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Laga Gimbi Small Scale Irrigation Project

1. Agronomy Study Report

1.1 Background of the study

The Agriculture sector in the country plays the entire and dominant role in the food supply, job opportunity and income sources of the population. In spite of the decisive role of this sector in the economy and livelihood of the people no significant effort was made in the past to improve its productivity. Eventually, the development and the productivity of the Agricultural sector are still at backward and traditional level. To this effect, the farmers in agricultural sector, which is featured by low input and low output production methodologies and low rainfall conditions, could not able to meet the food requirement of the ever increasing population. In other words, the available natural resources of the country have not been properly exploited so far to meet the increasingly high demand of the country for food, raw material for domestic agro-industries and for export market. Considering these facts, concerted efforts are being made at the moment both at national as well as regional levels to transform the prevailing subsistence production system to high value and market oriented production system. One of the efforts exerted in this line embarks on the judicious use of the available irrigation water potential found in different parts of the country. It is through irrigation and integrated crop development that sustainable crop production can be ensured. In this view, the feasibility study of Laga Gimbi small scale irrigation development project was carried out in Qimbibit district of North Shewa Zone of Oromia National Regional State to develop 46 hectares of command area.

Irrigated agriculture plays an important role in sustainable crop production in areas where the climatic variation and poor distribution of rainfall exists. The predominant agricultural system is based on smallholder production and the crop production is entirely dependent on rainfed agriculture with limited areas currently developed under irrigation. The natural supply of water to the agricultural land for crop production purpose is usually received from natural sources such as precipitation/rain, other atmospheric water, ground water and flood water. The proposed command area is flat land and there is serious waterlogging during the rainy season. On this command land crop production activities during the wet-season is totally impossible. The only option that the community has for crop production

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purposes is the use of the available surface water resource for irrigation during the dry season.

1.2 Objective of the Study

1.2.1 General Objective

The overall objective of the study is to increase production and productivity of the area through introduction of modern irrigated agriculture which is environmentally suitable, economically feasible and sustainable and identifying crops that are adaptable to the area and suitable for added food security/nutritional value and/or have market potential. Some 184 households (about 0.25ha/HH) which could be about 920 people (about 5 family sizes per household) will be direct beneficiaries of the irrigation development.

1.2.2 Specific Objectives

The specific objectives of Agronomy study of this irrigation project include:

- Evaluation of the existing agricultural situation of the study area,
- Investigation of the agricultural suitability of soils, climate, and water for the proposed irrigation project,
- Identification of the existing physical environment of the study area,
- Identification and evaluation of crop production constraints of the study area,
- Selection of suitable crops, cropping pattern and cropping calendar for the project,
- Estimation of input requirements for the selected crops,
- Prediction of yield projection for the selected crops,
- Recommendation of important agronomic practices and supporting services for the crops grown under irrigation, and
- Determination of crop-water requirement and irrigation scheduling for the proposed crops.

1.3 Review of Sector Policies, Strategies and Related Previous Studies

1.3.1 Agriculture Policy

The focus of agricultural policy has been to:

- Increase food security
- Increase the supply of agricultural raw materials to the local industry

- Expand the local manufacturing industries to supply the rural areas, and
- Increase foreign exchange earnings

As part of the agricultural development policy, Ethiopia's food security strategy was first issued in 1996 and updated in 2001. It has been observed that food insecurity is one of the defining features of rural poverty affecting millions of people, particularly in moisture deficit areas. Both chronic and transitory problems of food insecurity exist. The government is tackling food deficit problem through the introduction of: i) small, medium and large-scale irrigation; ii) drought resistant and early maturing varieties and with water harvesting technology; iii) soil conservation and environmental protection; iv) improved harvesting, handling and storage facilities.

1.3.1.1 Food Security Strategy

Food security is manifested directly in three security components: adequacy of supply (production, reduction of post-harvest loses), stability of supply (production and price stability), and access to supply (increase purchasing power of households and access to employment).

The consequences of food insecurity are reflected in the high level of malnutrition. The first version of food security strategy (FSS) was prepared in 1996 and has been revised as required by the national government. For instance, the revised FSS (2002) targeted mainly to the chronically food insecure, moisture deficit and pastoral areas, water harvesting and introduction of high value crops, livestock development were key development issues in the revised strategy.

In 2004 the new coalition for food security prepared a food security program that was more comprehensive and detailed than the earlier ones. The goal of the food security program is to drastically reduce food insecurity faced by vulnerable households. Its objective is to attain food security of the chronically food insecure population and significantly improve and sustain overall food security of population within five years.

1.3.1.2 Growth and Transformation Plan (GTP II-2015/16-2019/20)

The GTP II (2015/16-2019/20) has been formulated to carry forward the basis, objectives and strategic directions of GTP I. The achievements gained, challenges faced and lessons drawn from the implementation of GTP I was the basis for the formulation of GTP II. Nevertheless, with pertaining to irrigation development GTP II has its own distinguishing features. In GTP II period, agriculture will remain the main driver of the rapid and inclusive economic growth and development. It is also expected to be the main source of growth for the modern productive sectors. Therefore, besides promoting the productivity and quality of staple food crops production, special attention will also be given to high value crops, industrial inputs and export commodities. To this end irrigation based agriculture, horticulture, fruits and vegetables, livestock and Fisheries development will be promoted. Designing and providing support schemes to smallholder farmers where peasants and pastoralists are the main actors in the production process; and facilitating a joint participation of educated young farmers and private investors in the sector are strategic directions that will be pursued during the plan period. To this end, addressing constraints entrenched in the agricultural development and marketing systems will be given utmost emphasis and priority.

Fundamentals of the strategy include the shift to produce high value crops, a special focus on high-potential areas, facilitating the commercialization of agriculture, supporting the development of large-scale commercial agriculture where it is feasible. In addition, small, medium and large scale irrigation development and dam constructions were also targeted to be undertaken and strengthened by federal and regional government institutions. Increasing the area of land covered with irrigation from 2.34 million hectare in 2014/15 to 4.143 million hectares by the end of 2019/20 was set as the major targets with respect to irrigation development. As a result over 1,743,000 hectare additional irrigated land has been targeted to be developed during the plan period and providing access to at least one alternative water point for 80% of smallholder farmers (semi-pastoralists) of which 50% are users of the full irrigation farming package.

1.3.2 Irrigation Policy

1) Ensure the full integration of irrigation with the overall framework of the country's socio-economic development plans, and more particularly with the Agricultural Development Led Industrialization (ADLI) Strategy.
2) Promote the development of irrigation on two- pronged approaches of, i) strategic planning for achieving socio-economic goals, and ii) participatory-driven approach for promoting efficiency and sustainability.
3) Recognizing that irrigation is an integral part of the water sector and consequently develop irrigation within the domain and framework of overall water resources management.

4) Earmark on a reasonable percentage of the GDP as committed resource towards the development of irrigated agriculture, especially in capacity building and infrastructures.
5) Promote decentralization and users-based management of irrigation systems taking in to account the special needs of rural women in particular.
6) Develop a hierarchy of priority schemes based on food requirements, needs of the national economy and requirements of raw materials and other needs.
7) Support and enhance traditional irrigation schemes by improving water abstraction, transport systems and water use efficiency.
8) Ensure the prevention and mitigation of degradation of irrigated water and maintain acceptable water quality standards for irrigation.
9) Establish water allocation and priority setting criteria based on harmonization of social equity, economic efficiency and environmental sustainability requirements.
10) Integrate the provision of appropriate drainage facilities in all irrigated agriculture schemes.
11) Enhance greater participation by the Regional and Federal Governments in the development of large scale irrigated farms in high water potential basins, but with low population density (Ethiopian Water Sector Policy, 2001).

1.4 Methodology

The methods used in the study mainly focused on document review on related works and review of government policies and strategies on agriculture and irrigation as pre-field work, and direct field observation with full participation of the target community members of the proposed area as field work. Primary data were collected by employing quantitative and qualitative methods, generated through household survey that involves structured questionnaires, key informant interviews, focus group discussions and direct field visits. Secondary data were collected from different sectors of the woreda development structures such as Qimbibit woreda agriculture office, irrigation development authority, cooperative office, livestock and fishery development agency, market development office, rural land administration office, and the development agents (DAs) offices of the kebele in which the proposed irrigation scheme is located. Sheno Agricultural Research Center and other stakeholders have also been consulted and have a great part in contributing and providing data during the consultation period. Discussion among the study crew members has also been made in the field assessment activities. In the post-field work the collected information was processed, analyzed and critically evaluated for developing the suitable agricultural production plan. For data analysis, simple statistical models such as means, coefficient of variations, and standard deviations were used which were computed using SPSS 16.0 for Windows software. The water requirement of duly selected crops and cropping pattern was worked considering nearest station for representative meteorological parameters, crops and cropping factors, soil factors, etc**.** Meteorological elements for crop water assessment had been collected from pertinent stations and missing meteorological data had been filled by missing data models. In general, the water requirement was calculated following standard scientific procedures as suggested by FAO Irrigation and Drainage, Paper No. 56 and data processing and modeling for crop water requirement was undertaken by modified Penman Monteith method using CropWat-8.0 software for windows.

1.5 The Physical Features of the Project Area

The specific command area is found at the foot of the hill in plain, rugged and undulating landforms at slope range of 2-3% and an average altitude of 2782m.a.s.l at the assumed center of the command area. This area is surrounded by mountainous and hilly areas, especially in the southern, eastern, and western parts. Some indigenous scattered big trees and more eucalyptus trees are observed in the command area as well as on the hill surfaces surrounding the command area. Crops such as wheat, barley, F. bean, teff, potato, onion, garlic, cabbage, beetroot, and some other horticultural crops are cultivated on and around the command area with rainfall and traditional irrigation. The net command area is 46ha (21.2ha on left side, 24.8ha on right side) and the soil of the command area is dominantly clay vertisols in texture having pH value ranging from 6.3-6.8 with medium to high water holding capacity and low to fair infiltration rate. The upper horizon (25 to 30 cm) has almost partially granular structure and when goes downwards blocky to partially platy structures are observed. Red to brown color is dominant with sufficient agricultural depths. When wet it is sticky and hard when dry. As a general soil order, the area falls under pellic and chromic vertisols which are deposited from the highlands of the catchment for a certain period of years and seems rich in organic matter (humus) from the decomposition of grassy and bushy vegetation debris and other related materials. The primary clay mineral seems a mixture of micas and vermiculites which has a medium bondage between soil particles. This condition helps the soil structure to have a fair water movement during watering the soil. Generally, from physical condition and existing crop stand observation of the project area, the soil is suitable for most agricultural crops with minimum mitigation measures. Major soil textures of the project area include sand 35%, clay 43%, and silt 22% (data obtained from Lab. analysis). The detail chemical analysis can be referred on the soil study report of the project document.

FIGURE 0-1: PARTIAL VIEW OF THE COMMAND AREA

The water source of the future irrigation development is Laga Gimbi River which emanates from the swampy areas at the foot of the Mountain, a bit far away at south-east direction from the command area, and it flows to north-west direction to join Aleltu River, then to Jema River and eventually flows to the north to join the Abay River. During the assessment period the flow rate of the river is optimum and it can supply the required amount of water to the whole command areas of the proposed irrigation development activity. The proposed water abstraction method is gravity (diversion) on both sides of the river with furrow irrigation system. As it is observed during the field assessment and secondary data collected from the relevant parties, the area is suitable for small scale irrigation scheme development with some required amendment measures.

FIGURE 0-2: LAGA GIMBI RIVER AROUND PROPOSED WEIR SITE

1.5.1 Agro-climatic Zone of the Specific Area

The command area is located in Gimbi Qerransa kebele of Qimbibit woreda, North Shewa Zone of Oromia National Regional State at about 95 km (assumed centre of command area) North-east of Finfinne (Addis Ababa) city, about 15 km west of Sheno town, the capital of the woreda, and about 15 km away on the main asphalt road from Finfinne to Debre Birhan. The area is found in the cool sub-humid tropical highland agro-ecological zonation at an average altitude of 2782masl with crops having 120 to 180 days of growing period (LGP) based on type of crops and varieties to be produced. Meteorological data were obtained from Sheno National Meteorology Station which is found at an average altitude of 2870m.a.s.l and about 10km air distance from the command area. All necessary climatic data for crop water requirement computation were obtained from this station.

1.5.1.1 Length of Growing Periods

Growing period describes the period in which conditions for plant growth are adequate, in this case defined by the availability of soil moisture. It is estimated in days from the beginning to the end of crop growth. The length of this period is crucial to the satisfactory development and maturation of the crop. There are generally two categories of growing periods within the project area:

TABLE 0-1: AGRO-ECOLOGICAL DATA FOR CALCULATION OF LGP

Climate Fac.	Unit	Moths											
		J	F	M	A	M	J	J	A	S	O	N	D
P.RF	mm/M	15	18	48	30	72	196	313	224	90	18	16	1

PET	mm/M	94.8	104.4	111	110.1	120.3	115.8	93.6	99.9	105	106.5	103.5	95.4
0.5PET	mm/M	47.4	52.2	55.5	55.05	60.15	57.9	46.8	49.95	52.5	53.25	51.75	47.7

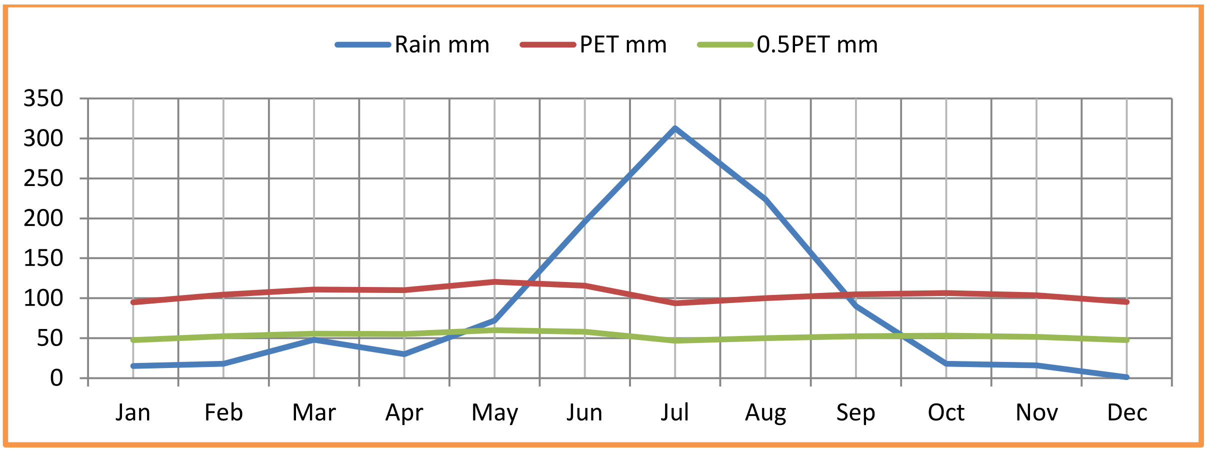

FIGURE 0-3: LGP GRAPH OF THE PROJECT AREA

1.5.1.2 Rainfall

Rainfall needs to be examined in terms of its ability to satisfy crop requirements. By comparing the results with the potential evapo-transpiration the water available to crops could be determined. For example a positive difference between rainfall and potential evapo-transpiration for the greater part of a growing season would ensure good crop growth. A negative result during the critical growing season would indicate insufficient moisture for that crop or the need for irrigation. On the other hand, an excess of precipitation over the potential evapo-transpiration during the wet season would indicate the importance of drainage. A study of the rainfall intensity (quantity over a given period of time) would give an indication of the potential water erosive or of the runoff to be expected and of the dimensions which would have to be given to surplus water disposal channels etc. Some qualitative aspects of precipitation are also worthy of attention: for example, the duration and frequency of hail storms, in relation to the periods when the land is occupied by crops, or the occurrence of rain storms associated with strong winds, etc. As the data collected from Sheno National Meteorology Station shows the project area (Laga Gimbi project site) has an average annual rainfall of 1041mm, mono-modal type, evenly distributed over more than four months. From this the highest rainfall is recorded in the month of July, and the lowest is recorded in the month of December.

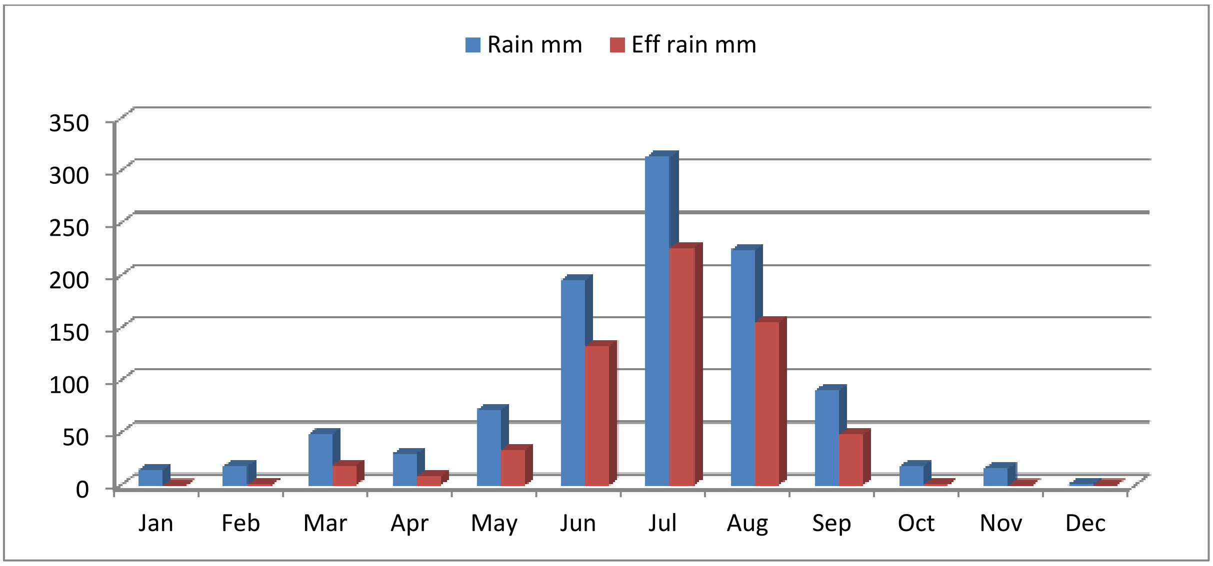

FIGURE 0-4: TREND OF MEAN MONTHLY RAINFALL AND EFFECTIVE RAINFALL OF THE STUDY AREA

1.5.1.3 Temperature, Relative Humidity and Wind Speed

Air temperature and relative humidity are the most important climatic variables that affect plant life. Each species and variety of plants and each age group of plants has its own upper and lower temperature limits. Beyond these limits, a plant becomes considerably damaged and may die. Relative Humidity (RH), the water vapor contained in the atmosphere, is expressed as the percentage of the ratio of actual to saturation vapour pressure. This, together with wind, gives an indication of drying power of the air important for drying and storage of crops while fluctuations in values often affect the incidence of plant diseases as well as the safe storage of harvested crops. Therefore, temperature, relative humidity and wind speed should be considered while dealing with agricultural planning of an area. Monthly maximum, minimum and mean temperatures are 20.4^{0}C, 8.3^{0}C & 14.3^{0}C, respectively. The hottest month is June, and the coldest one is December.

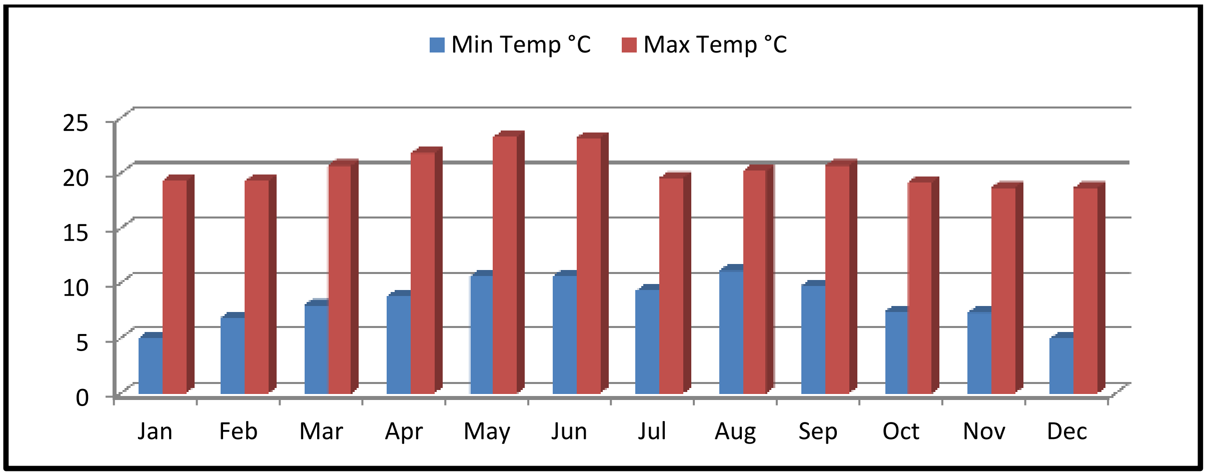

FIGURE 0-5: MEAN MONTHLY MAX AND MIN TEMPERATURES OF THE STUDY AREA

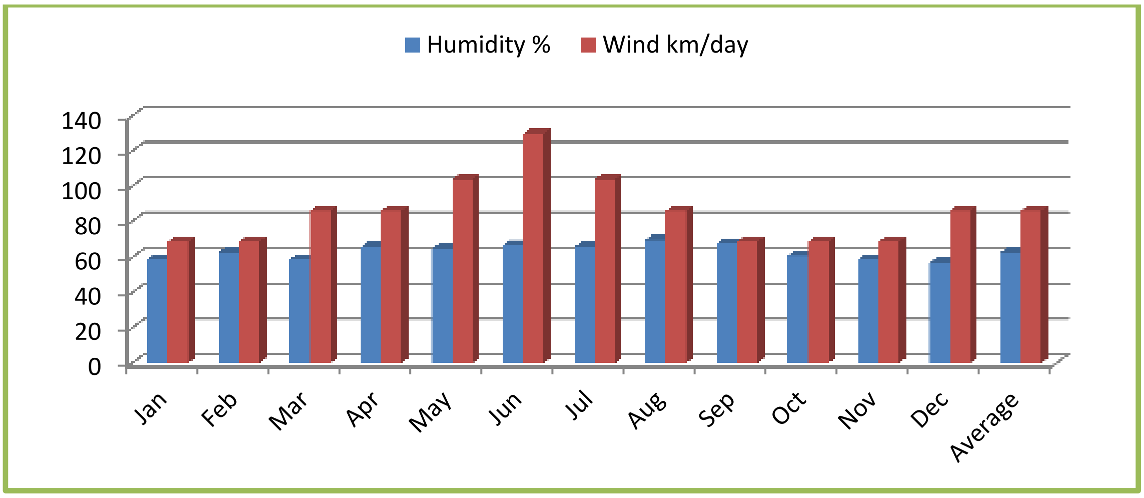

FIGURE 5-6: MEAN MONTHLY RELATIVE HUMIDITY AND WIND SPEED OF THE PROJECT AREA

1.6 Land Use

The land use pattern is mainly composed of an extensive grazing, subsistence type of agriculture and scattered settlement, situated within different landforms. The major land use types in the command area include cultivated land, grazing (fallow) land, and scattered settlement. Among the use types, arable land takes the largest proportion (50%) followed by grazing land (45%), and settlement land (5%). On the cultivated lands, crops such as wheat, barley, Faba bean, teff and other highland oil crops are cultivated under traditional way of farming practices. As the information obtained from the farmers and physical observation made in the field, about 40% of the command area is covered with horticultural crops such as onion, garlic, potato, beetroots, carrot, fenugreek, and others with traditional irrigation system during the field assessment period. Average landholding size of the study area is 1.5ha per household. According to the information obtained from the woreda agriculture and DA offices, the following land use patterns for the woreda and the project kebele are identified.

TABLE 0-2: LAND USE PATTERN OF QIMBIBIT WOREDA AND GIMBI QERRANSA KEBELE

S/N	Types of Land Use	Qimbibit Woreda		Gimbi Qerransa Kebele	
		(ha)	(%)	(ha)	(%)
1	Arable land	33,554	44.60	1538	74.08
2	Cultivated	32,124	95.74 of arable land	1408	91.55 of arable land
3	Grazing land	29,639	39.40	476	22.93
4	Settlements	9778	13.00	22	1.06
5	Forest lands (including bushes & shrubs)	2256	3.00	40	1.93
6	Other land	--	--	--	---
	Total	**75,227**	**100**	**2076**	**100**

Source: Qimbibit Woreda Agriculture Office, Gimbi Qerransa kebele DAs offices

1.7 Existing /Present Agricultural Conditions

Agriculture is the mainstay of the community at the project area. Traditional crop-livestock mixed farming practices, subsistence type of farming and high dependence on natural rainfall dominate the sector. However, at a specific project area crops such as onion, cabbage, potato, beetroot, carrot, and lentil are predominantly produced using small scale traditional irrigation on some part of the command area.

As witnessed by the local farmers the use of improved agricultural technologies such as improved seeds and fertilizers is not adequately well practiced on both irrigated and rain-fed crops production. The supply of improved seeds and fertilizers to farmers in the woreda for rain-fed crop production is not adequate because the area is not easily accessible during the wet season, less road network and far from the main road. The following table shows the supply and distribution trend of these improved agricultural technologies for the last three years.

FIGURE 0-7: LAND PREPARATION ACTIVITIES OF THE COMMAND AREA FOR DRY-SEASON TRADITIONAL IRRIGATION

TABLE 0-3: CHEMICAL FERTILIZERS, IMPROVED SEEDS AND AGRO-CHEMICALS USED BY THE WOREDA FARMERS

S/N	Items	2008		2009		2010	
		Supplied	**Distributed**	**Supplied**	**Distributed**	**Supplied**	**Distributed**
1	**Fertilizer (qt)**						
	NPS	5267	5267	184	184	1139.5	1072.5
	Urea	5928	5032	5032	4980.5	4620	4357.5
	NPSB	---	---	4048.5	3888.5	3652	3592.5
	Total	**11,195**	**10,299**	**9264.5**	**9053**	**9411.5**	**9022.5**
2	**Seed (qt)**						
	Barley	---	---	15	15	25.5	24
	Wheat	535.5	535.5	258.5	256.5	248	248
	F. bean	400	400	---	---	---	---
	Total	**935.5**	**935.5**	**276.5**	**271.5**	**273.5**	**272**
3	**Agro-chemicals (lts)**						
	2,4-D	700	641	1200	1212	1614	1446
	Nobl	---	---	120	98	80	130
	Mancozeb	---	---	120	120	50	71.5
	Tilt	---	---	453	453	108	108
	Natura	---	---	239	239	80	80
	Total	**700**	**641**	**2132**	**2122**	**1932**	**1835.5**

Source: Qimbibit Woreda Cooperative office

1.7.1 Existing Crop Calendar (rain-fed agriculture)

Length of growing period of the crops is mainly determined by the area agro climatic conditions. As indicated before, agro-climatic zonation for this particular area is cool sub-humid tropics (more of highland having mono-modal, but modest rainfall distribution with scattered trees, bushes and shrubs). Hence, generally crops growing with such type of climatic conditions have relatively a longer Total Growing Period of 120 to 180 days based on crop type and varieties. As the information obtained from woreda agriculture office, the project area development office, and from the interview of focal farmers indicated the following cropping calendar is presented for the rainy seasons.

TABLE 0-4: EXISTING CROPPING CALENDAR OF THE PROJECT AREA

S/N	**Crops**	**Land preparation**	**Ploughing frequency**	**Sowing date**	**Harvesting date**
1	Teff	Mar - June	3-4	July 25 – Aug 10	Nov 20 – Dec 15
2	Wheat	Apr - June	2-3	June 15 – July 10	Nov 10 – Dec. 10
3	Barley	Apr - June	2-3	June 10 – July 05	Nov 10 – Dec. 20
4	F. bean	May	1-2	June 1 - 15	Oct 20 - 30
5	Chickpea	May	1-2	June 1 - 15	Oct 20 - 30
6	Lentil	June	1-2	June 1 - 15	Sep 20 - 30
7	Noug	May	1-2	Jun 20 - 30	Nov 10 - 20
8	Potato	Mar - Apr	3-4	Early June	Oct 10 - 20

***Source: Qimbibit Woreda, Gimbi Qerransa Kebele & Farmers Interview.**

1.7.2 Major Rain-fed Crops of the Area

As the soil and climate is suitable for a wider variety of crop types, different crops and varieties are growing by farmers of the kebele in the project area. However, improved technologies are not fully and adequately utilized, mainly because of inadequate extension services rendered to the farmers, inaccessibility of the area, insufficient supply, poor distribution and unaffordable price of the improved technologies. According to the data obtained from the woreda Agriculture Office and the nearby DA Center, the information about the last cropping season has been compiled in the following table.

TABLE 0-5: MAJOR STAPLE FOOD CROPS OF QIMBIBIT WOREDA AND THE PROJECT KEBELE

S/N	Major crops (rain-fed)	Qimbibit Woreda			Gimbi Qerransa Kebele		
		Area Coverage		Yield, (qt/ha)	Area Coverage		Yield, (qt/ha)
		ha	(%)		ha	(%)	
1	Teff	544	1.80	8.24	0	---	---
2	Wheat	9234	30.58	16.47	400	36.40	6.0
3	Barley	8188	27.12	11.2	148	13.47	7.0
4	E. Wheat	165	0.55	4.4	3	0.27	5.3
5	F. bean	9035	29.92	14.42	465	42.31	15.48
6	Lentil	3026	10.02	11.6	83	7.55	5.65

Source: Qimbibit Woreda Office of Agriculture and Development Agents Office of the project kebele

From the above table, it can be understood that crops like wheat, barley, and F. bean are widely grown in the woreda and project areas as well. The above condition is also confirmed by the Woreda Office of Agriculture and Development Agents Center of the project kebele. As the information obtained from the Woreda indicated, almost all types of field crops are growing in the woreda.

TABLE 0-6: CROPS HARVESTED WITH RAINFALL IN QIMBIBIT WOREDA IN THE LAST THREE YEARS

S/N	**Crops harvested**	**2008**		**2009**		**2010**	
1	**Cereals**	**Area (ha)**	**Total prod. (qt)**	**Area (ha)**	**Total prod. (qt)**	**Area (ha)**	**Total prod. (qt)**
1.1	Teff	765	6448	420	4620	544	4488
1.2	Wheat	6011	183,304	8268	167,326	9234	152,072
1.3	Barley	7830	87,720	11,197	230,149	8188	91,700
1.4	E. Wheat	146	1419	120	960	165	726
2	**Pulses**						
2.1	F. bean	7941	59,120	8286	135,228	9035	130,241
2.2	F. pea	1305	8893	182	1165	216	1133
2.3	Chickpea	812	3756	102	933	200	1700
2.4	Lentil	2971	12,708	2562	19,369	3026	35,191
2.5	Grasspea	305	1281	310	1736	607	4249
3	**Oil Seeds**						
3.1	Linseed	1140	7296	2038	26,086	2306	22,207
4	**Total**	**29,226**	**371,945**	**33,485**	**587,572**	**33,521**	**443,707**

***Source: Qimbibit Woreda Office of Agriculture.**

According to the table above it can be concluded that wheat, barley, and teff are widely produced from cereal crops and cover the largest portion of arable land. Other crops such as F. bean, F. pea, lentil, and linseed are largely harvested from the pulses and oilseed crops respectively. The productivity of these crops is stagnant from year to year from almost constant land unit. On the other hand, the farmers in and around the project area have long experience in producing horticultural crops using traditional irrigation practices. During the field assessment period nearly 40% of the command area is cultivated for production of different horticultural crops, dominantly garlic, onion, potato, carrot, cabbage and the likes. The following crops have been harvested with traditional irrigation development in Qimbibit Woreda for the period of 2008 - 2010 cropping seasons, which could be used as baseline for the proposed irrigated agriculture.

TABLE 0-7: IRRIGATED CROPS HARVESTED IN QIMBIBIT WOREDA IN THE LAST THREE YEARS

S/N	Crops harvested	2008		2009		2010	
1	**Cereals**	**Area (ha)**	**Total prod. (qt)**	**Area (ha)**	**Total prod. (qt)**	**Area (ha)**	**Total prod. (qt)**
1.1	Barley	519	10,199	332	10,724	336	7757
1.2	F. bean	420	3145	318	10,904	381	9465
2	**Vegetables**						
2.1	Garlic	2146	123,983	1436	67,545	1581	69,932
2.2	Kale	533	64,880	301	55,891	362	47,756
2.3	Cabbage	544	60,721	309	45,435	405	46,770
2.4	Lettuce	319	38,818	166	19,871	196	20,978
2.5	Swisschard	248	95,944	138	16,107	173	18,873
3	**Roots and Tubers**						
3.1	Potato	984	162,509	535	118,293	722	127,396
3.2	Beetroot	464	47,975	258	28,809	358	42,094
3.3	Carrot	537	46,993	309	41,394	358	30,568
	Total	**6714**	**655,167**	**4102**	**414,973**	**4872**	**421,589**

***Source: Qimbibit woreda irrigation development authority.**

1.7.3 Livestock Production

Livestock production is a major component of the farming system. It is also one of the economic activities for traction powers, provision of dairy products, transportation and for household income generation. Oxen are selected for speed and endurance in pulling traditional ploughs. Small ruminants and chickens are generating additional incomes for the community. Traditional beekeeping is also normally known in the area. Modern beekeeping is not as such significantly practiced, but small scale activities are there in few pocket areas. Equines serve as means of transport for human beings and agricultural products. According to the information obtained from woreda livestock agency and health clinic, and the community, FMD, Pasturollosis, AHS, sheep & goat pox, Newcastle and Coccidiosis are the most prevalent diseases in the area. Vaccination and treatment is the major means of preventing these diseases and farmers use their traditional healing mechanisms practiced from generation. In the area natural grazing is the major sources of feed for livestock. In addition some improved forage grasses, multipurpose legume trees and few industrial byproducts are used for livestock feed in the area. Crop residues are largely consumed on the field and also collected, stored and fed during the season of feed shortage. Communal grazing land in some areas is the common means of grazing arrangements among the farmers of the area. Farmers allocate common grazing land at the bottom of the hill around river banks wetland to feed their animals in common. Individually, farmers in the command area allocate and fallow some part of their crop land for animal grazing. Zero grazing is also practiced by few farmers exercising animal fattening around homesteads. The major type and quantities of livestock in Qimbibit Woreda and the project Kebele (where the proposed irrigation project is located) are indicated in the table below.

TABLE 0-8: LIVESTOCK TYPES, QUANTITIES AND COMMON DISEASES IN QIMBIBIT WOREDA AND THE PROJECT KEBELES

S/N	**Qimbibit Woreda**		**Gimbi Qerransa Kebele**	**Diseases of the area**
	Type of livestock	**Qty**	**Qty**	
1	Cattle	318,878	6470	Foot & Mouth disease (FMD), Lumpy Skin Disease (LSD), Bovine and Ovine Pasturollosis, Senoryosis, sheep & goat pox, African horse sickness (AHS), endo and ecto parasites Newcastle, fowl typhoid, Coccidiosis, etc.
2	Sheep	338,980	8120	
3	Goats	4413	200	
4	Horses	38,890	565	
5	Donkeys	50,900	670	
6	Mules	955	35	
7	Poultry	90,130	1126	
8	Beehives			
	-Traditional	1232	50	
	-Transitional	615	2	
	-Modern	297	8	

***Source: Qimbibit Woreda Livestock Health Clinic and nearby Development Agents Offices.**

FIGURE: 5-8 LIVESTOCK PRODUCTION IN THE PROJECT AREA

1.7.4 Existing Agricultural Techniques

As observed from the field assessment and information obtained from the concerned institutions, the existing farming practice is traditional method of crop husbandry. As the project area is more of highland the sector is dominated by highland crops production and especially the farmers of the project area relatively produce wider range of crop types which are mainly used for their subsistence consumption and some more for additional household income generation. The supplying of agricultural inputs such as improved seeds and fertilizers for existing traditional rain-fed agriculture is low, not adequate for full potential use of the available resources. As information collected from the woreda cooperative office and local farmers the price of these agricultural inputs is increasing from time to time and get unaffordable. As a result, the farmers use few inputs, especially, fertilizers on large area of land, not according to the research recommendation. The credit service in the command area is not common and most farmers have little awareness of credit service rendering organizations. The basic agricultural techniques like crop rotation, crop diversification, double cropping, soil and water conservation and other related activities are not yet well practiced in the area. Most farmers use traditional oxen drawn plows to plough their crop land on sloppy farmland, and this plow is short and can cause the formation of a hard pan beneath the top soil. This lowers the water retention capacity of the soil and exposes the upper agricultural soil to water erosion. There are great variations among the farmers, depending on the different biographical conditions, skills, the availability of labor and access to resources outside the farm. Most are marginal subsistent farmers, cultivating basic food crops only. But the production of such crops is low, not enough to meet their requirements in most years. The number of livestock is higher, but the productivity of these livestock sector is very low mainly due to the poor feeding system and poor management of improved breeds. The prevalence of livestock diseases, feed shortage, and low awareness of improved management practices has its own impact to low productivity.

1.7.5 Existing Agricultural Problems

Generally, the following major agricultural problems are identified in and around the project area.

A. Low Technology Input Utilization

There is no adequate provision of agricultural inputs, like improved seeds, agrochemicals, and other related technology packages in the proposed development area. The farmers produce relatively limited range of improved crop types due to low awareness of improved, environmentally-friendly agricultural technologies. Although the Woreda Agricultural Extension Office has been supplying few improved crops varieties, adoption of improved farm practices is hardly seen in the area. This might be because of continuous price increase of important agricultural inputs, especially fertilizers. The price of agricultural inputs as common is high and farmers could not afford to purchase. Crop rotation, diversification, intercropping and soil water conservation are not seen well practiced.

B. Soil Erosion as a Result of Deforestation

Due to population increase which leads to horizontal expansion of agricultural lands, and the increasing fire wood consumption and other related human needs (construction, fencing timber etc.), deforestation is becoming a problem in the proposed project area. Moreover, replanting and other soil conservation activities are not yet well adopted by the community.

C. The Prevalence of Animal Diseases & Low Livestock Productivity

A free-type of grazing is extensively conducted on grazing and post harvested lands. The production & productivity is below the expected condition (as informed by the development agents & other concerned workers). The occurrence of different animal diseases, lack of quality breeding, shortage of high nutritional feeding and the dominance of traditional way of raring system are some of the many factors which reduce livestock productivity.

D. Poor Access to Markets

Marketing of agricultural production in the area poses significant constraints for the producers. Poorly developed or lack of proper infrastructure and marketing facilities (roads, bridges, and warehouses) are major constraints. Limited opportunities to send products to market have hampered the production of micro-businesses and petty trading that could have provided alternative incomes.

E. Inadequate Infrastructures & Institutional Setups

This should be emphasized as one of the major problems in the proposed project area. For instance, there are no road networks among the kebeles surrounding the command area.

No or little opportunities of local transportation available to the community. Basic Institutions such as large market opportunities, Shops, Credit Service giving sectors, Information providers and the likes are absent in the area.

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F. Insufficient Expertise of Irrigation Farming

The expansion of small scale irrigation in the study area and in the Woreda as a whole is still insignificant. This has got its own impact on the introduction of different vegetables and other cash crops in the area. Although there are many potential rivers for modern irrigation development, the practice is not yet developed as required and farmers try their best in developing traditional irrigation practices.

1.7.6 Labour Requirement

Labour requirement for the existing rain-fed agriculture system is calculated on the proposed command area. This is mainly based on the field assessment and secondary data gathered from the agriculture office of Qimbibit woreda and the project Kebele. As per the "without project" condition, a hectare of labor requirement is specified under the following condition.

TABLE 0-9: A HECTARE OF LABOR REQUIREMENT AS A "WITHOUT PROJECT" CONDITION

S/N	Crops	Activities	Unit	Frequency	Qty	Total Required	Cost (Birr)
1	Teff	Ploughing	OD	4	4	16	16*60=960
		Packing	OD	1	20	20	20*10=200
		Sowing + fertilizer	MD	1	2	2	2*60=120
		Weeding	MD	2	25	50	50*60=3000
		Harvesting	MD	1	20	20	20*60=1200
		Threshing	MD	1	10	10	10*60=600
		Transport	MD	1	4	4	4*50=200
		Total					**6,280**
2	Wheat	Ploughing	OD	3	4	12	12*60=720
		Sowing + fertilizer	MD	1	4	4	4*60=240
		Weeding	MD	2	20	40	40*60=2400
		Harvesting	MD	1	15	15	15*60=900
		Threshing	MD	1	10	10	10*60=600
		Transport	MD	1	5	5	5*50=250
		Total					**5,110**
3	Lentil	Ploughing	OD	3	4	12	12*60=720
		Sowing	MD	1	4	4	4*60=240
		Weeding/cultivation	MD	2	20	40	40*60=2400
		Fertilizer application	MD	1	4	4	4*60=240
		Harvesting	MD	1	30	30	30*60=1800
		Threshing	MD	1	30	30	30*60=1800
		Transport	MD	1	4	4	4*50=200
		Total					**7,400**
4	F. bean	Ploughing	OD	2	4	8	8*60=480

S/N	Crops	Activities	Unit	Frequency	Qty	Total Required	Cost (Birr)
		Sowing	MD	1	4	4	4*60=240
		Weeding	MD	1	20	20	20*60=1200
		Harvesting	MD	1	15	15	15*60=900
		Threshing	MD	1	10	10	10*60=600
		Transport	MD	1	4	4	4*60=240
		Total					**3,660**
		Grand Total					**22,450**

Note: The cost should not be computed, instead a column be inserted for unit price and total cost should be filled in.

1.8 Proposed Irrigated Agriculture

Irrigated agriculture is proposed based on the objectives of the agronomic study indicated in earlier parts of this study report under the following conditions. Since assisting with installation of irrigation scheme is a key part of the proposed program and development strategy, it is essential that sound environmental, agronomic, social, economic and technical criteria are met at all stages of planning and design activities. Modern crop technology has the power to increase farm incomes and lower food prices simultaneously, thus benefiting everyone in society, especially the poor who spend a larger portion of their income on food. Thus, clearly irrigation can and should play an important role in raising and stabilizing food production, especially in areas of the proposed project, where there is relatively better land and water potential suitable for irrigation.

1.8.1 Crop Selection

Crops are selected based on the following major criteria:

- Climatic & soil suitability of the area,
- Yield potentiality and marketability,
- Multiple purposes such as food, fodder, export value,
- Length of growing period (early maturing) and workability,
- Their places in rotation and contribution to soil fertility,
- As a basic staple food for existing community (farmers' crop selection preference), and
- Beneficiary's existing skill and level of technology utilization.

Whenever the construction of an irrigation project is proposed, it is essential first to evolve a cropping pattern for the command area to facilitate proper utilization of the project potential and to make the project economically viable. Considering the factors discussed above, the following general cropping patterns are recommended for major agro-ecologies of Ethiopia.

TABLE 0-10: GENERAL RECOMMENDED CROP MIX FOR MAJOR AGRO-ECOLOGIES OF ETHIOPIA

No.	Major agro-ecological zones	Altitude (m)	Average Temperature (^{o}C)	Annual Rainfall (mm)	Recommended crops
1	Moist Dega	2300-3200	12-18	900-1400	Barley, wheat, highland pulses, potato, cabbage, carrot, Swiss chard, garlic, etc.
2	Moist Weyna Dega	1500-2300	18-25	900-1400	Teff, maize, wheat, pulses, sorghum, Noug, potato, sweet potato, cabbage, carrot, Swiss chard, shallot, onion, pepper, tomato, garlic, coffee, etc.
3	Dry Weyna Dega	1500-2300	18-25	300-900	Maize, wheat, groundnut, haricot beans, sweet potato, shallot, onion, pepper, tomato, Swiss chard, coffee, banana, papaya, citrus, etc.
4	Moist Kolla	500-1500	>25	900-1400	Maize, groundnut, haricot beans, sweet potato, shallot, onion, pepper, tomato, banana, papaya, citrus, etc.
5	Dry Kolla	500-1500	>25	300-900	Maize, sorghum, groundnut, haricot bean, cotton, sweet potato, shallot, onion, pepper, tomato, banana, papaya, citrus, etc.

Source: Irrigation Agronomy Guideline, Ministry of Agriculture (2011)

Accordingly, crops such as **Onion, Cabbage, Potato, Garlic, and Carrot** are proposed for the project during the dry season. As the command area is wetland and waterlogged there is no crop proposed for production during the wet season. In selection of crops most attention was given for high value marketable crops. Vegetable crops provide steady income to producers besides using as a food, and make significant contribution to the economy in form of cash crops. They are also the main source of vitamins, minerals, proteins, carbohydrates and fats.

1.8.2 Cropping Pattern

After selection of the crops to be planted using irrigation, the seasonal cropping pattern and cropping calendar for each crop should be determined. This helps in establishing which crop will occupy what part of the available land area during each season, also taking into consideration the crop rotation requirements other than perennial crops. Moreover, the cropping pattern is based on the following basic considerations.

- The objective of the project,
- Production of high value crops, at least to satisfy the local market demand, increase export needs by producing an agricultural surplus,
- The proportion of land for different crops can be adjusted according to the market needs with the increase of local and export demand in raising the crop and preferences,
- Intensification of crop production from food crops to cash income generation,
- Immediate benefit in the form of more reliable harvest higher production per unit of labor.

TABLE 0-11: CROPS SELECTED FOR DRY SEASON IRRIGATION DEVELOPMENT

S/N	Proposed Crops	Area		Selected varieties	Planting/ Sowing date	Harvesting Date	Base-period (days)
		(ha)	(%)				
1	Onion	11.5	25	Adama Red and Bombe red	Dec. 10-20	Mar. 15-25	95
2	Cabbage	9.2	20	Copenhagen Market	Dec. 01-05	Mar. 15-20	115
3	Potato	9.2	20	Jalane, Gudane, Belete	Dec. 05-10	Apr. 05-10	120
4	Garlic	9.2	20	Tsedey, Bishoftu	Dec. 10-20	Mar. 20-30	110
5	Carrot	6.9	15	Scharwoode	Dec. 01-05	Mar. 01-05	90

1.8.2.1 Details of the Selected Crops

The essential climatic and soil needs, length of growing period, and their appropriate agronomic and other related requirements of the selected crops are identified below.

1.8.3 Vegetables

a) Onion (*Allium cepa*)

Bulbing takes place more quickly at warm than at cool temperatures provided the minimum photoperiod for the cultivars has been reached. Optimum conditions for germination are met at temperatures between 10-25^{0}C and a high soil temperature kills the young seedlings. The optimum temperature for growth is 16-22^{0}C. Early maturing and low yields occur at temperature <16^{0}C. A low air humidity and low temperature lead to flowering. Onion is sensitive to the day length and 12-13 hours are required in the yield formation period.

Onion grows on a wide variety of soils, provided they are well aerated and friable and as long as sufficient water can be retained. Fertile, loamy textured soils are most suitable. The maximum rooting depth of the crop is 0.5m. Soil pH range is 5.5-8.2; optimum pH is 6.0-7.8.

b) Cabbage (*Brassica oleracea var. capitata*)

Cabbage is a cool season crop and one of the oldest vegetable crops grown in the temperate regions but gradually distributed throughout the world where climatic conditions are found favorable for its successful growing. Cabbage can be generally grown more successfully in heavier loam soils, which are considered more suitable for cabbage production. Soils rich in soil organic matter and easy for free air movement are more suitable. Cabbage thrives best for high production during cool, moist season and the crop requires a cool, humid climate. The length of the total growing period varies between 90 and 200 days, depending on climate, variety and planting date, but for good production the growing period is about 120 to 140 days. Most varieties can withstand a short period of frost of -6°C, some down to -l0°C. Cabbage is successfully grown with an average rainfall of 450 mm during the growing season and if it is grown during the dry season the water requirement of the crop should be supplied through irrigation. Therefore, adequate supply of water either in the form of rainfall or through irrigation needs to be maintained in order to satisfy the crop water requirement at different growth stages. Planting can be done by direct seeding with a seed rate of 3.5 kg/ha, or by transplanting to open field from seedbeds and from cold frames which are used to protect the crop from cold during germination and early plant development.

c) Garlic (*Allium sativum*)

It grows under a wide range of climates from midland to highland (especially from 1700 to 2800m.a.s.l). It is a high value and demanded crop in the project area and surroundings. For a high yield of good quality, the crop needs controlled and frequent supply of water throughout the total growing period. Although the crop can be grown on various types of soils, it grows best on light soils, with a pH of 5.5 to 7.5. Optimum temperatures are ranging between 10^0c to 23^0c and low temperatures. So planting time adjustment for maximum yield is very much important. Irrigation should be discontinued as the crop approaches maturity to allow the tops to desiccate, and also to prevent a second flush of root growth. Has good economic and medicinal value at the community level. As it is easily attacked by diseases and insect pests careful crop protection measures should be employed during the growing period.

1.8.4 Roots and Tubers

a) Potato (*Solanum tuberosum*)

Potato is grown in a three or more year rotation with other crops such as maize, beans and alfalfa, to maintain soil productivity, to check weeds, and to reduce crop lass from insect damage and disease particularly soil borne diseases. Potato requires a well-drained, porous soil with a pH of 5 to 6 and it grows on ridges or on the flat seedbed. For rainfed production in dry conditions, flat planting tends to give higher yield due to soil water conservation. Under irrigation the crop is mainly grown on ridges. The sowing depth is generally 5 to 10 cm, while plant spacing is 0.75 x 0.3m for seed potato and 1m x 0.5m for ware potato conditions. Cultivation during the growing period must avoid damage to roots and tubers, and the ridges are earthen up to avoid greening of tubers

Potato is relatively sensitive to soil water deficit. To optimize yields the total available soil water should not be depleted more than 30 to 50 percent. Water deficit during the period of stolanization and tuber initiation and yield formation has the greatest adverse effect on yield. Whereas, ripening and early vegetative period are less sensitive. Supply of water can be restricted during the early vegetative and ripening periods. Good yields under irrigation of a crop taking 120 days in tropic climates are 15 to 25 tons/ha.

1.8.5 Irrigation Seasons

Irrigation seasons are decided based on the existing climatic condition, length of growing period of the proposed crops and capacity (efficiency) of the beneficiaries of the project. As to the proposed project condition, most of the command land is waterlogged and swampy during the rainy season so that only one time irrigation season as a "Dry-season" is possibly recommended. The "Dry-Season" is considered as "Full-Time" irrigation season and the second planting is only possible with rainfall on few areas of the command land during the "Wet-season". The full time irrigation season is proposed starting in the month of December. This period (December) is proposed to be a starting month considering the serious frost condition in the project area during the fall season, length of growing period of the selected crops, and appropriate marketing time of the produce.

1.8.6 Proposed Management

As a "With-Project" condition and modern farming system, all the required crop management approaches should be applied in the system. For instance crop spacing, method of irrigation, fertilizer application (type, amount, time and method) should be identified prior to the development phases. Accordingly, the following basic and integral parts of crop management approaches for the "would be" irrigated agriculture are identified.

1.8.6.1 Method of Irrigation

The major method of water application during the cultivation seasons is furrow system for the selected crops. Farmers of the proposed irrigation area have the experience of furrow application on the traditional irrigation activities. The detail condition is indicated in the following table.

TABLE 0-12: METHOD OF IRRIGATION AND SPACING FOR THE SELECTED CROPS

S/N	Selected Crops	Method of Irrigation	Recommended Furrow Length (m)	Plant spacing (cm)		Remark
				Intra-row	Inter-row	
1	Onion	Furrow	15-20	10	30	
2	Cabbage	Furrow	20-25	40	60	
3	Potato	Furrow	20-25	30	75	
4	Garlic	Furrow	15-20	10	30	

5	Carrot	Furrow	15-20	5	20	

1.8.6.2 Cultivation Activities

Different crops require different cultivation activities. Some crops require simple hoeing and some others require earthening up. Thus, it is advisable to understand these conditions prior to the development activities. Some of the major cultivation processes of crop production are summarized in the following table.

TABLE 0-13: MAJOR CULTIVATION ACTIVITIES IN IRRIGATED AGRICULTURE

S/N	Proposed crops	Seed Rate (Kg/ha)	Soil depth during Seeding/ planting (cm)	Cultivation time/Weeding
1	Onion	3-4	4-5 (Transplanting from nursery site after 30 days)	After 20 days of transplanting
2	Cabbage	2-3	Same	Same
3	Potato	2000	5-10	1st 25 days and 2nd 45 days after planting
4	Garlic	150	5-10	30 days after planting
5	Carrot	10-15	3-5 and drilling	20 to 25 days after sowing

1.8.7 Fertilizer Management

Adequate fertilization programs supply plant nutrients needed to sustain maximum crop productivity and profitability while minimizing environmental impact from nutrient use. In essence, fertilizers are used so that soil fertility is not a limiting factor in crop production. The major factors influencing the quantity of nutrients to apply are crop and soil characteristics, fertilizer placement, climate especially moisture and temperature, yield goals and economics. Considering these main factors in proper fertilizer management activities, the required fertilizers (that can be synthetic or natural), are given to the proposed crops. However, it should be applied after careful chemical analysis of the command soil. As to the proposed project condition, the following fertilizer and other agrochemicals are averagely determined. (The total yearly input required is referred in Agronomy Annexes).

TABLE 0-14: FERTILIZERS & AGROCHEMICALS PLANNED FOR EACH PROPOSED CROP

S/N	**Selected Crops**	**Fertilizers,(Kg/ha)**		**Pesticide s,(Lt, Kg/ha)**			**Remark**
		NPS	**Urea**	**Insecticides**	**Fungicide**	**Herbicide**	
1	Onion	100	100	Nimbicidine, etc.	Ridomil, etc.	-	Amount of pesticides is determined on the type of crop, kind of pest outbreak and type of pesticides to be used.
2	Cabbage	100	50	Dimethoate 40% EC	-	-	
3	Potato	180	100	Dimethoate 40% EC, Diazinone, etc.	Mancozeb, Ridomil, etc.	-	
4	Garlic	100	50	Nimbicidine, etc.	Ridomil, etc.	-	
5	Carrot	100	50	-	-	-	

1.8.7.1 Method of Fertilizer Application

There are a number of fertilizer application methods, based on the crop and its cultivation system. Among these, deep-banding, side/basal dressing, fertigation, foliar application and others are known. However, as to the level of irrigation and user's awareness, the basal and top dressing are the most important application methods in well managed irrigation development activities. Accordingly, the following application experiences are designed for the proposed project.

TABLE 0-15: METHODS OF FERTILIZER APPLICATION FOR THE PROPOSED CROP TYPES

S/N	Proposed Crops	Fertilizers to be applied	Method of Application	Time of Application
1	Onion	NPS	Top/Side dressing	At the time of transplanting
		Urea	Basal dressing	3 to 4 weeks after transplanting
2	Cabbage	NPS	Top/Side dressing	At the time of transplanting
		Urea	Basal dressing	3 to 4 weeks after transplanting
3	Potato	NPS	Top/Side dressing	At the time of planting
		Urea	Basal dressing	During earthening up stage
4	Garlic	NPS	Top/Side dressing	At the time of planting
		Urea	Basal dressing	3 to 4 weeks after planting
5	Carrot	NPS	Top/Side dressing	At the time of sowing
		Urea	Top/Side dressing	3 to 4 weeks after sowing

In general the assigned agronomist can select one of the following fertilizer management practices during the implementation period.

- Excessive use of external inputs,
- Intensified use of local resources with few or no external inputs,
- Integrated use of external inputs and local resources.

1.8.8 Plant Protection

Controlling insect pests, diseases, and weeds is very essential for the achievement of optimum crop yield from irrigated agriculture. Pesticides may be expensive and may cause environmental problems on the area for both human beings and animals. They also kill other important pests which are enemies of the non-advantageous pests. Thus, during the cultivation period, non-chemical methods of pest control should preferably be applied together with that of chemical ones (integrated method of pest management). Accordingly, the following protection methods are summarized to be used in the future plant protection activities of the proposed project.

TABLE 0-16: CHEMICAL & NON-CHEMICAL PLANT PROTECTION METHODS FOR THE PROPOSED CROPS

S/N	Proposed Crops		The Possible Pests & Diseases	Chemical Prevention Method	Non-chemical Prevention Method
1	Onion	Pests	Onion trips, cut worms, Onion flies, Termite.	Use different chemicals	Field sanitation, Crop rotation, and Disease free var., proper crop and water management.
		Diseases	Root rot, Purple Bloch, Downey Mildew	Use different fungicides.	Field sanitation, Crop rotation, and Disease free var., proper crop and water management.
2	Cabbage	Pests	Aphids, Flea, Beetle, Diamond Back	Use different Chemicals & pesticides	Field sanitation, Crop rotation, use of Disease free var., proper crop and water management.
		Diseases	Black rot, Downy Mildew, Leaf Spot	Use different fungicides.	Field sanitation, Crop rotation, use of Disease free var., proper crop and water management.
3	Potato	Pests	Soil borne Worms, Aphids, Army Worms	Use different Chemicals & pesticides	Field sanitation, crop rotation, and insect free var., proper crop and water management.
		Diseases	Late blight, Bacterial wilt, etc.	Use of different fungicides.	Field sanitation, crop rotation, and disease free var., proper crop and water management.
4	Garlic	Pests	Onion thrips, cut worms, Onion flies,	Use different chemicals	Field sanitation, crop rotation, and disease free var., proper crop and water management.
		Diseases	Root rot, Purple Bloch, Downey Mildew, rust spp.	Use different fungicides.	Field sanitation, crop rotation, and disease free var., proper crop and water management.
5	Carrot	Pests	Aphids, Jassids, Beetles, Worms	Use different fungicides.	Field sanitation, crop rotation, and disease free var., proper crop and water management.
		Diseases	-	-	Field sanitation, crop rotation, and disease free var.

1.8.9 Crop Rotation and Intercropping

Crop rotation is used to avoid the build-up of diseases and pests and to avoid or minimize loss of soil fertility. Intercropping allows efficient utilization of soil nutrients and increased harvest from limited land resource. It also enables to get minimum harvest in case of one component crop failure, so intercropping of leguminous crops with the major component crop is advisable. The possible arrangements in crop rotations and intercropping can be the following.

- Potato ↔ cabbage ↔ onion ↔ potato which helps for avoidance, especially of nematode build up, blight and bacterial wilt.

- Shallow rooted crops alternatively with deep rooted crops for efficient utilization of essential nutrient resources is also one of the rotational possibilities.
- Potato/cabbage intercropping used for efficient utilization of limited land resources.

1.8.10 Labor Requirement

As a "With-Project "condition, labor is calculated for each selected crop, for a hectare of irrigable land. All the required activities are specified in the next table.

TABLE 0-17: A HECTARE OF LABOR REQUIREMENT AS A "WITH-PROJECT" CONDITION

Activity	Unit	Proposed crops				
		Onion	Cabbage	Potato	Garlic	Carrot
Nursery	MD	60	60	0	0	0
Land preparation	OD	12	12	12	12	10
Pre planting operation	MD	12	10	10	10	8
Planting	MD	25	15	12	12	15
Fertilizer application	MD	5	5	4	4	4
Irrigation	MD	20	20	20	20	15
Weeding & hoeing	MD	50	20	40	30	20
Crop protection	MD	5	5	4	5	2
Harvesting	MD	20	15	20	20	20
Post-harvest operation	MD	15	15	15	15	10
Total	MD	224	177	137	128	104
Production Cost	**Birr**	**13,440**	**10,620**	**8,220**	**7,680**	**6,240**

1.8.11 Area Coverage/Intensity

For the irrigation project the development approach is assumed to double crop over one cropping season and the cropping intensity to approach 200%. The climatic condition of the command area allows producing crops twice in a year using irrigation system. This helps to increase the time and resource use efficiency and allows adopting irrigated agriculture through a sequence of irrigation practices. However, the proposed command land is waterlogged and swampy during the rainy season and it is only possible producing crops one time in a year. Accordingly, the following cropping pattern/intensity is designed for the first 5-year crop production schedule.

TABLE 0-18: A 5-YEAR CROPPING PATTERN/INTENSITY PLAN

S/N	Crops	Area coverage									
		1st-Yr/Season		2nd-Yr/Season		3rd-Yr/Season		4th-Yr/Season		5th-Yr/Season	
		ha	%	ha	%	ha	%	ha	%	ha	%
1	Onion	8.6	18.69	11.5	25	11.5	25	11.5	25	11.5	25
2	Cabbage	6.9	15.00	9.2	20	9.2	20	9.2	20	9.2	20
3	Potato	6.9	15.00	9.2	20	9.2	20	9.2	20	9.2	20
4	Garlic	6.9	15.00	9.2	20	9.2	20	9.2	20	9.2	20
5	Carrot	5.2	11.31	6.9	15	6.9	15	6.9	15	6.9	15
Intensity		**34.5**	**75**	**46**	**100**	**46**	**100**	**46**	**100**	**46**	**100**

1.8.12 Yield Projection

Crop yield is mainly estimated based on the level of crop management required practices, availability of agricultural inputs, proper extension services, and existing climatic situations for crop production. Apart from these basic factors, other trends should be assessed. For instance, observation of previous yield condition from traditional (rainfed) agriculture, anticipated research outputs, and other related sources are very important. Considering these parameters, the following yield projection is forecasted.

TABLE 0-19: YIELD PROJECTION FOR FIVE (5) YEAR/SEASON PRODUCTION PERIOD

S/N	Crop	1st-Year /season		2nd-year /Season		3rdYear /Season		4th-year /Season		5th-year /Season	
		Yield (qt/ha	Prodn (Qt)	Yield (qt/ha	Prodn (Qt)	Yield (qt/ha	Prodn (Qt)	Yield (qt/ha	Prodn (Qt)	Yield (qt/ha	Prodn (Qt)
1	Onion	65	559	70	805	75	862	75	862	75	862
2	Cabbage	120	828	125	1150	130	1196	130	1196	130	1196
3	Potato	150	1035	165	1518	175	1610	180	1656	180	1656
4	Garlic	60	414	65	598	70	644	75	690	75	690
5	Carrot	65	338	70	483	75	517	75	517	75	517

1.8.13 Post harvest Activities

a) Harvesting

Irrigated crops such as vegetables and fruits are highly perishable and subjected to chemical and physical changes and hence too rapid deterioration. Apart from some exceptions, most farm products are susceptible to damage, whether from mechanical shocks or climatic factors like atmospheric dryness, heat and cold. This sensitivity creates the need for a whole series of precautions in handling, storing, packing and transport. Therefore, care should be taken during harvesting and post-harvest activities. Recognition of the point of optimum maturity is important for the successful harvesting of certain fruits and vegetables. Correct handling is required during picking or lifting of crops manually. The grower must supervise the work and insists constantly that all rough handling is avoided. Every shock and small wound, even those not observable, will shorten the shelf life of the vegetable/seeds and deteriorates and reduces the quality and hence the profitability. Attention should be paid to the weather. Heat, rain, hail and dew may all damage the appearance of the crop after picking or lifting.

b) Storage

Storage under naturally ventilated conditions is the best. It is sometimes necessary to store produce for a considerable period, so as to space out the sales and avoid glutting the market. The site for the storage facility should be relatively elevated and well-exposed to the dominant winds. It can be located under the shade of a tree, with light air condition. Generally, cold storage is preferable. The crop should be spread on well-aerated open racks in layers not exceeding about 20cm in depth. The store must be kept clean and baskets and boxes packed, so that they do not interfere with the free circulation of air.

c) Packing & Grading

Packing concerns the preservation of the produce in the best possible conditions of freshness, appearance, hygiene and general attractiveness, hence protecting its market values.

d) Transport

Available transport should be prepared, at least to the farm gate condition. In hot climate where the distances to be covered are long journeys that are undertaken in day light, special protection and proper packing for the produce is very necessary. Bad road conditions will inflict further damage on produce before it reaches the market. Frequency and reliability of transport as well as distances to the market should be assessed and planned before complete harvesting activities.

1.8.14 Extension Service

Farm management deals with the organization and operation of a farm with the objective of maximizing profits from the farm business on a continuing basis. And hence, proper extension activities should be applied for the fact stated above. All the concerned stakeholders have their own parts in the achievement of the project objectives. The following are to be basic factors in extension approach.

1.8.15 Market

Agricultural marketing in irrigation scheme is an integral and general understanding involved in the process of marketing from farm gate to final consumption of irrigation farm products. Adequate market information, shops in the market place for sale of the produces, access road from farm place to the market outlet and good bargaining power are basic issues for the proper development of the proposed irrigated agriculture. Therefore, the irrigators shall get current market information and technical assistance in determination of demand in different crops in their specific area or as a whole in the region.

1.8.15.1 Timely Input Provision

Adequate agricultural input provision is another important issue for good output from irrigation farming. Inputs, like vegetable seeds, agrochemicals and fertilizers should be supplied and this should be supported by the extension agents and other relevant stakeholders. The current supply of agricultural inputs is given a priority for rain-fed agriculture. Thus, the detail demand of irrigation in fertilizers, seeds, and chemicals shall be analyzed and quantified as per the calculated demand shall be provided on time.

1.9 Crop Water Requirement

Crop water requirement (CWR) is defined as the depth of water needed to meet the water loss through evapotranspiration of a disease free crop growing in large fields under non-restricting soil conditions including soil water and fertility and achieving full production under the given growing environment (FAO, 1977). The crop water requirement calculation is computed using Cropwat-8 software based on modified Penman-Monteith Method (conducted on FAO-Irrigation & Drainage Paper No. 56). The estimation of crop water requirement underlies effective planning of crop production at farm level. Water requirement (WR) is related to water from soil profile(s), rainfall and irrigation.

(IR): $$WR = R + IR + S$$

Under this topic, the relevant parameters for proper irrigation water management, such as Irrigation Depth (d, mm), Interval (i, days) and frequencies of irrigation are calculated. Moreover, the design supply (duty) in (l/s/ha) for the maximum value of the project is computed in this part. As shown in water requirement analysis, the net water requirement of each crop is divided by the overall efficiency of 45% to obtain the gross water requirement. **The project supply of the irrigation project during full irrigation is indicated for <u>24 hour</u> irrigation and becomes <u>*0.91 l/s/ha*</u>.** This can be determining at the outlet head or canal head regulator for calculating the discharge capacity of the main off taking canal. The detail climatic data used for computing the crop water requirement and other soil and crop data with detail calculation procedures are seen in the annex part of this study report.

TABLE 0-20: DUTY OF DRY-SEASON CULTIVATION

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation deficit												
1. Onion	88.8	98.8	40.7	0	0	0	0	0	0	0	0	49.1
2. Cabbage	73.8	86.5	97.7	106.8	43.8	0	0	0	0	0	0	69.6
3. Potato	86.4	108	101.8	35.4	0	0	0	0	0	0	0	43.4
4. Garlic	88.8	98.8	40.7	0	0	0	0	0	0	0	0	49.1
5. Carrot	96	97.5	14.5	0	0	0	0	0	0	0	0	71.9
Net scheme irr.req.												
in mm/day	2.8	3.5	1.9	0.9	0.3	0	0	0	0	0	0	1.8
in mm/month	86.4	98	60.4	28.4	8.8	0	0	0	0	0	0	55.5
in l/s/ha	0.32	0.41	0.23	0.11	0.03	0	0	0	0	0	0	0.21
Irrigated area (% of total area)	100	100	100	40	20	0	0	0	0	0	0	100
Irr.req. for actual area (l/s/ha)	0.32	0.41	0.23	0.27	0.16	0	0	0	0	0	0	0.21
Project Efficiency	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Project Duty (l/s/ha)	0.71	**0.91**	0.51	0.60	0.36	-	-	-	-	-	-	0.47

1.9.1 Calculation procedure

The calculation of reference evapotranspiration (ETo) is based on the FAO Penman-Monteith method (FAO, 1998). Input data include monthly and daily for temperature (maximum and minimum), humidity, sunshine, and wind-speed are collected from the station. Crop water requirements (ETcrop) over the growing season are determined from ETo and estimates of crop evaporation rates, expressed as crop coefficients (Kc), based on well-established procedures (FAO, 1977), according to the following equation:

$$ETcrop = Kc \times ETo$$

FAO (1998) has presented updated values for crop coefficients. Through estimates of effective rainfall, crop irrigation requirements are calculated assuming optimal water supply. Inputs on the cropping pattern will allow estimates of scheme irrigation requirements. With inputs on soil water retention and infiltration characteristics and estimates of rooting depth, a daily soil water balance is calculated, predicting water content in the rooted soil by means of a water conservation equation, which takes into account the incoming and outgoing flow of water.

Stress conditions in the root zone are defined by the critical soil water content, expressed as the fraction of total available soil water between field capacity and wilting point that is readily available for crop transpiration, and characterizes a soil moisture condition in which crop transpiration is not limited by any flow restrictions in the root zone. The critical soil water content varies for different crops and different crop stages and is determined by the rooting density characteristics of the crop, evaporation rate and, to some extent, by the soil type.

1.9.2 Cropwat input data

Calculations of water and irrigation requirements utilize inputs of climatic, crop and soil data, as well as irrigation and rain data. The climatic input data required are reference evapotranspiration (monthly/decade) and rainfall (monthly/decade/daily). Reference evapotranspiration can be calculated from actual temperature, humidity, and sunshine/radiation and wind-speed data, according to the FAO Penman-Monteith method (FAO, 1998). The soil data include information on total available soil water content and the maximum infiltration rate for runoff estimates. In addition, the initial soil water content at the start of the season is needed. The impact on yield of various levels of water supply is simulated by setting the dates and the application depths of the water from rain or irrigation. Through the soil moisture content and evapotranspiration rates, the soil water balance is determined on a daily basis.

1.9.3 Determination of Evapotranspiration (ETo)

CROPWAT is a computer program for irrigation planning and management, developed by the Land and Water Development Division of FAO (FAO, 1998). Its basic functions include the calculation of reference evapotranspiration, crop water requirements, and crop and scheme irrigation. Through a daily water balance, the user can simulate various water supply conditions and estimate yield reductions and irrigation and rainfall efficiencies. Typical applications of the water balance include the development of irrigation schedules for various crops and various water irrigation methods, the evaluation of irrigation practices, as well as rain fed production and drought effects.

The estimation of crop water requirement needs the analysis of climatic data and Agronomic practices of the project area. The effect of climate on crop water requirement is given by the reference crop evapotranspiration ETo which is analysed using the modified Penman method.

1.9.4 Evapotranspiration (ETo)

Evapotranspiration (ETo) includes transpiration of the crop as well as evaporation of water from the soil. During the study, Penman method of estimating ETo has been utilized.

$$ETo = c\left[W.Rn + (1-W).f(u).(ea-ed)\right]$$

ETO = Reference crop evapotranspiration in mm/day

W = Temperature - related weighting factor

Rn = Net radiation in equivalent evaporation in mm/day

f (u) = Wind - related function

(ea-ed) = difference b/n the saturation vapor pressure at mean air temperature and the mean actual vapor pressure of the air, both in mbar

C = Adjustment factor to compensate for the effect of day and night weather conditions.

Pen-Man equation was used in ETo calculations.

1.9.5 Crop coefficient (Kc)

The effects of weather conditions are captured in the ETo estimate. Therefore, as ETo represents a factor of climatic demand, crop coefficient (Kc) varies mainly with the specific crop characteristics. The effects of crop transpiration and soil evaporation are combined into a single Kc coefficient. This coefficient combines differences in soil evaporation and crop transpiration rate between the crop and the grass reference surface. Crop coefficient (kc) is affected by many factors including crop type, climate, soil evaporation and crop growth stages.

Crop type: the large variation in Kc values between major groups of crops is due to the resistance to transpiration of different crops, such as closed stomata during the day (pineapple) and waxy leaves (citrus). Also, differences in crop height, crop roughness, reflection and groundcover produce different Kc values.

Climate: General climatic conditions, especially wind and humidity, affect crop coefficients. Variations in wind change the aerodynamic resistance of the crops and their crop coefficients, especially for those crops that are substantially taller than the grass reference crop. Crop aerodynamic properties also change with climate, in particular relative humidity. Kc for many crops increases as wind speed increases and as relative humidity decreases. More arid climates and conditions of greater wind speed will have higher values for Kc. More humid climates and conditions of lower wind speed will have lower values for Kc.

Soil Evaporation: Crop evapotranspiration is a combination of transpiration by the crop and evaporation from the soil surface. Differences in soil evaporation and crop transpiration between field crops and the reference surface are integrated within the crop coefficient. The Kc for full cover crops reflects differences in transpiration, as the contribution of soil evaporation is relatively small. After rainfall or irrigation, the contribution of soil evaporation is significant, especially if the crop is small and has small groundcover. For such low cover conditions Kc is largely determined by how frequent the soil is wetted.

***Crop growth stages*:** the Kc for a given crop changes over the growing period as the groundcover, crop height and leaf area changes. Four growth stages are recognized for the selection of Kc: initial stage, crop development stage, mid-season stage and the late season stage.

***Initial stage*:** the initial stage refers to the germination and early growth stage when the soil surface is not or is hardly covered by the crop (groundcover < 10%). The Kc during this initial stage (Kc ini) is large when the soil is wet from irrigation and rainfall and is low when the soil surface is dry.

***Crop development stage*:** the crop development stage is the stage from the end of the initial stage to attainment of effective full groundcover (groundcover 70-80%). As the crop develops and shades more and more of the ground, soil evaporation becomes more restricted and transpiration becomes the dominant process. During the crop development stage, the Kc values correspond to amounts of groundcover and plant development and thus vary.

***Late season stage*:** the late season stage runs from the start of maturity to harvest or full senescence. The calculation of Kc and ETo is presumed to end when the crop is harvested, dries out naturally, reaches full senescence, or experiences leaf drop. The Kc value at the end of the late season stage (Kc end) reflects crop and water management practices. The Kc end value is high if the crop is frequently irrigated until harvested fresh. If the crop is allowed to senescence and to dry out in the field before harvest, the Kc end value will be small.

TABLE 0-21: CROP DEVELOPMENT STAGE AND CROP COEFFICIENT FOR PROPOSED CROPS

Crop	LGP	Growing stage				Crop coefficient			
	(Days)	D_1	D_2	D_3	D_4	Kc_1	Kc_2	Kc_3	Kc4
Onion	95	20	30	30	15	0.40	0.70	0.95	0.85
Cabbage	115	25	30	35	25	0.40	0.70	0.95	0.80
Potato	120	25	30	40	25	0.40	0.70	1.05	0.85
Garlic	110	25	30	35	20	0.40	0.70	0.95	0.85
Carrot	90	20	25	30	15	0.40	0.70	0.95	0.80

Source: FAO Irrigation and drainage paper 24 (1977) and paper 33 (1979)

1.9.6 Effective Rainfall (Pe)

Not all dependable rainfall is effective and some may be lost through surface runoff, deep percolation or evaporation. Only a part of the rainfall can be effectively used by the crop, depending on its root zone depth and the soil storage capacity. Different methods exist to estimate the effective rainfall (FAO, 1992). But, for the proposed irrigation project, the effective rainfall is calculated using dependable rain (FAO/AGLW formula). Accordingly, Peff = 0.6*P-10 (P month ≤ 70mm) and Peff = 0.8*P-24 (P month > 70mm) where, Peff = effective rainfall (mm/month) and P = dependable rainfall (mm/month) respectively.

1.10 Irrigation Water Requirement

Irrigation water requirement is calculated using the crops requirements but takes into account the effective rainfall. It is derived from the formula ET_{CROP}-Pe (effective rainfall). Essentially effective rainfall is that proportion of the rain which is stored in the root zone and therefore available to the plants. Rainfall which percolates beyond the root zone or is lost to the plants through surface runoff is not effective in that it is unavailable for plant growth. The texture and structure of the soil are the two important factors which influence the portion of rainfall which may be considered as effective for plant growth. When the rainfall is high, a relatively higher proportion of the water is lost through runoff and deep percolation. In hilly areas, particularly where there is little vegetative cover, runoff can account for the higher losses.

1.11 Net irrigation requirements

The net irrigation requirement (net water depth application) is the depth of irrigation water needed to replenish the soil water deficit at the effective root zone to field capacity. Sometimes, the contribution of ground water and the available stored water at the beginning of irrigation period may not be significant. As a result, the net irrigation requirement (NIR) is determined by considering only the effective rainfall (i.e. NIR = ETc-Pe).

1.12 Irrigation Efficiency

To account for losses of water incurred during conveyance and application to the field, an efficiency factor was included while calculating the project irrigation requirements. Project efficiency is normally subdivided into conveyance efficiency, distribution efficiency and application efficiency. Accordingly, an overall project efficiency of **45%** for farmer managed furrow irrigation has therefore been adopted as the design criteria for the irrigation project. This is at the lower end of efficiencies that could be achieved for farmer managed furrow irrigation. (See the detail calculation in Agronomy Annex)

1.13 1.9.10 Field Irrigation Schedules

Field irrigation schedules are based on field water balance and are expressed in depth (d, in mm) and interval of irrigation (i, in days).

1.13.1 Depth of irrigation application (d)

Depth of irrigation application is the depth of water that can be stored within the root zone between the so-called field capacity (sfc) and the allowable level the soil water can be depleted for the given crop, soil and climate. Some crops, such as, vegetables, potatoes, onions and strawberries, require relatively wet soils to produce acceptable yields; others such as cotton, wheat and safflowers will tolerate higher soil water depletion level. However, the tolerated depletion varies greatly with crop development stages; for most crops a reduced level of depletion should be allowed during changes from vegetative to reproductive growth or during heading and flowering to fruit setting.

Depth of irrigation application (d) is equal to the readily available soil water (p.sa) over the root zone (D). An application efficiency factor (Ea) is always added to account for the uneven application over the field or

$$d = \frac{(p.sa).D}{Ea} = mm$$

Where –d=depth of application in mm

P=fraction of available soil water

Sa=available soil water in mm/m soil depth

D=Rooting depth of crops in m.

Ea=application efficiency

1.13.2 Irrigation application interval (i)

Correct time of irrigation application is over-riding importance. Delayed irrigations, particularly when the crop is sensitive to water stress, could affect yields, which cannot be compensated for by subsequent over watering. Timing of irrigation should confirm to soil water depletion requirement of the crops which are shown to vary considerably with evaporative demand, rooting depth and soil type as well as with stage of crop growth, therefore rather than basin irrigation interval on calendar or fixed schedules, considerably flexibility in time and depth of irrigation should be maintained to accommodate distinct difference needs during in crop's growth cycle water. These detailed considerations are often not cover at design stage. Normally the irrigation interval given in FAO Irrigation and drainage paper number 24 is for dry irrigation season which is. The irrigation interval can be obtained from:

$$i = \frac{(p.sa).D}{ET\ crop}$$

The average days of irrigation intervals for the proposed crops were calculated as for Onion every **9 days**, for Cabbage every **9 days**, for Potato every 8 **days,** for Garlic every **8 days**, and for Carrot every **9 days.** These irrigation intervals are applied only when maximum soil water depletion percentage is kept higher for all crops and when ample water is applied in single irrigation. However, **during critical water requirements of each crops, especially during flowering and seed or ball formation periods**, frequent application (less irrigation intervals) of water is highly recommended, (see the calculation procedure table on annex part).

1.14 Suggestion & Recommendation

Production of economically important crops more than twice in a year through irrigation development is highly encouraged in Ethiopia at present days. To fulfill the objectives of the project, irrigable crops which are suitable to the soil and climatic conditions of the project area, have short growing period and can give reasonable economic yield are proposed in this document. The agronomic study shows that, though the climate of the project area is suitable for the production of most crops, the soil of the command area is swampy and waterlogged during the rainy season and has significant limitation for implementation of the proposed irrigation project. Due to this limitation in command soil, sub-soil drainage is very crucial for effective utilization of the command land. The time of dry spell from the offset to the onset of the natural rainfall is wider and the amount and distribution of rainfall is insufficient in the project area. This situation allows the full utilization of irrigation practices throughout the growing season provided that the surface water for irrigation is not limiting. Therefore, production of crops one time in a year using only irrigation water application is recommended as full irrigation (dry period irrigation) season. However, irrigation is not an easy task. It needs an enormous capital investment and intensive workforce and requires integrated extension work throughout the development practices. The major actors (beneficiaries & development agents and other concerned stakeholders) must work together for sustainable irrigation development in the proposed project area. Since livestock is an integral part of the development, animals should be kept healthier and well fed. Production of animal feeds using irrigation water is also much important in order to help the animals play a vital role in agricultural development. To scale up the existing knowledge of the farmers and Subject Matter Specialists (SMS) on increasing productivity for sustainable growth and development, patterned and continuous trainings, workshops, opinion exchanges, etc. should be exercised.

1. Annexes

TABLE 0-1: CLIMATIC & AERODYNAMIC DATA COLLECTED FROM SHENO STATION

S/n	Climate Fac.	Unit	Months											
			J	F	M	A	M	J	J	A	S	O	N	D
1	Max. Mean tep.	^0C	19.3	19.3	20.7	21.8	23.3	23.2	19.6	20.2	20.7	19.2	18.7	18.7
2	Min .mean tem.	^0C	5	6.9	8	8.8	10.6	10.6	9.3	11.1	9.8	7.4	7.3	5
3	Re. humidity	%	59	63	59	66	65	67	66	70	68	61	59	57
4	W. speed	Km/day	69	69	86	86	104	130	104	86	69	69	69	86
5	Sunshine	Hrs/day	8	8.4	7.2	6.7	7.6	6.6	4.3	5.5	6.2	8	9.3	8.3
6	Radiation	MJ/m^2	19.3	21.1	20.4	19.8	20.8	18.8	15.5	17.6	18.8	20.7	21.4	19.2
7	P.RF	mm/M	15	18	48	30	72	196	313	224	90	18	16	1
8	Eff. RF	mm/M	0	0.8	18.8	8	33.6	132.8	226.4	155.2	48	0.8	0	0
9	Eto	mm/day	3.16	3.48	3.7	3.67	4.01	3.86	3.12	3.33	3.5	3.55	3.45	3.18
10	Eto	mm/M	94.8	104.4	111	110.1	120.3	115.8	93.6	99.9	105	106.5	103.5	95.4

Irrigation Efficiencies

Based on the type of irrigation, method of application and farmers' capacity on the given soil type, the following efficiencies are given below.

TABLE 0-2: PROJECT EFFICIENCIES

S/n	Type of Efficiencies		Suggested Values, in (%)
1	Conveyance Eff.	Ec	94 %
2	Distribution Eff.	Ed	80 %
3	Application Eff.	Ea	60 %
4	Project Eff.	Ep	45 %

Irrigation depth (d, mm)

This is calculated based on the depletion factor (p) of the crop, available soil moisture (Sa), application efficiency (Ea) of the project, and effective root zone (D) of the individual selected crop. The detail is shown in the following table.

TABLE 0-3: IRRIGATION DEPTH, (D, MM)

S/n	Crops	p-value	Sa (mm/M)	p.Sa	D (mts)	Ea	d (mm)	Remark
1	Onion	0.42	160	67	0.42	0.6	47	
2	Cabbage	0.42	160	67	0.42	0.6	47	
3	Potato	0.35	160	56	0.45	0.6	42	
4	Garlic	0.42	160	67	0.35	0.6	39	
5	Carrot	0.42	160	67	0.46	0.6	51	

Interval (days)

TABLE 0-4: THE REQUIRED INTERVAL FOR CROP WATERING AS TO THEIR REQUIREMENT IS CALCULATED BASED ON THE FOLLOWING CONDITION.

S/n	Crops	p-value	Sa (mm/M)	p.Sa	D (mts)	Etc (mm/day)	i, (days)	Remark
1	Onion	0.42	160	67	0.42	3.19	9	Average watering days are to be from 9 days.
2	Cabbage	0.42	160	67	0.42	3.19	9	
3	Potato	0.35	160	56	0.45	3.10	8	
4	Garlic	0.42	160	67	0.35	2.93	8	
5	Carrot	0.42	160	67	0.46	3.42	9	

TABLE 0-5: CLIMATIC, SOIL AND WATER REQUIREMENTS FOR MAJOR SELECTED IRRIGABLE CROPS

Crop	**Total Growing Period (days)**	**Temperature Requirements for Growth (^{0}C)**	**Specific Climatic Requirements/ Constraints**	**Soil Requirements**	**Sensitivity to Salinity**	**Water Requirements (mm/growing period)**
Onion	100- 140 (+30-35 in nursery)	15- 20 (10-25)	Tolerant to frost; low temp. (<14-16^{o}C) required for flower initiation, no extreme temp. or excessive rain	Medium-textured soil; pH= 6.0- 7.0	Sensitive	350-550
Cabbage	100-150	15-20 (10-24)	Short periods of frost (-6 to –10 oC) are not harmful; opt. RH = 60- 90 %	Well- drained; opt. pH = 6.0- 6.5	Moderately sensitive	380-500
Potato	100-140+	24- 30 (15-35)	Sensitive to frost; for germination temp. >10 ^{o}C; cool temp. causes problem of ripening	Well- drained and aerated soils with deep water table and without waterlogging; opt. pH =5.0-7.0	Moderately sensitive	500- 800

TABLE 0-6: INPUTS REQUIRED FOR THE IRRIGATION PROJECT FOR ONE YEAR

Crop	Dry Season (1st Irrigation)						
	Area, ha	NPS, qt	Urea, qt	Seeds, qt	Fungicide, lt	Insecticide, kg	Herbicide, lt
Onion	11.5	11.5	11.5	0.46	34	34	---
Cabbage	9.2	9.2	4.6	0.28	---	19	---
Potato	9.2	16.5	9.2	184	26	26	---
Garlic	9.2	9.2	4.6	13.8	26	---	---
Carrot	6.9	6.9	3.5	1.04	---	---	---
Total	**46**	**53.3**	**33.4**	**199.58**	**86**	**79**	**---**