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**Equity of River Water to Traditional Irrigation Users:
Case Study of Holetta River, Holetta Town, Ethiopia**

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**A Thesis Submitted to Graduate Studies of Addis Ababa University,
College of Development Studies, in Partial Fulfillment of the
Requirements for the Degree of Master of Arts in Water Resource
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June, 2011
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Title

*Equity of River Water to Traditional Irrigation Users:
Case Study of Holetta River, Holetta Town, Ethiopia.*

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Statement of Author

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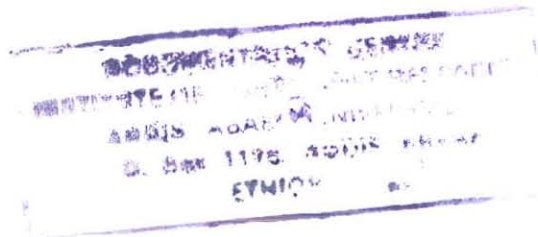




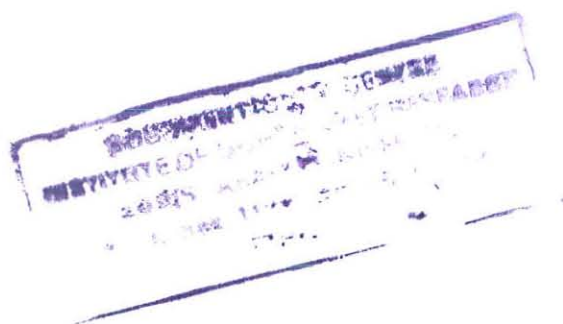
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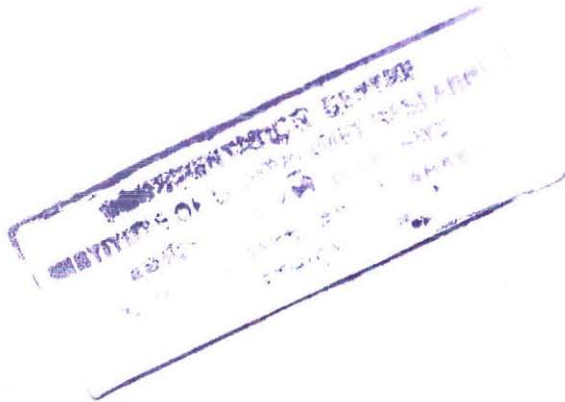
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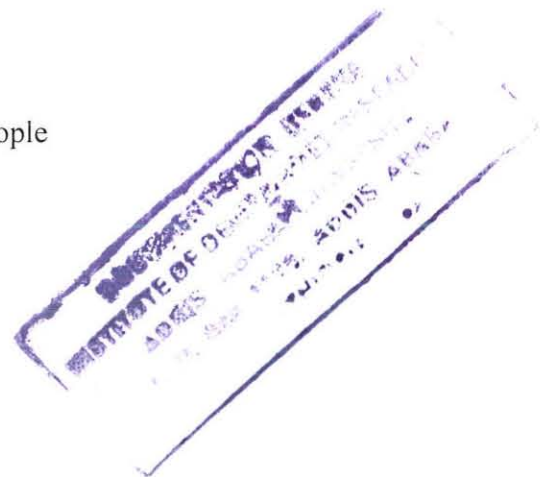
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Acronyms and Abbreviations

ATVET	Agricultural Technical and Vocational Education Training
Cu -	Cultivar
CWR	Crop Water Requirement (CROPWAT)
ET _o	Reference Evapotranspiration
E _c	Evapotranspiration of the crop
FC	Field Capacity
FAO	Food and Agricultural Organization
IIPE	Impact of Irrigation on Poverty and Environment
IWMI	International Water Management Institute
K _c	Crop Coefficient
Kebele	Administration unit below woreda
K _y	Yield response factor
LSD	List significant different
l/s/h	Liter per second per hectare
MoARD	Ministry of Agriculture and Rural development
MOWR	Ministry of Water Resource
N and E	North and East
qt	quintal
RCBD	Randomized Complete Block Design
RAW	Readily Available Moisture
SWB	Soil Water Balance
SNNP	Southern Nation and Nationalities of People
SPSS	Statistical Package for social Science
TAW	Total Available Water
USDA	United State Development Agency
WP	Wilting Point
WRSI	Water Requirement Satisfaction Index
WUC/WUAs	Water Users Committee/Associations



Equity of River Water to Traditional Irrigation Users: Case Study of Holetta River, Holetta Town, Ethiopia

Synopsis

The main objective of the study was to assess the equity and efficiency of Holetta River to traditional irrigation users and its management practices. In the study both qualitative and quantitative research approaches were used. By Purposive and convenient sampling methods open ended questionnaire and unstructured interview were employed with direct observation. In addition, crop water requirement studies were undertaken for the evaluation of balanced water distribution. In fact the range is not serious however there is a problem of equity in water distribution to users. The water distribution doesn't account for the type of crop and its stage, land hold and distant from the primary channel. Also farmers act makes problems on ensuring equity. On the other hand there is no participation of females' on equity of water. Farmers water applications being the same for all crop stage and wide furrow system causes water wastage. Scientifically suggestions are proposed to the farmers for crop water requirement and irrigation intervals. Thus to improve equity, the management of the irrigation is important. Also enabling the community to fully transfer the irrigation to them is significant. To perk up water productivity by new technology innovations with integrating farmer's knowledge and scientific water sharing principles from cropping calendar and land distance has to be seen. Also for water productivity farmers should develop storage pond and store water and use from it. Not only concerning crop stage but focusing on crops with its high profit margin and less water demanding need to be considered. As an option to farmers with high land size could plant perennial crops which their demand of water become decreasing at latter stage of crop life and its water demand is high only in flowering and fruiting period. Unlike that those who have small lands could plant annual crops but for both cases crop diversifications based on its financial return is significant. In the future it is imperative to study both engineering and social aspects via accounting all users including farmers and institutes and other users in the irrigation for better deployment. In Ethiopia crop water requirement studies should be given attentions for efficient utilizations of water resource to increase agricultural product. This thesis research can be a baseline for government interventions for community based irrigations system improvement and full transfer to the community.

Key words: - Equity, Irrigation, Holetta river, Crop water requirement

1. Introduction

1.1. Background

Irrigation has been practiced in Ethiopia since ancient times for producing subsistence food crops. However, modern irrigation systems were started in the 1960s with the objective of producing industrial crops in Awash Valley. Since mid-1980s, the Ethiopian government has responded to drought and famine through promoting and construction of irrigation infrastructure aimed at increasing agriculture production. These are traditional, small, medium and large-scale irrigation (Awulachew et al. 2007).

Although, various efforts have been made to develop Ethiopia's water resources to increase its contribution to the national economy, a number of factors hinder irrigation development in Ethiopia. According to Rahmato (1999), the major contributing factors for low irrigation development initiatives in Ethiopia is the rugged topographic feature of the country coupled with the lack of investment and technical capacity. Rahmato highlighted that many of the country's rivers flow over deep and narrow gorges that would require enormous resources to utilize the waters for agricultural purposes. Further to this he point out that except for the river Awash, many of Ethiopia's rivers cross international borders; the water is shared by two or more nations, and this creates significant 'ownership' issues with neighbouring countries (Tessfaye Haile 2008).

Overall irrigation development of Ethiopia is estimated to be 5-6% of the developable potential of the 3.7 million ha. The revised figure puts the total irrigated area at about 250,000 hectares. This number gives a per capita irrigated area of about 30 m². The value is very small compared to 450 m² global per capita irrigation area. According to the 2001 Water Sector Development Plan, the targeted growth expansion is also not significant and not expected to bring a significant change of the much-needed economic growth. Considering the population growth and the targeted development of the 2002, water sector development strategy, the per capita irrigated area only reaches 45 m² per head by the year 2015 and does not move the sector significantly. Therefore, given extreme meteorological and hydrological variability in Ethiopia, it is important that significant attention be given to enhance better water control, use and management of the water resources for agricultural production through irrigated agriculture (Awulachew et al. 2007).

Traditional irrigation has a very old history in Ethiopia, especially in some parts of the country like Konso. Traditional irrigation system has been practiced for centuries in highlands of the country (Rahel Deribe 2008). The traditional irrigation schemes are built under a self-help program carried out by farmers on their own initiative and vary from less than 50 ha to 100 ha. Traditional water committees administer the water distribution and coordinate the maintenance activities of the schemes. The total irrigated area under traditional system is estimated to be about 138,000 ha and about 572,000 farmers are involved. Traditional irrigation is also very common in peri-urban areas, particularly in Addis Ababa and Bahir Dar, for the production of vegetables for the local market (Gall 2007).

Farmers have built traditional small-scale schemes on their own initiative, sometimes with government technical and material support. They manage through their own water users association or committees. The household farm size varies between 0.25 ha and 0.5 ha. Water users associations have long existed to manage traditional schemes. They are generally well organized and effectively operated by farmers who know each other and are committed to cooperating closely to achieve common goals. Typical associations comprise up to 200 users who share a main canal or a branch canal. They may be grouped into several teams of 20 to 30 farmers each. Such associations handle construction, water allocation, operation and maintenance functions (Awulachew et al. 2005).

1.2. General problem statement

Current survey reveals evident successes on some schemes, where farmers admitted satisfaction in terms of improvement in incomes, as well as expansion of schemes (farm area) due to increased accessibility to water. However, evidence of conflicts between traditional irrigators and those on modern schemes regarding property rights to water creates a need for clearer water and irrigation management policies, which could be a basic framework for clear definition of water rights. Clearly defined rights to land and water are very crucial and must be taken into account in project design and implementation, if modest investments from farmers are to be expected in land improvement and other production enhancing activities (Seleshi and Merrey 2007).

Irrigation has a tremendous role in addressing food security, income generation and job opportunity for irrigation users. To understand the equity of river water for irrigation among its

users, we need to understand the farmers' interests of crop production, water management practices, socio-economic status and the technology they have been adopting.

In Holetta town of Madda Guddina kebele, the traditional irrigation user has water user associations with seven committee representatives. To control the water sharing using four stations the committee and users appoints two water dividers in each station. Each station would get water for 48 hours except station four to 30 hours which goes to kebele 03. They also have irrigation bylaws to punish those who violate the rules. The rule is a simple guideline rather than legal rules. From experience farmers not well obey the law of water users associations.

The major problem associated with this principle is the issue of equity in water sharing. The river is a perennial river though water sharing become problem in the dry seasons. Due to this the farmers violate the principle and displace the channel to their land. Sometimes the committees take some measures to balance the water sharing, however these measures were found to create conflict among users. The water sharing principle they adopt does not account for types of crops they plant, the stage of growth of the crop, production of land, crop water requirement and community management of the irrigation.

1.3. Focused research questions

There is problems of equitableness and management of Holetta River. This research tried to evaluate scientifically the equity of Holetta River among its users for irrigation purpose. This study would ultimately insure equitably of the river to its irrigation users and make communal irrigation management and utilization in safe way to improve equity.

To attain this goal the focused research questions include:

- Do the existing water sharing principles cause inequitableness?
- Are the traditional irrigation methods efficient?
- Do crop selections by the farmers have contribution to the problem of equitableness?
- What about gender issue in equity?
- What scientific methods would solve such water sharing problem?

1.4. Objective

To assess equity and efficiency of Holetta river water to its traditional irrigation users and the management practice.

Thus the specific objectives would be:

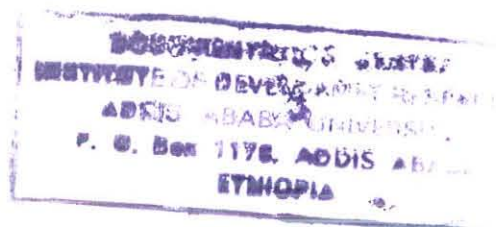
- To know the irrigation water requirement of the crops these villagers are growing based on its frequency and timing
- To improve the management of the river water
- To set scientific water sharing principles
- To improve gender effects in water sharing
- To propose technical and managerial solutions to the problems of equitableness

1.5. Significance of the study

It provides a base for future study to various users and give insight to projects that helps to the society. It is important for planning and management of the river. On the other hand, it support and give an idea for community takeover and management of the river as well. It also shows the status of farmers managed irrigation systems and gives recommendation for better management and capacitating farmer's ability to handle it.

1.6. Scope and limitation of the study

The subject of the study would be those who use or involve in the traditional irrigation at Madda Gudina kebele. Because there are 145 households uses the river with furrow irrigation to their 100 hectare of land for horticultural and field crops production. It is better to study the issue of equity of the rivers compared to among other Kebele's of the town. Thus, survey methods were employed in order to measure the equitableness of the irrigation water diverted from Holetta River. The research is limited to the appropriateness of information gained from the town administration and kebele office about the river and household also may not answers well of their income, capital, and production conditions.



1.7. Organization of the study

The study includes six chapters. Chapter two focuses on literatures related to introduction to irrigations and socio-economic issues. Also it explains traditional irrigation water management and some crop water requirements findings. Chapter three deals the methodology and design of the study and chapter four puts the study areas features and its facts. Then in chapter five detail analysis and result on the objectives to river equitability and scientific irrigation water management presented. Finally in chapter six, conclusion and recommendation are given from the result.

2. Literature review

2.1. Brief memo about irrigation

Irrigation development could be defined as a case of agricultural development in which technology intervenes to provide control for the soil moisture regimes in the crop root zone. The aim is in order to achieve a high standard of continuous cropping. Regarding the ways of supplying water, flood irrigation, furrow irrigation, sprinkling or spray irrigation and drip irrigation are identified. With respect to the area irrigated, scale of operation and type of control or management, irrigation is categorized either as small, medium or large scale. Irrigation may also be categorized using other criteria such as ownership, economic objective and modernity (Darout Gum'a 2004).

Tank irrigation, small dam irrigation and shallow or deep tube irrigation are termed as small-scale irrigation schemes. Some considerations of the criteria of classifying irrigation in terms of scale may vary from country to country. For example, in India an irrigation scheme of 10,000 hectares is classified as 'small' while in Ghana, the largest irrigation scheme is 3000 hectares. However, in most cases, large-scale schemes are formally planned and typically managed by government departments delegated with necessary authority for fairly comprehensive control and while small scale schemes are mostly user managed (Darout Gum'a 2004)

Irrigation projects in Ethiopia are identified as large-scale irrigation if the command area is greater than 3,000 ha, medium-scale if it falls in the range of 200 to 3,000 ha, and small-scale if it covers less than 200 ha. The categorization is based on the size of land area irrigated. In addition to the above classification according to MOWR (2002), the new classification developed by Lempérière also includes the dimensions of time and management. This system distinguishes between four different types of irrigation schemes in Ethiopia: traditional, modern communal, modern private and public (Awulachew et al. 2005).

According to the database developed in the study, "Impact of Irrigation on Poverty and Environment (IPE)", currently, data on 791 schemes has been collected from different regional states of Ethiopia. According to the database, the total estimated area of irrigated agriculture in the country is 107,265.65 hectares out of which 20,038.39 hectares are from small-scale,

30,291.26 hectares is from medium-scale and 56,936 hectares is from large scale (Awulachew et al. 2007).

From Awlacheve and others (2005), the small-scale irrigation schemes in Ethiopia are understood to include traditional small-scale schemes up to 100 ha and modern communal schemes up to 200 ha. However; 'traditional' spate irrigation scheme, for instance in Tigray, of up to 400 also observed

2.2. Irrigation and its socio-economic concerns

Equitable transfer schemes might shed light on how to divide water among farmers producing irrigated crops. The analysis deals with heterogeneous farmers (differing land size, crops) sharing the same pool of water. The only way to sustain no envy and equal sharing individual rationality is to split this pool equally, providing that the water market is competitive and production functions satisfy some regularity property. If not, or if farmers are reluctant to market, one way to implement an efficient allocation of water complying with no envy and equal sharing individual rationality is to price or tax water at its shadow cost (which nevertheless has to be estimated) and to redistribute equally the money collected (Ambec and Ehlers 2007).

A comprehensive study in Oromia, Amhara, and SNNP and Tigray regions of Ethiopia finds there is significant difference in incidence, depth and severity of poverty between households with access to irrigation and those without. However, the poverty incidence among the sample households is still unacceptably high irrespective of access to irrigation, indicating that poverty deeply entrenched in rural Ethiopia. Poverty incidence is also related to the cropping pattern, indicating that mere access to irrigation would not bring the desired results. Poverty situation is more sever among farmers devoting significant proportion of their cropping land to food grains (cereals, oil seeds and pulses) irrespective of access to irrigation. Vegetable growers are better off in terms of poverty situation. The implication is that irrigation project planners should consider the crop mix in future irrigation development plans (Namara eta'l. 2007).

Poverty indices were found also to be responsive to the irrigation intensity as measured by the size of irrigated area. Poverty incidence is significantly lower among households with higher irrigated area size. Due to demand outstripping the limited supply of irrigation service and considerations for equity, irrigation plots are rationed in Ethiopia. The limited differentiation observed in the size of irrigated land among sample farmers is due to the prevalence of informal

irrigable land markets. This calls for an investigation to determine a minimum irrigated area that needed to be allotted to a household for sustained poverty reduction and food insecurity eradication. Poverty indices are also responsive to irrigation typology and irrigation intensity. Among the irrigation the two irrigation typologies studied the poverty situation is relatively milder among modern irrigation scheme users (Namara et al. 2007).

Poverty and irrigation nexus whether has an effect on income inequality or not showed different assumption. In this regard quantitative evidences from empirical studies on various countries show a mixed picture. A study made by Marrit and Ruerd (2005) in Ethiopia found that irrigation stimulated growth without deepening inequality. However, Kimmage (1991) in Nigeria, Hussein and Hanjra, (2004) in India have argued that irrigation has large been more beneficial to the rich and thus increased inequality (Tessfaye Haile 2008).

On the other hand, Namara and other (2007) study showed that income inequality among households with access to irrigation is worse than that of those without access. The implication is that even though accesses to irrigation moves up the mean income, farmers have different capacity in making better use of the available irrigation water and therefore irrigation widens the income gap. However, the main policy concern in Ethiopia is reducing absolute poverty at this moment. Finally, the study confirms that while the income inequalities among households without access to irrigation are lower, it was found that inequality among rain-fed poor farmers is higher than those with access to irrigation.

The FAO (1999) pointed out that many Sub-Saharan countries have realized the critical role of irrigation in food production. However, the relatively high cost of irrigation development combined with the inadequate physical infrastructure and markets access, poor investments in irrigation, lack of access to improved irrigation technologies, and lack of affordable and readily available water supplies, have been responsible constraints for a relatively slow rate of irrigation development in this region. FAO further identified fragmented and small land holding, unsecured or lack of land titles, high interest rates, and poor transportation and marketing facilities as further constraints affecting the capacity of farmers to invest and manage irrigation projects (Tessfaye Haile 2008).

International experience with farmer irrigation management suggests that, for a successful community management of irrigation schemes, the economic and financial costs of sustainable self-management must be a small proportion of improved income. The transaction cost of the

organization must be low, and irrigation must be central to the improvement of livelihoods for a significant number of members. Developing local leadership skills for irrigation management also appears to be a key factor for successful collective irrigation management (Rahel Deribe 2008).

Irrigation systems are highly interdependent as the ability of individual farmers to appropriate water is greatly influenced by the behaviour of farmers in the area. Where irrigation water serves more than a single person, patterns of social interaction govern the use of those facilities. Realizing that irrigation water is a community property and therefore needs communal management can be the impetus for farmers to organize and community management of irrigation often involves the formation of organization of formal user groups known as Water Users Association (WUAs) (Darout Gum'a 2004).

Most of the new initiatives for forming WUAs and management strategies do not evolve from the traditional system. Instead, the structure is largely imposed by government agencies and the donor community. The long-run sustainability of these institutions often remains questionable. In general it seems desirable to use existing local organizations. If the existing organizations are insufficient or inadequate for the purpose, careful analysis should lead to the design of facilitating organizations congruent with local culture (Darout Gum'a 2004).

There is no specific policy on irrigation in Ethiopia. Therefore, it is part of general Water Management. The legal framework of water management is defined in the Ethiopian Water Resources Management Proclamation No 197/2000 and the Council of Ministers of Ethiopian Water Management Regulations No 115/2005. The Ethiopian Water Resource Management Policy defined the selected options to be used as instruments for achieving intended goals and objectives and give general principles and directives. To realize this goal, the government has spelled out a number of specific objectives (Gall 2007).

However in the existing documents the problem of water allocation between different uses is raised. The water is considered as an economic and social good. As it is states in Water Resources Management Proclamation the domestic use shall have the priority over and above other water uses (Federal democratic Republic of Ethiopia, 2000). But the first principle adopted is an Integrated Water Resource Management. Subsequently All social and economic development programmes, investment plans and programmes and water development activity of any person shall be based on relevant Basin Master Plan Studies (Gall 2007).

Irrigation development is one of the major pillars of the rural development strategy. In more recent years, the strategy of irrigation has shifted from large-scale approaches to small-scale and household level intervention. Following the new policy, most regional states have introduced household level irrigation schemes at massive scale aiming to achieve food security. For instance a report by the ministry of agriculture and rural development (MoARD, 2007) indicates that in 2007 alone about 952,000 households have built small water harvesting ponds to promote irrigation at farmer level .Nevertheless, such intensive interventions lack comprehensive studies that can help improve the effectiveness of policy approaches in achieving food security and poverty reduction (Berehanu Haile 2009).

2.3. Traditional irrigation water management in Ethiopia

The best starting point perhaps is to learn from the success of traditional irrigation systems, especially from the institutional and legal aspect of water administration and management. Understanding the evolution, development and functioning of traditional water users associations should give important insights as how to organize and develop modern irrigation associations (Rahel Deribe 2008).

Community participation in spate irrigation at Raya valley shows the farmers in the study sites is self-organized under water users associations. The major problem with traditional irrigation systems is the frequent damage caused by flooding on the traditional diversion weir and irrigation infrastructure. As the result, farmers are engaged in repeated maintenance of these structures (Haile Kidane 2009).

Another study in Eastern Oromia in two-irrigation system called Doni Kunbi and Bato Gegaga small-scale irrigation revealed that small holder's irrigation is very important. This is especially true in areas where insufficient and erratic rainfall is a recurrent phenomenon. Moreover this study revealed, a number of technical, institutional, policy and management problems that constraint irrigation performance. Despite the existing irrigation water users association (IWUAs), lack of support from different stakeholders' has affected their influence in the irrigation development (Lemma Dinku 2004).

For instance, the traditionally formed IWUA did not get facilities such as credit and market information because the agricultural policy gives priority to farmers that relay on rain fed agriculture. Generally, the result of this study showed, construction of irrigation infrastructures

by itself could not result in significant change. For successful irrigation project performance, beside construction of irrigation infrastructure it is equally important to consider the social aspects (Lemma Dinku 2004).

There are farmers' co-operative organisations in some places providing credit services for WUAs operated community-based small-scale irrigation schemes. Farmers participate in the construction and maintenance of community-based irrigation schemes by contributing labour and locally available materials. The efficiency of community-based irrigation schemes is generally low; although, there are efforts, in some donor-funded projects, to develop demonstration trials aimed at improving efficiency. The highly centralised top-down approach to rural development in the past has had a negative effect on farmers working together as a group. Therefore needs to be a concerted effort to create awareness among farmers' groups as to the benefits of working together - such as better services relating to water distribution, increased bargaining power, access to credit, and improved infrastructure (Mekuria Tafesse 2003).

Women are not participating, as expected, in irrigation activities. This is mainly because women are mainly engaged (culturally) in household activities such as child rearing, food preparation, water fetching, etc. However, addressing issues relating to gender sensitivity and balance is now a priority in the implementation of community-based projects (Mekuria Tafesse 2003).

Institutional analysis of water management on communal irrigation in Tigray (Atsbi Wemberta) district and Oromia (Ada'A) woreda in 22 schemes shows that the participation of female-headed household at forum and leadership is very low. However, the estimation result shows that less number of conflicts and violation of rules are associated with high proportion of female household headed. This suggests policy intervention is needed to encourage the participation of women in farm, forum and at leadership level in water users associations and in conflict resolution committee. In addition, effort should make to change the wrong perception of the society towards gender inequality (Rahel Deribe 2008).

The study was conducted using a sample of 80 farmers selected from four districts of Awi Zone, to detect where do inefficiencies exist and identify the possible causes. Following many of the previous empirical works, stochastic frontier production was employed to analyze the data. This method was used for its better ability to detect the level of efficiency through decomposing the error term into random noise and inefficiency effect (Temesgen and Ayalneh 2005).

The findings of the study indicated that farmers operating under traditional irrigation schemes are

efficient; hence, improving productivity requires introduction of new technology. On the other hand, farmers producing under modern community irrigation schemes have a significant inefficiency so that the productivity of these farmers can be raised through improving their efficiency. The main causes of inefficiency were identified to be inadequate irrigation experience and discouraging price of the produce. Higher size of livestock was also identified as one of the causes of inefficiency (Temesgen and Ayalneh 2005).

Through century old practices, farmers of Amhara region have used their indigenous knowledge to innovate sustainable irrigation practices to address their water management needs. These practices and innovations stretch from abstraction of water, designing and development of diversion structures, designing of irrigation canals, crossing of big gullies, developing appropriate cropping systems and equitable sharing of water to conflict management issues. Impact of such practices have led to improved irrigation water use efficiency and better cropping systems in most of the traditional. However, water allocation and distribution systems among users should be adjusted by considering problems of female-headed household and elders (Hanibal et al. 2008).

A case study on two traditional irrigation schemes in North Gondar shows the farmers have developed knowledge of irrigation management and crop selection in production. Farmers in Beles traditional scheme prefer to produce garlic because of its storage ability and high profit margin whereas farmers in Zarima prefer to produce pepper because of its profit margin and tomato due to its productivity (Hanibal et al. 2008).

Generally, farmers shift from consumption to market oriented farming system. They focus on crops that give high price per yield, high yield per unit area and market oriented agricultural system. Farmers of both schemes are trying to maximize their benefit through utilizing the synergetic effect of both irrigated and rain fed systems, i.e. some crops are sown under irrigated systems but are grown and matured in rainy season and vice versa. This helps to increase irrigation intensity by harvesting and replanting crops at any time of the season. The methods and frequency of irrigation and depth of application of water for each crop is developed and fine-tuned by farmers themselves (Hanibal et al. 2008).

2.4. Crop water requirements and water balance studies in Ethiopia

A water balance often leads to the understanding of hydrological systems. This water balance states that the water inflow to an area must equal the outflow, plus any change of water storage within the area. The major hydrological components that play a role in the water balance are precipitation, river flow, evapotranspiration, water storage and ground water flow (Eyasu Yazew 2005).

In 1998, International Water Management Institute (IWMI) performed a comprehensive water balance studies in the command area of Sirilanka's Oya irrigation scheme to assess the impact of water consumption by perennial vegetation. The study found that perennial vegetations' consumes almost twice the amount of water as crops in the area. The main conclusion from this study is that water consumption by perennial vegetation should be a significant consideration in irrigation planning management and performance assessment (Renault 2001).

A survey on the Godino irrigation scheme revealed that farmers used the same amount of water and intervals, regardless of crop species and growth stage. In an effort to improve the water productivity, two traditional irrigation-scheduling methods were compared with two scientific methods, using furrow irrigation. The growth performance and tuber yield of potato (cv. Awash) revealed that irrigation scheduling using a neutron probe significantly outperformed the traditional methods, followed by the SWB (Soil Water Balance) model irrigation calendar. Since the neutron probe method involves high initial cost and skills, the use of the SWB Calendar is suggested as replacement for the traditional methods (Geremew Eticha 2008).

Also series of field, rain shelter, growth cabinet and modelling studies were conducted to investigate hot pepper response to different irrigation regimes and to calibrate and validate the soil water balance (SWB) model. Soil, climate and management data of five hot pepper growing regions of Ethiopia were identified to develop irrigation calendars and estimate water requirement of hot pepper under different growing conditions. High irrigation regimes increased fresh and dry fruit yield, fruit number, harvest index and top dry matter production. Yield loss could be prevented by irrigating at 20- 25 % depletion of plant available water, confirming the sensitivity of the crop to mild soil water stress (Yibekal Alemayehu 2009).

Besides that to facilitate irrigation scheduling, simple canopy cover based procedure was used to determine FAO- type crop factors and growth periods for different growth stages of five hot

pepper cultivars. Growth analysis was done to calculate crop-specific model parameters for the SWB model and the model was successfully calibrated and validated for five hot pepper cultivars under different irrigation regimes. FAO basal crop coefficients (K_{cb}) and crop-specific model parameters for new hot pepper cultivars can now be estimated from the database, using canopy characteristics, day degrees to maturity and dry matter production (Yibekal Alemayehu 2009).

The comparison between a spatially distributed crop index and reported yield was evaluated in Ethiopia. The crop index was generated by a crop water balance model that simulates the reduction of crop yield (as a percentage of the potential) due to water deficit. This model is currently operational as a monitoring and forecasting tool for region-wide food security analyses in drought prone countries in Sub-Saharan Africa. The most important input parameters of the model are Africa-wide satellite-based rainfall estimate images and spatially distributed potential evapotranspiration images calculated from 6-hourly numerical weather model data. District level crop yield data from Ethiopia were used to evaluate the performance of the model. Historical sorghum yield data from 1996-1999 were used to evaluate the performance of a seasonal water requirement satisfaction index (WRSI) for sorghum. WRSI values and reported district yield data were significantly correlated (Gabriel and James 2002).

The WRSI model was particularly successful in capturing the response of the crop during a relatively dry year. In districts that never experienced water deficit during the study period, it was possible to infer the magnitude of yield variability that was caused by factors other than water supply. There was no indication that the percent area of sorghum in a district influenced the relationship between WRSI and reported yield. This was probably due to a wrong assumption in using only sorghum area instead of total agricultural area in the district (Gabriel and James 2002). Future studies should re-evaluate and address the importance of the size of agricultural area while comparing district-wide WRSI with yield data collected from a fraction of the district area. This study also showed that a small change in WRSI can result in a larger change in yield. Published yield reduction functions were generally at a plot level whereas the relationship evaluated comprised of several thousand farm-plots in a district. Instead of using or assuming a yield reduction function that was established at experimental stations it is recommended that such yield reduction function be established for various regions (Gabriel and James 2002).

Study examined the impact of climate change on crop production in two districts in Ethiopia and also assessed adaptation measures in these districts. The research was implemented by a

national team under the FAO leadership. It developed a unified approach to crop simulation modelling of the relationship between yield and evapotranspiration as the measure of water use by crops. The country team adapted the FAO's CROPWAT program to assess potential and actual crop water use by maize and sorghum in the Adama and Mieso districts. The simulation of yield reduction and estimation of crop use was based on ten-year crops and meteorological data using the model (CEEPA 2006).

The study results give realistic values for maize and sorghum evapotranspiration and actual yield. The crop water response analyses show markedly different results between the two districts. They also show that the gap remains wide between actual and potential yield and actual and maximum evapotranspiration, especially in drier conditions for rain fed crops. However, rain fed maize and sorghum seem to be performing better in terms of crop water use in the sub-humid climate of Adama than in the semi-arid climatic conditions of Mieso, since Adama has better rainfall (CEEPA 2006).

This corroborates the well-known fact that water is among the main limiting factors in most African farming systems and therefore irrigation could play an important role in agricultural development. The average values for crop water productivity (CWP) for these crops do not exactly match the commonly published ranges. As expected, sorghum appears to be the most water efficient crop grown in the selected districts and performs especially well in the dry conditions of Mieso, with very low actual evapotranspiration and still reasonable actual yields (CEEPA 2006).

Maize is a more water demanding and stress sensitive crop. From the results observed from Adama and Mieso, maize water productivity appears to be even poorer than usual standards. This might well be due to a varietal problem or to crop management issues. In any case, maize should be grown only where good availability of water can be guaranteed. It should therefore be grown under irrigation or in rain fed areas where rainfall is reliable and the crop needs can be adequately satisfied. In response to this situation, various adaptive measures have been undertaken in the selected districts as well as all over the country. Use of supplementary irrigation (small scale irrigation with tanks, water harvesting), mulching and the application of soil water conservation techniques, alternative crop management features (adapted planting densities, timing of operations, conservation tillage, intercropping) are being applied and should be further encouraged (CEEPA 2006).

The effect of rain-fed with rain-fed supplementary irrigation on yield and yield components of Maize (*Zea mays* L.) was carried out at Mekelle University main campus under Tigray region in Ethiopia. The experiment was laid out in a Randomized Complete Block Design (RCBD), and investigated in the early cropping season of the year 2007. There were two main treatments (Rain-fed (R1) and Rain-fed with supplementary irrigation (R2)). The R2 was irrigated three day interval after seedling at 110litre/plot. Fertilizer was applied to each plot at the rate of 180kg Dap/plot and 30gramUrea/plot. All management practices were the same with exception of water added to R2. Data were analyzed for variance and LSD at 5% level of significance (Bello 2008). Result showed significant response on soil moisture content, harvested plant stand with number of cobs, fresh grain weight (kg) and dry grain weight (kg) while other parameters (plant height, number of rows with cobs, number of seed/cob and 1000 fresh and grain weight (kg)), shown non-significant difference. The significant effect on harvested plant stand with cobs number indicated that the use of supplementary irrigation is essential for maize production in arid environment. However, there is need to re-investigate the same experiment during the late cropping season to strengthening water use efficiency of the crop and minimize the effect of climate impact (Bello 2008).



3. Methodology

3.1. Research design

This study includes one kebele traditional irrigation users that use Holetta River for agriculture purposes which are led by the community through water users associations. From Wikipedia (2011), a case study is a research method common in social science. It is based on an in-depth investigation of a single individual, group, or event. Due to this the researcher chooses a case study to raise detail and intensive analysis of the community.

For interpreting and validating results, combining qualitative and quantitative methods provides a richer, contextual basis. Combining these methods introduces testable research into the context. Collecting different kinds of data by different methods from different sources provides a wider range of coverage that may result in a fuller picture of the unit under study than would have been achieved otherwise (Kaplan and Duchon 1988).

Through the study both qualitative and quantitative approaches were taken to know the behavioral, knowledge and attitude of the target group. It also helps to understand the level of production, their irrigation utilization and management practice. Their experiences and issues on equity and management of the river were assessed by field observation as participatory manner.

3.2. Data source and type

Both primary and secondary data sources were utilized in the study. The researcher take up primary data collected through irrigators and relevant officials at town and kebele level in-person (face-to-face) interviews, questionnaires and direct observation of the site. In addition to these primary data, meteorological and agronomic data relevant to the crop water requirement computation also have been collected. Crop water requirement, irrigation water management and documentations on hydrology of Holetta River are used as secondary data.

For the evaluation of crop water requirement and water balance studies metrological data of the area from 1989-2009 years were used. The metrological data were maximum and minimum temperature, humidity, sunshine hours and wind speed. Also agronomic data specially type of

crop, harvesting and planting date and its area of coverage taken. Due to difficulty in getting general soil data of the area both FAOs and some information of the area were used.

The first step in data collection was rapid reconnaissance, where the researcher has been able to form household typology and familiarize him with the study area. During that time Oromia Water Resource Bureau, Oromia Environmental Protection Agency and Investment Bureau were visited concerning irrigation water management and water equity. In the respective offices there is no clear laws regarding community water right and investors act in using and managing the resources in and in the vicinity of leased areas. Also the direct observations of the traditional irrigation structure maintenance activities of the farmers in the winter were seen as the reconnaissance of this study.

Secondly after conducting a pre-test, a questionnaire survey to the household were taken. From this the researcher has got the current scenarios concerning to the study. The finding was the status of farmer's demographics, management and utilization of the irrigation. Next to the survey, to further magnify the research a key informant interview, frequent direct observation at field on farmer campaign activities and in meeting was evaluated.

3.3. Sampling design

There is no formula to determine the size of a non-random sample. Usually in qualitative research, it is possible simply to enlarge the sample gradually and analyze the results as they come. When new cases no longer yield new information, it is promising to conclude that the sample is saturated and finish the job. This method is however very sensitive to bias sampling, so care should be taken to avoid any important groups from the population under study (<http://www2.uiah.fi/projects/metodi>, 2010).

Before the households were selected for survey, the researcher made discussion with irrigation and agronomy expertise and certain households. Among 145 households that cultivate 100 hectare of land, 24 households were purposively selected for the questionnaire survey. Also from the four irrigation stations, the three stations were selected for the study. The selection of households and stations was dependent on the data from reconnaissance findings.

Convenient sampling was used to get 10 respondents for key informant interview to support the questionnaire collected. Five irrigation and agronomy professionals from Holetta town and Wolmera Woreda (district) agriculture office and five water user's committee member from

farmers were interviewed. From both categories one female on each had been get for the interview.

The selection of the household for interview from each station was attributed to the researcher perceptions that came from the prior visit to the study area. The respondents from each station were classified and arranged based on the land size and availability of water. It was difficult to include female-head due to the fact that they mostly have rented in/ shared in their plot to others or they hired to their children. But the researcher tried to include almost 20% from the total interviewed household.

Table 1: Total sample size for household interview.

Station	No of household	Sex		Av Land hold /ha	Water availability
		M	F		
1	7	5	2	0.25	Available
2	10	10	0	1	Shortage
3	7	4	3	0.75	Available

Source: - Prior study selection result, 2011

3.4. Instruments used

According to Sommer (1997), to collect more idea the questions have to be open ended. Therefore, the open ended questionnaire was developed to collect more information from the surveyed households. The questionnaire was divided in to four major parts. The first, two parts were used to collect information about the characteristics of the households. The last two focused on behavioral, skill and knowledge, attitudes and perceptions of the target group towards traditional irrigation. Also unstructured interview was used to collect data from water users committee and relevant experts. For the completion of the research a detailed structural observation about the crop production, water utilization and management was taken place. The questionnaire and interview was translated into Amharic for better communication and understanding.



3.5. Data analysis

The descriptive statistics and crop wat model were the major data analysis method employed in this study.

3.5.1. Descriptive statistics

The process of analysis has been carried out by using qualitative description and descriptive statistics. To analyze, the data on social aspects, Statistical Package for Social Science /SPSS/ (version 17) is used. Non-quantifiable data from open-ended questions, key informant interviews, and direct observation have been discussed through qualitative description.

3.5.2. Crop water requirement (crop wat)

According to FAO (1998), for analyzing the crop water requirement, irrigation scheduling and scheme design, metrological and agronomic data of the study area could be analysed by using the software of Crop Wat (8 version). Below general outlook of crop water requirement, scheduling and scheme design are highlighted but for detail understanding and elaboration see appendix two.

3.5.2.1. Crop water requirement (CWR) calculations

Calculation of the CWR can be carried out by calling up successively the appropriate climate and rainfall data sets, together with the crop files and the corresponding planting dates. In case of CWR calculation of soil data are also required.

3.5.2.2. Irrigation scheduling

The calculations of the scheduling module are based on a soil water budget, where on a daily basis, the soil moisture status is determined, accounting for incoming and outgoing water in the root zone.

3.5.2.3. Scheme and canal water requirements

The irrigation supply to any irrigation scheme or command area can be calculated by adding up the requirements of each cropped area. Any changes in cropping pattern can be conveniently calculated by modifying area size of the different crops.

4. The Study Area

Holetta is a town in central Ethiopia located in the Oromia region. This town has a latitude and longitude of 9° 3' 0'' N 38° 30' 0'' E, 9.05; 38.5 and an altitude of 2391 meters above sea level. The town also hosts a research station of the Ethiopian Institute of Agricultural Research founded in 1963; this station is the national center for research to improve the yield of barely, highland oil crops, potatoes, and dairy products. Holetta was the first place in Ethiopia to have a permanent water mill, built in 1909 on the Holetta River (Holetta Genet 2010). Currently the town is divided in to 8 kebeles and different governmental and non governmental institutions (Holetta town administration 2011).

Based on figures from the Central Statistical Agency (2005), Holetta Genet has an estimated total population of 30,007 (14,825 were men and 15,182 were women). (Holetta Genet, 2010). While from Holetta town Administration (2011), in 2010 census the population is 36,705. In general Madda Gudina Kebele has 1219 population of which 594 and 625 are male and female, respectively.

Holetta River is a perennial river with catchment area of 156 m² and 64 m³/sec of its maximum probable flood discharge from hydrology analysis. There are 145 households who use the river with furrow irrigation to their 100 hectares of land for horticultural and other field crops production. As seen from the command area the farmers have long experience on traditional irrigation cultivating specially potato and they sell their product at Addis Ababa. Beside on the traditional irrigation in Madda Gudina and 03 Kebele, Holetta research center has a command area of 50 hectares that use the river for irrigation by traditional way (Holetta town Administration 2011).

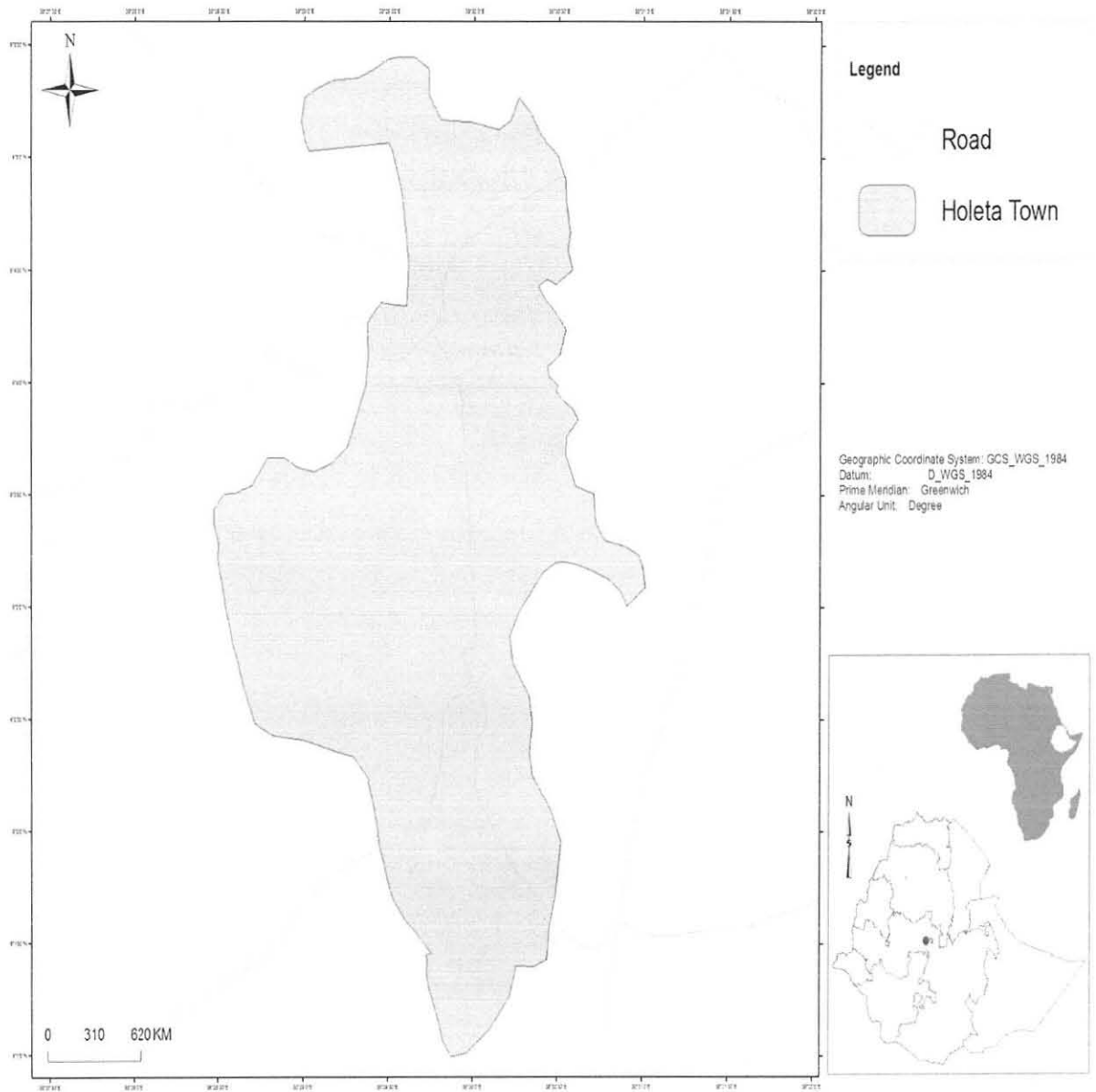
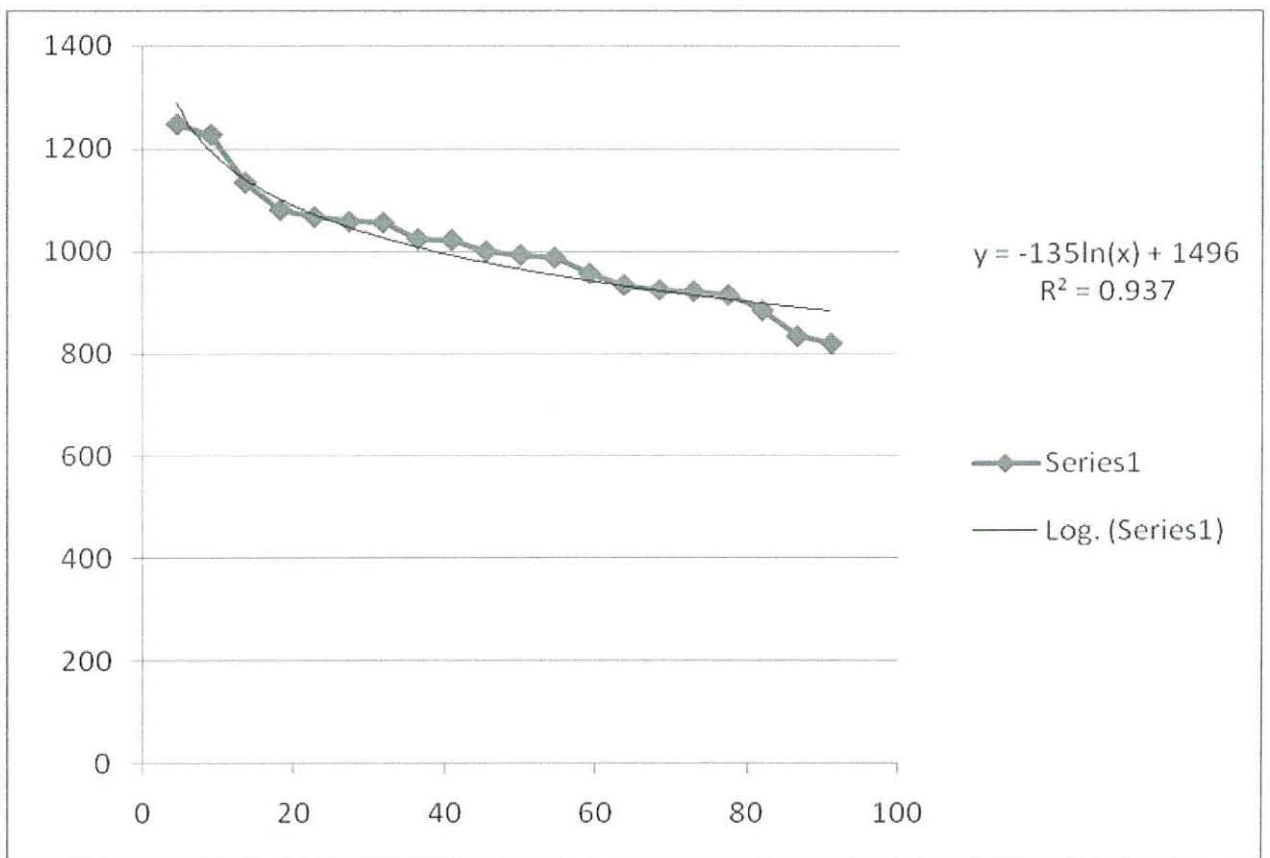


Figure 1. Map of the study area /Holetta/

The minimum and maximum temperature of the site is with range to 6 and 24 °c respectively. Annual rainfall is about 1100 mm and altitudes approaches to 2400m and clay loamy/red/ soil exist in the site. From Holetta town administration small scale irrigation project document (2010), recommended crops are potato, onion, garlic and tomatoes on the first cropping seasons with full irrigation. In second cropping also include cereal, wheat, and barely. The recommendation came from physical and social factors.

Figure 2. Yearly rainfall probability of Holetta (rain fall in mm and its percentage) from logarithmic regression



Source: - Own result, 2011



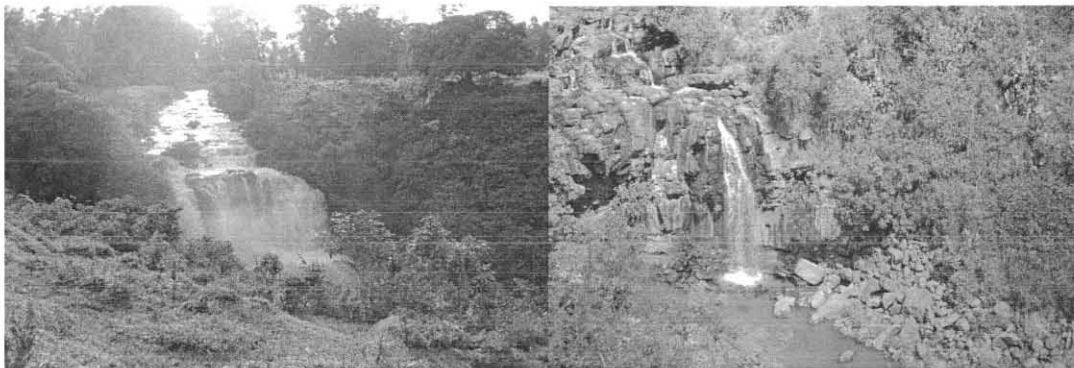
5. Result and Discussion

Three subsections are discussed in this section. In the first sub section direct observation result of traditional irrigation in Holetta River are described. In the second part the characteristics of sample households are discussed and in the third subsection crop water estimation results which include, crop water requirement, irrigation schedule and scheme design of traditional irrigation system of Holetta River in the Madda Gudina kebele are discussed.

5.1. Direct observation result on Holetta River and irrigation activities

Holetta River is a tributary of Awash River. This river is perennial but its level decrease in the dry period. From this water is distributed to users to ensure water shortage in the area without giving attention on the type of crops farmers grow (see fig 3).

Figure 3. Image of Holetta River in wet and dry season

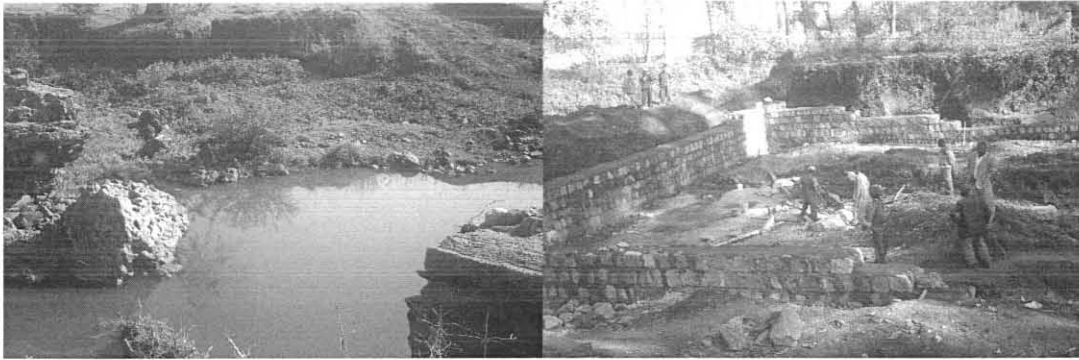


Source: - Survey result, 2011

In the wet period the river cause flood and the traditional irrigation system structure frequently gets damaged. Due to this farmers engaged in repetitive maintenance works. Soil erosion and natural resource degradation also became a problem in the village.

The dam was totally broken before six years. Here after there was no any activity to construct a dam. Recently some studies were initiated by Holetta research centre and town administration. But there was conflicting interest between Oromia irrigation office and research centre with location of the dam.

Figure 4. Holetta river old dam (left) and new diversion structure under construction



Source: - Survey result, 2011

The project was not proceeding due to budget constraint. After that the research centre and Holetta town administration (on the behalf of farmers) agreed to construct diversion structure in the place where the research centre selected before. Now it is on the way of construction but some peoples are not confident about its sustainability of the structure for long time. The reason they put are white stones which is used for the construction may leak water and from design perspective the height of the structure not long and covered (see fig 4).

Team leader of farmers who are responsible for mobilizing and collecting all the costs for the construction of new diversion structure are participate well in the meeting. The meeting was lead by the kebele chair man. In the occasions suggestions were given to those who do not contribute money for the construction has to be checked and their reasons also need to be seen whether it is political , administrable or carelessness, etc,. Also farmers who do not take part in campaign works should be punished and the social justice / Ferede Shengo / also has to abandon to farmers only warning without taking any measure.

The hand-outs of farmers for the construction are from 30 birr as of dwellers that do not own land and up to 200 birr depending on land. Farmers reply that the methods used for setting money in each user are not clear and fair.

Holetta research centre also monitoring the construction with supplying materials. Farmers perceived the fact that support from Tseday farm and Holetta ATVET College is low. Farmers also agreed to sign for the new bylaws which is given by Oromia irrigation office ordering them to use only 0.25 ha of their land from the irrigation.

With reference to water allocations different groups share. The college is getting once a week for 1.2 ha of potato field and the research centre is taking their way to get water for the whole research purposes without putting recommendations on crop water requirement. The research center constructs a big reservoir and also they get water four days a week sharing with farmers from 8 am – 3 pm (see fig 5 and 6).

Tseday farm sometimes use water from the river by pumping. Farmers were not happy with Tseday farm and the research centre for pumping water from feeder channel. These activities may lower the water which goes to farmers. The new reservoir is starting to store water but not work at this time totally. It is designed to deliver water to field through gravity. Both Tseday and Holetta research have 20 ha and 50 ha of land meant for production and research purpose respectively. Other kebele farmers also use the river for the irrigation purpose. As the result Madda Gudina kebele farmers are claiming for other kebele users to contribute money and labor for construction of the new structure.

Figure 5. Holetta research center open and closed channel for irrigation



Source:- Survey result, 2011

Figure 6. Holetta research center reservoir



Source: - Survey result, 2011

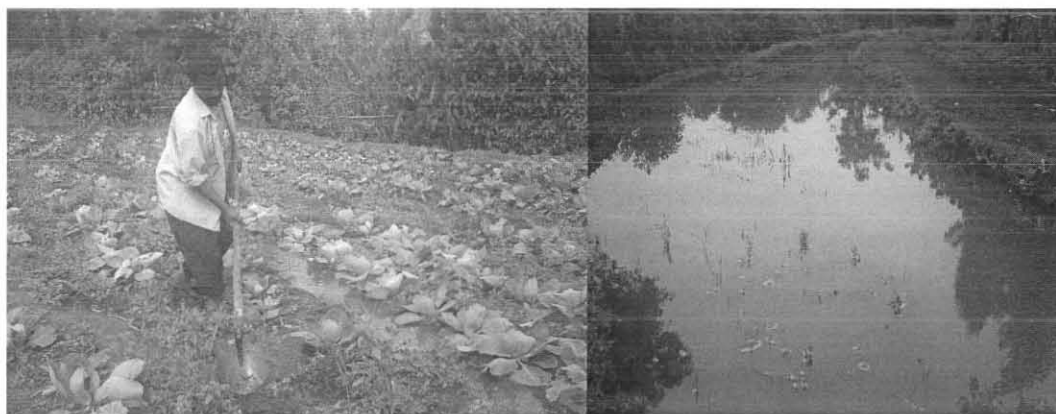
Farmers' participation in the diversion structure construction was less. In the campaign work of the new structure almost less number of farmers participates even though most of them called before. Farmers think this would be measure from the WUC become low. Due to this from time to time the participation of all farmers in the irrigation management of the whole aspect is not effective.

Entrepreneur invasion to the area is increasing. Farmers believe this result for conflict since they violate the water sharing principle. Intentionally they also disobey the law by guaranty of their money. The kebele and other responsible organizations do not take collective action.

Farmers' water application is subjected to water wastage. Their furrow system is not prepared on best way. Besides this the channels in which farmers transfer the water to their field are damaged and being wide. They didn't get any training towards how to manage and use water system and enlarge crop yield with mounting water productivity (see fig 7).

The water is travel more distance to address all users and the geographic features of area also upshot water wastage. There is also land which could not irrigate otherwise pump used. Farmers mainly use this type of field for production of cereals in the rainy season.

Figure 7. Farmers water application and channel widening



Source: - Survey result, 2011

Female mostly not involved in the general condition and status of irrigation. They spent much time on home duty. Those whom their husband died mostly rent/share their field. They also not

participate in the water management aspects. The society believes that managing the river and irrigation water is even difficult for male. Female achievement and empowering would be defect by this.

5.2. Result of household and key informant interview

This section is mainly concerned with demographics, production status, irrigation water management and issues of equity.

5.2.1. Demographics

Majority of respondent's age are between 30 and 45. The productive one with 45.8 % and 25 % are age range from 47 to 60 and youth comprise in 16.7 %. Ages representing between 65 and 84 are in 12.5% (elders). Table 2 shows the detail of age classifications.

Nearly everyone has leaved in the area more than 14 up to 60 years. From this it is possible to conclude that the localities are aware of the areas they live. Moreover some of them born and grew there. Table 3 shows the feature.

Table 2. Age of the respondent

Age	Frequency	Percent	Valid Percent	Cumulative Percent
	Number	%	%	%
19-28	4	16.7	16.7	16.7
30-45	11	45.8	45.8	62.5
47-60	6	25	25	87.5
65-84	3	12.5	12.5	100
Total	24	100	100	

Source: - Survey result, 2011

Table 3. Years live in the area up to now

Existence/Year/	Frequency	Percent	Valid Percent	Cumulative Percent
	Number	%	%	%
0.5	1	4.16	4.16	4.16
14-28	9	37.5	37.5	41.7
30-45	9	37.5	37.5	79.17
48-60	4	16.6	16.6	95.8
84	1	4.16	4.16	100
Total	24	100	100	

Source: - Survey result, 2011

Among 24 sample households the six are female and from the female the four are heads and others are house wife. Also from 18 male only the one is son of female head. To know heads as governing their house the researcher cross tabulate sex and responsibility. In further table 4 describes.

Table 4. Responsibility and sex of the respondent in the household

Sex	Responsibility			
	Head	Wife	Son	Unmarried
Male	17	0	1	1
Female	4	1	0	0
Total (24)	21	1	1	1

Source: - Survey result, 2011

Concerning education status in school years only 12.5 % has got the chance to join 9-11 years. Most of them are in the category of 5 -8 by 41.7 %. First cycle in addition includes in 25.1% and 16.7 % of the respondent doesn't get modern educations. Table 5 presents more of this. Regarding on family size, 75 % of selected households family size are 4-6 and 16.6 % has a family size of 1- 3. The family size having 7 to 9 members is 8.4 % (see table 6).

Table 5. Education level of respondent in school years

School years	Frequency	Percent	Valid Percent	Cumulative Percent
	Number	%	%	%
0	5	20.8	20.8	20.8
2- 4	6	25.1	25.1	48.8
5 -8	10	41.7	41.7	87.5
9-11	3	12.5	12.5	100
Total	24	100	100	

Source:-Survey result, 2011

Table 6. Family size of the respondent

Family size	Frequency	Percent	Valid Percent	Cumulative Percent
	Number	%	%	%
1-3	4	16.6	16.6	16.6
4- 6	18	75	75	91.7
7-9	2	8.4	8.4	100
Total	24	100	100	

Source: - Survey result, 2011

5.2.2. Production status

More than half of household's asset lies in 2,500 birr to 15,000. Only one household has 100,000 birr assets combined by agriculture and pension. Consequently seven households have possessions of 20,000-50,000. Regarding income source and property hold, more than half of them entirely rely on agriculture. Nine households are found to have additional income source beside agriculture. In table 7, part of the analyzed data is displayed.

Table 7. Assets hold in birr and source of income

Income source	Assets hold (1000 Birr)				
	2.5 -5	10 -15	20-30	47-50	100
Agriculture	6	4	2	3	0
Agriculture& government job	0	2	0	0	0
Agriculture& day labor	2	2	0	0	0
Agriculture& pension	0	0	2	0	1
Total (24)	8	8	4	3	1

Source: - Survey, 2011

Out of 24 households, 10 have landholding in the range of 0.75 -1.25 hectare. Only two own more than two hectare and five farmers has 0.125 -.025 ha and also six has in between 0.375 and 0.5ha. Most of households source of land are government and family also contributes. With assessing the sample households the rate for rent in and shared are less. Table 8 specify of these.

Table 8. Land hold in hectare and its source.

Source of land	Land hold (ha)			
	.125-.25	.375 -.5	.75-1.25	2- 3
Government	2	4	2	1
Inheritance from family	1	1	7	1
Shared in	2	0	0	0
Government& rented in	0	1	1	0
Inheritance& shared in	0	0	1	0
Total (24)	5	6	11	2

Source: - Survey result, 2011

Among vegetable Chinese cabbage production are high recording to 44.4 quintals. Eight households in Chinese cabbage productions prefer crop rotation. The seven whereas divided their land varyingly to different crops. Subsequently potato and tomato rank in two and three consequently. Most of farmers of which surveyed allocate their land to different crops but crop rotation is also an option existed in the study area. Production of cereals is to much less though barley goes around to 7.9 quintals. All cereals are cultivated in meher/summer season in Ethiopia in once a year. As regards to vegetables they produce with help of irrigations in dry seasons almost once a year except for tomato and cabbage which twice a year by belg/spring/ rain and irrigation in two households of the sampled farmers. Table 9 and 10 clearly explain both production and farming practices.

Table 9. Average annual production in quintal and land allotted by households

Crop	Annual Production (qt)		Land allotted by households	
	Number	Rotation	Divided	
Barley	7.9	4	1	
Wheat	4.6	7	14	
Tef	1.9	7	12	
Potato	39.15	11	11	
Tomato	16.2	6	4	
C.cabbage	44.4	7	2	
Cabbage	21.5	3		

Source: - Survey result, 2011

Table 10. Farming system and harvesting frequency per year of households

Crop	Farming system			Harvesting Frequency
	Irrigation	Belg rain& Irrigation	Rain fed	
Barley	0	0	5	1
Wheat	0	0	21	1
Tef	0	0	19	1
Potato	22	0	0	1
Tomato	9	1	0	2
C. cabbage	15	0	0	0
Cabbage	4	1	0	2

Source: - Survey result, 2011

5.2.3. Irrigation water management

The interview result of WUC revealed that out of five respondents three of them witnessed that most farmers cannot manage and control the irrigation water due to the lack of consensus and senses of ownership. In contrary to the above idea the remaining two respondents said that there are farmers which manage and control the irrigation water for its sustainable utilization.

5.2.3.1. Access to traditional irrigation

Most of the respondents (62.5 %) are witnessed on they get water once a week for unknown time. Farmers face difficulty to say about the time limit that they get water as the result to varying land size and their locations of land and water applications by them. Though 12.5 % of interviewed said for six hours per a week. Afterwards about 4.2 and 8.2 % of households get water two and three hours per week respectively. Due to water shortage and place of land far to the primary channel, farmers may get water per 10 days to once/ twice a week suggesting by 4.2 % for three cases individually. For more clarifications see table 11.

Table 11. Access to irrigation water per week/days in hours

Interval	Frequency	Percent	Valid Percent	Cumulative Percent
	Number	%	%	%
Once a week for 6 hours	3	12.5	12.5	12.5
Once a week for unknown hours	15	62.5	62.5	75.0
Once a week for 2 hours	1	4.2	4.2	79.2
Once a week for 3 hours	2	8.2	8.2	87.5
Once a week & per 10 days	1	4.2	4.2	91.7
Once per 10 days	1	4.2	4.2	95.8
Once a-week & twice a week	1	4.2	4.2	100
Total	24	100	100	

Source: Survey result, 2011

5.2.3.2. Conflict in traditional irrigation

Amongst surveyed 29.2 % enter to conflict due to irrigation. The remaining does not take part in conflict. From those who involved the four said that, the range of conflict per year is high and others respond it is less. Table 12 and 13 shows the result.

Table 12. Farmer faced conflict related to irrigation water

	Frequency	Percent	Valid Percent	Cumulative Percent
	Number	%	%	%
No	17	70.8	70.8	70.8
Yes	7	29.2	29.2	100
Total	24	100	100	

Source: - Survey result, 2011

Table 13. Range of conflict per year

	Frequency Percent		Valid Percent	Cumulative Percent
	Number	%	%	%
Less	3	42.86	42.86	42.86
High	4	57.14	57.14	100
Total	7	100	100	

Source: - Survey result, 2011

The major causes for conflict are water shortage. For causes result from water shortage are account to 42.85 % and increasing in demand for water by farmers also lead to them for disagreement which approach to 28.57 %. Farmers also displace the water to their plot without already established program and water divider at some circumstances biased for water distribution by money. For the last two cases farmers respond 14.29 % assuring this. Detail of these presented in table 14.

Table 14. Cases and causes of the conflict

	Frequency Percent		Valid Percent	Cumulative Percent
	Number	%	%	%
Demanding more water	2	28.57	28.57	28.57
Displacing of water	1	14.29	14.29	42.86
Distributors biased by money	1	14.29	14.29	71.42
water shortage	3	42.85	42.85	100
Total	7	100	100	

Source: - Survey result, 2011



Table 15. Hostile activities of the community result from conflicts over irrigation water

	Frequency	Percent	Valid Percent	Cumulative
	Number	%	%	Percent
No	4	16.7	16.7	16.7
Displace channel	2	8.3	8.3	25.0
Physical attack & end to death	7	29.2	29.2	54.2
Remove cultivation of other	1	4.2	4.2	58.3
Remove other plot, physical attack & death	4	4.2	4.2	75.0
Insulting & physical attack	6	25.0	25.0	100
Total	24	100	100	

Source: - Survey result, 2011

Due to conflict to irrigation water hostile activities by farmers has been practiced. The actions are physical attack and some years before there was death incidence. The respondents who thought this are reach to 29.2%. Among interviewed 25 % of the farmers said that insulting and physical attack also lead to death before some years whispered by farmers. Displacing the water, remove cultivation of others and a combination of all remarked by farmers in different degree and percent. Table 15 shows further of this.

5.2.3.3. Farmer participation in irrigation water management aspects

Concerning irrigation water management, 98.5% of the surveyed households are participating in meeting on the utilization issues. However, some time the meeting ends up with disagreement among the participants of the congregation (table 16).

Table 16. Farmers' participation in irrigation communities meeting and orientations

	Frequency	Percent	Valid Percent	Cumulative Percent
	Number	%	%	%
No	1	4.2	4.2	4.2
Yes	23	95.8	95.8	100
Total	24	100	100	

Source: - Survey result, 2011

The damage of the channel and diversion structure is one of a common problem that encounters the irrigation water users of the Madda Guddina kebele. It costs the farmers money and time that could be used for other purposes. The study revealed that channel damage occurs three times and above every year in the wet seasons. However the participations of households to the maintenance of the damaged channel are less and this causes the loss of irrigation water that should be used for their farming. Moreover, the farmers' participation for channel maintenance varies from person to person. From the survey 87.5 % of the households participate in the maintenance of the primary channel and proximity to their field. (table 17 and 18).

Table 17. Frequency of participation in maintenance of irrigation canals and the structure get damaged per year

Frequency of participation	Frequency of structure damage					Total(24)
	Five	Four	Three	Two	Once	
Five	2	0	0	1	0	3
Four	0	3	2	0	0	5
Three	0	2	4	1	0	6
Two	0	0	5	1	0	7
Once	0	0	2	0	1	3
Total (24)	2	5	13	3	1	

Source: - Survey result, 2011

Table 18. Farmers place of participation

	Frequency	Percent	Valid Percent	Cumulative Percent
	Number	%	%	%
Primary channel & around my plot	21	87.5	87.5	87.5
Primary channel	3	12.5	12.5	100
Total	24	100	100	

Source: - Survey result, 2011

Farmers participate in flood control activities in the summer. The main things that were prepared are soil structure and terrace to protect their field and transfer the water in to the canal. In some areas the incidence of flooding are less since they are located far away from the primary channel. During the winter period the channel were cleared as usual which is covered by soil and grass. From observation farmers knowledge to flood control and soil and water conservation measure are less.

5.2.3.4. Efficiency of traditional irrigation

According to the interviewed five committee members, the four suggesting that the traditional irrigation system is not efficient. The justification for this are always water wastage created in line with taking more time to irrigate. As the result productivity from this are decreased. One farmer excluding the other get difficulty to compare with the modern due to of less knowledge to modern irrigation but believing that if the traditional system managed well could be good.

As shown in table 19, farmers perception towards the efficiency of this irrigation system are low. About 75% of selected sample household recognize this. However 25% of them are confident about its efficiency in different outlooks. The main justifications with 50% of them are confident on there is a possibility of crop cultivation without considering equity (see table 20). Afterwards 33.33% also recommended that all users are benefited from it and 16.7 % of respondents irrationally perceived it is efficient.

Table 19. Perception of households on efficiency of traditional irrigation

	Frequency	Percent	Valid Percent	Cumulative Percent
	Number	%	%	%
Not efficient	18	75.0	75.0	75.0
Efficient	6	25.0	25.0	100
Total	24	100	100	

Source: - Survey result, 2011

Table 20. Justification for the efficiency of the traditional irrigation

	Frequency	Percent	Valid Percent	Cumulative Percent
	Number	%	%	%
All users are benefited	2	33.3	33.3	33.3
Possible to cultivate	3	50.0	50.0	83.3
I don't know	1	16.7	16.7	100
Total	6	100	100	

Source: - Survey result, 2011

From table 21, the reasons behind to the traditional irrigation being not efficient are diverse. The key findings are water wastage created as it goes from stations to stations and from farmers' to farmer field. The percentage that point out by farmers' are around 38.9. The combined effect of water wastage, frequent structure damage, flooding and erosion are at 22.2% responded by farmers. The structure is mainly damage by flooding and fastened due to prepared from soil, woods and locally available materials. The canals also covered by grass, soil and waste materials. Flooding and soil erosion also exist and answered by 22.2 % of the interviewed group. Farmers who say only structure damage contribute for its inefficiency is 5.6 %. The aggregate effect of structure damage and water wastage is clearly explained by households in 11.1 %.

Table 21. Reason for the traditional irrigation system not efficient

	Frequency	Percent	Valid Percent	Cumulative Percent
	Number	%	%	%
Water wastage	7	38.9	38.9	38.9
Structure damage	1	5.6	5.6	44.4
wastage& structure damage	2	11.1	11.1	55.6
Flooding&soil erosion	4	22.2	22.2	77.8
All above	4	22.2	22.2	100
Total	18	100	100	

Source: - Survey result, 2011

5.2.3.5. Support to farmers for irrigation water management

The status of support in skill and technical aid to farmer are less. 37.5 % of them replied that now there is some initiation by the town administration and neighboring institutions that use the river for irrigation purpose. 25 % of them in both division individually identify that there is support and not. 12 % of the total believes the support does not make a significant change and it is not effective. The community expects that the government has to support them in technical and skill with mobilization activities for better management of the irrigation. The farmers also interested to take part in management of the irrigation by using it sustainably without harming it and participate in some acceptable cost to further higher the efficiency of the irrigation. Table 22, shows the support to farmers regarding to irrigation water.

Table 22. Support gained about irrigation water management

	Frequency	Percent	Valid Percent	Cumulative Percent
	Number	%	%	%
No	6	25.0	25.0	25.0
Yes	6	25.0	25.0	50.0
Some but Not efficient& productive	3	12.5	12.5	62.5
Some initiation at this time	9	37.5	37.5	100
Total	24	100	100	

Source:-Survey result, 2011

5.2.4. Issue of Equity and its general view

In this sections the concern of equity in different perspectives are discussed with integrating household and key informant interview.

5.2.4.1. Water allocation and distribution

The responses of the interview from the WUC showed that the water user committees distribute and allocate water for the stations in a traditional way. Then the water dividers at the station distribute and allocate water for farmers. The respondents confirmed that water dividers at the station do not distribute and allocate water among the user farmers equally. In addition to unfair distribution of the water the farmer also violate the schedule set by the committee.

From table 28, only 29.2 % of the respondents feel they share unequal water from other users in the irrigation system. They explain that the most important cause is water allocations not performed well and water divider abuse their power. Some of them said also the capacity of the kebele to make the community able to manage the irrigation is low (see table 29).

Due to equity problems two groups appeared which get more and less. They further put that station one and three get more due to its proximity to the primary channel. Also youth, stronger one and who rent their plot get more water by power. Differently those who get less water are, station two, weak, elders, female and female head and also those who has small plot. Farmers said that they do not take anything in response of this but sometimes they are asked the water divider to get more though doesn't get water.

Table 23. Feeling of farmers to share equal water with every users of the river

	Frequency	Percent	Valid Percent	Cumulative Percent
	Number	%	%	%
No	7	29.2	29.2	29.2
Yes	17	70.8	70.8	100
Total	24	100	100	

Source: - Survey result, 2011

Those who feel they share equal water with other explains about responsible organ for ensure equity are complex. Some gives water user representatives and water divider is responsible. Others said in cooperation of the committee and the kebele administration. Also farmers suggested that the committee and chief of the committee are responsible.

Table 24. Reason for farmers not share the river water equally

	Frequency	Percent	Valid Percent	Cumulative Percent
	Number	%	%	%
Water allocation problems	3	42.85	42.85	42.85
Abuse by water divider	3	42.85	42.85	85.7
Less capacity of the kebele	1	14.3	14.3	100
Total	7	100	100	

Source: - Survey result, 2011

The type of crop which farmers used do not contribute to the problem of equity of water is assumed almost by 66.7 % of the interviewed farmers. They divided in to two which half of them examines that the crop are high water demanding and others say demanding low however both argues the water is enough. The remaining percent of farmers perceived that due to high water demand from the crop all may not get water equally and shortage formed. Though there is no special consideration for crop type and stage of growth for water allocation. Some cases this may be seen by the committee and water divider when farmers convincing higher need of water for their field. As general rule farmers has to use already given period. All farmers except the one, water their crop up to the rates met for their crop growth and development acquiring from long experience. The basis for one farmer from sample household not stop watering even the time which allocated are not end was believed that there are no agreement between users. All the farmers accepts that to whom the water belong when it is at the gate of their plot and just getting to their plot when the water turn would be next farmers or based on the program. For further see table 30 and 31.

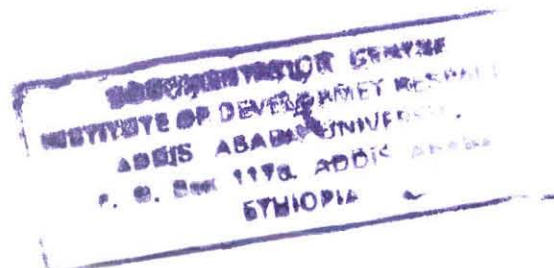


Table 25. Farmers crop selection contribution to the problem equitableness

	Frequency	Percent	Valid Percent	Cumulative Percent
	Number	%	%	%
No	16	66.7	66.7	66.7
Yes	8	33.3	33.3	100
Total	24	100	100	

Source: Survey result, 2011

Table 26. Special consideration for crop type and stage of growth during water allocation

	Frequency	Percent	Valid Percent	Cumulative Percent
	Number	%	%	%
No	16	66.7	66.7	66.7
Yes	8	33.3	33.3	100
Total	24	100	100	

Source: - Survey result, 2011

Water distribution and allocation from experts' viewpoints was found out that there is no equal distribution of water among the farmers. The bylaws practiced at the localities doesn't consider the land size of the farmers and it is simply based on the duration of watering the plot.

Through scientific way of water allocations it is possible to ensure the equity of irrigation water. Hence, the experts responded that improved cropping calendar, propose crop water requirement, construction of modern closed channel and diversion structure, crop intensification and the community awareness toward modern irrigation systems and water allocation based on the size of the land should become in to practices to alleviate the water equity problems experiential in the study area.

5.2.4.2. Sufficiency of the river

The sustainability of the irrigation water is determined by different factors such as porosity of the soil, the discharge of the river, method of irrigation and others. In sight of these factors the

interview with expertise revealed that the sustainability of Holetta River is also threatened by the factors aforementioned.

From table 23, 91.7 % of farmers not use supplementary irrigation during wet season. The others whereas tried to take it. The main reason for farmers not use both rain and irrigation at the same time are the rain is enough for production and less number of them has a knowledge gap of how to use it (see table 24).

Table 27. Perception of the farmers to supplementary irrigation during wet season

	Frequency	Percent	Valid Percent	Cumulative
	Number	%	%	Percent
No	22	91.7	91.7	91.7
Yes	2	8.3	8.3	100
Total	24	100	100	

Source:-Survey result, 2011

Table 28. Reason to farmers not prefers supplementary irrigation during wet season

	Frequency	Percent	Valid Percent	Cumulative
	Number	%	%	Percent
Enough Rain	19	86.4	86.4	86.4
Knowledge gap	3	13.6	13.6	100
Total	22	100	100	

Source: - Survey result, 2011

From gathered information 58.3 % of farmers believe the river is sufficient in dry and wet seasons. Nevertheless the others think that there is possibility of water shortage in the dry season. Among the justifications for its adequacy in dry seasons are all get water equally and there is option for cultivation in the dry season. Table 25 and 26 shows the detail of the result.

Table 29. Adequacy of the river water for wet or dry season irrigation

	Frequency	Percent	Valid Percent	Cumulative Percent
	Number	%	%	%
Sufficient in both	14	58.3	58.3	58.3
Not sufficient in dry	10	41.7	41.7	100
Total	24	100	100	

Source: - Survey result, 2011

Farmers from experience they have knowledge and understanding when the river water is reduced. Mostly it is reduced from January to May when there is no belg/spring rain and they need it from September to May.

Table 30. Justification for adequate river water in dry season irrigation

	Frequency	Percent	Valid Percent	Cumulative Percent
	Number	%	%	%
All able to cultivate	5	35.72	35.72	35.72
All gets equally	9	64.28	64.28	100
Total	14	100	100	

Source: - Survey result, 2011

Predominantly as such a measure not used to ensure equity in dry seasons in the midst of users. Already water distributed by settled programs but in some extent water may given to those who do not get enough amount and also decreasing of water wastage being done by maintaining the channels. Table 31 elaborates all the cases with percentage.

Table 31. Measures used to ensure equity on dry season

	Frequency	Percent	Valid Percent	Cumulative Percent
	Number	%	%	%
No	5	50.0	50.0	50.0
Equal water by program	3	30.0	30.0	80.0
More to who not get	1	10.0	10.0	90.0
Decrease water wastage	1	10.0	10.0	100
Total	10	100	100	

Source: - Survey result, 2011

5.2.4.3. Water distribution mistake and irrigation bylaws

As shown in both table 32 and 33, farmers make mistakes in the canals. The degree of defaults is high in the area. Types of mistakes are displacing the canals water to their field. To correct this and other aspects the community system of bylaws not as whole executed as of formulated.

All farmers place their assumptions to what the bylaws declare. They are not well known what statements of bylaws say for diverse condition. In the statement there would be punishment ranging from warning to money up to prison. It penalizes 10-50 birr those who break water distribution program in/out of stations. In the case of out of the station the punishment is high. Those who are not participate in campaign works and those remove other field would be punished by accounting day labor payment in the area and pay the loss of the product in field for both circumstances.

Table 32. Mistake in water distributions in the canal

	Frequency	Percent	Valid Percent	Cumulative Percent
	Number	%	%	%
No	2	8.3	8.3	8.3
Yes	22	91.7	91.7	100
Total	24	100	100	

Source: - Survey result, 2011

Table 33. Enforcement of bylaws

	Frequency	Percent	Valid Percent	Cumulative Percent
	Number	%	%	%
Not executed as formulated	10	41.7	41.7	41.7
Executed	11	45.8	45.8	87.5
Sometimes not	1	4.2	4.2	91.7
I don't know	1	4.2	4.2	95.8
Differ with case	1	4.2	4.2	100
Total	24	100	100	

Source: - Survey result, 2011

The weaknesses of enforcing bylaws are goes to the kebele and committee capacity. The committee does not give attention for its enforcement. It is not that much but water distributors and the committee susceptible to corruption. But mostly both fear to punish those who disobey due to not harming their neighbors and others in the culture of living together. The responsible organ in managing the irrigation by employing the bylaws is quite contradicted by the locality. Both the committee and kebele administration involved in more cases but both and including water divider as combined not practiced yet (see table 34).

Table 34. Responsible body for enforcement of bylaws

	Frequency	Percent	Valid Percent	Cumulative Percent
	Number	%	%	%
Committee	8	33.3	33.3	33.3
Kebele	3	12.5	12.5	45.8
Committee & Kebele	11	45.8	45.8	91.7
Water divider	1	4.2	4.2	95.8
All	1	4.2	4.2	100
Total	24	100	100	

Source: - Survey result, 2011

5.2.4.4. Involvement of female and female heads on equity

Like to male generally female head involved in some events of irrigation water management. They involve in meeting, campaign works and contributing in money for maintenance of the irrigation system. In a little number of occasions they fear to take any positions in the water user committee. One of the reasons that does not female involved is also believed by other farmers that the activity is even difficult to male (see table 35).

Table 35. Female head household involvement on equity of water

	Frequency	Percent	Valid Percent	Cumulative Percent
	Number	%	%	%
No	4	16.7	16.7	16.7
Yes	20	83.3	83.3	100
Total	24	100	100	

Source: - Survey result, 2011

The information obtained from WUC shows that special support is not given for female-heads concerning equity. Also the interview with experts confirmed the same idea raised by WUC.

5.2.4.5. Other users result on equity

The majority of farmers accept all users including government institutions are belong to use the river. But its amount and timing has to be accounted not challenging the farmers. Whole of them agreed that investor has to use ground water from the surrounding.

Other users cause water shortage seriously and sometimes in slightly. Some of farmers think they do not cause anything to them. Farmers more or less they have agreement with Holetta research centre and some level with Holetta ATVET College regarding with technical support and cost recovery on irrigation water utilization and better management for the future excluding to private company. (See table 36 and 37).

Table 36. Consequence of other users to farmers

	Frequency	Percent	Valid Percent	Cumulative Percent
	Number	%	%	%
Nothing	8	33.33	33.33	33.33
Water shortage	11	45.83	45.83	79.17
Sometimes water shortage	5	20.83	20.83	100
Total	24	100	100	

Source: - Survey result, 2011

Table 37. Agreement with other users

	Frequency	Percent	Valid Percent	Cumulative Percent
	Number	%	%	%
No	2	8.3	8.3	8.3
Yes	6	25.0	25.0	33.3
I don't know	2	8.3	8.3	41.67
Only Holetta R.C	5	20.8	20.8	62.5
Holetta R,C & ATVET college	5	20.8	20.8	83.33
Not clear & effective	2	8.3	8.3	91.67
I don't know the extent	1	4.2	4.2	95.83
Recently	1	4.2	4.2	100
Total	24	100	100	

Source: - Survey result, 2011

5.3. Crop water requirement and water balance computation

In this part irrigation requirement and scheduling of cabbage, tomato and potato in the dry period are presented. To see the result of wet season crop cultivation on supplementary irrigation requirement and intervals see appendix 4.

5.3.1. Crop water requirement

Crop water requirements of the cabbage become low in the initial and late stage as shown in table 38 below. During the developmental and mid season stage of the crop, the demand of water becomes increasing especially high in the mid stage. Similarly in the initial stage of crop growth its irrigation requirement is lower from late period. From FAO (1977), for the period of head formation and enlargement are a critical period to soil water stress in cabbage. At this moment farmers has to irrigate more water. From the result the overall irrigation requirement to produce cabbage are 384.44 mm depth with 70 % field efficiency.

Table 38. Crop water requirement for cabbage

Crop Water Requirements							
ETo station : - Holetta				Crop : - Cabbage			
Rain station : -Holetta				Planting date :- 08/12			
Month	Decade	Stage	Kc Coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Dec	1	Init	0.6	2.17	6.5	0	6.5
Dec	2	Init	0.6	2.13	21.3	0	21.3
Dec	3	Init	0.6	2.15	23.6	0.1	23.5
Jan	1	Deve	0.65	2.34	23.4	0.4	23
Jan	2	Deve	0.75	2.74	27.4	0.6	26.8
Jan	3	Deve	0.86	3.25	35.8	1.3	34.5
Feb	1	Deve	0.97	3.79	37.9	1.9	36
Feb	2	Mid	1.06	4.27	42.7	2.5	40.2
Feb	3	Mid	1.07	4.4	35.2	3.7	31.5
Mar	1	Mid	1.07	4.49	44.9	4.9	40
Mar	2	Mid	1.07	4.58	45.8	6	39.8
Mar	3	Late	1.06	4.44	48.8	7.2	41.6
Apr	1	Late	0.98	4.04	24.2	5.5	19.7
					417.5	34	384.4

Source: - Own result, 2011

In table 39, crop water demand for tomato is less in initial stage. As compared to both developmental and late stage the demand of irrigation in mid stage is much greater with lengthy of this stage. Otherwise the irrigation requirement at late and development stage are somewhat similar. Irrigation requirement of tomato are higher than cabbage. This may be manifested with deep root nature of the crop. The most critical period which tomato plantation face soil water

stress is when flower are formed and fruits are rapidly enlarging (FAO 1977). Likewise more water has to apply at crop water stress period. Generally 494.6 mm of depth of water needed for production of tomato.

Table 39. Crop water requirement for tomato

Crop Water Requirements							
ETo station : - Holetta				Crop : - Tomato			
Rain station : -Holetta				Planting date :- 18/11			
Month	Decade	Stage	Kc Coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Nov	2	Init	0.6	2.24	6.7	0	6.7
Nov	3	Init	0.6	2.2	22	0	22
Dec	1	Init	0.6	2.17	21.7	0	21.7
Dec	2	Deve	0.61	2.16	21.6	0	21.6
Dec	3	Deve	0.73	2.61	28.7	0.1	28.5
Jan	1	Deve	0.88	3.18	31.8	0.4	31.4
Jan	2	Deve	1.02	3.73	37.3	0.6	36.7
Jan	3	Mid	1.15	4.35	47.9	1.3	46.6
Feb	1	Mid	1.17	4.58	45.8	1.9	43.8
Feb	2	Mid	1.17	4.73	47.3	2.5	44.8
Feb	3	Mid	1.17	4.82	38.6	3.7	34.9
Mar	1	Mid	1.17	4.92	49.2	4.9	44.3
Mar	2	Late	1.13	4.83	48.3	6	42.4
Mar	3	Late	1	4.21	46.3	7.2	39.1
Apr	1	Late	0.88	3.6	36	9.1	26.9
Apr	2	Late	0.81	3.26	3.3	1.1	3.3
					532.3	38.7	494.6

Source: - Own result, 2011

In the initial stage the water requirement for potato is less. The planting time is responsible for zero irrigation demand is due to getting rain water. In development stage its water requirement are lower to that of late stage. Due to tuber formation and longevity of the stage in the mid season, water demand become escalating. So care must be taken for not make stress in soil water after the formation of tubers and blossom to harvest (FAO 1977). As compared to tomato, irrigation requirement for potato are lesser with general demand of 416.8 mm of depth to whole season of the crop. For detail see table 40.

Table 40. Crop water requirement for potato in dry period

Crop Water Requirements							
ETo station : - Holetta				Crop : - Potato – Winter			
Rain station : -Holetta				Planting date :- 26/09			
Month	Decade	Stage	Kc Coeff	ETc mm/day	Etc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Sep	3	Init	0.5	1.45	7.3	6.9	0.3
Oct	1	Init	0.5	1.54	15.4	1.9	13.5
Oct	2	Init	0.5	1.62	16.2	0	16.2
Oct	3	Deve	0.64	2.16	23.8	0	23.7
Nov	1	Deve	0.87	3.11	31.1	0.1	31
Nov	2	Mid	1.09	4.09	40.9	0	40.9
Nov	3	Mid	1.18	4.32	43.2	0	43.2
Dec	1	Mid	1.18	4.24	42.4	0	42.4
Dec	2	Mid	1.18	4.17	41.7	0	41.7
Dec	3	Mid	1.18	4.21	46.3	0.1	46.2
Jan	1	Late	1.14	4.12	41.2	0.4	40.8
Jan	2	Late	1.01	3.68	36.8	0.6	36.2
Jan	3	Late	0.86	3.27	36	1.3	34.7
Feb	1	Late	0.78	3.04	6.1	0.4	6.1
					428.2	11.8	416.8

Source: - Own result, 2011

5.3.2. Irrigation scheduling

From table 41, in the development and proceeding to end stage of the cabbage, irrigation scheduling per 15 days of period can be suggested with 40 – 49mm of depth. It is practiced by increasing the rate and finally reduces to 47mm considering head formation and enlargement in the cabbage possibly scheduled. In the initial stage on planting time once the crop get 39 mm depth of water they can enter in to development stage without getting other irrigation in lined with no yield reductions.

The timing for irrigation to apply is at critical depletion. It is exercised when readily available moisture (RAM) is depleted and is defined as 100% of RAM. This is the most common way to schedule irrigations. It results in minimum irrigations, but also in irregular intervals and may thus not be easy to implement in the field. In application the water have to refill to field capacity level. The application depth will bring soil moisture content back to field capacity. The depth applied

will be equal to the depleted soil moisture in the root zone. The application depth will vary, as the season progresses, with changing root depth and allowable depletion levels at each growth stage (Savva and Frenken 2002).

The deficit indicates the soil moisture depletion level after irrigation. A zero value represents a refill to field capacity and a positive value represents an under irrigation, equal to the amount needed to refill the root to field capacity.

The scheduling efficiency is 100 %. Almost in all cases the potential and actual use of water by the crop is equal. Also efficiency of the field is 70 %, but from Savva and Frenken (2002) efficiency of surface irrigation is 45 %. As the result more additional 25 % of net irrigation water required to deploy this in the furrow irrigation.

From table 42 of irrigation scheduling in tomato at initial stage only taking 17-25 mm depth of irrigation per 10 days, the crop can stay to the beginning of development stage. About 32– 48 mm in the development stage and in the interval of 7-14days by increasing the amount and 52-55 mm depth of irrigation can be applied in the mid stage. The interval for this are almost per 14 day can be given to the crop. The timing and application of irrigation, efficiency of scheduling and field are similar to cabbage.



Table 41. Irrigation scheduling for cabbage

Crop irrigation schedule		Crop :- Cabbage	Planting date :- 08/12									
Eto station :- Holetta		Soil :- Clay	Harvesting date :- 06/04									
Rain station: - Holetta		yield red. :- 0 %										
Table format : - Irrigation schedule												
Timing :-		Irrigate at critical depletion										
Application :- Refill soil to field capacity												
Field eff. 70 %												
Date	Day	Stage	Rain mm	Ks fract.	Eta %	Depl %	Net Irr Mm	Deficit Mm	Loss Mm	Gr. Irr mm	Flow l/s/ha	
15 Dec	8	Init	0	1	100	48	39	0	0	55.9	0.81	
5 Jan	29	Dev	0	1	100	46	40	0	0	57.4	0.32	
25 Jan	49	Dev	0	1	100	46	44	0	0	62.3	0.36	
10 Feb	65	Dev	0	1	100	47	46	0	0	65.8	0.48	
25 Feb	80	Mid	0	1	100	49	49	0	0	70.6	0.54	
12 Mar	95	Mid	0	1	100	49	49	0	0	70.3	0.54	
26 Mar	109	Mid	0	1	100	47	47	0	0	66.7	0.55	
6 Apr	End	End	0	1	0	32						
Totals												
Total gross irrigation :- 448.9 mm					Total rainfall :- 113.2mm							
Total net irrigation :- 314.2 mm					Effective rainfall:- 95.3 mm							
Total irrigation losses :- 0.0 mm					Total rain loss :- 17.9 mm							
Actual water use by the crop :- 413.5 mm					Moist deficit at harvest :- 32.0 mm							
Potential water use by the crop: -413.5 mm					Actual irrigation requirement :- 318.2 mm							
Efficiency irrigation schedule :- 100 %					Efficiency :- 84.2 %							
Deficiency irrigation schedule :- 0.0 %												
Yield reductions												
Stage label		A	B	C	D	Season						
Reduction in Etc		0	0	0	0	0 %						
Yield response factor		0.2	0.4	0.5	0.6	1 %						
Yield reduction		0	0	0	0							
Cumulative yield reduction		0	0	0	0	0 %						

Source: - Own result, 2011

Table 42. Irrigation scheduling for tomato

Crop irrigation schedule			Crop :- Tomato		Planting date :- 18/11						
Eto station :- Holetta			Soil :- Clay		Harvesting date :- 11/04						
Rain station: - Holetta			yield red. :- 0 %								
Table format :- Irrigation schedule											
Timing :- Irrigate at critical depletion											
Application :- Refill soil to field capacity											
Field eff. 70 %											
Date	Day	Stage	Rain mm	Ks fract.	Eta %	Depl %	Net Irr Mm	Deficit Mm	Loss Mm	Gr. Irr mm	Flow l/s/ha
18 Nov	1	Init	0	1	100	32	17	0	0	23.6	2.7
26 Nov	9	Init	0	1	100	33	19	0	0	27.4	0.4
5 Dec	18	Init	0	1	100	31	21	0	0	30.1	0.4
16 Dec	29	Init	0	1	100	31	25	0	0	35.3	0.4
29 Dec	42	Dev	0	1	100	34	32	0	0	45.1	0.4
11 Jan	55	Dev	0	1	100	37	38	0	0	54.9	0.5
25 Jan	69	Dev	0	1	100	40	48	0	0	68.4	0.6
8 Feb	83	Mid	0	1	100	42	50	0	0	71.5	0.6
21 Feb	96	Mid	0	1	100	43	52	0	0	73.7	0.7
8 Mar	111	Mid	0	1	100	41	49	0	0	69.8	0.5
25 Mar	128	End	0	1	100	46	55	0	0	78.5	0.5
11 Apr	End	End	0	1	0	30					
Totals											
Total gross irrigation :- 578.3 mm					Total rainfall :- 127.1 mm						
Total net irrigation :- 404.8mm					Effective rainfall:- 121.5. mm						
Total irrigation losses :- 0.0 mm					Total rain loss :- 5.6 mm						
Actual water use by the crop :- 529.0 mm					Moist deficit at harvest :- 36.3 mm						
Potential water use by the crop: -529.0 mm					Actual irrigation requirement :- 407.5 mm						
Efficiency irrigation schedule :- 100 %					Efficiency :- 95.6 %						
Deficiency irrigation schedule :- 0.0 %											
Yield reductions											
Stage label			A	B	C	D	Season				
Reduction in Etc			0	0	0	0	0 %				
Yield response factor			1	1	1.1	0.8	1.1 %				
Yield reduction			0	0	0	0					
Cumulative yield reduction			0	0	0	0	0 %				

Source: - Own result, 2011

Table 43. Irrigation scheduling for potato in dry period

Crop irrigation schedule		Crop :- Potato - W	Planting date :- 26/09									
Eto station :- Holetta		Soil :- Clay	Harvesting date :- 02/02									
Rain station: - Holetta		yield red. :- 0 %										
Table format :- Irrigation schedule												
Timing :- Irrigate at critical depletion												
Application :- Refill soil to field capacity												
Field eff. 70 %												
Date	Day	Stage	Rain mm	Ks fract.	Eta %	Depl %	Net Irr mm	Deficit mm	Loss Mm	Gr. Irr mm	Flow l/s/ha	
26 Sep	1	Init	0	1	96	30	19	0	0	26.4	3.1	
21 Oct	26	Dev	0	1	100	27	24	0	0	34.1	0.2	
4 Nov	40	Dev	0	1	100	30	31	0	0	44.3	0.4	
14 Nov	50	Dev	0	1	100	29	34	0	0	48.2	0.6	
23 Nov	59	Mid	1	1	100	30	37	0	0	52.1	0.7	
2 Dec	68	Mid	0	1	100	32	38	0	0	54.2	0.7	
11 Dec	77	Mid	0	1	100	31	37	0	0	53	0.7	
21 Dec	87	Mid	0	1	100	33	40	0	0	56.5	0.7	
31 Dec	97	Mid	0	1	100	32	38	0	0	54.9	0.6	
14 Jan	111	End	0	1	100	39	47	0	0	67.1	0.6	
2 Feb	End	End	9	1	100	41						
Totals												
Total gross irrigation :- 491.0 mm					Total rainfall :- 66.3 mm							
Total net irrigation :- 343.7 mm					Effective rainfall:- 65.3							
Total irrigation losses :- 0.0 mm					Total rain loss :- 1.0 mm							
Actual water use by the crop :- 425.1 mm					Moist deficit at harvest :- 49.7 mm							
Potential water use by the crop: - 425.1. mm					Actual irrigation requirement :- 359.8							
Efficiency irrigation schedule :- 100 %					Efficiency :- 98.5 %							
Deficiency irrigation schedule :- 0.0 %												
Yield reductions												
Stage label			A	B	C	D	Season					
Reduction in Etc			0	0	0	0	0 %					
Yield response factor			0	1	0.3	0.3	1.1 %					
Yield reduction			0	0	0	0						
Cumulative yield reduction			0	0	0.1	0	0 %					

Source: - own result, 2011

From Table 43, irrigation scheduling in potato at initial stage only taking 19mm depth of irrigation the crop can stay until the development stage. It needs 24 – 34 mm in the development stage in 9 days interval by rising and 37- 40 mm depth of water in the mid stage. Prior to the end of crop growth, 47mm of depth of irrigation can be applied after 14 days of mid stage. Besides the timing and application of irrigation, scheduling and field efficiency is similar to cabbage and tomato.

5.3.3. Scheme supply

Result of table 45, shows Holetta river scheme supply to farmers. It doesn't represent for other users. Highest irrigated area from the total is on November to February. Percentage of irrigated area is less during March - May including September. During summer there is no irrigation activity as the rain fall is enough. Precipitation deficit is high both in cabbage and tomato. Also barley, wheat and potato in the winter countenance on precipitation deficit.

Table 44. Scheme supply of Holetta

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation deficit												
1. Barley	0	0	0	0	0	0	0	0	11.8	94.1	49.6	0
2. Wheat	0	0	0	0	0	0	0	0	11.8	94.4	52.9	0
3. Potato - Winter	96.1	6.1	0	0	0	0	0	0	0	38	110.5	123.6
4. Potato - Summer	0	0	0	0	0	0	0	0	0	0	0	0
5. Tomato	99.4	105.7	103.6	21.4	0	0	0	0	0	0	27.4	65.1
6. Chinese Cabbage	65	72.8	95.6	72.7	65.5	0	0	0	0	0	0	54.9
Net scheme irr.req.												
in mm/day	1.4	1	1	0.5	0.4	0	0	0	0.2	1.4	1.5	1.4
in mm/month	43.5	27.7	30.6	16.4	12.4	0	0	0	4.6	44.4	45.5	43
in l/s/h	0.16	0.11	0.11	0.06	0.05	0	0	0	0.02	0.17	0.18	0.16
Irrigated area (% of total area)	51	51	31	31	19	0	0	0	39	59	71	51
Irr.req. for actual area (l/s/h)	0.32	0.22	0.37	0.2	0.24	0	0	0	0.05	0.28	0.25	0.31

Own result, 2011

6. Conclusion and Recommendation

In this chapter brief conclusion on the base of objective and finding of the study presented and finally recommendation towards this are suggested.

6.1. Conclusion

Farmers are not in the position to manage the irrigation water for assuring all and in the sustainable way. In fact some interest on construction of the new structure has been seen but continuous construction and maintenance activities by some users in the traditional irrigation system doesn't proof their capacity, initiations and agreement of the total. The ownership of the irrigation system also confusing becomes confusing. As the result the kebele administration, water user committee and water divider act differently.

Farmers participate in the irrigation water utilization and management meeting. The meeting is obviously focused on construction and maintenance of the old system. Comparing farmers' participation in the maintenance and construction with structure damage is less. There are also farmers who not involve at all. The place of participation is mainly in the primary channel. From this farmers activity is not practical in the vicinity of their field. The committees also not supervise each of channels to correct channel widening that result for water wastage.

The type of support and skill transformations to farmers from the responsible organ is fewer. There are also no conducive and functional agricultural extension activities. This might be the result of urban thinking towards the town. Agricultural technology transformation and dissemination from Holetta research centre to the kebele not considered. This also might be due to the conflicting interest between the town and the research centre about land which is under the research centre. Beside this the community expects that the government has to hold up them in practical and skillfulness with call-up activities for enhanced management of the irrigation. Farmers also have a plan to manage the irrigation by contributing money in acceptable cost to promote the competence of the irrigation.

From the research questions and objectives, crop water requirement has been evaluated. Crops persistent to the district were cabbage, tomato, potato in dry and potato, barley and wheat in the summer have been used for evaluation. The overall irrigation requirements of the crops in dry period are 384.44, 494.6 and 416.8 mm of depth respectively. The crop sensitivity period to water stress are differ on three crops based on their nature but they need more water in the mid stage. The other crops are cultivated with supplementary irrigation in the rainy seasons and don't result for equity problems. For further information see appendix four about the three crops in the wet season.

Irrigation scheduling of the three crops is not uniform. Cabbage needs 40-49 mm depth of irrigation in the development stage up to ahead of harvesting. The interval is approximately per 15 days by increasing the range and finally end to 47mm. In the development stage of tomato from 32-55mm depth of irrigation per 14 days of interval could be applied by increasing its amount. Whereas potato consumes 24 – 34 mm in the development stage per 9 days with rising and 37- 40 mm depth of water in the mid. Finally it needs 47 mm prior to the end of crop growth after 14 days. Potato and cabbage water requirement at initial stage are 19 mm and 39 mm depth of irrigation respectively. In this stage both can stay and enter in to the development stage after they irrigate only once without yield reduction and tomato require 17- 25 mm depth of irrigation per 10 days in the initial stage.

For the whole crop, the timing of irrigation to apply is at critical depletion. In the application the water have to refill to the field capacity level. The application depth will bring soil moisture content back to field capacity and the depth applied will be equal to the depleted soil moisture in the root zone. Generally scheduling efficiency is 100 % and in all cases the potential and actual use of water by the crop is equal and also the efficiency of the field is 70 %, but in surface irrigation the efficiency is 45 %, which is practically need 25 % additional net irrigation in the case of furrow irrigation.

In relation to scheme supply of Holetta, only farmers cropping pattern and season used. Due to this it is only represent farmer's side. Highest irrigated area per percentage is at November to February. Percentage of irrigated area is less in March-May including September. During

summer there is no irrigation activity since the rain fall is enough. Precipitation deficit is high both in cabbage and tomato. Also barley, wheat and potato in the winter face precipitation deficit.

6.2. Recommendation

The Water sharing principle has to be fixed with farmers land size, crop stage and distance from the primary channel. Those who have large land have to get water by giving additional cost for the management and utilization of the river. Also farmers with small lands their interest has to be fulfilled. In the water sharing the committee should include programs that go with crop stage. Not only focusing crop stage but planting perennial crops to those has large lands and annual crops to those who have small lands can be an option. Farmers farming practice directly relate with crops that have high market return related to its cost of irrigation and other inputs are also essential. In water application and timing should be correlated with the crop water demand. To ensure water to farmers that found far from the primary channel should get enough time as compared to others.

The participation of all users is important to improve the management of the river and the irrigation. To overcome this responsible organ has to capacitate the community by training and technical support. Government organ has to work closely with the farmers to increase their production by new technology innovations with integration of farmer prior knowledge of water management. Government should take part in empowering activity rather involve in the decisions for the success of community fully take over the irrigation system. But farmers' decision has to see from government and responsible organ for its implications.

It is possible to higher the efficiency of the irrigation system. Primarily good diversion structure has to be prepared. Also it is important to transform from open channel to close to improve water productivity. Provision of close channel may be expensive but at least establishing of the channels with local available materials and concrete has to be used. On the other hand to ensure equity farmers has to aware with water saving practice. Instead of watering their field by preparing pond storage and store with it is important and decreases water wastage.

Female role in the managing and ensuring equity among users need to be seen. From experience and understanding female engage in this activities conflict may be minimized. On the other hand females are mostly discouraged in farming practices. So as the main concern the committee should take this as an advantage which female to participate and encouraged.

Future studies have to focus both technical and social aspects concerning all users. This present study focuses were farmers in Madda Gudina kebele. But in the future water demand from different users may come and without go through all users including institutes in the area and others is not possible to think of equity and management of the river in the sustainable way.

Still focus on crop water requirement studies in general and on small scale or community based irrigations is not much addressed in Ethiopia. Less number of research activities was done on large scale irrigations. To solve water management and improve crop productions future studies has to be relay on this.

This case study would give insight for wide country level implications. For successful management of community based irrigation system the government interventions on enabling the community to capture the whole aspects of the irrigations are important. General policies and strategies for creating better environment for community based irrigation system are significant.



References

- Ambec, S and Ehlers, L. 2007. Cooperation and Equity in the River Sharing _Problem. Toulouse School of Economics (INRA-LERNA), Université de Montréal and CIREQ.
- Awulachew, S. B, Yilma, A. D, Loulseged, M, Loiskandl, W, Ayana, M and Alamirew, T. 2007. Water Resources and Irrigation Development in Ethiopia. Colombo, Sri Lanka, International Water Management Institute. 78p (Working Paper 123).
- Awulachew, S. B, Merrey, D. J, Kamara, A. B, Van Koppen, B, Penning de Vries, F, Boelee, E and Makombe, G. 2005. Experiences and Opportunities for Promoting Small-Scale/Micro Irrigation and Rainwater Harvesting for Food Security in Ethiopia. Colombo, Sri Lanka, IWMI.v. 86p (Working paper 98).
- Bello, W. B.2008. The Effect of Rain-Fed and Supplementary Irrigation on the Yield and Yield Components of Maize in Mekelle, Ethiopia. Ethiopian Journal of Environmental Studies and Management Vol.1 No.2 June. 2008.
- Berhane, H and Steenbergen, F.V., 2007. Agricultural Water Management in Ephemeral Rivers, Community Management in Spate Irrigation in Eritrea, African Water Journal, Ministry of Agriculture Government of Eritrea and MetaMeta Research Paardskerkhofweg 14 5223 AJ Den Bosch, Netherlands.
- Berehanu Hailu. 2009. The Impact of Agricultural Policies on Smallholder Innovation Capacities. The Case of Household Level Irrigation Development in Two Communities of Kilte Awlalo Woreda, Tigray Regional State, Ethiopia. MSc Thesis in Communication and Innovation Studies Group.Wageningen University ,Department of Social Science.
- CEEPA. 2006. Climate Change and African Agriculture: Climate Change and Crop Water Use and Productivity in Ethiopia. Centre for Environmental Economics and Policy in Africa, Policy Note No. 31, August 2006.
- Darout Gum'.2004. The Socio-Cultural Aspects of Irrigation Management: The Case of Small-Scale Irrigation Schemes in the Upper Tekeze Basin, Tigray Region. A Thesis Submitted to Addis Ababa University, College of Development Studies, Institute of Regional and Local Development Studies.
- Eyasu, Yazewe. 2005. Development and Management of Irrigated Lands in Tigray, Ethiopia. PhD Dissertation, the Academic Board of Wageningen University and the Academic Board of the UNESCO-IHE Institute for Water Education.
- FAO.1977. Crop Water Requirements. Food and Agricultural Organization. Irrigation and Drainage Paper No 24. Rome, Italy.

- FAO.1998. Crop Evapotranspiration: Guidelines for computing crop water requirements. Food and Agricultural Organization. Irrigation and Drainage Paper No. 56. Rome, Italy.
- Gabriel B. S and James, V.2002. Evaluating the Performance of a Crop Water Balance Model in Estimating Regional Crop Production. On the Need for Dynamic Scheduling of Imaging Satellites. Pecora 15/Land Satellite Information IV/ISPRS Commission me /FIEOS 2002 Conference Proceedings.
- Gall, Le. A. 2007. Impacts of Modernization on Traditional Irrigation Schemes, the case of Burkaa Alifif, East Hararghe, Ethiopia. Master of Science thesis in Social Water Management and Tropical Agricultural Development.
- Geremew E, B.2008.Modeling the Soil Water Balance to Improve Irrigation Management of Traditional Irrigation Schemes in Ethiopia. PhD Dissertation in Agronomy, Department of Plant Production and Soil Science, Faculty of Natural and Agricultural Sciences, University of Pretoria, Pretoria.
- Haile Kidane .2009. Community Spate Irrigation in Raya Valley: The Case of three Spate Irrigation Systems. A Thesis Submitted to Addis Ababa University, College of Development Studies, Institute of Regional and Local Development Studies.
- Haile Tesfay. 2008. Impact of Irrigation Development on Poverty Reduction in Northern Ethiopia. A thesis presented to the Department of Food Business and Development in fulfilment of the requirement for the degree of Doctor of Philosophy, National University of Ireland, and Cork.
- Hanibal L, Habtamu Y and Tsedalu J.2008. Analytical Documentation of Traditional Practices and Farmer Innovations in Agricultural Water Management (AWM) in Amhara Region, A case study on two Traditional Irrigation Schemes in North Gondar. Gondar Agricultural Research Center, Gondar, Ethiopia.
- Holetta Genet Multimedia Information, 2010, Internet document (<http://en.wikipedia.org/wiki/Holetta-Genet>), Accessed on Aug. 31, 2010.
- Holetta Town Administration. 2010. Holetta Small Scale Irrigation Projects, March, 2009.
- Holetta Town Administration. Annual Plan. 2010/2011.
- Internet document, 2010, <http://www2.uiah.fi/projects/metodi>, Accessed on Dec. 28, 2010.
- Internet document, 2011, http://en.wikipedia.org/wiki/Case_study, Accessed on May, 30, 2011.
- Kaplan, B and Duchon, D.1988. Combining Qualitative and Quantitative Methods in Information Systems Research: A Case Study. This paper was presented at the Ninth Annual International Conference on Information Systems, Minneapolis, MN, and November 30-December 3, 1988.

- Lemma Dinku. 2004. Smallholders' Irrigation Practices and Issues of Community Management: The Case of Two Irrigation Systems in Eastern Oromia, Ethiopia. A Thesis Submitted to Addis Ababa University, School of Graduate Studies. Institute of Regional and Local Development Studies.
- Mekuria Tafesse .2003. Small-Scale Irrigation for Food Security in Sub- Saharan 20–29 January 2003, CTA Working Document Number 8031. Organised CTA with the support of Tigray Water Resources Development by Bureau, Ethiopia, Published and printed by: The ACP-EU Technical Centre for Agricultural and Rural Cooperation (CTA).Africa Report and Recommendations of a CTA study visit in Ethiopia.
- Namara, R.E, Makombe, G, Hogose, F and Awulachwe, S.B. 2007. Rural Poverty & Inequality in Ethiopia: Can irrigation make a difference. IIPE Workshop, 27-29 Nov, 2007, Addis Ababa.
- Rahel Deribe.2008. Institutional Analysis of Water Management on Communal. Irrigation Systems in Ethiopia: The Case of Atsbi Wemberta, Tigray Region and Ada'a Woreda, Oromia Region. A Thesis Submitted to Addis Ababa University, School of Graduate Studies, Faculty of Business and Economics.
- Renault, D, Hemakumara, M and Molden, D.2001. Impacts of Water Consumption by Perennial Vegetation in Irrigated Areas of the humid Tropics. A case for Rethinking Traditional Values of Irrigation Design, Management and Performance Assessment, Annual Report 2000-2001. Improving Water and Land Resource Management for Food, Livelihoods and Nature Case Studies, Impacts and Outputs Strategic Priorities, 2000- 2005.
- Seleshi, B. A and Merrey, J. D. 2007. Assessment of Small Scale Irrigation and Water Harvesting in Ethiopian Agricultural Development. International Water Management Institute (IWMI).
- Sommer, B and Sommer, R.1997. A Practical Guide to Behavioral Research: Tools and Techniques. Fourth Edition, Oxford University Press, Inc., New York.
- Savva .P,A and Frenken , K. 2002 Crop Water Requirements and Irrigation Scheduling, Irrigation Manual Module 4, Harare, Zimbabwe.
- Temesgen, B and Ayalneh, B.2005.Technical Efficiency of Resource Use in the Production of Irrigated Potato: A Study of Farmers Using Modern and Traditional Irrigation Schemes in Awi Zone, Ethiopia. Journal of Agriculture and Rural Development in the Tropics and Subtropics, Volume106, No. 1, 2005.
- Yibekal Alemayehu. 2009. Managing the Soil Water Balance of Hot Pepper (*Capsicum annum L.*) to Improve Water Productivity. Submitted in Partial Fulfilment of the Requirements for the Degree, Doctor of Philosophy in Horticultural Science, University of Pretoria, and Pretoria.

Appendix 1. Sample household questionnaires, WUC and Expertise interview guide

Questionnaire for Equity of River Water to Traditional Irrigation Users: Case Study of Holeta River, Holetta Town, Ethiopia

I. Demographics (Conditions)

1. Gender -----
2. Age -----
3. Nation -----
4. Education background -----
5. Family responsibility -----
6. Family no -----
7. Income source -----
8. Capital(assets) birr -----
9. Number of years lives in this village -----

II. Production Status

1. Land hold -----
2. Land tenure system -----

Crop type grown	Production/land hold			Number of Harvest/year
	Minimum	Average	Maximum	
Vegetable crops				
Field crops				
Fruit crops				
Other crops				

III. Irrigation Water Management Practice

1. How often do you get water?
2. Do you believe that the traditional irrigation system are efficient if yes in what way, if not what are the problems?
3. What are the activities done by the irrigation water users during flood?
4. Have you ever participate in maintenance of the irrigation canals? (Yes No)
5. If no, why not?
6. If yes, how many times in a year do you participate approximately?
7. If yes to Q4, is it on your own plot or on the whole scheme?
8. How frequently does the structure get damaged per year?
9. What is/are the main cause/s of structure damage in your scheme? List down in order of importance
10. Have you received any training and/or technical assistance from the town administration and other responsible organization about river and irrigation utilization and management?
11. Have you ever participate in irrigation communities meeting and orientations? If so what idea raised, how about your participation?
12. In general what are the irrigation water management and utilization practice done by the users in wet and dry period?
13. What do you expect from societies and government in managing the river sustainably?
14. Have you ever had a conflict related to irrigation water? If yes, how many times in irrigation season would it be approximately? Please mention all cases and their causes you remember.
15. What hostile activities are there among the community members resulting from conflict over irrigation water?

IV. Irrigation Water Allocation and Distribution

1. Do you use water for supplementary irrigation (During the wet season)? (Yes/No)
2. If not, why?
3. Are there any water resources like ground water, spring, etc. for irrigation other than the river?
4. Is the water in the river sufficient for: Wet season irrigation? Dry season irrigation? Wet and Dry season irrigation? If yes what are your justifications? If not, what measures were used to ensure equity?
5. Do you feel you share equal water with every user of the river? If yes what are the responsible to ensure equity? If not, what do you think is the reason for the inequality?
6. If there is inequality, which groups of people get more?
7. If there is inequality, which groups of people get less?
8. If there is inequality, do you get more or less? If you get more, do you believe this is reasonable? Why? If no, what measures do you take in response?
9. In which time of the year the river water reduced and when farmers need the river for irrigation?
10. Do you use crop water requirement rates for watering your fields? If yes, who gives you the rate?
11. If yes to Q 10, do you always stop watering when the rate is met even if the usual time given to watering turn is yet to get?
12. If no to Q 10, why don't you stop at the given rate?
13. Does farmers crop selection has contribution to the problem of equitableness? If yes, in what way? If no, do you think the crops selected by the farmers require less water?
14. Are there special considerations for crop-type and stage of growth during water allocation? If No, what happens when somebody is convincingly in higher need of water for his/her field?
15. Have there been any defaulters of water distribution in the canal? If yes, what is done in cases of water distribution defaults?
16. Does the community have a system of rule for controlling water distribution default? If yes, what does the rule say?
17. If yes to Q16, do you believe the rule is enforced in the way formulated?

18. If no, what are the weaknesses? Please, list down in order of importance
19. Who or what body is responsible for enforcing the rules?
20. Are there involvements of female-headed households in ensuring equity among users? If Yes what activities done by them? If not, why they are not involved?
21. Whom, do you think does the water in the river belong to?
22. Whom, do you think; does water belong to when it is at the gate of your plot just getting to your plot at your watering turn?
23. Do you pay any water use fees? If yes, what kind?
24. Are there other irrigations user that use the river other than Meda gudina kebele households, if yes, what consequences comes towards yours?
25. Is there an agreement with other users/out of households/ in sharing rivers for irrigation and managing it with technical and cost recovery activities?

V. Unstructured interview for town and kebele irrigation and agronomy expertise

1. Do you think all households are benefited from the existing water sharing principles? If yes what implication are, no why?
2. Does female heads and females benefited from the traditional irrigation? If yes how? If not, why not?
3. Do you think the traditional irrigation methods are adequate for the sustenance of household's economic wellbeing?
4. Do you observe any inequality in water distribution? (Yes/No)
5. If Yes to Q4, could you list the reasons behind according to their importance?
6. If yes to Q 4, do you think scientific methods can solve such water sharing problem? If yes what are you suggesting?

VI. Unstructured interview for water user association representatives

1. How is water allocated and distributed to users? Is there a problem in allocation and distribution of water?
2. Is there any special support to female-headed households that use the irrigation? If yes list?
3. Do you think the community be able to manage the irrigation? If yes in what way? If not, why?
4. Do you think the traditional irrigation methods are efficient?
5. Do you observe any inequality in water distribution? (Yes/No)
6. If Yes to Q4, could you list the reasons behind according to their importance?

Appendix. 2. Crop water requirement calculation

1.1. Calculation of reference evapotranspiration

The Reference Evapotranspiration (ET_o) represents the potential evaporation of a well-watered grass crop. The water needs of other crops are directly linked to this climatic parameter. The reference surface is a hypothetical grass reference crop with an assumed crop height of 0.12 m, a fixed surface resistance of 70 s m⁻¹ and an albedo of 0.23. The reference surface closely resembles an extensive surface of green, well-watered grass of uniform height, actively growing and completely shading the ground. The fixed surface resistance of 70 s m⁻¹ implies a moderately dry soil surface resulting from about a weekly irrigation frequency (FAO 1998)

the FAO Penman-Monteith method to estimate ET_o can be derived

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T + 273} \cdot u_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)}$$

where ,

ET _o	reference evapotranspiration [mm day ⁻¹],
R _n	net radiation at the crop surface [MJ m ⁻² day ⁻¹],
G	soil heat flux density [MJ m ⁻² day ⁻¹],
T	mean daily air temperature at 2 m height [°C],
u ₂	wind speed at 2 m height [m s ⁻¹],
e _s	saturation vapour pressure [kPa],
e _a	actual vapour pressure [kPa],
e _s -e _a	saturation vapour pressure deficit [kPa],
Δ	slope vapour pressure curve [kPa °C ⁻¹],
γ	psychrometric constant [kPa °C ⁻¹].

Several methods exist to determine ET_o, the Penman-Monteith Method has been recommended as the appropriate combination method¹ to determine ET_o from climatic data on: temperature, humidity, sunshine, wind speed.

In order to calculate ETo, the respective climatic data should be collected from the nearest and most representative meteorological station. Several institutes and agencies may keep climatic records such as the Irrigation Department, the Meteorological Service or nearby Agricultural Research Stations and may provide information on climatic stations inside or in the vicinity of irrigation scheme which should be considered for crop water requirement (CWR) calculations. In some cases, when the scheme is large, more than one station may be available, but often no suitable stations with sufficient climatic data are located in the scheme. In such a case a careful selection should be made of the data.

Normally some conversions are required in order to adjust the data into the format accepted by CROPWAT 8.0. In particular, attention should be given to the units in which the climatic records are given.

Temperature data :- Maximum and Minimum Temperature, [° C]

Humidity data :- Average daily Relative Humidity [in percentage] or Vapour Pressure [kPa]

Sunshine data :- Sunshine hours (heliograph) or sunshine percentage

$$SSP = 0.95 - \frac{LC1 + LC2}{2} + \alpha * \frac{AC1 + AC2}{2}$$

where: SSP = sunshine rate (fraction)

LC1 = low clouds at sunrise

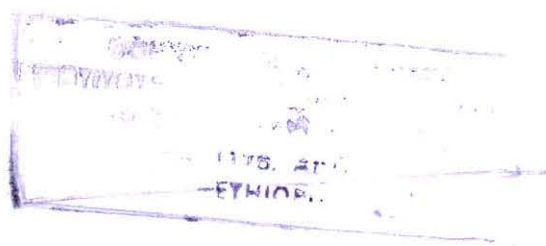
LC2 = low clouds at noon

AC1 = high clouds at sunrise

AC2 = low clouds at noon

α = empirical parameter (≈ 0.3)

Wind speed data :- Average Daily Wind speed in km/day or m/sec



1.2. Processing of rainfall data

The rainfall contributes to a greater or lesser extent in satisfying CWR, depending on the location. During the rainy season in tropical and some semi-tropical regions, a great part of the crop's water needs are covered by rainfall, while during the dry season, the major supply of water should come from irrigation. How much water is coming from rainfall and how much water should be covered by irrigation is, unfortunately, difficult to predict as rainfall varies greatly from season to season (FAO,1992).

In order to estimate the rainfall deficit for irrigation water requirements, a statistical analysis needs to be made from long-term rainfall records. In addition to the variability of rainfall from year to year, not all rain which falls is used by the crop. The intensity of rain may be such that part of the rainfall is lost due to surface runoff or due to deep percolation below the root zone. In order to determine that part of the rainfall which effectively contributes to cover CWR, a number of definitions are first given, while subsequently it is explained how the different rainfall values can be calculated and how they are incorporated in the CWR calculations.

Rainfall Definitions

Average monthly rainfall: Mathematically determined average for a series of rainfall records, most commonly available. To be used for CWR calculation to represent average climatic conditions.

Dependable rainfall: The amount of rainfall which can be depended upon in 1 out of 4 or 5 years corresponding to a 75 or 80% probability of exceedance and representing a dry year. The dependable rainfall (80%) is used for the design of the irrigation system capacity.

Rainfall in wet, normal and dry years: Defined as the rainfall with a respectively 20, 50 and 80% probability of exceedance, representing a wet, normal and dry year. The three values are useful for the programming of irrigation supply and simulation of irrigation management conditions.

The rainfall in normal years (50% probability) is, in general, well approached by the average rainfall.

Historical or actual rainfall data: The actual recorded rainfall used for evaluation purposes.

Effective rainfall:

Defined as that part of the rainfall which is effectively used by the crop after rainfall losses due to surface run off and deep percolation have been accounted for. The effective rainfall is the rainfall ultimately used to determine the crop irrigation requirements.

Rainfall Data Collection

The precipitation data required for CROPWAT 8.0 can be daily, decade or monthly rainfall, commonly available from many climatic stations. In addition, substations may be found with single rainfall records. For larger schemes, records of several rainfall stations may be available, allowing an analysis of the spatial variability. To allow a calculation of rainfall probabilities, rainfall records from a range of years (15-30) are to be collected.

Rainfall Data Processing

For programming of irrigation water supply and management, rainfall data of normal, wet and dry years are used. An estimate of the respective rainfall data can be obtained by computing and plotting probabilities from the rainfall records. The different steps involved are:

- i. Tabulate yearly rainfall totals for a given period.
- ii. Arrange data in descending order of magnitude.
- iii. Tabulate plotting position according to:

$$F_a = 100 * m / (N + 1)$$

where: N = number of records

m = rank number

F_a = plotting position

- iv. Plot values on log-normal scale and obtain the logarithmic regression equation
- v. Calculate year values at 20, 50 and 80% probability:
- vi. Determine monthly values for the dry/normal/wet year according to the following relationship:

$$P_{\text{idry/wet/normal}} = P_{\text{iaav}} * \frac{P_{\text{dry/wet/normal}}}{P_{\text{av}}}$$

Effective Rainfall Method

To account for the losses due to runoff or percolation, a choice can be made of one of the four methods given in CROPWAT 8.0 (Fixed percentage, Dependable rain, Empirical formula, USDA Soil Conservation Service).

In general, the efficiency of rainfall will decrease with increasing rainfall. For most rainfall values below 100 mm/month, the efficiency will be approximately 80%. Unless more detailed information is available for local conditions, it is suggested to select the Option "Fixed percentage" and give 80% as requested value. In the water balance calculations included in the irrigation scheduling part of CROPWAT, a possibility exists to evaluate actual efficiency values for different crops and soil conditions.

1.3. Crop and cropping pattern data collection

A local survey should be carried out in the irrigation scheme to assess the crops grown rain fed as well as under irrigation. Through field observations, interviews with extension agents and farmers and additional information from other agencies, for instance a revenue department, an assessment can be made of the present cropping pattern.

Essential information collected from the field should include:

1. Crop and crop variety
2. First and last planting date
3. First and last harvesting date

Additional information may include:

4. Indicative yield level
5. Indicative irrigation practices:
 - field irrigation methods
 - irrigation frequencies and interval
 - irrigation application depths

From the Agricultural Research Stations, more accurate information may be collected on:

6. Crop characteristics:
 - length of individual growth stages
 - crop factors, relating crop evapotranspiration to reference

- evapotranspiration
- rooting depth
- allowable depletion levels
- yield response factors.

The Crop module requires crop data over the different development stages, defined as follow:

- Initial stage: it starts from planting date to approximately 10% ground cover.
- Development stage: it runs from 10% ground cover to effective full cover. Effective full cover for many crops occurs at the initiation of flowering.
- Mid-season stage: it runs from effective full cover to the start of maturity. The start of maturity is often indicated by the beginning of the ageing, yellowing or senescence of leaves, leaf drop, or the browning of fruit to the degree that the crop evapotranspiration is reduced relative to the ETo.
- Late season stage: it runs from the start of maturity to harvest or full senescence.

Data required differ in case of a non-rice or a rice crop. In case of non-rice crop, the following information is necessary:

Crop name

Planting date

Crop coefficient (Kc)

Stages length

Rooting depth

Critical depletion fraction (p)

Yield response factor (Ky)

If available, maximum crop height should be provided.

The cropping pattern module is primary data input, requiring information on the crops (Up to 20) being part of the scheme. With reference to each crop, the following data should be provided:

Crop file

Planting date

Area: extension of the area dedicated to each crop, as a percentage of the total cropped area. Care should be taken that at any given moment the sum of the individual crops does not exceed 100 % of total scheme area.

1.4. Crop water requirement calculations

Calculation of the CWR can be carried out by calling up successively the appropriate climate and rainfall data sets, together with the crop files and the corresponding planting dates. In case of CWR calculation of soil data are required.

Soil Data Collection

The Soil module is essentially data input, requiring the following general soil data:

Total Available Water (TAW)

Maximum infiltration rate

Maximum rooting depth

Initial soil moisture depletion

1.4. Irrigation scheduling

To develop indicative irrigation schedules:

- for the agricultural extension service to promote better irrigation practices
- for the irrigation service to establish improved rotational delivery schedules;
- to evaluate existing irrigation practices on water use efficiency and water stress conditions;
- to evaluate crop production under rain fed conditions, to assess feasibility of supplementary irrigation and to develop appropriate irrigation schedules;
- to develop alternative water delivery schedules under restricted water supply conditions

The calculations of the scheduling module are based on a soil water budget, where, on a daily basis, the soil moisture status is determined, accounting for incoming and outgoing water in the root zone

The schedule module essentially includes calculations, producing a soil water balance on a daily step. The following parameters are used:

- Effective rainfall, over dry, normal and/or wet years
- Water stress coefficient (K_s)
- Crop evapotranspiration under non-standard conditions ($ET_c \text{ adj}$)
- Root zone depletion
- Net irrigation (IR_n) = IR_g/E , E = Overall project efficiency
- Deficit
- Irrigation losses
- Gross irrigation (IR_g)
- Flow

1.5. Scheme and canal water requirements

The irrigation supply to any irrigation scheme or canal command area can be calculated by adding up the requirements of each cropped area. Any changes in cropping pattern can be conveniently calculated by modifying area size of the different crops.

The scheme module includes calculations, producing:

- Irrigation requirement for each crop of the scheme
- Net scheme irrigation requirement
- Irrigated area as a percentage of the total area
- Irrigation requirement for the actual area

Appendix 3. Metrological data of Holetta

Table 45. Average monthly minimum temperature ($^{\circ}c$) from 1989 - 2009

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average	3.87	5.09	6.78	8.29	7.65	7.77	9.22	8.94	7.45	4.72	2.34	2.18

Source :- Holetta Research center, 2010

Table 46. Average monthly maximum temperature ($^{\circ}c$) from 1989 - 2009

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average	23.4	24.2	24.4	23.4	24.8	22.4	20.2	19.6	20.5	19.6	22.6	23.2

Source :- Holetta Research centre, 2010

Table 47. Average monthly relative humidity (%) from 1989- 2009

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average	50	48	50	55	53	67	80	82	73	57	49	49

Source :- Holetta Research centre, 2010

Table 48. Average monthly wind speed in km/hr (2m) from 1989-2009

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average	3.91	4.37	5.43	4.78	4.59	3.21	2.92	2.60	3.07	4.02	4.36	3.88
Km/day	93.84	104.48	130.32	114.72	110.16	77.04	70.08	62.40	73.68	96.48	104.64	93.12

Source :- Holetta Research centre, 2010

Table 49. Average monthly sunshine hours(hours per day) from 1989 -2009

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average	8.75	8.53	7.48	6.72	7.04	5.23	2.93	2.34	3.05	5.79	8.89	8.87

Source :- Holetta research centre, 2010

Table 50. Annual and monthly average rain fall

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1989	7.1	86.9	78.0	69.8	8.3	74.9	240.7	278.6	117.5	3.0	0.3	21.6	986.7
1990	0.5	162.4	34.9	95.4	55.5	131.8	263.4	338.2	155.5	8.0	0.0	0.9	1246.5
1991	23.9	74.8	118.0	27.3	37.2	89.9	241.1	229.0	172.6	2.6	0.3	5.8	1022.5
1992	57.4	34.8	58.8	95.0	34.6	115.3	190.9	312.8	112.1	35.1	0.6	7.8	1055.2
1993	18.2	83.8	3.8	127.0	60.3	103.1	218.1	276.1	214.8	27.4	0.0	0.0	1132.6
1994	0.0	2.3	86.7	45.9	29.8	107.3	216.4	209.3	149.7	0.0	36.6	0.0	884.0
1995	0.0	84.6	41.9	122.8	81.3	86.4	191.9	262.7	82.1	3.9	0.0	34.0	991.6
1996	62.6	8.5	96.1	58.4	45.4	192.6	249.8	236.4	120.7	5.3	1.4	2.3	1079.5
1997	15.3	0.0	21.1	77.4	13.5	131.0	233.5	206.6	42.5	53.5	23.6	2.1	820.1
1998	54.6	42.3	25.7	65.7	80.4	141.5	341.6	238.1	168.3	67.4	0.8	0.0	1226.4
1999	77.3	4.6	34.0	16.6	54.6	98.9	272.8	307.7	88.9	65.4	0.0	0.0	1020.8
2000	0.0	0.0	12.5	123.8	50.8	89.8	187.1	260.6	120.5	9.5	38.9	30.4	923.9
2001	7.9	10.6	130.7	48.6	101.2	176.5	301.6	161.2	103.2	24.2	0.0	0.0	1065.7
2002	72.6	25.7	56.9	38.1	49.4	123.2	273.1	194.0	77.4	0.0	0.0	22.1	932.5
2003	17.5	11.3	33.3	84.2	13.6	117.1	194.0	237.2	107.4	10.0	0.0	8.4	834.0
2004	12.7	0.8	42.5	155.1	27.0	121.4	204.0	226.6	119.7	3.6	0.7	0.0	914.1
2005	22.0	4.5	61.7	49.1	94.4	81.8	253.9	187.5	130.7	31.5	3.8	0.0	920.9
2006	0.0	9.0	68.4	99.1	98.4	113.7	288.6	250.0	116.1	13.1	0.0	0.6	1057.0
2007	0.0	14.0	61.2	36.4	73.5	253.3	159.3	249.5	90.0	18.8	0.0	0.0	956.0
2008	0.0	18.5	1.0	31.3	88.8	99.0	287.1	220.0	195.7	54.0	NA	3.5	998.9
2009	20.4	8.6	4.7	30.9	10.6	64.8	208.8	242.7	75.9	15.6	6.2	39.4	728.6
Average	22.4	32.8	51.0	71.3	52.8	119.7	238.9	244.0	122.0	21.5	5.7	8.5	990.6

Source :- Holetta research centre,2010

Table 51. (a and b) .Yearly value of rainfall and its probability of exceedance

a

	Probability %	Rainfall in mm
Dry	80	904.4
Wet	50	967.8
Normal	20	1091.6

Own result,2011

b

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average	22.4	32.8	51	71.3	52.8	119.7	238.9	244	122	21.5	5.7	8.5	990.6
Dry	20.4	29.9	46.6	65.1	48.2	109.3	218.1	222.8	111.4	19.6	5.2	7.8	904.4
Wet	21.9	32	49.8	69.7	51.6	116.9	233.4	238.4	119.2	21	5.6	8.3	967.8
Normal	24.7	36.1	56.2	78.6	58.2	131.9	263.2	268.9	134.4	23.7	6.3	9.4	1091.6

Own result, 2011

Appendix 4. Crop water requirement and irrigation scheduling

Table 52. Monthly reference evapotranspiration (ET_o) of Holetta

MonthlyEtoPenman-Monteith - Program/CROPWAT/data/climate/Holetta.PEM

Month	Min Temp °C	Max Temp °C	Humidity %	Wind km/day	Sun hours	Rad MJ/m ² /day	ET _o mm/day
January	3.9	23.4	50	94	8.8	20.5	3.65
February	5.1	24.2	48	105	8.5	21.3	4.04
March	6.8	24.4	50	130	7.5	20.8	4.29
April	8.3	23.4	55	115	6.7	19.8	4.01
May	7.7	24.8	53	110	7	19.8	4.11
June	7.8	22.4	67	77	5.2	16.8	3.26
July	9.2	20.2	80	70	2.9	13.5	2.6
August	8.9	19.6	82	62	2.3	12.8	2.46
September	7.5	20.5	73	74	3	13.9	2.74
October	4.7	19.6	57	96	5.8	17.5	3.24
November	2.3	22.6	49	105	8.9	20.8	3.74
December	2.2	23.2	49	93	8.9	20.1	3.55
Average	6.2	22.4	59	94	6.3	18.1	3.47

Source :- Own result, 2011

Table 53. General clay soil information of Holetta

Soil name :- Clay
General soil data

Total available soil moisture (FC-WP)	200	mm/meter
Maximum rain infiltration rate	40	mm/day
Maximum rooting depth	60	Centimetre
Initial soil moisture depletion (as % TAM)	28	%
Initial available soil moisture	144	mm/meter

Soil - C:/ProgramData/CROPWAT/data/soils/FAO/Holetta -Clay.SOI

Source :- FAO and Holetta research centre

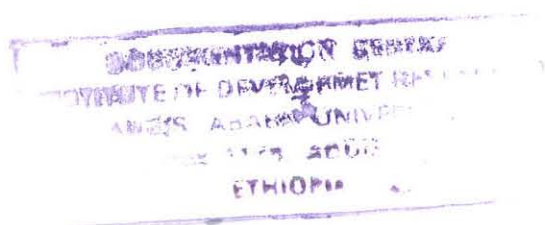


Table 54. Monthly effective rain fall (mm) of Holetta

Monthly rain :- C:/ProgramData/CROPWAT/data/Holetta DRY.CRM
 Station :- Holetta Eff.rain method :- FAO/AGLW formula

	Rain	Eff rain
	mm	mm
January	20.4	2.2
February	29.9	7.9
March	46.6	18
April	65.1	29.1
May	48.2	18.9
June	109.3	63.4
July	218.1	150.5
August	222.8	154.2
September	111.4	65.1
October	19.6	1.8
November	5.2	0
December	7.8	0
Total	904.4	511.2

Source :- Own result, 2011

Table 55. Cropping pattern of Holetta

Cropping pattern - C:/ProgramData/CROPWAT/data/sessions/Holetta.PAT

Cropping patter name :- Holetta

No	Crop file	Crop name	Planting date	Harvesting date	Days	Area (%)
1	Holetta-Barley.CRO	Barley	01/07	27/11	150	16
2	Holetta-Wheat.CRO	Wheat	01/07	27/11	150	23
3	Holetta-Potato- S.CRO	Potato/summer	23/05	29/09	130	10
4	Holetta-Potato-W.CRO	Potato/winter	26/09	02/02	130	20
5	Holetta-Tomato.CRO	Tomato	18/11	11/04	145	19
6	Holetta-Chinese cabbage.CRO	Cabbage	08/12	06/04	120	12

Source :- Survey result, 2011

Table 56. Crop water requirement of barely

Crop Water Requirements							
ETo station : - Holetta				Crop : - Barley			
Rain station : -Holetta				Planting date :- 01/07			
Month	Decade	Stage	Kc	Etc	Etc	Eff rain	Irr. Req.
			coeff	mm/day	mm/dec	mm/dec	mm/dec
Jul	1	Init	0.3	0.85	8.5	43.1	0
Jul	2	Deve	0.34	0.89	8.9	54.1	0
Jul	3	Deve	0.6	1.54	16.9	53.2	0
Aug	1	Deve	0.89	2.23	22.3	53.9	0
Aug	2	Mid	1.11	2.73	27.3	55.8	0
Aug	3	Mid	1.12	2.87	31.6	44.4	0
Sep	1	Mid	1.12	2.98	29.8	30.8	0
Sep	2	Mid	1.12	3.08	30.8	20.5	10.3
Sep	3	Mid	1.12	3.27	32.7	13.9	18.8
Oct	1	Mid	1.12	3.45	34.5	1.9	32.6
Oct	2	Late	1.12	3.61	36.1	0	36.1
Oct	3	Late	0.95	3.23	35.5	0	35.5
Nov	1	Late	0.72	2.57	25.7	0.1	25.5
Nov	2	Late	0.5	1.87	18.7	0	18.7
Nov	3	Late	0.32	1.16	8.1	0	8.1
					367.2	371.8	185.7

Source :- Own result, 2011

Table 57. Irrigation scheduling and supplementary irrigation in barley

Crop irrigation schedule			Crop :- Barley		Planting date :- 01/07							
Eto station :- Holetta			Soil :- Clay		Harvesting date :- 27/11							
Rain station: - Holetta			yield red. :- 0 %									
Table format : - Irrigation schedule												
Timing :- Irrigate at critical depletion												
Application :- Refill soil to field capacity												
Field eff. 70 %												
Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow	
			mm	fract.	%	%	Mm	mm	mm	mm	l/s/ha	
19 Oct	111	End	0	1	100	57	68.5	0	0	97.8	0.1	
27 Nov	End	End	0	1	0	69						
Totals												
Total gross irrigation :- 97.8 mm					Total rainfall :- 577.2 mm							
Total net irrigation :- 68.5 mm					Effective rainfall:- 248.6 mm							
Total irrigation losses :- 0.0 mm					Total rain loss :- 328.6 mm							
Actual water use by the crop :- 366.0 mm					Moist deficit at harvest :- 82.6 mm							
Potential water use by the crop:-366.0 mm					Actual irrigation requirement :- 117.5 mm							
Efficiency irrigation schedule :- 100 %					Efficiency :- 43.1 %							
Deficiency irrigation schedule :- 0.0 %												
Yield reductions												
Stage label	A	B	C	D	Season							
Reduction in Etc	0	0	0	0	0 %							
Yield response factor	0.2	0.6	0.5	0.4	1 %							
Yield reduction	0	0	0	0								
Cumulative yield reduction	0	0	0	0	0 %							

Source:-Own result,2011

Table 58. Crop water requirement of wheat

Crop Water Requirements							
ETo station : - Holetta				Crop : - Wheat			
Rain station : -Holetta				Planting date :- 01/07			
Month	Decade	Stage	Kc	Etc	Etc	Eff rain	Irr. Req.
			coeff	mm/day	mm/dec	mm/dec	mm/dec
Jul	1	Init	0.3	0.85	8.5	43.1	0
Jul	2	Deve	0.34	0.89	8.9	54.1	0
Jul	3	Deve	0.6	1.54	16.9	53.2	0
Aug	1	Deve	0.89	2.23	22.3	53.9	0
Aug	2	Mid	1.11	2.73	27.3	55.8	0
Aug	3	Mid	1.12	2.87	31.6	44.4	0
Sep	1	Mid	1.12	2.98	29.8	30.8	0
Sep	2	Mid	1.12	3.08	30.8	20.5	10.3
Sep	3	Mid	1.12	3.27	32.7	13.9	18.8
Oct	1	Mid	1.12	3.45	34.5	1.9	32.6
Oct	2	Late	1.12	3.61	36.1	0	36.1
Oct	3	Late	0.96	3.26	35.9	0	35.8
Nov	1	Late	0.74	2.65	26.5	0.1	26.4
Nov	2	Late	0.54	2	20	0	20
Nov	3	Late	0.36	1.33	9.3	0	9.3
					370.9	371.8	189.4

Source :- Own result, 2011

Table 59. Irrigation scheduling and supplementary irrigation in wheat

Crop irrigation schedule		Crop :- Wheat	Planting date :- 01/07									
Eto station :- Holetta		Soil :- Clay	Harvesting date :- 27/11									
Rain station: - Holetta		yield red. :- 0 %										
Table format : - Irrigation schedule												
Timing :- Irrigate at critical depletion												
Application :- Refill soil to field capacity												
Field eff. 70 %												
Date	Day	Stage	Rain mm	Ks fract.	Eta %	Depl %	Net Irr mm	Deficit mm	Loss Mm	Gr. Irr mm	Flow l/s/ha	
19 Oct	111	End	0	1	100	57	68.5	0	0	97.8	0.1	
27 Nov	End	End	0	1	0	72						
Totals												
Total gross irrigation :- 97.8 mm					Total rainfall :- 577.2 mm							
Total net irrigation :- 68.5 mm					Effective rainfall:- 248.6 mm							
Total irrigation losses :- 0.0 mm					Total rain loss :- 328.6 mm							
Actual water use by the crop :- 369.6 mm					Moist deficit at harvest :- 86.2 mm							
Potential water use by the crop: -369.6 mm					Actual irrigation requirement :- 121.0 mm							
Efficiency irrigation schedule :- 100 %					Efficiency :- 43.1 %							
Deficiency irrigation schedule :- 0.0 %												
Yield reductions												
Stage label		A	B	C	D	Season						
Reduction in Etc		0	0	0	0	0 %						
Yield response factor		0.4	0.6	0.8	0.4	1.15 %						
Yield reduction		0	0	0	0							
Cumulative yield reduction		0	0	0	0	0 %						

Source :- Own result, 2011

Table 60. Crop water requirement of potato in the summer

Crop Water Requirements							
ETo station : - Holetta				Crop : - Potato - summer			
Rain station : -Holetta				Planting date :- 23/05			
Month	Decade	Stage	Kc coeff	Etc mm/day	Etc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
May	3	Init	0.5	1.95	17.5	7.8	8
Jun	1	Init	0.5	1.77	17.7	14.9	2.8
Jun	2	Deve	0.52	1.7	17	19.1	0
Jun	3	Deve	0.69	2.1	21	29.5	0
Jul	1	Deve	0.89	2.52	25.2	43.1	0
Jul	2	Mid	1.08	2.8	28	54.1	0
Jul	3	Mid	1.11	2.83	31.1	53.2	0
Aug	1	Mid	1.11	2.78	27.8	53.9	0
Aug	2	Mid	1.11	2.73	27.3	55.8	0
Aug	3	Late	1.11	2.83	31.1	44.4	0
Sep	1	Late	1.02	2.72	27.2	30.8	0
Sep	2	Late	0.9	2.46	24.6	20.5	4.1
Sep	3	Late	0.78	2.26	20.3	12.5	6.5
					315.8	439.7	21.4

Source :- Own result, 2011

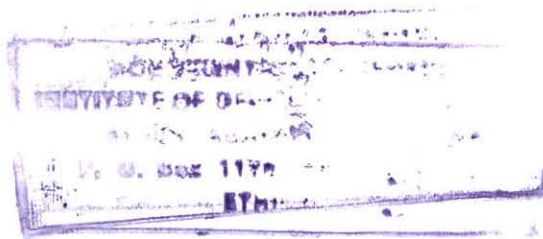


Table 61. Irrigation scheduling and supplementary irrigation in potato in the summer

Crop irrigation schedule		Crop :- Potato -S		Planting date :- 23/05								
Eto station :- Holetta		Soil :- Clay		Harvesting date :- 29/09								
Rain station: - Holetta		yield red. :- 0 %										
Table format : - Irrigation schedule												
Timing :- Irrigate at critical depletion												
Application :- Refill soil to field capacity												
Field eff. 70 %												
Date	Day	Stage	Rain mm	Ks fract.	Eta %	Depl %	Net Irr Mm	Deficit mm	Loss mm	Gr. Irr mm	Flow l/s/ha	
1 Jun	10	Init		0	1	100	26	18.8	0	0	26.8	0.31
29 Sep	End	End		8.8	1	100	4					
Totals												
Total gross irrigation :- 26.8 mm				Total rainfall :- 681.9 mm								
Total net irrigation : - 18.8 mm				Effective rainfall:- 323.8. mm								
Total irrigation losses :- 0.0 mm				Total rain loss :- 358.1 mm								
Actual water use by the crop :- 313.5 mm				Moist deficit at harvest :- 4.5 mm								
Potential water use by the crop: -313.5 mm				Actual irrigation requirement :- - 10. 3 mm								
Efficiency irrigation schedule :- 100 %				Efficiency :- 47.5%								
Deficiency irrigation schedule :- 0.0 %												
Yield reductions												
Stage label	A		B		C		D		Season			
Reduction in Etc	0		0		0		0		0 %			
Yield response factor	0.5		0.8		0.8		0.3		1.1 %			
Yield reduction	0		0		0		0					
Cumulative yield reduction	0		0		0		0		0 %			

Source :- Own result, 2011

Declaration

This is to certify that this thesis entitled “**Equity of River Water to Traditional Irrigation Users: Case Study of Holetta River, Holetta Town, Ethiopia**” Submitted in partial fulfilment of the requirements for the award of the degree of M.A in Water Resource Planning and Management from the School of Graduate Studies, College of Development Studies, Addis Ababa University, through the Department of Water and Development, done by Mr.Getamesay Shiwenzu, with ID. No.GS/3581/02 is an authentic work carried out by him under my guidance. The matter embodied in this thesis work has not been submitted earlier for award of any degree or diploma to the best of my knowledge and belief.

Name of the student

Getamesay Shiwenzu; Signature Getamesay Shiwenzu Date 4/07/2011

Name of the Advisor

Mebruk Mohammed (PhD); Signature _____ Date _____

