

**Socio-economic assessment of two small-scale irrigation  
schemes in Adami Tullu Jido Kombolcha Woreda, Central Rift  
Valley of Ethiopia**

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MSc Thesis in Environmental Economics and Natural Resources Group,  
Department of Environmental Sciences

June, 2008



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## List of Acronyms

ADLI: Agricultural Development Led Industrialization  
ATJK: Adami Tullu Jido Kombolcha  
BCEOM: French Engineering Group  
CBA: Cost-Benefit Analysis  
CRS: Catholic Relief Service  
CRV: Central Rift Valley  
CTA: Technical Center for Agriculture and Rural Development Cooperation  
GDP: Gross Domestic Product  
EPA: Environmental Protection Authority  
EWRMP: Ethiopian Water Resource Management Policy  
FAO: Food and Agricultural Organization  
IDD: Irrigation Development Department  
IDE: International Development Enterprise  
MoA: Ministry of Agriculture  
MoRDA: Ministry of Agriculture and Rural Development  
MoWR: Ministry of Water Resources  
NEPAD: New Partnership for Africa's Development  
NGO: Non Governmental Organization  
NMTDP: National Medium-Term Development Program  
ODI: Overseas Development Institute  
OESPO: Oromia Economic Study Program Office  
OIDA: Oromia Irrigation Development Authority  
OSRDF: Oromia Social Rehabilitation development Fund  
PA: Peasant Association  
RCWDA: Rift Valley Children and Women development  
SMS: Subject Matter Specialist  
SNNPR: Southern Nations Nationality People  
SSA: Sub-Saharan African  
SSI: Small-scale Irrigation  
WSPD: Water Sector development Program  
WUA: Water User Association

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## Summary

The Central Rift Valley (CRV) in Oromia and the Southern Nations and Nationality Peoples Region (SNNPR) covers approximately 10000 km<sup>2</sup>. The CRV is one of the areas where large investments in irrigation take place for the production of cash crops. The increased use of water for irrigation puts a great pressure on the local hydrology and ecosystem. The competition for irrigation water, land and biomass increases resource management complexity. 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 in the CRV.

The aim of this research is to assess the social-economic performance of two community-based small-scale irrigation schemes in Adami Tullu Jido Kombolcha Woreda (ATJK) and to identify options to improve irrigation performance and resource management. To realize these objectives structured household survey questionnaires, semi-structured interviews, group discussions, field observations and literature were used. Various households' socio-economic characteristics 'before and after' implementation of the irrigation schemes were compared to study the socio-economic impact of irrigation.

Among the 31 small-scale irrigation schemes in ATJK two modern community-based small-scale irrigation schemes in the Kebeles Haleku and Dodicha were selected based on accessibility, management differences, and available research time. A total of 80 households, i.e. 26 and 54 households in Haleku and Dodicha, respectively, were interviewed based on the proportion of members in both schemes. Random sampling method was used for the selection of households while purposive sampling was used for the selection of key informants and focus group discussion members.

The average rain fed land holding size after implementation of the irrigation schemes increased from 2.67 to 3.16 ha in Haleku and decreased from 1.47 ha to 1.13 ha in Dodicha. The mean number of animals increased after implementation of the scheme in Haleku whereas it decreased in Dodicha. However, the changes were not statistically

significant. The number of farm implements increased in both irrigation schemes after implementation of the schemes.

Labor requirements for the production of onion, tomato and green bean are almost the same in both schemes. Depending on crop type labor requirements vary between 45-117 and 42-109 man days per ha in Haleku and Dodicha, respectively. The mean production costs for the various crops between the two irrigation schemes were not statistically different. The production costs for onion are highest, on average 2354 birr/0.25 ha whereas they are lowest in maize (983 birr/0.25 ha). Mean yields of onion, maize and green bean are significantly higher in Haleku, i.e. 3462, 2796, 1416 and 2227 kg/0.25 ha in Haleku and 2379, 2483, 729 and 1596 kg/0.25 ha in Dodicha, respectively. As a result, mean net revenue obtained from onion, maize and green bean are significantly higher in Haleku. The net revenue from four different crops ranges from 7040 to 33298 birr/0.25 ha in Haleku and from 609 to 31040 birr/0.25 ha in Dodicha. Implementation of the irrigation schemes in Haleku and Dodicha increased the households' income compared to the situation before implementation of the schemes and thus contributed to the food security of households.

Farmers use on average 25-50 kg/0.25 ha DAP and 25 kg/0.25 ha urea in irrigated crops. The types of insecticide used in both irrigation schemes are Selecron, Karate and Mitga, and the used fungicides include Kocide, Bayleten, Pencozeb, Ridomil and Bumper. Marketing of products, lack of extension services, lack of post-harvest facilities and lack of credit are major constraints in both irrigation schemes.

WUAs committees are fully in charge of the scheme coordination and water management in both irrigation schemes. Pump capacity, maintenance cost, lack of transparency (corruption), poor scheme coordination and management were identified as major problems in Dodicha. The lack of an auditing and monitoring system and little experience of farmers in irrigation contributed to mismanagement and corruption. Coordination, transparency of WUAs committees and farmers cooperation in management were identified as important factors to improve the functioning of both irrigation schemes.

Transaction costs, i.e. time for negotiating contracts, motivating the members and costs for coordination and monitoring of scheme activities were higher in Dodicha due to poor scheme management. Environmental problems associated with the small-scale irrigation schemes were assessed only qualitatively. Farmers argue that water is used efficiently since pumping bears fuel costs. Further research should investigate this claim also in relation to the relatively low crop yields obtained in both schemes.

To improve the economic and environmental performance of small scale-irrigation schemes institutional support (input supply, output marketing and credit services), training of farmers on improved crop and water management issues, regular supervision and monitoring of scheme activities are crucial.

# **1. Introduction**

## **1.1 Background and justification**

Agriculture is the mainstay of the Ethiopian economy as it accounts for about 46% of the GDP, 85% of the export and 80% of the employment opportunities (Makombe et al., 2007). Both industry and services depend strongly on the performance of agriculture, which provides raw materials, generates foreign currency for import of essential inputs and food for the fast growing population. Despite its importance 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 resulting in food insecurity. 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. Thanks to the enabling policies, irrigated agriculture is expanding rapidly in those areas where there is access to irrigation water. The Central Rift Valley is one of the areas where large investments in irrigation development are taking place for the production of cash crops.

Rapid population growth results in encroachment of marginal and environmentally sensitive areas contributing to declining soil fertility, erosion, low crop yields, feed shortages, progressive land degradation, and reduction of areas under fallow (Kamara et al., 2002). The declining productivity in rain fed agriculture and the need to double food production over the next two decades has increased the need for expansion of effective and efficient irrigation systems (Kamara et al., 2002). Ethiopia has a National Irrigation Development Strategy to use water and land potential to meet food self-sufficiency, generate export earnings, and provide raw materials for industry on a sustainable basis (MoWR, 2001). Specific objectives include to increase the irrigated area, to improve water productivity in irrigated agriculture, to ensure the financial and technical sustainability of irrigated areas, and to mitigate water-logging and salinity.

The favorable environmental conditions for the production of both horticultural and floricultural crops in the Central Rift Valley (CRV) and the value of these crops on international markets led to the expansion of the irrigated area. However, improperly planned expansion of irrigation is often associated with low efficiency in water use and with environmental problems such as salinisation, nutrient depletion, water pollution, loss of vegetation cover, soil erosion, over grazing, soil degradation, groundwater depletion and reduction of surface water tables (McCornick et al., 2003). These processes could reduce the potential and actual land productivity and thus affecting food security at both the national and local levels. At present water resources of the CRV are noticeably over-exploited mainly due to water extraction for irrigated agriculture (Jansen et al., 2007). As a consequence of high water abstraction for irrigation, the water level of some of the lakes has already decreased. This may affect the productivity of the lakes, for example the fish population in lake Abijata is affected by upstream water abstraction (Legesse et al., 2005).

Management of land and water resources in the CRV is complex due to increased competition for irrigation water, land and biomass. The challenge that irrigated agriculture faces in the coming years is: How to increase water productivity in the face of growing water scarcity and the limited availability of water for agriculture. Moreover, climate change may affect the amount of rainfall and its distribution and requires policy development. Therefore, it is important to evaluate the socio-economic and environmental performance of current irrigation schemes which may contribute to (re)design of improved resource management options. Several civil society organizations such as Rift Valley Children and Women Development Association (RCWDA), International Development Enterprise (IDE) and Selam Environment and Development Association (SEDA) have projects to improve water use efficiency in irrigated smallholder schemes to reduce poverty. My research contributes to this effort with a focus on the institutional understanding of irrigation schemes, input use and cost-benefit analysis of irrigated crop production as indicator of economic and institutional performance.

## **1.2 Problem statement**

The increased competition for water in the CRV puts a great pressure on the local hydrology and ecosystem. The sustainability of irrigated agriculture is being questioned, both economically and environmentally (Jansen et al., 2007). The majority of existing irrigation schemes are small, serving usually not more than 200 to 300 households (Tahal Consulting Engineers, 1988). Many of these schemes are based on stream and river diversions and ground water wells, while some depend on small dams and perennial springs. Most of the schemes were designed and developed without the consent of the local communities. As a result, many of the small-scale irrigation projects have been operating below expected returns. The sustainability of small-scale irrigation projects depends on (operational) management. Many studies in Ethiopia focus on technical aspects of irrigation schemes, and very little is known of the socio-economic implications of irrigation development (Van Den Burg and Ruben, 2006).

Hence, there is a need for better understanding of the socio-economic functioning of smallholder irrigation schemes in the CRV, which could contribute to improvements in their performance. The aim of this research is to assess the socio-economic benefits of two community-based small-scale irrigation schemes in Adami Tullu Jido Kombolcha Woreda, to identify operational constraints, and to identify options to improve their performance.

## **1.3 Research objectives**

The overall objective of this study is to assess the profitability and sustainability of community-based small-scale irrigation schemes in two selected study areas, i.e. the Kebeles Haleku and Dodicha in Adami Tullu Jido Kombolcha Woreda.

More specifically, the study aims to:

- ❖ Assess changes in household's socio-economic characteristics before and after implementation of both irrigation schemes.
- ❖ Analyze costs and revenues of four irrigated crops in both irrigation schemes.
- ❖ Identify the institutional arrangements for water management in both irrigation schemes.

- ❖ Identify transaction costs involved in irrigation scheme management.

#### **1.4 Research questions**

- What are the changes in land holding size, number of livestock and farm implements before and after implementation of the irrigation schemes?
- What are the costs and benefits of irrigated crops in both schemes?
- What are the institutional arrangements for water management in small-scale irrigation schemes?
- What are the transaction costs involved in irrigation scheme management?
- What measures are required to improve the performance of the existing irrigation schemes?

#### **1.5 Organization of the thesis**

Chapter 1 introduces the problem (problem statement), defines the objectives and specifies the research questions. Chapter 2 describes the study area and Chapter 3 explains the methodologies used for data collection, data analysis and it discusses the scope and limitations of the study. Chapter 4 presents relevant literature related to irrigation in Ethiopia and other parts of the world. Chapter 5 presents the main results of the study and is the central part of the thesis. In Chapter 6 the results are discussed while Chapter 7 presents conclusions and recommendation for future development of small-scale irrigation schemes in the study area.

## 2. Description of the study area

The CRV is situated in the administrative regions of Oromia and the Southern Nations and Nationality Peoples Region (SNNP) and covers approximately 10,000 km<sup>2</sup>. It is a closed river basin and consists of a chain of lakes, streams and wetlands making the CRV an environmentally vulnerable area. The diversity of landscapes and ecosystems comprise unique biodiversity-rich wetlands. Due to the favorable conditions for horticultural crop production and water availability the irrigated area has increased rapidly in recent years. The total irrigated area was about 10,000 ha in 2007 (Rodriguez de Francisco, 2008). This study was carried out in one of the Woredas' in CRV, Adami Tullu Jido Kombolcha (ATJK).

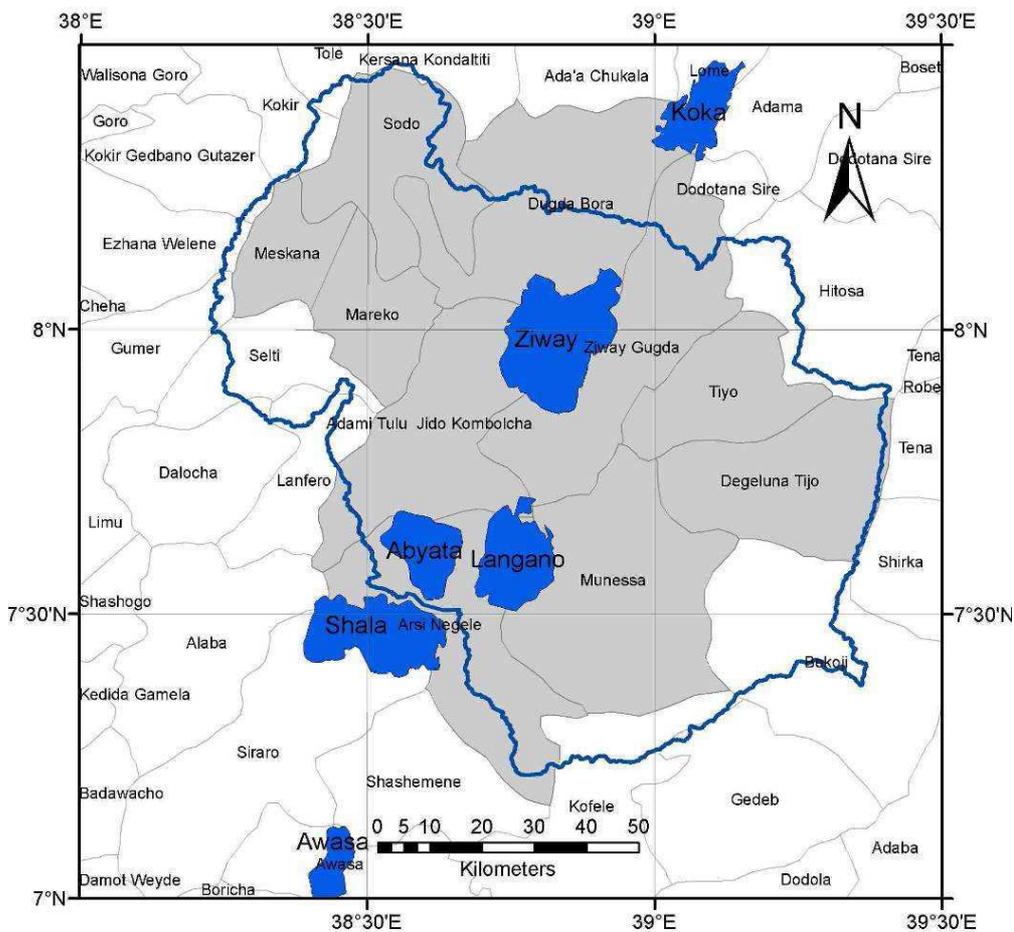


Figure 1: Map of CRV and its Woredas' (Jansen et al., 2007)

## **2.1 Physical characteristics**

Adami Tullu Jido Kombolcha Woreda ( $7^{\circ}37' -04'N$ ,  $38^{\circ}32' -39^{\circ} 04'E$ ) is 167 km from the Capital Addis Ababa. Its area is  $1403.3 \text{ km}^2$  with a total population of 141,745 (in 1997) of which more than 70% lives in rural areas (OESPO, 2003). The elevation of the Woreda ranges from 1500 to about 2300 masl with mountain Aluto as highest peak of 2335 masl. The livelihoods of local farmers mainly depend on mixed farming of crops and livestock (OESPO, 2003). There are 38 administrative Kebeles covering about 80% of the total Woreda area; towns, military camps, private investors and other companies occupy the remaining 20%. From the total area 45% is cultivated, about 30% is used for grazing and woodlands, 7% is classified as marginal land and other land uses account for about 18% (OESPO, 2003).

## **2.2 Climate**

Adami Tullu-Jido Kombolcha (ATJK) Woreda has a semi-arid and arid climate. The average annual precipitation is about 700 mm of which 42% falls in the period June to September (OESPO, 2003). The driest months are November and December. The mean annual temperature is  $20^{\circ}\text{C}$  at Ziway and Adami Tullu station (OESPO, 2003). May is the hottest month with a mean maximum temperature of  $28^{\circ}\text{C}$  and the coolest month is December with a mean minimum temperature  $10^{\circ}\text{C}$ .

## **2.3 Agriculture**

Land use is characterized by open wood land, annual crops, livestock grazing and some irrigated agriculture (OESPO, 2003). Livestock, crops and forest products are the main sources of income for the farmers in ATJK. Resource poor farmers (landless, few oxen and female headed households) earn money mainly from sales of firewood and charcoal (OESPO, 2003). During years with crop failure, most households depend on income from tree resources, livestock and food aid. The majority of the households sell firewood and /or charcoal during the food shortage months (June to September) (OESPO, 2003). Farm size, number of livestock and draught animals (oxen) are the main factors which determine the wealth status of farmers. Farm holding size ranges from 0.75 to 3 ha with

an average size of 1.5 ha. The average family size is 4.6 (4.9 for rural and 4.2 for urban) (OESPO, 2003). Horticultural crop production is becoming the main source of income for farmers living around Lake Ziway and the Bulbula River.

## **2.4 Crops**

Maize, haricot bean, teff, wheat and sorghum are mainly grown under rain fed conditions. The greatest proportion of the land is grown with maize and haricot bean. The land allocated to crop production has increased from 32,030 to 63,015 ha between 1995 and 2000 (OESPO, 2003). At the same time, the average crop yield remained very low (OESPO, 2003). In addition to low and erratic distribution of rainfall, most farmers in the Woreda are significantly constrained by available resources such as draught power and other agricultural inputs. The frequent droughts and high costs of the technologies (improved seeds, fertilizers and pesticides) causes that farmers are risk-averse and reluctant to adopt new technologies developed for rain fed conditions.

## **2.5 Livestock**

Livestock production is one of the major economic activities in ATJK and the number of animals still is a symbol of wealth among farmers. The estimated livestock population in AJTK is 139,486 cattle, 39465 goats, 6424 sheep, 11573 equines, and 45378 chickens (OESPO, 2003). Animals graze along roads, in semi natural wood and shrub land, and on stubble o

f harvested crops. Most of the fertile soils are cultivated with maize, haricot bean and other crops and are not available for grazing. Due to low feed availability the output per animal is very low (OESPO, 2003). As compared to other animal types, goat is best adapted to prevailing conditions. Due to the shortage of water, good feed and inadequate veterinary services, the condition of livestock is poor.

## **2.6 Natural resources**

The natural vegetation of the area is under high pressure due to the expansion of cultivated land, overgrazing and deforestation (OESPO, 2003). Wood and grazing land is poorly managed and comprises scattered acacia species and shrubs, which are either

resistant to the destruction or inaccessible to people or livestock. The rate with which vegetation is used for fuel or construction is far greater than the rate of regeneration. Fuel wood is collected not only for household consumption but also for selling. Charcoal of acacia species is an important source of income for most resource poor farmers in AJTK. Low and irregular rainfall, lack of incentives for natural resource conservation, increasing population, land scarcity, land tenure arrangements, and increasing demand for fuel wood and lack of alternative energy sources together with inefficient resource management are associated with the degradation of the natural vegetation (OESPO, 2003).

## **2.7 Irrigation**

The agricultural potential of ATJK is low and mainly determined by the semi-arid and arid climate. The amount of rainfall is low in relation to the high evaporative demand. Erratic, late onset or early withdrawal of the rainy season cause frequent crop failures. However, the availability of accessible water resources, relatively good infrastructure, suitable soils, proximity to the market (Addis Ababa) and high radiation provide opportunities for irrigated agriculture. In the year 2000 the irrigated area by different sectors (small-scale farmers, State farm, Red Cross Prison farm, Churches and others) was 1848 ha (OESPO, 2003). Both traditional and modern irrigation schemes exist in ATJK<sup>1</sup> with 97 pumps of different capacity (OESPO, 2003). On the basis of ownership, and farm type and size four major irrigated production system can be identified in the CRV (Hengsdijk and Jansen, 2006), i.e. closed vegetable and flower production systems on private farms (Sher-Ethiopia), open field vegetable and fruit production systems on state farm (Ziway State Farm), open field vegetable and fruit production systems on private farms (e.g. Ethio-Flora and Segel Agro P.L.C) and smallholder open-field vegetable and fruit production systems. Latter are the largest in the CRV in terms of land use. The total cultivated land in ATJK is 62,288 ha of which only 1210 ha is under small-scale irrigation (Mr. Abreham, pers. com.). There are 31 small-scale irrigation schemes in ATJK with 2250 beneficiary households.

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<sup>1</sup> Traditional irrigation in this context refers to those schemes that have been initiated and constructed by the farmers using their knowledge and available resources whereas modern irrigation schemes use pumps and they are engineered and built with funds from government or NGOs.

### **3. Research methodology and data sources**

This study was carried out in ATJK in two small-scale irrigation schemes, i.e. Haleku and Dodicha during September to December 2007.

#### **3.1 Selection of irrigation schemes**

A reconnaissance survey was carried out with Social workers of Rift Valley Children and Women Development (RCWDA) to get an overview of the different irrigation schemes in ATJK. Results of the survey were discussed with the RCWDA irrigation department staff, Woreda agricultural office irrigation experts and staff of IDE to identify the irrigation schemes to be included in the study. Among the 31 small-scale irrigation schemes in ATJK two modern schemes in the Kebeles Haleku and Dodicha were selected based on accessibility, available time and management differences. These two irrigation schemes are representative for modern small-scale irrigation schemes in ATJK. The total number of households in the two irrigation schemes is 222, i.e. 72 in Haleku and 150 in Dodicha. Based on the proportion of the members in each irrigation scheme a total of 80 households, i.e. 26 and 54 households in Haleku and Dodicha, respectively, were selected for the household survey. Purposive sampling method was used for the selection of farmers, key informants, and focus group discussion members. The WUA member's registries were used as a sampling frame.

#### **3.2 Irrigation schemes**

##### **3.2.1 Haleku Melaka Teso**

Haleku irrigation scheme is 173 and 10 km from Addis Ababa and Ziway town, respectively, along the Bulbula River at an elevation of 1640 masl. The irrigation site is characterized by plain to very gentle sloping land, which is suitable for irrigation. The soil type of the project site is sandy loam. Prior to the development of Haleku irrigation scheme, local farmers relied on the production of rain fed crops and livestock. The agricultural production was low due to the low and erratic rainfall. Following the government strategy to expand irrigated crop production, the government aimed at leasing the land to large private investors. In response, local people organized themselves

and requested financial support from the RCWDA for a pump and construction of irrigation infrastructure. In 2001, RCWDA started to support the local farmers because of the food security problem in the area and the number of interested farmers. After establishment of the scheme, the local farmers organized themselves in a Water Users Association (WUA). The WUA administrative committees were formed to organize and monitor the performance of the scheme. The WUA was registered as a cooperative society by Cooperative Society of Oromia on July 20, 2005. The scheme comprises an area of 36 ha and 72 beneficiary households. The irrigation scheme withdraws water from the Bulbula River that flows throughout the year to the terminal Lake Abijata. The amount of the water in the river depends on the rain fall which means that the amount of water decreases during the dry season. The scheme has two pumps (one electric and one diesel) to abstract water from the river. These pumps are used alternately as one pump has sufficient capacity for providing water to the entire scheme. The water from the river is pumped to a higher elevation over a distance of 400 meters and then distributed by gravity over the plots. The main canal has a length of 500 meters.

### **3.2.2 Dodicha**

The Dodicha scheme is located 170 and 7 km from Addis Ababa and Ziway town, respectively, near the outlet of Bulbula River from Lake Ziway. This area is also characterized by uneven distribution of rainfall and frequent droughts. This scheme has fertile soils and abstracts water from the Bulbula River. Farmers requested the Oromia Social Rehabilitation Development Fund (OSRDF) for financial support to develop the scheme. This resulted in a project aimed at improving family income and livelihood through the production of high value vegetable crops. After farmers obtained funds from OSRDF a pre-feasibility study and construction of the canal systems were done by Oromia Irrigation Development Authority (OIDA). The construction of the scheme started in 1999 and crop production in 2001. Although the design aimed at three pumps, OSRDF financed only two pumps. The WUA covered 10 % of the total construction costs of the project. The scheme is legally registered by the Cooperative Society of Oromia in 2005. Based on the capacity of two pumps 153 farmers were registered with in total 69 ha irrigated land. Land size of individual farmers varies from 0.25 to 0.5 ha and

no effort was made to redistribute the land equally among farmers. Currently, the scheme has a total area of 75 ha and 150 household beneficiaries.

### **3.3 Data collection methods**

#### **3.3.1 Primary data**

Primary data collection was started with a reconnaissance survey of scheme sites and discussions with relevant governmental and non-governmental organizations (RCWDA, IDE and Woreda agricultural office). Primary data collection consisted of key informant interviews, semi-structured interviews, focus group discussions, direct observations and structured questionnaires for household surveys. Key informant interviews have been made with RCWDA irrigation experts, development agents, scheme committee members, WUA members and experts from Woreda agricultural offices to improve 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.

Semi-structured interviews were made with RCWDA irrigation experts, district irrigation officer, Oromia Irrigation Development Authority (OIDA), managers of private farms (Ethio Flora, Sher Flower Complex and Segel Farm), irrigation and agronomy experts of the state farm and the manager of Adami Tullu Pesticide factory. Structured questionnaires were used for collecting quantitative and qualitative data from selected households. The household survey covered demographic characteristics, household socio-economic factors, plot characteristics, water management practices, yields at plot level, and labor requirements. Focus group discussions were conducted in both irrigation schemes with selected elder community WUA members, executive, and PA leader. Six and eight people participated in the focus group discussion in Haleku and Dodicha, respectively. The prices of inputs were from the WUAs office. Qualitative observations were made on soil conditions of irrigated plots, water use and deforestation.

### 3.3.2 Secondary data

Literature on socio-economic impact of small-scale irrigation, irrigation scheme management, institutional arrangements for irrigation schemes, environmental regulation policies, development plans of the Woreda and other studies were collected from RCWDA, OIDA, Environmental Protection Agency, Woreda Agricultural Office, IDE, Ethiopian Institute of Agricultural Research, International Livestock Research Institute, Addis Ababa University, Adami Tullu Oromia Research Institute and internet to supplement the primary data collected through the survey.

### 3.4 Method of data analysis

#### 3.4.1 Comparison of costs and revenues

To estimate the financial costs and revenues of irrigated crop activities information was collected on the type of crops, crop yields, quantity of inputs (seed, fertilizer, fuel, labor, insecticides and fungicides) and input and output prices. Crop yields, output prices and labor data were collected at farm household level while input use and input prices were collected at scheme level. The local wage rate was used as the opportunity cost for labor. Results and data used for cost and revenue analysis were standardized for 0.25 ha in both schemes. Costs of pump operation and maintenance and equipment depreciation are not included in the analysis. The net revenue obtained by farmers at scheme level is calculated as:

$$NR = \sum_{i=1}^4 [y_{i,n} * p_{i,n} - q_{i,n} * r_{i,n} - l_{i,n} * w]$$

Where  $NR =$  Net revenue from sales of different crops (in Birr/0.25 ha)

$y_i =$  Total yield from crop  $i$  in one growing season (in kg/0.25 ha)

$p_i =$  Sale price of crop  $i$  (Birr  $kg^{-1}$ )

$i =$  Different crops (onion, tomato, maize and green bean)

$q_i =$  Quantity of different inputs used for production of crop  $i$  (kg or lt)

$l_i =$  Total amount of labor used for production of crop  $i$  (in man days)

$r_i =$  Price of different inputs used for production of crop  $i$  (birr  $kg^{-1}$  or  $lt^{-1}$ )

$w =$  Local wage rate which is the same for all households and all crops (Birr man day<sup>-1</sup>).

$n =$  Different households (where  $n$  is 1, 2, 3..., 80)

The average crop productivity per 0.25 ha in the schemes for the sample households is calculated as:

$$AP_{i,H} = \frac{\sum_{i=1}^k y_{i,n}}{k} \quad \text{and} \quad AP_{i,D} = \frac{\sum_{i=1}^k y_{i,n}}{k}$$

The average production cost per 0.25 ha in the schemes for the sample households is calculated as:

$$APC_{i,H} = \frac{\sum_{i=1}^k [q_{i,n} * r_{i,n} + l_{i,n} * w]}{k} \quad \text{and} \quad APC_{i,D} = \frac{\sum_{i=1}^k [q_{i,n} * r_{i,n} + l_{i,n} * w]}{k}$$

Where:

$AP_{i,H}$  &  $AP_{i,D}$  = Average productivity of crop  $i$  in Haleku and Dodicha (kg/0.25 ha)

$APC_{i,H}$  &  $APC_{i,D}$  = Average production cost of crop  $i$  in Haleku and Dodicha (birr/0.25 ha)

$k =$  Total number of producers in each scheme

To study the socio-economic impact of irrigation various households socio-economic characteristics 'before and after' the implementation of the irrigation schemes were compared. Data were collected on land holding size, number of livestock, number of farm tools and family food security conditions at household level 'before and after' the implementation.

### 3.4.2. Statistical analysis

The quantitative and qualitative data collected from the primary and secondary sources were analyzed using qualitative methods and descriptive statistics. Statistical Package for Social Sciences (SPSS) software was used for the analysis of quantitative data. Data collected from key informant interviews, group discussions and observations were

qualitatively assessed. Finally, outputs of the statistical analysis were discussed using tabulation, cross-tabulation, means, frequencies and percentages.

### **3.5 Scope and limitations of the study**

Because of budget and time constraints the study has the following limitations:

- Soils were not analyzed to assess the impact of irrigation on soil properties because of lack of time and lab facilities.
- The analysis is limited to one year due to the lack of time series data.

## **4. Literature review**

### **4.1 Irrigation development in Ethiopia**

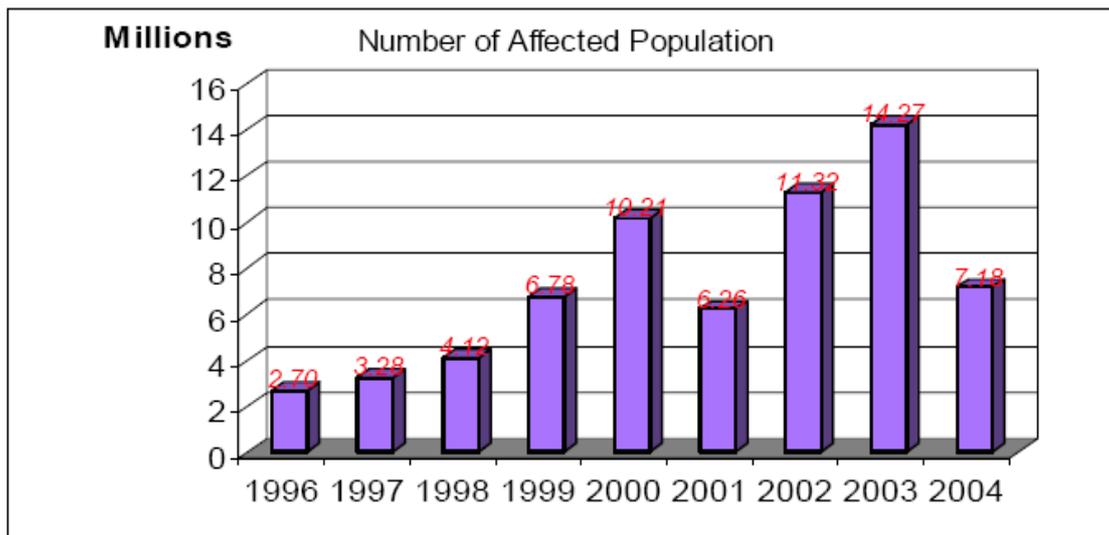
The Ethiopian economy is dominated by smallholder subsistence agriculture, which accounts for 46% of the GDP, 85% of export commodities and 85% of the employment (Makombe et al., 2007). The majority of the sector depends on rainfall. Irrigation and improved agricultural water management provide opportunities to cope with the impact of climatic variability and to enhance productivity per unit of land and to increase the production volume. The irrigated area has increased rapidly: In 1995 it was 75,000 ha and in 2003 it had increased to 200,000 ha (Diao and Nin Pratt, 2007).

The history of modern irrigated agriculture in Ethiopia dates back to 1960 when it started with the production of industrial crops (sugar and cotton) on large-scale farms by private investors in the Awash area. However, local farmers had already been practicing traditional irrigation during the dry season using water from river diversions for subsistence crop production (Awulachew, 2006). Modern small-scale irrigation (SSI) development and management started in the 1970s initiated by the Ministry of Agriculture (MoA) in response to major droughts, which caused wide spread crop failures and food insecurity. After the rural land proclamation in 1975, the government nationalized the large irrigated farms and the small-scale-irrigation schemes were transformed into cooperatives. The government began to focus on the potential of small-scale irrigation to improve food security and started promoting farmers and community based small-scale irrigation through giving assistance and support to adopt modern technologies, rehabilitation and upgrading of traditional schemes after major famines in 2000/2001 (Habtamu, 1990).

There is a great variation in the estimated irrigation potential of Ethiopia due to lack of standard or agreed criteria to estimate this potential (Awulachew et al., 2005). Awulachew et al. (2005) citing Rahmeto (1990) estimated the minimum irrigation potential between 1 and 1.5 million ha and the maximum potential at 4.3 million ha

(Tilahun and Paulos, 2004). The Ministry of Water Resources (MoWR) estimated the irrigation potential of different river basins at 2,583,000 ha (MoWR, 2001). There is also no consistent information on the current irrigated area, which is estimated at 161,125 ha out of which 63,830 ha under large scale and 97,275 ha under small-scale irrigation (MoWR, 2001). BCEOM (1998) in Awulachew et al. (2005) estimated a similar figure, i.e. 161,000 ha of which 64,000 ha in small-scale schemes and the rest in medium and large scale irrigation schemes. About 38,000 ha was under development. However, Tilahun and Paulos (2004) in Awulachew et al (2005) estimated the traditional irrigation schemes at 138,339 ha and modern small-scale and medium and large scale irrigation schemes at 48,074 and 61,057 ha, respectively, totaling 247,470 ha under irrigation.

Food insecurity and famine in Ethiopia is the result of erratic and low rainfall (Awulachew et al., 2005). Ethiopia faced three large-scale drought-induced food shortages and famines in recent history, i.e. in 1972/73, 1983/84, 2002/03, which costed many lives (Awulachew et al., 2005). In 2002/03 about 15 million people (over 20% of the population) received food aid. Both, the absolute number and share of the population affected by drought and flood show an increasing trend (Figure 2).



**Figure 2. Drought and disaster affected populations during the last decade.**  
Source: (Awulachew et al., 2005)

To reduce the risk of crop failure due to drought and erratic rain fall conditions in Ethiopia, the MoWR has prepared a National Medium-Term Investment Program (NMTIP) for Water Sector Development Program (WSDP) for 15 years (2002-2016) that include small-scale irrigation development as one of its main components to reduce dependency on rain fed production. The WSDP aims at the development of 127,000 ha of SSI schemes over the program period (NEPAD and FAO, 2005). The MoWR is currently implementing thirteen irrigation projects located in different parts of the country (Teshome, 2006), covering an area of 493,603 ha, which are expected to be completed before the end of the NMTIP in 2016.

#### **4.2 Water sector institutions in Ethiopia**

The most widely used definition for institutions is ‘a set of formal (laws, contracts, political systems, organizations, markets, etc.) and informal rules of conduct (norms, traditions, customs, value systems, religions, sociological trends, etc.) that facilitate coordination or govern relationships between individuals or groups’ (Kherallah and Kirsten, 2001). Institutions support policy goals such as improving economic performance, efficiency, economic growth and development and facilitate human interaction (North, 1990). Institutions operate at two levels, i.e. macro and micro level and the macro-level institution are the set of fundamental political, social, and legal ground rules for production, exchange and distribution while the micro-level deals with the institution of governance and refers to modes of managing transactions and includes markets, quasi-markets and hierarchical modes of contracting (Williamson, 2000).

The institutional arrangement for water management changes frequently in Ethiopia. In 1996 the Government of Ethiopia established the MoWR for further development and implementation of a new National Water Resources Plan. After its establishment, the MoWR has the mandate to regulate and manage water resources development and utilization. Particularly MoWR is responsible for water policies and strategies, setting and enforcing safety and quality directives and standards for waterworks design and construction and ensuring that studies are conducted on water resources development, protection and control. Before the establishment of MoWR, panning and development in

the water sector was constrained by the lack of a central institution for coordinating all planning, development and policy issues related to water (Awulachew et al., 2005).

The MoWR is also accountable for upstream water resources control and development activities, including determining conditions and methods for optimal allocation of water, as well as transboundary regional water issues. Activities downstream are carried out by different organizations under the general guidance of the Ethiopian Water Resource Management Policy (EWRMP). At regional level, states have the responsibility of both urban and rural water supplies implemented through the regional water bureau and commissions or authorities.

After its establishment in 1985 under the Ministry of Agriculture (MoA), the responsibility of small-scale irrigation was transferred to the Irrigation Development Department (IDD). In the late 1990s, MoA was transformed to the currently functioning Ministry of Agriculture and Rural Development (MoARD). In collaboration with regional Bureaus of Agriculture and Rural Development the MoWR has been responsible for capacity building, demonstration and promotion of small-scale irrigation since the late 1990s. After the recent reorganization of MoARD, the overall responsibility of small-scale irrigation (SSI) schemes has been shifted from MoWR to MoARD while planning and development of medium and large scale irrigation projects is still under the mandate of the Federal MoWR. The Regional Bureau of Water or Irrigation Authority as in the case of Oromia and Southern Nations Nationality Peoples Region (SNNPR) are responsible for the planning and implementation of small-scale irrigation schemes. Regions like Tigray and Amhara have established a Commission for Sustainable Agriculture and Environmental Rehabilitation for the implementation and management of small-scale irrigation (Gebremedhin and Pedon, 2002). At the regional level, agricultural extension service and technical support for small-scale irrigation schemes is provided by the MoARD. Subject matter specialist and Development Agents (DAs) are employed at the Woreda and kebele level, respectively to provide the required service for farmers. At the scheme level, the small-scale farmers organize them selves in to WUAs to participate in activities like implementation, operation and maintenance and the management of

schemes. Many NGOs have been providing financial and technical support for implementation of small-scale irrigation schemes.

The institutional set-up and responsibility issues for the implementation and management of small-scale irrigation schemes varies from region to region (Awulachew et al., 2005). Consequently, there is confusion on the mandate, resulting in scheme failures due to lack of accountability. Planning, design and construction of small-scale irrigation schemes is done by the regional irrigation authority or Water Bureaus and handed over to the Agricultural Bureau for implementation, operation and maintenance in regions like Tigray and Amhara. According to Awulachew et al., (2005) this has resulted often in unsustainable development. In Oromia, small-scale irrigation schemes are fully implemented by the OIDA, which has its own extension service and DAs to support small-scale irrigation.

### **4.3 Environmental policy in relation to Irrigation**

Policy can be understood as formal decisions, laws and programs, and actual practice what is often called 'implementation' (James and Ian, 2000). The natural resources (water, soil and forests) are the foundations of the economic development in Ethiopia as more than 85% of the population depends on agriculture. The population growth puts a greater pressure on these resources and poor management contributes to their degradation. Therefore, establishment of an environmental policy for different economic sectors is important for the sustainable use of natural resources. The Government of Ethiopia has established a macro-environmental policy and strategy framework. The environmental policy has been approved by the Council of ministers in April 1997 (EPA, 1997). This policy was based on the recommendation for conservation and sustainability: "To improve and enhance the health and quality of life of all Ethiopians and to promote sustainable social and economic development through the sound management and use of natural, human-made and cultural resources and the environment as a whole so as to meet the needs of the present generation without compromising the ability of the future generation to meet their own needs".

Irrigation development may have both positive and negative impacts on the environment. To be sustainable, irrigation projects must avoid the negative impacts starting from the design of the project till its implementation (EPA, 2004). The Environmental Protection Authority (EPA) has prepared the national water sector policy and environmental impact assessment guidelines for irrigation to mitigate potential negative impacts of irrigation development projects (EPA, 2004). These water sector policy and environmental impact assessment guidelines for irrigation are based on the general environmental policy for natural resources and include (EPA, 1997):

- To ensure that the control of environmental health hazards be a necessary condition in the design, construction and use of dams and irrigation systems;
- To recognize that natural ecosystems, particularly wetlands and upstream forests, are fundamental in regulating water quality and quantity and to integrate their rehabilitation and protection into the conservation, development and management of water resources;
- To ensure that any proposed introduction of exotic species into water ecosystems be subject to detailed ecological studies and environmental impact assessment;
- To promote the protection of the interface between water bodies and land (e.g. lake shores, river banks and wetlands);
- As most large and medium scale irrigation potential is located in the rangelands of the lowlands occupied by pastoralists, to consider the opportunity costs of irrigating important dry season grazing areas of the pastoralists for crop production in any cost-benefit analysis of such irrigation projects;
- To involve water resource users, particularly women and herders, in the planning, design, implementation and follow-up of projects so as to carry them out without affecting the ecological balance;
- To subject all major water conservation, development and management projects to the environmental impact assessment process and to include the costs and benefits of protecting watershed forests, wetlands and other relevant key ecosystems in the economic analysis of such water projects; and

- To promote, through on-site training, effective water management techniques at the farm level for improved performance of medium to large-scale irrigation schemes.
- To promote, to the extent possible, viable measures to artificially recharge ground and surface water resources.
- To recycle waste water when it has been found to be safe for health and the environment or when it has been made safe without entailing high cost.

#### **4.4 Current status of small-scale irrigation schemes in Ethiopia**

There are different criteria's for the classification of irrigation schemes around the world. The main criteria's frequently used for the classification of irrigation schemes are the irrigated area, scale of operation and management types. The most commonly used classification is small, medium and large scale irrigation schemes, though the interpretation of these categories may vary from country to country. For example, in Ghana an irrigation scheme of 300 ha is classified as small-scale, whereas in India 10,000 ha is categorized as small-scale (Smith, 1998).

In Ethiopia during the Dergue regime, irrigation schemes were categorized into three types based on size into small-scale (<200 ha), medium scale (200-3000 ha) and large scale (>3000 ha) (Rahemeto, 1999).

Another classification takes into account size and management (Werfring et al., 2004):

- Traditional small-scale irrigation schemes up to 100 ha built and operated by farmers in local communities.
- Modern commercial schemes up to 200 ha built by Government agencies with farmer participation.
- Modern private schemes up to 2,000 ha owned and operated by private investors individually, in partnership, or as corporations.
- Public schemes of over 3,000 ha owned and operated by public enterprises as state farms.

The study of programmatic environmental assessment of small-scale irrigation in Ethiopia used the following classification based on water sources (CRS, 1999):

#### *Diversion systems*

Often referred to as off-take systems, diversion systems are probably the most common form of irrigation system in Ethiopia. Diversion systems often utilize natural river flows, however, regulation of river flows via a permanent structure in the river bed is also a common practice to increase the off-take. Diversion systems abstract water over a sustained period and are able to deliver regularly water throughout the cropping regime. A key characteristic of diversion systems is the adequacy of water supply during the dry season and the ability to irrigate a dry season crop in addition to providing supplemental irrigation during the rainy season.

#### *Spate systems*

Spate systems use occasional flood flows of temporary streams and, therefore, operate intermittently during part of the year. In Ethiopia, there are two types of spate systems. The first, often referred to as a run-off system, diverts run-off from rainfall received in the same catchment from natural waterways on to agriculture land. The second, most common on foothill sites in arid and semiarid areas, diverts flood flows originating in highland areas. Spate systems have proven difficult to rehabilitate due to the difficulty of designing weirs to divert flows that change rapidly and which also resist structural damage from flood flows.

#### *Spring systems*

These systems exploit flows from small springs. Water is often shared with household and livestock users. Water is often stored over night in small reservoirs (night storage) and emptied daily.

#### *Storage systems*

These systems, referred to as tanks in South Asia and earthen dams in Ethiopia, store water for an extended period behind dams. In Ethiopia, storage systems are introduced recently and pose technical and production challenges. It is important to consider the catchment flow and amount of sediment in designing storage systems. Cropping must be

planned according to the amount of water stored and available for irrigation. Typically, the irrigated area is much larger during the rainy season than during the dry season.

#### *Lift systems*

Lift systems extract water from rivers, irrigation canals, reservoirs and wells. Lift systems have low development costs, but usually high operating costs. Pumps can be manual or motorized.

The Federal or Regional Government Bureau of Water Resources, Irrigation Authorities or Commission for Environment and Sustainable Development are responsible for the construction of modern small-scale irrigation schemes. These bureaus or authorities transfer irrigation schemes to WUAs after the construction is completed for management, operation and maintenance with professional support from concerned regional bureaus or authorities. It is difficult to get reliable statistics on the area of small-scale irrigation schemes, which also include traditional schemes. However, the area with small-scale irrigation increases after the catastrophic drought in 1973 (Awulachew et al., 2005). Small-scale irrigation has been chosen by the majority of the Cooperating Sponsors as a strategic intervention to address food security in Ethiopia. A number of factors led to this choice, the most obvious of which is that irrigation increases the potential for producing more food more consistently in the drought-prone food-insecure areas (Awulachew et al., 2005). Irrigated small-scale farmland increased country wide from 64,000 ha to 87,145 between 1991 and 1998 (MoWR, 2002). During this time more focus was given to small-scale irrigation development and there was little or no development in medium-and large-scale irrigation during that period. WSDP envisages the development of 127,000 ha on new irrigation land over the program period (2002-2016).

Traditional small-scale irrigation schemes have been built through farmers initiatives, sometimes with technical and material support from the government. The management of the irrigation schemes is done by WUAs or committees and they are generally well-organized and effectively operated by farmers who know each other and are committed to cooperate closely to achieve common goals. Typical associations comprises up to 200 users who share a main canal or branch canal (MoWR, 2002). The WUAs may be

divided into many teams of up to 20 to 30 farmers each for construction, water distribution and maintenance of irrigation canals. The farm holding size of these traditional irrigation scheme ranges from 0.25-0.5 hectare.

CTA (2003) pointed out that government-managed (large-scale and small-scale) schemes have generally performed far below expectations and most of the time, initial capital costs have not been recouped and the financial returns have not been able to cover operation and maintenance (O&M) costs. However, privately developed and managed (small-scale) irrigation schemes in most of the Sub-Saharan African (SSA) countries show that there is business potential for private entrepreneur involvement in irrigation. WUAs running parts of the irrigation scheme activities can also be considered as operating private irrigation schemes (CTA, 2003). Recent developments have shown the increasingly important role of these new operators. However, for private operators to function efficiently a clear institutional framework is required but in many parts of SSA this framework is not in place (CTA, 2003). According to the same report, small-scale irrigation schemes are also being promoted because of the associated benefits listed below:

- Lower investment costs
- Ease in maintenance
- End-users being able to have more control of the water they need
- The possibility of remote areas (where there are poorer farmers) gaining access to controlled water
- Small-scale irrigation requires very little in terms of enterprise and management capability
- Their potentially less negative environmental impact.

Small-scale irrigation (those schemes under the direct management of smallholders) will also enable farmers to increase crop intensities through double cropping, through supplementary watering during drought, as well as enable crop/forage growth in dry areas (crop expansion).

Although the irrigated area is increasing in Ethiopia, the growth rate is rather low. There are a number of constraints related to the slow rate of irrigation development, such as weaknesses in management (O&M), equity issue, cost recovery and agricultural productivity (ODI, 1995). Social, economic, institutional and policy problems are general constraints for the development of small-scale irrigation schemes (Shawki and Le Guy, 1990; FAO, 1986; Teshome, 2003). Poor design and management have contributed to few peasant irrigation systems in SSA countries (FAO, 1986; World Bank, 1986). Moreover, both technical and social factors constrain small-scale irrigation development in SSA and among them institutional and management problems tend to be most constraining (FAO, 1986). Small-scale irrigation schemes in Ethiopia are generally characterized by (CTA, 2003):

- Low efficiency
- Lack of finance
- Inadequate marketing
- Weak extension services

#### **4.5 Socio-economic impact of small-scale irrigation**

Impact studies differ in terms of geographic coverage, scale of analyses, and approach adopted in measuring impacts (Hussain and Hanjira, 2004). Accordingly, the scale of analyses varies among different studies, ranging from household to village, region, national to international levels. The approaches adopted to study the socio-economic impacts of irrigation in various studies can be classified into three major categories: (1) “before and after” comparisons; (2) “with and without” comparisons; and (3) “more and less” comparisons (Hussain and Hanjira, 2004).

Small-scale irrigation schemes as compared with other irrigation strategies used in Africa, if properly implemented with appropriate technologies, may have a considerable potential in improving rural livelihoods. However, the viability of such systems becomes questionable when the financial responsibility rests entirely on the community in the absence of institutional support services that enhance market orientation (Kamara et al., 2002). Literature on smallholder irrigation in SSA gives conflicting conclusions on the

viability and sustainability of smallholder schemes (FAO, 1986; Webb, 1991; Teshome, 2003). The sustainability of the irrigation sector in Africa has been an issue of debate because of its disappointing performance in many cases. Because of the complex set of constraints facing smallholder producers, providing access to irrigation water by itself is not enough. Smallholders also require a broad range of support services (access to inputs, credit, and output markets), knowledge of farming and secure land tenure. To achieve economic viability in small-scale irrigation schemes on a market-oriented basis requires access to support services and opportunities for producing high value crops.

There are strong direct and indirect linkages between irrigation and poverty (Hussain and Hanjira, 2004). Direct linkages operate through localized and household level effects, whereas indirect linkages operate through aggregate or sub-national and national level impacts. Irrigation benefits the poor through higher production, higher yields, lower risk of crop failure, and higher and year-round farm and non-farm employment. Irrigation enables smallholders to adopt more diversified cropping patterns, and to switch from low-value staple production to high-value market-oriented production. Increased production makes food available and affordable for the poor. Since irrigation investments leads to production and supply shifts, indirect linkages operate through regional and national level and have a strong positive effect on the national economy.

Past interventions in irrigated agriculture have yielded immense benefits, for example, cereal production in Asia has more than doubled between 1970 and 1995, from 300 million tons to 650 million tons (Hussain and Hanjira, 2004). Many SSA countries have recognized the contribution of irrigation to food production despite all the constraints identified (FAO, 2000). Also in Africa there are examples of success. For example, in Zimbabwe farmers could secure food production thanks to irrigation and the use of high-yielding varieties and fertilizers (FAO, 2000).

In India poverty head count ranges from 18 to 53% in irrigated and 21–66% in rain fed areas and poverty incidence is 20–30% lower in most irrigated areas compared to rain fed areas (Hussain and Hanjira, 2004). Studies using a dynamic concept of poverty show that

the incidence of chronic poverty is 10% (5%) lower for irrigated areas in Sri Lanka (Pakistan) than adjoining rain fed areas (Hussain and Hanjra, 2004). These authors also identified five key interrelated linkages of how access to good irrigation water contributes to socioeconomic uplift of rural communities and poverty alleviation. These are production, income and consumption, employment, food security, and other social impacts contributing to overall improved welfare. The access to good irrigation facilities helps smallholders to increase their production and income, creates employment opportunities for the local people, increases the opportunity of smallholder to diversify their income base, and to decrease their vulnerability to drought due to short and erratic rain fall conditions.

In Gambia, irrigation provided smallholder farmers the chance for increasing income that was reflected on increased expenditure, investment in productive and household assts, saving and trade (Webb, 1991).

#### **4. 6 Transaction costs of irrigation water management**

Transaction costs are costs associated with searching (information), negotiation and decision-making, and monitoring and enforcement (Huylbroeck et al., 2005). The most important public transaction costs are related to administration (Falconera and Saunders, 2002). Transaction costs increase as the diversity and number of parties involved increases Oate, 1986; and Williamson 1993 in Williamson (2000). Transaction costs explain alternative forms of economic organization and contractual arrangements.

In many developing countries the management of irrigation schemes is transferred from the government to WUAs to reduce the transaction cost associated with their management (Easter and Zekri, 2003). According to them the same argument can be made for reforming the institutional and organizational arrangements for irrigation systems and water agencies. In empirical studies, a direct measurement of transaction costs is the economic value of resources used in locating trading partners and executing transactions. The aggregate value of transaction costs in the economy are the total value of resources used in the transaction sector (Wallis and Noth, 1986). WUAs are the most

frequently recommended organizational forms for irrigation management (Vermillion, 1999 in Penov, 2004). The associations are supposed to have full control over the irrigation infrastructure in the territory they serve. However, problems with under financing of O&M and investments are observed (Vermillion, 1999; Vermillion and Carces-Restrepo, 1998 in Penov, 2004) due to incomplete decentralization processes.

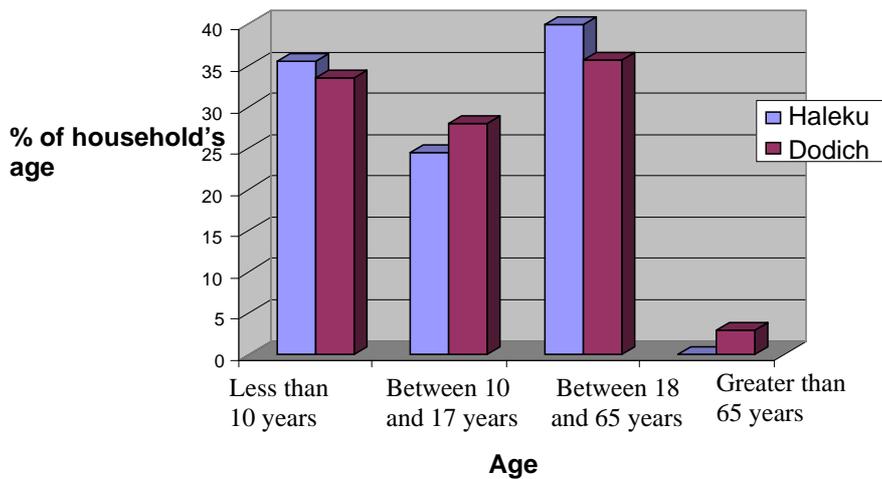
The major problems for many irrigation systems are: free riding, rent seeking, and corruption (Ostrom, 1992 in Penov, 2004). Free riding evokes lack of trust between the actors. Potential rents stimulate efforts to influence public decision-making and evoke corruption. Free riding can be overcome when farmers are convinced that the benefits exceed cost as well as by improvement of communication among them. Establishing institutions that do not allow single officials to have full control over the resources can help to reduce corruption. Improvement of communication between farmers, irrigation schemes, and state institutions could make the parties more aware of the problems and reduce both rent seeking and corruption (Penov, 2004). To reduce the transaction costs of changing government policy, one of the key steps is to reduce the expenses of organization and involve the stakeholders in specific water management reforms (Penov, 2004). Some specific tasks that will be added to the transaction costs of water reform include designing regulations for allocating water in an open and transparent manner, developing water delivery schedules in conjunction with stakeholders, enacting water-use rights and procedures, and resolving disputes over water allocation (Penov, 2004).

## **5. Results**

The first part of the analysis compares the household's socio-economic characteristics before and after implementation of the irrigation scheme in Haleku and Dodicha. The second part focuses on the analysis of qualitative information obtained through qualitative household surveys, interviews and group discussions. It describes the institutional arrangements of both small-scale irrigation schemes. The third and last part describes in short the environmental impacts of both small irrigation schemes.

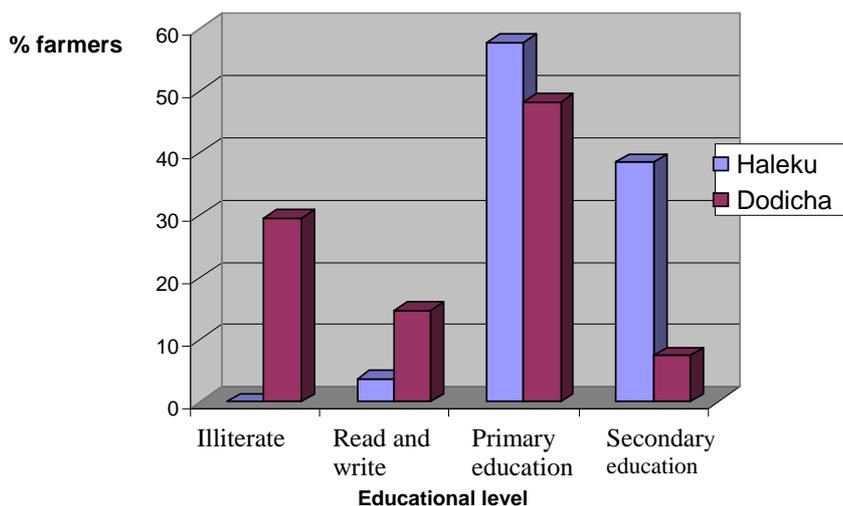
### **5.1.1 Socio- economic characteristics of the study areas**

The total population of Haleku and Dodicha peasant associations (kebeles) are 1445 (505 male and 940 female) and 1509 (826 male and 683 female), respectively. Among these 72 and 150 household heads are users of irrigation schemes in Haleku and Dodicha, respectively. From the selected household heads in both irrigation schemes 91% are male. The average family size of the sample households was 6.7 and 7.2 with a standard deviation of 1.9 and 2.8 in Haleku and Dodicha irrigation schemes, respectively. The average family size in both schemes was not statistically significant at 5% probability level. The average family size of the Woreda is 4.6 (4.9 for rural and 4.2 for urban). The mean age of the sample households was 35 and 44 with a standard deviation of 11.1 and 13.4 years at Haleku and Dodicha, respectively. The average age of the sample households was highly significant at 5% probability level. The minimum and maximum age of the sample household heads was 23 and 60 in Haleku and 22 and 76 in Dodicha, respectively. Family age composition is shown in Figure 3.



**Figure 3. Household's age composition.**

Among others, the educational level of farmers is considered important for technology adoption (Tesfaye et al., 2001). According to the survey, 4% can read/write, 58% have attended primary education and, 38% have secondary education in Haleku irrigation scheme (Figure 4). There is no illiteracy among the respondents in Haleku, and they have had at least informal education. In Dodicha irrigation scheme 29% of the respondents is illiterate, 15% can read/write, 48% have had primary education and only 8% have had secondary education suggesting a lower level of education in Dodicha.



**Figure 4. Educational status of sample household heads in Haleku and Dodicha.**

### **5.1.2 Farming system, land holding size and cropping pattern**

All farmers in both irrigation schemes have mixed systems consisting of crops and livestock. The livelihoods of the farmers in both peasant associations depend on rain fed crop production and livestock rearing. In Haleku peasant association only 20% of the farmers are member of the WUA and the land allocated for irrigated crop production is small compared to the total land size of the peasant association. Except for maize, which is grown both under rain fed and irrigated conditions all other cereals cultivated (haricot bean, teff, wheat and sorghum) are produced under rain fed conditions only. The greatest proportion of the land is allocated to maize and haricot bean. Onion, tomato, maize, green bean and cabbage are produced under irrigation.

Before implementation of the irrigation schemes, the scheme sites were owned by few farmers. After establishment of the WUAs, its members agreed to exchange their land, i.e. those with more than 0.5 ha in the scheme sites exchanged their land with other members without land in the scheme sites. In Haleku, after this land reallocation the scheme site was divided into different blocks and allocated to members on lottery basis to avoid possible conflicts due to differences in soil fertility and access to water. The total scheme area is divided into three blocks and every beneficiary has a plot in each block, facilitating equal access to water and practicing crop rotation on block basis. However, in Dodicha individual land holdings vary from 0.25 to 0.5 ha because the land ownership from before the scheme was respected, and land was not equally reallocated. The annual production plan of the schemes is prepared by the executive committee of the WUA and each member is obliged to follow the production plan. According to the rules and regulations of the WUA, failure to act according the production plan leads to penalty.

Since 1975, land has not been redistributed by the Government as a result of which the land holding size of households with many male children decreased as these children inherit land from their parents. The average rain fed land holding size before the implementation of the irrigation scheme was 2.67 and 1.47 ha in Haleku and Dodicha, respectively (Table 1). The rain fed land holding size after implementation of the irrigation schemes is 3.16 and 1.13 ha in Haleku and Dodicha, respectively. The average

land holding size in AJTK is 1.5 ha (OEPO, 2003). In Dodicha the land holding size decreased after implementation of the irrigation scheme. Farmers mentioned high land fragmentation as the main reason for decreasing land holding size in the scheme. In Haleku irrigation scheme the land holding size increased after implementation of the irrigation scheme due to long-term lease constructions. There are mainly two land lease systems in the area: The first one is leasing land for short periods, i.e. less than 10 years and mostly for 2-5 years. The other one is long-term lease which is equal to selling of land, although formally selling is prohibited in Ethiopia. To comply with this rule, farmers lease their land for longer periods. Both the mean rented in and rented out land size decreased after implementation of the irrigation scheme in Haleku, while it increased in Dodicha (Table 1). The size of the irrigated plots per household remained the same since implementation of the irrigation schemes. Taking into account that irrigated crop production requires large amount of inputs (labor and agrochemicals) and to ensure equity, OIDA has designed small-scale irrigation schemes with a maximum plot size of 0.5 ha. Accordingly, all WUA members have 0.5 ha or less irrigated land.

**Table 1. Average land holding size in Haleku and Dodicha before (2001) and after (2007) implementation of the irrigation schemes (in ha).**

Ownership status	Haleku			Dodicha		
	2001	2007	Changes in land holding	2001	2007	Changes in land holding
Own land	2.67	3.16	0.49	1.47	1.13	-0.34
Rented in	0.06	0.01	-0.05	0.05	0.14	0.09
Rented out	0.49	0.36	-0.13	0.09	0.19	0.1

Table 2 shows average yields of different crops under irrigation in ATJK and Ziway Dugda Woreda. All respondents in both irrigation schemes rotate crops (e.g. onion followed by maize and tomato). However, the WUAs do not follow strict crop sequences and there is no fixed schedule for planting the crop in both irrigation schemes. The farmers grow crops throughout the year based on the availability of water. They plant usually maize in April and June, onion in December, July and August; green bean is mostly planted in January, while tomato is planted in April.

**Table 2. Yield ranges in ATJK Woreda, Ziway Dugda Woreda and Haleku in (kg ha<sup>-1</sup>).**

Type of crops	ATJK Woreda	Ziway Dugda Woreda	Haleku
Onion	12000-36000	17000-20000	10000-12000
Tomato	20000-40000	30000-40000	10000-20000
Green bean	4000-8000	-	5500-6500
Irrigated maize	-	-	6000-8000

Implementation of the irrigation schemes has increased the cropping intensity per year in both study areas (Table 3). Before farmers were dependent on rain fall and only one crop per year was grown.

**Table 3. Cropping intensity in Haleku and Dodicha irrigation schemes.**

Crop type	Haleku			Dodicha		
	Once per year	Twice per year	Three times per year	Once per year	Twice per year	Three times per year
Onion	23	65	12	63	37	0
Tomato	46	42	12	43	57	0
Maize	92	8	0	94	6	0
Green bean	77	23	0	98	2	0

### 5.1.3 Livestock holding

Major animal types in both schemes are cattle, goat, and sheep. Oxen are used as draught power for plowing and threshing, manure for fuel and for fertilizer. The economic contribution of livestock to households is milk, meat and hides. Sheep and goats are also used as a source of cash income in time of need. Donkeys are widely used to transport agricultural products, fuel wood, and water and to transport agricultural products to the markets. About 16, 23 and 43% of the sample households did not have cattle, oxen and donkeys in Haleku before implementation of the irrigation scheme, respectively (Table 4). After implementation of the scheme these numbers decreased to 12, 4, and 39%

respectively. In Dodicha 15, 22 and 48% of the households did not have cattle, oxen and donkeys before implementation of the irrigation scheme, respectively. After implementation these numbers were 22, 20 and 48%, respectively.

The mean number of animals in Dodicha was higher than in Haleku before implementation of the irrigation schemes (Table 5). But after implementation the number of animals per household increased in Haleku whereas it decreased in Dodicha. The farmers in Haleku irrigation scheme gain more than in Dodicha from irrigation and therefore they are able to invest more in livestock. There were no statistical significant differences in the number of animals before and after implementation of the irrigation schemes. However, the reported numbers of animals by farmers are likely underestimated because farmers are generally reluctant to tell the size of their herd as they present their capital. So, the actual number of animals might be more than the survey result in the irrigation schemes.

**Table 4. Livestock holding in Haleku and Dodicha irrigation schemes.**

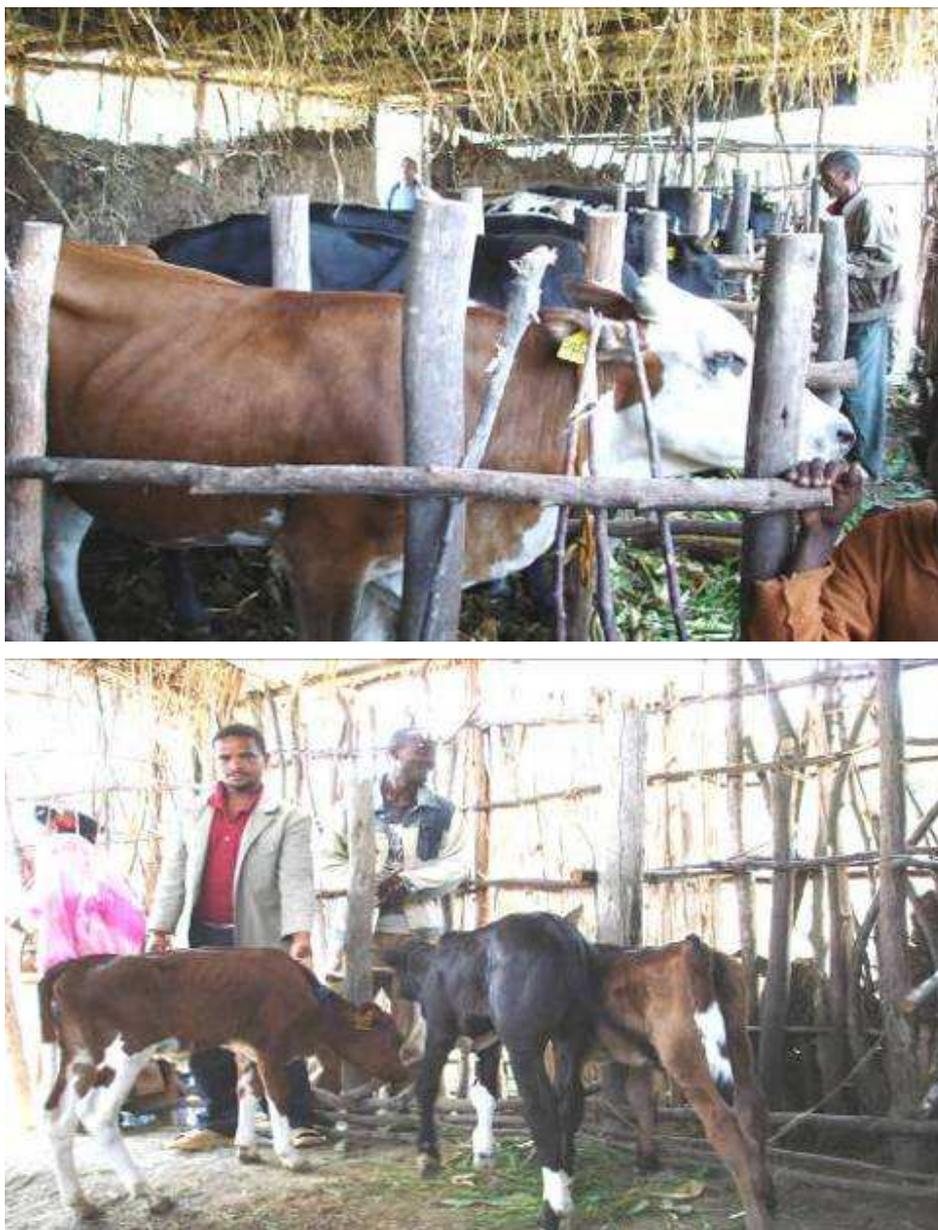
Type of livestock	Holding categories	Before implementation of schemes		In 2007	
		Haleku	Dodicha	Haleku	Dodicha
Cow	0	15.4	14.8	11.6	22
	1-5	69.2	59.2	61.6	63
	6-10	15.4	24.1	23	15
	>10	0	1.9	3.8	0
Oxen	0	23.2	22	3.8	20.3
	1-5	73	72.3	92.4	76
	6-10	3.8	3.8	0	3.7
	>10	0	1.9	3.8	0
Heifer	0	34.6	38.9	27	35.5
	1-5	50	48	57.7	50.3
	6-10	11.6	11.2	15.3	12.3
	>10	3.8	1.9	0	1.9
Sheep	0	80.8	77.5	73.3	72.2
	1-5	19.2	14.9	22.9	22.2
	6-10	0	1.9	3.8	3.7
	>10	0	5.7	0	1.9
Goat	0	53.9	46.1	38.9	29.4
	1-5	26.9	20.5	38.3	50.1
	6-10	15.4	25.9	15.2	18.6
	>10	3.8	7.5	7.6	1.9
Donkey	0	42.4	48.1	38.5	48.1
	1-5	57.6	51.9	61.5	51.9
	6-10	0	0	0	0
	>10	0	0	0	0
Poultry	0	57.8	64.5	38.5	59
	1-5	15.4	13.1	26.9	18.6
	6-10	15.3	16.7	26.9	20.5
	>10	11.5	5.7	7.7	1.9

**Table 5. Mean livestock holding in Haleku and Dodicha before (2001) and after (2007) implementation of the irrigation schemes.**

Type of livestock	Haleku			Dodicha		
	2001	2007	Change	2001	2007	Change
Cow	3.31	3.85	0.54	4.07	2.74	-1.33
Oxen	1.81	2.35	0.54	2.11	1.67	-0.44
Heifer & bulls	2.85	2.85	0.00	2.69	2.30	-0.39
Sheep	0.73	1.08	0.35	1.50	0.94	-0.56
Goat	2.88	3.96	1.08	4.81	3.30	-1.51
Donkey	0.85	0.96	0.11	1.03	0.95	-0.8
Hen	4.54	4.31	-0.23	3.41	2.94	-0.47

Recently, the WUA of Haleku bought eleven improved dairy cows from Adami Tullu Oromia Agricultural Research Centre, a total investment of 24,000 EB <sup>II</sup>(Figure 5). The WUA distributed these dairy cows over eleven members on the basis of a lottery with binding rules to transfer newly born female heifers to the other members of the association. Those who won the improved dairy cows paid the initial costs to buy these cows. Now these farmers are getting 4-6 litters of milk per day per cow.

<sup>II</sup> EB=Ethiopian Birr (during the survey 1EURO= 12.45EB )



**Figure 5. Improved dairy cows bought by Haleku WUA.**

#### **5.1.4 Farm implements**

Farm implements are used for different production activities and or facilitate transportation and marketing of farm products. In both schemes the number of farm implements increased after the implementation of the irrigation schemes (Table 6). In Haleku irrigation scheme the percentage of farmers who own a watering can increased from 4% to 94% whereas in Dodicha it increased from 6% to 59%. The ownerships of donkey cart increased from 35 to 50% in Haleku and from 22 to 41% in Dodicha.

**Table 6. Mean farm implements per household in Haleku and Dodicha before (2001) and after (2007) implementation of the irrigation schemes.**

Type of farm implements	Haleku			Dodicha		
	2001	2007	Change	2001	2007	Change
Shovel	0.58	1.62	1.04	0.41	1.46	1.05
Folk	0.12	0.58	0.46	0.28	0.91	0.63
Cart	0.35	0.88	0.53	0.23	0.46	0.23
Watering can	0.04	1.35	1.31	0.07	0.76	0.69
Sprayer	0	0.04	0.04	0.04	0.09	0.05
Sickle	1.31	1.85	0.54	1.39	1.43	0.04

Donkey carts are very important farm implements to transport inputs to the field and products from the field to home stead or market place. During market days the cart is also used as a source of income for the households as it is used to transport products and people from Adami Tullu to Ziway and vice versa.

### **5.1.5 Labor input**

Labor is one of the major inputs used in small-scale irrigation schemes. Trained and experienced labor is an essential production factor. Family labor is the major source of labor for both irrigation schemes except during peak production period, i.e. transplanting, weeding and harvesting when farmers hire additional labor. The wage rate in the area ranges from 10-15 birr per day depending of the production period. During peak periods wage rate increases due to shortage of labor. Both male and female laborers are involved in the production activities. Male labors are involved in all production activities whereas females are mostly involved in planting, weeding, and harvesting. Labor data for different production activities are indicated in Table 7.

**Table 7. Amount of labor used for different field operations in onion, tomato, maize and green bean in Haleku and Dodicha (in man days per 0.25 ha).**

Scheme	Production activities	Labor requirements			
		Onion	Tomato	Maize	Green bean
Haleku	Land preparation	5	4	4	4
	Planting	9	5	4	7
	Weeding	18	11	8	11
	Crop protection *	4	4	1	4
	Irrigation/watering*	17	15	14	12
	Cultivation	24	16	8	17
	Harvesting	17	33	5	61
Dodicha	Land preparation	4	4	3	4
	Planting	12	6	4	8
	Weeding	17	17	10	7
	Crop protection *	4	4	1	4
	Irrigation/watering*	17	15	11	11
	Cultivation	21	15	7	15
	Harvesting	16	36	5	57

\*Labor requirements for crop protection and watering corresponds directly to the number of spray and irrigation operations per cropping season.

Labor requirements for onion, tomato, and maize and green bean production are statistically the same in both irrigation schemes (Table 8)

**Table 8. Mean total labor used for production of different crops in Haleku and Dodicha (in man days per 0.25 ha).**

Type of crop	Scheme		Significance
	Haleku	Dodicha	
Onion	94	93	NS
Tomato	96	93	NS
Maize	45	42	NS
Green bean	117	109	NS

NS= non significant, \* significant at P< 0.05 \*\* significant at P< 0.01

### 5.1.6 Average costs and returns

The net production cost for the different crops in the irrigation schemes are summarized in Table 9 and indicates no significant differences in individual crop production costs between both schemes at 5% probability level.

**Table 9. Mean total production costs of different crops in Haleku and Dodicha (in birr/0.25 ha).**

Type of crop	Scheme		Significance
	Haleku	Dodicha	
Onion	2368	2341	NS
Tomato	2305	2270	NS
Maize	986	981	NS
Green bean	2264	2187	NS

NS= non significant, \* significant at P< 0.05 \*\* significant at P< 0.01

Mean yields of onion, maize and green beans are significantly higher at 1% probability level in Haleku (Table 10).

**Table 10. Average productivity of different crops in Haleku and Dodicha (in kg/0.25 ha).**

Type of crop	Scheme				Significance
	Haleku		Dodicha		
	Yield range	Net yield	Yield range	Net yield	
Onion	1000-6400	3462	500-6000	2379	**
Tomato	600-4200	2796	500-5000	2483	NS
Maize	200-4000	1416	200-2000	729	**
Green bean	1200-4900	2227	500-4200	1596	**

NS= non significant, \* significant at P< 0.05 \*\* significant at P< 0.01

The net revenues obtained from onion, maize and green bean are significantly higher in Haleku at 1% probability level but not significant for tomato (Table 11). Although net revenues of most households are positive some farmers produced with loss. In Haleku irrigation schemes 4% and 9% of the farmers produced tomato and green bean with financial losses, respectively, whereas 4, 29 and 17% of the farmers produced onion, maize and green bean with losses in Dodicha, respectively. In Haleku, 16% of farmers produced maize with losses. The loss range and average loss per crop in the schemes are indicated in Table 12. The standard deviation in net revenue is very high within and between both irrigation schemes.

**Table 11. Net revenues, range of net revenues and percentage of farmers with positive revenue for different crops in Haleku and Dodicha irrigation schemes (in birr per 0.25 ha).**

Crop type	Percent of farmers with positive revenue		Revenue range		Net revenue	
	Haleku	Dodicha	Haleku	Dodicha	Haleku	Dodicha
Onion	100	96.3	1932-17246	59-17089	8155	5286
Tomato	88.5	88.9	535-10525	79-11591	5941	4789
Maize	80.8	59.3	485-6497	43-2510	1662	649
Green bean	100	79.6	176-8180	6-2849	2273	1383

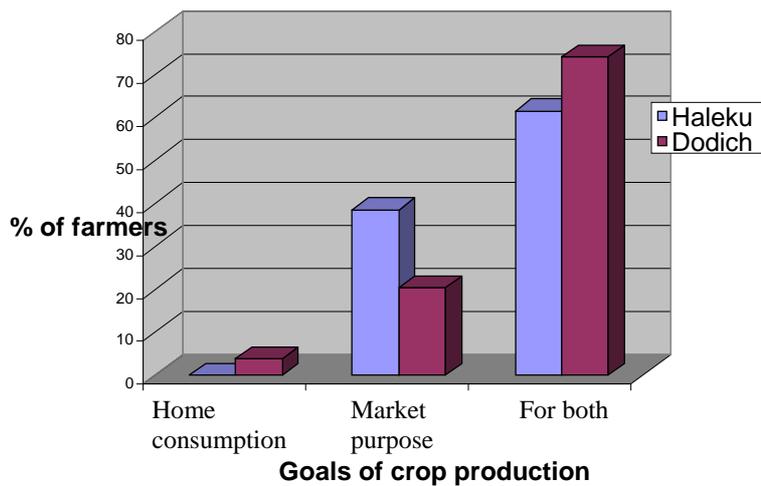
**Table 12. Loss ranges and net loss from production of different crops in Haleku and Dodicha (birr per 0.25 ha).**

Crop type	Percent of farmers with loss		Loss range		Average loss	
	Haleku	Dodicha	Haleku	Dodicha	Haleku	Dodicha
Onion	0	3.7	-	254-398	-	376
Tomato	3.8	9.3	883	229-516	883	404
Maize	15.4	24.1	5-517	4-697	178	325
Green bean	0	16.7	-	168-828	-	472

### **5.1.7 Households' food security**

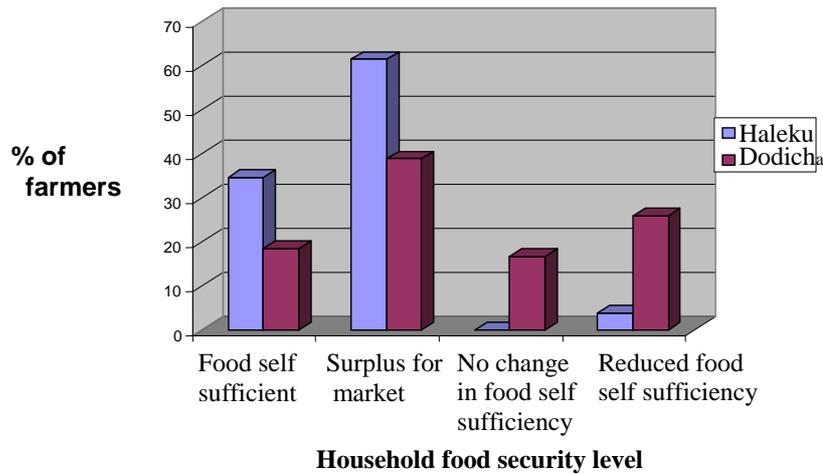
The development of small-scale irrigation schemes in the survey areas has increased cropping intensity and crop income. According to the survey results and group discussions with farmers their income has increased as compared to the situation before implementation of both irrigation schemes. Before implementation of the irrigation schemes, farmers used rain fed production both for home consumption and to cover other household expenses (school, cloth, health care) together with income from livestock. The farmers indicated that the income from crop sale and livestock was not sufficient for home consumption to cover these household expenses. As a result they faced shortages in food, seeds for the next season and cash to buy inputs. Implementation of the irrigation schemes helped them to diversify crops and income sources. The majority of the households currently use rain fed staple production for home consumption and income

from irrigation to cover the household expenses and for saving. In Haleku, 39 and 61% of the respondents uses irrigated products for market and both for market and home consumption purposes, respectively (Figure 6). In Dodicha 6% of the households use irrigated products only for home consumption, 20% for market purpose and 74% for both purposes.



**Figure 6. Production goals of irrigated crops.**

The major area of concern among the rural farming community is the availability of food at household level. In Haleku, 35% of the respondents have secured their family food consumption year round, 61% has a surplus for market purpose and 4% indicated a worsening of their family food security after the implementation of the irrigation scheme (Figure 7). In Dodicha, 19% of the respondents produced sufficiently to secure their family food consumption, 38% produced a surplus for market purposes, 17% had no change in family food security level as compared to implementation of the irrigation scheme and 26% faced a decrease in food security.



**Figure 7. Perception of household’s food security after implementation of the irrigation schemes.**

### **5.1.8 Linkages of irrigation**

Access to and reliable supply of water can enable farmers to adopt new technologies and intensify cultivation, leading to increased productivity, overall higher production, and greater returns from farming (Hussain and Bhattarai, 2003). This may open up new employment opportunities, both on-farm and off-farm, and can improve incomes, and the quality of life in rural areas. The farmers were interviewed about the different linkages<sup>III</sup> to identify spill-over effects of small-scale irrigation schemes.

Hussain and Hanjira (2004) identified five key dimensions of how access to good irrigation water contributes to socioeconomic uplift of rural communities and alleviate poverty: production, consumption, employment, food security, and other social impacts contributing to overall improved welfare. There are various linkages that connect different fields of activities in the form of backward and forward linkages (Ray, 1998) Forward linkages are essentially facilitators and they increase the viability of other economic activities from the supply side. Backward linkages increase the demand for the product of another sector. In the study area four types of linkages have been identified although the levels of linkages are low. These are production linkages, consumption linkages, investment linkages and employment linkages.

<sup>III</sup> In this discussion the concept of linkages refers to the development of different aspects of production activities and services created/and/or facilitated as a result of small-scale irrigation development in the area

Production linkages can be either backward or forward. Forward linkages relate to marketing and processing industries while the backward linkage to input and resource suppliers. Implementation of the irrigation schemes in the study area facilitated the intensification and diversification of crop production and allowed the farmers to grow several crops per year on the same plot of land (Table 3). Implementation of the irrigation schemes also enabled to diversify from low yielding and low profitable crops to new high yielding and more profitable crops. Before implementation of the irrigation schemes the farmers grew maize, haricot bean, sorghum and teff. Now the production has shifted to high value and high yielding maize variety, green bean and vegetable crops (onion, tomato, green bean and cabbage). The intensification and diversification of crop production also facilitated the linkages between farmers and input suppliers. The increase in farm income created high demand for modern agricultural farm inputs such as improved seeds, fertilizers and pesticides. Thus, irrigation development has led to higher production, which implies increased consumption of inputs, as well as higher production receipts for the farmer.

Apart from production linkages there are also consumption linkages because of the higher income from irrigation agriculture (Kirsten and Van Zyl, 1990). Crop intensification, diversification, and market-oriented production provide food to producers as well as to consumers. The forward consumption linkage is the increased supply of products for the local and national markets. In the study areas maize is produced for home consumption and local market in Adami Tullu and Ziway town. Onion and tomato are mostly produced for markets such as Addis Ababa and Adama. Only the low grade products are used for home consumption and local markets. Green bean is produced for export markets (mostly Netherlands and Italy). In most case farmers sell tomato and onion before the harvest. Green bean is sold to the private farms (Ethio-Flora) found in the locality of the irrigation schemes that export it to European market. As a backward linkage, irrigation has increased the household's income and as a result increased the consumption of industrial products like cloths, food oil, kerosene, sugar, etc.

The benefits of higher yields and income increased the savings of households in the study area. At the end of each cropping season the farmers save 5-10% of their total sales. Hirschman (1958) in Ray (1998) explained the relationship between saving rate and investment: the higher the saving rate the greater the investment potential and the higher the growth rate. Various investments by farmers were observed in the schemes. About 31% of the sample respondents in Haleku built a house in nearby Adami Tullu Kebele after implementation of the scheme. Some farmers opened a kiosk in Adami Tullu. The Haleku irrigation scheme also has started investing in improved dairy cattle. Donkeys' carts ownership has increased after implementation of the schemes. The price of a cart ranges from 1500-3000 birr depending on the type of cart. The establishment of the irrigation schemes in the study areas showed more positive implication on the backward investment linkage through investment in small businesses. The investment expenditure in local hotels, kiosks, local drink houses, shops etc. increased in nearby Adami Tullu. According to owners of local hotels, kiosks and shops the development of irrigation schemes created favorable conditions for the expansion of their businesses.

The labor-intensive nature (increased cropping intensity, cropping area and crop diversification) of irrigation development has increased the employment opportunity both on-farm and off-farm. The irrigation farmers cultivate both rain fed and irrigated land. As a result, family labor is not sufficient to support all production activities. This has created employment opportunities for local landless poor and others. Irrigation development has also created additional employment opportunities outside the irrigation sector through increased demand for inputs and increased supply of outputs.. Off-farm employment opportunities created due to the irrigation schemes include local traders, brokers, whole sellers, and loaders of products. The irrigation schemes employ treasures, guards and storehouse keepers.

### **5.1.9 Commercial aspects**

#### *Input source and utilization*

Proper utilization of modern inputs such as improved seeds, chemical fertilizers, pesticides and fungicides are basic and essential to any farm enterprise especially in the production of high value horticultural crops.

However, the efforts to develop efficient and effective technologies have achieved limited success in the case of small-scale farmers who are often regarded as resistant to changes (Sands, 1986). According to him some researchers have attributed small-scale farmers' failure to adopt improved technologies partly to the inadequacy of support systems, such as extension services, credit, and input supplies. All farmers apply fertilizers and pesticides

DAP and urea are the major fertilizers used. Depending on the availability of fertilizer farmers apply 25-50 kg/0.25 ha DAP and 25 kg/0.25 ha urea (Table 13). The types of insecticide used in both irrigation schemes are Selecron, Karate and Mitga. Fungicides used in the schemes are Kocide, Bayleten, Pencozeb, Ridomil and Bumper. Among these chemicals Selecron, Kocide, Pencozeb and Ridomil are mostly used chemicals in the irrigation schemes. Often two or more chemicals are applied together depending on pest and disease pressure. Farmers use the same type of insecticides and pesticides for tomato and onion. Apart from lack of cash or credit services, high prices of these input and timely availability of inputs are reasons for underutilization of farm inputs. The amount of inputs distributed by the association does not meet the demand of farmers resulting in yield reduction. Some farmers also apply manure to increase soil fertility of their plot Table 13.

**Table 13. The average amount of inputs used in both schemes (per 0.25 ha).**

Crop	Seed		DAP (kg)	Urea in (kg)	Insecticide/fungicide			
	variety	Amount (kg)			Selectron (lt)	Kocide in (kg)	Pencozeb (lt)	Ridomil (kg.)
Onion	Bombe.red, Adam red	2	25-50	25	1	1	1.5	0.5
Tomato	Roma B	0.1	25-50	25	1	1	1.5	0.5
Green bean	Zera	6	25	25	1	1	1	0.5
Maize	BH660, PHB-2553 and Pioner	6	25	25	0.5			

The mean chemical application frequency per growing season is the same for tomato and onion (Table 14). The application frequency depends on the growing season, i.e. frequency of application is high during the main growing season (rainy season) due to higher pests and disease pressure. Green bean needs only sixty five days for harvesting while tomato and onion needs 90-150 days depending on the variety used. Although green bean has a shorter growing season, it needs frequent pesticide applications since it is produced for export markets which require strict disease control to guarantee product quality.

**Table 14. Mean pesticide application frequency in different crops in Haleku and Dodicha.**

Crop	Minimum	Maximum	Mean	Std. Deviation
Onion	3	6	4.09	1.05
Tomato	2	9	4.09	1.61
Green bean	2	8	3.73	1.36
Maize	0	2	0.84	0.77

High yielding seed varieties are another important input that contributes to high output, but access in the study area is very low. The sources of seeds are private shops, individual seed producers and local open markets. Due to the high price of seeds in private shops as compared to open markets and individual seed producers most of the farmers buy seeds from local open markets and local seed producers. The quality of seeds from local open markets is often low which affects yield negatively. Seeds from local open markets is of unknown purity and usually susceptible to disease, pests and low yielding (Lemma, 2004). There is no government institution responsible for multiplication and distribution of vegetable seeds in the Woreda. Therefore, farmers use mainly low yielding local crop varieties. Recently, the number of private farmers producing vegetable seeds is increasing in the CRV. In 1996 about 13 % of onion and tomato seeds were produced by small private vegetable growers in the CRV (Dawit et al., 2004), in 2002 it was 50%. However, the sample irrigation schemes have no experience in vegetable seed production. The sources of other agro-chemical inputs (fertilizer, pesticides and fungicides) are unions (mostly Meki Batu vegetable union) and private shops. The sale committee of the WUAs is responsible for buying inputs (seeds, fertilizers, and chemicals) and distributes them to the members on credit bases. Depending on the availability, these inputs are distributed for the farmers on fixed quota bases.

#### *Out put marketing*

As horticultural crops have a short shelf-life marketing is a central issue in their production process. Household decisions and responses are governed by markets and related institutions (FAO, 1989). The price of horticultural crops fluctuate from year to year, season to season, from day to day and from market to market (Table 15). Therefore, profitability of horticultural crops depends on marketing skills and getting good market information rather than production expertise (FAO, 1989). The great variation in prices makes horticultural crop production potentially very profitable but also very risky. The study areas are found near the main highway from Addis Ababa to Awassa via Shashemene and are easily accessible to whole traders from Awassa, Shashemene, Ziway, Adama and Addis Ababa. Although, marketing is one of the crucial components of agricultural development, it is not well addressed by extension agents. For

example agricultural extension does not deliver market information to farmers as it is outside its mandate. The SMSs and DAs have not received training on facilitating market services. The lack of full market information reduces bargaining power of the farmers and forces them to accept prices given by traders. The WUAs have their own sale committee which is responsible for marketing of the products. Generally, the WUAs sell their products to traders or brokers except for low quality products which are sold on local markets.

**Table 15. Crop prices during the study period (2007 cropping season) in different market places.**

Market out let	Onion (birr kg <sup>-1</sup> )	Tomato (birr kg <sup>-1</sup> )	Maize (birr kg <sup>-1</sup> )	Green Bean (birr kg <sup>-1</sup> )
Farm gate	2.90-3.40	2.80-3.00	1.40- 2.30	2.00-2.10
Local market in Ziway	4.00	4.00	-	-
Central market in Addis Ababa	4.50	5.00	-	-
Mini super market in Addis	5.00	5.50	-	-
Big super market (Shoa Super market)	5.70	6.00	-	5.50

#### *Credit and saving services*

Credit service is very important for capital intensive farming like horticulture. In the study areas, there are no well-established credit services for farmers. Particularly, in Dodicha, production activities are highly constrained by the lack of credit services. Haleku irrigation scheme receives credits from RCWDA to buy the necessary inputs for crop production. Both irrigation schemes save 5-10% of their total sale at the end of each cropping season and use these savings for pump maintenance and buying inputs.

#### *Agricultural extension services*

Extension is the mechanism by which information and technologies are delivered to farmers (Moris, 1991). A more comprehensive definition of extension service is given by the World Bank as a 'process that helps farmers to become aware of improved technologies and adopt them in order to improve their efficiency, income and welfare' Purcell and Anderson (1997) in Gebremedihnn and Pedon (2006). Extension services in

Ethiopia until 2002 focused on increasing production and productivity in view of achieving food security Mathewos and Chandargi (2005) in Gebremedihn and Pedon (2006). Most farmers are illiterate and can not read information in printed form. Thus, DAs need to disseminate agricultural information to farmers through other means.

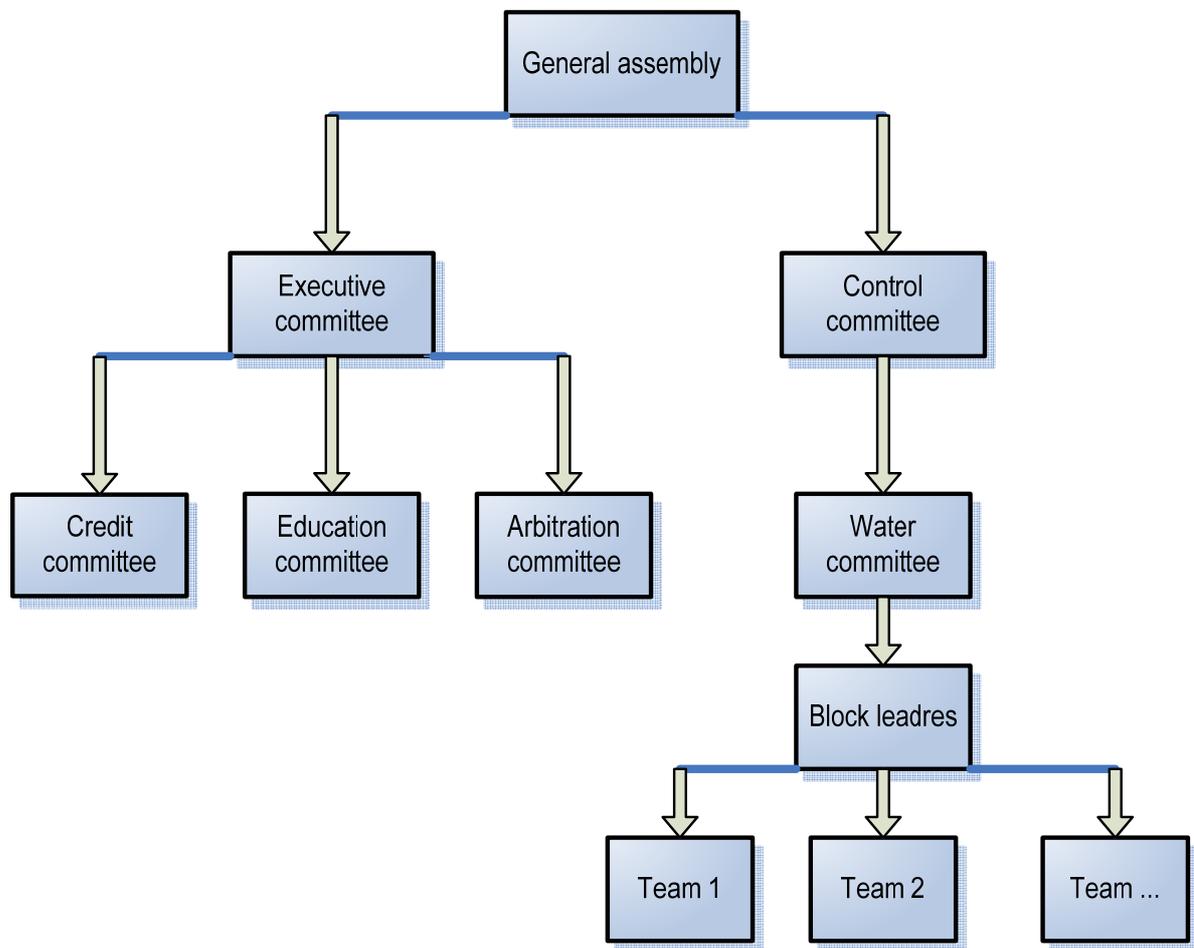
Adami Tullu Jido Kombolcha Woreda agricultural office has a shortage of Subject Matter Specialists (SMS) and DAs to support farmers. The number of DAs in both peasant associations is very low. In Dodicha there are two DAs of which one works on animal sciences and the other on crop production and natural resources. The latter works on horticultural crops without any special training on these crops. The WUA had employed a skilled specialist on vegetable production with a salary of Birr 500 per month, but a nearby private investor paid a better salary and he left the WUA. In Haleku there is no DA but there is one social worker employed by RCWDA to assist farmers. The absence of DAs and little experience of farmers with horticultural crop production hamper improvement. The limited numbers of DAs are assigned with a lot of work (administration and political committees, tax collection, aid distribution, etc.) in addition to extension services. The involvement of DAs in administration and political issues could reduce the trusts between farmers and DAs. In addition, there is a serious shortage of trained personnel in agricultural economics, agribusiness and related disciplines in the Woreda agriculture office. Facilitation of linkages between producers and market parties and between farmers and credit and input suppliers is lacking in the study areas.

The farmers in the study area have no training on horticultural crop production and are practicing irrigation without much know-how on agronomy, water application and crop protection. For example, the farmers in both irrigation schemes do not use sticks in tomato to tie up the plants. Instead tomato fruits are laid down on the ground reducing the quality due to rotting, insect damage and sun bleaching.

## **5.2 Institutional arrangement**

### **5.2.1 Organization of the irrigation schemes**

Poven (2004) pointed out that WUAs are the most frequently recommended organizational form for management of irrigation schemes. WUAs are legal entities which are supposed to have full control over the irrigation infrastructure in their scheme. Establishing a strong irrigation organization is one of the major aspects for a successful and sustainable irrigation management (Boelens, 1998). Sustainable management of farmers-managed irrigation systems requires well established rules that ensure the interest of all farmers. The two irrigation schemes studied have a legal certificate from the Cooperative Society of Oromia and turned to cooperative society. The organizational structure of Cooperative Society (Certified WUAs) is indicated in the Figure 8. This structure is developed by OIDA for modern small-scale irrigation schemes in Oromia. Certification is important to get legal access to credit services from governmental and non-governmental organizations. They can also legally enter into different agreements with different unions, governmental and non-governmental organizations. Uncertified WUAs have not such legal rights.



**Figure 8. Organization of modern small-scale irrigation schemes.**

The duties and responsibilities of each committee mentioned in Figure 8 are described in the section.

**General Assembly:** The general assembly is the supreme authority of the cooperative comprising all members of the scheme. It is the organizational level at which all members collectively discuss the most important issues and make final decisions. The general assembly meets twice a year and if needed the executive committee can call for extra meetings. Moreover, if more that 15% of the members asks for a meeting the executive committee has the responsibility to organize such a meeting. As indicated in the bylaw of the WUAs, the general assembly has the following duties and responsibilities:

- Elect all committee members.
- Approve annual plan and budget.
- Discuss annual reports and the audit report and pass the needed decision.
- Consider applications against the exclusion of members and refusal of membership by the management committee.
- Approve and amend the bylaw and internal regulation.
- Assign internal auditor and or also assign the external audit with the approval of appropriate authority.
- Decide on the employment of workers.
- Settle all disputes that may arise among the committee.
- Approve regulation regarding staff employment promotion and maximum payment and carry out other necessary activities.

**Executive Committee:** The executive committee is the governing authority elected by the general assembly and subject to any decision from the general assembly and responsible to undertake day-to-day management of the scheme. The five committee members are elected from the members of the association. The term of office of the management committee is three years and one member can not be elected more than two consecutive terms. They are responsible for all losses and shortages incurred because of actions contrary to the proclamation, bylaw and decision of the general assembly. In general this committee performs the following duties and responsibilities:

- Prepare annual production plan and budget and implement it upon approval by the members.
- Prepare draft bylaw and internal regulations and implement them upon approval.
- Ensure that the proper accounting records are kept in the office.
- Collect regulation fee, sale share and saving.
- Prepare guidelines on employment of staff and implement same upon approval by the general assembly.
- Settle disputes that may arise among the members and the cooperative before it is sent to general assembly.
- Facilitate the approval of employment of workers by the general assembly

- Perform or authorize any action consistent with the proclamation regulation and bylaw unless specifically reserved for general assembly.
- Delegate in writing an officer or employee of the society such of its duties as it deem necessary.
- Ensures that the employees of the societies have carried out their duties and responsibilities.
- Prepare schedule for water distribution.
- Takes care of physical structures such as water gates, canals and other properties of the association.
- Monitoring pump operation.

**Control Committee:** The control committee is also elected by the general assembly and accountable to it. The committee consists of three members and they are elected every three year. The general responsibility of this committee is to monitor the activities of the different committees and individuals of the association whether they are operating according the bylaws. In particular the control committee is responsible for the following activities:

- Prepare monthly audit report and make report for the members on general meeting of WUA.
- Monitor whether the executive committee accomplished their responsibility.
- Monitor the proper use of money and other resources of the WUA.
- Monitor the implementation of decisions passed at general meeting.
- Monitor credit and saving activity of the WUAs, etc.

**Water committee** is established under the control committee and accountable to it. To decentralize the scheme management and make the operation of the scheme more effective different teams are organized under the water committee. For that reason the irrigation land has been divided into blocks that comprise a team and all members of the association are grouped in one of the teams. At Haleku there are six teams and each team has 12 members. Every team has a team leader for water and input distribution. The team leaders are responsible to inform the members about the water distribution schedule

prepared by the executive committee. The team leaders also record the amount of lt/kilo watt power that the group has used for pumping irrigation water. The most important function is the timely distribution of irrigation water to the team members. Some of the responsibilities of this committee are:

- Coordinate activities of team members (canal maintenance, cleaning, etc.).
- Implement water distribution plan prepared by the executive committee and monitor proper application of water at plot level.
- Monitor implementation of production plan prepared by the executive committee
- Coordinate sale activities.
- Distribute input to members of the team and assure proper use of inputs.
- Solve disputes among the different team leaders.

**Arbitration or conflict management committee** is elected by the general assembly and consists of three elder people who are respected by the community and it is their responsibility to solve any disputes among the beneficiaries, between different committees and between the committees and beneficiaries. This committee is accountable for executive committee and makes a report of their accomplishment to executive committee once every three months.

**Education committee:** Education committee is another committee organized under the executive committee consisting of three members elected by the general assembly. The responsibilities of this committee are the following:

- Organize training for WUA members, committee members and new employees.
- Advice members on the use of available credit.
- Explain the association bylaw and internal regulations.
- Buy, collect and prepare different posters and educational materials which are important to transfer information.
- Give advice to different committee members.
- Collect information which is important for the development of the association.

**Saving and credit committee:** The saving and credit committee arranges credit facility for the members and collects savings after the product is sold. The association can only give credit to its members and for similar types of associations. Before credit is provided the executive committee insures that the requested credit is for reasonable purpose and will be paid back. The credit committee submits the credit applications from users to the executive committee for approval. The credit needs to be paid back at the end of each production season after the product is sold. If the user is not able to pay back the credit at the end of the production season the executive committee can extend the payment period with four months.

The interest rate depends on source of credit. If it is from own WUA sources the interest rate is 7.5% whereas it is 10% for money from other organizations. According to the WUAs bylaw if members use credit for other purposes than the intended purpose he/she is obliged to repay the credit and the full interest before the intended period. The saving and credit committee encourage members and facilitate conditions to open an own bank account to save money. The users can save money within the association bank account and get the interest rate paid by the bank. This committee also negotiates with traders or brokers about the product price of individual water users/growers or of the WUA. The committee informs the producers about the price agreement with the traders. The producers receive the amount of money which is left after all input costs given on credit and association savings are deducted from the gross sale. At the end of each production season the users save 5-10% of their total sale. To become member of the WUA one has to fulfill the following criteria:

- ✓ The livelihood is based on agriculture.
- ✓ A plot of land in the irrigation command area.
- ✓ Willing to exchange land that he/she may own more than the maximum (0.5 ha) holding allowed in smallholder irrigation schemes.
- ✓ Dweller of the peasant association where the project is operating.
- ✓ His/her age must be 18 or older.
- ✓ He/she agrees with the objectives and bylaw of the cooperative.
- ✓ In good physical well-being

- ✓ Not member of another irrigation cooperative

### **5.2.2 Irrigation scheme management**

All management activities in the schemes are carried out by the WUAs. The main activities include repair, maintenance of canals, supervision of water distribution, settling any conflicts and raising internal resources to sustain the WUA. Where farmers cultivate on adjacent plots using common pumps, certain tasks and activities should be properly coordinated to smoothly run the irrigation scheme and avoid possible conflicts (Stern, 1988). In the following the management performance of the irrigation schemes is described based on the qualitative survey, interviews and group discussions.

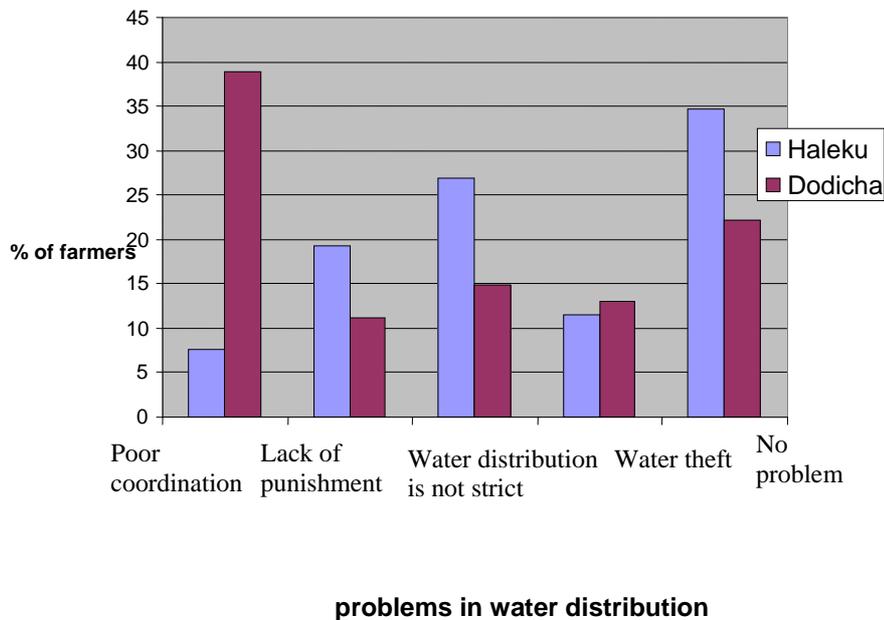
### **5.2.3 Irrigation infrastructure**

Both irrigation schemes provide water using a motor pump that discharges water to a concrete canal at the top of a raised embankment. Through well-constructed secondary and tertiary canals water is applied using furrow irrigation. Haleku has two motor pumps (diesel and electric pump) which are alternatively used depending on the availability of fuel and electricity. The electricity costs are lower than fuel costs but sometimes farmers pay for higher electricity costs since the rate of electricity per kilo watt is not fixed. Dodicha has two diesel pumps of which one is working. The pump capacity is too small for the irrigated area and there is no standby pump when the pump fails which happens frequently. Rodents are a major problem along the main canals and causing water losses in both irrigation schemes.

### **5.2.4 Water distribution and management**

There are two major water distribution systems, i.e. free irrigation and scheduled distribution. The choice between both distribution systems depends on the availability of water. The former distribution system is used when there is sufficient water available whereas the later is used when water is scarce. In both Haleku and Dodicha pumps are owned by the groups, which need scheduled water distribution to avoid potential water conflicts. In Haleku the scheme is divided into three blocks to facilitate the distribution of water and to rotate crops. Every WUA member has a plot of land in each block. Crops planted in each block are the same and determined by the executive committee. Members

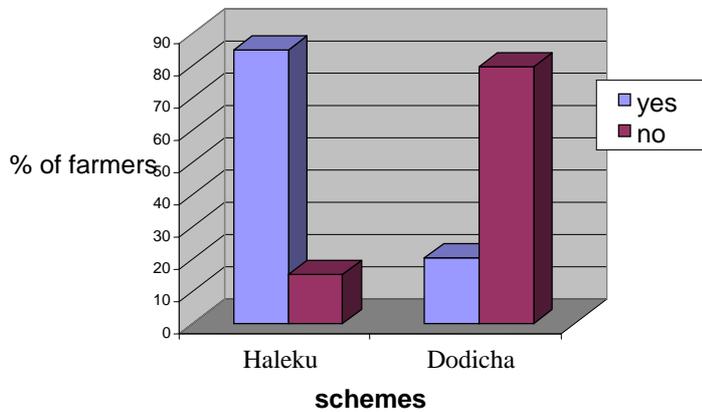
are imposed to follow the production plan approved by the general assembly. The failure to follow the production plan results in penalty. In Haleku, there are four teams which are organized according to the nearness of plots. The team leaders are responsible for the proper distribution and allocation of water according to the schedule of the water committee. Major problems in Haleku (in decreasing level of importance) are the lack of strict water distribution schedule, poor punishment of farmers break the association bylaws, water theft and poor coordination by water committee (Figure 10). In Dodicha major problems relate to poor coordination by water committee, lack of strict water rotation, water theft and poor imposition of punishment against illegal water users.



**Figure 9. Water distribution problems in Haleku and Dodicha irrigation schemes.**

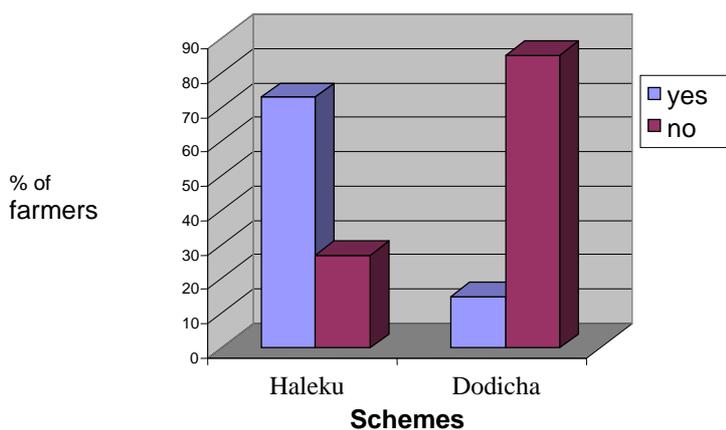
Based on the interviews and group discussions it became clear that there are no major problems with respect to field water management. The shortage of water in Dodicha and high pumping costs in both irrigation schemes are an incentive to use water carefully. However, water losses occur due to rodents and lack of proper clearing of weeds and other grasses in the canal lines. About 85% of the respondents in Haleku indicated to

receive enough irrigation water (Figure 10). In contrast, 80% of the households in Dodicha receive to little irrigation water.



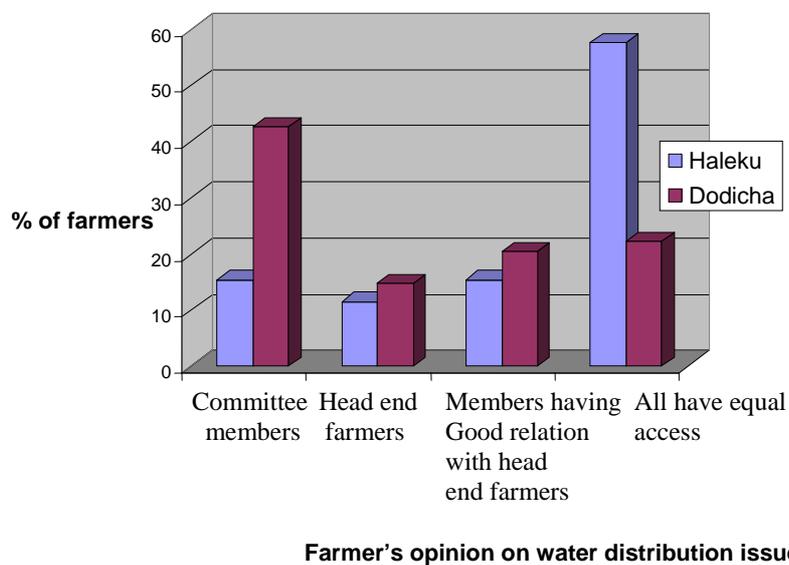
**Figure 10. Percentage of households facing irrigation water shortages in Haleku and Dodicha**

Due to the lack of coordination, pump failure and or low pumping capacity and lack of fuel and oil, water is not received when it is needed by the farmers. The severity of these problems is less in Haleku since it has two pumps and the management of the scheme is better organized. In Haleku, 73% of the households receive sufficient irrigation water (Figure 11). In Dodicha 85% of the respondents pointed out that they do not receive enough water when needed for irrigation (Figure 11).



**Figure 11. Availability of irrigation water at the time when needed by farmers in Haleku and Dodicha**

Farmers also indicated unequal water distribution, i.e. 27% and 65% in Haleku and Dodicha, respectively mentioned this issue. Some of the members use more water than the others. This problem seems more severe in Dodicha where farmers associate unequal distribution to head-end farmers, committee members, and farmers with a good relation with the water committee (Figure 12). In Haleku about 60% of the respondents think that water distribution in the scheme is fair, in contrast with Dodicha where only 22% of the respondents are convinced of equal water distribution.



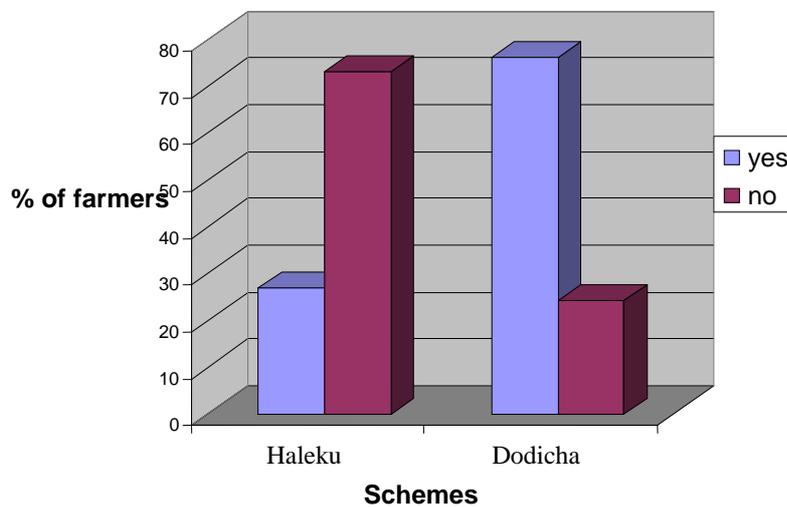
**Figure 12. Opinion of farmers on the equal distribution of irrigation water in Haleku and Dodicha scheme**

In both irrigation schemes the use of water from irrigation canals for other purposes than irrigation is forbidden. Only 5% of the respondents use irrigation water illegally for other purposes (house hold and watering of cattle). Violation of this rule may lead to punishment and charges which are sufficient incentives to use irrigation water only for agriculture.

In general, leasing out of irrigation land is not allowed according to WUA regulations and only possible when a member is unable to work on his/her plot due to health-related and financial problems. Approval is needed from the executive committee. According to the bylaws of the WUAs every member is allowed to leave the association but s/he has to

leave the irrigated land to the association. The association allows another interested individual from the same PA and the new member exchange the same plot size with the out going member. Animals are not permitted to graze in the irrigation command area. The enforcement of the organizational bylaw is higher at Haleku compared to Dodicha. Poor coordination of the committee and corruption results in less enforcement in Dodicha.

There are also conflicts in the irrigation schemes, i.e. among committee members, among members, and between committee and members. There are various sources of conflicts in both irrigation schemes, i.e. water theft; unfair water distribution, product marketing, corruption, untimely revenue distribution and free riding of members. The conflicts seem more severe in Dodicha and associated with poor scheme coordination, water shortages and corruption. About 75% of the respondents in Dodicha mentioned conflicts with neighboring farmers or committee members against about 25% of the respondents in Haleku (Figure 13).



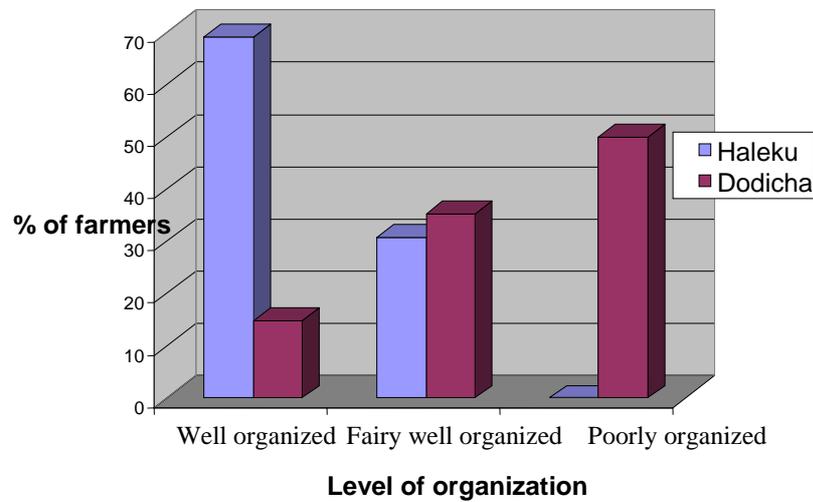
**Figure 13. Farmers facing conflicts in Haleku and Dodicha**

### **5.2.5 Maintenance**

Maintenance of the irrigation infrastructure is done by the WUA members. The Water committee is responsible for the mobilization of resources required for maintenance activities and for the scheduling of maintenance of the primary, secondary and tertiary canals. Maintenance activities within a block covering small areas are done by the block or team members and coordinated by the team leaders. In general, WUAs are effective in the management of water allocation and distribution but often maintenance and especially investment activities are not regularly performed (Agarwal, 2000; Vermillion, 1999).

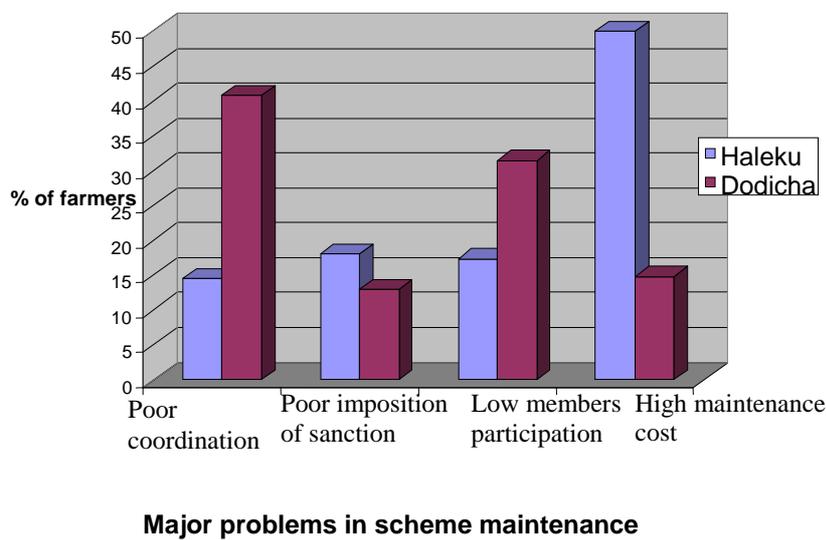
The maintenance costs for motor pumps and irrigation infrastructure are covered by the WUAs in both irrigation schemes. The pump O&M costs during the growing season are equally distributed among the water users and the money is paid back to the WUAs at the end of the growing season after the product is sold. The team covers the expenses for fuel and motor oil that can be paid after the product is sold. Team leaders withdraw fuel and oil from the WUAs store and keep records of the amount of fuel and oil. The store keeper also keeps records of all inputs used by each team.

In Dodicha, the intensive use of the one pump available and the low technical knowledge leads to frequent pump failures and high repair costs, i.e. 45,000 EB in 2007. Major concern of the farmers is pump failure when they need water for their crops. The high pump maintenance costs, other costs like the per diems of committee members and corruption discouraged farmers in Dodicha to contribute to scheme maintenance. There is no big problem with labor mobilization and enforcement of bylaws in Haleku irrigation scheme. In Haleku 69 and 30% of the respondents indicated that their scheme is well organized and fairly well organized, respectively (Figure 14). In contrast, in Dodicha only 15% of the respondents are satisfied with the scheme organization.



**Figure 14. Opinion of farmers about their scheme organization in Haleku and Dodicha**

In Haleku, high maintenance cost (50%), poor enforcement of sanctions (18%), low level of members participation (17%) and poor scheme coordination (15%) are the major problems in Haleku (Figure 15). Poor scheme coordination (40%), low level of member's participation (31%), high maintenance costs (15%) and poor enforcement of sanctions (13%) are the major problem in Dodicha (Figure 15).



**Figure 15. Problems in scheme maintenance according farmers in Haleku and Dodicha**

Both schemes have some common problems, i.e. marketing, lack of extension services, absence of cold post-harvest storage and lack of credit facility. Poor scheme coordination

and lack of motor pump are the main problems in Dodicha irrigation scheme. 61.11% of the respondents in Dodicha irrigation scheme have shown that shortage of motor pump is the major problem in the irrigation scheme. The marketing problem is less relevant in Dodicha since most farmers do not produce for the market. Sufficient irrigation water and good scheme coordination in Haleku is associated with higher yields (Table 10) and a higher surplus which is marketed. Therefore, marketing is more a problem in Haleku, i.e. it is mentioned by 77% of the respondents as major problem in Haleku.

### **5.2.6 Transaction costs in irrigation scheme management**

The net revenue differences between Haleku and Dodicha for onion, tomato, maize and green bean are 2560, 655, 1266 and 1210 birr/0.25 ha, respectively. These differences can be considered the transaction costs associated with poor scheme organization and management, lack of credit facilities, lack or absence of supervision and corruption in Dodicha.

### **5.3 Environmental impacts small-scale irrigation**

Although irrigated agriculture in the study area has contributed to increased food production and to over all socio-economic development, irrigation in general has been subject to increased criticism over the past decades, including the concern on socio-economic inequality, social disruption and environmental degradation. During the field survey physical observation on soil erosion and deforestation was made. Also information was collected concerning land use change, plot fertility and human and animal disease occurrences due to implementation of irrigation schemes in the area. According to the information from farmers, the pressure on the surrounding acacia trees has been slightly decreased because most WUAs members produce enough food for their families. Therefore, the dependency on income from charcoal and fuel wood during bad years has decreased. About 69 and 78 % of the respondents indicated that there is no land use change at Haleku and Dodicha irrigation scheme, respectively. The current irrigation command area was under rain fed crop production in the past. On the other hand, 31 and 22% of the respondents indicated land use changes, i.e. increased deforestation at Haleku and Dodicha peasant association mainly associated with deforestation activities of non-

members living in the area. In both irrigation schemes no soil erosion observed due to the implementation of the irrigation schemes.

However, the increase in the irrigated area especially around Lake Ziway has a considerable effect on the Lake water level (Jansen et al., 2007): the minimum, maximum and average levels of Lake Ziway have significantly decreased since 2002, which is associated with an increase in the number of pumps along Lake Ziway and along the Meki River, upstream of Lake Ziway. The other effect of irrigation development around Lake Ziway is the increase of siltation. According to information from the Woreda Agricultural Office, small-scale farmers cultivate the shore around the lake during the dry season when the water body shrinks and this increases siltation during the rainy season. The sample households have different opinions regarding fertility of their plots, i.e. 65, 24 and 11% of the respondents in Haleku and 54, 23 and 23% in Dodicha stated that it increased, decreased and showed no change after the implementation of the irrigation schemes, respectively. The use of manure and chemical fertilizers were mentioned as reason for increased soil fertility while the continuous cultivation is mentioned as a reason for decreasing soil fertility. Sample respondents did not indicate an increase of human or animal diseases after implementation of the irrigation schemes.

## **6. Discussion**

This chapter discusses the main findings presented in Chapter 5 and my personal observations during the interviews, group discussions and field visit.

### *Main findings*

#### *Households' income situation and food security condition*

This study shows that small-scale irrigation schemes increased average households' income compared to before implementation of these schemes. Irrigation increased crop diversification, cropping intensity from one crop to two or three crops per year, production volume, households' income and consumption and employment. Access to irrigation water created the opportunity for the households to diversify their income base and reduced their dependency on rain fed agriculture and livestock. This reduced their vulnerability to the seasonality of agricultural production and external shocks. About 70% (96% in Haleku and 57% in Dodicha) of the household respondents secured their family food consumption through increased income from irrigation.

#### *Institutional arrangement*

All O&M activities in both irrigation schemes are coordinated by WUAs committees. There are some important issues identified in this study that constrain the coordination in the schemes, especially in Dodicha. After establishment of this scheme land was reallocated among farmers. Those who owned more than 0.5 ha in the scheme site gave land use ownership right to their children and wives and not to others without land in the irrigation command area. Therefore, the land remained within the families. However, scheme expenses such as salary for guards, committee per diem, pump maintenance and service charges are equally shared and paid by WUA members without taking in to account the land holding size. Some households find this unfair and it was a reason for low participation in contribution for O&M, canal cleaning and maintenances.

In both irrigation schemes the annual production plan is prepared by the executive committee and individual farmers are obliged to follow it. Some farmers in both

irrigation schemes mentioned this as constraint for crop diversification. One farmer said “I know that hot pepper requires less water, less chemical input while it is less perishable and more profitable than tomato and onion, but I am not allowed to plant the crop”. Although the production plan at WUA level facilitates water distribution and marketing of products, it is important to assess the market potential of other crops and explore ways to incorporate alternative crops in the production plan.

Supervision and monitoring of WUAs by Woreda agricultural offices hardly happens contributing to low economic performances of both irrigation schemes, especially of Dodicha. The transaction costs for supervision and monitoring of schemes by the Woreda agricultural office is higher than by RCWDA supervising Haleku. Since there are many small-scale irrigation schemes requiring supervision from the Woreda agricultural office, Dodicha gets little supervision and monitoring. CTA (2003) in its study on small-scale irrigation schemes in Sub-Saharan Africa concluded that government-supported projects consistently ranked last in the effectiveness of their support to small-scale irrigation after NGOs, donors and commercial farmers. Moreover, NGO-supported schemes were more successful in integrating diverse activities associated with irrigation development than government-supported schemes.

According to farmers in Dodicha lack of monitoring from the Woreda agricultural office opened a way for corruption. Most farmers indicated a lack of transparency of financial scheme management. Since there is no external auditing, committees prepare fake receipts for different expenses, which increased transaction costs of the scheme. For example, one farmer said “my product was sold at 17,280 birr and I only received 7,000 birr from WUA. Most of the costs included in the production costs were unknown to me and now I really hate to work in the association”. Another farmer said in Oromo language “*Haala maallaqa qabiinsaa irratti iftoominni fi to’annaan waan hin jirreef koreen nyaattee nufixxe*” which means that because of a lack of transparency in financial book keeping the committees are taking away a large share of the revenues.

Limited pump capacity, high cost of pump maintenance and lack of transparency (corruption), poor scheme organization are main problems in Dodicha. The WUA has only one functioning pump and therefore, part of the scheme was not in production. Limited pump capacity led to competition for water and created conflicts and water theft.

The variation in crop yields within and between both schemes is very high. The reason for the high variation is not addressed in this study but the water distribution problems in Dodicha due to limited pump capacity could be related to these high yield variations. However, variation in yields is also very high between adjacent farmers due to differences in crop management (timely weeding, tillage and use of agrochemicals, etc.).

#### *Extension service provision*

Horticultural crop production is knowledge intensive and requires careful crop management starting from nursery to post-harvest handling and marketing. Therefore, education and training of farmers is extremely important. Educated and trained farmers can use information from different sources i.e. folders, posters and information on input packages. In Haleku most farmers have attended primary and secondary education and this might have contributed to the better field management observed and to higher profits. Moreover, education is an important factor for WUAs since the entire management is done by the committees elected by its members. In particular financial management (book keeping of input prices, input use, yields and revenue distribution) needs good book keeping procedures to guarantee transparency and to avoid possible conflicts within WUAs. The provision of agricultural extension services in both irrigation schemes is very low. There are no DAs trained in horticulture to advice farmers, while farmers in both schemes have little experience in horticulture. For example, farmers had problems with identification of various crop pests and diseases which is required for the proper application of agro-chemicals.

During field visits it was also observed that many agronomic practices are not according to the recommendations. Plant spacing, threshold level for applying agrochemicals and the amount of irrigation water are based on farmers' knowledge. In both irrigation

schemes farmers do not use sticks in tomato production to tie up plants. Unavailability of the sticks and high cost were mentioned as reasons for not using sticks. Instead tomato fruits are laid down on the ground reducing the quality due to rotting, insect damage and sun bleaching. Consequently, yield losses may be greater than the cost of using sticks. The other problem, especially in Haleku is product marketing. Most of horticultural growers follow a similar cropping calendar and the seasonality of production results in a high supply of the same product and consequently low prices. The WUAs have no planning system to match production and demand better. Moreover, there are no active unions in the area that coordinate the WUAs to increase their bargaining power in marketing of their product. About 81% and 77% of tomato and onion around Ziway are traded at farm gate level, respectively (Jaleta, 2006). Since the WUAs have little market information their bargaining power is low and makes them price-takers instead of price-setters (Cartom, 1994 in Jaleta, 2006).

#### *Transaction costs*

According to Ostrom (1992) in Poven (2004) free riding, rent seeking, and corruption are the major problems (opportunistic behavior) in many irrigation systems. These problems were also observed in Haleku and especially in Dodicha. According to Easter and Zekri (2003), if power imbalances prevail at the community level, more decentralized approaches to irrigation management may lead to rent-seeking and corruption and thus may be socially undesirable. Lack of training and skills make farmers more dependent on WUA staff and encourages informal arrangements and corruption (Neubert et al., 2002). The lack of auditing and monitoring system and little experience of farmers in irrigation created opportunity for corruption. In irrigation systems corruption is prevalent in the assessment and collection of revenues, construction and maintenance works, and water allocation and distribution (Theesfeld, 2001). According to UNDP (2004) in (Tropp and Stålgren, 2005), corruption is a function of monopoly and discretion minus accountability, integrity and transparency. The presence of corruption and other related problems in Dodicha increased transaction costs of coordination and management.

Milligrom and Roberts (1992) in Pevon (2004) explain transaction costs as the costs for operating the system, i.e. the costs for coordination and motivation. In Dodicha, the poor performance in coordinating and managing the scheme created many other interlinked problems increasing the transaction costs and low participation of members in canal maintenances and contribution to fees for pump maintenance. Haleku and Dodicha are close to each other (about 7 km) so that most conditions (climate, market access and water sources) are the same. However, the differences in mean crop net revenues between both schemes are considerable and can be considered the transaction costs due to poor coordination and management in Dodicha.

#### *Environmental impacts of irrigation*

Compared to large and medium scale irrigation projects small-scale irrigation scheme are promoted because of their potentially lower negative environmental impacts, low investment cost, ease in maintenance, and low management requirements (CTA, 2003). During the study field visits were made to WUA fields, state and private farms. In both state and private farms soil salinity was observed although most schemes are quite recent. Environmental problems associated with small-scale irrigation schemes appear low. However, further study is needed to identify the impacts of small-scale irrigation schemes on soil quality and ground water quantity and quality.

## **7. Conclusions and recommendations**

To enhance the productivity of the agricultural sector and to improve food security, the Ethiopian Government designed the Agricultural Development Led Industrialization strategy and one of the policies within this strategy is to stimulate and/or support the development of small-scale irrigation. Small-scale irrigation schemes aim to increase agricultural production and to contribute to improved food security through improving income of participating farmers. Based on this study, various lessons can be learned for improving the sustainability of small scale irrigation schemes:

The analysis of the costs and revenues of various production activities in both irrigation schemes indicates positive crop revenue. The net revenue of four different crops (per 0.25 ha) ranged from 7040 to 33298 in Haleku and from 609 to 31040 birr in Dodicha. Except for tomato the net revenues from three different crops (onion, maize and green bean) are statistically significantly higher in Haleku at 1% probability level. Although mainly assessed qualitatively, irrigated farmers perceived their food security condition better than compared to the situation before implementation of the irrigation schemes. In Dodicha, land holding size and number of animals decreased whereas the number of farm implements increased.

In both irrigation schemes there are no location-specific recommendations for input use and, therefore the farmers apply different rates based on the availability of inputs. Improved management recommendations and better skills of farmers to apply inputs can improve the yield performance in both schemes considerably.

WUAs committees are in charge of the coordination and management in both irrigation schemes. The institutional performance has a great impact on the profitability of schemes. In Haleku committees and farmers cooperate well and WUA committees are transparent creating trust between farmers and committee members. Members are actively participating in the management of their scheme. The organization (for maintenance, water distribution, marketing, input and revenue distribution) in Haleku is better than in

Dodicha. The low level of transparency in financial issues and poor coordination in Dodicha results in a lower economic performance and farmers may lose interests in community-based management if this situation does not improve. The lack of supervision and monitoring from the Woreda agricultural office contributed to mismanagement and corruption. As a result, transaction costs are higher in the Dodicha scheme.

Among others, one of the benefits of small-scale irrigation schemes is their potentially lower environmental impacts compared to large scale schemes. Soil erosion was not observed in both schemes and according to farmers little water is wasted as high costs of fuel are a strong incentive for efficient water use.

Lack or absence of DAs trained in horticulture and crop protections are the main production constraints in both irrigation schemes. Low crop yields are associated with poor agronomic practices. Marketing of product is another major constraint faced in both irrigation schemes. Due to incomplete market information and the perishable nature of most vegetables bargaining power of WUAs is low and usually the product price is set by traders or brokers. Provision of extension services from the Woreda agricultural office hardly exists in both irrigation schemes. In general, in most aspects considered in this study Haleku (NGO-supported) performed better than Dodicha (Government-supported).

Based on this study, the following recommendations may contribute to a sustainable development of smallholder irrigation schemes:

- ❖ Better training of farmers on improved agronomic practices, crop protection aspects, book keeping, irrigation practices, and product marketing is required to increase crop productivity, price bargaining power and profitability of small-scale irrigation schemes.
- ❖ The Woreda agricultural office/NGOs could support the previous recommendation through setting up farmers training center.
- ❖ Strengthening or establishing institutions for input supply, output marketing and credit service to allow rapid progress in the introduction and adoption of productivity improving technologies and farming practices.

- ❖ The WUAs should find ways to better match the production plan with market demand.
- ❖ The WUAs should form producer unions and focus on the production of high quality products so as to compete with other producers and to increase their bargaining power.
- ❖ The WUAs should be involved in seed multiplication programs to reduce seed costs and to improve access to high quality seed.
- ❖ The WUAs should be supported and encouraged to strengthen their own credit systems to reduce dependency on other institutions. Until this has been realized Woreda agricultural office and NGOs should facilitate access to credit.
- ❖ Training, capacity building and encouraging development agents and WUAs committee members are essential to build the local understanding and management capabilities to effectively support farmers.
- ❖ Regular supervision and monitoring is needed, for example, from Woreda agricultural office and NGOs to improve transparency of WUAs and prevent corruption.

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## **Appendices**

### **Appendix 1: Household survey questionnaires**

**Wageningen University**

**Environmental Economics and Natural Resources Group**

#### **Socio-economic assessment of two small scale irrigation schemes in the Central Rift Valley of Ethiopia**

Dear respondent,

This household survey questionnaire is planned to assess the socio-economic of two small scale irrigation schemes in the Central Rift Valley of Ethiopia. The study focuses on the investigation and quantification of agricultural input uses at plot level, constraints that limit smallholders' access to these inputs and assessing comparison of costs and revenues of different far crops in two irrigation schemes .The over all goal of the study is to understand socio-economic performances of the two schemes and propose alternative options in order to improve their performance.

Therefore, your active participation and genuine responses is very curtail in meeting the intended objectives of the study. I kindly request your active cooperation in responding to the questionnaires. The questionnaires are fully for the academic research purpose and so that any information you provide will be kept confidential.

Thank you!

**1. General Information**

Date of interview: Day \_\_\_\_ Month \_\_\_\_ Year \_\_\_\_ Enumerator's name: \_\_\_\_\_

Woreda: \_\_\_\_\_ Peasant Association: \_\_\_\_\_ Scheme Name:

\_\_\_\_\_

Number of families: \_\_\_\_ Farmer's name \_\_\_\_\_ Age \_\_\_\_\_

Sex \_\_\_\_\_ Education level \_\_\_\_\_

**1.1 Households characteristics/composition**

No	Sex	Age	Educational level for family members greater than 5 years	Occupation	
				Primary	Secondary

**Variable code:**

*Sex 1=Male 2=Female*

*Age: 1= less than 10 years 2= 10-17 years 3= 18-65 years 4= greater than 65 years*

*Educational status 1=Illiterate 2=read and write 3= primary education (grade 1-8)*

*4= Secondary education (grade 9-12) 5= College and above*

*Occupation: 1=Farmer 2=Trader 3=Housewife 4=Student 5=herding*

## 1.2 Household resources

### 1.2.1 Farm size

Owner ship status	Farm Size in Qarxi	
	Before the implementation of the irrigation scheme	In year 2000 EC
Owned		
Rented out		
Rented in		

### 1.2.2 Livestock

Type of livestock	Number of livestock	
	Before the implementation of the irrigation scheme	In year 2000 EC
Oxen		
Cow		
Heifer and bull		
Sheep		
Goat		
Donkey		
hen		

### 1.2.3 Farm implements

Type of implements	Number of implements	
	Before the implementation of the irrigation scheme	In year 2000 EC
Shovel		
folk		
Cart		
Watering can		
Sprayer		
sickle		

1Qarxi= 0.25ha

EC = Ethiopian calendar

## 2. Crop production

### 2.1 Labor requirement

Crop Type	Production activity	Total labor required
Onion	Land preparation	
	Sowing	
	Weeding	
	Chemical application	
	Harvesting	
	Transporting	
	Threshing	
Tomato	Land preparation	
	Sowing	
	Weeding	
	Chemical application	
	Harvesting	
	Transporting	
	Threshing	
Maize	Land preparation	
	Sowing	
	Weeding	
	Chemical application	
	Harvesting	
	Transporting	
	Threshing	
Green Bean	Land preparation	
	Sowing	
	Weeding	
	Chemical application	
	Harvesting	
	Transporting	
	Threshing	

## 2.2 Chemical input use

Type of crop	Type and amount of inputs							
	Seed		Fertilizer		Insecticide		Fungicide	
	type	amount per qarxi(kg)	type	amount per qarxi(kg)	Type	amount per qarxi(kg of lt)	Type	amount per qarxi(kg of lt)
Onion								
Tomato								
Maize								
Green bean								

## 2.3 Yield

Type of crop	Plot size in (qarxi)	Total yield in (kg) per qarxi
Onion		
Tomato		
Maize		
Green Bean		

## 3. Irrigation water management and agronomic practice

1 When did you start irrigated crop production? Since 19\_\_\_\_\_EC

2. What type of water application method you use?

1. Flooding
2. Furrow application

3. Sprinkler irrigation
  4. Drip irrigation
  5. Others (specify) \_\_\_\_\_
3. What methods of water abstraction do you use?
    1. by gravity
    2. using rope and washer pump
    3. motor pump
    4. Using treadle pump
  4. Does your access to water limit the area that you cultivate in any season of the year? 1= yes 2= no
  5. If your answer to question 4 is yes, indicate the reason based on the magnitude of the problem
    - 1<sup>st</sup> \_\_\_\_\_
    - 2<sup>nd</sup> \_\_\_\_\_
    - 3<sup>rd</sup> \_\_\_\_\_
  6. Does irrigation water availability affect your decision the type of crop you grow?
 

1 = yes 2 = no
  7. If yes, which crop you give the priority?
 

1<sup>st</sup> \_\_\_\_\_ 2<sup>nd</sup> \_\_\_\_\_ 3<sup>rd</sup> \_\_\_\_\_
  8. What type of farming system(s) practiced in the area?
    1. Crop production
    2. Livestock rearing
    3. Both
  9. what are the main problems in livestock production in the area? Circle multiple responses if any
    1. Shortage of feed 2. Shortage of water 3. Diseases
  10. How many times you cultivate the following crops per year?
 

Onion \_\_\_\_\_ Tomato \_\_\_\_\_ Maize \_\_\_\_\_ Green Bean \_\_\_\_\_
  10. Do you use crop rotation system? 1= yes 2= no
  11. If your answer to question 11 is yes, mention the sequence of rotation?

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12. Do you sow your crops in time (according to the sowing date)?

1= yes 2= No

13. If the answer to question 13 is no, why?

1. water shortage
2. hired labor shortage
3. Inability to get input on time (seed & fertilizer)
4. Others (specify) \_\_\_\_\_

14. For what purpose you use the crop you produced under irrigation?

1. Home consumption only 2. Market purpose 3. Both

15. In your opinion how do you judge the contribution of irrigated crop production for your family food security?

1. It secured my family home consumption
2. I got surplus for market
3. No change in food security
4. It reduced my food security

16. For what other purpose you use irrigation water?

1. For home consumption
2. For cattle drinking
3. Only for irrigation

17. Do you make any payment for using water for irrigation

1=yes 2= No

18. Do you have adequate knowledge on irrigation practices?

1= Yes 2= No

19. Do you get extension services from Woreda Agricultural offices?

1. Yes 2. No

20. Do you get sufficient credit services?

1. yes 2. No

21. Do you need additional training on irrigation practices?

1= yes 2= No

22. What are the different linkages created due to the implementation of the irrigation schemes in the

area? In circle if there are multiple responses

1. Production linkage
2. Employment linkage
3. Consumption linkage
4. Investment linkage

#### **4. Institutional arrangement**

1. How are the committees for scheme coordination elected?

1. Nominated by the kebele leaders
2. Elected by the water users in the scheme
3. No coordinator

2. Who makes a decision on the sequence of irrigation water use?

1. Executive committee
2. Water committee
3. based on the agreements between the water users
4. others (specify)\_\_\_\_\_

3. How do you rank the internal organization of the irrigation system (the canal clearing, canal maintenance, water distribution, etc) of your scheme?

1. Well organized
2. Fairly organized
3. Poorly organized

4. If the maintenance of canals is poor in your irrigation scheme what do you think the causes?

(Circle multiple responses if any)

1. Poor coordination of maintenance activities by WUA committee?
2. Poor imposition of sanctions on reluctant users?
3. Low level of members participation in maintenance activities?
4. Cost of maintenance is high and not affordable by members
5. Other (specify) \_\_\_\_\_

5. What are the major problems in the irrigation scheme?

1. Poor scheme management
2. market

- 3. Shortage of pump
  - 4. Flooding
  - 5. Poor drainage system
6. Do you receive enough water?                      1. Yes                      2. No
7. Do you receive water when needed?              1. Yes                      2. No
8. Is water distribution fair?                          1. Yes                      2. No
9. If you answer for Qn 10 is no, which socio-economic groups consume or use more water? (Circle multiple responses if any)
- 1. Committee members
  - 2. head end farmers
  - 3. Association member having good relations with committee members
  - 4. All WUA have equal access to irrigation water
10. What are the major management problems related to water distribution in the irrigation system (if applicable) (Circle multiple responses if any)
- 1. poor coordination by water committee
  - 2. Lack of punishment against illegal water users
  - 3. Rotations are not strictly implemented
  - 4. Water theft
  - 5. We have no problem
11. Have you ever faced any conflict with neighboring farmers because of using irrigation water?  
1= Yes 2= no
12. If yes, what were the problems or sources of the conflict? Rank
- 1st \_\_\_\_\_
- 2nd \_\_\_\_\_
- 3rd \_\_\_\_\_
13. what measures were taken to resolve the conflict?
- 1 \_\_\_\_\_
- 2 \_\_\_\_\_
- 3 \_\_\_\_\_

**5. Environmental impacts of irrigation**

1. Is there a land use change associated with the expansion of irrigated crop production?  
1= yes 2= no

2. If your answer is yes, do you think the change had negative effects on the local environment

(deforestation, erosion, water level of the lake, water pollution etc)

1= yes 2= no

3. If your answer is yes, mention the impacts according to their severity.

1<sup>st</sup> \_\_\_\_\_

2<sup>nd</sup> \_\_\_\_\_

3<sup>rd</sup> \_\_\_\_\_

4. How did you judge the fertility level of your land after you started using irrigation water?

1. Increased

2. Decreased

3. No change

5. Have you ever faced any human health problem due to irrigation water use?

1 = yes 2 = NO

6 If yes, rank the problems according to importance

1 \_\_\_\_\_

2 \_\_\_\_\_

3 \_\_\_\_\_

7. Do you have ever faced animal disease problem due to using irrigation? 1 = yes 2=no

8. If yes, list all animal diseases you faced?

\_\_\_\_\_

## **Appendix 2: Checklists**

### **I) Checklist for focus group discussion**

1. When did your Woreda start irrigated crop cultivation?
2. What is your source of water for irrigation?
3. Who owns the irrigation water in your scheme (encircle the response)?
4. How do you manage your irrigation system ( construction, maintenance, operation activities ,water allocation, distribution, drainage etc )?
5. What are the formal and informal institutions there in relation to irrigated agriculture?
6. How you evaluate the prevailing land tenure system in the area as to the sustainability and productivity of the irrigation agricultural practice of small holder irrigators ?
  - issues of tenure security
  - issues of equity in land subdivision among small holders
7. What are the sources of conflict in relation to irrigation agriculture in the area and how could you manage these conflicts?
8. What are the various traditional conflict man agreement institutions you have? And how strong they are now ?
9. What are your major problems in irrigated crop cultivation and what supports you need most and from where you expect? Please rank the first three 1st, 2nd, 3rd problems
10. What is the contribution of irrigated crop production in facilitating households' access to different services(Health center, Veterinary clinic, input supply Shope,School ,and others)
11. What is your general opinion on the contribution of irrigated agriculture to household food security?
12. According to your opinion what is the negative and positive socio-economic impact of irrigation practices in your scheme?
13. What do you suggest for the improvement of your irrigation scheme performance in the future?

## **II) For key informants**

1. What is the contribution of small scale irrigation in creating employment conditions for the local society?
2. According to your opinion what is the contribution of the small scale irrigation for the local and national economy of the country?
3. Who initiated the construction of the small-scale irrigation projects in the area?
4. Did the community participate in the construction?
5. Whose are the irrigation structures now?
6. What are the bases or criteria's for land subdivision and access right to irrigable land?
7. Is there equity consideration by the organization in access to and allocation of water?
8. What are the bases /rules or criteria's for water allocation to individual water users?
9. How is the relation between the Woreda Agriculture Office and the irrigation schemes?
10. Do you have rules and regulations for water allocation?
11. Do you think the existing land tenure system is fair and help full for the sustainability of the irrigation schemes? How?
12. What are the major social and technical problems in the irrigation system?

### **III) Checklist for Woreda Irrigation Office**

1. What is/are the socio-economic contribution of small scale irrigation for the Woreda?
2. Is there any social conflict in the Woreda due to expansion of small scale irrigation?
3. What are the impact of small scale irrigation on the natural resource base of the Woreda?
4. How does the organization resolve water disputes among users within the Woreda?
5. What are the organization's rules and regulations in irrigation water allocations if there is water scarcity?
6. What are the supports provided by the Woreda irrigation office to small scale holders in the area?
7. What looks like your organization level of communications with the different water users in the area? (investors, state farms, farmers, pastoralists, other institutions)
9. Do you think the organization is efficient enough to manage the irrigation system in the woreda? If not why?
10. What are the main problems that your organization faced in the management of small scale irrigation system?
11. What do you suggest for the improvement of small scale irrigation in the Woreda?