Annex 3.9

Performance assessment of selected irrigation schemes

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Ministries of Water Resources
and
Agriculture and Rural Development

Food and Agriculture Organization of the United Nations

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PERFORMANCE OF SELECTED IRRIGATION SCHEMES

Final Report

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Acronyms

ABA	Awash Basin Authority
ADLI	Agricultural Development Led Industrialization
CD	Check Drops
Co-SAERAR	Commission for Sustainable Agriculture and Environmental Rehabilitation of Amhara Region
DA	Development Agent
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
HH	Households
IC	Irrigation Cooperative
IPTRID	International Programme for Technology and Research in Irrigation and Drainage
ITRC	International Technology and Research Center
IWMI	International Water Management Institute
MAADE	Middle Awash Agricultural Development Enterprise (MAADE)
MoARD	Ministry of agriculture and Rural Development
MoWR	Ministry of Water Resources
OIDA	Oromia Irrigation Development Authority
PO	Primary offtakes
PRDA	Participatory Rapid Diagnosis and Action Planning
RAP	Rapid Appraisal Procedure/Process
WARC	Werer Agriculture Research Center
WUA	Water User Association

Table of Contents

EXECUTIVE SUMMARY *1*

1. INTRODUCTION *4*

1.1 Background- Irrigation Development in Ethiopia **4**

1.2 Objective **5**

2. Methodology and Data sources *6*

2.1 Selection of Irrigation Schemes **6**

2.2 Performance Indicators and Data Requirements **8**

2.3 Data collection **9**

2.4 Limitations **10**

3. General Background of the Irrigation Schemes *11*

3.1 Small Scale Irrigation Schemes **11**

3.2 Amibara Large Scale Irrigation Scheme **13**

4. GENERAL OBSERVATION *15*

4.1 Small Scale irrigation Schemes **15**

4.1.1 Irrigation Infrastructure 15
4.1.2 Cropping Patterns 20
4.1.3 Water Distribution and Irrigation Scheduling 21
4.1.4 Community Organization and Scheme Management 25
4.1.5 Extension Service 27

4.2 Large Scale Irrigation Project **29**

4.2.1 Irrigation Infrastructure 29
4.2.2 Water Distribution 31
4.2.3 Cropping Pattern, Crop Water Requirement and Irrigation Application 32
4.2.4 Maintenance and Water Charges 34

5. ANALYSIS *35*

5.1 Computation and Analysis of Performance Indicators **35**

5.1.1 Small Scale Irrigation Schemes 35
5.1.2 Amibara Irrigation Project 38

5.2 Environmental Aspects **40**

5.3 Problems of Irrigation Schemes **42**

6. CONCLUSIONS AND RECOMMENDATIONS *45*

6.1 Conclusions **45**

6.2 Recommendation **46**

Annexes

Annex 1: Actual cropping pattern of Assessed Irrigation Schemes
Annex 2: Performance Indicators of Small Scale Irrigation Schemes
Annex 3: Problems Identified by Small Scale Irrigation Users

Annex 4: Cause and Effect Relationship of Inadequate Water Supply of an Irrigation Scheme
Annex 5: Analysis of Flows in the Check Drops and Secondary Offtakes
Annex 6: Water Quality of Awash River at Melka Sedi Weir Site
Annex 7: Efficiency of Irrigation Service Fee Collection

List of Tables

Table 1: Location of Selected Irrigation Schemes
Table 2: Typical Irrigation Intervals for Selected Community Managed Irrigation Schemes
Table 3: Actual Irrigation Intervals for Cotton in Melka Sedi and Amibara Farms in Middle Awash
Table 4: Efficiency of Irrigation Service Collection (Birr)
Table 5: Selected Irrigation Performance Indicators (Internal Indicators)
Table 6: Performance Indicators for Cotton in Melka Sedi and Amibara Irrigation Farms in 2008
Table 7: Satisfaction or dissatisfaction in the taking irrigation service

List of Figures

Figure 1: Location of Irrigation Schemes Visited

References

EXECUTIVE SUMMARY

Irrigation development in Ethiopia dates back centuries while the construction of modern irrigation schemes was started in the 1950s. Thousands of irrigation schemes have been developed. However, most irrigation schemes are not operating to their full potential while some others are not functional at all due to factors related to hardware and software problems and shortage of water. Some schemes do not only perform poorly but also cause undesirable environmental consequences. The ever increasing use of water for irrigation puts a great pressure on the local hydrology and ecosystem. Competition for water is becoming critical, and environmental degradation related to water usage is serious. Hence, the sustainability of irrigated agriculture is questioned and the challenge is to increase simultaneously land and water productivity in the face of the limited availability of land and water.

This performance assessment was carried out as part of the project for "Strengthening National Water Monitoring Capacity with Emphasis on Agricultural Water Management" funded by Italian Government and implemented by the Food and Agriculture Organization (FAO). The overall objective of the assessment is to identify constraints of poor performance of water control systems and suggest feasible and sustainable water management tools.

The assessment was carried out by a team of experts from FAO, MoWR and Regional Water and Agriculture Bureaus. The study team visited six irrigation schemes (five small scale community-managed schemes and one large scale irrigation scheme), four in Awash River Basin - one in each of Abbay Basin and Gibe Sub-basin). The major criteria for the selection of the irrigation schemes included administrative and agro-ecology representation, socio-economic condition and scale Other schemes which have impacts on the performance of any of the above schemes particularly in water supply were also visited. Relevant information was also obtained from baseline surveys carried out by the project.

Full assessment of the irrigation performance was constrained by lack of water supply and production data and hence, the assessment is limited to process indicators, some external indicators are considered for the large scale irrigation project. Irrigation intensities varied from about 24% for Saraweba scheme (Oromia) due to water shortage to 272% for Sewir scheme (Amhara). All considered, the performance of small irrigation schemes visited is not satisfactory due to both hardware and software problems.

- While layouts of small scale irrigation schemes are generally good but drainage systems are not incorporated at all. Offtakes which are not provided with gates are poorly located in some cases and this led to the construction of new offtakes by users. Construction quality of some irrigation structures is poor. The irrigation systems are not also maintained or are poorly maintained and this coupled with uncontrollable offtakes led to reduction of canal capacity, waterlogging and excessive water loss through seepage, overtopping and leakage.

- Water scarcity is the common problem in all gravity irrigation schemes except one scheme constraining irrigation performance. This water shortage is caused by the development of both traditional and modern irrigation schemes upstream of an irrigation scheme, reduction of natural river flow due to land degradation (poor infiltration), expansion of command area adjacent to the command area, poor irrigation practices and water losses. Rigid irrigation scheduling which is common to all irrigation schemes also contributes to the poor performance because it does not allow irrigation application according to crop water demand.

- Poor irrigation extension service caused by lack of DAs, inadequate irrigation skills of DAs and woreda staff, or inadequate logistic support constrained irrigation performance in all schemes. Similar irrigation practices, social equity as the main factor for irrigation scheduling (not crop water requirement), construction of illegal offtakes or water 'theft' are common in all small scale irrigation schemes irrespective of the locations and cultural differences Other constraints include weak water users' organizations and system management, access to inputs, and lack of market for outputs. All these are attributed to poor extension service.

- Irrigation intensities varied from about 24% for Saraweba (Oromia) to 272% for Sewir (Amhara) schemes. The latter is relatively performing better although his system is ill-maintained. The performance of other visited small irrigation schemes is not satisfactory. Compared to the expensive infrastructures the performance of Saraweba and Chacha schemes is appalling and this is caused by combination of poor design/construction and extension service.

Similar conclusion holds true for Melka Sedi and Amibara Irrigation Project. The main findings include the following:

- Poor water regulating structures including intakes coupled with poor maintenance of secondary and lower level canals constrained proper water regulation and distribution to farms and caused disagreement between service provider and receivers. Not only the amounts of water delivered and actually applied remain unknown, but it also causes dissatisfaction of the farmers and enterprises.

- Poor irrigation application or non-uniform irrigation caused by poor land levelling, release of water from lower canals to drains by small farms instead of closing offtakes did not only waste the precious water resource but also caused the rise of groundwater table and soil salinization. This has been a major concern in the project area and still remained unattended. The construction of illegal offtakes is also becoming a concern which ABA could not solve it due to administrative problems.

- Rising of grown water table associated with increased salinity and application of medium saline irrigation water is a major concern Middle Awash irrigated fields.

All the foregoing issues in both small and large scale irrigation schemes indicate the need for taking appropriate measures if sustained productivity of irrigated agriculture is to be ensured.

Recommendations

- As the under-performance of irrigation schemes is caused by both hardware and software aspects of irrigation schemes, remedial measures should include improving irrigation infrastructure and management of the irrigation schemes. It should never be a choice of one or the other if good water delivery service is desired. Water regulating structures of Melka Sedi- Amibara irrigation project needs recalibration while it needs to enforce the incorporation of flow measuring structures at critical locations of small scale irrigation system.

- Water's natural abundance in many areas may explain why the central water supply issue has been that of water delivery engineering (getting water to where it is needed) rather than managing water demand. The thinking of water's natural abundance is now changed to water scarcity in many areas. This does not only call for efficiently managing the available water for effective use but also indicates the need for designing irrigation systems not merely for conveying water but for easing water management.

- The issue of upstream and downstream users requires due attention. Although proper planning may be one aspect to deal with the problem, policy measures such as conflict-free irrigation development may be needed particularly in the development of irrigation schemes upstream of a well functioning small scale irrigation schemes.

- The prevalence of poor water distribution and irrigation practices indicates the need for improving the capacity of farmers through strengthening the water user association and tailor-made practical training.

- Irrigation extension only exists nominally because neither the development agents nor the woreda extension desks have the required irrigation skills or the latter are equipped with the required logistic support to provide support to the DAs. Therefore, practical training needs to be organized for development agents prior to and after their assignment to their duty stations. The woreda irrigation desks should also be strengthened in all aspects. Irrigation management manuals would also help a lot as witnessed by the lessons learned from the baseline survey questionnaires distributed to woredas in North Shoa Zone.

- As the objective of monitoring and irrigation performance assessment is to improve system management and draw lessons for future planning, it becomes imperative that monitoring of irrigation performance should be part and parcel of irrigation extension. For this, performance measurement system should be designed to take into consideration physical and financial performance indicators as well as social performance indicators in a balanced and integrative perspective. Benchmarks should be set early on in order to facilitate data collection, assessment including comparison of performance.

1. INTRODUCTION

1.1 Background- Irrigation Development in Ethiopia

Agriculture is the mainstay of Ethiopian economy accounting about 47% of GDP, 85% of export earnings and 80% of rural employment. Industry and services depend strongly on the performance of agriculture for raw materials, generating foreign currency for import of essential inputs and food for the fast growing population. Despite its contribution for the national economy, agriculture is largely based on subsistence farming. The productivity of the agricultural sector is very low and lags behind the population growth rate. To address this problem the Ethiopian Government designed an Agricultural Development Led Industrialization (ADLI) strategy which aims to use agriculture as the base for the country's overall development (MoWR, 2001). This strategy aims to enhance the productivity of small-scale farmers and to improve food security both in the rural and urban areas. One of the policies within this strategy is stimulate and/or support the development of small-scale irrigation. Currently irrigated agriculture is expanding rapidly in those areas where there is access to irrigation water but the sector is predominantly rainfed and is very much affected by climatic vagaries. Considering the fact that rainfed agriculture could not be relied on to supply the food requirements of the Ethiopian people, irrigation development is given a top priority in the development agenda. However, despite water resources and irrigation potential Ethiopia is endowed with the area developed under irrigation is less than five percent of its irrigation potential. Even those developed irrigation schemes do not perform well as planned and expected because of several inter-related factors.

How well are the irrigation systems managed? This question should be asked by all stakeholders including the system's policy-makers, technical staff, and water users.

Therefore, assessment of the irrigation performance is very crucial to identify the factors that promote and inhibit the performance which can be assessed against key indicators. Objective and measurable indicators for assessing irrigation performance are required by managers and users to improve their water management practices, by technical experts who learn to improve future project identification, design and implementation; and by policy-makers who aim to maximize the benefits gained from irrigated agriculture.

Assessing performance of irrigation schemes or water control systems is difficult because being multi-dimensional it requires a multi-disciplinary approach. An aggregate term performance assessment is too imprecise for practical use and an approach based on the assessment of system performance, operation and maintenance and an overall impact within the context of logical hierarchy of objectives food security is preferred.

This study was carried out within the limited time, money, and information resources that were readily available. Hence, the indicators are oriented toward items that directly or indirectly affect water deliveries, rather than indicators like crop yields that are also affected by other factors. Indicators are also oriented toward the existing system, aspects which do not require major modification of the infrastructure.

The rationale of conducting this irrigation performance assessment is that water management needs to be improved if all the involved farmers in the irrigation schemes are to obtain adequate and sustainable livelihoods through market-oriented production and to contribute to the national economy growth.

1.2 Objective

The overall objective of the assessment is to identify constraints of poor performance of water control systems and suggest feasible and sustainable water management tools and instruments that foster improved water management practices which lead to improved crop production and thereby increase income of the irrigation users

The specific objectives of the assessment include the following:

- Assess infrastructural performance of the irrigation systems;
- Assess current match between water supply and demand, and identify reasons of mismatch
- Analyze current water management practices, and identify constraints and feasible interventions for improvement ;
- Analyze the institutional aspects of the irrigation schemes with regard to water management; and
- Assess socioeconomic and environmental conditions such as extension services, marketing, etc that promote and inhibit performance of the irrigation schemes

2. Methodology and Data sources

2.1 Selection of Irrigation Schemes

In the selection of the irrigation sites for performance assessment was made in consultation with Ministry of Water Resources, Amhara and Oromia regions. The initial selection criteria were:

- Agro-ecology setting
- Rural and urban irrigation
- Administrative Representation
- Scale
- Accessibility

Initially 10 irrigation schemes were proposed (four in Amhara, five in Oromia and one in Addis Ababa). Considering the time and available resources, the number of schemes was reduced to six (two in each of Amhara and Oromia, one in Addis Ababa and one large scale scheme in Afar). However, as small scale irrigation schemes located in highland areas were to be covered and Amhara and Oromia regions badly needed the inclusion of two schemes in the assessment, two of the selected irrigation schemes are located in Abbay Basin and Gibe Sub-basin. The location of schemes in different basins does not change the objective of the assessment which is aimed at drawing lessons on the performance of schemes. In all cases the selection of small scale irrigation schemes was made by the respective regions while the large scale scheme was selected by MoWR. Accordingly, the irrigation schemes selected for the assessment are listed in Table 1. Urban irrigation in Addis Ababa was to be selected after visiting some schemes.

Table 1: Location of Selected Irrigation Schemes

Name of Scheme	River Basin	Region	Woreda	Agro-ecology	Geographical Coordinates (deg)		Scale of scheme	Years Operati
					Lat	Long		
1. Sewir	Awash	Amhara	Kewot	Tepid moist mid highlands	10.068	39.876	Small	Since 2
2. Chacha	Abbay	Amhara	Angulala Tera	Cool sub-humid mid highland	9.518	39.481	Small	Since 2
3. Walga 2	Omo-Gibe	Oromia	Weliso and Wonchi	Tepid sub-humid mid highlands	8.512	37.931	Small	Since 2
4. Saraweba	Awash	Oromia	Fentale	Warm arid lowlands	8.774	39.879	Small	Since 2
5. Melka Sedi	Awash	Afar	Amibara	Warm arid lowlands	9.338	40.184	Large	Since 1
6. Chelo	Awash	Addis Ababa (urban irrigation)	Kaliti Subcity	Tepid sub-humid mid highlands	8.749	39.878	Small	Since 1

Figure 1: Location of Irrigation Schemes Visited (Map)

Sewir
Abbay Basin
Awash Basin
Chacha
Amibara
Melasedi
Chelo
Addis Ababa
Saraweba
Saraweba
Walga
Walga Diversions
Omo-Gibe Basin
Wabe Shebele Basin
Wabi Shebele

2.2 Performance Indicators and Data Requirements

Considering the problem associated with availability of data on water use and crop yield for small-scale irrigation schemes in Ethiopia, internal or process indicators were considered in this assessment. It was assumed that data required for estimating external indicators would be available for large irrigation scheme, Table 2 shows indicators considered and data requirements.

Table 2: Some Selected indicators and data requirements

Indicators	Data Requirement
Flexibility in water supply	Irrigation scheduling, views of beneficiaries,
Reliability of water supply	Availability of water and timing, views of beneficiaries
Equity in water distribution	Beneficiary views, level of water supply to individual plots
Application of by-laws	Views of beneficiaries, penalty applied, etc
Adequacy of extension service	Stakeholders' views, technology applied
Sustainability	Community organization, status of irrigation infrastructure, crop production, market, environmental conditions (salinity, waterlogging, erosion)
Cropping intensity	Command/Equipped and actual cropped areas
Overall consumed ratio	Crop water demand, effective precipitation and irrigation water supply
Water productivity	Crop production, cropped/harvested area and, water supplied

The coherent parts of irrigation performance include mainly three dimensions - physical condition of irrigation system, water delivery, and agricultural productivity. These parts are neither additive nor can any one of them be completely substituted by any of the others and they are interdependent with one another. For example, well maintained canal dose not indicate good performance an irrigation system if there is unsatisfactory water delivery. Similarly, with effective water delivery, the performance of an irrigation system may be poor if the farmers are not able or encouraged to use the water efficiently to increase agricultural productivity. These three dimensions of irrigation performance are assessed in terms of the following four components.

- **Irrigation Infrastructure:** An irrigation system basically consists of headwork, and conveyance and distribution structures designed to deliver water to farm plots in the command area and as such it is technical performance depends on design, construction and maintenance of the physical infrastructures.

- **Crop Production:** This refers to the cropping patterns adopted in the irrigation scheme and production process. The differences between the recommendations in feasibility studies, cultural and irrigation practices, and crop yields are the main aspects considered in the assessment.

- **Organization:** Irrigation is group action and hence it requires forced cooperation. Water delivery, sustainability and productivity of an irrigation system are influenced by

organizational performance of the scheme. Therefore, the assessment has to look into the organization in charge of operation and management.

- **Socio-economic environment:** Socio-economic environment such as extension service, input supplies, upstream and downstream water users plays significant role in the performance particularly water availability to an irrigation scheme. The relationship of the farmers' organization with external entities positively or negatively affects the performance of an irrigation scheme. This has to be critically assessed if the performance of an irrigation scheme is to be improved.

The following external performance indicators were considered for large scale irrigation project:

- Output per water abstracted;
- Relative water and irrigation supplies; and
- Qualitative indicator in irrigation service provision

Based on the above performance indicators the types of data to be collected were determined as listed below.

- Statistics on irrigated area
- Cropping patterns and proportion of area under each crop
- Irrigation intervals and number of irrigation by crop per season
- Durations of irrigation
- Type of water distribution
- System layout and physical conditions of an irrigation scheme
- Irrigation water requirements and actually applied irrigation depth
- Information on arrangements for water distributions (water user associations)
- Level and quality of extension service
- Crop yield or production per crop type
- Availability of market and prices of crops
- Views on irrigation services by government agency for large scale irrigation
- External factors affecting irrigation performance

2.3 Data collection

Rapid Appraisal Procedure/Process (RAP) developed by FAO and International Technology and Research Center (ITRC) and Participatory Rapid Diagnosis and Action Planning (PRDA) developed by FAO, International Programme for technology and Research in Irrigation and Drainage (IPTRID) and IWMI International Water Management Institute was used for this irrigation performance assessment.

Specifically the methodology consists of the following:

- Document review wherever available
- Semi-structured questionnaire for discussion with beneficiaries and extension providers
- Field observation including measurement

Primary data were collected using semi-structured questionnaires for beneficiary group discussions and field observations of the irrigation infrastructures as well as discussions with woredas and Development Agents (DAs). Group discussants included top, middle and tail end farmers, executive committee members and water management group leaders. Being impressed by active participation of all group members in expressing what went wrong and right in all aspects of water management and in appreciating or blaming woredas for the extension service which is contrary to the tradition of such practice, the assessment team noted that there is still a lot to be done to increase the participation of women.

The discussion focused on understanding of the institutional functioning of the scheme, water management within the scheme, input use, resource use conflict resolution mechanisms, and to gain insight in their perception on the importance of irrigation for local food security and other issues like market conditions. Group sizes vary from 10-25 farmers with women participation of up to 16 percent.

Field observation included mapping of irrigation systems or layouts, sizes and conditions of structures, measurement of canal flows where conditions allow. It would be good to document how much time the team spent on average in each scheme to get a feeling of the resources necessary to carry out such an assessment.

2.4 Limitations

The following constraints posed difficulties in full assessment of irrigation performance.

- **Observation:** This assessment was carried out in March-April when irrigation activities were very limited to a few plots in most schemes and this had somehow affected observation of full irrigation practices such as water distribution and field irrigation applications.

- **Lack of Quantitative Data**: Production and water related data were not available either with the water user associations or woreda agriculture offices as well as farms in the large scale irrigation project

- **Incomplete data**: Data recorded by Awash Basin Authority (ABA) contains irrigated area and volume of water requested but not actually delivered and these are also incomplete. Moreover, discharge and volume measurements by the authority are not free of errors. Reporting period using Ethiopian calendar is also another problem. Production season in Melka Sedi and Amibara from April to December but annual and bi-annual reports of ABA are in Ethiopian calendar where only April, May and June water delivery and acreage are reported in one year and other months in the following year. This where area and water delivery statistics are inconsistent.

- **Unavailability of project documents**: Lack of project design reports for some irrigation schemes and construction completion reports for all schemes.

3. General Background of the Irrigation Schemes

3.1 Small Scale Irrigation Schemes

The irrigation schemes under consideration are located in Amhara and Oromia Regions and Addis Ababa Administration City. Two of the irrigation schemes are located in lowland areas where moisture is a limiting factor for crop production while others are located in highland areas. General characteristics of each scheme are given below.

Table 8: General Characteristics of visited irrigation schemes

Name of Scheme	Area (ha)		Number of Beneficiaries			Irrigated crops
	Equipped	Actually irrigated	Planned	Actual	Female-Headed	
1. Sewir	191	260	596	689	17	Maize, onion, teff, sorghum, pepper
2. Chacha	191	191	192	260	58	Barley and garlic
3. Walga 2	75	240	?	?	?	Maize, onion, pepper, potato, tomato, beetroot, cabbage, sugar cane,
4. Saraweba	280	33	536	481	19	Maize
5. Chelo	6	4	91	65	65	Beetroots, cabbage, carrot, kale and potato

Sewir irrigation scheme

This irrigation project is found in Yelen Kebele in Kewot woredas in North Shoa of Amhara Region about 25 km north of Shoa Robit, the main town of the woreda, which is about 225 km north of Addis Ababa and through which the Addis Ababa- Dese road traverses. Kewot woredea is characterized by food insecurity due mainly to drought. The woreda has rugged terrain with mountain hill interspersed with valley bottoms suitable for cultivation. Rivers flowing from highlands provide good irrigation potential in the valley bottoms. Cultivation of rainfed crops supported by livestock farming is the main livelihood of all the communities in the woredas.

Sewir irrigation scheme is located in warm sub-humid lowlands at an altitude of 1,260m and has mean temperature of 23.7ºC and average annual rainfall in the range of 530-1,100 mm thus indicating a poor spatial and temporal distribution with more than 55% falling in July-August. Due to this erratic rainfall, rainfed agriculture was increasingly becoming a risk business. Therefore, traditional irrigation has been practiced since several decades ago. The topography of the area is flat to rolling land with slope in the range of 0.5-4%. The soil is predominantly clay and is imperfectly drained. It was planned to develop 191 ha for 596 farming households.

Chacha irrigation scheme

Chacha is located about 27 km south of Debre Berhan, the capital town of Shoa Zone in Amhara Region, Abbay Basin (Blue Nile). Falling in the altitude range of 2770- 2764 masl, the area has an average monthly temperature of 10 to 14.4 ºC and used to get bimodal rainfall of about 884 mm per year. The farmers drive their living from subsistence mixed crop-livestock farming. Due to the location of the area in highland, the poor performance of the traditional crop production practice was aggravated by natural calamities such as frost, snow and flood. Incidence of crop pests aggravated by poor use of agricultural inputs due to high cost of inputs and shortage of credit facilities curtained the farmers' efforts. The area is flooded from June to September and remains waterlogged until October-November. Hence, crop production is possible only from December to May but the rainfall in these production months had increasingly declined since 2000. Due to these natural problems and absence of cash crop production and off-farm income-generating opportunities the farmers are not able to improve their livelihoods and are vulnerable to any shock of natural disaster. The farmers had then started traditional irrigation on 130 ha.

The above problem and initiative had led to the construction of the irrigation scheme in 2003/04 by the then Commission for Sustainable Agriculture and Environmental Rehabilitation of Amhara Region (Co-SAERAR) on a command area of 112 ha.

Walga 2 Irrigation Scheme

Weliso and Wonchi woredas receive mean annual rainfall of 1,000 -1,400 mm with mean minimum and maximum temperatures of 13°C and 25°C respectively. While agro-climate is favourable for the production of different crops, the area is densely populated and food insecurity is becoming a serious concern. Walga is a river in Gibe Sub-basin originating from Wonchi Lake and flowing through Woliso woreda to Gibe River in Oromia region originating. This river is highly tapped for irrigation. There are seven gravity diversion schemes - two modern diversions (Walga 1 and Walga 2) and five traditional diversions in between the two modern schemes all within a total of about 11 km .No document is available for the two modern irrigation schemes but according to the beneficiaries and woreda offices Walga 1 irrigation scheme was constructed in 1988 while Walga 2 was constructed by the then Oromia Irrigation Development Authority (OIDA) in 2004. The beneficiaries of Walga 1 reported in the discussion that they opposed the construction of Walga 2 as it would create shortage of water on their scheme.

Saraweba irrigation schemes

These two schemes are founded in Oromia Region, East Shoa Zone, Fental Woreda on both sides Awash River about some 30 km south of Metahara town which is about 200 km east of Addis Ababa and through which Addis Ababa - Djibouti main asphalt road passes. They are located in the rift valley of Ethiopia on both sides Awash River. With altitude of 900-1050 m, and mean annual minimum and maximum temperatures of 17.1°C and 32.5°C respectively, the area is characterized by drought receiving an annual rainfall 277-653 the average being 553 mm of which 46% falls in July-August and has a declining trend. There are years where the area did not

receive any rain at all. As availability of pasture is dependent on rainfall, livestock production was also very much affected by drought.

Swaraweba pastoralists were facing frequent drought and according to the design document these pastoral households lost about 20% of their livestock due to drought event in 1994. Hence, the people had since then relied on food aid. The Saraweba irrigation scheme was then constructed by OIDA in 2006 in order to improve food security and livelihoods of the pastoral community.

Chelo Irrigation Scheme (Urban-Addis Ababa)

There are a number of small scale irrigation schemes in and around Addis Ababa. Chelo pump irrigation scheme which is located in Akaki area and established in 1994 is one of them. The beneficiaries are women and are organized under the name "Chelo Mothers Horticulture Producers Association" whose members were 91 women. There are many such producers associations in the Akai area. The Chelo command area is about 6 ha and is adjacent to the Akaki on the lower part of the all farms. The location of the command area in a flood zone, flat topography and the type of soil (clay) of low infiltration rate exposed the command area to inundation and waterlogging respectively.

3.2 Amibara Large Scale Irrigation Scheme

Middle Awash is located in southern part of Afar Region about 220 km east of Addis Ababa in the rift valley of Ethiopia, and the main highway to Djibouti passes through Amibara woreda where the Amibara irrigation farm is located. Falling in altitude the range of 500-800 masl and in semi-arid climate, the area Amibara woreda has minimum and maximum average annual temperatures of 18.9 and 34.1°C respectively. The woreda receives a bi-modal rainfall (February-April and July-September) with average annual rainfall of 530 mm concentrated in a few days or weeks of the year (annual rainfall varies from 290 to 686 mm). According to the Melka Werer Agriculture Research Center (WARC), average annual evaporation is about 2,700 mm. The Middle Awash is vulnerable area to drought conditions. No rainfed agricultural production is possible in this area.

The Amibara irrigation project was started as a private farm in 1967. This farm was then reorganized into many private companies until 1972 when Melka Sedi banana plantation was established. Subsequently a number of small farmers were established on either side of Awash River in 1973/74 making a total of 30 farms with net irrigated area of about 5,000 ha. All these farms were nationalized in 1976 and other farms in Gewane woreda (north east of Amibara woreda) were brought under one management, Middle Awash Agricultural Development Enterprise (MAADE) under the Middle Awash Agricultural Development Corporation in the then Ministry of State Farms in 1982. The Amibara irrigation Project with a total irrigated area of 6,686 ha was also incorporated into MAADE, making the total irrigated area under its management of 12,000 ha in 1984/85.

One year after the change of government in 1991, about half of the irrigated area was transferred to the clans as a compensation for loss of grazing lands and to encourage the pastoralists to

establish irrigated pasture and thereby supplement the already deteriorating natural rangeland. Currently, there are three farms under state ownership or MAADE.

The clans lease their irrigated farms to private investors through clan leaders and hence there are many commercial farms. However, since the regional government has no formal land use policy promoting investment in irrigated agricultural development, agreements made between clan leaders and agricultural entrepreneurs are usually breached due to conflicts of interest between clans or within clan members. There are cases that the entrepreneurs have been evicted or are forced to abandon their farms without any kind of compensation (List of farms in 2008 is provided in Annex -8)

4. GENERAL OBSERVATION

4.1 Small Scale irrigation Schemes

4.1.1 Irrigation Infrastructure

Sewir Irrigation Scheme (Amhara)

Sewir gravity irrigation scheme gets its water supply from Sewir River which is tributary of Jewuha River, a tributary of Awash River. An extract of the design document made available to the study team provides a summary of the irrigation scheme. Irrigation water requirements were estimated to be 0.1 l/s/ha (August) and 1.41 l/s/ha in March and September for irrigation duration of 15 hours per day and an overall irrigation efficiency of 41%. No irrigation was required in May, July and November. Cropping intensity of 197% was adopted in both cases. The base flow was estimated to be 300 l/s in February and the intake was designed for this flow while it was planned to irrigate 191 ha net in February. There is no clear information how this was arrived at.

The sloping side of the diversion weir was well constructed with reinforced but reinforcing bars are exposed to surface. These reinforcing bars affect the normal flood flow and cause heading up. Part of the stilling basin has deteriorated and gabion works are dismantled thus endangering the sustainability of the structure. The intake is also well constructed and fitted with vertical lift gate which is in good condition and easily operated. The upstream of the intake area is clear of silts. The conveyance system consists of 5.083 km of trapezoidal main canal (about 215 m of upper reach is lined with stone masonry), elevated concrete flume, drop structures and division boxes some combined with drop structures. The main canal runs along the middle of the field and irrigates on both. The blind canal starting from the intake runs along contour but cutoff drain is not provided along its upslope side, the canal is exposed to siltation from overlying areas. The canal also crosses different sizes of gullies where pipe culverts are provided. A large elevated concrete flume which about 10 m is also provided at a gully crossing. Excessive leakage is observed at the downstream transition of the flume which, unless remedied, will endanger the transition and pillar-flume junction.

The irrigation distribution network comprises of six blocks each with 6 tertiary units. There are 14 water division structures feeding double number of tertiary canals on both sides of the field. The capacities of tertiary canals vary from 10 to 23 l/s. The division boxes have raised sill and facilitate easy offtaking of water while the downstream ones are with sills and offtaking water takes some until the water level increase to produce appropriate head. According to the beneficiaries, the division boxes without raised sill were constructed towards the end of the construction period when the construction crew was preparing for demobilization. Field canals are left for farmers and no turnouts were provided on tertiary canals. However, some plots at the top part of the command area were left as out of command but the farmers have made miracle to irrigate these plots. For example one farmer constructed an offtake on the left side to irrigate his plot on the right side by constructing local crossing structure on the main canal downstream of the offtake. While some tertiary canals end at natural waterways and end of the farmland, others

end within the command area and this provided a good opportunity for excluded farms to extend the canals. Accordingly, currently irrigated area increased by 36 percent of the planned area.

Earth canals are obviously designed to have trapezoidal cross-section but none of the tertiary canals was observed with that shape. The offtakes to the tertiary canals are narrow presumably designed based on proportionality principle. The canal structures are well constructed with stone-masonry works. According to the beneficiaries, only some division boxes were provided with gates for closing. Some dilapidated gates are still in use although they are not effectively controlling water. Hence, water regulation is by stone mixed with mud and grass causing severe siltation of the main canal and weed growth. Main and tertiary canals were recommended to run continuously and field canals on rotation.

Neither farm roads nor drainage system are constructed although they are indicated in the design. As there is no access road to the diversion site, one has to walk. Absence of drainage system coupled with lack of water control devices aggravated by canal breaching resulted in non-uniform irrigation application, soil erosion and waste of water through runoff and deep percolation.

Improperly managed Sewir canals and structures: Photo by Yibeltal Tiruneh

Chacha Irrigation Scheme (Amhara)

The source of water for Chacha irrigation scheme is Chacha River which is tributary of Jema River, a tributary of Abbay River. According to the design document the water resources potential this river in April which is the driest month in the area can irrigate only 160 ha after allowing about 16% for downstream release. This was estimated based on a peak discharge of 80 l/s (an irrigation duty of 0.5 l/s per hectare with an overall irrigation efficiency of 50% and 24 hours of irrigation per day).

The headwork includes a masonry diversion weir of 85 m long and 4 m high and is provided with a square box intake of 50 cm fitted with vertical lift gate. The layout of the conveyance and distribution network includes 3.27 km of main canal, 20 tertiary canals directly offtaking from the main canal and drainage system. The area equipped for irrigation is 112 ha and only outlets were to be provided for 48 ha. Field units are in the range of 1.5-2 ha. Intake, main canal and related structures were designed for 150 l/s. Tertiary canals were designed based on a block size

of 6 ha, peak water requirement of 0.78 l/s/ha, irrigation interval of 7 days and operation of the canals only for three hours.

The command area has flat topography with slope not exceeding 2% and is predominantly of black soil with poor permeability and infiltration, poorly drained and waterlogged. Most of the area used to be cultivated during dry season using traditional irrigation while part of it was pastureland. Hence, drainage system was designed.

While the farmers were able to practice traditional irrigation on 130 ha and the irrigation potential is 160 ha, Co-SAERAR designed and constructed the irrigation network for 112 ha. The beneficiaries complained for not being involved in the study process and are not satisfied with the irrigation layout because the layout considered new lands while the land under traditional irrigation was left out.

The diversion weir and the intake are well constructed and are all in good condition with the vertical lift being easily operated. The trapezoidal main canal is lined with rubble masonry and tertiary offtakes are provided as designed but none of the offtake was provided with gate for water control. The first or upper-most field offtake on the tertiary canals is provided, on average some 10 m downstream of the main canal which leaves such a wide strip of land along the main canal. This idea was to protect the lined main canal from seepage in the field canals. However, the levels of most of these offtakes are below the adjacent farmlands. Hence, the farmers have constructed field offtakes on the tertiary canals just nearby the main canal (only 2-3 m from it) by simply breaching the canals.

The main canal is contour canal and requires the construction of cutoff drain to intercept the runoff from overlying farm lands but that was not provided.

Cracks are observed on internal sides of the main canal and excessive seepage along the canal particularly at the downstream reaches has resulted in ponding of water on the upslope side of the canal. Water regulation at the tertiary offtakes is by mud. Silt from sloping farmlands and use of mud and grasses for water control caused severely siltation of the main canal and significant weed growth. This not only results in the reduction of canal capacity but also aggravates seepage due to widening of cracks by weed roots.

As explained above, the command area is waterlogged for which drainage system was designed but not constructed and the original problem remains as it was.

Downlsope tertiary canals and structures on them are silted up with grass growth and are not effectively utilized. The farmers are irrigating their plots by simply breaching canals anywhere appropriate them. Tertiary canals are also overtopped.

It was reported in the group discussion that the irrigation scheme was provisionally handed over to some of the beneficiaries, without involving the executive committee which would refused to take over before proper completion, because some works were still remaining. After this provisional handover, CO-SAERAR has not completed the remaining works such as irrigation network for important part of the command area, drainage system and offtake gates.

Seepage in the lined Canal

Walga Irrigation Scheme (Oromia)

The good condition of the diversion weir of Walga 1 and the intake structure fitted with vertical lift gate clearly indicates that it was well constructed. The conveyance system consists of about 4-5 km main canal with division boxes, night storage and culverts while the distribution network includes five secondary canals and 26 tertiary canals. According to the beneficiaries and observation of the traces of the structures, the layout was well designed and constructed. However, only the upper 500 m of the main canal is serving due to shortage of water. Hence, all the conveyance and distribution canals below this 500 m are changed to farmlands and structures silted. Only about 80 ha of land which is one-third of the designed area due to shortage of water.

Walga 2 diversion weir is also well constructed and two intakes with vertical lift gates are provided to irrigate on both sides of Walga River, the command areas in the right and left side Wonchi and Weliso woredas respectively. The canals traverse long distances, may be in the order of 8-12 km, through villages and shrubs mixed with eucalyptus trees. Both the main canals run along contours and cross many drainage lines. However, neither drain culverts nor cutoff drains are constructed and where the former are provided they are not properly located and constructed and this resulted in siltation and overtopping of canals. The main canal of right command area is poorly laid out by the fact that the contour canal is abruptly changed to downslope canal for about 80 m and then back to contour canal. This 80m length is lined with stone masonry to protect the canal from being eroded. This change resulted in loss of command and caused unnecessary expenses in lining. There is no reason why this layout was changed. Culverts are provided but because of under-designed or inappropriately located, they are either not giving the intended service or are destroyed. Tertiary canals directly take off water from the main canal with turnouts provided at uppermost canal reach. Similarly, most of the turnouts are not functional because of either inappropriate location or poor construction. Hence, the farmers construct offtakes anywhere they want. While some box culverts are constructed on the left conveyance system no offtakes were provided at all and this forced the farmers to breach the main canal here and there.

The conveyance systems on both sides traverse along porous formation. The canals particularly the upper reaches are silted and infested with weeds thus retarding water flows. Some maintenance activities caused irregularities in canal shapes and beds and cattle crossing the canals widened the cross sections forming a sort of ponds. These coupled with lack of regulation at offtakes, long canal and subdivision of the flows into several small canals caused excessive seepage resulted not only in water loss but also in waterlogging in the order of 5-6 ha.

Inadequate culvert capacity causing damage

Saraweba Irrigation Scheme (Oromia)

Saraweba irrigation scheme takes water from Sogido intake which was constructed on the right side of Awash River. The headwork of Sogido is a simple intake with some gabion works and intake abutments. The intake capacity as reported in the Saraweba design document is 1.6 m^3/ha to irrigate 140 ha (about 11.43 l/s/ha). It is not clear how this discharge was determined. As the conveyance system was designed for this discharge (over-designed), the same system capacity was found to be adequate for both irrigation schemes. Therefore, a division box and masonry lined canal were simply constructed for Saraweba. This canal was taken across Awash River with concrete flume. Therefore, the conveyance system of Saraweba irrigation is a 6.91 km contour canal (5 km lined with stone masonry) and consists two elevated flumes of 96 and 75 m long, 100 m inverted siphon and drainage culverts. However, the canal runs along hillsides and no cutoff drain is constructed, the canal is exposed to siltation which includes fine to coarse soils, gravel to big stone and tree branches. These easily clogged the inlet to the inverted siphon causing heading up and finally destroyed the canal. Recently maintenance was carried out but no measure was taken to prevent runoff from the hillsides. Seepage is also observed in the lined canal indicating poor construction quality and this may endanger the foundation.

The distribution system of Saraweba irrigation scheme which is designed to irrigate 280 ha consists of secondary, tertiary and field canals with some of the latter two directly offtaking from the main canal. All of them are provided with gates. However, water does not reach to the tail end command area due to poor layout and water shortage. Hence, at the time of this study (March 2009), only 33 ha was irrigated. The conveyance system of Saraweba irrigation scheme is not accessible even during dry season.

Canal silting from overlying land (no cutoff drain is provided)

Chelo Irrigation Scheme (Addis Ababa)

The infrastructure of his irrigation scheme consisted of a large pump and flexible plastic hose that directly deliver water to furrows. The irrigation system lacks drains and this coupled with the micro-relief irregularity (spots and depressions), the area becomes waterlogged from June-October every year. The breakdown of the pump coupled with the damage of hoses due to dragging them along rough surfaces, irrigation was not possible for some seasons and this forced them to request FAO through Addis Ababa Agriculture Office for support in 2005. FAO supported the repair of the pump and replaced the hoses with steel pipes according to their preferences through a Telefood Project.

4.1.2 Cropping Patterns

Sewir Irrigation Scheme

The cropping pattern proposed included sorghum, maize, haricot bean and groundnut in the wet season under supplementary irrigation, maize, tomato, pepper and groundnut in the dry season. Currently teff, maize and onion are grown with onion taking the lion's share of production and Teff, sorghum and maize are mainly for home consumption while onion is for market. According to the farmers, the main criterion for crop selection is market and because onion is getting good demand and price, they have adopted onion-dominated cropping pattern. This onion-domination rendered onion production at risk of high pest and disease infestation which forced them to make significant expenses on chemicals. They also apply fertilizers. Recently they have introduced a legume crop of local variety, known as '*masho'*. This crop is important in nitrogen fixation.

Chacha Irrigatin Scheme

A single copping season was proposed with irrigation intensity of 100%. Cropping patterns include cereals- barley and wheat (50-55%), vegetables-garlic and potato (30%) and pulses-field peas and lentil (15-20%) in any year in rotation. The proposed irrigation methods were furrow for potato and border/flooding for all other crops.

However, the only crop grown in the irrigated area has been barley until recently but currently garlic is included in the cropping pattern. This limited cropping pattern is attributed to poor extension service as witnessed by the production of multiple crops in nearby irrigation scheme supported by World Vision Ethiopia. Potato was tried but unsuccessful because of frost attack.

Walga 2 Irrigation Scheme

What crops were proposed is unknown because of lack of any sort of information source (no documents or one involved in the study). According to the beneficiaries, maize, sorghum bean, potato, shallot and beetroot and were proposed. However, currently maize, onion, tomato, cabbage and pepper as well as potato are grown. Sugar cane and '*chat*' are also well grown .

Saraweba irrigation Scheme

The proposed cropping pattern for Saraweba consisted of cereals (maize and sorghum), vegetables (tomato, onion, pepper and cabbage) and fodder crops (sesbania, Rhodes grass, buffel grass and desmodium). However, shortage of water forced the beneficiaries to grow only maize.

Chelo Irrigation Scheme

As indicated above, the area used to be inundated and waterlogged from June to October. This forced the beneficiaries to produce only once in a year. The crops grown include carrot, cabbage, kale, potato and beetroots with proportions in decreasing order. One-third of the total six hectares of command area was to be planted with forage crops but the entire command area used to be planted only with the above crops. At the time of this assessment, only four hectares of land were actually covered with the above crops and irrigated with rented pump as their pumps were not functional.

4.1.3 Water Distribution and Irrigation Scheduling

There are four types of water distribution methods: continuous supply and scheduled distribution (on-demand, semi-demand and rotation), the choice being dependent on the availability of water and irrigation system. Continuous supply and scheduled distribution are used when sufficient water is available and water is scarce respectively. In all the irrigation schemes under consideration scheduled distribution or fixed rotation system is adopted. Some differences are noted in irrigation scheduling in the irrigation schemes assessed.

Sewir Irrigation Scheme

As indicated above, the command area is divided into six blocks with six tertiary units of different sizes in each block. Irrigation schedule is fixed so that each block receives water once in a week. The block leaders are responsible for the proper distribution and allocation of water. Water in one block rotates among tertiary canals within eight hours and two hours are allocated for one farmer irrespective of a plot size. The seventh day is a compensatory day in which plots which did not receive water or are not adequately irrigated during the six days will be irrigated. In this case, the available water is divided among many tertiary and field canals from top to tail end plots and because the flows are so small in large canals, flow velocities are retarded and water does not only take long time to reach the target plots but also results in percolation loss due to retarded flow. Accordingly, water 'theft' is a common practice although penalty rule is strictly applied.

Irrigation is applied for 24 hours against the planned 15 hours of irrigation per day due to shortage of water and irrigation interval of six days is adopted irrespective of crop type and growing stage. This shortage is caused by increased traditional irrigation schemes upstream, natural flow reduction and expansion of Sewir irrigation area. Within 24 hours, water is rotated every eight hours among tertiary canals. Each farmer gets water only for two hours irrespective of plot size and crop type. As many farmers as the flow in tertiary canal suffices can irrigate in parallel. Flow estimation in the lined main canal measured using float method in March resulted

in 75 l/s (50% of the designed flow). Considering seven days of irrigation interval and 24 hours of irrigation per day, the total cropped area would receive a gross irrigation supply of 17.5 mm (2.5 mm/day). If a combined conveyance and distribution efficiency of 75% is considered, the application depth would fall to 1.85 mm/day. Estimated irrigation water requirements with 60% of application efficiency are 2.5-2.65 mm/day in April which clearly indicates a shortage of water by about 26%.

Irrigating onion (Sewir)

Chacha Irrigation Scheme

According to beneficiary group the team had discussed with, supply of water has not reduced since the construction of the scheme. Although the command area has expanded to 300 ha and there is no well structured water management system, conflict over water has not been observed. The beneficiaries indicated that they irrigate barley twice during initial and crop development stages only. Except indicating irrigation interval of seven days, how the irrigation scheme would be managed was not explained in the design document. Garlic is irrigated 18 times at irrigation intervals of 5-15 days depending on the crop stage.

Border/flooding is practiced on unlevelled plots. Some plots are irrigated by horizontal infiltration from a nearby field canal or field ditches. In both cases, the water is maintained so long until the high spots and the plot edge on the side of the field ditches receive adequate water and by so doing excessive water is lost through percolation and runoff. Irrigation application is not attended. Once the farmers open canals and let the water to their fields, they leave the field or do other activities. Moreover, tertiary and field canals as well as field ditches are usually overtopped thus saturating and waterlogging surrounding plots.

Whoever wants to irrigate, he/she can do so. Hence, water is available whenever required although the quantity is unknown.

Walga 2 Irrigation Scheme

Generally water is in short supply in Walga area. Hence, there is an agreement among all the modern and traditional irrigation users that water for irrigation is diverted to farms only for five days per week (Monday to Friday). The water is released to the river for ecosystem conservation and wild life during the week ends. The application of this rule is monitored by a community

consisting of 15 members from each irrigation scheme. However, it was observed in this assessment that the agreement is breached in many places depending on the accessibility of the farms.

Accordingly, in the group discussion with Walga 2 irrigation beneficiaries, it was aired that they have faced great shortage of water due to four main reasons: expansion of irrigated area, excessive seepage in the conveyance system, upstream traditional irrigation practices and non-irrigating on the weekends.

In regards to water distribution, the main canal runs continuously for five days per week while water is rotated among 15 tertiary blocks and 75 groups with different number of farmers per group depending on topographic situation. Duration of irrigation per tertiary unit depends on number of users in a unit but one farmer receives water only for one hour irrespective of plot size. Hence, according to the beneficiaries only about 22 percent of the command area receives water during the dry season and crop yield is significantly affected. As the command area has a rolling topography, irrigation is non-uniform.

Difficult to control irrigation application (Walga 2)

Saraweba Irrigation Scheme

As described earlier, tertiary and field offtakes are designed to directly take water from the main canal in proportion to the area they serve on continuous basis. Water is too inadequate in this irrigation scheme. Hence, water is distributed to plots in fixed rotation and irrigation is applied for 21 hours per day. Water delivery is controlled by subgroups of actually irrigated area. Even if water distribution is made on social equity, the plots on the top end receive higher amount of water due to their location. As water moves down, the flow decreases due to seepage loss and overtopping affecting the delivery of the required amount of water even for top to some middle plots (tail-end plots do not receive water at all). The problem of water shortage and inequitable distribution is aggravated by 'theft'.

There is no fixed irrigation interval but the irrigation is applied based plant and soil symptoms (leaf wilting and dryness). According to the beneficiaries, maize is generally irrigated 3-4 times on every 7-9 days.

Broadcast planting of maize- non-uniform irrigation

Chelo Irrigation Scheme

At the start of the irrigation scheme the command area was communally owned. Out of the 4 ha under irrigation three hectares were distributed to 8 groups as individual holdings in order to encourage production which was not the case for communal ownership, only one hectare being under communal ownership. Water distribution in this scheme remains to be well organized and both group and communal holdings get water equally. There is no also top-end and tail problem.

As indicated in Table 5 below, irrigation intervals for vegetables vary from 5 t0 12 days. Even for one crop, irrigation interval varies widely. For example, carrot is irrigated 15 times in irrigation interval of 5-12 days. With four months of growing season, on average, carrot is irrigated every 8 days. The pump operating for 10 hours per day could deliver about 324 m^3 of water per day. Considering the minimum irrigation interval 5 days, a total of 1,620 m^3 of water is applied over 4 ha per irrigation. This is equivalent to 40.5 mm depth of irrigation (8.1 mm/day) and it is applied during flowering and fruit setting. During the other growing stages a relaxed irrigation interval is used. In some years, irrigation is also applied to prevent the crops from frost in October.

Table 9: Typical Irrigation Intervals for Selected Community Managed Irrigation Schemes

Crops	Irrigation Schemes									
	Sewir		Chacha		Walga 2		Saraweba		Chelo	
	II	No. Irr.	II	No. Irr.	II	No. Irr.	II	No. Irr.	II	No. Irr.
Beetroots									5-12	12
Cabbage									5-7	15
Carrot									5-12	15
Garlic			5-15	18						
Kale									5-7	7-8
Onion	6	14			20	5-6				
Pepper	6	14								
Potato									7-10	5-6
Maize	6	13-15					7-9	4-3		
Masho	6	8								
Sorghum	6	15								
Teff	6	12								
Barley			30	2						

NB: II= Irrigation interval (days), No. Irrigation = Number of irrigations

4.1.4 Community Organization and Scheme Management

Establishing a strong irrigation organization is one of the major aspects for a successful and sustainable irrigation management. Sustainable management of irrigation systems requires well established rules that ensure the interest of all farmers. Accordingly, the beneficiaries of the small irrigation schemes under consideration are organized under irrigation water user association (WUA) or irrigation cooperative (IC). These organizations have differences. Membership in irrigation cooperative is voluntary while it is mandatory in WUA. The IC manages the irrigation scheme and performs other activities such as input-output marketing while the WUA deals mainly with scheme management. The irrigation schemes in Amhara regional are organized into irrigation cooperative while those in Oromia are organized in WUA. Chelo users were organized in Horticulture Producers Association prior to getting the land.

The establishment of these community organizations has two major objectives or functions:

- Operation and maintenance (planning of cropping seasons, water distribution management; resolve conflicts over water use, and maintenance)
- Input supply and marketing of produces

The ICs and WUAs under consideration are found at different levels of carrying out these functions. Some carry out all the functions although limited in planning of cropping season and marketing while others even could not perform the functions related to irrigation scheme management. Specifics are explained blow.

Sewir Irrigation Scheme

Actual beneficiaries of this irrigation scheme are 689 farmers and they are organized into Sewir irrigation cooperative. The cooperative is well organized and legally registered by Amhara Regional Cooperative Promotion Bureau. This cooperative is managed by an executive committee of seven members and administered by by-laws. There is also water committee under which six groups are also formed for water management based on blocking of the command area and village setting. All irrigation users are not IC members. The members of the cooperative are 412 including two non-water users. Those cultivating the expanded area users are not allowed to be member of the IC in order to avoid the right to claim for water. There are 17 female-headed households and all are IC members.

As indicated above, all water users are not IC members while two of IC members are non-water users. These have caused difficulty in benefit sharing because non-IC members are not entitled to annual membership collected money, non-water users are not entitled to water use related contributions and penalties. Apart from this problem the cooperative is very strong in managing the irrigation scheme. The rules are well applied particularly in water allocation. When the irrigation beneficiaries often breach the rules in water ‘stealing’, they are penalized according to the rule and this applies equally to both water user IC members and water user non-IC members.
So far, the cooperative has collected penalty of Birr 21,600 (US$ 2,270). These penalty and annual membership and water fees enabled the cooperative to accumulate about Birr 100,000 in its back account.

The cooperative is also smart in assessing cropping patterns adopted by other irrigation schemes like Bole in Fentale Woreda (Oromia) and Mersa in North Welo some 275 km away. The visits are made once prior to planting by two or one of the executive members.

Chacha Irrigation Scheme

The irrigation scheme was to be managed by irrigation user association which was proposed to be established as a pre-condition of project implementation. Totosena Tach Sanka irrigation cooperative was then established after the construction of Chacha irrigation scheme. The design document puts the beneficiaries as 451 households but it was reported in the group discussion that the beneficiaries were 192 households and these increased to 260 households. Out of these only 137 members are members of the irrigation cooperative. There is also a control committee consisting of 3 members. Four Ketenas (groups) are also formed for water management based on village settings and each group has 1-4 subgroups depending on the number of beneficiaries or layout of the irrigation system. According to the group discussants, the reason for not being a cooperative member is unknown but some of them said that the reasons are two:

- One is related to the policy on membership eligibility which states that membership should be on voluntary basis and because of bad experience in cooperatives in the last regime, no farmer is willing to join a cooperative
- The second reason is simply lack of awareness about the benefit of coordinated and joint action in management of an irrigation scheme and enlightenment on the difference between the current irrigation and the old producer cooperatives.

The cooperative has by-laws and executive committee with seven members but has never been put into action except penalizing ten farmers for driving their livestock across the main canal. Annual fee payment of 2 Birr/ha was also started but stopped due to a problem associated with its collection without receipt. Currently the cooperative has about 18,000 Birr in its bank account at commercial bank of Ethiopia. Apart from these, the cooperative remained inactive.

Walga 2 Irrigation Scheme

While the Wonchi woreda irrigation scheme currently serves 712 beneficiaries, only 118 beneficiaries are members of the water user association by the name of "Horticulture Producers Association". Although the association does not have legal entity, it has stamp. Water management groups are organized under the executive committee. Governing rules are also put in place. However, the association is not managed according to its by-laws. Traditional proceedings are mostly applied to solve the problems of conflicts and water "theft'. However, penalties are applied against water 'theft' only when it is only considered a serious fault but the collected money does not reach the association treasurers. Instead it is used by the water management groups for relaxation. Collection of water fees was not initiated.

One major management problem is noted in Walga 2 irrigation scheme. Some farmers in Wonchi woreda, who have plots in the left command area in Woliso woredas, are not organized in any of the water user associations. Because of this and due to the location of the plots in top end of the

command area, they free to use water any time they want and manipulate it in their way. For example, they don't close offtake when they finish irrigation. Instead, they lead the water to return to the river downstream of their plots. This does only cause shortage of water for others but also it is causing riverbank erosion and aggravating waterlogging.

Saraweba Irrigation Scheme

As explained above, the beneficiaries were organized into water user association (WUA). The WUA nominally exists because the users are discouraged by the shortage of water and inequity in water distribution due to improper layout or poor construction.

Chelo Irrigation scheme

As indicated above, the beneficiaries are organized into horticultural production association which is in still good management by 5-member executive committee. The management is however problems from external intervention of the kebele.

4.1.5 Extension Service

If irrigated agriculture is to be effective in meeting the objective of improving food security and livelihood of the involved farmers and contribute to the national economy on sustainable basis, the required infrastructures and services have to be availed. Good extension service and availability of inputs aimed at crop-diversification and market-oriented production and availability of marketing for products contribute to the effective use of an irrigation system and avoid negative environmental consequences (water quality issues from pesticide overuse, soil degradation from limited crop rotation, waterlogging, and salinisation). In this regard the small scale irrigation schemes are found at different levels.

Sewir Irrigation Scheme

The beneficiaries do not appreciate the extension service for the service particularly in availing or facilitating inputs such as fertilizers and chemical as well as in making of agricultural produces. In fact, they are complaining about the instructions or policy on co-operative membership which allowed farmers are not irrigation water users to be a member of the co-operative. As far marketing is concerned, they get good prices for onions not because of the extension service but because of the hardworking of the cooperative executive members.

The extension service is not only poor in input supply and output marketing but also in irrigation management. The conditions of canals clearly indicate this case. The farmers throw weeds and crop residues in the canals and structures. They construct canal long slopes and drain directly to main canal at the end of irrigation application instead of closing outlet. All canal gets are missing and areas around division boxes and drop structures are becoming ponds. The farmers whose plots are along the main canal construct offtakes here and there on the main canal until they get good hydraulic command and by doing so they damage the area.

The fact that the farmers plant onion every season and spend a lot of money on pest control which is due to poor or absence of crop rotation is another weakness of the extension service. It was not possible to confirm this with the Head of Woreda Agriculture Office but the extension agents reported that the farmers have raised complaints on this issue. There is one development agent for the irrigation scheme but what matters is not the physical presence but the skill and commitment.

According to the beneficiaries, monoculture onion is due to good market for this crop. There is dry weather access road connecting the main asphalt road and a small town near Sewir irrigation scheme which is about 2 km from the town. Access road to the command area and in-farm road are virtually lacking. Hence, products are transported to the small town by camel. Not only, the woreda extension office does not have any plan for improving access road and it does not also assisting the beneficiaries in marketing of products and accessing inputs. Supply of inputs is made by individual as high prices.

Unless this poor irrigation practice is improved, the probability risk of environmental deterioration particularly along the main canal is high.

Chacha Irrigation Scheme

Chacha beneficiaries complained about the extension service. They get credit service from commercial Bank of Ethiopia for purchase of inputs but it is too inadequate. The beneficiaries complained not only about shortage and high cost of seeds and fertilizers but also timely unavailability. The main asphalt road from Addis Ababa to Debre Berhan passes nearby the irrigation scheme and there is no access problem but the beneficiaries get low prices for garlic only due to mismanagement of the cooperative. This is attributed to lack of supported from the woreda agriculture offices. Extension service for this irrigation scheme is totally absent. . The woreda is in full agreement with the complaints of the beneficiaries although the reasons are not spelled out clearly. As the woreda does not have a plan to provide extension service, the water management problem and hence the negative environmental impacts is expected to worsen.

Walga 2 Irrigation Scheme

According to the farmers, they have been receiving good support from the woreda agriculture office including training in irrigated agriculture. However, because of the weak management of the association, the members do not apply the trainings and obey the regulations of the association. Accordingly, they face problems in water management and marketing of agricultural products. Although the main road from Weliso to Ambo passes through the command area, there is no access problem but prices of agricultural produces are very low due to weak organization management and failure to implement the trainings and advices from the extension service. There was clear-cut answer to the question, why the farmers do not practice the trainings. In the group discussion, it was simply voiced that farmers are wedded to the traditions and it requires unreserved effort to bring attitudinal changes. The fact that they are not able to promote crop diversification due to shortage of water is another factor that made the farmers reluctant to apply trainings and extension advice.

Saraweba Irrigation Scheme

The extension service is inadequate or poor. The irrigation users have never received any kind of training related to agricultural production. They are not supported by the extension provider in accessing seeds and fertilizers the latter of which is highly required due to the poor fertility of the soil. This forced them to buy fertilizers from retailers and pay high prices. As explained earlier, they resorted to mono-cropping of maize due to lack of adequate extension service in growing vegetables coupled with lack of market for onion. Irrigation extension desk is recently organized under water team at woreda level but the desk does not seem to receive the required attention.

As far as accessibility is concerned, the site is not accessible year round. It is only approached by the Metehara in-farm roads. Lack of market for vegetables is attributed to poor access due to which they plant only maize. As indicated above, the extension desk is so weak let alone improving access.

Saraweba irrigation users have good relationship with Sogido irrigation users which share the same intake. Both water user associations discuss amicably on water related issues without the involvement of the extension agents.

Chelo Irrigation Scheme

The Akaki Subcity Agriculture Office provided good extension services including technical advice, assisting them in getting seeds and chemicals. The group discussants appreciate the office's support in all aspects. However, they blamed the kebele administration for not only assisting them but and for its interference in their organizational management. For example, more than 30 members left the association in search of other alternatives at the time of the association's poor performance. When the association started performing well, the ex-members requested to rejoin the association after three years. According to the by-laws of the association, these people would have been treated as new applicants. However, the kebele administration forced the association to treat them as existing members and they acted accordingly. This may have implications in the performance of the irrigation scheme and its sustainability

The association gets extension service from the Subcity Urban Agriculture Office. In fact, it is due to the extension service that this women association is alive. However, the office's extension service is constrained by inadequate budget and logistics. There is no access problem during crop calendar. The site is not accessible at other times due to flooding.

4.2 Large Scale Irrigation Project

4.2.1 Irrigation Infrastructure

The headwork infrastructure of this irrigation system consisted of rock-fill diversion structure of 4-m high submerged under aggrading river bed, an intake feeding twin barrels, each of 1.65 m x 1.65 m and scouring sluice of 1.5 m x 1.5 m which is completely buried with sediment There are no structures in place to exclude sediment and primary canal sedimentation rates are high with

about 0.5 m removed annually. Silt and debris have been blocking the intake during rainy season when the scouring sluices stopped functioning due to low differential head. Special screens installed to deflect large trees did not bring appreciable effect in removing the deposition of silts in the intake. Silt in the intake was cleared manually by swimmers but removal of silt in the months of July-September is very difficult because of high flood level and during this time irrigation supply significantly reduced. To solve the problem, an intake was constructed upstream of the first intake with the normal flow level of 3.5 m above the downstream weir, both intakes discharging into a common stilling basin. Flow through both intakes is controlled by two vertical lift gates. Water abstraction used to be measured by staff gauges installed in the downstream intake but accuracy of discharge measurement is suffered due to sedimentation. Hence, amount of water abstracted in unknown.

The conveyance system consists of 25.5 km of main canal and supplies water to secondary canals through 13 primary offtakes (PO).. The main canal was originally design for irrigation duty of 1.0 l/s/ha at field gate and 1.43 l/s/ha at the intake, making the canal capacity of designed to 13.45m^3/s at the intake gradually reducing to 2.8m^3/s at the tail-end. The POs are constant head orifice structure with two gates. The upstream gate is adjusted to regulate flow to the secondary canal while the downstream gate is required to maintain submerged flow conditions across the upstream gated orifices. Once the upstream gate is adjusted, the orifice opening and head loss across the orifice are measured, and discharge determined using the submerged orifice flow equation (charts are provided for this). There are six controlled check drops (CDs) some combined with drop structures and along the main canal. These are provided with overshot gates to maintain design water levels in the primary canal. Flow over these gates used to the sharp crested weir formulae. . All cross and head regulators are provided with vertical lift gates. Rejection spillways are also provided just upstream of the regulators. As per the Feasibility Study for Irrigation Modernization, the CDs are in good condition and are enable to provide good control of measured flow deliveries if operated properly.

The distribution system comprises of eight secondary of 30 km long, tertiary canals of 93 km and field canals of 270 km.. The secondary canal was designed for irrigation duty of 1.0 l/s/ha at the PO based on with assumed distribution loss of 1.5% per kilometre. The canals were constructed with constant cross-section along the entire length in order to allow flow rejections. Cross regulation of flows to tertiary canals is by stony-masonry duckbill weirs with sloping rubble aprons. Each secondary canal commands at east two tertiary canals and rejects into secondary or tertiary drain. All the tertiary canals were design for maximum discharge of 0.4 m^3/s.

Drainage system is incorporated in the conveyance and distribution system. The main drain is about 29 km and was designed to carry rejection flows from irrigation canals and excess water following rainstorms from an area of about 9,000 ha. Subsurface PVC drainage system was also provided to about 3,820 ha of the command area with the main and secondary drains deepened. However, this was not completed due to functional outfall problem. Hence, the subsurface drainage system is not functional not only due the fundamental outfall problem but also due to inadequate deepening of secondary and main drains and blockage of pipes or pipe slots by silt of sand sediments, small dead roots, as well as chemicals such as slack lime.

As the command area is flood plain, flood protection dykes are constructed along the river banks to an average height of 3 m.

The main canal was silted up at the time of the visit in April. Maintenance was delayed because some irrigation blocks were unusually covered with maize. According to the information, Afar Presidential Office instructed planting of maize in February order to contribute to improving food security in the area and the main canal was running partially full. This prevented the Awash Basin Authority (ABA) from carrying out maintenance of canals and structures.. Therefore, full canal operation was commenced when cotton was planted in May without removing sediment.

4.2.2 Water Distribution

Water distribution to all Melka-Sedi and Amibara irrigation farms is managed by Awash Basin Authority the office of which is located at Werer, the former town of Amibara woreda. The ABA has a total of 93 staff including 24 gate operators, two water distribution controllers, five water bailiffs, and 13 multipurpose water distribution workers, 24 guards and others who are directly involved in water distribution.

Irrigation is supplied over 24 hours per day. Water distribution is made based on requests from the farms and the requested water is generally delivered within 6-12 hours. The requests which include quantity and duration processed by the Operation and Maintenance Department of the authority which instructs the water distribution controllers who in turn pass instructions to appropriate gate operators. Instructions are passed by radios, vehicle or motor bikes. The gate operators adjust the gate openings and gauges accordingly. The flows and durations are registered in office while the gate operators register the gate openings and staff gauges twice, sometimes three times daily.

All the entrepreneurs complain about the quantity of water delivered. According to them, amount of water released to them d is often less than requested but it the requested amount is registered by the ABA as if it is delivered and they are charged based on the requested amount. Most have the same opinion regarding timing of the water delivery depending on the location of the farms relative to the intake. The tailend farms receive water about 12 hours after the request is made. Some farms like Werer Agriculture Research Center are the most affected farms due to the problems related to inadequate offtake size, canal slope (improper maintenance) and illegal offtakes constructed by other farms.

According to ABA, there are two reasons for inadequacy of water supply. The first one is related to maintenance of canals. Lower level canals and structures are not properly maintained by the farms and this does not enable to take the required water although the gate openings and staff gages adjusted. The other major reason is improver irrigation application. Maintenance of main canal and drainage system is carried out by the ABA whereas the farmers are responsible for operating and maintaining the lower level canals including secondary canals. There is often non-uniform irrigation (over-irrigation to extent of water logging and under-irrigation) depending on the topography and location of the command areas from offices. The ABA advises the farms to improve the quality of maintenance and irrigation application but the farms do not usually apply

the advice. According most farms, the water shortage is caused by reduction of water from the sources due to reduced capacity of intake.

Check Drop (CD) and primary offtake (PO)

Illegal offtakes constructed by some clans are also the major problems constraining equitable and proper water distribution. The ABA has taken such cases to local administration and courts but they were not attended. Hence, the ABA has resorted to traditional proceedings or negotiation with the beneficiaries to solve the problem.

A question can be raised regarding the quantity of water delivered to each farm. As explained above, there is disagreement between the farms and the ABA on the amount of water delivered. One possible reason is related to the accuracy of flow measurement. As indicated above, the offtakes are provided with constant head orifice gates. Each gate has its own calibration curve and based on the request amount of water the gate operator adjusts the water level and notes the amount of discharge from the curve. Two points can be mentioned. The first is related to possible changes of canal bed slopes and cross-sections due to siltation and repeated maintenance which could affect the stage-discharge relationship. Re-calibration has not been made since the construction of the offtakes and development of the rating curves for more than 20 years. The other is related to personal errors. The operators use either wrong rating curves or misread them. This error was verified by checking the measured flows on 11-20 May 2008. Although data for three cross-regulators is missing, the available data indicates that flows at downstream cross-regulators are greater than those at upstream cross-regulator which should have been the other way round for continuous supply. In such water delivery, flows normally decrease downstream because of release in the offtakes. Flow data are also missing for some head regulators.

4.2.3 Cropping Pattern, Crop Water Requirement and Irrigation Application

As recorded by the Awash Basin Authority, the current irrigated area is about 10,322 ha but varies from one year due to water shortage, leasing arrangements by Afar clans and others.
Although the water management manual (1983) is prepared based on a cropping pattern consisting of banana, cotton, pepper, haricot beans, maize, onions and sesame, cotton is predominantly grown in all the farms with very minimal area (3-4) planted with onion in

Amibara by some small scale investors, and sesame, groundnut and rice for adaptation trial in Melka Sedi irrigated field (about 1.5ha). Banana plantation in Meka Sedi farm is converted to cotton field.

A number of factors including climate, soil type, variety, date of planting, farm management practices, pests/diseases availability of irrigation water and harvesting efficiency affect cotton yield. Accordingly, to the Phase III study (2008), cotton yield has showed a declined trend from about 2.7 t/ha in 1980s to 21 t/ha recently. But the information from state farm and other private the collected in this performance assessment indicates that higher yields of 2.7-3.5 t/ha.

It was also difficult to get adequate information on irrigated area planted with cotton because the clans lease their lands for different entrepreneurs every year or one farm is leased for two or more investors. Due to this, irrigated areas registered by ABA are both incomplete and inconsistent. As per ABA's record, a total of 10,322 ha of land were planted with cotton in 2008.

Gross seasonal irrigation water requirement of cotton was estimated to be 720 mm including leaching requirement. Pre-irrigation depth of 310 mm was recommended 12 days before planting. It was also recommended to apply a constant post planting irrigation depth of 130 mm at different intervals, the first irrigation being applied two days after planting. Subsequent irrigation intervals proposed were 28 days, 21 days and 14 days (three times) and 21 days (two times) making a total of eight irrigations including the first one.

Actual practice differs from the recommendations. Only 5-6 irrigations are applied in any of the farms with irrigation intervals slightly different from the recommendation. The total depth of irrigation depth applied is in the range of 510-1250 mm (Table 3). The delivery of water by ABA is based on users' request but is not an actual measured volume. Net and gross application depths are measured in Melka Sedi Farm. Gross depths varied from 48-273 mm making a total of 960 mm per season Werer Agriculture Search Center recommends 75-100 or 125-150 mm of water every two weeks with the first irrigation applied 21 days after planting

Application depths at Melka Sedi were also calculated using theoretical formulae and roughly measured dimensions. Three siphons of half inch are used for 6 hours to irrigate one furrow of 220 m long, average width and water depth of 45 cm and 20 cm respectively. At furrow spacing of 90cm, there are 111 furrows per ha. With an average working head of 45 cm, the depth of application per irrigation is calculated to be about 148.9 mm or 1,489 m^3/ha and with 6 irrigations, irrigation requirement is 8,934 m^3/ha per season. The net irrigation water requirement is estimated to be 9770 m^3/ha per season. Part of the Melka Sedi area is also irrigated using 1.5 inch siphon per furrow. Similar calculation gave almost double of that of the half-inch siphon.

All the forgoing clearly indicates that the information on irrigation application and water withdrawal or delivery is unreliable. Hence, the amount of water used for irrigation is not well understood. As explained earlier due to poor water flow control in canals, there is no real information as to how much water is being released and how much water is actually applied. It is however believed that the amount of water released is decreasing from time to time and the supply might have been smaller than the crop-water requirement as confirmed by all the irrigation users who complain about the shortage.

Table 10: Actual Irrigation Intervals for Cotton in Melka Sedi and Amibara Farms

Descriptions		Irrigation interval (days)		
	Irrigations	Melka Sedi	Amibara	Mehado
	1st	21	30	35
	2nd	14	21	18
	3rd	14	14/15	14
	4th	14	14/15	14
	5th	21	14/15	26/28
	6th	21	21	
Total number of irrigations		6	5-6	5
Water application (mm)		48/146/247/273/246/246	250 (3) /200 (3)	150/100/150
Water applied per season (mm)-data from farms		960	1350	650
Estimated application –siphon based		893		
Yield (ton/ha)		3	2.7	3.5
Total water supplied by ABA (mm)		868	1240	1969

Source: ABA and Respective Farm Enterprises (Survey 2008)

4.2.4 Maintenance and Water Charges

As explained above the Awash Basin Authority is responsible for operation and maintenance of the Melka Sedi-Amibara irrigation project and distributes water to farmers based on the request. It also advises farms in water management. Maintenance cost is covered by the farms in proportion to the areas irrigated by each farm. ABA undertakes maintenance and requests the farms to refund the cost. In addition, the farms pay water charges at a rate of Birr 3 per 1,000 cubic meter of water delivered.

The 8-year average collection rate for both services is about 84% as shown in Table 4. Annex 7 provides breakdowns of water charge and maintenance cost. Collection rate for water charges is about 72% and that of maintenance about 92%. Some small farms particularly the clans' farms and those leased to private commercial investors are the ones who make partial payment both for maintenance and water charges. The ABA sometimes takes cases to local courts be remained unsolved.

Table 11: Efficiency of Irrigation Service Fee Collection (Birr)

Year	Total Due to ABA and Collected		
	Due to ABA	Collected	% collected
2000/01	724,160.70	505,527.26	69.8
2001/02	130,978.92	76,331.72	58.3
2002/03	47,720.81	25,133.91	52.7
2003/04)	5,054,757.76	3,693,933.72	73.1
2004/05	2,789,665.35	2,552,497.40	91.5
2005/06	1,396,743.33	2,483,398.10	177.8
2006/07	3,527,451.42	2,347,849.29	66.6
2007/08	1,251,219.51	846,126.30	67.6
Total	**14,922,697.80**	**12,530,797.70**	**84.0**

5. ANALYSIS

5.1 Computation and Analysis of Performance Indicators

5.1.1 Small Scale Irrigation Schemes

As explained earlier, performance indicators for small scale irrigation schemes is limited to process or internal indicators. The major internal indicators are given below while details are provided in Annex 2. The information presented in Table 5 indicates a variation in water distribution among the systems.

Physical Condition of the Irrigation Infrastructure

The physical condition of irrigation systems pertains to whether the system provides a sound technical basis for effective water delivery which depends on the technical efficacy of irrigation infrastructure and economic efficacy of maintaining irrigation system. Technical efficacy of a system refers to the capacity of the system to deliver water from headwork to outlets and is concerned with whether or not the infrastructure is well maintained. A technically efficient system is one which minimizes water loss in the process of delivery. The technical efficacy of a system is determined by its physical characteristics; such as types of headworks, terrain, canal lining and so on. It is against this definition that assessment of the physical conditions of the irrigation schemes is made.

With regard to water control at the intake, the headworks (diversion weirs) of Sewir, Chacha and Walga are in good condition with the gates being easily operated and water entry to the canals is properly controlled while that of Saraweba is poorly controlled because of the damaged gabion structure. The deterioration of the Sewir weir and stilling basin is however a concern unless immediately repaired. In terms of the control of water distribution, all the schemes are in equal status although Saraweba is slightly in a better condition. No a single division structure has been observed with gate. Not only gates are missing but the use of stones, wood and earth for water control resulted both water loss and silts in the canals thus aggrading canal bed and cross sections. Inappropriate location or inadequate capacity of canal structures also forced farmers to construct offtakes anywhere in the canals system thus aggravating the problem of water control.

Equipped area

In Sewir and Walga small scale irrigation schemes, the equipped areas are expanded to the extent of more than doubling thus aggravating water shortage created by natural reduction of flows and upstream diversions. For example, the equipped areas of Sewir and Walga irrigations scheme have been expanded by 36% and 220% respective.

Irrigation intensity

In Sewir (Amhara) and Walga (Oromia) irrigation schemes, irrigation intensities are as high as 300% when compared with initial area equipped for irrigation and more than 100% when expanded area is considered. This has undoubtedly affected crop yields due to water shortage caused by rigid irrigation duration per farmer irrespective size of plot area and type of crop. Yield reduction was voiced by the beneficiary group discussants although they could not tell the magnitude of reduction. In Chelo pump system (Addis Ababa) and Saraweba (Oromia), irrigation intensities level at about 66% while in Chacha (Amhara), it is 100% and is dictated by the climate which does not permit second cropping.

Flexibility of water supply

All the irrigation schemes use fixed rotation system of water delivery and as such there is no flexibility except in exceptional cases which is observed and authorized by the executive committee of the association in Walga and Saraweba schemes depending on plant or soil status. Although a problem has not been reported by any of the users and the practice has been used for many years in several irrigation schemes in many areas of the country, there are cases in some schemes where committees do mistakes in deciding and allocating water depending on the smartness of those requesting water.

Equity in water distribution

Unless it is unintentional and due to some unauthorized/illegal offtakes, the guiding principle of the irrigation schemes is that each beneficiary has the right to get water irrespective of gender, status within the community, membership of WUA or irrigation cooperative and location of plots. Equity is the major criterion for water distribution. Of course, those plots at the tail end do not receive as much water as others but in every scheme additional time required for water to travel to the head of each plot is considered in fixing of irrigation time per plot/user. How accurate is the estimation of the travel time remains a challenge. This equity is the main reason for expansion of area if the topography allows.

Reliability of water supply

The fact that all the irrigation schemes have adopted fixed rotation system of watered delivery the reliability of water supply is ensured as far timing is concerned because every user knows his/her turn but the adequacy of supply for meeting crop water need is not always ensured. That means the adequacy of water supply is not reliable or the amount of the supply is known. This is due to lack of flow measurement and shortage of water. Cases for oversupply are rare except in Chacha irrigation scheme.

Table 12: Selected Irrigation Performance Indicators (Internal Indicators)

Scheme	Sewir	Chacha	Walga 2	Saraweba	Chelo
1. Physical condition of irrigation infrastructure for water control	Poor except headwork- missing gates	Poor except headwork- no gates	Poor except headwork- structural damaged and missing gates	Poor headwork damage and Some gates missing and	Pump but perforated pipes leaking
2. Equipped area	191	191	75	280	6
3. Expanded area (ha)	260	191	240		-
4. Actual cropped area (ha)	260	191	240	33	4
5. Irrigation intensity based on initially equipped area (%)	272	100	320	66	67
6. Irrigation intensity based on expanded area (%)	200	100	320	-	-
7. Water control gates	Missing	Missing	Missing	Some exist	NA
8. Water abstraction	Modern diversion	Modern diversion	Modern diversion	Modern diversion	Pumping
9. Water availability	Scarce	adequate	very scarce	Extremely scarce	Depends on pump availability
10. Flexibility of irrigation supply	Fixed rotation but inadequate	Fixed rotation by village but adequate water	Fixed rotation but inadequate water	Fixed rotation but inadequate	NA
11. Reliability of irrigation supply	Reliable in terms timing but volume is unknown and inadequate	Reliable but volume is unknown	Unreliable	Unreliable	Unreliable due to pump failure
12. Equity in water distribution	Equitable but unauthorized offtakes	Whoever wants water can take it	Equitable but unauthorized offtakes	Equitable within actually irrigated area	Equitable
13. Application of by-laws	Penalty and annual payments	No applied	Not applied	Not applied	NA
14. Adequacy of extension service	Poor service in all aspects	No service at all	Fair	Inadequate	Fair
15. Sustainability	Mal-practice damaging canals and poor canal maintenance Excessive use agro-chemicals on onions	Excessive seepage leading to structural damage and waterlogging	Waterlogging and uncontrolled offtakes leading to canal erosion	Likelihood of canal damage by runoff from overlying areas, salinization	Waterlogging and pump investment cost

NA- Not applicable

5.1.2 Amibara Irrigation Project

5.1.2.1 Water Delivery Indicators

As explained in the Methodology Section, water delivery is concerned with appropriation problems of water distribution and allocation. The dimension of water delivery captures not only the adequacy of water delivery, but also such elements as equity (allocation of water in an equitable manner) and reliability (predictability and timeliness of water delivery). Water adequacy refers to whether an irrigation system is able to make enough water available to meet the irrigation needs of farmers. Thus, adequacy should be measured in terms of needs of farmers keeping in view the seasonal variation in the demand for water.

Both adequacy and equity in water distribution partly depend on the well being of irrigation structures such as canal bed slopes and accuracy of measuring structures as well as canal conditions upstream of the measuring structures. Water delivery performance in Amibara- Melka Sedi Irrigation Project is assessed in terms of considering the above situations.

Reliability of Water Delivery

Water is delivered as per the requests of the farm enterprises indicating that water delivery is reliable as far as timeliness is concerned but in terms of adequacy it is not reliable.

Water Supply and Productivity Indicators

As explained earlier, the amount of water abstracted from Awash River is not accurately known due to lack of measuring facility in the second intake and accuracy of flow measurement in the first intake due to siltation. The main canal used to be silted up and de-silting might have affected the original cross-section of the canal and thereby the accuracy of flow measuring. The farm enterprises argue that they don't receive the required amount of water at any time.

Water productivity is the most important performance indicator of irrigation system Water productivity is one of the significant values to determine that water is used efficiency. There are several definitions to calculate water productivity, but in this study, water productivity is defined (production per cubic meter of available water supply within a command area (Burt, 2002) and calculated as follows. Inadequate information on irrigated area, crop production, water abstraction and water actually consumed by crop constrained the accurate analysis.

The only information on water consumed by cotton and gross application of irrigation water is from Melka Sedi and Amibara irrigated fields. The computation of indicators based on information from three farm enterprises and Awash Basin Authority is summarized in Table 12. The computation results should be taken carefully because of the reliability of the data.

Table 13: Performance Indicators for Cotton in Melka Sedi and Amibara Irrigation Farms in 2008

Indicator/Data	Method	Melka Sedi Farm	Amibara Farms	Mahdo farm
a) Area planted (ha)	Data	6,308	2617	34
b) Production (ton)	Data	18,924	7066	119
c) Water supply ('000 m^3)	Data	54,728	32,456	670
d) Effective rainfall (('000 m^3)	Data	19,567	8,118	105
e) Irrigation duty (m^3/ha)	b/a	8,676	12,402	19,694
f) Gross irrigation application ('000 m^3)	Estimate	56,358	31,797	199
g) Gross irrigation application ('000 m^3)	Data	62,260	35,330	221
h) Crop water demand ('000 m^3)	Estimate	61,635	25,571	332
i) Irrigation water requirement ('000 m^3)	Estimate	118,814	57,508	747
Indicators				
1. Output per cropped area (t/ha)	b/a	3	2.7	3.5
2. Output per water supply (t/m^3)	b/c	2.96	2.70	3.50
3. Output per irrigation supply (t/m^3)	b/f	0.35	0.22	0.18
4. Relative water supply (dec.)	(c+d)/h	0.34	0.22	0.60
5. Relative irrigation supply (dec.)	c/i	1.21	1.59	2.33
6. Conveyance efficiency (%)	f/c	0.46	0.56	0.90
7. Overall efficiency (%)	g/c	103.0	98.0	29.7

Relative water supply is higher than unity for the three farms considered indicating that water river diversion and rainfall were supplied in excess of the crop water demand. On the other hand, the relative irrigation supply is less than unity for all farms indicating that the amount of irrigation water supplied through river diversion was low in all schemes in comparison with the estimated irrigation demand because the latter was partly satisfied with rainfall. In fact, the farms did not irrigate whenever there is adequate rainfall but there could be rainfall following irrigation. Conveyance and overall irrigation efficiencies higher than 100% clearly reinforce the sceptism about the reliability of the data.

Despite the poor salinity and water quality problem and reportedly shortage of water, cotton yield is reasonable.

5.1.2.2 Irrigation Service Performance

Assessment of irrigation service performance is also an essential aspect of water delivery assessment in situations where farms and irrigation system management are in different hands. The objective of this assessment is to recommend the performance of irrigation water management of Awash Basin Authority in delivering the service. The point of view of farm enterprises and others about the irrigation water management was designated according to satisfaction or dissatisfaction on the base of taking some services from the authority and this is assessed using four variables: adequacy of irrigation water supplied, fairness in water

distribution among the farms, timeliness of water delivery and maintenance of irrigation and drainage canals and structures. For this assessment eight persons from different farms of the same or different enterprises were interviewed. The views of the interviewees are related to location of locations of farms with regard to main canal and offtakes. As the responses summarized in Table 7 indicate dissatisfaction of the users of the irrigation service with the service of the Awash Basin Authority.

Table 14: Satisfaction or dissatisfaction from the taking irrigation service

Variables	**Responses**		**Percentage**	
	Yes	No	Yes	No
Adequacy of irrigation water supplied		11		100.0
Fairness in water distribution among the farms	3	8	27.3	72.7
Timeliness of water delivery	7	4	63.6	36.4
Maintenance of irrigation infrastructures	6	5	54.5	45.5
Total	**20**	**28**	**36.4**	**63.6**

5.2 Environmental Aspects

As explained in Section 4.2.1 above, due to lack of exclusion of sedimentation at the headwork, and over-flat slope towards the tail the main canal suffers from chronic sedimentation preventing reliable supply of adequate water to the farms. Annual accumulation of sediment along the main canal raises the bed level by about 0.5-0.8 m reducing discharge capacity and blocking offtakes. Sediment is removed annually during canal closure in February-April. Average annual volume of sediment removed over the last three years was 145,000 m^3 forming large spoil embankments reducing access and encroaching onto the field.

While irrigation is a key for food security and economic development, it is deleterious to environment if improperly managed. There are instances of environmental consequences particularly in large scale irrigation schemes. Salinization is one of the most critical problems in the Middle Awash particularly in Melka Sedi-Amibara irrigated areas. Although problem of mono-cropping of cotton has not been noticed may be due to the application of silt-laden water particularly in July-September, there could be land degradation due to mono-cropping. Planting maize in January-March started by some farms in 2009 may reduce the potential of this problem.

The ABA supposed to carry out a monthly monitoring programme of the rise of groundwater and its electrical conductivity (EC) 71 piezometers randomly located in Amibara and Melka Sedi areas. However, only 51 piezometers are functional at present. Even these are not continuously monitored due to capacity limitation and there is no complete data for a year without which trend analysis difficltu. However, the abandoned area of about 80 ha in Melka Sedi in 2008 is a concrete evidence of the increasing trend of salinization.

The high soil salinity levels are related to groundwater level rise due to non-uniform irrigation caused by poor land levelling. In most cases and unless there is water shortage, the tendency is over-irrigation which led to capillary rise. The level of ground water table increased from 0.9 m

below ground in 2006 to 0.7 m in 2008 with monthly variations depending on irrigation application.

ABA also monitors the water quality. According to the ABA records, the electrical conductivity of the water used for irrigation varies seasonally based on the flow regime of the Awash River. This varies from 0.688 to 1.3 mS/cm in June-May in 2006 and 0.223 in July to 0.397 mS/cm in September when the river flows full during rainy season. In 2008, the EC values varied from 0.475 mS/cm in July to 0.183 mS/cm in September and then to 0.65 mS/cm in November. Data for June-May in 2008 are not available but with the salinity levels in July to September in the same year, the salinity levels in these months could be extrapolated to be higher than in 2006. Accordingly, the Awash River water could be classified as medium salinity which can only be used on a long-term basis if a moderate amount of leaching occurs.

Although salinity has not be so far observed in small scale irrigation schemes, waterlogging which is caused mainly by seepage in porous canal reaches and construction of uncontrollable illegal offtakes is becoming a major concern. More than 4 ha of land is waterlogged in Walga 2 irrigation scheme. Similarly, a wetland or waterlogged area below Sewir command area is developed for irrigation. As the water from this wetland is saline the area which used to be cultivated for rainfed production is now irrigated with this water, the risk of salinaztion of about 4-5 ha is very high.

Waterlogging due to excessive seepage in lined canal and inappropriate irrigation supply in Chacha irrigation scheme also requires due attention.

One of the major concerns in urban/peri-urban irrigation is water quality. Water supply for Chelo irrigation scheme in Addis Ababa is Akaki River which is the sink of all effluents from Addis Ababa. According to the irrigation beneficiaries, they have not faced any water-related health problem but their hands become floury colour for which they simply use skin lotions. This indicates some sort of microbial contamination and parasites and this is a concern particularly for vegetables such as lettuce and cucumber.

Waterlogged Areas due to seepage

5.3 Problems of Irrigation Schemes

Water control devices are provided in all irrigation schemes in order to facilitate management of water distribution. Yet there is widespread disparity between anticipated and actual water control, which is generally reflected in low water-use efficiency and poor economic performance. Unless there is an adequate control over the water flows to, and within, the system, there will be a close match between supply and demand. This applies equally to both small and large scale irrigation schemes.

Several problems which are related to infrastructure, water supply, organization and socioeconomic environment constrain the performance of both small and large scale irrigation schemes. General problems are briefly explained below while site specific problems are provided in Annex 3.

a) Irrigation Infrastructure

i) System layout and design

Layout of irrigation system depends primarily on topography, soil heterogeneity, water delivery choices and cost. As such it should be influenced by the perceptions of the community about how the schemes' size and shape will affect them. In some cases, the layouts of the small scale irrigation schemes under consideration deviate from that as evidenced by the construction of new offtakes due to ineffectiveness of the provided ones. Offtakes are designed or dimensioned in proportion of the areas they are intended to serve. This is possible for continuous supply in situations where there is adequate water supply but fixed rotation is the sole method of water distribution adopted in the irrigation schemes assessed. In this rotational supply, water in excess of the offtake sizes is rotated among tertiary or field canals for a short duration and because of offtake capacity limitation, heading-up is created in the parent channels thus causing excessive leakages.

ii) Structural damages and canals as 'rubbish bins'

Lack of timely maintenance particularly missing gates and damages of water distribution structures is the main problem constraining fair water distribution in 'the schemes. The beneficiaries are supposed to maintain the irrigation systems but a contrary was observed in that canals are sometimes used as 'rubbish bins' such as in Sewir where crop residues are dumped in the canals. Regulating water distribution with soil and stone caused canals to be infested with weed affecting the canals. Silting of canals does not only create favorable conditions for weed growth but also causes irregular cross-section and longitudinal slopes which resulted in non-uniform flows and overtopping in some cases.

b) Water Shortage

Water shortage is the main problem in all irrigation schemes including large scale irrigation project. The shortage is caused by a number of causes as shown in Annex 4 in a form of problem tree.

- **Expansion of command area:** Canals are usually extended to irrigate additional areas if topography allows.

- **Mismanagement of water**: As indicated earlier, mismanagement of water including runoff, distribution loss due to absence of water control devices, seepage due to flowing in weed-infested canals and irregular canal sections, non-uniform applications and layout of furrows.

- **Poor cropping pattern**: Neither selection of crops considers water availability nor staggered planting is adopted. Hence, crops with high water requirement are planed at the same time. Poor cropping plan is also a major problem in the small scale irrigation schemes. Planting different crops with different water requirements in one plot constrains the application of the required water to each crop due to a fixed irrigation interval.

- **Natural flow reduction:** Natural river flows are reduced due to land degradation which does not allow infiltration of rainfall for recharge of groundwater.

- **Upstream users:** After irrigation scheme is constructed, new schemes, both traditional and modern schemes are developed or existing ones expanded. For example, government constructed Walga 2 scheme upstream of Walga 1 which was constructed by the government even after discussing with and getting advice from Walga 1 beneficiaries that the construction of Walga 2 would create social conflict. The question is that is it a planning problem or related to policy? Good resources assessment can lead to proper planning so that irrigation development will not be a source of social conflict. In such a case, government or NGO will not plan to construct an irrigation scheme upstream of an existing one within a short distance. The question is if upstream communities construct new traditional schemes. As far as use right is concerned both the upstream and downstream communities have the right to use the stream water but constructing a scheme upstream will definitely reduce water supply to downstream users. This calls for a mechanism to handle the issue which is prevalent in river diversion schemes.

c) Weak organization

All the O&M activities of the small scale irrigation schemes are coordinated by the irrigation cooperatives or water user associations. However, failure to apply organizational rules, illegal offtakes, damaged canal structures that can be easily repaired by the users, silting and weed infestation of canals as well as improper disposal of water after irrigation application are clear indications of weak management. Abuse of penalty fee collected from water 'theft' is also another example of organizational weakness particularly in schemes Oromia.

d) Socio-economic environment including extension service

All small scale irrigation schemes do not get adequate extension service due to lack of technical expertise and logistics at the woreda offices or both. The development agents stationed in the irrigation schemes do not have technical know-how in irrigation agronomy. The farmers do not get adequate support in accessing inputs and marketing their products.

Lack of capital and credit, and unavailability of improved seeds are other constraints hindering irrigation performance. Hence the users are either forced to pay high prices for seed and chemical or they don't use such inputs at all and to sell their products at low prices or change cropping patterns.

Except in Saraweba scheme, there are often conflicts between upstream and downstream water users outside the schemes thus constraining the performance of the schemes.

Chelo association does not have vegetable shops either at Akaki or in the center of the city and this forced it to sell the vegetables at low farm gate prices. If fact, most urban irrigation schemes have similar problem. For example, Mekanisa Vegetable Producers Cooperative had one vegetable shop in each Higher Kebele (the second lowest administrative setup during former regime) in Addis Ababa and this was beneficial both for the cooperative to sell at reasonable price to the people. However, the shops were taken by the Addis Ababa Municipality in 1993 and the cooperative is forced to sell to middle men at farm gate prices.

Similarly, none of the irrigation schemes in rural areas have vegetable stores. Hence, they are forced to sell or transport the products to market the day they harvest. Lack of market is the major problem due to lack of access road to Saraweba and this combined with water shortage forced the beneficiaries to practice mono-cropping of maize.

Although inadequate market is not a pronounced problem for Sewir irrigation scheme due to the strength of the irrigation cooperative, accessibility of the scheme is poor. On the contrary is Walga 2 is accessed by all-weather road but constrained by poor market due to ill-management.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

This study tried to assess the performance of irrigation schemes but full assessment has been constrained by lack of data. As reliable production and water supply data are lacking even for large scale irrigation scheme, the study was limited to analysis of process or internal indicators from which the following conclusions are made:

Small scale irrigation schemes

- **Irrigation Infrastructure**: While layouts of water distribution network including positioning of offtakes are generally good, there are some cases where these are poorly made and offtake sizes are provided as evidence by the construction of new offtakes by users abandoning the already constructed ones. Some irrigation structures are poorly constructed and inadequate provision of offtake gates is common to all small irrigation schemes considered in this assessment. None of the irrigation schemes have drainage systems constructed. Moreover, the irrigation structures are not or are poorly maintained although the beneficiaries are aware of their responsibility for maintenance and gates of all offtakes are missing thus constraining proper water regulation.

- **Water Management**: Water shortage which is caused by different factors including increased upstream users, natural river flow reduction, command area expansion, inefficient irrigation practices and seepage losses coupled with rigid irrigation schedule irrespective of crop water demand is another main problem constraining irrigation performance.

- **Extension Service**: Lack of DAs, inadequate irrigation skill of DAs and woreda staff, or inadequate logistic support constrained crop production in all schemes. Similar irrigation practices including rigid irrigation schedule, social equity (not crop water requirement) for water distribution, command area expansions without considering water availability, construction of illegal offtakes or water 'theft' and flood irrigation are common in all small scale irrigation schemes irrespective of the locations and cultural differences and this is attributed to poor extension service. Other constraints include weak organization, unavailability of inputs and their associated prices, and lack of market for outputs. Provision of extension services from the Woreda agricultural office hardly exists in Chacha irrigation scheme. Weak organization is constrained by the woreda organizational setup in which agriculture office is not involved organizational aspects of the irrigation users in Amhara irrigation schemes.

- **Irrigation Intensity**: Irrigation intensities varied from about 24% for Saraweba to 272% for Sewir schemes. All considered, Sewir is relatively performing better followed by Walga 2. The performance of other visited small irrigation schemes is not satisfactory. Compared to the expensive infrastructures the performance of Saraweba and Chacha

schemes is appalling and this is caused by combination of poor design/construction and extension service.

- **Environment**: Waterlogging due to mismanagement of irrigation deliveries and seepage is the main environmental problem observed in Walga 2 and Chaca irrigation schemes and impending salizination at Sarawaba. Unauthorized construction of offtakes and improper disposal of excess water are damaging canals to the extent of causing gullies and gradually encroaching in-farm roads and plots mainly in Sewir and Walga 2. All these are clear indications of environmental concern jeopardizing sustainability.

Melka Sedi and Amibara Irrigation Project

- **Infrastructure**: Poor water regulating structures including intakes coupled with poor maintenance of secondary and lower level canals constrained proper water distribution to farms and caused disagreement between service provider and receivers. Due to this the amount of water withdrawal from the river remains unknown. What is reported is the request made by the farm, not measured flows.

- **Water Management:** Poor irrigation application or non-uniform irrigation caused by poor land leveling, inadequate monitoring, release of water from lower canals to drains by small farms instead of closing offtakes did not only waste the precious water resource but also caused the rise of groundwater table and soil salinization. This has been a major concern in the project area and still remained unattended. The construction of illegal offtakes is also becoming a concern which ABA could not solve it due to administrative interference.

- **Irrigation Service**: The fact that the farms that get irrigation service from Awash Basin Authority are not satisfied with the service clearly indicates the poor performance of the service provider in terms of service and water charge.

All the foregoing issues in both small and large scale irrigation schemes indicate the need for taking appropriate measures if sustained productivity of irrigated agriculture is to be ensured.

6.2 Recommendation

General Recommendations

- The poor performance of irrigation schemes is attributed to both hardware and software aspects of irrigated agriculture indicating the need for strategic intervention for improving irrigation infrastructure and management of the irrigation schemes. It should never be a choice of one or the other if good water delivery service is desired. Water regulating structures of Amibara irrigation needs recalibration.

- Water's natural abundance in many areas may explain why the central water supply issue has been that of water delivery engineering (getting water to where it is needed) rather than managing water demand. The thinking of water's natural abundance is now changed

to water scarcity in many areas, and this calls for managing the available water for effective use.

- The issue of upstream and downstream users requires due attention. Although proper planning may be one aspect to deal with the problem, policy measure may be needed particularly in the expansion of traditional irrigation schemes upstream of a well functioning modern small scale irrigation schemes.

- The prevalence of poor water distribution and irrigation practices indicates the need for improving the capacity of farmers through strengthening the water user association and tailor-made practical training.

- Waterlogging is caused by canal seepage, lack of water control due to missing gates and construction of illegal offtakes as well as poor irrigation practices such as flooding is becoming a serious problem. Therefore, structural measures such as appropriate location of offtakes and provision of gated offtakes, lining of porous can reaches and discouraging the construction of illegal offtakes should be duly considered both in planning, construction and operation of the irrigation systems.

- Irrigation extension only exists nominally because neither the development agents nor the woreda extension desks have the irrigation skills or the latter are equipped with the required logistic support to provide support to the DAs. Therefore, practical training needs to be organized for development agents prior to and after their assignment to their duty stations and the woreda irrigation desks should also be strengthened in all aspects.

- As the objective of monitoring and irrigation performance assessment is to improve system management and draw lessons for future planning, it becomes imperative that monitoring of irrigation performance should be part and parcel of irrigation extension. For this, performance measurement system should be designed to take into consideration of physical and financial performance indicators as well as social performance indicators in a balanced and integrative perspective. Benchmarks should be set early on in order to facilitate data collection, assessment including comparison of performance.

Specific Recommendations

Sewir Irrigation Scheme

- The infrastructure of this scheme including weir spillway section, stilling basins and a leaking elevated flume require urgent maintenance before the damage will aggravate and may stop functioning.

- The construction of haphazard field canals along footpaths between the main canal and farm plots and the improper releasing water back to the main canal after irrigation are causing gulley erosions and the main canal is being endangered. Such practice should be discourages by constructing a proper field canal with controllable offtake gate and advising the farmers to close the gates instead of releasing water everywhere.

- The problem related to cooperative membership has to be sorted out and as water is the common property of the irrigation users and its management requires group action, all irrigation users should member of the irrigation cooperative. The beneficiaries of the annexed command area (expansion) are requesting to be members of the irrigation cooperative but the executive committee has not accepted the requested in fear of their full right or entitlement for water use. This also needs to be carefully looked at considering water resource potential.

- A tertiary canal is extended to the annexed command area crossing gullies with traditional structure constructed with wood and plastic and there is significant water loss. Therefore, it is recommended to properly re-study the expansion and construct appropriate crossing structures if the expansion is found be feasible.

- The plan of the irrigation cooperative to provided dividend indicates a good financial capacity of the cooperative. Therefore, maintenance of the damaged irrigation infrastructure with cooperative's financial resource should be encouraged in order to ensure the proper upkeep of the irrigation system due to own investment.

Chacha Irrigation Scheme

- Seepage loss in the part of the lined main canal is very serious and regulation of water distribution with mud is not only difficult but also is damaging canal structures, timely rehabilitation of the canal and all canal structures including provision of gates becomes very imperative for protecting the command area potential waterlogging. A drain should also be constructed to divert the surface runoff from cultivated area lying above the canal to protect the canal from siltation. Some tertiary offtakes require relocating.

- As the present situation stands, Chacha irrigation cooperative is very weak in managing and maintaining the irrigation system due to lack of extension support from the Woreda Agriculture and Rural Development Office. In order to improve the use of the irrigation scheme and to avoid its damaging effect on the environment, the zone with the woreda needs to seriously consider strengthening of the cooperative.

- The woreda and the Totosena Tach Sanka irrigation cooperative need to learn from the WVE-supported irrigation schemes in terms of multiple cropping and improved water management as well as in cooperative management.

- Sand mining in Chacha River is damaging the stable river morphology and encroaching into the farmland. The woreda needs to consider environment in issuing licenses for natural resources mining.

Walga 2 Irrigation Scheme

- As seepage due to the geological nature of the canal route and uncontrolled illegal offtakes is the main problem in this irrigation, both lining critical porous canal reaches and construction of gated offtakes at appropriate locations should be urgently considered

in order to prevent waterlogging which is already a serious problem causing lands out of production.

- Wonchi and Weliso woredas should strengthen the respective water user associations in order to use the scarce water efficiently for maximizing economic benefit and to check further waterlogging and land degradation due to mismanagement of water. They also need to discuss and enforce the Wonchi farmers who use water unwisely from the Weliso side irrigation system to be member of the water user association.

- The water management committee consisting of all the seven traditional and modern irrigation schemes should be strengthened in order to enable the beneficiaries abide by the traditional rules and reduce significant water loss due to water 'theft'.

Saraweba Irrigation Scheme

- The fact that water does not reach the middle and tail plots indicates the need for infrastructural intervention particularly main canal route and its bed slope including related structures.

- A contour canal is normally provided with a cutoff drain to intercept runoff from overlying areas is not constructed. The absence of this in the Saraweba conveyance has resulted in excessive siltation of the canal to extent of clogging the inlet to the long inverted siphon. This clogging caused heading up of water and to overflow which finally damaged the canal. Therefore, the provision of intercepting or cutoff drain should be to be seriously considered. Moreover, a silt trap provided at the inlet to the inverted siphon is too deep and inconvenient for removing silts manually. Therefore, a mechanism has to be devised to facilitate silt removal and one of them could be providing wooden trash track just upstream of the silt trap. The construction of a cutoff drain will solve the problem of inlet clogging.

- Seepage is observed at some points in the upper reach of the main canal. This should be remedied before it damages the canal.

- As mono--cropping of maize due to partly water shortage and lack of market for vegetables, the marketing aspect should be due consideration by applying the lessons from Sogido irrigation scheme.

Chelo Peri-Urban Irrigation Scheme

- As the main problem is pump failure which forced them to pay high rent for pump in the period of peak water requirement, it is very imperative to either repair their pumps if that is feasible or assist them buy new ones. In pump irrigation scheme, there should be always one standby pump in order to guarantee uninterrupted irrigation supply.

- External interference in the organizational management particularly in application of membership related rules of the association are detrimental to the well being of the

association of the poor women. Therefore, it recommended that any external assistance should be limited to assisting them in technical aspects and advice but to force them do that is contrary to their rules.

- The major problem not only in this irrigation scheme but also in all adjacent irrigation farms is inundation or flooding for more than three months due to overflowing of Akaki River and runoff from overlying areas. The construction of food protection dykes along low riverbanks and cutoff drain to intercept and safely dispose of the runoff from overlying areas need to be considered.

Melka Sedi- amibara Larcge Scale Irrigaiton Scheme

- The ABA and farm enterprises do not agree on the amount of water delivered by the former. ABA assumes it has delivered as per the requested amount while the farm managers say that most of the time, they receive less than the request and they rarely receive excess water. This is due to improperly functioning of the measuring structure. Improve irrigation efficiency and water productivity and more importantly controlling sanitization, the mount of water withdrawn and applied for irrigation should be known which requires measuring structures within the irrigations system. Therefore, it is recommended that the flow measuring structures should be re-calibrated.

- Cross and long sections of canals particularly the reaches near secondary and tertiary offtakes are irregular as observed in disproportionate distribution of water to farms. Although the farm enterprises are responsible for secondary and lower level canals, it is recommended that ABA need to lead system improvement because improper canal system affects proper delivery service.

- In addition to improperly functioning of flow measuring structures, ABA staff controlling water distribution either misread gauges or calibration curves. Records are also incomplete. This is due to the fact that checking of daily records of water supplies is not regularized by technical staff of ABA. As the purpose of measuring flow is to know actual amount of water delivered and enable decision-making but not simply to keep records, ABA needs to give due attention for timely checking records, otherwise there no need for wasting resources.

- Full analyses of water supply and salinity data was not possible due to lack of time series data and inconsistency. Reports needs to be consistent and complete to enable complete situation analysis as this enables timely decision-making.

- While WARC is believed to be the model for irrigation water management, it was found otherwise as irrigation application observed in the center is worse than is practiced by the surrounding farms.

- As this study assessed the performance of this large scale irrigation system in general terms, it is highly recommended detail assessment involving service provider and receivers led by an external body is required.

Annex 1: Actual cropping pattern of Assessed irrigation schemes

Irrigation Scheme and area*	Type of Crop	J	F	M	A	M	J	J	A	S	O	N	D	Irrigation intensity (%)	
														Compared to equipped area	Compared to actual physical area
1.Sewir , Equipped area (191/260 ha)	Sorghum										36.5			272	200
	Maize										15.4				
	Teff				32.7						17.3				
	Onion				57.7						28.8				
	Pepper										2.0				
	Mahso/chickpeas				9.6										
2.Chacha, equipped area (191 ha)	Barley			90%										100	100
	Garlic			10%											
3.Walga 2, Wonchi woreda equipped area (75/220) ha)	Maize				9.1%									333.8	113.8
	Onion										9.1%				
	Tomato				22.7%						22.7%				
	Cabbage				1.4%										
	Pepper				1.4%										
	Potato				9.1%						32%				
	Beet root										4.5%				
	'Chat'				1.1%										
	Sugar cane				0.7%										
4.Saraweba, Command area (280/33 ha)	Maize				11.7%						11.7%			23.6	
5.Chelo Urban Irrigation Scheme (6/4)	Cabbage											40%		67	100
	Potato											30%			
	Beetroots											15%			
	Kale											10%			
	Carrot											5%			

NB: (191/260): numerator= equipped area, denominator = actual physical area including expansion

Annex 2: Performance Indicators of Small Scale Irrigation Schemes

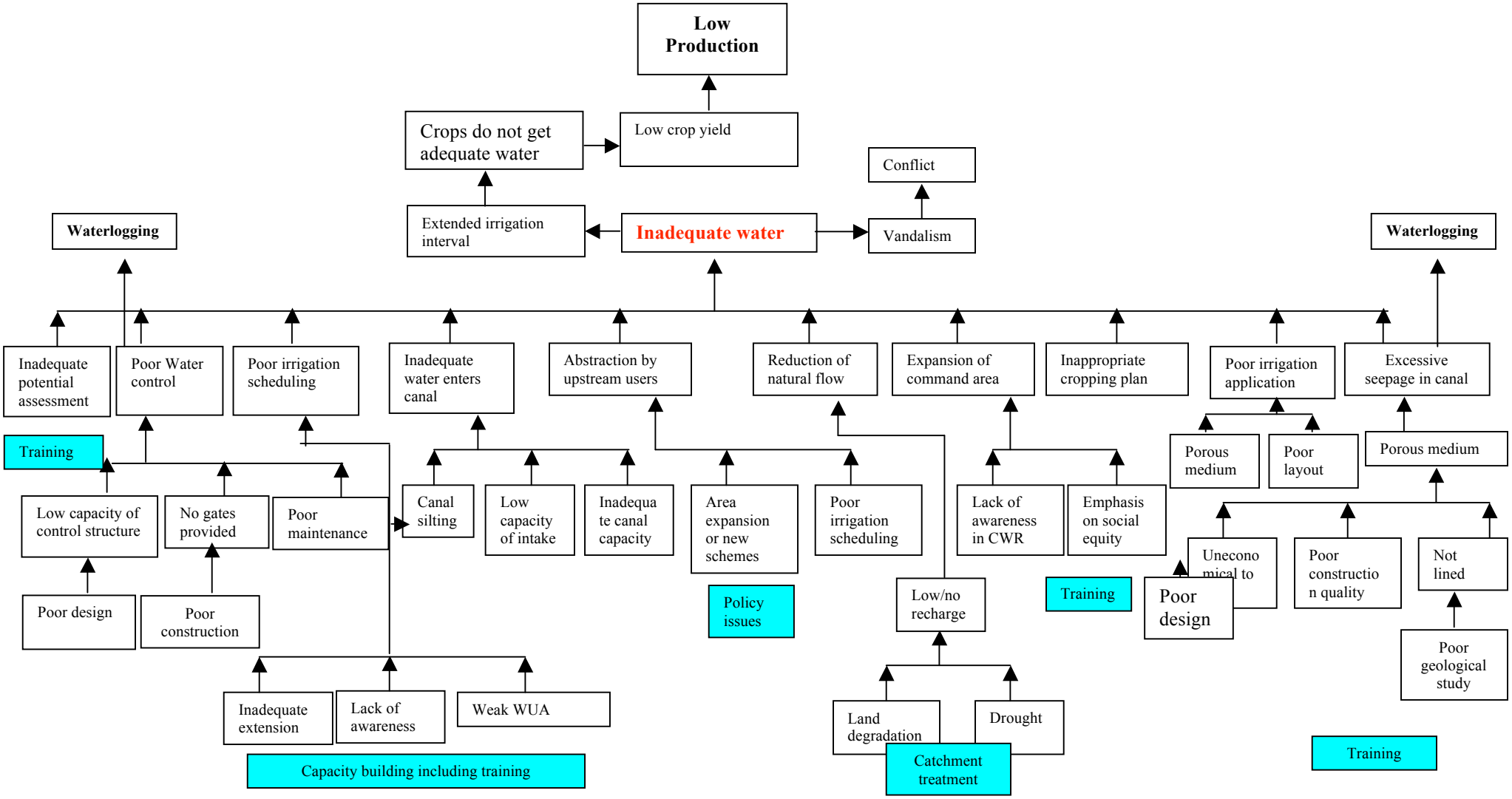
Scheme	Unit	Sewir	Chacha	Walga 2	Saraweba	Chelo
1. Irrigation infrastructure and system layout	-	Well done irrigation network	Fair but poorly constructed	Only main canal with some inappropriately located distribution structures	Masonry lined contour main canal without cutoff drain, fair irrigation layout	No canal and drainage system
2. Drainage system		No	No	No	No	No
3. In-farm roads	-	No	Well laid along SC and TC	No	No	No
4. Water control gates		Missing	Missing	Missing	Exist within actually irrigated area	NA
5. Measurement of volumes	-	No	No	No	No	No
6. Equipped area	ha	191	191	75	280	6
7. Actual physical irrigated area	ha	260*	191	240*	33	
8. Irrigation intensity (based on initially equipped area)	%	272	100	320		
9. Irrigation intensity (based on expanded area)	%	200	100	320		
10. Water Use (IWR)	m^3	7851,000			860,000	
11. Flexibility of irrigation supply	-	Fixed rotation but inadequate	Fixed rotation by village but adequate water	Dictated rotation but inadequate water	Dictated rotation but inadequate	NA
12. Reliability of irrigation supply	-	Reliable in terms timing but volume is unknown and inadequate	Reliable but volume is unknown	Unreliable	Unreliable	Unreliable due to pump failure
13. Equity in water distribution	-	Equitable but 'theft' is common	Equitable	Equitable but 'theft' is common	Equitable within the actually irrigated area	Equitable
14. Crop rotation	-	Inappropriate	Inappropriate	Inappropriate	Only maize	Poor
15. Beneficiaries	No	689				
16. Community Organization	Type	Irrigation Cooperative	Irrigation Cooperative	WUA	WUA	Irrigation Cooperative
17. Members of Organization	No	388				
18. Legal status of the association	-	Registered with Bureau	Registered with Bureau	Not Registered with Bureau	Not legally registered	Registered

* Due to area expansion

Annex 3: Problems Identified by Small Scale Irrigation Users

Problems	Irrigation Schemes				
	Sewir	**Chacha**	**Walga2**	**Saraweba**	**Chelo**
1. Water shortage	X				
2. Irregular topography constraining non-uniform irrigation and waterlogging	X				
3. Improved seed availability	X	X		X	
4. Missing gates difficult to effectively control and regulate water distribution	X				
5. Weir damage and flume leakage	X				
6. Lack of skill in irrigation water management	X				
7. Weak WUA or Cooperative	X	X	X	X	
8. Impeded internal drainage, and salinization (lack of drainage system)	X	X			
9. Share croppers or employed labour do not take care of irrigation structures	X				
10. Diseases (rust and trips) due to onion-dominated cropping pattern	X				
11. Poor market for products		X		X	
12. Lack of capital associated with availability of appropriate seeds					
13. Waterlogging due to leakage, seepage, overtopping of some tertiary canals and poor irrigation application		X			
14. Existence of water users who are not members of the WUA					
15. Poor accessibility				X	
16. Pump failure					X
17. Flooding/waterlooging					X
18. External interference e in cooperative management					X

Annex 4: Cause and Effect Relationship of Inadequate Water Supply of an Irrigation Scheme



Annex 5: Analysis of Flows in the Check Drops and Secondary Offtakes
Date: 11 May 2008

Cross-Regulator	Length of canal (km)	Surface area of canal (m^2)	Canal wetted perimeter (m)	Flow Measured at cross regulator (m^3/s)	Flow measured at Head Regulator* (m^3/s)	Estimated flow upstream excluding loss (m^3/s)	Estimated Loss (m^3/s)	Total flow upstream (m^3/s)
At Intakes	0	37.481	32.988					
CD1	1.934	85.598	83.169	3.283	1.8	5.336		
CD2	7.179	61.088	66.322	1.796	0.8	2.596	0.687	
CD3	11.704	64.186	78.460	ND	0.75	0.75		
CD4	17.169	11.641	17.100	ND	0.65	3.903		
CD5	19.269	10.805	19.654	3.253	0.65			
CD6	20.716	18.666	38.931	ND	1.4			
CD7	25.5	37.481	32.988	ND	1.85			

Check drops and Secondary Turnouts

Date: 12/5/2008

Cross-Regulator	Length of canal (km)	Surface area of canal (m^2)	Canal wetted perimeter (m)	Flow Measured at cross regulator (m^3/s)	Flow measured at Head Regulator* (m^3/s)	Estimated flow upstream excluding loss (m^3/s)	Estimated Loss (m^3/s)	Total flow upstream (m^3/s)
Intake								
CD1	1.934	37.481	32.988	3.238	1.800	5.038		
CD2	7.179	85.598	83.169	1.977	0.800	2.777	0.461	
CD3	11.704	61.088	66.322	ND	0.750	0.75		
CD4	17.169	64.186	78.460	ND	0.650	0.65		
CD5	19.269	11.641	17.100	3.253	0.65	3.903		
CD6	20.716	10.805	19.654	ND	1.400	1.4		
CD7	25.5	18.666	38.931	ND	1.650	1.65		

ND=No data

* = Sum of all offtake flows upstream of the cross regulator

<u>Calculation Example for 11-12/5/2008 flow records</u>

Flow at CD2 should be less than a flow at CD1 for a main canal running continuously

11/5/2008

Q_{CD2} = Q_{CD2}-Q_{01}-Q_{02}-Losses

1.796 = 3.283-1.8-0.8-Losses

= 0.673-Losses

QCD2<0.673 m^3/s but the measured flow is 1.796 m^3/s

12/5/2008

Q_{CD2} = Q_{CD2}-Q_{01}-Q_{02}-Losses

1.977 = 3.238-1.8-0.8-Losses

= 0.638-Losses

QCD2<0.638 m^3/s but the measured flow is 1.977 m^3/s.

This simple calculation clearly indicates the problem with flow records which could be inappropriate gauge, rating curve reading or both.

Annex 6: Water Quality of Awash River at Melka Sedi Weir Site

2006-2007									2007-2008							
Month	EC, mS/cm	TDS	PH	Cations Meg/li		Anions Meg/li			EE, mS/cm	TDS	PH	Cations Meg/li		Anions Mg/li		
				Ca	Mg	Co3	HCo3	Cl				Ca	Mg	Co3	HCo3	Cl
July	0.396	218	8.52	1	0.5	nil	0.5	0.5	0.0.223	123	8.26	2.86	0.82	Trace	2.76	2.36
August	0.317	175	7.8	1.05	0.95	nil	1	0.8								
September	0.266	147	7.8	1	0.9	nil	0.8	1.2	0.397	225	7.9			0.1	1.7	1
October	0.410	22.6	8.7	1.5	0.7	Trace	0.7	0.8	0.196	108	6.75	1.05	1.16	0.12	0.5	1.66
November	0.396	218	8.2	0.5	1.5	Trace	1.5	0.8	0.374	206	5.69				1.5	0.6
December	0.461	254	8.3	0.8	1.3	Trace	4	1								
January	0.506	278	8.2	1.4	0.8	Trace	3.9	2								
February	0.462	254	8.2	1	1.5	Trace	2.1	1.3								
March																
April	0.484	266	8.7	0.75	0.25	Trace	2	1								
May	0.480	264	8.8	1.3	0.8	Trace	5.5	2.5	1.296	713	5.85	1.05	1		0.5	1
June									0.688	378	5.22	0.75	1	0.4	0.55	0.85

Annex 7: Efficiency of Irrigation Service Fee Collection

Year	**Water Charges**			**Maintenance charges**			**Total Due to ABA and Collected**		
	Due to ABA	Collected	% Collected	Due to ABA	Collected	% Collected	Due to ABA	Collected	% collected
1993	24,735.76	20,790.46	84.1	699,424.94	484,736.80	69.3	724,160.70	505,527.26	69.8
1994	48,157.90	40,806.63	84.7	82,821.02	35,525.09	42.9	130,978.92	76,331.72	58.3
1995	21,876.23	4,494.56	20.5	25,844.58	20,639.35	79.9	47,720.81	25,133.91	52.7
1996	561,026.90	388,623.02	69.3	4,493,730.86	3,305,310.70	73.6	5,054,757.76	3,693,933.72	73.1
1997	1,397,512.56	1,237,684.05	88.6	1,392,152.79	1,314,813.35	94.4	2,789,665.35	2,552,497.40	91.5
1998	1,234,960.44	1,130,758.74	91.6	161,782.89	1,352,639.36	836.1	1,396,743.33	2,483,398.10	177.8
1999	1,299,196.95	533,947.62	41.1	2,228,254.47	1,813,901.67	81.4	3,527,451.42	2,347,849.29	66.6
2000	1,217,354.91	812,261.70	66.7	33,864.60	33,864.60	100.0	1,251,219.51	846,126.30	67.6
Total	**5,804,821.65**	**4,169,366.78**	**71.8**	**9,117,876.15**	**8,361,430.92**	**91.7**	**14,922,697.80**	**12,530,797.70**	**84.0**

Annex 8: Water Supplied Served by Melka Sedi Irrigation Project to Irrigation Farms in 2008 ('000m^3)

Name of farm	Area (ha)	Off- Take	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Misadi farm	732.05	1	2903	2100	2091	3231	3501	1944	1555	1348	778
Sidhafage farm	203.22	2A+B	3629	1884	2799	2696	2074	1555	1555	1417	1037
Misadi farm	573.00	3	2938	1892	1917	2212	2108	1555	1555	1417	1037
Africa farm		4A	1106	1503	1555	460	1555	1555	583	1120	609
Bedulale farm		4B	501	363	518	475	518	467	130	130	130
Tewodros farm		4C		90	104	104	104	104	104		
M/werer farm	502.23	5	454	389	670	652	798	622	570	553	916
M/werer farm	449.94	6A	1175	1041	998	1166	1236	915	337	268	
Amibara farm		6B	91	48	30	17					
M/werer farm	1,011.45	7A	981	441	579	605	410	220	130	112	
Amibara farm		7B	441	143	389	52	389	389	389	298	
WARC		8A	527	812	570	618	816	581	626	389	371
Mahdo farm		8B		39	130	112	130	130	130		
Mahdo farmers Cooperative		BC									
Amibara farm		9	1979	2730	3110	1884	2108	1901	665	151	151
Amibara farm		10	1495	804	1374	1365	1378	933	1417	933	933
M/werer farm	1,074.31	11A	1918	2195	1849	1758	1175	1089	319	246	60
Awash Tefases		11B	55	104	41	104	104	104			
Tadese Yadene		11C		62	104	104	104	104			
Abera Serto		11G	28	50	36	33	52	52			
Bezu Anshebo		11H	35	45	43	41	54	65			
Andinet		11K		11	13	13	13	13			
Bereket Gona		11O	33	52	52		52	52			
Ashebir Seid		11P				17	26	26			
Anshe Habib		11R	3	52	52	52	52	52			
M/werer farm	5,776.26	12A	2125	2022	1953	2212	2013	1322	419	354	60
Abdela Ari Alge		13A		117	130	130	130	130			
Hassen Ibrahim		13B	22	65	65	65	65	65			
Amibara farm		13C	907	778	665	380	588	778	376		
Total	**10,322.46**		**23343**	**19828**	**21836**	**20557**	**21551**	**16719**	**10859**	**8736**	**6082**

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