maximum design flood was estimated as 38 m^3/s and the section to accommodate this flow was designed. Bed slopes were estimated as 0.00196 upstream and 0.00267 downstream of the weir. The design section has been determined with a bed width of 4.0 m, side slope of 1:1.5, depth of 2.5 m. Using a Manning coefficient of 0.04, the velocity is 1.57 m/s which on the high side but acceptable for short durations. The spoil from the de-silting will be compacted on the banks to create a flood bund and the side of the main canals. The height of these bunds will vary between 0.8 m and 1.5 m, depending on the space available for this material. The design section is shown in Figure C3.

2.3.4 Operation of Water Delivery

The controls on the main canals consist of masonry structures with an outlet opening size of 0.2 m. Although there is provision for gates in these structures, none were supplied. Farmers have mostly ignored these structures and cut the canal banks wherever they need. There are also a few masonry drop structures, one of which has been bypassed. The study has not recommended any change to this system as the level of control is low and measurement is non existent. The installation of measuring weirs on both left and right bank canals will be done as a first action. As farmers take more control of the water and WUO are set up, this aspect of water management will become more important. Until this level is reached, no further measures are recommended.

2.3.5 On-Farm Irrigation Practise

A major limitation to productivity in the project is the aspect of irrigation cultural practises. In all cases none of the crops were planted in rows with effective ridges. This means that all irrigation is by uncontrolled flooding. Farmers need to be trained to plant in furrows and all irrigation water should be run down furrows in a short time to reduce over-watering. This is the only basic improvement identified for this aspect.

Other improved methods of irrigation like drip or mini-sprinkler are too expensive to be recommended at this stage. Once farmers are trained in effective flood irrigation methods there will be an increase in productivity and hence income increase. This will allow the situation of introducing mechanical irrigation to be considered in the future.

2.3.6 Cropping Pattern

The estimate of the present cropping of the scheme (185 net ha) was based on plot level data from farms sampled in the household survey and generalised into a model farm cropping pattern. There are about 235 model farms in the present scheme area (compared to 266 actual irrigators). With project, an additional 20 ha can be irrigated, which it is assumed 25 additional farm households can development and irrigate. The present gross cropped area and cropping intensity are shown in Table 2-11. The present benefit from the without project cropping pattern is given below in Table 2-14.

The with project cropping pattern is also shown in Table 2-11. It is simple, based on maize, potatoes and vegetables (onions was taken as representative). It was introduced into CROPWAT 8 to derive with project CWR. The intention of the project is to provide flood protection to enable summer cropping (with supplementary irrigation) as well as rehabilitate and modernise the existing winter irrigation system.

Table 2-11 Present and Future With Project Cropping Pattern, ha

	without project irrigated area			with project irrigated area		
	wet	dry	total	wet	dry	total
Winter maize	0	139	139	0	144	144
Summer maize	0	0	0	164	0	
Potato	0	48	48	31	82	113
Vegetables	0	44	44	10	41	51
Gross irrigated area	0	231	231	205	267	308
Cropping intensity	0%	125%	125%	100%	130%	150%

Month	Dry season					Rainy season					Dry season		% area
Crop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Potato													15
Maize													80
Vegetable													5
Potato													20
Maize													70
Vegetable													10

Solid cell color = Duration of crop in the field   Red color= Duration of irrigation

The irrigation crop water requirements have been worked out for the with-project cropping pattern, presented below in Table 2-12.

Table 2-12 Robi River Crop Water Requirements

Robi Scheme	Met. Station : **Ambo**											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation deficit												
1. MAIZE (Grain)									27.8	14.9		
2. Potato									16.6	64.6		
3. Small Vegetables									0.2			
4. Potato	101.3	106.6	104.5	25.1								63.1
5. MAIZE (Grain)	123.3	141.5	90.0									39.6
6. Small Vegetables	131.0	124.5	18.4									95.3
Net scheme irr.req.												
in mm/day	3.9	4.7	2.8	0.2					0.8	0.7		1.6
in mm/month	119.6	132.8	85.8	5.0					24.8	21.6		49.8
in l/s/h	0.5	0.6	0.3	0.0					0.1	0.1		0.2
Irrigated area (% of total area)	100	100	100	20					100	95		100
Irr.req. for actual area (l/s/h)	0.45	0.55	0.32	0.10					0.10	0.08		0.19
at Efficiency of %	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Gross Irr.req. for area (l/s/h)	0.64	0.79	0.46	0.14					0.14	0.11		0.27
Mm^3/ha/day	55.5	67.9	39.5	12.3					12.3	9.9		23.5
Gross irrigated area ha	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0
Gross Irr.req. (l/s)	115.7	141.4	82.3	5.1					25.7	19.5		48.9

2.3.7 Institutional Strengthening

2.3.7.1 Scheme Organisation

It is recommended that BWR will remain responsible for major repairs/maintenance works (when needed) in the headwork and main canal system for at least one year after the proposed improvement works to restore functionality of Robi Scheme has been implemented. However, responsibility for preventive and routine maintenance in the headwork and main canal level will remain with the WUA after the improvement works. It is suggested that functionality of the existing WUCs be evaluated and develop the capacity of these WUCs to manage O&M of the headwork and main canal system: one

WUC will be assigned the head works and 2 WUCs main canal system, one for each main canal. With regard to the MOM of the secondary unit, formation and capacity building of 2 sub-WUCs are proposed. There will be 4 person-members in each sub-WUC who will oversee and manage O&M of the secondary canals in the scheme. Finally, it suggested that the WUA will also form and develop the capacity of 3 Tertiary Farmers' Groups (TFGs) to oversee and manage O&M of the tertiary Unit. Each TFG will consist of 3 persons. Aside from the O&M tasks to be performed by the WUA at various levels of the scheme, the WUA should fix water charge for the use of the scheme after its improvement. The amount of water charge proposed by the study will be presented and discussed in the WUS programme. A fee collector is proposed to be appointed by the WUA and can be paid on commission basis for this responsibility.

In addition, there are a number of general organisational issues common to all three schemes. They are described here under the Robi River Scheme and referred to in the institutional sections for Geray (section 3.3.5) and Gereb Mihiz (section 4.3.6).

2.3.7.2 Social Mobilisation

The Robi River scheme strongly needs the deployment of an experienced and well trained Social Mobilizer who can conduct an in-depth evaluation of the WUO functionality and help in strengthening its functionality and at the same time further raise the level of awareness of the water users regarding water related and productivity issues and motivate them to actively get involved in addressing these. It is strongly recommended that the DAs and Water Technicians be closely involved in the activities to be initiated by the Social Mobilizer in order to enhance their mobilization and organizing skill so that when the Social Mobilizer moves out of the area, they can continue the work she/he started in strengthening functionality of the WUO.

Specific to Robi Scheme, more in-depth social investigation on the internal conflict existing within one sub-kebele covered by the WUA has to be initiated by the DA of ARD with the involvement of the community elders, Kebele Chairman and WUA officers.

Detailed description of the qualifications, duties and responsibilities of the Social Mobilizer and the suggested steps in strengthening the WUO are discussed in the Appendices of this report.

2.3.7.3 Legal Personality for the WUA

When groups of individuals are expected to carry-out an important task in an organized manner on a long-term basis, their organization needs clear societal recognition. One means of conveying such recognition is for the group to exist as a legal entity. The WUA in Robi River Scheme does not have legal personality and as such it will be difficult to implement fully their tasks and functions in the management of O&M as well as carry-out their operation and maintenance responsibility. Moreover, based on the Philippines experience on Water Users Associations, WUAs need the authority and ability to make independent decisions, collect and manage sufficient resources, appoint staff, establish and enforce rules, resolve conflicts (in accordance with local norms), and act in their own interests etc, rather than depend on external sources or influences.

Legally, BWR and/or ARD should hand over a completed irrigation scheme for O&M to a users' organization which has legal personality. Signing any Memorandum of Agreement between parties necessitates that the parties involved are legal entities.

It is therefore strongly recommended that the should be transformed into a legal entity. There already exists a Policy Framework and Legal Policy in Ethiopia on this regard which will support this proposed measure. Part Eight of the Ethiopian Water Resources Management Proclamation No. 197/2000 which pertains to Association of Water Users stipulates that the Supervising Body (in this case, the BWR) may, in consultation with the appropriate public bodies, encourage the establishment of water users' associations, as it deems necessary to utilize water for beneficial uses. But the Proclamation does not mention obtaining legal personality for association of water users. However, Part Seven of the Council of Ministers Regulation No. 115/2005 Ethiopian Water Resources Management Regulations provide for the formation and registration of a Water Users Co-operative Society to undertake medium or large scale irrigation. The Regulations further stipulate that a water users' co-operative society established to undertake small scale irrigation shall be registered by an organ established by law at Regional or City Administration level to organize and register Cooperative Societies.

The officers of the WUA in both schemes shall be motivated by BWR/ARD to transform their association into a Water Users' Cooperative Society to enable it to have legal personality following the stipulations under Part Eight of the Council of Ministers Regulation No. 115/2005.

The staff of BWR/ARD in coordination with the Kebele Chairmen shall initiate a series of meetings with the WUA officers and leaders of the WUSCs to discuss and decide on this issue. In these meetings, the following will be discussed: a) the significance and benefits of the WUA having a legal personality for them to understand the need for legal personality; b) Objectives, tasks and functions of a Water Users' Cooperative Society including sample by-laws and the existing WUA by-laws; and c) steps and requirements for the WUA to establish and register the cooperative society. Afterwards, a general assembly meeting with the members will be called to discuss outcome of these meetings to get the views of the members and agreement to establish a water users' cooperative society.

2.3.7.4 Establish "Water Users School (WUS)"

The study's proposed detailed action plans for each scheme should be discussed and implemented through the medium of "water users' schools" (WUS). This concept has been tried in Nepal in the project called "Promoting Good Governance of Water Users' Associations." The concept of a water users' school is not a new one, it was adapted from the farmers' field school approach (FAO, 2001). The fundamental approach is one of learning by doing aimed at developing skills amongst the farmers and other key stakeholders (staff from concerned agencies/institutions), through an effective programme of transfer of knowledge, using adult learning techniques. It can be an effective tool in building a commitment on the part of the WUO to participate in irrigation management, in understanding the issues and ways to solve problems, and in ensuring that *the process of institutional development is embedded in the community rather than being externally driven*. Transferring management responsibilities should be accompanied by a careful review of the infrastructure with the WUO and concerned agency/institutions including the proposed design for system improvement/ rehabilitation and proposed action plan for crop production and cropping pattern, water distribution, O&M, fee collection and others. The outcome of this process will be joint action plan agreed upon by both the WUO and concerned agencies/institutions that specifies who will do what, where, when, how and resources needed.

The suggested steps, content and methodology for establishing the WUS programme are discussed in greater detail in the Appendices of this report.

The following is a general description for WUS implementation:

i. Introductory meetings will be initiated first by the BWR/ARD staff and these will be done in two parts – an initial visit to the WUO officers to ensure that they are willing, in principle, to participate. Following this visit, the next visit will involve a larger general meeting to which all farmers will be invited, during which the WUS programme will be explained and discussed with a larger group of stakeholders. The general meeting can directly lead to a system walk-through with the project map, which aims to develop a common perspective among participants on the irrigation system that can lead on to discussion of the system and its problems.

ii. The 2nd stage in the WUS programme will be done in a workshop setting, the venue should be at a place accessible to the water users. Half-day to full-day workshops (from 5 to 10 days) can be planned with the participants to ***present and discuss the proposed action plans developed for each scheme culminating in a joint action plan among the key stakeholders***.

There should be follow-up WUS programme which should coincide with the schedule when the WUO gathers its members for regular development work and for planning water distribution and scheduling. The follow-up WUS programme aims to further upgrade the level of awareness and develop WUO's skill in O&M planning and budgeting, organizational and financial management. Monitoring and evaluation of the action plan implementation should also be undertaken during the follow-up WUS programme.

2.3.7.5 Organization for Management of O&M, O&M and Fee Collection

BWR/ARD staff at Regional/Woreda level should assist in developing the capacity of the WUO to assume more responsibility for the MOM and O&M of the irrigation scheme. The Social Mobilizer with the involvement of the DAs' and Kebele Chairmen, should initiate consciousness raising efforts to facilitate internalization on the part of the farmers/water users that they need to become responsible users of the scheme. The farmers in the command area should be made aware of their duties and responsibilities with regard to the operation, upkeep/ maintenance of the irrigation structures and facilities. They should be made to realize that long-term functionality of the irrigation scheme entirely rests in their shoulders.

2.3.7.6 Capacity Building Program for ARD Staff

O&M Planning and Budgeting, Irrigation Water Management and Irrigation System Management Transfer, Community Organizing and Organizational Development and how to run/facilitate WUS programme with the WUO will be the important subject matters for this capacity building program.

Basically, the DAs assigned in Geray should be included in the capacity building program and key staff from the Cooperative Association office and from zonal ARD-irrigation unit. For Robi and Gereb Mihiz, the Head of BWR and ARD, Water Technicians, and the DAs assigned should be included.

One of the important objectives of this program is to equip them with basic skill and knowledge in developing the capacity of the WUO to make it strong, functional and effective and in the process develop in them the appropriate attitude in working with the water users.

Detailed description and curricula are discussed in the appendices of this report.

2.3.7.7 Address Technical Constraints to Water Availability and Sufficiency

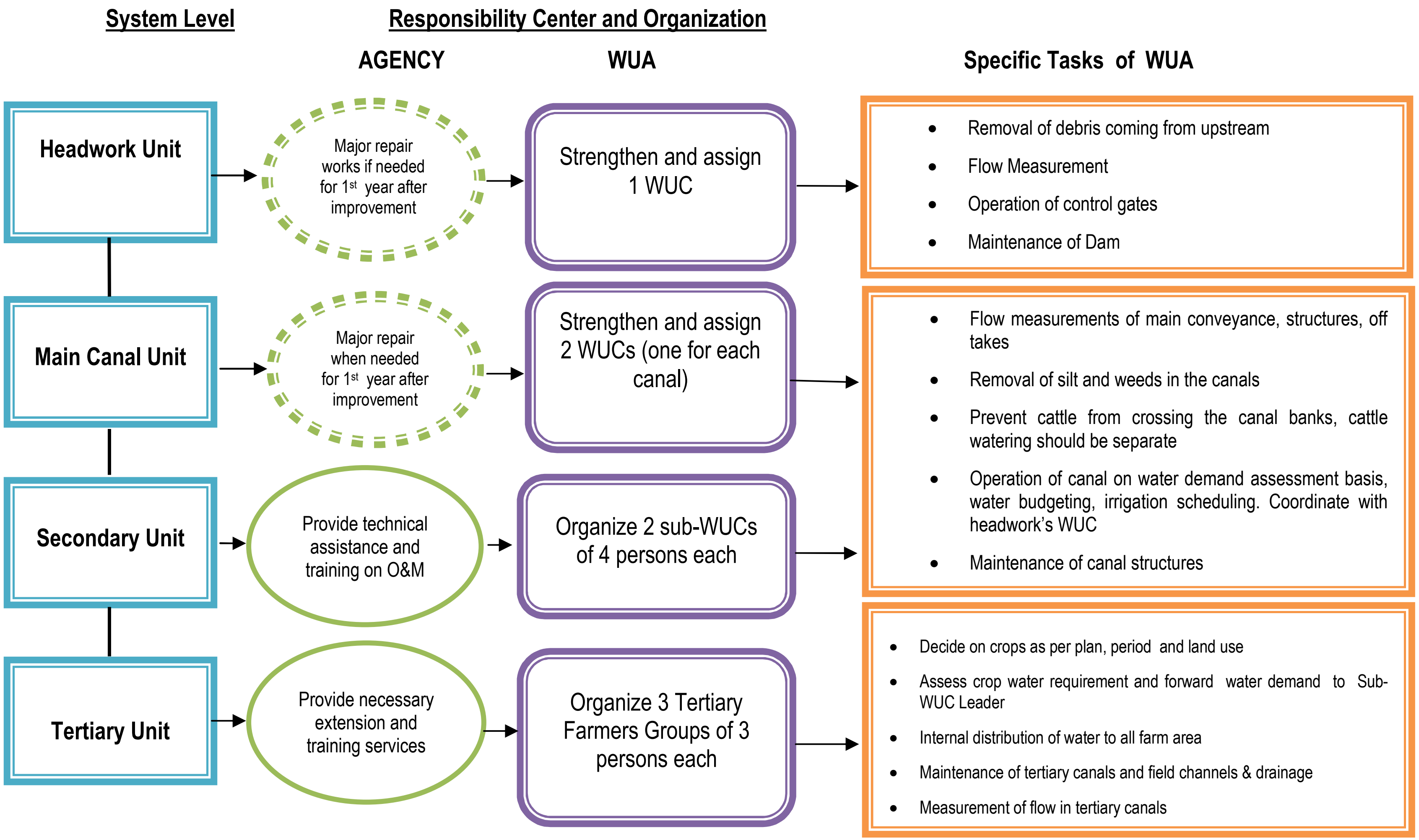
This will be the implementation of the proposed physical improvements/rehabilitation works in the irrigation scheme which should be implemented with full involvement of the WUO in the planning and actual construction works. Proposed improvement works will be presented and discussed during the WUS programme. The WUO should be motivated to provide free labour and locally available materials as its counterpart.

2.3.7.8 Implement Regular Coordination Meetings at Woreda Level

This is proposed in order that progress on WUO-Agency joint action plan implementation and outcome of the WUS/on site-workshops can be reviewed and accordingly monthly or quarterly work plan of the agency staff will be formulated to facilitate and sustain the progress. This coordination meeting can be done on a monthly or quarterly basis involving the following: a) head of BWR/ARD; b) ARD Extension Staff; c) ARD Cooperative Association Staff; c) Social Mobilizers; e) Water Technician; and f) representatives from Woreda and Kebele Administration when necessary.

Figure 2-2 shows a diagram describing the proposed organization of MOM and O&M for Robi Scheme.

Figure 2-2 Proposed Organisation of MOM and O&M of Robi River Irrigation Scheme



2.3.8 Financial Strengthening

Credit requirements for this project should be limited to support to the existing Farmers' Association for the supply of incremental inputs required. Introducing summer cropping, interrupting annual flooding and raising cropping intensity to 230% will require a high level of incremental input use. These include improved maize and potato seed and fertiliser and crop protection chemicals. Fertiliser use will need to rise from about 50 bags now to 1,400 bags with project at full development. At present farmers see fertility replenished each year by sediment in flood water. With project this will cease, and moderately high fertiliser applications will be required. Plant protection will also be required as a regular application, and use is also expected to rise by a factor of 10. Financing at 20% of the value of the inputs has been added to project costs to cover interest and administration charges, and comes to about ETB 60,000 per annum.

2.4 BUDGET FINANCIAL COSTS

2.4.1 Costs and Quantities

Table 2-13 gives the estimated quantities and costs for Robi River Irrigation Scheme.

Table 2-13 Costs and Quantities for the Robi River Scheme

Oromia Region, Robi River Scheme							
Item	Description	Unit	Quantity	Unit Cost (US$)			Amount
				L/C	F/C	Total	US$
1	**Preparatory Works**						
1.1	Mobilization of plant, equipment and personnel to site	LS	0.2	8,340.80	158,475.22	166,816.02	33,363
1.2	Demobilization of plant, equipment and personnel	LS	0.2	7,190.42	136,618.11	143,808.53	28,762
						Sub-Total	**62,125**
2	**Earth**						
2.1	Stripping to a depth of 15cm	m^2	3,256	0.21	4.10	4.31	14,033
2.2	Compacted earth fill for left bank dyke	m^3	5,660	0.35	6.67	7.02	39,733
2.3	Compacted earth fill for right bank dyke	m^3	5,830	0.35	6.67	7.02	40,927
2.4	Compacted earth fill embankment for canal closure	m^3	480	0.35	6.67	7.02	3,370
						Sub-Total	**98,063**
3	**Weir**						
3.1	Raise masonry side walls of weir by 2m	m^3	170	4.05	77.04	81.09	13,785
3.2	Foot bridge across Robi weir	L.S.	1	667.85	12,689.22	13,357.07	13,357
3.3	Supply, install and test one slide gate with necessary fittings						
3.3.1	#2 under sluice gates (gate leaf size, 0.6m by 1m)	m^2	1.20	333.92	6,344.61	6,678.53	8,014
3.3.2	#2 outlet gates (gate leaf size, 0.6 by 0.6m)	m^2	0.72	333.92	6,344.61	6,678.53	4,809
						Sub-Total	**39,965**
4	**Drain**						
4.1	Excavation of channel section	m^3	28,563	0.17	3.24	3.41	97,400
4.2	Compacted fill for canal banks	m^3	11,460	0.35	6.67	7.02	80,449
						Sub-Total	**177,849**
					Total for Robi Scheme		**378,002**

2.4.2 Total Project Costs

The civil works are calculated to be ETB 5.292 million (US$ 0.378 million) in current 2010 prices. Construction has been assumed to be phased over three years, 25% in the first year, 50% in the second and 25% in the third. Sustainable maintenance of structures was estimated ETB 0.39 million. Management and operation costs were added. Management costs were estimated assuming that the scheme at full development will be managed by two or three WUSC (as it is now), the total management cost will be about ETB 28,600 per annum (fees of chairman, treasurer and secretary plus stationery etc.). The operation cost will be ETB 9,760 per annum, to cover the scheme requirement of two gatemen and 4 water masters. The total MOM is therefore estimated as ETB 391.200 per annum.

The benefit phasing assumptions depend on project support operations. These are:

- community mobilisation (cost estimated at ETB 174,900 pa), scheduled for three years during construction
- agricultural extension support (cost estimated at ETB 85 per gross cropped hectare under development) scheduled for ten years starting in Year 2 of the project
- credit for planting material and the supply of other inputs through the Farmers' Association.

The fixing of a charge for water is the pivot between costs and benefits on which project design hinges. It must be fixed so that it allows sustainable MOM, and be affordable to irrigators. Project support enables farmers to realise expected scheme benefits and attain income to meet the charge. The MOM cost per m^3 was obtained by dividing the sustainable MOM requirement by the volume delivered to meet irrigation future requirements (1.2 million m^3 per annum, derived from CROPWAT8, 70% efficiency). The MOM cost per ha was calculated by the volume required by crop, times price divided by crop area. It varies between ETB 500 and ETB 700 depending on crop. This is high, but also includes the cost of flood protection – a significant proportion of the cost of the capital works proposed.

2.4.3 Project Benefits

With project, it is assumed that full irrigation supply will be provided to the present scheme area of 185 net hectares, plus an additional 20 ha of land which is currently out of command. This area is currently a grazing area and the present value of production is probably about ETB 5,000 per ha. In addition, flood protection will be provided and drainage improved, so that summer cropping can take place on the entire 205 ha. This will mostly be rainfed, but supplementary irrigation will be available if required. See Table 2-14.

Phasing to achieve full project benefit is important. It is unlikely that even the modest future irrigated yields expected with project will be achieved immediately. On 185 ha of presently irrigated land without project irrigated crop gross margins are phased to reach with project irrigated annual and perennial crop gross margins in five years. On the additional 20 ha it is assumed the first project year will have no production, after which it will take five years to reach full with project irrigated yields.

The future without and future with project benefits are given in Table 2-14 and Table 2-15.

Table 2-14 Estimate of Without Project Scheme Benefits, Financial ETB

			Gross Margin					Value of Production, ETB '000				
	Net ha	Gross ha	Year 1	Year 2	Year 3	Year 4	Year 5	Year 1	Year 2	Year 3	Year 4	Year 5
Irrigated crops												
Winter maize	139	139	8,419	8,419	8,419	8,419	8,419	1,168,076	1,168,076	1,168,076	1,168,076	1,168,076
Summer maize	0	0						0	0	0	0	0
Potato	24	48	29,456	29,456	29,456	29,456	29,456	1,416,810	1,416,810	1,416,810	1,416,810	1,416,810
Vegetables	22	44	28,126	28,126	28,126	28,126	28,126	1,248,809	1,248,809	1,248,809	1,248,809	1,248,809
	units											
Dairy cows	670		1,255	1,255	1,255	1,255	1,255	840,556	840,556	840,556	840,556	840,556
Beef cows	940		560	560	560	560	560	526,222	526,222	526,222	526,222	526,222
Without project smallholder benefit	ETB							5,200,473	5,200,473	5,200,473	5,200,473	5,200,473

Table 2-15 Estimate of With Project Benefits, Financial ETB

Smallholders on present irrigated area	Gross ha	Gross Margin ETB/ha					Value of Production, ETB				
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 1	Year 2	Year 3	Year 4	Year 5
Irrigated crops	ha										
Winter maize	130	8,419	9,679	10,939	12,199	13,460	1,090,205	1,253,408	1,416,611	1,579,815	1,743,018
Summer maize	148	0	2,187	4,374	6,561	8,748	0	323,665	647,329	970,994	1,294,659
Potato	102	29,456	30,375	31,294	32,213	33,132	2,997,098	3,090,629	3,184,161	3,277,692	3,371,223
Vegetables	46	28,126	29,319	30,511	31,704	32,896	1,300,843	1,355,995	1,411,147	1,466,300	1,521,452
	units										
Dairy cows	670	1,255	1,305	1,355	1,405	1,455	840,556	874,032	907,508	940,984	974,461
Beef cows	940	285	285	285	285	285	267,810	267,810	267,810	267,810	267,810
With project smallholder benefit	ETB						6,496,511	7,165,539	7,834,566	8,503,594	9,172,622

Smallholders on incremental irrigated area		Gross Margin ETB/ha					Value of Production, ETB				
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 1	Year 2	Year 3	Year 4	Year 5
Irrigated crops	ha										
Winter maize	14	0	3,365	6,730	10,095	13,460	0	47,109	94,217	141,326	188,434
Summer maize	16	0	2,187	4,374	6,561	8,748	0	34,991	69,982	104,972	139,963
Potato	11	0	8,283	16,566	24,849	33,132	0	91,114	182,228	273,342	364,457
Vegetables	5	0	8,224	16,448	24,672	32,896	0	41,120	82,241	123,361	164,481
	units										
Dairy cows	72	1,255	1,305	1,355	1,405	1,455	90,871	94,490	98,109	101,728	105,347
Beef cows	102	285	285	285	285	285	28,952	28,952	28,952	28,952	28,952
With project smallholder benefit	ETB						119,823	337,776	555,729	773,682	991,635

2.4.4 Cost Benefit Analysis

The CBA in 2010 financial ETB is given in Table 2-16. Like most rehabilitation the returns are comparatively attractive, until one considers the rehabilitation cost is required to cover deferred maintenance costs, and the scheme is only about 10 years old.

Another issue is whether or not farmers will grow maize under supplementary irrigation in the summer. Supplementary irrigation is costly – the irrigation scheme must remain open and scheduling is more difficult because of frequent rainfall. Drainage must work well. Farmers have large areas of land outside the scheme which is more suitable (better drained) for summer cereal crops than the river valley, on which there is no experience of summer cultivation. Household labour is limiting because household size is (surprisingly) small, and the summer period is very busy, so farmers may simply not have the time to cultivate an additional grain crop in the scheme during this period. A further potential problem is that maize prices are much lower at the end of the summer season, and irrigated maize will be much less competitive than it is in May and June. Farmers are well aware that with flood protection and drainage they will be able to carry out year round irrigation, and they say they are enthusiastic to do so. But if in practice they do not, then it is very likely the flood protection works on the scheme will deteriorate and lose functionality very quickly.

If the summer maize crop is included in the cropping pattern, the FIRR will be 40%, and the project remains financially viable. However, if no summer cropping is carried out at all than the FIRR falls to only 19%. This is not a good IRR for a rehabilitation project. Further farmer consultation is required to mitigate this risk.

Table 2-16 CBA Robi River Irrigation and Drainage Scheme Financial 2010 ETB

	PRESENT	FUTURE	BENEFIT STREAM	CIVIL WORKS	INSTITUTIONAL SUPPORT	AGRICULTURAL EXTENSION	FINANCING CHARGES ON INCREMENTAL INPUTS USED	MOM COST		NET BENFIT STREAM
Year 1	5,205,473	5,205,473	0	1,323,006	174,932					-1,497,938
Year 2	5,205,473	5,205,473	0	2,646,013	174,932	17,425	241,388			-3,079,758
Year 3	5,205,473	6,616,334	1,410,861	1,323,006	174,932	17,425	241,388			-345,890
Year 4	5,205,473	7,503,315	2,297,841		174,932	17,425	241,388	428,353		1,435,744
Year 5	5,205,473	8,390,295	3,184,822			17,425	241,388	428,353		2,497,656
Year 6	5,205,473	9,277,276	4,071,803			17,425	241,388	428,353		3,384,637
Year 7	5,205,473	10,164,257	4,958,783			17,425	241,388	428,353		4,271,617
Year 8	5,205,473	10,164,257	4,958,783			17,425	241,388	428,353		4,271,617
Year 9	5,205,473	10,164,257	4,958,783			17,425	241,388	428,353		4,271,617
Year 10	5,205,473	10,164,257	4,958,783			17,425	241,388	428,353		4,271,617
Year 11	5,205,473	10,164,257	4,958,783			17,425		428,353		4,513,005
Year 12	5,205,473	10,164,257	4,958,783					428,353		4,530,430
Year 13	5,205,473	10,164,257	4,958,783					428,353		4,530,430
Year 14	5,205,473	10,164,257	4,958,783					428,353		4,530,430
Year 15	5,205,473	10,164,257	4,958,783					428,353		4,530,430
Year 16	5,205,473	10,164,257	4,958,783					428,353		4,530,430
Year 17	5,205,473	10,164,257	4,958,783					428,353		4,530,430
Year 18	5,205,473	10,164,257	4,958,783					428,353		4,530,430
Year 19	5,205,473	10,164,257	4,958,783					428,353		4,530,430
Year 20	5,205,473	10,164,257	4,958,783					428,353		4,530,430
	INTERNAL RATE OF RETURN									40%
	NET PRESENT VALUE									64,767,794
	NPV BENEFIT STREAM									80,388,291
	NPV COST STREAM									15,620,497
	BENEFIT TO COST RATIO									5.15

Despite the high unit cost of irrigation (which includes flood control) MOM is affordable by project farmers. Assuming 100% command area development, MOM costs would be only 4% of expected model farm net household return.

The value of the scheme has also been calculated in economic prices. The Standard Conversion Factor (SCF) and specific conversion factors for construction, crop inputs, main commodities and labour have been calculated based on border prices and import or export parity as appropriate. The calculations are not reproduced here. Economically the project is more attractive than the CBA expressed in financial prices. This is normal, and because taxes and transfer payments have been removed and labour is valued at its opportunity cost (which is relatively low) so investment and production costs tend to fall, while commodity prices tend to maintain their value.

The economic analysis suggests a project which is very attractive to public investment, with a CBR exceeding 7. But it is important to remember that this is an investment for rehabilitation and modernisation, which would be fair if the project had reached the end of its economic life with all depreciation paid. This is not so. The "capital cost" of rehabilitation is really a deferred maintenance payment.

Table 2-17 CBA Robi River Irrigation and Drainage Scheme Economic 2010 ETB

	PRESENT	FUTURE	BENEFIT STREAM	CIVIL WORKS	INSTITUTIONAL SUPPORT	AGRICULTURAL EXTENSION	FINANCING CHARGES ON INCREMENTAL INPUTS USED	MOM COST		NET BENFIT STREAM
Year 1	4,403,456	4,403,456	0	1,154,351	174,932					-1,329,283
Year 2	4,403,456	4,403,456	0	2,308,703	174,932	14,931	0			-2,498,565
Year 3	4,403,456	5,420,763	1,017,307	1,154,351	174,932	14,931	0			-326,907
Year 4	4,403,456	6,486,143	2,082,686		174,932	14,931	0	385,518		1,507,306
Year 5	4,403,456	7,551,522	3,148,066			14,931	0	385,518		2,747,617
Year 6	4,403,456	8,616,901	4,213,445			14,931	0	385,518		3,812,996
Year 7	4,403,456	9,682,281	5,278,825			14,931	0	385,518		4,878,376
Year 8	4,403,456	9,682,281	5,278,825			14,931	0	385,518		4,878,376
Year 9	4,403,456	9,682,281	5,278,825			14,931	0	385,518		4,878,376
Year 10	4,403,456	9,682,281	5,278,825			14,931	0	385,518		4,878,376
Year 11	4,403,456	9,682,281	5,278,825			14,931		385,518		4,878,376
Year 12	4,403,456	9,682,281	5,278,825					385,518		4,893,307
Year 13	4,403,456	9,682,281	5,278,825					385,518		4,893,307
Year 14	4,403,456	9,682,281	5,278,825					385,518		4,893,307
Year 15	4,403,456	9,682,281	5,278,825					385,518		4,893,307
Year 16	4,403,456	9,682,281	5,278,825					385,518		4,893,307
Year 17	4,403,456	9,682,281	5,278,825					385,518		4,893,307
Year 18	4,403,456	9,682,281	5,278,825					385,518		4,893,307
Year 19	4,403,456	9,682,281	5,278,825					385,518		4,893,307
Year 20	4,403,456	9,682,281	5,278,825					385,518		4,893,307
	INTERNAL RATE OF RETURN									47%
	NET PRESENT VALUE									72,344,803
	NPV BENEFIT STREAM									84,365,048
	NPV COST STREAM									12,020,245
	BENEFIT TO COST RATIO									7.02

2.4.5 Sensitivity Analysis

Sensitivity analysis has been carried out in economic prices for the following scenarios:

- Changes in capital costs of the main cost items
- Failure to develop the full command area as anticipated
- Changes in the cost of MOM

- Changes in the prices of agricultural labour, crop inputs, crop prices and crop yields.

For efficiency in presentation, sensitivities are calculated as two variable Data Tables. Examining first the relationship between total capital cost and MOM cost, it is evident that a +20% increase in MOM cost would lower EIRR to 45.9%, though the project economic return would still be well above the assumed discount rate. A similar increase +20% in the capital costs of a similar amount would lower EIRR to 41.6%, so we may conclude that scheme economic performance is more sensitive increases in investment costs than to increases in MOM. This is normal because MOM is more heavily discounted, but if MOM charges as a proportion of household income were high, the risk of farmers leaving irrigation would be high and the size of the irrigated area would fall, leading to rising MOM costs. MOM as a proportion of household income has already been investigated and found to be satisfactory.

Table 2-18 Sensitivity of EIRR to Changes in Capital and MOM Costs

Change in MOM cost	Change in Capital Cost				
	-20%	-10%	0%	+10%	+20%
-20%	53.8%	50.2%	47.2%	44.5%	42.2%
-10%	53.4%	49.9%	46.8%	44.2%	41.9%
0%	53.0%	49.5%	46.5%	43.9%	41.6%
+10%	52.6%	49.2%	46.2%	43.6%	41.3%
+20%	52.3%	48.8%	45.9%	43.3%	41.0%

Note: the EIRR of the project without sensitivity changes at 0% change is 46.5%

In respect of sensitivity to the individual cost items, the tables are not reproduced, since changes in price of none of them in isolation have a substantial impact on the economic performance. Changes in estimated costs can always happen as a result of exchange rate changes or cost over-runs or delays in implementation. However, it would appear that the proposed project is very resilient to such changes.

The project return is also very resistant to changes in the economics of crop production. Cropping pattern is diversified and there is a large proportion of high value crops. If crop prices fell by -20% of the assumed values and inputs rose to +20% of their present cost, then the EIRR would hardly fall, to 44.9%. This may seem surprising but low sensitivities should be expected in the case of "benefit overload", for example assuming with-project crop yields much higher than those observed. In this analysis winter maize yields are expected to increase by 83%, together with (almost) a doubling of the cropping intensity.

Table 2-19 Sensitivity of EIRR to Changes in Crop Price and Cost of Crop Inputs

Change in cost of crop inputs	Change in Crop Price				
	-20%	-10%	0%	+10%	+20%
-20%	47.6%	47.7%	47.8%	48.0%	48.1%
-10%	44.7%	47.0%	47.2%	47.3%	47.5%
0%	46.2%	46.4%	46.5%	46.7%	46.8%
+10%	45.6%	45.7%	45.8%	46.0%	46.1%
+20%	44.9%	45.0%	45.1%	45.3%	45.4%

In an economy which is industrialising, the cost of agricultural labour may increase relatively faster than other cost elements in agricultural budgets. Nevertheless, the Table below suggests that this is unlikely to have a dramatic impact on project performance.

Table 2-20 Sensitivity of EIRR to Changes in Crop Price and Cost of Labour

Change in cost of agricultural labour	Change in Crop Price				
	-20%	-10%	0%	+10%	+20%
-20%	48.1%	48.2%	48.3%	48.5%	48.6%
-10%	47.2%	47.3%	47.4%	47.6%	47.7%
0%	46.2%	46.4%	46.5%	46.7%	46.8%
+10%	45.3%	45.4%	45.6%	45.7%	45.9%
+20%	44.3%	44.5%	44.6%	44.7%	44.9%

MOM costs are entirely attributed to farmers, on the assumption of full cost recovery. A small increase in MOM (required for example if not all farmers participate in the proposed project) combined with a small change in crop price would have a slight negative impact on economic performance, reducing EIRR to about 46%.

Table 2-21 Sensitivity of EIRR to Changes in Crop Price and MOM

Change in price of irrigation	Change in Crop Price				
	-20%	-10%	0%	+10%	+20%
-20%	46.9%	47.0%	47.2%	47.3%	47.4%
-10%	46.6%	46.7%	46.8%	47.0%	47.1%
0%	46.2%	46.4%	46.5%	46.7%	46.8%
+10%	45.9%	46.0%	46.2%	46.3%	46.5%
+20%	45.6%	45.7%	45.9%	46.0%	46.1%

Assumptions on crop yield increments were initially modest, and substantially below the technically possible. They have subsequently been revised upwards. In the Table below, the equivalent winter maize yield is shown for each percentage crop yield change in the sensitivity analysis. Present yields are about 35 quintals per ha.

The sensitivity analysis below suggests that failure to meet even modest yield increases could be disastrous, while substantial benefits accrue to improvements. It would be good to be sure of the impact of the extension component, but so much is dependent on the availability of a large well qualified, well-resourced and motivated extension service. A large budget allocated in the project costs by no means guarantees that such a service will materialise.

Table 2-22 Sensitivity of EIRR to Changes in Crop Price and Crop Yield

Equivalent winter maize yield, q/ha		Change in crop yield				
		-20%	-10%	0%	+10%	+20%
39	-30%	18%	19%	19%	19%	19%
44	-20%	30.4%	30.4%	30.8%	30.9%	31.1%
50	-10%	39.1%	39.1%	39.4%	39.6%	39.7%
55	0%	46.2%	46.2%	46.5%	46.7%	46.8%
61	+10%	52.3%	52.3%	52.6%	52.7%	52.9%
73	+20%	57.7%	57.7%	58.0%	58.1%	58.2%

Similarly, if the irrigated area is not achieved in full, the economic return will be prejudiced; the Table shows that even if crop price is maintained, if the with-project farm area achieved is only -20% of that assumed then the EIRR falls to 30.8%. The proposed project economic performance is therefore very sensitive to this parameter. Conversely even a small increase in the irrigated area can boost project performance.

Table 2-23 Sensitivity of EIRR to Changes in Crop Price and Irrigated Area

Ha irrigated	Change in area developed	Change in Crop Price				
		-20%	-10%	0%	+10%	+20%
188	-20%	29.0%	29.1%	293.0%	29.4%	29.6%
212	-10%	37.7%	37.8%	38.0%	38.1%	38.2%
235	0%	46.2%	46.4%	46.5%	46.7%	46.8%
259	+10%	54.7%	54.8%	55.0%	55.1%	55.2%
310	+20%	63.1%	63.2%	63.3%	63.5%	63.6%

Combining the very sensitive parameters, with project crop yields and irrigated area, it is evident that an -20% reduction in with project yields (which would still represent a 50% increase on present winter maize yields) and a similar reduction in the with-project irrigated area will lead to an EIRR below the discount rate.

Table 2-24 Sensitivity of EIRR to Changes in Crop Yield and Irrigated Area

Equivalent winter maize yield, q/ha	Change in crop yield	Change in Irrigated area							
	ha developed	118	141	165	188	212	235	259	282
		-50%	-40%	-30%	-20%	-10%	0%	+10%	+20%
33	-40%	#	#	#	#	#	#	9%	22%
39	-30%	#	#	#	-11%	8%	19%	29%	38%
44	-20%	#	#	-0.3%	11.9%	21.6%	30.8%	39.7%	48.5%
50	-10%	#	0.6%	12.4%	21.8%	30.7%	39.4%	48.0%	56.6%
55	0%	-2.0%	10.6%	20.3%	29.3%	38.0%	46.5%	55.0%	63.3%
61	+10%	6.9%	17.4%	26.7%	35.5%	44.1%	52.6%	61.0%	69.3%
73	+20%	13.1%	23.0%	32.1%	40.9%	49.5%	58.0%	66.4%	74.6%

Note: # signifies than an EIRR is not calculable, usually because the net benefit stream is consistently negative.

2.5 Conclusions

2.5.1 Oromiya Region– Robi River Scheme

Robi River Irrigation Scheme has had enormous success since its construction in 1998/99. Crop Area Ratio has steadily increased to 1.32 due to the expansion and intensification of cropping of winter vegetables. Potatoes have become an important crop, and winter maize is also prominent in the cropping pattern, giving a stable, productive and profitable crop rotation. Cropping is however confined to the dry season, because the Robi River valley is inundated during the rains. The proposed project aims to provide flood protection, drainage and irrigation to expand this success into the summer season. Also returning to the original command area by re-instating the damaged upper left canal.

However, there are problems with this scheme. The deferred maintenance is probably in excess of ETB 0.5 million which will have to be made up as part of the ETB 7 million investment programme proposed in this study. ARD has had constant difficulties in obtaining a wereda budget line to carry out any maintenance at all since construction but at the same time has been unable to encourage the development of a budget line from water users. Ownership of structures remains with MoWR, the kebele based WUC has little interest in taking them over, particularly with deferred maintenance running at the high level mentioned. Some difficulties date from design. The lack of flood protection means that, apart from farmers being unable to crop the land during the rains, canals and drains must be re-built each year before the irrigation season. There is a feeling in the community that the design was neither in the right place, nor large enough. Another problem is that the Robi River scheme is downstream from other irrigation schemes with informal off-takes. There is evidence (e.g. the breakdown of planting irrigation deliveries at the tail) that competition for water is increasing. The Robi River scheme should be in a good position to resist this, having formally constructed storage and headworks, but with the deterioration of structures due to lack of maintenance this advantage may be lost in time. The team concludes that until the institutional problems affecting this scheme are solved – by training the WUC in O&M and making them responsible for raising funds and carrying out routine repairs – the accumulation of deferred maintenance will persist.

There are also risks attached to the team's development proposals: whether or not farmers will crop the command area in summer. Supplementary irrigation is more costly in management. Farmers have large areas of land outside the scheme which is more suitable for summer cereal crops than the river valley. Household labour may be limiting. Crop prices are lower at the end of the summer season. Farmers are well aware that with flood protection and drainage they will be able to carry out year round irrigation, and they say they are enthusiastic to do so. But if in practice they do not, then it is very likely the flood protection works on the scheme will deteriorate and lose functionality very quickly.

In short the Robi River scheme has been a success, but its institutional problems need to be addressed and future maintenance budget lines assured before considering it for future funding.

3 AMHARA REGION, - GERAY SCHEME

3.1 AMHARA REGION - GERAY SCHEME

3.1.1 Background – Brief History

Geray Irrigation Scheme is constructed in the Jabi Tehnana Wareda, in West Gojjam Zone. It is located at 37° 17.2' E and 10° 39.5' N.

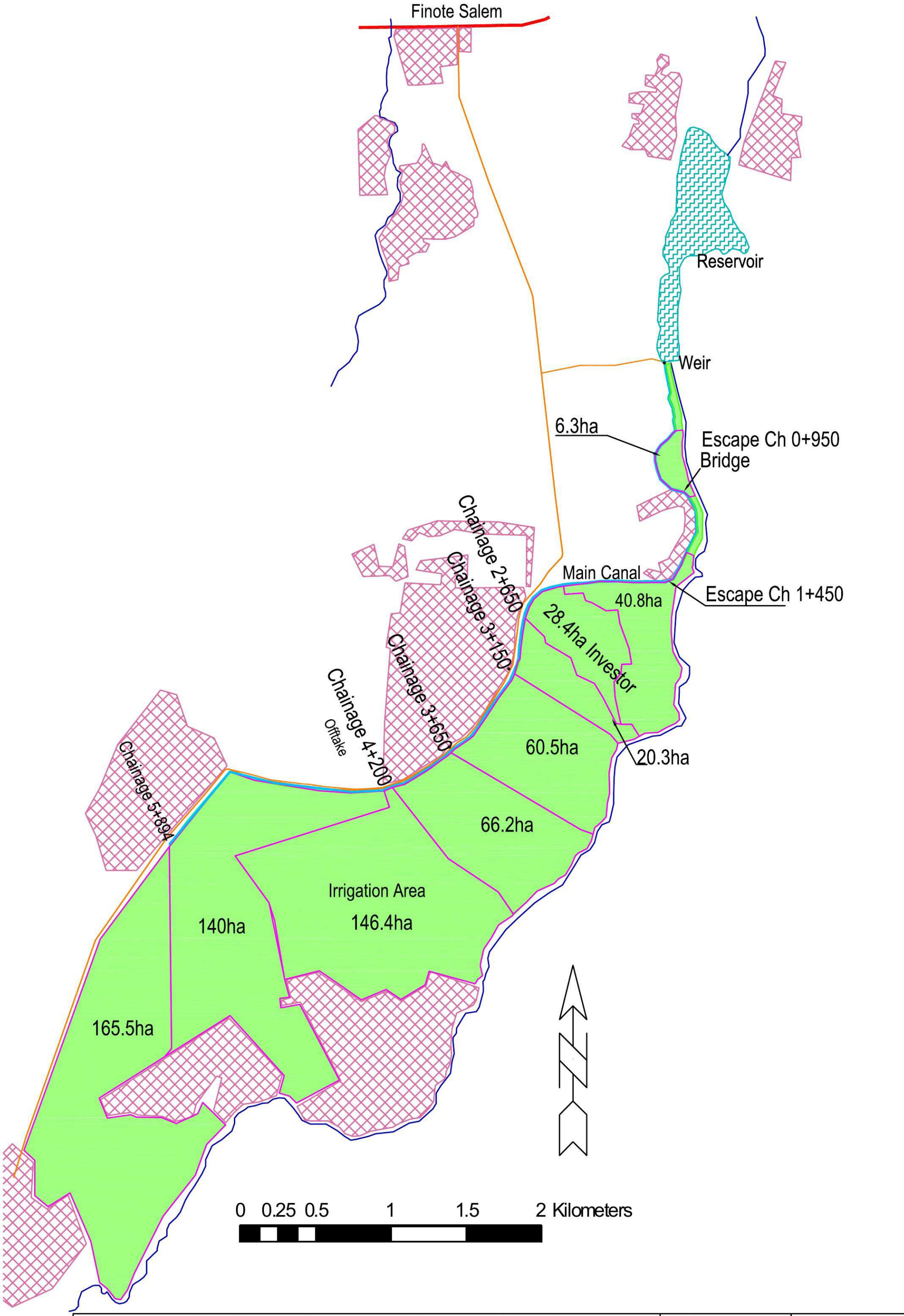
This scheme was built in 1983 to command of 618 ha. A masonry weir provides water to a right bank canal, running for about 5.3 km. There are about 4 secondaries. There are no drawings of the infrastructure and no recording devices. All canals above ground are in poor condition, being eroded away by livestock and seepage is high. There is high infestation of weeds in the main canal and a number of illegal off-takes. A porous left bank at the weir means about 500 l/s is lost and only about 150 l/s passes to the main canal. The scheme consists of re-settled farmers from the highlands.

This scheme has one investor and there are issues with this person amongst other farmers as he tends to dominate the water use. However, it is clear that the investor is highly productive and not wasting the water, and he should be used as an example of the potential, even though he is farming the area rejected by other farmers.

No records exist of flows and no measurements are taken. But according to the original design, the intake to the main canal was sized to release 1,445 l/s. This appears far in excess of the requirements of 600 ha.

The layout of the scheme is shown in Figure 3-1.

Figure 3-1 Layout of the Geray Scheme



PROJECT NAME: Pilot Study on Water Use efficiency and Productivity on Existing Schemes in Ethiopia.			CLIENT ENTRO Eastern Nile Irrigation and Drainage Study	CONSULTANT SMEC international
DRAWING TITLE: GERAY SCHEME LAYOUT				
DRAWING No:	REVISION:	DATE: September 2010	FIGURE No: Figure 3-1	

3.1.2 Climate of Geray

Table 3-1 Climatic Data for the Geray Scheme

Country	ETHIOPIA		Station	Lay Bir	Altitude	2020m	
Month	Min Temp	Max Temp	Humidity	Wind	Sunshine	Radiation	ETo
	°C	°C	%	km/day	hours	MJ/m²/day	mm/day
January	9.1	30.8	40	128	9.2	20.7	4.17
February	10.6	31.8	40	154	9.0	21.8	4.73
March	13.6	32.5	38	174	8.3	22.0	5.31
April	14.4	32.4	39	171	7.8	21.5	5.36
May	15.3	30.4	51	180	7.5	20.7	5.03
June	13.8	26.6	61	180	6.2	18.4	4.19
July	13.7	23.9	73	113	4.4	15.8	3.24
August	13.2	23.8	74	89	4.3	15.9	3.15
September	12.8	25.3	67	102	6.0	18.4	3.62
October	11.7	27.2	56	105	8.0	20.6	4.00
November	10.2	28.8	46	107	9.0	20.7	3.99
December	9.1	29.7	41	116	9.2	20.2	3.93
Average	12.3	28.6	52	135	7.4	19.7	4.23

3.2 PERFORMANCE INDICATORS

3.2.1 Water and Engineering Indicators

In Robi River no records of flows or other irrigation factors are taken. However, some assessment has been made on the basis of the inspections in the field. A structural indicator, Effectivity of Infrastructure (EI) can be calculated from the inspection made. There are 14 structure observed in the scheme, of which 8 are operational and in working order. This gives an EI of 0.57.

The Irrigated Area Ratio is calculated from the actual are irrigated compared to the measured irrigated area from GPS measurements. There measurements are gross so have been reduced by 5% to obtain a net irrigated area. The irrigated area is different to the cropped are, which can be higher when double cropping is practised, like in Robi River. Below is the estimated IAR:

Scheme	Gross Area	Net Area	Irrigated Area	IAR
	ha	ha	ha	
Robi River	183.6	174.4	134.7	0.77
Geray	674.4	640.7	238.0	0.37
Gereb Mihiz	94.7	90.0	18.0	0.20

In two of the schemes, irrigation was taking place and flows could be estimated. No flows were observed in Robi River, as irrigation was not taking place as rain had recently fallen. The flow is used in a Delivery Performance Ratio calculation, but this is rather crude. The intended flow is taken as the future water requirement, as an indicator. Below is the estimated DPR:

Scheme	Measured Flow	Intended Flow	DPR
	l/s	ha	
Robi River			
Geray	150	585	0.26
Gereb Mihiz	10	68.0	0.15

3.2.2 Institutional Indicators

Performance indicators for institutional aspects of the three irrigation schemes, namely: Robi; Geray; and Gereb Mihiz are focused on institutions involved in the: management and operation and maintenance of the irrigation scheme; fee collection and extension services provided to the water users of the irrigation scheme.

In assessing the performance of the institutions involved, the following variables and methodology for data gathering were used:

Variables

e. Mandate/Functions of the institution

f. Organization, System and Procedures for MOM, O&M and extension services

g. Fee Collection (components, amount and efficiency)

h. Perception on efficiency of the organization, system and procedures

Methodology and Data Gathering

d. Household Survey

e. Direct on-site observation

f. Semi-Structured Interviews with water users and relevant officials and staff at regional, zonal, woreda and kebele levels.

In line with the objectives of the pilot study on improving Water Use Efficiency, the institutional performance indicators used in the study are presented in the following Table 2-3. It shows the performance indicators with the corresponding performance assessment for the three irrigation schemes.

Table 3-2: Geray Irrigation Scheme Performance Indicators

No.	Performance Indicators	Performance Assessment
1.	Functionality of Gov't. institutions e.g. BWR and ARD	• BWR at Regional Level rating is 2 (fair): technical preparation given to the water users before the scheme was handed over to them is perceived as inadequate. There seem to be also very limited technical guidance and support given to ARD and Geray Irrigation Cooperative (IC) on proper operation and maintenance of the scheme facilities. • Rating of ARD Staff at zonal and regional level is also perceived as fair (2): no operation and maintenance planning and budgeting; zonal irrigation staff confused where O&M budget should come from • Performance of ARD Extension Staff at Woreda level is perceived satisfactory (3) with regard to extension services in general but poor on irrigation related assistance to the farmers. They need more orientation/training on irrigation system management and proper operation and maintenance of the scheme facilities. • Performance assessment of the ARD Cooperative Association staff at Woreda level is perceived to be good=4. The staff was able to assist the Geray IC Association formulate its by-laws with rules and regulations on maintenance, water distribution and fee collection, and install financial

No.	Performance Indicators	Performance Assessment
2.	Functionality of Farmers' Institutions e.g. Geray IC Association and Farmers' Cooperative	• Overall, performance at present of the Geray IC Association is satisfactory based on the following observations: a) the officers and management committee and members are aware of their duties and responsibilities but now weak in carrying these out; b) water charge was • Fees are reported to be collected with high collection efficiency prior to the leakage in the weir but now majority refused to pay; c) maintenance/development work regularly undertaken in the early stage of the scheme but now stopped; d) water rotation system is still being implemented; and e)basic financial management and bookkeeping system are in place but not implemented. Record entries appeared old. • The Geray IC Association needs more knowledge and skill in: proper O&M planning and budgeting and implementing proper preventive maintenance; formulating cropping pattern and determining crop water requirement; and proper irrigation use and water distribution planning. • Farmers' Cooperative at Woreda level is functioning well and able to supply adequately the inputs needed by the farmer-members except for improved seeds. However, the farmers randomly interviewed in the cooperative compound said that the price of inputs is high compared to the selling price of their produce. Overall, its performance assessment is perceived as good (4).
3.	Adequacy and effectiveness of Extension Services	Based on perception of the Irrigation officers and Kebele Chairman, they need more assistance from professional experts on what type of crops to grow and proper use of irrigation/water management. Performance assessment on adequacy of extension services is satisfactory (3).

Note: Scale of 1-5 with 1= Poor 2= Fair=; 3=Satisfactory; 4= Good; 5= Very Good

Key Institutional Issues in Geray Scheme

The following issues were presented during the FGD with the officers of the cooperative which was also attended by the Kebele Chairman and partly by the Cooperative Association, Extension and Establishment Expert from ARD.

- No O&M Planning and Budgeting. Ato Tenaw Ejigu (ARD-Regional Head, Irrigation) admitted that ARD does not formulate annual O&M plan and budget for Geray scheme nor for other irrigation schemes under their jurisdiction. When there is demand for maintenance and repair budget from the Woreda level, ARD at Bahir Dar tries to look for funds from the recurrent budget or from other project left-over funds.
- Water Issue with the Investor. The Geray IC Association officers accused the investor for blocking the water flow by pumping directly from the main canal. He is currently using 3 pumps. They said they tried to negotiate and have dialogues with him but he continued to ignore their request to pump at the river and not in the main canal. In connection with the allegation of the cooperative officers that the pumping of the investor in the main canal has worsened water scarcity, it should be mentioned here that the household survey showed that last year, the investor only used 12% of the irrigation water for his land which is 34% of the land area sampled. However, the data is actually based on what the investor supplied at the time of the survey and may therefore be unreliable.
- Weakening Functionality of the Geray IC Association. The officers are becoming de-motivated and admitted that they are losing control of the Association and unable to implement its rules and regulations due to the dysfunctionality of the irrigation scheme and the problem with the investor.

They added that they are losing their credibility to manage the association as well as the scheme. Defaulters are increasing in number. Some even wanted the association to refund their membership fee and shares.

- Uncertainty over land right. Based on information from the ARD Extension Staff at Woreda level, farmers in the scheme resettled in the area in 2 batches, the first batch in 1985 then followed by the 2nd batch in 1988. They came from the highlands (Quarit and Sakela Woreda, some 60-80 kms away). The government through the Woreda Administration allocated them land and provided them with certificates authorizing them to use the land. Since the Woreda administration handed over a parcel of their land to an investor (about 30 hectares) there is growing fear and uncertainty among them over their land right. This was expressed by the Geray IC association officers and the Kebele Chairman during the FGD.
- Water Users lack technical knowledge on proper water management, O&M of the scheme, and type of crops to plant. This was expressed by the Kebele Chairman during the FGD. Maintenance work or what they term as development work done in the past specifically on canal embankment had been undertaken without technical supervision or guidance from ARD. With regard to water distribution aspect, the household survey showed strong inequality in the distribution of the small amount of water available.[2] Concerning extension services, ARD experts like the agronomist and DAs are frequently changed and they could not work full time for Geray since they are posted at the Woreda level.

3.2.3 Economic Indicators

3.2.3.1 Relative Water Cost

The relative water cost indicator (*RWC*) is calculated using the formula:

$$RWC = \frac{C_w}{C_{tc}}$$

where C_w is the total cost of irrigation water and C_{tc} is the total cost of production of crops. RWC is the cost of providing water as percentage of the total cost of crop production.

RWC for Geray has been calculated as 0.14. This is a low ratio. Water is cheap because there is no expensive storage and the canal system is simple and robust (though deteriorating).

Table 3-3 The Relative Water Cost Indicator

Scheme	Key Parameters		Relative Water Cost Indicator
	Total Scheme Production Cost ETB	Scheme MOM and field irrigation cost, ETB	
Robi River	1,286,724	519,223	0.40
Geray	1,193,062	162,045	0.14
Gereb Mihiz	344,423	28,879	0.08

[2] Geray Household Survey Report

3.2.3.2 Operation and Maintenance Fraction

The operation and maintenance fraction (O&M) is calculated using the formula:

$$O\&M = \frac{C_{o\&m}}{I_S}$$

where $C_{o\&m}$ is the cost of operation and maintenance and I_s is the budget for sustainable MOM. The O&M fraction is the cost of O&M proportional to the total cost MOM cost.

One of the indicators of a well-run business is low management overhead costs, and an efficient water user association would be expected to have a fraction of about 0.90, depending on its size. For both Geray and Gereb Mihiz the O&M fraction is about 0.75. This is a low value, indicating little being spent on maintenance and much being spent on management. In Geray management of voluntary community labour is difficult. In neither case is it surprising that the fraction is low.

The future expected O&M fraction is also shown in Table 2-5, taking into account full maintenance costs on the structures proposed, and the irrigation management structure expected.

Table 3-4 The O&M Fraction

Scheme	Key Parameters			O&M Fraction	Future Expected O&M Fraction
	Scheme MOM ETB/ha	Scheme Management ETB/ha	Scheme O&M ETB/ha		
Robi River	564	11	553	0.98	0.93
Geray	255	65	190	0.75	0.87
Gereb Mihiz	181	48	133	0.73	0.96

3.2.3.3 MOM Funding Ratio

The MOM funding ratio (*MOM_FR*) is calculated using the formula:

$$MOM\_FR = \frac{I_a}{I_S}$$

where I_a is actual annual income and I_s is the budget for sustainable MOM. The ratio measures the impact of the cost of water on farmer's incomes. It is calculated first using present MOM. The method used was to compare the estimated net household income with the sample of the Household Survey for each scheme and calculate the MOM payment at current rates that would be required on the irrigated area of each – assuming MOM costs were distributed pro rata to irrigated area. The ratio is also calculated for future expected MOM against the future expected farm budget.

For Geray the MOM ratio has been calculated as 0.20, which is very high, but are there issues with the estimated net household income on this scheme. Also the equity of distribution water seems very poor and the water payment system seems to have broken down in the last two or three years. The sustainable MOM funding indicator is only 0.05 (based on with project farm budgets), which would be much more attractive to farmers.

Table 3-5 The MOM Funding Ratio

Scheme	Key Parameters			Present MOM Funding Ratio	Future Expected MOM funding Ratio
	Total Net Income of HHS sample, ETB pa	Net irrigable area of HHS sample, ha	MOM Requirement of HHS sample, ETB		
Robi River	264,319	23	12,904	5%	5%
Geray	78,783	79	20,111	26%	5%
Gereb Mihiz	73,001	7	1,204	2%	10%

3.2.4 Environmental Indicators

Sustainability indicators are classified under environmental indicators in Bos et al (2005) and are intended to indicate trends in the proportion of the command irrigated, and the tonnage of biomass produced per unit volume of water and area of land.

3.2.4.1 Cropped Area Ratio

The cropped area ratio (*CAR*) is calculated using the formula:

$$CAR = \frac{A_a}{A_I}$$

where A_a is average cropped area and A_I is the initial total irrigable area. CAR is a measure of the intensity of use of the command area. Table 2-7 summarises the calculation for each of the three schemes. For Geray the CAR at 0.39 is very low, suggesting that a large proportion of the scheme has gone out of production or was never fully irrigated. Of interest is the rate of decline of the ratio over time. Historical records show that since 1991 the net irrigated area never exceeded 133 ha, similar to the present.

Table 3-6 The Cropped Area Ratio

Scheme	Key Parameters		Cropped Area Ratio
	Gross cropped ha 2009/10	Designed net irrigable ha	
Robi River	232	175	1.32
Geray	238	618	0.39
Gereb Mihiz	18	80	0.22

3.2.4.2 Water Productivity Indicator

The water productivity indicator (*WP*) is calculated using the formula:

$$WP = \frac{Y_c(kg)}{V_a(m^3)}$$

where Y_c is the crop yield in kilograms and V_a is the application of water in m^3.

The land productivity indicator (*LP*) is similar, and calculated using the formula:

$$LP = \frac{Y_c}{A_a}$$

where Y_c is the crop yield in kilograms and A_a is the net scheme area in hectares. The indicator is simply aggregated tons of crop production divided by scheme area. The water productivity indicator requires an estimate of present irrigation practice. The Household Survey requested farmers to report the frequency, depth and duration of irrigation for each plot and crop they irrigated. The weakness of this approach is that the information is based on recall – though farmers generally have good memories. The strength of the method is that data is compiled on a large number of plots (Robi 224 plots of which about 180 were irrigated); Geray 158 plots of which about 40 were irrigated and Gereb Mihiz 106 plots of which 32 were irrigated). The variance of the data reduces with the size of the sample. Also the data is not only plot specific but also crop specific, as land use was recorded for each plot, including planting and harvest dates. CROPWAT8 was then used to estimate the impact of the reported applications on the reported crops, and build up a scheme level estimate of use based on the reported cropping pattern.

Water and land productivity indicators are shown for Robi River, Geray and Gereb Mihiz Irrigation schemes in Table 2-8. Geray has a low land productivity index, 2,360 kg/ha especially considering that about 25% of the gross cropped area is fruit and vegetables. Most striking though is the low water productivity index; 0.84 kg per m^3. It is not very clear why this scheme should be particularly water inefficient, but one possible reason is the apparent inequity in water distribution which is not a characteristic of the other two schemes.

Table 3-7 Water and Land Productivity Indicators

Scheme	Key Parameters				Land productivity kg/ha	Water Productivity kg/m^3
	Irrigated gross ha	Non irrigated ha	Total crop production, quintals	Water application, m^3		
Robi River	231	0	19,558	140,101	10,572	13.96
Geray	156	82	4,506	535,249	2,359	0.84
Gereb Mihiz	18	62	1,278	19,419	1,598	6.58

3.2.4.3 Biomass Productivity Indicator

Biomass productivity is calculated in a similar way to the land and water productivity indices, but includes the weight of crop residues as well as main crop in the calculation. There are measurement difficulties here, because crop and residue yields may be measured with different water contents. Also residue yields are not well known; they vary considerably depending on crop yield and management and really need to be measured directly. With this in mind, the estimates given in Table 2-9 should be considered indicative only.

The best estimate for biomass production in the Geray scheme in 2009/10 is 5,900 kg per current net scheme hectare. The biomass production per unit of water is estimated as 1.64 kg per m^3 which is low.

Table 3-8 Biomass Productivity Indicators

Scheme	Key Parameters				Biomass Productivity, kg/ha	Biomass Productivity, kg/m³
	Main crop quintals/ha	Residues quintals/ha	Net scheme area, ha	Water application, m³		
Robi River	120	35	89	140,101	15,556	25.70
Geray	7,553	3,762	191	535,249	5,924	2.11
Gereb Mihiz	1,249	647	80	19,419	2,370	9.76

3.2.5 Summary of Performance Indicators

The scheme indicators calculated above are summarised in Table 3-9.

Table 3-9 Summary of Performance Indicators

Performance Indicators		Robi		Geray		Gereb Mihiz	
		Value	Rate	Value	Rate	Value	Rate
Irrigated Area Ratio	IAR	0.77	3	0.37	1	0.20	1
Delivery Performance Ratio	DPR	-		0.26	1	0.15	1
Function BWR/ARD			3		3		2
Function FU/WUA			2		4		2
Function Extension			3		3		2
Relative Water Cost	RWC	0.40	1	0.14	2	0.08	3
O&M Fraction	O&M F	0.98	5	0.75	3	0.73	3
MOM Funding Ratio	MOM R	0.05	1	0.26	4	0.02	1
Crop Area Ratio	CAR	1.32	4	0.39	1	0.22	1
Land Productivity	BIO kg/ha	10,572	5	2,359	1	1,598	1
Water Productivity	BWP kg/m³	13.92	5	0.84	2	6.58	5
Biomass Land Productivity	BIO kg/ha	15,556	5	5,924	2	2,370	2
Biomass Water Productivity	BWP kg/m³	25.70	5	2.11	2	9.76	4
Scheme Average Score			3.50		2.23		2.15

Table 3-9 shows that the overall rating for Geray is 2.23, which is considered fair.

For the details of the performance rating for the indicators, see Table 5-2.

3.3 DETAILED ACTION PLAN

This project is the largest of the three studied. It also has the greatest potential for improvement as productivity is low. The main reason is the loss of water at the diversion weir, and this is the first focus of attention. The second focus is the rehabilitation of the canals which have been eroded away almost completely in places. As part of the rehabilitation of the canal should be modernisation of the delivery control by installing downstream control. This will allow on-demand irrigation and farmers can decide then to irrigate and what crops.

There are no drawings or design of this system and a basic survey was made of the main canal. Levels were taken of bed and ground levels with left and right banks every 300 m. It shows the canal has two distinct reaches, the first a steep reach with a slope of 0.003 and velocity of 0.9 m/s, and the second flatter reach, with a slope of 0.0005 and velocity of 0.45 m/s.

The survey also shows that the reach immediately after the change in slope, the canal has been over excavated many times and is a maximum of 0.8 m too deep. This gives the appearance that the canal stops flowing, leading the farmers to dig even deeper to get the water to flow. There is a high point, at about chainage 2+450, after which the canal goes down hill.

At one point, at about chainage 0+950, the canal has breached and has been repaired by the farmers. Here a side escape should be built.

The main thrust of the action plan is stop the weir leakage, rehabilitate the canal with concrete lining, install sluice gates on all control structures, train the farmers and strengthen the institutions.

3.3.1 Seepage control

3.3.1.1 Diversion Weir

The left abutment is built on a fractured volcanic rock which has erodible layers of soil between the fractures. It is these layers of erodible soil that has washed out and creating porous conditions on this side. The study considered two options for increasing the water tightness of this bank, an impervious clay blanket and grouting of the weir foundation. Of the two options, the clay blanket is the cheapest and should be attempted first. A coffer dam of graded gravel should be dumped in an arc from above the water line to join the weir. This is achieved by working out from dry land and dumping gravel into the reservoir, building out as the coffer dam is constructed. Behind the coffer dam the water and saturated material should be removed and dried out. Against the coffer dam inside slope a filter layer of 0.24 m of sand is placed and the compacted clay blanket filled up to weir height. The extent of the coffer dam can only be guessed at this time in the absence of more detailed investigations, but has been set as a radius of 15 m.

The design and layout of this work is shown in Figure C4.

3.3.2 Rehabilitation of Water Delivery

The rehabilitation of the main system will take three forms, rehabilitation of the canal earthworks, concrete lining of the canal and installing sluice gates on all control outlets.

3.3.2.1 Rehabilitation of Infrastructure

From the canal survey, a design has been made using assumptions of water use from the crop water demands. However, the gross IWR only gives a duty of 0.91 l/s at 70% efficiency. It was thought that this duty is on the low side, and was increased to allow for a higher intensity of cropping than offered in the action plan. The canal design duty was set at 1.08 l/s/ha.

The canal should also be rehabilitated to allow controlled irrigation, giving the farmer a reliable supply. This will be done by installing sluice gates on all control structures. As part of the project should be Participatory Irrigation Management (PIM) with will induce the farmers to be included in the process and feel more like the owners of the project. The canal has been designed with concrete lining to improve the performance, reduce seepage and increase the life of the system. The design profile of this canal is shown in Figure C5. This design was also used in calculating embankment quantities.

The canal actually continues for another 1,644 m beyond chainage 4+250, the last structure. But water has not passed this point for many years. Most of the irrigation command is beyond this point and needs to be brought back into production. Both the estimated quantity and structures have been taking into account in the design although the survey did not reach to the end, chainage 5+894.

No measuring structure was found despite many attempts to find one. So a new measuring structure in the form of a broad crested weir (BCW) will be built near the head works, see Appendix C, Figure C-4.

3.3.2.2 Future Potential for Automatic Control Structures

One major limitation of any irrigation scheme is the management of water, and when left to humans, this often leads to problems and water wastage. The latest thinking in irrigation management is that left to the farmers when to irrigate, productivity is increased. A modified form of downstream control is the best method of on-demand control. This study recommends the use of an Automatic Diaphragm Valve (ADV) manufactured in South Africa and used successfully for downstream control in canals. Water would therefore be available in the canal all the time and allow farmers to irrigate at any time of day or night.

The layout of this valve is shown in Figure C6. The diaphragm is controlled by a 1" tube using the head available between the two reaches at the control point. There is a float valve, similar to that found in bathroom cisterns that will release the pressure in the diaphragm as the water level lowers, opening the valve and allowing water to pass downstream. The size of valve is determined by the head available to close the valve and the required flow.

With the opportunity of modernisation the scheme should be the implementation of a Participatory Irrigation Management (PIM) system. The farmers will have to be trained extensively in both modern farming techniques and also management of the scheme. Once the farmers are involved in the decision process, they should be given the decision to what extend and direction the rehabilitation takes. Geray scheme is in a unique opportunity to modernise its operation by the use of downstream control which will enable much greater flexibility in the system and ensuring that the tail farmers will get water.

3.3.3 On-Farm Irrigation Practice

3.3.3.1 Furrow Irrigation

A major limitation to productivity in the project is the aspect of irrigation cultural practises. In all cases none of the crops were planted in rows with effective ridges. This means that all irrigation is by uncontrolled flooding. Farmers need to be trained to plant in furrows and all irrigation water should be run down furrows in a short time to reduce over-watering. This is the only basic improvement identified for this project. The investor farmer should be used as a model to demonstrate what effective irrigation is like.

Other improved methods of irrigation like drip or mini-sprinkler are too expensive to be recommended at this stage. Once farmers are trained in effective flood irrigation methods there will be an increase in productivity and hence income increase. This will allow the situation of introducing mechanical irrigation to be considered in the future.

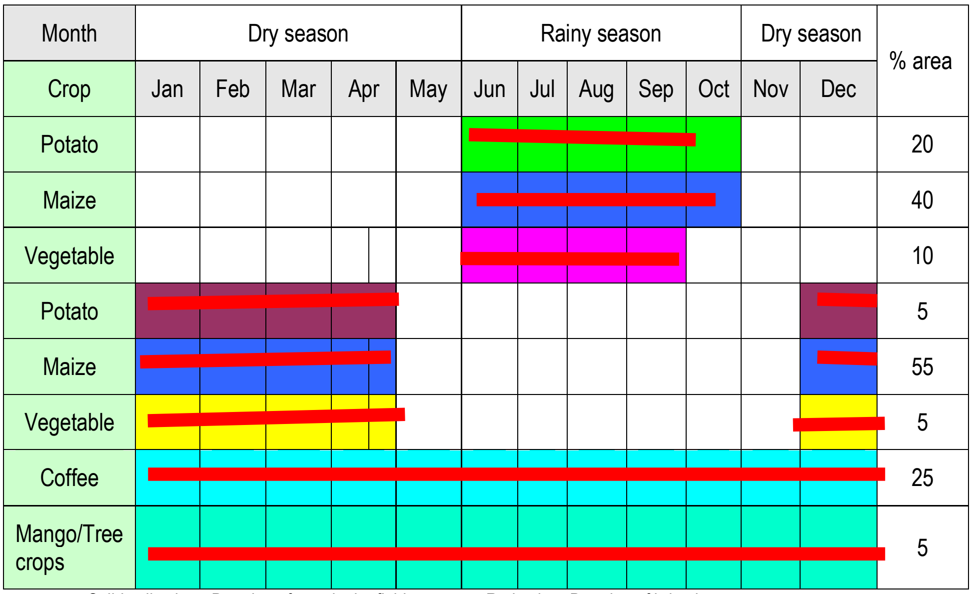
3.3.4 Cropping Pattern

The estimate of the present cropping of the scheme (191 ha) was based on plot level data from farms sampled in the Household Survey and generalised into a model farm cropping pattern. Some 44% of this area is irrigated at some time during the year. There are about 123 model farms in the present scheme area. Data on cropping patterns in the non irrigated area of the scheme command (427 ha and 275 model farms) can be elaborated from the rainfed cropping of Household Survey respondents. The present gross cropped area and cropping intensity are shown in Table 3-10. The with project cropping pattern is also shown in this Table. It is simple, based on maize, potatoes and vegetables (onion was taken as representative) and perennial crops (coffee, and mango was taken as representative of fruit). It was introduced into CROPWAT 8 to derive with project CWR.

Table 3-10 Present and Future With Project Cropping Pattern, ha

	without project irrigated area			without project non irrigated area			with project		
	wet	dry	total	wet	dry	total	wet	dry	total
Annual crops, irrigated									
Maize	16	28	44				247	340	587
Potato	11	20	30				124	31	154
Onions	12	21	32				62	31	93
Annual crops, rainfed									
Maize	32	0	32	170	0	170			
Teff	31	0	31	152	0	152			
Chickpea	5	0	5	29	0	29			
Pepper	9	0	9	33	0	33			
Perennial crops, irrigated									
Coffee	15	15	31				154	154	309
Fruit (mango)	20	20	41				31	31	62
Gross irrigated area	151	105	256	384	0	384	618	587	1205
Cropping intensity	79%	55%	134%	90%	0%	90%	100%	95%	195%

The irrigation water requirements have been calculated for the with-project cropping pattern and the maximum future irrigated area of 674 ha, presented in Table 3-11 below.



Solid cell color = Duration of crop in the field   Red color= Duration of irrigation

Table 3-11 Geray Scheme Crop Water Requirements

Geray Scheme	Met. Station : **Lay Bir**											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation deficit												
1. Potato									7.5	2.6		
2. MAIZE (Grain)								2.3	1.4			
3. Coffee	140.6	141.2	152.4	129.2	95.0	2.6			3.1	45.1	100.4	124.4
4. MANGO	165.0	164.8	170.8	135.7	70.9	7.3			12.0	66.5	123.6	147.1
5. Small Vegetables	139.1	146.8	24.0									87.7
6. MAIZE (Grain)	131.9	163.4	125.9	3.2								37.5
7. Potato	111.2	129.2	141.2	37.2								58.7
8. Small Vegetables												
Net scheme irr.req.												
in mm/day	4.1	5.3	4.0	1.4	0.9				0.1	0.5	1.0	2.1
in mm/month	128.5	147.2	124.2	42.7	27.3	1.0		0.9	3.4	15.1	31.3	66.4
in l/s/h	0.5	0.6	0.5	0.2	0.1				0.0	0.1	0.1	0.3
Irrigated area (% of total area)	95	95	95	90	30	30		40	90	50	30	95
Irr.req. for actual area (l/s/h)	0.5	0.6	0.5	0.2	0.3	0.0		0.0	0.0	0.1	0.4	0.3
at Efficiency of %	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Gross Irr.req. for area (l/s/h)	0.7	0.9	0.7	0.3	0.5	0.0		0.0	0.0	0.2	0.6	0.4
Mm^3/ha/day	61.7	79.0	60.5	22.2	42.0	1.2		1.2	1.2	13.6	49.4	32.1
Gross irrigated area ha	674	674	674	674	674	674	674	674	674	674	674	674
Gross Irr.req. (l/s)	457.4	585.4	448.2	156.0	98.2	2.9		3.9	8.7	53.0	115.5	237.8

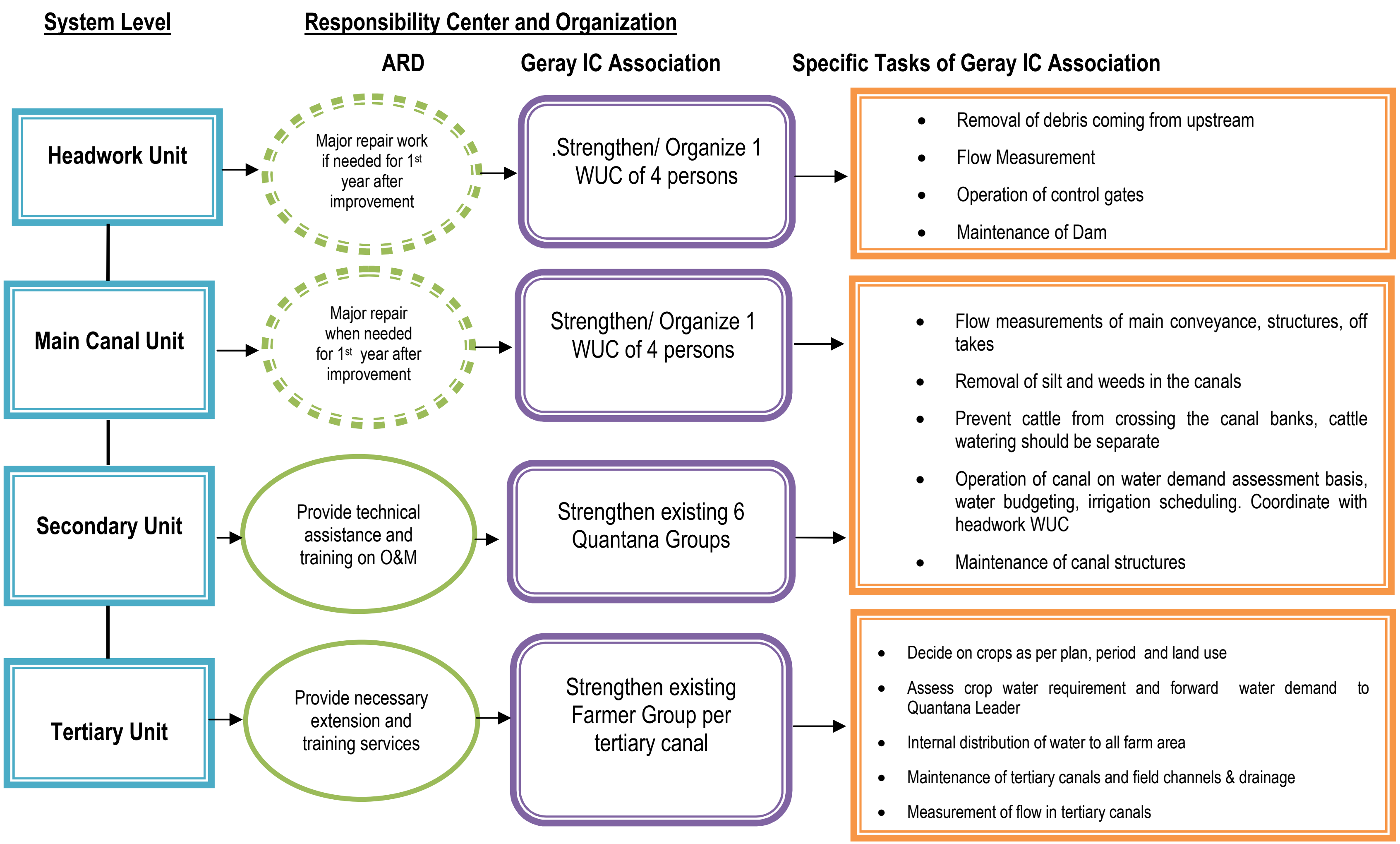
3.3.5 Institutional Strengthening

It is recommended that ARD will remain responsible for major repairs/maintenance works (when needed) in the headwork and main canal system for at least one year after the proposed improvement works to restore functionality of Geray Scheme has been implemented. However, responsibility for preventive and routine maintenance in the headwork and main canal level should already be assumed by the Geray IC Association with technical guidance from the ARD after the improvement works. It is suggested that if the IC Association has no existing WUCs, it should form WUCs and develop their capacity to manage O&M of the headwork and main canal system: one WUC will be assigned for the headwork and the other for the main canal system. Each WUC will have 4 to 5 members. With regard to the MOM of the secondary unit, the existing 6 Quantana Groups will be maintained and strengthened. Also, the existing 12 Tertiary Farmers' Groups (TFGs) will be maintained and strengthened to oversee and manage MOM and O&M of tertiary unit. Aside from the O&M tasks to be performed by the Geray IC Association at various levels of the scheme, the association should evaluate its water charge for the use of the scheme after its improvement. The amount of water charge proposed by the study will be presented and discussed in the WUS programme. A fee collector should be appointed by the Association and can be paid on commission basis for this responsibility.

The Geray Scheme needs the deployment of an experienced and well trained Social Mobilizer. The role for this person is discussed in section 2.3.7.2. In particular, the water use issue between the Geray Irrigation Cooperative Association and the investor needs more investigation. A WUS and on-site workshops should be established, as described in section 2.3.7.4. BWR/ARD staff at Regional/Woreda level should assist in developing the capacity of the WUO to assume more responsibility for the MOM and O&M of the irrigation scheme, as described in section 2.3.7.5. A capacity building programme should be established to develop skills in O&M Planning and Budgeting, Irrigation Water Management and Irrigation System Management Transfer, Community Organizing and Organizational Development and how to run/facilitate WUS programme with the WUO. Basically, the DAs assigned in Geray should be included in the capacity building program and key staff from the Cooperative Association office and from zonal ARD-irrigation unit. Regular coordination meetings are required at wereda level for review and planning (see section 2.3.7.8).

Figure 3-2 shows a diagram describing the proposed organization of MOM and O&M for Geray Scheme.

Figure 3-2 Proposed Organisation of MOM and O&M of Geray Scheme



3.3.6 Financial Strengthening

Credit requirements for this project should be limited to support to the existing Farmers' Association for the supply of incremental inputs required. These include planting material (especially improved maize seed, coffee and fruit seedlings, fertiliser and crop protection chemicals. The amount of these inputs is not great, for example fertiliser requirements will only triple in this scheme. Financing at 20% of the value of the inputs has been added to project costs to cover interest and administration charges, and comes to about ETB 413,000 per annum at full development.

3.3.7 Agricultural Extension

Agricultural extension support to the existing service, mainly for equipment and recurrent costs of demonstrations, has been budgeted at ETB 85 per gross cropped hectare for a 10 year period starting in Year 2 of the project.

3.4 BUDGET FINANCIAL COSTS

3.4.1 Costs and Quantities

Table 3-12 gives the costs and quantities for the Geray scheme.

Table 3-12 Costs and Quantities Geray Scheme

Amhara Region, Geray Scheme							
Item	Description	Unit	Quantity	Unit Cost (US$)			Amount
				L/C	F/C	Total	
1	**Preparatory Works**						
1.1	Mobilization of plant, equipment and personnel to site	LS	0.2	8,341	158,475	166,816	33,363.20
1.2	Demobilization of plant, equipment and personnel	LS	0.2	7,190	136,618	143,809	28,761.71
						Sub-Total	**62,124.91**
2	**WEIR**						
2.1	Dumped rock for coffer dam wall construction	m^3	25	1.00	19.03	20.03	500.75
2.2	25 cm gravel transition filter	m^3	2	0.74	14.20	14.94	22.41
2.3	Compacted clay fill for plugging in leakage	m^3	35	0.35	6.67	7.02	245.70
2.4	Supply, install and test one slide gate with necessary fittings (gate leaf size, 1.1m by 1.22m)	m^2	1.34	333.92	6,344.61	6,678.53	8,962.59
						Sub-Total	**9,731.45**
3	**Construction for rehabilitation of main Canal**						
3.1	Earth excavation (cut)	m^3	2,166	0.17	3.24	3.41	7,386.06
3.2	Impervious fill	m^3	14,265	0.35	6.67	7.02	100,140.30
3.3	Concrete lining, 0.075m, Class C20	m^3	1,228	10.39	197.50	207.89	255,288.92
						Sub-Total	**362,815.28**
4	**Construction for rehabilitation of Secondary Canals**						
4.1	Earth excavation (cut)	m^3	220	0.17	3.24	3.41	750.20
4.2	Impervious fill	m^3	7,500	0.35	6.67	7.02	52,650.00
						Sub-Total	**53,400.20**
5	**Structure**						
5.1	**Sluice Gate Outlet on Main Canal**						
5.1.1	Supply, place concrete class C-30	m^3	6	11.76	223.54	235.30	1,411.80
5.1.2	Masonry riprap around transition	m^3	0	4.05	77.04	81.09	0.00
5.1.3	Masonry for main Canal Side Escap	m^3	25	4.05	77.04	81.09	2,027.25
5.1.4	Supply, install and test one slide gate with necessary fittings (gate leaf size, 1.1m by 1.22m)	No.	1	440.77	8,374.89	8,815.66	8,815.66
5.1.5	Supply, install and test one slide gate with necessary fittings (gate leaf size, 1.0m by 1.0m)	No.	1	333.92	6,344.61	6,678.53	6,678.53
5.1.6	Supply, install and test one slide gate with necessary fittings (gate leaf size, 1.0 by 0.8 m)	No.	1	267.14	5,075.69	5,342.82	5,342.82
5.1.7	Supply, install and test one slide gate with necessary fittings (gate leaf size, 0.8 by 0.8 m)	No.	7	213.71	4,060.55	4,274.26	29,919.81
						Sub-Total	**54,195.88**
5.2	**Sluice Gate Outlets on Secondary Canals for 6 SC**						
5.2.1	Concrete	m^3	45	11.76	223.54	235.30	10,541.44
5.2.2	Masonry	m^3	9	4.05	77.04	81.09	729.81
5.2.3	Supply, install and test one slide gate with necessary fittings (gate leaf size, 0.8 by 0.8 m)	No.	15	213.71	4,060.55	4,274.26	64,113.89
5.2.3							
5.3	**Flow Measuring Weir**						
5.3.1	Concrete for broad crested measuring weir on main canal	m^3	3	10.39	197.50	207.89	623.67
5.3.2	Supply and place reinforcing steel	ton	0.1	346.76	6,588.59	6,935.35	693.54
						Sub-Total	**76,702.34**
					Total for Geray Scheme		**618,970.06**

3.4.2 Total Project Costs

The civil works are calculated to be ETB 8.66 million (US$ 0.619 million) in current 2010 prices. Construction has been assumed to be phased over three years, 25% in the first year, 50% in the second and 25% in the third.

Sustainable maintenance of structures was estimated ETB 0.42 million. To this must be added management and operation costs. Management costs were estimated assuming that the scheme at full development will be managed by four WUSC, the management cost for all will be ETB 65,000 per annum (fees of chairman, treasurer and secretary plus stationery etc.). The operation cost will be ETB 23,000 per annum, to cover the scheme requirement of two gatemen and 12 water masters. The total MOM is therefore estimated as ETB 507,800 per annum. Project support costs are:

- community mobilisation (cost estimated at ETB 201,100 pa), scheduled for three years during construction
- agricultural extension support (cost estimated at ETB 85 per gross cropped hectare under development) scheduled for ten years starting in Year 2 of the project
- credit for planting material and the supply of other inputs through the Farmers' Association.

The fixing of a charge for water is the pivot between costs and benefits on which project design hinges. It must be fixed so that it allows sustainable MOM, and be affordable to irrigators. Project support enables farmers to realise expected scheme benefits and attain income to meet the charge. The MOM cost per m^3 was obtained by dividing the sustainable MOM requirement by the future volume to meet irrigation requirements (4.1 million m^3 per annum, derived from CROPWAT8, 70% efficiency). The MOM cost per ha was calculated by the volume required by crop, times water price divided by future expected crop area.

3.4.3 Project Benefits

The future value of production without project is calculated on the present partially irrigated area of 191 net scheme hectares, and the rest of the net command area which is not irrigated, 427 net scheme hectares. This is straightforward; there are 123 model smallholder farms in the former and 275 in the latter. The production of a single model farm can be bulked up accordingly. Without project crop and livestock enterprise gross margins have been prepared using data from the Household Survey and these are available in the Annex material.

With project, it is assumed that full irrigation supply will be provided to the whole scheme area of 618 net hectares and at full development the cropping pattern will resemble the with project cropping pattern shown in Table 3-13. Rain fed cropping will therefore become irrigated, though during the summer months only supplementary irrigation will be required.

Table 3-13 Geray Scheme, Present and With Project Cropping Pattern

	without project irrigated area			without project non irrigated area			with project		
	wet	dry	total	wet	dry	total	wet	dry	total
Annual crops, irrigated									
Maize	0.13	0.23	0.36	0	0	0.00	0.62	0.85	1.47
Potato	0.09	0.16	0.25	0	0	0.00	0.31	0.08	0.39
Onions	0.09	0.17	0.26				0.15	0.08	0.23
Annual crops, rainfed									
Maize	0.26	0	0.26	0.62	0	0.62			0.00
Teff	0.25	0	0.25	0.55	0	0.55			0.00
Chickpea	0.04	0	0.04	0.11	0	0.11			0.00
Pepper	0.08	0	0.08	0.12	0	0.12			0.00
Perennial crops, irrigated									
Coffee	0.13	0.13	0.25				0.39	0.39	0.77
Fruit (mango)	0.17	0.17	0.33				0.08	0.08	0.15
Gross irrigated area	1.23	0.85	2.08	1.39	0.00	1.39	1.55	1.47	3.02
Cropping intensity	79%	55%	134%	90%	0%	90%	100%	95%	195%

Phasing to achieve full project benefit is very important. It is unlikely that even the modest irrigated yields expected with project will be achieved immediately. Also, perennial crops in the presently non irrigated area will have to be established. The following assumptions have been made for the presently irrigated scheme area:

- Without project irrigated crop gross margins are phased to reach with project irrigated annual and perennial crop gross margins in five years
- Without project rainfed crop gross margins are phased to reach without project irrigated levels immediately, and then take five years to reach full development.

The following assumptions have been made for the scheme non irrigated area:

- Without project rainfed crop gross margins take five years to develop to full with project gross margins
- Coffee and mango areas are established in year 1 and take five years to reach full with project development. Establishment costs are mitigated with inter-cropped maize.

The future without and future with project benefits are given in Table 3-14 and Table 3-15.

Table 3-14 Estimate of Without Project Scheme Benefits, Financial ETB

SMALLHOLDER FARMS IN PARTIALY IRRIGATED AREA	ha		Gross Margin, ETB						Value of Production, ETB				
			Year 1	Year 2	Year 3	Year 4	Year 5		Year 1	Year 2	Year 3	Year 4	Year 5
Annual partially irrigated													
Maize	44	ETB/ha	8,646	8,646	8,646	8,646	8,646		380,401	380,401	380,401	380,401	380,401
Potato	31	ETB/ha	8,872	8,872	8,872	8,872	8,872		270,872	270,872	270,872	270,872	270,872
Onion	32	ETB/ha	10,110	10,110	10,110	10,110	10,110		327,168	327,168	327,168	327,168	327,168
Annual rainfed													
Maize	32	ETB/ha	2,249	2,249	2,249	2,249	2,249		71,368	71,368	71,368	71,368	71,368
Teff	31	ETB/ha	5,736	5,736	5,736	5,736	5,736		179,333	179,333	179,333	179,333	179,333
Chickpea	5	ETB/ha	3,134	3,134	3,134	3,134	3,134		16,502	16,502	16,502	16,502	16,502
Pepper	9	ETB/ha	14,767	14,767	14,767	14,767	14,767		136,922	136,922	136,922	136,922	136,922
Perennial, partially irrigated													
Coffee	15	ETB/ha	12,666	12,666	12,666	12,666	12,666		195,570	195,570	195,570	195,570	195,570
Fruit (mango)	21	ETB/ha	8,050	8,050	8,050	8,050	8,050		165,090	165,090	165,090	165,090	165,090
Livestock													
Dairy Cows (1 cow unit), milk & calf	123	ETB/unit	1,255	1,255	1,255	1,255	1,255		154,988	154,988	154,988	154,988	154,988
Beef Cattle (1 head unit) meat	247	ETB/unit	285	285	285	285	285		70,367	70,367	70,367	70,367	70,367
Smallholders on Non Irrigated Area		427	ha										
SMALLHOLDER FARMS IN NON IRRIGATED AREA	**ha**		**Gross Margin, ETB**						**Value of Production, ETB**				
			Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**		**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Annual partially irrigated													
Maize	0												
Potato	0												
Onion	0												
Annual rainfed													
Maize	170	ETB/ha	2,249	2,249	2,249	2,249	2,249		381,556	381,556	381,556	381,556	381,556
Teff	152	ETB/ha	5,736	5,736	5,736	5,736	5,736		870,743	870,743	870,743	870,743	870,743
Chickpea	29	ETB/ha	3,134	3,134	3,134	3,134	3,134		91,373	91,373	91,373	91,373	91,373
Pepper	33	ETB/ha	14,767	14,767	14,767	14,767	14,767		481,347	481,347	481,347	481,347	481,347
Perennial, partially irrigated													
Coffee	0												
Fruit (mango)	0												
Livestock													
Dairy Cows (1 cow unit), milk & calf	275	ETB/unit	1,255	1,255	1,255	1,255	1,255		345,574	345,574	345,574	345,574	345,574
Beef Cattle (1 head unit) meat	551	ETB/unit	285	285	285	285	285		156,897	156,897	156,897	156,897	156,897

Table 3-15 Estimate of With Project Benefits, Financial ETB

SMALLHOLDER FARMS IN PRESENT SCHEME AREA	ha		Gross Margin, ETB						Value of Production				
			Year 1	Year 2	Year 3	Year 4	Year 5		Year 1	Year 2	Year 3	Year 4	Year 5
Annual irrigated													
Maize	105	ETB/ha	8,646	11,143	13,639	16,136	18,632		907,980	1,170,141	1,432,302	1,694,462	1,956,623
Potato	48	ETB/ha	8,872	9,800	10,729	11,657	12,586		423,490	467,807	512,125	556,442	600,760
Onion	29	ETB/ha	10,110	12,411	14,712	17,014	19,315		289,550	355,457	421,364	487,271	553,178
Annual rainfed													
Maize	76	ETB/ha	7,467	7,467	7,467	7,467	7,467		570,253	570,253	570,253	570,253	570,253
Teff	0	ETB/ha	5,736	5,736	5,736	5,736	5,736		0	0	0	0	0
Chickpea	0	ETB/ha	3,134	3,134	3,134	3,134	3,134		0	0	0	0	0
Pepper	0	ETB/ha	14,767	14,767	14,767	14,767	14,767		0	0	0	0	0
Perennial, irrigated													
Coffee	48	ETB/ha	12,666	13,897	15,129	16,361	17,593		604,569	663,368	722,168	780,967	839,767
Fruit (mango)	10	ETB/ha	8,050	8,467	8,884	9,301	9,718		76,851	80,832	84,814	88,796	92,777
Livestock													
Dairy Cows (1 cow unit), milk & calf	123	ETB/unit	1,255	1,373	1,490	1,607	1,724		154,704	169,149	183,593	198,038	212,482
Beef Cattle (1 head unit) meat	246	ETB/unit	285	285	285	285	285		70,239	70,239	70,239	70,239	70,239
IRRIGATED SMALLHOLDER FARMS IN EXTENDED AREA	ha		Gross Margin, ETB						Value of Production				
			Year 1	Year 2	Year 3	Year 4	Year 5		Year 1	Year 2	Year 3	Year 4	Year 5
Annual irrigated													
Maize	235		0	4,658	9,316	13,974	18,632		0	1,093,558	2,187,115	3,280,673	4,374,231
Potato	107		0	3,146	6,293	9,439	12,586		0	335,765	671,530	1,007,295	1,343,060
Onion	64		0	4,829	9,657	14,486	19,315		0	309,171	618,343	927,514	1,236,686
Annual rainfed													
Maize	171	ETB/ha	7,467	7,467	7,467	7,467	7,467		1,274,858	1,274,858	1,274,858	1,274,858	1,274,858
Teff	0	ETB/ha	5,736	5,736	5,736	5,736	5,736		0	0	0	0	0
Chickpea	0	ETB/ha	3,134	3,134	3,134	3,134	3,134		0	0	0	0	0
Pepper	0	ETB/ha	14,767	14,767	14,767	14,767	14,767		0	0	0	0	0
Perennial, irrigated													
Coffee	107		-18,350	6,650	12,811	8,388	17,593		-1958223.6	709591.4	1367119	895094.6	1877384.1
Fruit (mango)	21		5,655	6,199	9,866	4,256	9,718		120690.96	132312	210567.9	90829.45	207412.96
Livestock													
Dairy Cows (1 cow unit), milk & calf	275	ETB/unit	1,255	1,373	1,490	1,607	1,724		345,857	378,149	410,442	442,734	475,026
Beef Cattle (1 head unit) meat	551	ETB/unit	285	285	285	285	285		157,026	157,026	157,026	157,026	157,026
NON IRRIGATED SMALLHOLDER FARMS IN EXTENDED AREA	ha		Gross Margin, ETB						Value of Production				
			Year 1	Year 2	Year 3	Year 4	Year 5		Year 1	Year 2	Year 3	Year 4	Year 5
Annual irrigated													
Maize	0		0	0	0	0	0		0	0	0	0	0
Potato	0		0	0	0	0	0		0	0	0	0	0
Onion	0		0	0	0	0	0		0	0	0	0	0
Annual rainfed													
Maize	0	ETB/ha	2,249	2,249	2,249	2,249	2,249		0	0	0	0	0
Teff	0	ETB/ha	5,736	5,736	5,736	5,736	5,736		0	0	0	0	0
Chickpea	0	ETB/ha	3,134	3,134	3,134	3,134	3,134		0	0	0	0	0
Pepper	0	ETB/ha	14,767	14,767	14,767	14,767	14,767		0	0	0	0	0
Perennial, irrigated													
Coffee	0		0	0	0	0	0		0	0	0	0	0
Fruit (mango)	0		0	0	0	0	0		0	0	0	0	0
Livestock													
Dairy Cows (1 cow unit), milk & calf	275	ETB/unit	1,255	1,255	1,255	1,255	1,255		345,574	345,574	345,574	345,574	345,574
Beef Cattle (1 head unit) meat	551	ETB/unit	285	285	285	285	285		156,897	156,897	156,897	156,897	156,897

3.4.4 Cost Benefit Analysis

The CBA in 2010 financial ETB is given in Table 2-16. It is an optimistic scenario, assuming full command area development. However, if only 50% of the area of 427 ha presently outside the scheme is achieved, the FIRR falls to 10%, which would be financially very marginal. With full scheme area development, the BCR is over 4, so this represents an attractive investment, if financing can be obtained.

Table 3-16 CBA Geray Irrigation Scheme Financial 2010 ETB

	PRESENT & FUTURE WITHOUT PROJECT BENEFIT	FUTURE WITH PROJECT BENEFIT	BENEFIT STREAM	CIVIL WORKS	INSTITUTIONAL SUPPORT	AGRICULTURAL EXTENSION	FINANCING CHARGES ON INCREMENTAL INPUTS USED	MOM COST		NET BENFIT STREAM
Year 1	4,296,069	3,222,052	-1,074,017	2,166,395	201,117		61,441			-3,502,971
Year 2	4,296,069	2,148,034	-2,148,034	4,332,790	201,117	86,644	122,883			-6,891,469
Year 3	4,296,069	3,222,052	-1,074,017	2,166,395	201,117	86,644	184,324			-3,712,497
Year 4	4,296,069	3,540,314	-755,755	0		86,644	245,765	507,840		-1,596,005
Year 5	4,296,069	8,440,147	4,144,078			86,644	307,206	507,840		3,242,387
Year 6	4,296,069	11,396,328	7,100,259			86,644	368,648	507,840		6,137,126
Year 7	4,296,069	13,024,962	8,728,894			86,644	430,089	507,840		7,704,320
Year 8	4,296,069	16,344,233	12,048,164			86,644	491,530	507,840		10,962,149
Year 9	4,296,069	16,344,233	12,048,164			86,644	491,530	507,840		10,962,149
Year 10	4,296,069	16,344,233	12,048,164			86,644	0	507,840		11,453,679
Year 11	4,296,069	16,344,233	12,048,164					507,840		11,540,323
Year 12	4,296,069	16,344,233	12,048,164					507,840		11,540,323
Year 13	4,296,069	16,344,233	12,048,164					507,840		11,540,323
Year 14	4,296,069	16,344,233	12,048,164					507,840		11,540,323
Year 15	4,296,069	16,344,233	12,048,164					507,840		11,540,323
Year 16	4,296,069	16,344,233	12,048,164					507,840		11,540,323
Year 17	4,296,069	16,344,233	12,048,164					507,840		11,540,323
Year 18	4,296,069	16,344,233	12,048,164					507,840		11,540,323
Year 19	4,296,069	16,344,233	12,048,164					507,840		11,540,323
Year 20	4,296,069	16,344,233	12,048,164					507,840		11,540,323
	INTERNAL RATE OF RETURN									30%
	NET PRESENT VALUE									38,189,576
	NPV BENEFIT STREAM									50,902,933
	NPV COST STREAM									12,713,357
	BENEFIT TO COST RATIO									4.00

MOM is affordable by project farmers. Assuming 100% command area development, MOM costs would be only 3.2% of expected model farm net household return. Should only 50% of the area of 427 ha presently outside the scheme be developed, it would rise to 6.7%, which is moderately high. Project implementation should aim at implementation on at least 65% of the scheme command.

The Standard Conversion Factor (SCF) and specific conversion factors for construction, crop inputs, main commodities and labour have been calculated based on border prices and import or export parity as appropriate. The calculations are not reproduced here. Economically the project is more attractive than the CBA expressed in financial prices. This is normal, because taxes and transfer payments have been removed and labour is valued at its opportunity cost (which is relatively low) so investment and production costs tend to fall, while commodity prices tend to maintain their value.

The economic analysis suggests a project which is very attractive to public investment, with a CBR of 5.6. It is important to remember that this is an investment for rehabilitation and modernisation, which would be fair if the project had reached the end of its economic life with all depreciation paid. This is not so. The “capital cost” of rehabilitation is really a deferred maintenance payment.

Table 3-17 CBA Geray Irrigation Scheme Economic 2010 ETB

	PRESENT & FUTURE WITHOUT PROJECT BENEFIT	FUTURE WITH PROJECT BENEFIT	BENEFIT STREAM	CIVIL WORKS	INSTITUTIONAL SUPPORT	AGRICULTURAL EXTENSION	FINANCING CHARGES ON INCREMENTAL INPUTS USED	MOM COST	NET BENFIT STREAM
Year 1	3,192,304	2,394,228	-798,076	1,890,226	172,332		44,842		-2,905,476
Year 2	3,192,304	1,596,152	-1,596,152	3,780,452	172,332	74,243	89,684		-5,712,863
Year 3	3,192,304	2,394,228	-798,076	1,890,226	172,332	74,243	134,526		-3,069,403
Year 4	3,192,304	2,882,908	-309,396	0		74,243	179,368	457,056	-1,020,063
Year 5	3,192,304	8,459,949	5,267,645			74,243	224,209	457,056	4,512,136
Year 6	3,192,304	11,571,850	8,379,547			74,243	269,051	457,056	7,579,196
Year 7	3,192,304	13,381,055	10,188,751			74,243	313,893	457,056	9,343,558
Year 8	3,192,304	17,108,613	13,916,309			74,243	358,735	457,056	13,026,274
Year 9	3,192,304	17,108,613	13,916,309			74,243	358,735	457,056	13,026,274
Year 10	3,192,304	17,108,613	13,916,309			74,243	0	457,056	13,385,009
Year 11	3,192,304	17,108,613	13,916,309					457,056	13,459,252
Year 12	3,192,304	17,108,613	13,916,309					457,056	13,459,252
Year 13	3,192,304	17,108,613	13,916,309					457,056	13,459,252
Year 14	3,192,304	17,108,613	13,916,309					457,056	13,459,252
Year 15	3,192,304	17,108,613	13,916,309					457,056	13,459,252
Year 16	3,192,304	17,108,613	13,916,309					457,056	13,459,252
Year 17	3,192,304	17,108,613	13,916,309					457,056	13,459,252
Year 18	3,192,304	17,108,613	13,916,309					457,056	13,459,252
Year 19	3,192,304	17,108,613	13,916,309					457,056	13,459,252
Year 20	3,192,304	17,108,613	13,916,309					457,056	13,459,252
	INTERNAL RATE OF RETURN								38%
	NET PRESENT VALUE								50,155,830
	NPV BENEFIT STREAM								61,100,646
	NPV COST STREAM								10,944,816
	BENEFIT TO COST RATIO								5.58

3.4.5 Sensitivity Analysis

Sensitivity analysis has been carried out in economic prices for the following scenarios:

- Changes in capital costs of the main cost items
- Failure to develop the full command area as anticipated
- Changes in the cost of MOM
- Changes in the prices of agricultural labour, crop inputs, crop prices and crop yields.

For efficiency in presentation, sensitivities are calculated as two variable Data Tables. Examining first the relationship between total capital cost and MOM cost, it is evident that a 120% increase in MOM cost would lower EIRR to 38%, and the project economic return would still be well above the assumed discount rate. A similar increase in the capital costs of a similar amount would lower EIRR to 36%, so we may conclude that scheme economic performance is more sensitive to increases in investment costs than to increases in MOM. This is normal because MOM is more heavily discounted, but if MOM charges as a proportion of household income were high, the risk of farmers leaving irrigation would be high and the size of the irrigated area would fall, leading to rising MOM costs. MOM as a proportion of household income has already been investigated and found to be satisfactory.

Table 3-18 Sensitivity of EIRR to Changes in Capital and MOM Costs

Change in MOM cost	Change in Capital Cost				
	-20%	-10%	0%	+10%	+20%
-20%	41.5%	39.9%	38.5%	37.3%	36.1%
-10%	42.1%	39.7%	38.3%	37.0%	35.9%
0%	41.0%	39.5%	38.1%	36.8%	35.6%
+10%	40.7%	39.2%	37.8%	36.6%	35.4%
+20%	40.5%	39.0%	37.6%	36.4%	35.2%

Note: the EIRR of the project without sensitivity changes is 38.1% (0% change)

In respect of sensitivity to the individual cost items, the tables are not reproduced, since changes in price of none of them in isolation have a substantial impact on the economic performance. Changes in estimated costs can always happen as a result of exchange rate changes or cost over-runs or delays in implementation. However, it would appear that the proposed project is very resilient to such changes.

The project return is much more sensitive to changes in the economics of crop production. If crop prices fell to -20% of the assumed values and inputs rose to +20% of their present cost, then the EIRR would fall to 27.6%. Nevertheless, this is still a satisfactory rate of return and the data table shows that the impact of increases in crop input costs barely impacts on the EIRR.

Table 3-19 Sensitivity of EIRR to Changes in Crop Price and Cost of Crop Inputs

Change in cost of crop inputs	Change in Crop Price				
	-20%	-10%	0%	+10%	+20%
-20%	31.1%	35.6%	39.7%	43.4%	46.9%
-10%	30.2%	34.8%	38.9%	42.6%	46.1%
0%	29.3%	33.9%	38.1%	41.9%	45.3%
+10%	28.5%	33.1%	37.3%	41.1%	44.6%
+20%	27.6%	32.3%	36.5%	40.3%	43.8%

In an economy which is industrialising, the cost of agricultural labour may increase relatively faster than other cost elements in agricultural budgets. Nevertheless, the Table below suggests that this is unlikely to have a dramatic impact on project performance – the effect is very similar to increasing the costs of crop inputs.

Table 3-20 Sensitivity of EIRR to Changes in Crop Price and Cost of Labour

Change in cost of agricultural labour	Change in Crop Price				
	-20%	-10%	0%	+10%	+20%
-20%	31.1%	35.5%	39.5%	43.2%	46.6%
-10%	30.2%	34.7%	38.8%	42.5%	46.0%
0%	29.3%	33.9%	38.1%	41.9%	45.3%
+10%	28.5%	33.1%	37.3%	41.2%	44.7%
+20%	27.6%	32.3%	36.6%	40.5%	44.1%

MOM costs are entirely attributed to farmers, on the assumption of full cost recovery. A small increase in MOM (required for example if not all farmers participate in the proposed project) combined with a small reduction in crop price would have a slight negative impact on economic performance, reducing EIRR to about 29%.

Table 3-21 Sensitivity of EIRR to Changes in Crop Price and MOM

Change in price of irrigation	Change in Crop Price				
	-20%	-10%	0%	+10%	+20%
-20%	29.9%	34.4%	38.5%	42.3%	45.8%
-10%	29.6%	34.2%	38.3%	42.1%	45.6%
0%	29.3%	33.9%	38.1%	41.9%	45.3%
+10%	29.1%	33.7%	37.8%	41.6%	45.1%
+20%	28.8%	33.4%	37.6%	41.4%	44.9%

Assumptions on crop yield increments were initially too modest, and substantially below the technically possible. They have subsequently been revised upwards. In the Table below, the equivalent winter maize yield is shown for each percentage crop yield change in the sensitivity analysis. Present irrigated yields are estimated to be about 25 quintals per ha.

The sensitivity analysis below suggests that failure to meet even modest yield increases could be disastrous, while substantial benefits accrue to improvements. It would be good to be sure of the impact of the extension component, but so much is dependent on the availability of a large well qualified, well-resourced and motivated extension service. A large budget allocated in the project costs by no means guarantees that such a service will materialise.

Table 3-22 Sensitivity of EIRR to Changes in Crop Price and Crop Yield

With project yield of winter maize, q/ha	Change in crop yield	Change in Crop Price				
		-20%	-10%	0%	+10%	+20%
28	-50%	#	-2%	6%	11%	15%
33	-40%	4%	11%	16%	20%	23%
39	-30%	13%	18%	23%	27%	30%
44	-20%	19.3%	24.4%	28.6%	32.4%	35.8%
50	-10%	24.6%	29.5%	33.6%	37.4%	40.6%
55	0%	29.3%	33.9%	38.1%	41.9%	45.3%
61	+10%	33.4%	38.0%	42.1%	45.9%	49.5%
66	+20%	37.1%	41.7%	45.6%	49.7%	53.3%

Note: # signifies than an EIRR is not calculable, usually because the net benefit stream is consistently negative.

Similarly, if the irrigated area is not achieved in full, the economic return will be prejudiced; the Table shows that even if crop price is maintained, if the with project farmer area achieved is only 50% of that assumed then the EIRR falls to 18%. Implementation should aim at a bare minimum of 60-70% of the area under sustainable irrigation. The proposed project economic performance is therefore very sensitive to this parameter. Conversely even a small increase in the irrigated area can boost project performance.

Table 3-23 Sensitivity of EIRR to Changes in Crop Price and Irrigated Area

Irrigated ha developed	Change in area developed	Change in Crop Price				
		-20%	-10%	0%	+10%	+20%
185	-70%	#	-5%	1%	6%	9%
247	-60%	1%	7%	11%	15%	15%
309	-50%	9%	14%	18%	21%	24%
371	-40%	15%	19%	23%	26%	29%
433	-30%	19%	24%	27%	31%	34%
494	-20%	23%	27%	31%	35%	38%
556	-10%	26%	31%	35%	39%	42%
618	0%	29%	34%	38.1%	42%	45%
680	+10%	32%	37%	41%	45%	49%
816	+20%	35%	40%	44%	48%	52%

Combining the very sensitive parameters, with project crop yields and irrigated area, it is evident that an 80% reduction in anticipated with project yields (which would still represent a 50% increase on present winter maize yields) and a 50% reduction in the with-project irrigated area will lead to an EIRR below the discount rate.

Table 3-24 Sensitivity of EIRR to Changes in Crop Yield and Irrigated Area

With project yield of winter maize, q/ha	Change in crop yield	Change in Irrigated Area									
	Ha developed	185	247	309	371	433	494	556	618	680	742
		-70%	-60%	-50%	-40%	-30%	-20%	-10%	0%	+10%	+20%
17	-70%	#	#	#	#	#	#	#	#	#	#
22	-60%	#	#	#	#	#	#	#	#	-15%	-7%
28	-50%	#	#	#	#	-12%	-3%	2%	6%	9%	11%
33	-40%	#	#	-13%	-1%	5%	9%	13%	16%	18%	21%
39	-30%	#	-11%	2%	8%	13%	16%	20%	23%	26%	28%
44	-20%	#	0%	8%	14%	18%	22%	26%	29%	31%	34%
50	-10%	-6%	7%	14%	19%	23%	27%	30%	34%	37%	39%
55	0%	1%	11%	18%	23%	27%	31%	35%	38.0%	41%	44%
61	+10%	6%	15%	21%	27%	31%	35%	39%	42%	45%	48%
73	+20%	9%	18%	25%	30%	35%	39%	42%	46%	49%	52%

Note: # signifies than an EIRR is not calculable, usually because the net benefit stream is consistently negative.

3.5 Conclusions

3.5.1 Amhara Region – Geray Scheme

At first sight the Geray Scheme is poorly performing with serious sociological problems and de-motivated farmers and a non-functioning WUC. The CAR is only 0.39, indicating a large proportion of the scheme command being out of irrigation. Both land and water productivity appears very low. Equity of water distribution appears to have broken down – an unusual phenomenon in Ethiopia where the WUC are usually so good at achieving equity between WUC members (often at the expense of optimum productivity, but always to the gain of water efficiency). There is a large sum accumulated in deferred maintenance, although this could not be calculated with the data to hand. There is insecurity of rights to both land and water.

Nevertheless, this scheme is recoverable with little expenditure, and a serious effort by ARD in order to solve the sociological and institutional problems. The capital costs of re-development are less than US$ 1,000 per ha due to the favourable terrain and good water source. The scheme would be cheap and relatively easy to manage. The WUC (which has legal identity) was formally strong, with apparent technical ability and an inclination for differential charging by crop for water. There was a culture for paying for water amongst members, albeit at a low level. An investor has recently opened a farm in the scheme, and although this has led to social conflict, the farm is apparently productive and a good example to smallholders.

Geray is the scheme with the best potential out the three schemes studied. The irrigation area is the largest and with sufficient water to irrigate the whole command area all year. With modernisation of the defunct structures, this project could become a model irrigation scheme for Ethiopia. The use of downstream control structures will ensure that tail farmers will get equitable distribution of water. All the scheme needs is for all the elements to come together, the technical irrigation, the crop cultural aspects and the institutional aspects which are not very demanding.

4 TIGRAY REGION – GEREB MIHIZ IRRIGATION SCHEME

4.1 TIGRAY REGION – GEREB MIHIZ SCHEME

4.1.1 Background – Brief History

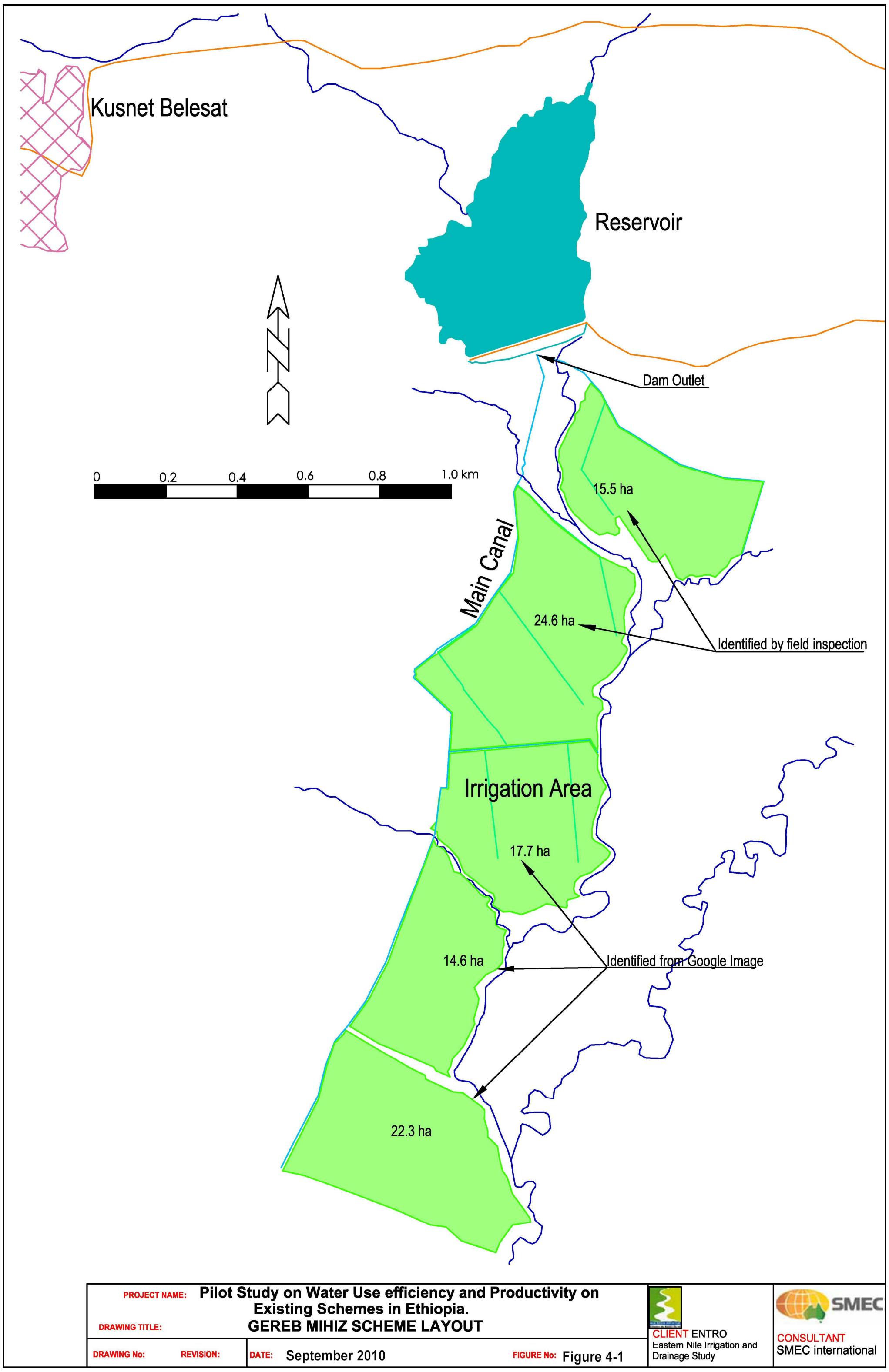
Gereb Mihiz Scheme is constructed in the Hintalo Wajirat Wareda. It is located at 39^{o} 28.2' E and 13^{o} 17.7' N.

This scheme uses water stored in a dam built in 1998, but sedimentation from the catchment has severely limited its success. Although catchment conservation measures were identified at the time of building, their implementation and success has not been sufficient to stop the sedimentation.

The dam crest length is 365 m with a height of 17.5 m. The reservoir area is 30 ha with a net capacity of 0.96 MCM. The catchment area is 17.2 km^2 and provides enough run-off to maintain water levels, but the sediment is blocking the outlet. The irrigated area is 80 ha. For the scheme layout, see Figure 4-1 Layout of the Gereb Mihiz Scheme. Salinity and drainage are also considered a constraint.

The layout of the scheme of shown in Figure 4-1.

Figure 4-1 Layout of the Gereb Mihiz Scheme



4.1.2 Climate of Gereb Mihiz

Table 4-1 Climatic Data for the Gereb Mihiz Scheme

ETHIOPIA		Station	**Mekele**	Altitude	**2070m**	
Min Temp	Max Temp	Humidity	Wind	Sunshine	Radiation	ETo
°C	°C	%	km/day	hours	MJ/m²/day	mm/day
9.0	23.0	60	284	9.4	20.2	3.87
10.0	24.2	53	347	9.8	22.4	4.77
11.3	25.1	57	344	8.8	22.4	4.90
12.9	25.4	59	321	9.2	23.7	5.10
13.5	26.7	51	251	9.8	24.4	5.42
13.2	26.8	55	181	7.2	20.2	4.55
12.8	23.1	73	173	4.9	16.8	3.44
12.7	22.3	80	142	5.1	17.2	3.21
11.6	24.2	63	163	7.5	20.5	4.03
11.0	23.6	57	262	9.5	22.3	4.49
9.8	22.5	58	301	10.0	21.3	4.16
9.1	22.1	55	319	9.9	20.3	4.06
11.4	24.1	60	257	8.4	21.0	4.33

4.2 PERFORMANCE INDICATORS

4.2.1 Water and Engineering Indicators

In Robi River no records of flows or other irrigation factors are taken. However, some assessment has been made on the basis of the inspections in the field. A structural indicator, Effectivity of Infrastructure (EI) can be calculated from the inspection made. There are 14 structure observed in the scheme, of which 8 are operational and in working order. This gives an EI of 0.57.

The Irrigated Area Ratio is calculated from the actual are irrigated compared to the measured irrigated area from GPS measurements. There measurements are gross so have been reduced by 5% to obtain a net irrigated area. The irrigated area is different to the cropped are, which can be higher when double cropping is practised, like in Robi River. Below is the estimated IAR:

Scheme	Gross Area	Net Area	Irrigated Area	IAR
	ha	ha	ha	
Robi River	183.6	174.4	134.7	0.77
Geray	674.4	640.7	238.0	0.37
Gereb Mihiz	94.7	90.0	18.0	0.20

In two of the schemes, irrigation was taking place and flows could be estimated. No flows were observed in Robi River, as irrigation was not taking place as rain had recently fallen. The flow is used in a Delivery Performance Ratio calculation, but this is rather crude. The intended flow is taken as the future water requirement, as an indicator. Below is the estimated DPR:

Scheme	Measured Flow	Intended Flow	DPR
	l/s	ha	
Robi River			
Geray	150	585	0.26
Gereb Mihiz	10	68.0	0.15

4.2.2 Institutional Indicators

Performance indicators for institutional aspects of the three irrigation schemes, namely: Robi; Geray; and Gereb Mihiz are focused on institutions involved in the: management and operation and maintenance of the irrigation scheme; fee collection and extension services provided to the water users of the irrigation scheme.

In assessing the performance of the institutions involved, the following variables and methodology for data gathering were used:

Variables

i. Mandate/Functions of the institution

j. Organization, System and Procedures for MOM, O&M and extension services

k. Fee Collection (components, amount and efficiency)

l. Perception on efficiency of the organization, system and procedures

Methodology and Data Gathering

g. Household Survey

h. Direct on-site observation

i. Semi-Structured Interviews with water users and relevant officials and staff at regional, zonal, woreda and kebele levels.

In line with the objectives of the pilot study on improving Water Use Efficiency, the institutional performance indicators used in the study are presented in the following Table 2-3. It shows the performance indicators with the corresponding performance assessment for the three irrigation schemes.

Table 4-2: Gereb Mihiz Scheme Performance Indicators

No.	Performance Indicators	Performance Assessment*
1.	Functionality of Government Institutions e.g. BWR and ARD	• BWR regional level has no annual O&M Plan and budget for the scheme but makes annual program for major repair works to be undertaken in the region. There is no continuous training and guidance to the WUA after turn-over. • BWR at Woreda level previously conducted annual maintenance need assessment for Gereb Scheme. No water charge introduced yet. BWR head said that farmers lack knowledge on proper use of irrigation water. Need to enhance capacity of water technician. Performance assessment is fair (2)
2.	Functionality of Farmers' Institutions e.g. WUA	• Performance assessment of WUA is fair (2): a) no legal personality; b) does not collect water charge but collects water distribution fee to valve operator; c) performed regular maintenance work before; and d) conducts WUA meetings (Officers and General Assembly)
3.	Adequacy and effectiveness of Extension Services	• Performance assessment is fair (2). According to the head of ARD and BWR at Woreda level, farmers lack knowledge on proper planting and weeding, use of inputs and fertilizers. Need to enhance DAs' capacity.

Note: Scale of 1-5 with 1= Poor 2= Fair=; 3=Satisfactory; 4= Good; 5= Very Good

It should be mentioned that during the visit to Gereb Mihiz, the Consultant was able to meet the head of BWR and ARD offices at the Woreda level (Hintalo Wejerat) and only one WUA officer (former WUA treasurer) and 2 water user-members at the project site. Performance assessment on institutional indicators was based mainly on the Study's perception based on observations during the study visit and semi-structured interviews conducted.

4.2.3 Economic Indicators

4.2.3.1 Relative Water Cost

The relative water cost indicator (*RWC*) is calculated using the formula:

$$RWC = \frac{C_w}{C_{tc}}$$

where C_w is the total cost of irrigation water and C_{tc} is the total cost of production of crops. RWC is the cost of providing water as percentage of the total cost of crop production.

RWC for Gereb Mihiz has been calculated as 0.08. This is a very low ratio. Water is cheap relative to other factors of production but only because there is so little of it in relation to the size of the scheme. Most crops are grown rainfed. However, though the cost of providing water is small relative to the cost of other factors of production, the unit cost of supply is expensive because of storage costs and problems of sedimentation.

Table 4-3 The Relative Water Cost Indicator

Scheme	Key Parameters		Relative Water Cost Indicator
	Total Scheme Production Cost ETB	Scheme MOM and field irrigation cost, ETB	
Robi River	1,286,724	519,223	0.40
Geray	1,193,062	162,045	0.14
Gereb Mihiz	344,423	28,879	0.08

4.2.3.2 Operation and Maintenance Fraction

The operation and maintenance fraction (O&M) is calculated using the formula:

$$O\,\&\,M = \frac{C_{o\&m}}{I_S}$$

where $C_{o\&m}$ is the cost of operation and maintenance and I_s is the budget for sustainable MOM. The O&M fraction is the cost of O&M proportional to the total cost MOM cost.

One of the indicators of a well run business is low management overhead costs, and an efficient water user association would be expected to have a fraction of about 0.90, depending on its size. For both Geray and Gereb Mihiz the O&M fraction is about 0.75. This is a low value, indicating little being spent on maintenance and much being spent on management. In the case of Gereb Mihiz there is little water to manage and the scheme is small.

The future expected O&M fraction is also shown in Table 2-5, taking into account full maintenance costs on the structures proposed, and the irrigation management structure expected. The high fraction predicted for Grebe Mihiz assumes that local irrigation management will not be responsible for management of dredging and catchment protection, which will be the responsibility of ARD or the regional authorities.

Table 4-4 The O&M Fraction

Scheme	Key Parameters			O&M Fraction	Future Expected O&M Fraction
	Scheme MOM ETB/ha	Scheme Management ETB/ha	Scheme O&M ETB/ha		
Robi River	564	11	553	0.98	0.93
Geray	255	65	190	0.75	0.87
Gereb Mihiz	181	48	133	0.73	0.96

4.2.3.3 MOM Funding Ratio

The MOM funding ratio (*MOM_FR*) is calculated using the formula:

$$MOM\_FR = \frac{I_a}{I_S}$$

where I_a is actual annual income and I_s is the budget for sustainable MOM. The ratio measures the impact of the cost of water on farmer's incomes. It is calculated first using present MOM. The method used was to compare the estimated net household income with the sample of the Household Survey for each scheme and calculate the MOM payment at current rates that would be required on the irrigated area of each – assuming MOM costs were distributed pro rata to irrigated area. The ratio is also calculated for future expected MOM against the future expected farm budget.

For Gereb Mihiz the MOM funding indicator has been calculated as 0.02. It is very small because most of the scheme is un-irrigated and there is very little water to manage. The sustainable MOM funding indicator would be about 0.10 (based on with project farm budgets), which is very high due to dredging and catchment management costs. There may be a case for partial subsidy of dredging costs by MoWR.

Table 4-5 The MOM Funding Ratio

Scheme	Key Parameters			Present MOM Funding Ratio	Future Expected MOM funding Ratio
	Total Net Income of HHS sample, ETB pa	Net irrigable area of HHS sample, ha	MOM Requirement of HHS sample, ETB		
Robi River	264,319	23	12,904	5%	5%
Geray	78,783	79	20,111	26%	5%
Gereb Mihiz	73,001	7	1,204	2%	10%

4.2.4 Environmental Indicators

Sustainability indicators are classified under environmental indicators in Bos et al (2005) and are intended to indicate trends in the proportion of the command irrigated, and the tonnage of biomass produced per unit volume of water and area of land.

4.2.4.1 Cropped Area Ratio

The cropped area ratio (*CAR*) is calculated using the formula:

$$CAR = \frac{A_a}{A_I}$$

where A_a is average cropped area and A_I is the initial total irrigable area. CAR is a measure of the intensity of use of the command area. Table 2-7 summarises the calculation for each of the three schemes. The CAR for Gereb is also very low; 0.22, suggesting that a large proportion of the scheme has gone out of production due to siltation of the dam.

Table 4-6 The Cropped Area Ratio

Scheme	Key Parameters		Cropped Area Ratio
	Gross cropped ha 2009/10	Designed net irrigable ha	
Robi River	232	175	1.32
Geray	238	618	0.39
Gereb Mihiz	18	80	0.22

4.2.4.2 Water Productivity Indicator

The water productivity indicator (*WP*) is calculated using the formula:

$$WP = \frac{Y_c(kg)}{V_a(m^3)}$$

where Y_c is the crop yield in kilograms and V_a is the application of water in m^3.

The land productivity indicator (*LP*) is similar, and calculated using the formula:

$$LP = \frac{Y_c}{A_a}$$

where Y_c is the crop yield in kilograms and A_a is the net scheme area in hectares. The indicator is simply aggregated tons of crop production divided by scheme area. The water productivity indicator requires an estimate of present irrigation practice. The Household Survey requested farmers to report the frequency, depth and duration of irrigation for each plot and crop they irrigated. The weakness of this approach is that the information is based on recall – though farmers generally have good memories. The strength of the method is that data is compiled on a large number of plots (Robi 224 plots of which about 180 were irrigated); Geray 158 plots of which about 40 were irrigated and Gereb Mihiz 106 plots of which 32 were irrigated). The variance of the data reduces with the size of the sample. Also the data is not only plot specific but also crop specific, as land use was recorded for each plot, including planting and harvest dates. CROPWAT8 was then used to estimate the impact of the reported applications on the reported crops, and build up a scheme level estimate of use based on the reported cropping pattern.

Water and land productivity indicators are shown for Robi River, Geray and Gereb Mihiz Irrigation schemes in Table 2-8. For Gereb Mihiz the land productivity indicator is low; 1,600 kg/ha, but understandably so bearing in mind the semi-arid climate, the very small proportion of the scheme being irrigated and the inadequacy of irrigation supply due to dam sedimentation. The Water Productivity index on the other hand is high, 6.58 kg per m^3 suggesting a high efficiency of water use.

Table 4-7 Water and Land Productivity Indicators

Scheme	Key Parameters				Land productivity kg/ha	Water Productivity kg/m^3
	Irrigated gross ha	Non irrigated ha	Total crop production, quintals	Water application , m^3		
Robi River	231	0	19,558	140,101	10,572	13.96
Geray	156	82	4,506	535,249	2,359	0.84
Gereb Mihiz	18	62	1,278	19,419	1,598	6.58

4.2.4.3 Biomass Productivity Indicator

Biomass productivity is calculated in a similar way to the land and water productivity indices, but includes the weight of crop residues as well as main crop in the calculation. There are measurement difficulties here, because crop and residue yields may be measured with different water contents. Also residue yields are not well known; they vary considerably depending on crop yield and management and really need to be measured directly. With this in mind, the estimates given in Table 2-9 should be considered indicative only.

The estimate for Gereb Mihiz in 2009/10 is 2,370 kg per current net scheme hectare. Because the climate is semi arid and the amount of irrigation is very limited this is unsurprisingly low. The biomass production per unit of water is estimated as 10 kg per m^3, a high return which is again unsurprising as water is in very short supply.

Table 4-8 Biomass Productivity Indicators

Scheme	Key Parameters				Biomass Productivity, kg/ha	Biomass Productivity, kg/m^3
	Main crop quintals/ha	Residues quintals/ha	Net scheme area, ha	Water application, m^3		
Robi River	120	35	89	140,101	15,556	25.70
Geray	7,553	3,762	191	535,249	5,924	2.11
Gereb Mihiz	1,249	647	80	19,419	2,370	9.76

4.2.5 Summary of Performance Indicators

The performance indicators described above are summarised in Table 4-9.

Table 4-9 Summary of Performance Indicators

Performance Indicators		Robi		Geray		Gereb Mihiz	
		Value	Rate	Value	Rate	Value	Rate
Irrigated Area Ratio	IAR	0.77	3	0.37	1	0.20	1
Delivery Performance Ratio	DPR	-		0.26	1	0.15	1
Function BWR/ARD			3		3		2
Function FU/WUA			2		4		2
Function Extension			3		3		2
Relative Water Cost	RWC	0.40	1	0.14	2	0.08	3
O&M Fraction	O&M F	0.98	5	0.75	3	0.73	3
MOM Funding Ratio	MOM R	0.05	1	0.26	4	0.02	1
Crop Area Ratio	CAR	1.32	4	0.39	1	0.22	1
Land Productivity	BIO kg/ha	10,572	5	2,359	1	1,598	1
Water Productivity	BWP kg/m^3	13.92	5	0.84	2	6.58	5
Biomass Land Productivity	BIO kg/ha	15,556	5	5,924	2	2,370	2
Biomass Water Productivity	BWP kg/m^3	25.70	5	2.11	2	9.76	4
Scheme Average Score			3.50		2.23		2.15

The average overall indicator for Gereb Mihiz is 2.15, which is considered a fair indicator.

For the details of the performance rating for the indicators, see Table 5-2.

4.3 DETAILED ACTION PLAN

For Gereb Mihiz to succeed, solutions have to be found for reducing the sedimentation to acceptable levels and for the outlet to operate every year without major work required to clear the outlet. The farmers have found a solution to the outlet by using a siphon over the embankment wall. This idea is exactly what will work, only a better engineered solution is required rather than a 3" tube. Then the sedimentation solution has two parts, conservation and sediment removal.

4.3.1 Security of Water Supply

The farmers have identified a solution to the outlet by using a siphon over the wall, however, they can only afford a 3" tube, without and valves either end. This makes keeping it operational a continuous task. In fact, the siphon over the wall can take care of the changes in sediment level, but a more permanent solution is required. This study has designed a 10" pipe with foot valve in the intake and a gate valve (or butterfly valve) on the outlet. To cope with the fluctuating water levels the section of pipe on the upstream side of the dam should be flexible with a float. The foot valve is attached in the correct angle to the float. This whole contraption will then move up and down with the water level and maintain a constantly primed siphon. At the crest of the dam will be a reservoir to allow priming of the siphon. On the downstream side a gate valve will control the flow. This should have a USBR type of pipe outlet to reduce the energy and stop erosion of the banks. The most suitable type of pipe for this application is a continuous welded pipe, like HDPE that has a heat welded joint. The flexible pipe on the inlet side should be armoured rib flexible 10" hose. The floats can be two 210 litre drums welded to a frame and the foot valve suspended 2.0 m below this. As the pipe passes the crest of the dam, it should be buried to just above the maximum water level and allow traffic to pass unhindered. The position of the pipe should be at a height now to induce cavation, or a maximum of 7.0 m above the minimum water level. Below the baffled outlet will be a measuring devise to allow the operators to keep measurements of flows and water charges can be made. For the drawing of this arrangement, see Figure C7.

4.3.2 De-silting Reservoir at Head works.

Many of the dams in the area have similar conditions to Gereb Mihiz and attempts to remove the sediment from the double dams of Mia Gessa 1 & 2 have been very expensive. The cheapest method of moving sediment is undoubtedly using a dredger. Pumping sediment through a long pipe is much cheaper than hydraulic excavator and truck. The question is what to do with the slurry pumped over the wall. Investigations should be undertaken into the fertility properties of the sediment. If it is found to be suitable for growing crops, the best solution is to place in on the land immediately over the wall, creating level area of land with pure sediment. Many of the lands below the dam are quite stony with what appears to be poor fertility. This can be done for over 500 metres, as far as the dredger pump will pump it and it is all down hill. In fact the dredger will also act as a siphon and the pumping cost will be low. It all depends on the suitability of the sediment for crop production. If this proves to be successful, it could become a self sustaining process with fresh sediment placed on the land every year.

4.3.3 Sediment control - Catchment conservation plan

There is no question that attention should continue to be paid to conservation of the catchment. Farmers were complaining that they have to spend much time building stone bunds to conserve the catchment. More funds are needed to complete this work and also a start should be made to introducing conservation tillage techniques which will make a huge impact on the amount of sediment washed into the dam. If the farmers in the catchment continue to farm in the traditional method of three ploughs per crop, soil will continue to end up in the dam. Only conservation tillage, which conserves a layer of mulch to stop soil erosion will there be any reduction of sediment. Stone bunds and check dams will only reduce the sediment already on its way down the slope to the dam. Conservation tillage actually slopes the soil from moving off the field, at source, which is ultimately the best approach.

4.3.4 On-Farm Irrigation Practice

A major limitation to productivity in the project is the aspect of irrigation cultural practises. In all cases none of the crops were planted in rows with effective ridges. This means that all irrigation is by uncontrolled flooding. Farmers need to be trained to plant in furrows and all irrigation water should be run down furrows in a short time to reduce over-watering. This is the only basic improvement identified for this project.

Other improved methods of irrigation like drip or mini-sprinkler are too expensive to be recommended at this stage. Once farmers are trained in effective flood irrigation methods there will be an increase in productivity and hence income increase. This will allow the situation of introducing mechanical irrigation to be considered in the future.

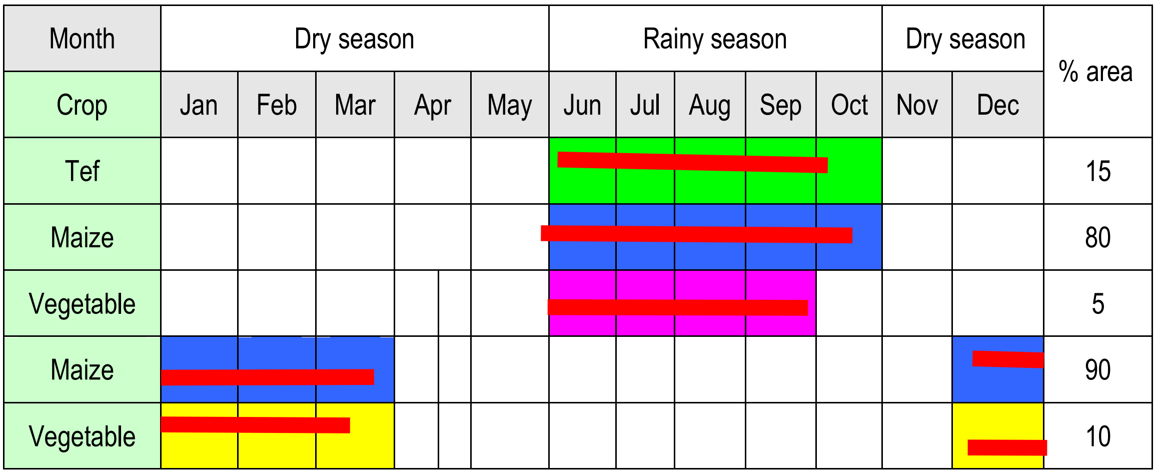
4.3.5 Cropping Pattern

The estimate of the present cropping of the scheme (80 ha, of which 18 ha is presently irrigated) was based on plot level data from farms sampled in the household survey and generalised into a model farm cropping pattern. There are 67 farms in the present irrigated area and a further 133 farms in that part of the command which is presently not irrigated. The present gross cropped area and cropping intensity are shown in Table 2-11. The with project cropping pattern is also shown in this Table. It is simple, based on irrigated maize, onion and vegetables and the staple grains, rainfed teff, barley and maize. It is assumed that in the future with project, rainfed crops in the scheme area will receive supplementary irrigation. A large proportion of farmers associated with the scheme farm land outside of it. It was important to identify this land in order to prepare farm budgets. The cropping pattern was introduced into CROPWAT 8 to derive with project CWR.

Table 4-10 Present and Future With Project Cropping Pattern, ha

	Present				Future with project			
	Within scheme area		Outside scheme area		Within scheme area		Outside scheme area	
	Irrigating Farmers	Non irrigating farmers	Irrigating Farmers	Non irrigating farmers	Present Irrigating Farmers	Future irrigating farmers	Present Irrigating Farmers	Future irrigating farmers
Irrigated crops on irrigable area								
Maize	11	0			24	48		
Onion	5	0			1	3		
Vegetables	3	0			1	3		
Rainfed crops on irrigable area								
Teff	9	18			9	18		
Wheat	9	18			9	18		
Barley	9	18			9	18		
Rainfed crops outside scheme area								
Teff			25	50			25	50
Wheat			25	50			25	50
Barley			25	50			25	50
Scheme cropping intensity	123%				200%			

The irrigation water requirements have been calculated for the with-project cropping pattern, presented in Table 4-11, below.



Solid cell color = Duration of crop in the field Red color= Duration of irrigation

Table 4-11 Gereb Mihiz Scheme Crop Water Requirements

Gereb Mehiz Scheme		Met. Station : **Mekele**										
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation deficit												
1. MAIZE (Grain)						6.5		10.2	120.1	43.8		
2. Small Vegetables						34.3		5.1	50.8			
3. MAIZE (Grain)	143.3	188.2	142.2	5.1								53.1
4. Small Vegetables	148.3	166.0	26.5									111.0
Net scheme irr.req.												
in mm/day	4.6	6.6	4.2	0.2		0.3		0.3	3.9	1.3		1.9
in mm/month	143.8	186.0	130.7	4.6		7.8		9.9	116.7	41.6		58.9
in l/s/h	0.5	0.8	0.5	0.0		0.0		0.0	0.5	0.2		0.2
Irrigated area (% of total area)	100	100	100	90		100		100	100	95		100
Irr.req. for actual area (l/s/h)	0.5	0.8	0.5	0.0		0.0		0.0	0.5	0.2		0.2
at Efficiency of %	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Gross Irr.req. for area (l/s/h)	0.8	1.1	0.7	0.0		0.0		0.1	0.6	0.2		0.3
Mm^3/ha/day	66.7	95.0	60.5	2.5		3.7		4.9	55.5	19.7		27.2
Gross irrigated area ha	80	80	80	80	80	80	80	80	80	80	80	80
Gross Irr.req. (l/s)	61.7	88.0	56.0	2.1		3.4		4.6	51.4	17.4		25.1

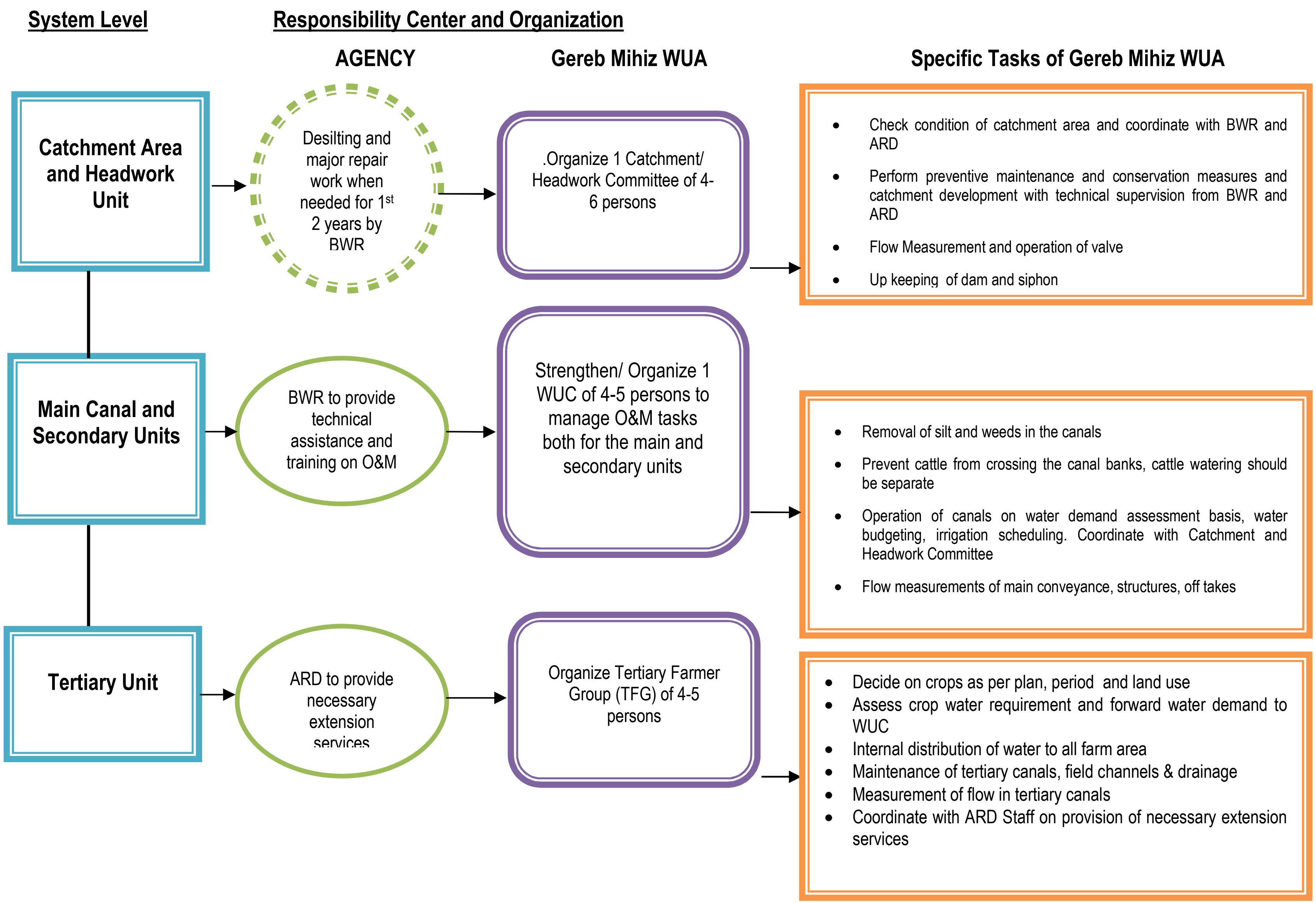
4.3.6 Institutional Strengthening

It is recommended that BWR at regional level will remain responsible for desilting and major repairs/maintenance works (when needed) in the catchment and headwork system for a maximum of 2 years after the proposed improvement works to restore functionality of scheme has been implemented. However, responsibility for preventive and routine maintenance in the catchment and headwork should already be assumed by the WUA after the improvement works. It is suggested that one Committee be formed to manage O&M of the catchment and headwork unit. For the main and secondary units, only one WUC is suggested to be formed with 4-5 persons as members. Finally, it is suggested that the WUA will also form one Tertiary Farmers' Group (TFG) to oversee and manage O&M of the tertiary Unit. The TFG will consist of 4-5 persons. Aside from the O&M tasks to be performed by the WUA at various levels of the scheme, the WUA should fix water charge for the use of the scheme after its improvement. The amount of water charge proposed by the study will be presented and discussed in the WUS programme. A fee collector is suggested to be appointed by the WUA and can be paid on commission basis for this responsibility.

The Gereb Mihiz Scheme needs the deployment of an experienced and well trained Social Mobilizer. The role for this person is discussed in section 2.3.7.2. Legal personality to the WUA is required, see section 2.3.7.3. A WUS and on-site workshops should be established, as described in section 2.3.7.4. BWR/ARD staff at Regional/Woreda level should assist in developing the capacity of the WUO to assume more responsibility for the MOM and O&M of the irrigation scheme, as described in section 2.3.7.5. A capacity building programme should be established to develop skills in O&M Planning and Budgeting, Irrigation Water Management and Irrigation System Management Transfer, Community Organizing and Organizational Development and how to run/facilitate WUS programme with the WUO. For Gereb Mihiz, the Head of BWR and ARD, Water Technicians, and the DAs assigned should be included. Regular coordination meetings are required at wereda level for review and planning (see section 2.3.7.8).

Figure 4-2 shows a diagram describing the proposed organization of MOM and O&M for Gereb Mihiz Scheme.

Figure 4-2 Proposed Organisation of MOM and O&M of Gereb Mihiz Irrigation Scheme



4.3.7 Financial Strengthening

Credit requirements for this project should be limited to support to the existing Farmers' Association for the supply of incremental inputs required. These are mostly fertiliser and crop protection chemicals, for which the incremental requirement will be very limited. Fertiliser requirements for example will increase by no more than 60%. Financing at 20% of the value of the inputs has been added to project costs to cover interest and administration charges, and comes to about ETB 10,000 per annum.

4.4 BUDGET FINANCIAL COSTS

4.4.1 Costs and Quantities

Table 4-12 Costs and Qantities for Gereb Mihiz Irrigation Scheme

Tigray Region - Gereb Mihiz Scheme

Item	Description	Unit	Quantity	Unit Cost (US$)			Amount
				L/C	F/C	Total	
1	**Preparatory Works**						
1.1	Mobilization of plant, equipment and personnel to site	LS	0.05	8,340.80	158,475.22	166,816.02	8,340.80
1.2	Demobilization of plant, equipment and personnel	LS	0.05	7,190.42	136,618.11	143,808.53	7,190.43
						Sub-Total	**15,531.23**
2	**Syphon**						
2.1	Supply & laying HDPE DR11 welded joints, nominal bore 250mm	lm	90	2.86	54.46	57.32	5,158.80
2.2	Floats	1 set	1	13.35	253.78	267.13	267.13
2.3	Diameter 250mm Foot Valve at inlet	N0.	1	44.52	845.94	890.46	890.46
2.4	Diameter 250mm Gate Valve at outlet	N0.	1	44.52	845.94	890.46	890.46
2.5	Outlet Structure						
2.5.1	Excavation	m^3	6.00	0.17	3.24	3.41	20.46
2.5.2	Concrete	m^3	3.00	11.76	223.54	235.30	705.90
2.5.3	Supply and install form work	m^2	26.90	0.11	2.27	2.38	64.02
2.5.4	Supply and place reinforcing steel	ton	1.00	138.70	2,635.43	2,774.13	2,774.13
						Sub-Total	**10,771.36**
3	**Dredging**						
	Dredger Purchase cost and transport	No.	1	2714.28	51571.42	54,285.70	54,285.70
	Operation to remove sediment	m^3	51,810	0.05	1.06	1.11	57,509.10
4	Catchment conservation plan	No.	1	1864.5	35425.5	37,290.00	37,290.00
						Sub-Total	**149,084.80**
						Total for Gereb Mehiz Scheme	**175,387.39**

4.4.2 Total Project Costs

The civil works are calculated to be ETB 2.46 million (US$ 175,387) in current 2010 prices. Works have been assumed to be phased over two years, 50% in the first year and 50% in the second.

Sustainable maintenance was estimated ETB 0.32 million, including dredging and watershed management. This is a very high figure, raising O&M together to nearly US$ 300 per hectare. To this must be added management and operation costs. Management costs were estimated assuming that the scheme at full development will be managed by one WUC, the management cost will be ETB 14,200 per annum (fees of chairman, treasurer and secretary plus stationery etc.). The operation cost will be ETB 4,200 per annum, to cover the scheme requirement of one gateman and 2 water masters. The total MOM is therefore estimated as ETB 340,400 per annum.

Project support costs are:

- community mobilisation (cost estimated at ETB 150,500 pa), scheduled for three years during construction
- agricultural extension support (cost estimated at ETB 85 per gross cropped hectare under development) scheduled for ten years starting in Year 2 of the project
- credit for planting material and the supply of other inputs through the Farmers' Association.

The fixing of a charge for water is the pivot between costs and benefits on which project design hinges. It must be fixed so that it allows sustainable MOM, and be affordable to irrigators. Project support enables farmers to realise expected scheme benefits and attain income to meet the charge. The MOM cost per m^3 was obtained by dividing the sustainable MOM requirement by the volume delivered to meet irrigation requirements (0.37 million m^3 per annum, derived from CROPWAT8, 70% efficiency). The MOM cost per ha was calculated by the volume required by crop, times price of water divided by expected future crop area.

4.4.3 Project Benefits

The future value of production without project is calculated on the present partially irrigated area of 27 net scheme hectares, and the rest of the net command area which is not irrigated, 53 net scheme hectares. This is straightforward; there are 67 smallholder farms in the former and 133 in the latter. The production of a single future with project model farm can be bulked up accordingly from two present farm models. Without project crop and livestock enterprise gross margins have been prepared using data from the Household Survey and these are available in the Annex material.

The future value of production without project is calculated on the present irrigated area of 27 net scheme hectares, which is expected to decline to less than half this area in five years, due to declining volume of the water source as a result of sedimentation and increasing difficulties in passing water from the dam to the irrigating area (siphons over the dam wall are used at present). The without project benefit stream is shown inTable 4-13.

With project, it is assumed that full irrigation supply will be provided to the present scheme area of 80 net hectares. Phasing to achieve full project benefit is important. It is unlikely that even the modest future irrigated yields expected with project will be achieved immediately. On 18.76 ha of presently irrigated land without project irrigated crop gross margins are phased to reach with project irrigated annual and perennial crop gross margins in five years. On the additional 61.24 ha it is assumed the first project year will have no irrigated production after which it will take five years to reach full with project irrigated yields. There will be improvements of rainfed yields with project, due to the possibility of supplementary irrigation. Benefits from model farm livestock enterprises are internalised within scheme benefits.

The future without and future with project benefits are given in Table 4-13 andTable 4-14. Note that rainfed crop production of scheme model farms outside the scheme area is not shown. It is expected to be the same both without and with project.

Table 4-13 Gereb Mihiz Estimate of Without Project Scheme Benefits, Financial ETB

IRRIGATING SMALLHOLDER FARM AREAS WITHIN SCHEME	Gross ha		Gross Margin, ETB						Value of Production, ETB				
			Year 1	Year 2	Year 3	Year 4	Year 5		Year 1	Year 2	Year 3	Year 4	Year 5
Irrigated crops on irrigable area													
Maize	11	ETB/ha	10,292	10,292	10,292	10,292	10,292		115,841	86,881	57,921	28,960	0
Onion	5	ETB/ha	8,453	8,453	8,453	8,453	8,453		39,645	29,733	19,822	9,911	0
Vegetables	3	ETB/ha	25,480	25,480	25,480	25,480	25,480		71,701	53,776	35,850	17,925	0
Rainfed crops on irrigable area													
Teff	9	ETB/ha	4,945	4,945	4,945	4,945	4,945		44,171	44,171	44,171	44,171	44,171
Wheat	9	ETB/ha	7,891	7,891	7,891	7,891	7,891		70,490	70,490	70,490	70,490	70,490
Barley	9	ETB/ha	6,014	6,014	6,014	6,014	6,014		53,722	53,722	53,722	53,722	53,722
Livestock													
Dairy Cows (1 cow unit), milk & calf	67	ETB/unit	1,255	1,255	1,255	1,255	1,255		84,115	84,115	84,115	84,115	84,115
Beef Cattle (1 head unit) meat	134	ETB/unit	285	285	285	285	285		38,190	38,190	38,190	38,190	38,190
NON IRRIGATING SMALLHOLDER FARM AREAS WITHIN SCHEME	**ha**		**Gross Margin, ETB**						**Value of Production, ETB**				
			Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**		**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Irrigated crops on irrigable area													
Maize	0												
Onion	0												
Vegetables	0												
Rainfed crops on irrigable area													
Teff	18	ETB/ha	4,945	4,945	4,945	4,945	4,945		87,683	87,683	87,683	87,683	87,683
Wheat	18	ETB/ha	7,891	7,891	7,891	7,891	7,891		139,927	139,927	139,927	139,927	139,927
Barley	18	ETB/ha	6,014	6,014	6,014	6,014	6,014		106,642	106,642	106,642	106,642	106,642
Livestock													
Dairy Cows (1 cow unit), milk & calf	133	ETB/unit	1,255	1,255	1,255	1,255	1,255		166,975	166,975	166,975	166,975	166,975
Beef Cattle (1 head unit) meat	266	ETB/unit	285	285	285	285	285		75,810	75,810	75,810	75,810	75,810

Table 4-14 Gereb Mihiz Estimate of With Project Benefits, Financial ETB

IRRIGATING SMALLHOLDER FARM AREAS WITHIN SCHEME	ha		Gross Margin, ETB						Value of Production, ETB				
			Year 1	Year 2	Year 3	Year 4	Year 5		Year 1	Year 2	Year 3	Year 4	Year 5
Irrigated crops on irrigable area													
Maize	24	ETB/ha	10,292	11,109	11,926	12,744	13,561		248,231	267,948	287,665	307,381	327,098
Onion	1	ETB/ha	8,453	10,228	12,003	13,777	15,552		11,327	13,705	16,083	18,462	20,840
Vegetables	1	ETB/ha	25,480	29,753	34,026	38,298	42,571		34,143	39,869	45,594	51,320	57,045
Rainfed crops on irrigable area													
Teff	9	ETB/ha	4,938	5,492	6,046	6,600	7,154		44,113	49,061	54,009	58,957	63,905
Wheat	9	ETB/ha	7,878	8,381	8,884	9,387	9,890		70,374	74,869	79,364	83,859	88,355
Barley	9	ETB/ha	5,994	6,414	6,834	7,254	7,674		53,547	57,299	61,051	64,803	68,555
Livestock													
Dairy Cows (1 cow unit), milk & calf	67	ETB/unit	1,255	1,305	1,355	1,405	1,455		84,115	87,465	90,815	94,165	97,515
Beef Cattle (1 head unit) meat	134	ETB/unit	285	298	310	323	335		38,190	39,865	41,540	43,215	44,890
NON IRRIGATING SMALLHOLDER FARM AREAS WITHIN SCHEME	**ha**		**Gross Margin, ETB**						**Value of Production, ETB**				
			Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**		**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Irrigated crops on irrigable area													
Maize	48		0	3,390	6,781	10,171	13,561		0	162,328	324,657	486,985	649,314
Onion	3		0	3,888	7,776	11,664	15,552		0	10,342	20,684	31,027	41,369
Vegetables	3		0	10,643	21,286	31,928	42,571		0	28,310	56,620	84,930	113,240
Rainfed crops on irrigable area													
Teff	18	ETB/ha	4,938	5,492	6,046	6,600	7,154		87,568	97,390	107,212	117,034	126,856
Wheat	18	ETB/ha	7,878	8,381	8,884	9,387	9,890		139,697	148,620	157,544	166,467	175,391
Barley	18	ETB/ha	5,994	6,414	6,834	7,254	7,674		106,296	113,744	121,192	128,640	136,088
Livestock													
Dairy Cows (1 cow unit), milk & calf	133	ETB/unit	1,255	1,305	1,355	1,405	1,455		166,975	173,625	180,275	186,925	193,575
Beef Cattle (1 head unit) meat	266	ETB/unit	285	298	310	323	335		75,810	79,135	82,460	85,785	89,110

4.4.4 Cost Benefit Analysis

The CBA in 2010 financial ETB is given in Table 4-15. The FIRR is 24%, which is well above the discount rate, which has been taken at 10%. The BCR is 2.1 and the FNPV is ETB 5.2 million. The proposed project is attractive financially under the assumptions described. The net benefit is the increment between rainfed farming at 100% cropping intensity and irrigated farming at 200% cropping intensity, so naturally the proposed project is resilient to high cost.

Table 4-15 CBA Gereb Mihiz Irrigation Scheme Financial 2010 ETB

	PRESENT & FUTURE WITHOUT PROJECT BENEFIT	FUTURE WITH PROJECT BENEFIT	BENEFIT STREAM	CIVIL WORKS	INSTITUTIONAL SUPPORT	AGRICULTURAL EXTENSION	FINANCING CHARGES ON INCREMENTAL INPUTS USED	MOM COST		NET BENFIT STREAM
Year 1	1,094,912	1,094,912	0	1,227,712	150,532		0			-1,378,243
Year 2	1,038,115	65,475	-972,641	1,227,712	150,532	6,800	2,296			-2,359,980
Year 3	981,319	1,160,387	179,068	0	150,532	6,800	4,591			17,145
Year 4	924,522	1,594,724	670,202	0		6,800	6,887	340,365		316,150
Year 5	867,725	2,029,061	1,161,335			6,800	9,183	340,365		804,987
Year 6	867,725	2,463,398	1,595,672			6,800	9,183	340,365		1,239,324
Year 7	867,725	2,897,735	2,030,009			6,800	9,183	340,365		1,673,661
Year 8	867,725	2,897,735	2,030,009			6,800	9,183	340,365		1,673,661
Year 9	867,725	2,897,735	2,030,009			6,800	9,183	340,365		1,673,661
Year 10	867,725	2,897,735	2,030,009			6,800	9,183	340,365		1,673,661
Year 11	867,725	2,897,735	2,030,009					340,365		1,689,644
Year 12	867,725	2,897,735	2,030,009					340,365		1,689,644
Year 13	867,725	2,897,735	2,030,009					340,365		1,689,644
Year 14	867,725	2,897,735	2,030,009					340,365		1,689,644
Year 15	867,725	2,897,735	2,030,009					340,365		1,689,644
Year 16	867,725	2,897,735	2,030,009					340,365		1,689,644
Year 17	867,725	2,897,735	2,030,009					340,365		1,689,644
Year 18	867,725	2,897,735	2,030,009					340,365		1,689,644
Year 19	867,725	2,897,735	2,030,009					340,365		1,689,644
Year 20	867,725	2,897,735	2,030,009					340,365		1,689,644
	INTERNAL RATE OF RETURN									24%
	NET PRESENT VALUE									5,222,325
	NPV BENEFIT STREAM									9,851,665
	NPV COST STREAM									4,629,340
	BENEFIT TO COST RATIO									2.13

However, the main problem with the project as designed is affordability of MOM to project farmers. Assuming 100% command area development, MOM costs (as translated into a crop water charge) are 10% of expected model farm net household return. This is because all maintenance costs are expected to be met by irrigators, including dredging the dam and improving the quality of the catchment. It may be that the dredging costs will be partly subsidised by MoWR, in which case this problem would be reduced.

The Standard Conversion Factor (SCF) and specific conversion factors for construction, crop inputs, main commodities and labour have been calculated based on border prices and import or export parity as appropriate. The calculations are not reproduced here. Economically the project is more attractive than the CBA expressed in financial prices. This is normal, and because taxes and transfer payments have been removed and labour is valued at its opportunity cost (which is relatively low) so investment and production costs tend to fall, while commodity prices tend to maintain their value. Note though that the dredger is not expected to incur import duty (being imported by MoWR) and the CIF price quoted by the supplier has not been adjusted.

The economic analysis suggests a project which is attractive to public investment, with an EIRR of 31% and a CBR of 2.9. The returns are normal for irrigation rehabilitation, though with the Gereb Dam and Irrigation Project it would not be correct to comment that the project is merely addressing an issue of deferred maintenance (as are this Study's proposals for the Geray Irrigation Project). In this case the problem is dam sedimentation, which could not have been solved at design stage, given the hydrology of the area and the intensification of land use in the catchment since construction.

Table 4-16 CBA Gereb Mihiz Irrigation Scheme Economic 2010 ETB

	PRESENT & FUTURE WITHOUT PROJECT BENEFIT	FUTURE WITH PROJECT BENEFIT	BENEFIT STREAM	CIVIL WORKS	INSTITUTIONAL SUPPORT	AGRICULTURAL EXTENSION	FINANCING CHARGES ON INCREMENTAL INPUTS USED	MOM COST		NET BENFIT STREAM
Year 1	749,343	749,343	0	1,149,458	128,987		0			-1,278,445
Year 2	695,896	110,175	-585,721	1,149,458	128,987	5,827	1,516			-1,871,509
Year 3	642,448	859,518	217,069	0	128,987	5,827	3,033			79,223
Year 4	589,001	1,380,755	791,754	0		5,827	4,549	306,329		475,050
Year 5	535,554	1,901,993	1,366,439			5,827	6,066	306,329		1,048,218
Year 6	535,554	2,423,230	1,887,677			5,827	6,066	306,329		1,569,456
Year 7	535,554	2,944,468	2,408,914			5,827	6,066	306,329		2,090,693
Year 8	535,554	2,944,468	2,408,914			5,827	6,066	306,329		2,090,693
Year 9	535,554	2,944,468	2,408,914			5,827	6,066	306,329		2,090,693
Year 10	535,554	2,944,468	2,408,914			5,827	6,066	306,329		2,090,693
Year 11	535,554	2,944,468	2,408,914					306,329		2,102,586
Year 12	535,554	2,944,468	2,408,914					306,329		2,102,586
Year 13	535,554	2,944,468	2,408,914					306,329		2,102,586
Year 14	535,554	2,944,468	2,408,914					306,329		2,102,586
Year 15	535,554	2,944,468	2,408,914					306,329		2,102,586
Year 16	535,554	2,944,468	2,408,914					306,329		2,102,586
Year 17	535,554	2,944,468	2,408,914					306,329		2,102,586
Year 18	535,554	2,944,468	2,408,914					306,329		2,102,586
Year 19	535,554	2,944,468	2,408,914					306,329		2,102,586
Year 20	535,554	2,944,468	2,408,914					306,329		2,102,586
	INTERNAL RATE OF RETURN									31%
	NET PRESENT VALUE									7,933,749
	NPV BENEFIT STREAM									12,150,790
	NPV COST STREAM									4,217,040
	BENEFIT TO COST RATIO									2.88

4.4.5 Sensitivity Analysis

Sensitivity analysis has been carried out in economic prices for the following scenarios:

- Changes in capital costs of the main cost items
- Failure to develop the full command area as anticipated
- Changes in the cost of MOM
- Changes in the prices of agricultural labour, crop inputs, crop prices and crop yields.

For efficiency in presentation, sensitivities are calculated as two variable Data Tables. Examining first the relationship between total capital cost and MOM cost, it is evident that a 120% increase in MOM cost would lower EIRR to 32%, and the project economic return would still be well above the assumed discount rate. A similar increase in the capital costs of a similar amount would lower EIRR to 30%, so we may conclude that scheme economic performance is more sensitive to increases in investment costs than to increases in MOM. This is normal because MOM is more heavily discounted, but if MOM charges as a proportion of household income were high, the risk of farmers leaving irrigation would be high and the size of the irrigated area would fall, leading to rising MOM costs. MOM as a proportion of household income has already been investigated and found to be dangerously high.

Table 4-17 Sensitivity of EIRR to Changes in Capital and MOM Costs

Change in MOM cost	Change in Capital Cost				
	-20%	-10%	0%	+10%	+20%
-20%	33.7%	32.9%	32.0%	31.2%	30.5%
-10%	33.3%	32.4%	31.6%	30.8%	30.1%
0%	32.9%	32.0%	31.2%	30.4%	29.7%
+10%	32.4%	31.6%	30.8%	30.0%	29.3%
+20%	32.0%	31.1%	30.3%	29.6%	28.9%

Note: the EIRR of the project without sensitivity changes is given as 31.2%, as 0% change

In respect of sensitivity to the individual cost items, the cost of the dredger and the costs of initial de-siltation are obviously important as this accounts for over 60% of the investment costs proposed. Comparing Table 4-18 and Table 4-17 shows the relative importance compared with other capital costs.

Table 4-18 Sensitivity of EIRR to Changes in Capital Cost of Dredger and De-silting

Change in MOM cost	Change in Cost of Dredger and Initial De-silting				
	-20%	-10%	0%	+10%	+20%
-20%	34.1%	33.0%	32.0%	31.1%	30.2%
-10%	33.7%	32.6%	31.6%	30.7%	29.8%
0%	33.2%	32.2%	31.2%	30.3%	29.4%
+10%	32.8%	31.7%	30.8%	29.9%	29.0%
+20%	32.3%	31.3%	30.3%	29.4%	28.6%

Changes in estimated costs can always happen as a result of exchange rate changes or cost over-runs or delays in implementation. However, it would appear that the proposed project is fairly resilient to such changes.

The project return is much more sensitive to changes in the economics of crop production. If crop prices fell to -20% of the assumed values and inputs rose to +20% of their present cost, then the EIRR would fall to 23.4%. Nevertheless, this is still a satisfactory rate of return and the data table shows that the impact of increases in crop input costs barely impacts on the EIRR.

Table 4-19 Sensitivity of EIRR to Changes in Crop Price and Cost of Crop Inputs

Change in cost of crop inputs	Change in Crop Price				
	-20%	-10%	0%	+10%	+20%
-20%	23.9%	27.8%	31.4%	34.9%	38.1%
-10%	23.8%	27.7%	31.3%	34.7%	38.0%
0%	23.7%	27.5%	31.2%	34.6%	37.9%
+10%	23.5%	27.4%	31.1%	34.5%	37.8%
+20%	23.4%	27.3%	30.9%	34.4%	37.7%

In an economy which is industrialising, the cost of agricultural labour may increase relatively faster than other cost elements in agricultural budgets. Nevertheless, the Table below suggests that this is unlikely to have a dramatic impact on project performance – the effect is very similar to increasing the costs of crop inputs.

Table 4-20 Sensitivity of EIRR to Changes in Crop Price and Cost of Labour

Change in cost of agricultural labour	Change in Crop Price				
	-20%	-10%	0%	+10%	+20%
-20%	24.9%	28.7%	32.3%	35.7%	39.0%
-10%	24.3%	28.1%	31.8%	35.2%	38.4%
0%	23.7%	27.5%	31.2%	34.6%	37.9%
+10%	23.0%	27.0%	30.6%	34.1%	37.4%
+20%	22.4%	26.4%	30.0%	33.5%	36.8%

MOM costs are entirely attributed to farmers, on the assumption of full cost recovery. A small increase in MOM (required for example if not all farmers participate in the proposed project) combined with a small reduction in crop price would have a negative impact on economic performance, reducing EIRR to about 23%. The EIRR is as sensitive to changes in MOM costs as other inputs and agricultural labour. This is intuitively reasonable and shows that water is well priced, on the assumption that the three inputs of crop production are labour, inputs and water and each has an equal marginal return.

Table 4-21 Sensitivity of EIRR to Changes in Crop Price and MOM

Change in price of irrigation	Change in Crop Price				
	-20%	-10%	0%	+10%	+20%
-20%	24.6%	28.4%	32.0%	35.4%	38.7%
-10%	24.1%	28.0%	31.6%	35.0%	38.3%
0%	23.7%	27.5%	31.2%	34.6%	37.9%
+10%	23.2%	27.1%	30.8%	34.2%	37.5%
+20%	22.7%	26.7%	30.3%	33.8%	37.1%

Assumptions on crop yield increments were initially too modest, and substantially below the technically possible. They have subsequently been revised upwards. In the Table below, the equivalent winter maize yield is shown for each percentage crop yield change in the sensitivity analysis. Present irrigated yields are estimated to be about 26 quintals per ha. The sensitivity analysis below suggests that failure to meet even modest yield increases could be disastrous, while substantial benefits accrue to improvements. 45 q/ha of irrigated maize would be the minimum target to be achieved. It would be good to be sure of the impact of the extension component, but so much is dependent on the availability of a large well qualified, well-resourced and motivated extension service. A large budget allocated in the project costs by no means guarantees that such a service will materialise.

Table 4-22 Sensitivity of EIRR to Changes in Crop Price and Crop Yield

Equivalent irrigated maize yield, q/ha	Change in crop yield	Change in Crop Price				
		-20%	-10%	0%	+10%	+20%
22	-60%	#	-11%	-3%	1%	5%
28	-50%	-3%	3%	7%	10%	13%
33	-40%	6%	10%	13%	16%	19%
39	-30%	11%	15%	19%	22%	25%
44	-20%	16.0%	19.8%	23.2%	26.3%	29.3%
50	-10%	20.0%	23.8%	27.3%	30.6%	33.7%
55	0%	23.7%	27.5%	31.2%	34.6%	37.9%
61	+10%	27.0%	31.0%	34.8%	38.4%	41.9%
66	+20%	30.2%	34.4%	38.3%	42.1%	45.7%

Note: # signifies than an EIRR is not calculable, usually because the net benefit stream is consistently negative.

Similarly, if the irrigated area is not achieved in full, the economic return will be prejudiced; the Table shows that even if crop price is maintained, if the with project farmer area achieved is only -20% of that assumed then the EIRR falls to 23.7%. Implementation should aim at a bare minimum of 60-70% of the area under sustainable irrigation. The proposed project economic performance is therefore very sensitive to this parameter. Conversely even a small increase in the irrigated area can boost project performance.

Table 4-23 Sensitivity of EIRR to Changes in Crop Price and Irrigated Area

Ha equivalent	Change in area developed	Change in Crop Price				
-		-20%	-10%	0%	+10%	+20%
64	-20%	16.0%	19.6%	22.9%	26.0%	28.9%
72	-10%	20.0%	23.7%	27.1%	30.4%	33.5%
80	0%	23.7%	27.5%	31.2%	34.6%	37.9%
88	+10%	27.2%	31.3%	35.1%	38.8%	42.2%
96	+20%	30.7%	34.9%	39.0%	42.8%	46.5%

Combining the very sensitive parameters, with-project crop yields and irrigated area, it is evident that an -20% reduction in anticipated with-project yields (which would still represent a 70% increase on present winter maize yields) and an -20% reduction in the with-project irrigated area gives an EIRR of 16% - adequate, but close to the minimum return the scheme would need in order to be considered a satisfactory investment.

Table 4-24 Sensitivity of EIRR to Changes in Crop Yield and Irrigated Area

Equivalent irrigated maize yield,	Change in crop yield	Change in Irrigated Area				
	Ha developed	64	72	80	88	96
		-20%	-10%	0%	+10%	+20%
22	-60%	#	-10%	-3%	1%	4%
28	-50%	-2%	3%	7%	10%	13%
33	-40%	6%	10%	13%	17%	20%
39	-30%	11%	15%	19%	22%	25%
44	-20%	15.6%	19.5%	23.2%	26.7%	30.1%
50	-10%	19.4%	23.5%	27.3%	31.0%	34.7%
55	0%	22.9%	27.1%	31.2%	35.1%	39.0%
61	+10%	26.2%	30.6%	34.8%	39.0%	43.1%
66	+20%	29.2%	33.8%	38.3%	42.7%	47.0%

4.5 Conclusions

4.5.1 Tigray Region – Gereb Mihiz Scheme

The problems of the Gereb Mihiz scheme are dominantly technical, and concerned with the management of the catchment to reduce erosion and therefore the reduction of live storage in the dam, and the problem of managing the dam itself which is subject to aggressive sedimentation. These problems were recognised by the region during scheme implementation, but lack of funds for catchment management, rather less enthusiasm amongst farmers in the area to carry out soil conservation works and lack of good empirical hydrological data (which is being rectified by the region) meant that the opportunity for short term benefits from catchment management have disappeared. The dam is already sedimented. That being the case, the team recommends a small transportable dredger to remove sediment from this dam and others in the area. The team also recommends improvements to the inefficient and cumbersome siphon arrangement that farmers have improvised to extract water from the dam now that the formal out-flow structure is obstructed. In addition, there may be innovative ways to dispose of dredged sediment (using slurry flowing onto fields to improve both grade and fertility) that may improve productive.

The Gereb Mihiz scheme is very small – 80 ha – and for this reason may not be an appropriate subject for intensive empirical study. Nevertheless the potential benefits from improving irrigation are large. Most of the command is under rainfed cropping at less than 100% cropping intensity. This could be improved to over 200% irrigated cropping, because there are good returns to supplementary irrigation in this semi arid area.

5 UNIT RATES and PERFORMANCE INDICATOR VALUES

The unit rates are compiled from current prices and also previous rates, updated to today's financial costs.

Table 5-1 Unit Rates Used in the Study

Unit Rates

Item	Description	Unit	Unit Cost (US$)		
			L/C	F/C	Total
A.1	**Preparatory Works**				
A.1.1	Mobilization of plant, equipment and personnel to site	L.S.	8,340.80	158,475.22	166,816.02
A.1.2	Demobilization of plant, equipment and personnel	L.S.	7,190.42	136,618.11	143,808.53
B.1	**Excavation**				
B.1.1	Clearing and stripping of foundation up to 50 cm depth	m^2	0.21	4.10	4.31
B.1.2	Earth excavation not exceeding 4m depth (colluvial deposit)	m^3	0.32	6.20	6.52
B.1.3	Permanent access road excavation of common or unsuitable material for a depth not exceeding 4m	m^3	0.55	10.61	11.16
B.2	**Earth fill**				
B.2.1	Impervious fill zone, clay core	m^3	0.35	6.67	7.02
B.2.2	Cement pitching masonry drainage ditch along downstream berm and rock toe	m^3	0.89	16.95	17.84
B.2.3	Concrete pipe for horizontal drain		3.63	69.13	72.76
	i)Masonry work for collector	m^3	5.19	98.65	103.84
	ii)Reinforced concrete for collector cover 1.5m diamete	m^3	-	-	-
C.1	**Excavation**				
	Earth excavation	m^3	0.17	3.24	3.41
D.1	**Concrete**				
D.1.1	Supply and place concrete class C-10	m^3	6.22	118.27	124.49
D.1.2	Supply and place concrete class C-15	m^3	6.06	115.24	121.30
D.1.3	Supply and place concrete class C-20	m^3	10.39	197.50	207.89
D.1.4	Supply and place concrete class C-25	m^3	11.63	221.01	232.64
D.1.5	Supply and place concrete class C-30	m^3	11.76	223.54	235.30
D.1.6	Supply and install formwork	m^3	1.06	20.24	21.30
D.1.7	Supply and place reinforcing steel	ton	138.70	2,635.43	2,774.13
D.1.8	Supply and place masonry paving on the slopes of the open channel	m^3	0.29	5.66	5.95
E.1	**Gate and Valves**				
	Supply, install and test one slide gate with necessary fittings	m^2	333.92	6,344.61	6,678.53
E.1.1	Supply, and install one valves		167	3,172	3,339
	i)Diameter 600mm (PN10)	No	111	2,115	2,226
	ii)Diameter 250mm (PN10)	No	65.67	1,247.77	1,313.44
	iii)Diameter 450mm (PN50)	No	-	-	-

Item	Description	Unit	Unit Cost (US$)		
			L/C	F/C	Total
F.1	**Masonry Works**				
F.1.1	Supply and place 5 cm thick lean concrete of class C-1	m^2	0.24	4.64	4.88
F.1.2	Supply and place cyclopean concrete 60% rock fill and 40% concrete class C-30	m^3	4.58	87.17	91.75
F.1.3	Masonry wall with 1:3 cement mortar	m^3	4.05	77.04	81.09
F.1.4	Supply and place stone pitching	m^3	1.07	20.34	21.41
G.1	Slope protection of dumped rip-rap	m^3	1.00	19.03	20.03
	Transition filter material (natural river sand)	m^4	0.74	14.20	14.94
H.1	Supply & laying HDPE DR11 welded joints, nominal bore 250mm	lm	2.86	54.46	57.32
H.2	Floats	set	13.35	253.78	267.13
H.3	Diameter 250mm Foot Valve at inlet	N0.	44.52	845.94	890.46
H.4	Diameter 250mm Gate Valve at outlet	N0.	44.52	845.94	890.46
H.5	Supply and install form work	m^2	0.11	2.27	2.38
H.6	Supply and place reinforcing steel	ton	346.76	6,588.59	6,935.35
H.7	Foot bridge up to 15m span	L.S.	667.85	12689.22	13357.07
I.1	Supply, install and train on use of Badger floating Dredger	No.	2714.28	51571.42	54,285.70
I.2	Operate, and excavate sediment and transport over dam wall for a distance of 350 m	m^3	0.05	1.06	1.11
J.1	Cstchmant conservation plan	No.	1864.5	35425.5	37,290.00
K.1	600 mm ADV, Supply, install, commission,	No.	640	12160	12,800.00
K.2	500 mm ADV, Supply, install, commission,	No.	617.5	11732.5	12,350.00
K.3	450 mm ADV, Supply, install, commission,	No.	571	10849	11,420.00
K.4	300 mm ADV, Supply, install, commission,	No.	417.5	7932.5	8,350.00

Each performance indicator can be compared with another by giving a rating according to normal values. The Table 5-2 gives the ratings used in this study. These are based on values used in the EWUAP LSI study and interpretation of the indicators where these are not included in the LSI report.

Table 5-2 Performance Rating used in Overall Evaluation

Performance Indicators		Performance Rating				
		1	2	3	4	5
Irrigated Area Ratio	IAR	<0.6	0.6-0.7	0.7-0.8	0.8-0.9	0.9-1.0
Delivery Performance Ratio	DPR	<0.6	0.6-0.7	0.7-0.8	0.8-0.9	0.9-1.0
Function BWR/ARD		poor	fair	satisfactory	good	very good
Function FU/WUA		poor	fair	satisfactory	good	very good
Function Extension		poor	fair	satisfactory	good	very good
Relative Water Cost	RWC	>0.15	0.09-0.15	0.06-0.09	0.03-0.06	<0.03
O&M Fraction	O&M F	<0.6	0.6-0.7	0.7-0.8	0.8-0.9	0.9-1.0
MOM Funding Ratio	MOM R	<0.1	0.1-0.15	0.15-0.25	0.25-0.5	>0.5
Crop Area Ratio	CAR	<0.6	0.6-0.8	0.8-1.0	1.0-1.5	1.5-2.0
Land Productivity	BIO kg/ha	<3,300	3,300-4,400	4,400-7,800	7,800-10,000	>10,000
Water Productivity	BWP kg/m^3	<0.7	0.7-1.0	1.0-1.5	1.5-2.3	>2.3
Biomass Land Productivity	BIO kg/ha	<3,300	3,300-4,400	4,400-7,800	7,800-10,000	>10,000
Biomass Water Productivity	BWP kg/m^3	<0.7	0.7-1.0	1.0-1.5	1.5-2.3	>2.3

6 LESSONS FROM GOOD PERFORMING SCHEMES

The Study Team made field visits to schemes considered "good performers" by local technical staff. These included The Engua Mesk and Borale Micro Earth Dam schemes near Debre Birhan, North Shoa Zone, Amhara Region. The characteristics of these schemes are shown below. Both schemes only became operational in 2008. Neither scheme has therefore a proven track record as a "good performer". The information obtained on Engua Mesk was more comprehensive than was available for Borale.

The Table shows that Engua Mesk has made a good start as a contender for a "good performer". The cropping intensity of the scheme exceeds 250%, with two dry season irrigated crops being taken, as well as a rainy season crop. The scheme has expanded beyond its designed area. Equity of distribution appears to be good with most plots being irrigated once every 14 days. Detailed investigation would probably reveal that quality of irrigation in terms of flexibility, timeliness and required volume of delivery (which characterises a "modern" irrigation scheme) has been sacrificed to achieve equity of distribution amongst a larger number of farmers than was envisaged at design. In addition, there are problems of seepage from the unlined sections canals sections, and some damage to the LB canal from spillway flooding. Neither of these problems is being addressed, due to lack of funds.

	Engua Mesk	Borale
Capital cost (ETB million 2008)	2.5	
Design Command	85	100
Net Cropped area	112	99
Gross cropped area	303	99
Number of farmers irrigating	280	126
Estimated annual income for O&M	33,600	no data
O&M income as % of capital cost	1.3%	no data
O&M as annual proportion of capital cost	4.0%	no data

There are issues which threaten the sustainability of the Engua Mesk scheme. A detailed feasibility study for Engua Mesk was prepared in 2002 by Co-SAERAR (now replaced by Regional Technical Bureaux). It was well prepared and included an estimate of scheme annual O&M requirements. The study budgeted farmer training for 5 years after scheme construction, which amounted to nearly 30% of estimated annual costs. Annual O&M as a proportion of capital cost was estimated to be about 4%. However, the farmer training did not materialise, and neither did training in scheme operation for DA in post. Worse, present scheme revenue to meet operational costs is insufficient. Annual O&M income in Engua Mesk is raised as an ETB 5-10 flat rate charge per month for each beneficiary farmer, plus a surcharge levied per quintal on produce sold through the kebele cooperative. Apart from the desirability of raising O&M income as a charge on volume of water used, the volume of annual funds raised is only 1.5% of capital investment per annum rather than the envisaged 4%.

Lack of technical and managerial knowledge in scheme operation represents a significant risk to the sustainability of the Engua Mesk scheme. Failure to collect adequate operational funds means that the two technical problems mentioned above (canal seepage and flood damage) are not being remedied and will worsen. The DA Team estimate that 33 ha are being affected by seepage. Inspection shows the LB canal could easily be severed by further flood damage, reducing the scheme irrigable area by about half. The risk of this happening is compounded by lack of clarity of ownership of scheme structures. The study team understands that structures are now the responsibility of the wereda ARD, though no legal hand over had been made from the Regional Bureau of Water Resources. Farmer beneficiaries have neither been trained in basic maintenance and repair, nor have a sense of ownership of the structures; in fact they complain to ARD that structures are not operating properly (vid. seepage and flood damage described above). ARD then has to secure a budget line to undertake repairs, but in view of competing budget requirements it may be impossible for ARD to respond. In such a situation it is essential that the WUA has funds to undertake O&M. Farmers are using the scheme to full capacity now for very low payment, and an excellent opportunity to generate these funds is being missed.

In summary, Engua Mesk has some characteristics of "good performance" which could be transferred to other schemes:

- The DA team have planned to increase fertiliser application by procuring through the local cooperative because they understand that soil fertility will quickly be reduced by the high intensity of cropping
- Extension initiatives are being made by the DA to increase row planting, the quality of planting material and crop rotations
- The WUA officials are appointed by direct election of farmers and include a treasurer and inspector, the latter being responsible for over-seeing irrigation scheduling
- Group (block) leaders and gatemen are elected, though these are voluntary positions.

However, the study team feels that several necessary characteristics of good performance have been by-passed or over-looked:

- Water charge revenue from beneficiaries should cover budgeted O&M
- the WUA should be seeking to generate contingency funds whilst the scheme is new and O&M costs are comparatively low
- Ownership of and responsibility for structures should be established by involving farmers in PIM from inception
- The provision of training in irrigation O&M was budgeted for but in the end not provided – this is a missed opportunity which threatens scheme sustainability.

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Recommendations

7.1.1 Irrigation Scheme Benchmarking

The ENIDS CRA study team experienced grave difficulties in obtaining complete accurate lists of irrigation schemes at national level in its study of LSI in the Nile Basin, and in the end resorted to remote sensing to derive comparable performance indicators to measure irrigation extent and productivity. The team sympathises with this experience. It was necessary to travel to all three Regions to obtain regional lists of irrigation schemes. Also, while the senior staff at regional level was intuitively well aware of individual scheme performance in their area of operation, there was no way to distinguish objectively poor performers from good performers, and even less information to analyse gradational differences between schemes. Visiting schemes on the ground it was also apparent that basic data collection on scheme performance was sporadic and ad hoc. The best that could be expected were crop areas and yields for the last few years, and a list of irrigators kept at kebele level. Water measurement on these small schemes is almost unknown.

At the same time, the team were unable to commit to the value of collecting performance indicators on schemes in isolation. The indicators are data intensive to calculate and having collected the data and done the calculations merely confirm what the investigator already knew.

The team recommend that each region prepares guidelines on routine data collection for all schemes which meet regionally set criteria – a minimum size or number of irrigators for example. The guidelines should allow ARD staff to collect required data annually according to their discipline and this should be forwarded to the regional team to calculate basic performance indicators. This should include some simple flow measurements at critical times of year which only locally based staff can be on hand to carry out. It should also include basic data on MOM activities including water charging and repayments. Agronomic information is usually put together by DAs: this data needs to be augmented to include planting dates and simple information on gross margins and irrigation.

The routine data should allow senior staff at regional level to prepare performance indicators annually for each scheme that meets the criteria for performance measurement. Indicators may not support perceived performance. If so they should be reviewed, or perceptions about performance should be changed.

This benchmarking activity only becomes useful after several years of data collection. In the Robi River Scheme for example some benchmarks could be deduced from scheme construction and compared with present performance. This provided an interesting perspective of the scheme's long term performance, together with indications of the remedial action necessary to improve it.

7.1.2 Institutional Policy Recommendations

The proposed institutional strengthening measures as well as the proposed organization for the management of O&M (MOM) in the 3 pilot irrigation schemes entail policy changes and new policies. The following are policy recommendations to support the proposed institutional arrangements:

1. Policy framework on transfer of management should address the financial sustainability and capacity of the WUA. Recent efforts to hand-over government constructed schemes to the WUAs have not addressed these issues. The study showed that the WUAs were not ready financially and technically to assume management of the scheme. Support and assistance are extremely needed after completion of small scale irrigation schemes. This is on paper the responsibility of the Woreda Agriculture Office, but, due to lack of financial and technical capacities, they face difficulties to provide this assistance. Creating an Institutional Development unit with the corresponding regular budget in the organizational set-up of the Woreda Agriculture will be needed to strengthen and develop capacity of WUAs before handing over the scheme to them for MOM. An experienced Senior Community Organization Specialist can be appointed to head this unit with a staff consisting of experienced and trained community organizers. Assistance of experienced International and local NGOs can be sought in the recruitment and training of the Institutional Development Staff. Preferably, select the experienced NGOs who have projects or are working in the region or Woreda where the pilot schemes are located.
2. It is recommended that the draft Water Resources Management (WRM) regulation proposing a legal recognition of WUAs be approved immediately in order to facilitate the establishment and strengthening efforts for WUAs in Robi and Gereb Mihiz schemes. Policy on WUO formation and participation in the planning, design, construction and operation and maintenance needs to be formulated in order to effectively and successfully transfer management of O&M responsibility to the WUO. In addition, a minimum counterpart of WUO in the construction/rehabilitation of the schemes is suggested to be stipulated in the policy because this would help create a sense of responsibility and ownership of the scheme on the part of the potential water users even before the scheme is constructed. Creation of an institutional development unit as mentioned in item # 2 above will be required for this policy to get implemented. Social Mobilizers should be fielded at least 6 months to one year before actual construction/rehabilitation works are started in the scheme to assist in the formation/strengthening of WUO.
3. Based on the Council of Ministers Regulation No. 115/2005 Ethiopian Water Resources Management Regulations, the Supervising Body (Ministry of Water Resources, MWR) has the mandate to issue permits for water resources in the country. This is also true for collection of fees and water use charges. In the same regulation it is stipulated that MWR, where necessary, can delegate its powers and duties to the appropriate body for efficient execution of its duties. It is therefore proposed that MWR delegate authority to the Water Users' Organization/Irrigation Cooperatives to collect water charges/fees that will be used for the management of O&M and maintenance of the schemes now under the responsibility of the Ministry of Agriculture and Rural Development (MARD). It will also be efficient to delegate this activity to a lower level like the Woreda BWR and/ or Woreda ARD if the WUO in the scheme has no legal identity yet so that timely maintenance/repair works can be done.

The suggested institutional development processes need to be integrated in the whole irrigation development policy framework of the MWR. This means that genuine participation by the water users becomes part and parcel of the whole development processes from planning, design, and construction and ultimately the operation and maintenance phase of the irrigation scheme. This would entail extensive institutional development training programme for the key staff from the federal, regional, zonal, and woreda levels of MWR and MARD on participatory irrigation management (PIM) concepts and processes.