  

THE NATIONAL REGIONAL STATE OF OROMIA
WAGUR SMALL SCALE IRRIGATION PROJECT

IRRIGATION AGRONOMY STUDY FINAL REPORT

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ACRONOYMYS

^0C	Degree centigrade
CWR	Crop water requirement
DAP	Di ammonium phosphate
EC	Ethiopian Calendar
IPM	Integrated pest management
L/s/h	Litres per second per hectare
LGP	Length of growing period
MD	Man days
OD	Oxen days
OWWDSE	Oromia Water Works Design and Supervision Enterprise
PET	Potential evapotranspiration
RF	Rainfall
SMS	Subject Matter Specialist
SSIP	Sall Scale Irrigation Project
TAM	Total available moisture

1. INTRODUCTION

Recently, the problem of global warming is becoming the main issue of the world as well as the country which results an increase in temperature and decrease in rainfall both in amount and distribution. This unreliable rainfall and desertification in turn reduce the production return from the existing limited natural resource. This problem is becoming the main constraints for development and increasing agricultural production. Besides increase in population is other constraint which needs special mechanism to facilitate food availability for the rapid increasing population.

Irrigation plays an important role in the development of agricultural sector and contributes much in economy development of the country. It ensures production of high value crop, protection of crop failures due to drought, cultivation of suitable multi cropping practices in a season; maximize the value of land and farmers and increase their living standards, create job opportunity and additional income generate.

The purpose of the agricultural component of the feasibility study of Wagur Small-Scale irrigation Scheme has been to investigate the present state of agriculture and to make an assessment of the prospect of irrigated agriculture in the area.

This report, therefore, deals with

(i) the description of the project area in terms of location, climate, soils and topography;

(ii) the present agriculture of the project area providing baseline data and background information on farming practices, where available;

(iii) Irrigated agriculture focusing on crop production, the crops to be grown, practices to be introduced and the problems of irrigated crop production.

1.1. Study Objectives

The objective of the envisaged project is to increase agricultural production through the introduction of irrigated agriculture and thereby attain food self-sufficiency and food security for the population of the area. The specific objectives of the agricultural/agronomic study are:

- to evaluate the existing agricultural situation of the area including crops grown, the cropping pattern, farming practices (both crops and livestock husbandry);
- to investigate the suitability of soils, climate and water to irrigated agriculture;
- to estimate crop water requirements; and
- to estimate input requirements of irrigated crops and determine crop and farm budgets.
- Develop land for irrigation and irrigate dry season crops as well as supplement wet season crops during times of early withdrawal of the rains;
- Recommend cropping pattern for irrigated farming;
- Determine input requirement for the proposed scheme;
- Realize higher crop yields and raise the household income of the beneficiaries.

2. STUDY METHODOLOGY

The methodology consisted of collecting and checking existing agricultural data from Woreda, kebele administration and development agent and others. The field survey, a detailed checklist that guides the agricultural survey was prepared and incorporated in the overall sectoral study components.

Available primary and secondary data of the woreda as well as the project area was collected during the field survey period. Primary information was gathered from various focus group discussions and individual interactions of elders and other farmers in and around the project site. In these discussions, the primary focus was on the farming environment of the area as related to the farming system, land use, food availability, crops preferred, attitudes towards irrigation development, constraints in farming practices, etc.

Collection of secondary data was mainly from related woreda government institutions, information collected include the general land use of the project woreda, commonly employed agricultural practices, types and varieties of crops grown, crop pests of the area (diseases, insects, weeds, others), use of agricultural inputs (fertilizers, improved seeds, etc.), production performance and crop yields, livestock rearing practices and off-farm activities of the farmers

2.1. Description of the Scheme/Area

2.1.1. Location

Wagur Small-Scale Irrigation Project is located in Oromia regional state, Western Harerghe Zone Doba Woreda, Jalala and Mada Talila Kebeles' administrations (PAs), It is about 24 km from Woreda Doba. The Location of Wagur small scale irrigation is 9^0 13' N latitude and 41^0.06' E longitude with the altitude of 1660 m.a.s.l.

2.1.2. Climate

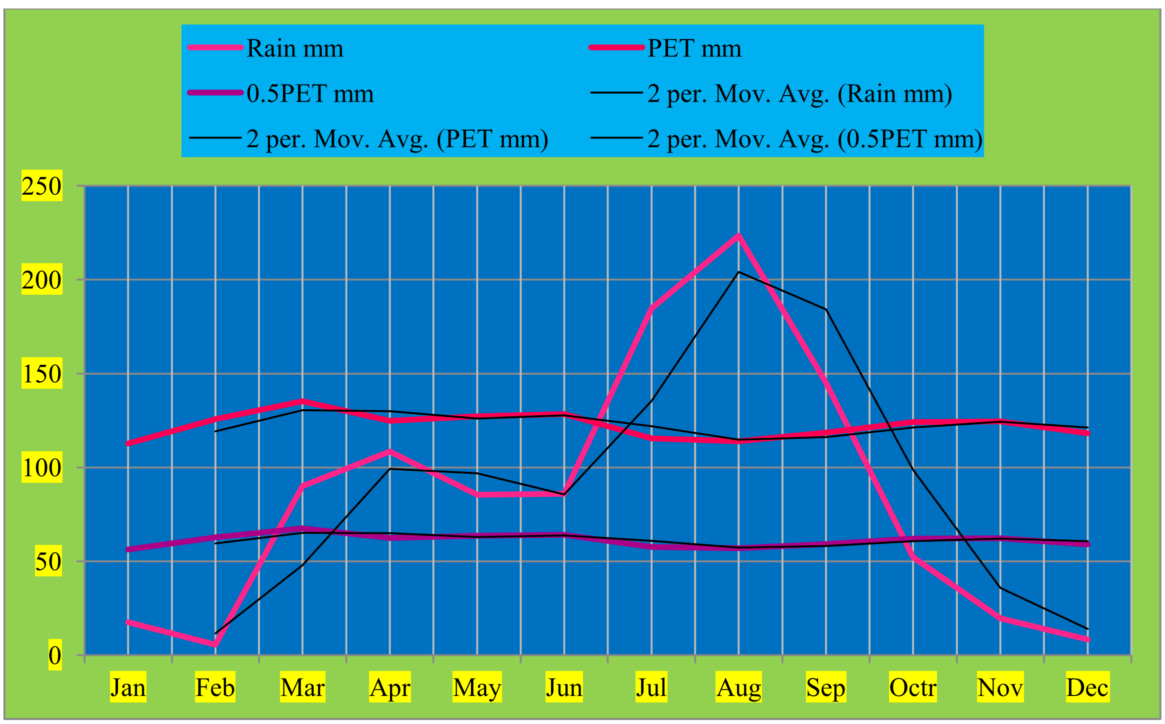
According to information from Doba woreda agricultural office, it exhibits the (Dega 4%, Weina dega 54% and Kola 42%). The altitude of the woreda lies between 1200-2000 masl.

Project area is, however, characterized as Weina dega agro-ecological zone. The main rainy season in the surroundings of the project area stretches from early June to early September

Table 1 LGP (Length of Growing Period)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rain (mm)	17.6	5.7	90.1	108.5	85.4	86	184.8	223.4	145.2	52.2	19.6	8.4	1026.9
PET (mm)	112.8	125.7	135.3	124.8	127.2	128.4	115.5	114	118.5	124.2	124.5	118.2	122.4
0.5PET (mm)	56.4	62.85	67.65	62.4	63.6	64.2	57.75	57	59.25	62.1	62.25	59.1	61.2125

Figure 1. Length of Growing Period of Wagur SSIP



The mean minimum annual temperature is 21^0C while the mean maximum annual Temperature is 29ºC. The annual mean temperature of the woreda is 25ºC. This is favorable for the growth of various crops in the area. The mean annual rain fall of the woreda is 850 mm.

Table 2 Mean Annual Temperature of Hirna Meteorological Station

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct r	Nov	Dec	Average
Min Temp (^{0}C)	8.2	8.7	10.3	11.6	11.7	12.2	12.9	12.6	12.6	11.3	8.5	7.5	10.7
Max Temp (°C)	27.3	28.8	28.1	27.8	28.5	28.5	27.8	26.9	26.9	27.5	27.8	26.9	27.7

Source: Hirna Metrological Station

Figure 2 Mean Annual Temperature at Hirna Meteorological Station

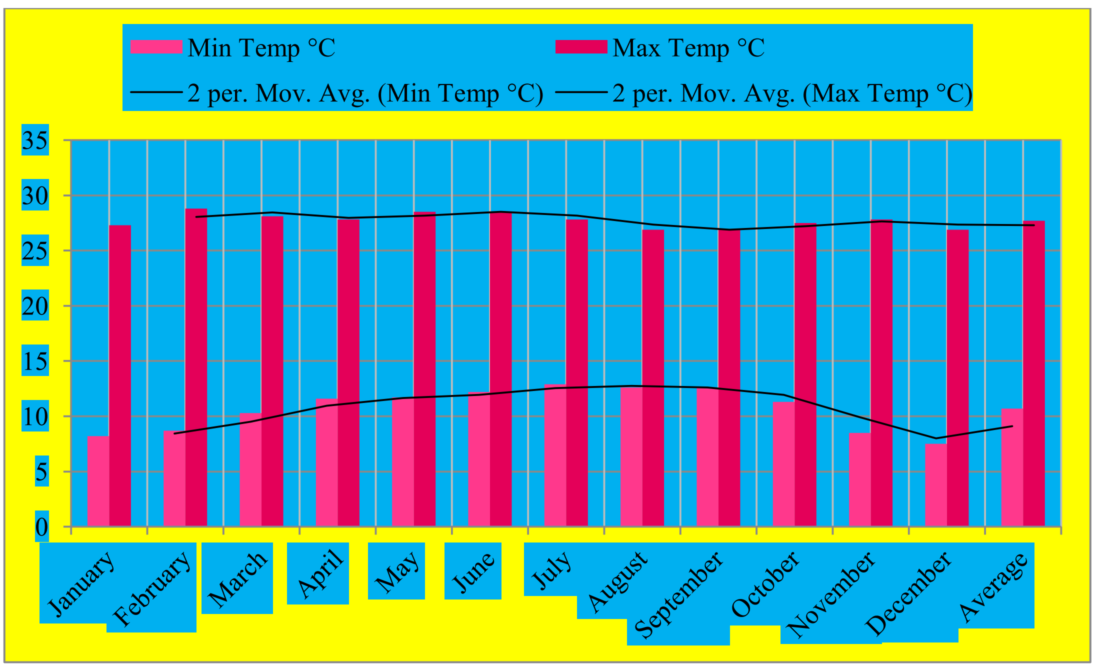
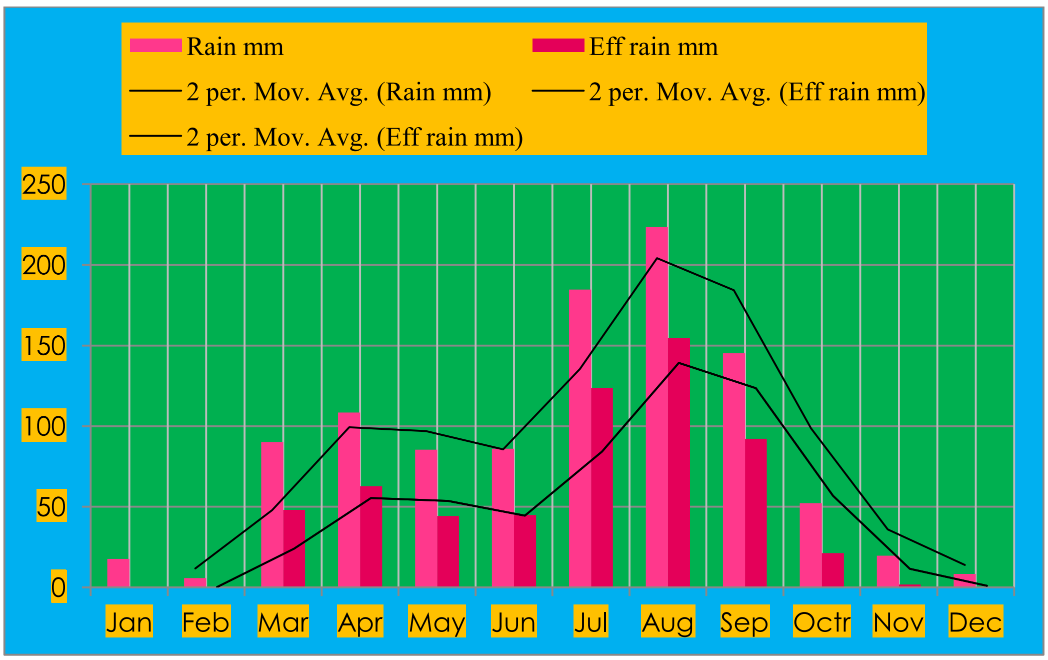


Table 3 Mean Annual Rainfall of Hirna Meteorological Station (mm)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rain (mm)	17.6	5.7	90.1	108.5	85.4	86	184.8	223.4	145.2	52.2	19.6	8.4	1026.9
Eff rain (mm)	0.6	0	48.1	62.8	44.3	44.8	123.8	154.7	92.2	21.3	1.8	0	594.4

Figure 3 Mean Annual Rainfall of Tullo Woreda (mm)



The envisaged command area lies in almost a flat terrain with the major area somewhat from gentle slope of 0-2-0.5%, 2-5=22%, 5-8=25%, 8-15=27% to 10 %. This land is mostly cultivated by rain fed and traditional irrigation to grow Maize, Onion, Sugarcane, Chat, Banana and Tomato. The surrounding areas especially at upper stream are somehow hilly and moderately steep lands with slopes greater than 10%.

The topographic situation of the command area is a flat terrain or plain area and its altitude range is in the category of slight Midland (Woina Dega). However, the minimum temperature condition of the area is 21^{0}C that is not in the limit of Midland (Woina Dega).

Therefore, with the overall conditions, intended proposed crops are suitable to the area with no significant kola damage.

2.1.3. Soil

The major soil groups in Wagur small scale irrigation project are vertisols, pellic vertisols and chromic vertisols. The texture of the soils in the study area is medium with clay and clay loam dominance that has no soil depth limitation with imperfectly drained to poor-drained soil condition. $_{P}$H of the top and sub soils ranges from 7.1-7.3 and 6.7-7 respectively.

2.1.4. Land Use Pattern

The woreda comprises about **19254** hectares of land. About 71%of land is currently under cultivation. Other land use categories include grazing land (4.15%), forest land (7%), bush land (26.34%), wet land (0%).The pattern of land use of the Woreda is shown in Table below. In Woreda and project area land holding size with an average of 0.5. These holdings are fragmented and some farmers cultivate land both within and outside the scheme area

Table 4. Major Land Use Types of Doba Woreda

No	Land use types	Area (ha)	Proportion (%)
1	Arable land	27085	38.5
2	Cultivated land	19254	71(of arable land)
3	Grazing land	2920	4.15
4	Forest land	4922	7
5	Bush and shrubs	18500	26.34
6	Settlement land	7350	10.46
8	Rock land	9505	13.55
9	Others	00	00
	Total	**70282**	100

Source: Doba Woreda Agricultural office

Table 5 Major Land Use Type of Project Area (Mada Talila and Jalala Kebeles)

No	Land use types	Jalala		Mada Talila	
		Area (Ha)	Proportion (%)	Area (Ha)	Proportion (%)
1	Arable land	600	65.43	863	67.42
2	Cultivated land	460	76.66 (of arable land)	443	51.33 (of arable land)
3	Grazing land	40	4.37	60	4.7
4	Forest land	91	9.93	102	8
5	Bush & shrubs	60	6.55	35	2.73
6	Settlement land	23	2.5	63	4.9
7	Wet Land	100	10.9	144	11.25
8	Rock Land	00	00	13	1
9	Others	3	0.32	00	00
	Total	**917**	**100**	**1280**	**100**

Source: Jalala and Mada Talila kebeles' Development Center Office

3. RESULT AND DISCUSSION

3.1 Farming System

A ‘farming system’ is the complex arrangement of soils, water sources, crops, livestock, labor, and other resources and characteristics within an environmental setting that a farm family manages in accordance with its preferences, capabilities and available technologies. Smallholder farmers manage the household resources involved in the production of crops, livestock, and non-agricultural commodities such as earn income off the farm. The certain factors, such as soil type, agro climate zone, socio economic conditions there may be differences in the farming methods. Since the farming systems are age old and gained through long experiences, these may also consist of benefiting details that could be utilized in an improvement program.

3.2. Existing Cropping Practices and Cropping Pattern

The cropping calendar for major crops of the area and the main operations are presented in the following table. These operations follow normal rainfall regime as in many parts of the mid land of Oromia. In times of abnormality such as late on set of the rains, area coverage and volume of production are greatly affected.

At present, most of the farmers of the command area and the surrounding produce crops only once in a year. But some farmers around the project area produce two times per year using traditional irrigation. They produce cereals and some vegetables at the main rainy season and vegetables by irrigation.

Table 6 Existing Cropping calendar for Rain fed

Types of crops	Time of Seed bed Preparation		Sowing	Harvesting Date	Base Period
	ploughing	Freq.			
Maize	March	2	April-May	October	120-150
Sorghum	March	2	March-April	December-January	180
Haricot bean	May-June	2	July-August	October-December	90

Source: Doba Woreda Agricultural office

Table 7. Existing Cropping Calendar for Traditional Irrigation

Types of crops	Time of Seed bed Preparation		Sowing	Harvesting Date	Base Period
	ploughing	Freq.			
Maize	October	2-3	November	March	90-100
Tomato	October	2-3	November	March	90-100
Onion	October	2-3	November	March	90-100
Potato	October	2-3	November	March	90-100
Pepper	October	2-3	November	March	90-100

Source: Doba Woreda Irrigation Office.

The frequency of ploughing depends on the soil type and the type of crop grown. In most cases, two to four passes are practiced for most types of crops. Plowing is done just after the onset of the first rains (March-April) when the soil is somehow moist enough to allow smooth pass and continues till June-July Local seeds are usually selected from the previous crop (based on vigor, yield and other desired merits) to be used as planting material. Improved seeds of maize and Sorghum are currently being used through the extension package program.

Many of the crops are planted by broadcasting, but maize and some vegetable crops are row planted as a result of the effort made by the development agents and most probably from observations made in the Research center. Farmers are also very much aware of the benefits of row planting as it facilitates post emergence operations, improves water retention capacity of the soil and promotes nutrient use efficiency resulting in increased yield.

Weeding is a labor-intensive operation. The exception is the application of herbicides in selected few crops. One to three weeding operations are made for most crops and there are evidences of crop diseases and insect pests even though less control measures are carried out by the farming community. Harvesting starts in the months of October/November for early maturing crops and extends to December and January for late maturing varieties. Threshing follows soon after harvest using animal power and human labor. Produces are, in most cases, stored in traditional structures (*gotera,* bola etc.).

3.3. Crop Production and Yield

The major Rainfall crops grown in the area include Sorghum, Maize, Teff, Haricot bean, and potato. These crops are staple food crops for the area and relatively fetch fair price in the local market. Yields are generally low but are comparable to the national average. Area coverage, production and yield per unit area are directly related to the timing, distribution and amount of rainfall that prevails in any given year.

The area cultivated and yield obtained per hectare for most of major crops grown shows an increasing rate. This indicates the progress of extension activities and farmers know how about agronomic practices and other related agricultural activities. The following table shows the present status of input utilization of the farmers for major crops grown by rain fed .As indicated on the following table, farmers grow the crops by four methods i.e. local seeds without fertilizers, local seeds with compost, local seeds Witt fertilizers and improved seeds with fertilizers. For all crops grown by using improved seeds and fertilizers shows yield increment by far than grown without fertilizer/compost. Due to less soil fertility, NPS fertilizer is applied for crops like Sorghum, Maize, Teff, Haricot bean. This indicates using agricultural input is very important for yield increment and can help for attaining food self-sufficiency within a short period of time.

Table 8 Rain fed Crop Production With and Without Technological Package from 2008-2010 E.C

Crop Type	With technology									Without Technology								
	2008			2009			2010			2008			2009			2010		
	Area (ha)	Production (qt)	Yield	Area (ha)	Production (qt)	Yield	Area(ha)	Production (qt)	Yield	Area (ha)	Production (qt)	Yield	Area (ha)	Production (qt)	Yield	Area (ha)	Production (qt)	Yield
Cereals	1618	22659	14	1120	24428	22	908	15790	17	4987	55977	11	1963	12960	7	6689	103578	15
Maize	1569	21966	14	1093	24046	22	508	12700	25	3018	34707	12	0	0	0	1642	42861	26
Sorghum	0	0	0	0	0	0	0	0	0	60	480	8	63.3	506.4	8	3237	27196.5	8.4
Teff	0	0	0	0	0	0	190	570	3	0	0	0	0	0	0	0	0	0
Barley	0	0	0	0	0	0	210	2520	12	68	544	8	210	1470	7	210	2520	12
Wheat	49	693	14	27	382	14	0	0	0	1841	20245.5	11	1689.8	10983.4	7	1600	31000	19
Pulses	0	0	0	0	0	0	195	1280	7	1001	6897	7	1348	10386	8	1360	48320	36
H.bean	0	0	0	0	0	0	40	480	12	953	6705	7	1148	9186	8	1160	48220	42
Lentil	0	0	0	0	0	0	145	800	6	48	192	4	200	1200	6	200	1000	5
Oilseed Crops	0	0	0	0	0	0	210	2420	12	545	3085	6	790	1530	2	260	1900	7.3
Groundnut	0	0	0	0	0	0	0	0	0	40	200	5	130	650	5	50	400	8
Sesame	0	0	0	0	0	0	10	20	2	460	2760	6	500	200	0	50	700	14
Flax	0	0	0	0	0	0	200	2400	12	45	125	3	160	680	4	160	800	5
Horticulture	0	0	0	0	0	0	0	0	0	500	8000	16	650	12500	19	850	20000	24
Potato	0	0	0	0	0	0	0	0	0	500	8000	16	650	12500	19	850	20000	24
Perennial Crop	200	1000	5	350	1750	5	400	2000	5	0	0	0	0	0	0	0	0	0
Coffee	200	1000	5	350	1750	5	400	2000	5	0	0	0	0	0	0	0	0	0
Grand Total	**1818**	**23659**	**13**	**1470**	**26178**	**18**	**1713**	**21490**	**13**	**7033**	**73959**	**11**	**4751**	**37375**	**8**	**9159**	**173798**	**19**

Source: Doba woreda Agricultural Office

Table 9 Rain fed and Irrigated Crops Harvested with and without Technological packages in 2010 E.C in project area

Crop Type	Jalala Kebele												Mada Talila Kebele											
	With technology in 2010 E.C						Without Technology in 2010 E.C						With technology in 2010 E.C						Without Technology in 2010E.C					
	Rain fed crop			Irrigated crop			Rain fed crop			Irrigated crop			Rain fed crop			Irrigated crop			Rain fed crop			Irrigated crop		
	Area (ha)	Production (qt)	Yield	Area (ha)	Production (qt)	Yield	Area (ha)	Production (qt)	Yield	Area (ha)	Production (qt)	Yield	Area (ha)	Production (qt)	Yield	Area (ha)	Production (qt)	Yield	Area (ha)	Production (qt)	Yield	Area (ha)	Production (qt)	Yield
Cereals																								
Maize	150	3900	26	175	4375	25	50	750	15	6	90	15	105	2665	25	100	1300	13	0	0	0	0	0	0
Sorghum	160	2620	16	0	0	0	100	600	6	0	0	0	300	3900	13	0	0	0	4	52	13	0	0	0
Wheat	100	1300	13	0	0	0	0	0	0	0	0	0	8	104	13	0	0	0	0	0	0	0	0	0
Pulse Crop	**0**	**0**	0	**0**	**0**	0	**0**	**0**	0	**0**	**0**	0	**0**	**0**	0	**0**	**0**	0	**0**	**0**	0	**0**	**0**	**0**
Haricot bean	25	250	10	0	0	0	60	600	10	0	0	0	0	0	0	20	260	13	0	0	0	0	0	0
Faba bean	20	200	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil Crops	**0**	**0**	0	**0**	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Sesame	10	60	6	0	0	0	1	6	6	0	0	0	30	120	4	0	0	0	0	0	0	0	0	0
Vegetable	**0**	**0**	0	**0**	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Beet Root	10	500	50	15	750	50	0	0	0	0	0	0	0	0	0	12	150	13	0	0	0	0	0	0
Potato	40	1800	45	50	2000	40	0	0	0	0	0	0	5	80	16	5	80	16	0	0	0	0	0	0
Total	**515**	**10630**	21	**240**	**7125**	30	**211**	**1956**	9.27	**6**	**90**	15	**448**	**6869**	15	**137**	**1790**	13	**4**	**52**	13	**0**	**0**	**0**

Source from irrigation project area (Jalala and Mada Talila kebeles')

Irrigation is traditionally practiced in the woreda and around the command area. However, the practice is limited to supplementary irrigation. Crops grown in the irrigated plots are vegetables and other crops. In this woreda and around the command area, vegetables are both grown by rain fed during rainy season and irrigation during dry months.

Therefore, even though very limited, there are irrigation activities and the farmers have experience of traditional irrigation practices.

.However, there are various agronomic problems prevailing in these practices like

Water management problems

- Less disease, insect pests and weeds management
- Less land preparation
- Transplanting time not maintained
- Less appropriate seed bed preparation
- Planting and plant population per hectare less followed
- No timely and proper weeding
- Problem in harvesting ,time and methods
- Lack of improved varieties and other inputs
- Et

Table.10. Summary of Irrigation Production with and without technological package from 2008-2010 E.C

Crop	With Technology									With out Technology				
	2008			2009			2010				2009		2010	
	Area (ha)	Production (qt)	Yield	Area (ha)	Production (qt)	Yield	Area (ha)	Production (qt)	Yield	Production (qt)	Area (ha)	Production (qt)	Area (ha)	Production (qt)
Cereals	1228	87875	72	855.5	45395	53	555	31357	56	0	0	0	0	0
Maize	1228	87875	72	855.5	45395	53	555	31357	56	0	0	0	0	0
Horticulture	5009	442806	88	6486	545538	84	2919	257075	88	0	0	0	0	0
Tomato	744	63435	85	829	88604	107	599	65386	109	0	0	0	0	0
Onion	1516	159952	106	2576	141238	55	822	49416	60	0	0	0	0	0
Potato	765	46771	61	1095	86979	79	330	26139	79	0	0	0	0	0
Sweet Potato	1984	172648	87	1985.5	228717	115	1168	116134	99	0	0	0	0	0
Fruit	262	33682	129	196	15648	80	133	9454	71	0	0	0	0	0
Papaya	124	21034	170	89	7217	81	65	4629	71	0	0	0	0	0
Banana	138	12648	92	107	8431	79	68	4825	71	0	0	0	0	0
Others	5124	371065	72	5044	161704	32	4603	138134	30	0	0	0	0	0
Coffee	427	14477	34	390	279	0.7	264	202	1	0	0	0	0	0
Chat	4579	339852	74	4559	158530	35	4240	135155	32	0	0	0	0	0
Sugar Cane	118	16736	142	95	2895	30	99	2777	28	0	0	0	0	0
Total	11623	935428	80	12581	768285	61	8210	436020	53	0	0	0	0	0

Source: Doba Woreda Irrigation Office

3.4 Input Use

Farmers of the woreda as well as the project area are well aware of the importance of agricultural inputs including fertilizers, improved seeds and agro-chemicals. However, in recent years, the use of inputs has been decreasing steadily due to a number of factors. Chief among these factors are high input prices, limited or total unavailability of credit facilities,

Moreover, farmers complain that unavailability of improved different vegetable seeds around/ nearby market has negatively affected vegetable yields.

Table 11 Summary of Agricultural input supplied and distributed from 2007/08-2009/10 E.C

Type of inputs	2008		2009		2010	
	Supplied	**Distributed**	**Supplied**	**Distributed**	**Supplied**	**Distributed**
Fertilizer						
DAP						
NPS	2117	1997	3054.5	1179	-	2709
Urea	-	1270.5	2162.5	2064.5	-	2023
Total	**2117**	**3267.5**	**5217**	**3243.5**		**4732**
Seed						
Maize	-	37	-	40		122.5

Source: Doba Agricultural Development Office and Cooperative Agency

Table 12 Summary of Agricultural input supplied and distributed from 2007/08-2009/10 E.C in project area

Type of inputs	Jalala Kebele						Mada Talila Kebele					
	2008		2009		2010		2008		2009		2010	
	Suppli ed	Distribut ed	Suppli ed	Suppli ed	Distribut ed	Suppli ed	Suppli ed	Distribut ed	Suppli ed	Suppli ed	Distribut ed	Suppli ed
Fertiliz er												
NPS	50	45	70	25	90	52	150	96	150	120	160	130
Urea	40	35	60	50	60	30	50	40	80	60	100	60
Total	**90**	**80**	**130**	**75**	**150**	**82**	**200**	**136**	**230**	**180**	**260**	**190**
Seed	**30**	**30**	**20**	**20**	**00**	**00**	**5**	**2**	**00**	**00**	**5**	**5**
Maize	30	30	20	20	00	00	5	2	00	00	5	5
Total												

Source: From Jlala and Mada Talila kebele (project area)

The seed rate and fertilizer rate utilized is almost similar in the area. Up to now, there is no specific site or PA recommendation for the intended inputs like everywhere .This is because to specifically recommend such inputs , it needs detail soil fertility analysis , agro-climatic and other socioeconomic surveys to be conducted at large scale. Thus it is hardly possible to get a specific inputs rate utilized for the actual command area that is different from the woreda recommendation

3.5. Major Crop Pests Prevailing in the Woreda

Diseases, pests and weeds are considered to be major contributing factors to the low yield of major crops produced in the Woreda. The main diseases, parasitic weeds and insect pests are CBD on coffee, *strigahermontheca*on sorghum and maize, and aphide problem on orange. Local out breaks of army Worms and grasshoppers have been reported. In addition to these pests yellow rust on wheat, bollworm on pulse crops and on some vegetables, early blight and late blight on vegetables, stalk borer on maize and sorghum, invasive and noxious weeds such as *Partheniumhystrophorus*, *Digitariaspp*, *Xanthium stramonium* ”Wonjali” and “Namele” are very problematic pests in the basin and they cause high yield reduction. The use of herbicides, insecticides and fungicides among the peasant farmers is low. This is due to high cost and poor availability. Farmers lack spraying equipment and technical skills for the timely and effective application of pesticides, which is wrongly applied pose dangers to people, crops and wider environment. Farmers are often applied pesticides without proper recommandations. Pesticides are often sold without proper recommandations for use and threshold levels of insects’ infestation. Farmers apply pesticides on their field without any protective clothing. IPM and efficient agricultural extension services help to alleviate the problem. Sufficient information of the area about diseases, insect pests, rodents, domestic animals and wild animas on crops help to select suitable crops grown for future irrigation development in the area winch are not severely attacked. *Partheniumhystrophorus*is not only a serious problem of crop production. This invasive and noxious weed invade vast areas of grass lands and bush lands shrink grazing lands and becomes animal husbandry a problem in the basin. So policy or strategy intervention is required by government because controlling this weed is beyond farmers’ capacity.

3.6. Controlling Method

Generally, the following cultural practices are recommended for weeds, insect pest and diseases control

A) For parasitic weeds

- Using weed free seed
- Cleaning farm implements
- Destroying parasitic weeds before setting seeds by proper weeding
- Maintaining soil fertility
- Crop rotation practices
- Herbicides

B) For non-parasitic weeds

- Proper land preparation
- Using weed free seeds
- Hand weeding and Inter cultivation
- Crop rotation
- Herbicides

C) Insect pests

For control of stalk borer

Using tolerant varieties

- Site clearing and sanitation
- Early sowing

- Chemically, use endosulfan 1kg/ha a.i. 4-5 weeks after crop emergence or Carbaryl 2.3kg/ha 4-5 weeks after crop emergence or Diazinon 10 kg/ha 4-5 weeks after crop emergence or cypermetrin 3-3.8kg granule /ha or 2 lt Ec /ha

For control of Weevils and Other Storage Pests

- Proper cleaning of storage houses
- Avoiding suffocation
- Chemically use primofosmetine (actilin) 25-50 grams mixed in 100 kg of seed.

To control Spodoptera exampta (Army worm):

- Use light and pheromones traps to predict outbreak.
- Seed dressing with insecticides and/or fungicides can be used but not effective

To control Cut worms

- Crop rotation
- Field sanitation
- Timely sowing
- Chemicals

To control aphid and cabbagebuterfly

- spraying with dimecron 0.8lt/ha

D) Diseases

Smut is controlled by

- Using resistant varieties
- Rouging infected plants
- Crop rotation
- Sowing treated seeds by anti fungus.

For controlling wheat rust

- Use of clean and healthy crop seeds

- Crop rotation
- Use of improved wheat varieties
- Timely harvesting

To control bacterial wilt of potato

- Use of healthy seed. Care should be taken not to use planting materials from areas where the existence of bacterial wilt is reported, such as shashemenie area.
- The use of resistance/tolerance varieties.
- Plant in R.solanacerum free soil.
- Removal of potato haulms and rotted potato tubers.
- Weeding, since R.solanacerum survives in weed.
- Roguing of wilted and volunteer potato plants.
- Use of clean farm equipment's.
- Use of clean and uncontaminated irrigation water.
- Crop rotation with cereals, legumes and etc.
- Avoid tomato and other solanaceous crops.

For controlling Bacterial and fungus diseases in allium species , crop rotation and chemical treatment could be applied

Table 13 major Type Of Crop Diseases

Type Of Diseases	Crops Mostly Attacked	Prevention method	
		Chemical	Non-Chemical
Yellow and leaf Rust	Wheat	Tilt, Rex-Do, bail	Sowing Resistant Variety
Smut	Barley, wheat, sorghum and Maize		Crop rotation, removal of infected crops, sowing disease free seeds and sowing resistant variety
Septoria and Fusarium	Wheat and Barley	Tilt,	sowing disease free seeds and sowing resistant variety
Powdery Mildew	Field Pea, Tomato		Crop Rotation, sowing resistant variety
Purple blotch	Onion	Mancozeb	Sowing resistant variety
Downy mildew	Onion	Apronostar	Sowing resistant variety
White rot	Onion		Sowing resistant variety
Early Blight	Potato	Mancozeb	Crop Rotation, sowing resistant variety
Late Blight	Potato, Tomato, Pepper	Mancozeb	Crop rotation, removal of infected crops
Yellowish Leaf	Carrot		Crop rotation, removal of infected crops
Black rot	Cabbage	Bumper	Use of Resistant Variety
Bacteria Wilt	Potato		Use of Resistant Variety
Garlic Rust	Garlic		Use of Resistant Variety
MLND	Maize		Use of Resistant Variety
Damping off	Vegetables	Mancozeb	Water management,
Anthracnose	Mango,Maize,SorghumAvocado,Maiz		Planting resistant variety
Leaf Rust	Wheat,Barley,Haricotbean,n,		Sowing resistant variety
Maize rust	Maize		Planting resistant variety
CBD	Coffee	Chemical spray	Planting resistant variety

Source: From Doba Woreda & Hirna Plant Clinic (West Harerge).

Table 14. Major types of Insects

Insect pests	Crops Mostly Attacked	Prevention method	
		Chemical	Non-Chemical
Stalk Borer	Maize and Sorghum	Diazinon, Malathion, Dizole	burning of crop residue, crop rotation
Aphids	All crops	Highway, Carate, Pyrethorid, Deltamethrin, Lambda	
Cut Worm	Maize, Sorghum and Vegetables	Diaznon	Hand cleaning
Barley shoot fly	Barley	Seed dressing Chemicals, karate	Use of Resistant Variety
Crickets	Cereals	Chemical	
Grass Hopper	Teff,Maize&Sorghum	Malathion	Early Sowing
Army worm	Cereals	Malathion, Sevin	
Trips	Onion, Tomato	Malathion,Mancozeb,Elerate	Destruction of Crop residual
African ball worm	Tomato, Fieldpea, Fababean, Linseed, Niger seed	Agro-Lambacin	Weeding,Resanitation
Diamond back moth	Cabbage	Karate,Helerat	
Potato tuber moth	Potato		
Termite	Teff,Maize, Wheat,etc	Dursuban	Queen Destruction
Aphids	All Vegetable crop	Pyrethorid, ,Deltamethrin,Lambda	Removing crop residual
White fly	Pepper		
Chaffer grub/white grub	Wheat, Barley and Maize	Seed dressing with Chemicals	
Loop Worm	Cabbage	Karate,Helerat	Crop Rotation
Red scales	Citrus	Systemic insecticide	
Woolly whitefly	Citrus and Mango		
Storage pests Weevils	Cereals and pulses grain	Actelic	Storage sanitation

Source: From Doba Woreda & Hirna Plant Clinic (West Harerge).

Table 15 Common Types of Weeds

Scientific name of weeds	Local or common name of weeds	Crops mostly attacked	Prevention method	
			Chemical	Cultural
Amaranthusspp	Spiney pigweed	All cereal crops	2-4-D	Hand weeding, sowing weed free seed
Parthiniumhystrophorus	Congress weed	All Crops	2-4-D	Hand Weeding,
Avenaspp	"Sinar"	Wheat &Barley	Topic, Palas	Hand weeding & clearing
Chenopodiumspp	"Amedmado"	All Crops	2-4-D	Hand weeding
Datura-sraminium	"Atefaris" "Banji"	All Vegetable Crop	2-4-D	Hand Weeding
Cyprus-rutandans Cyprus-esculentus Cyprus-esculentus	"Yewefkolo" "Qorsosinbiro" Nutgrass	All crops Especially in waterlogged areas		dry ploughing and hand weeding
Guizotia-scabra	"Hada" "Mece"	All Cereals&Pulse	2-4-D	Hand weeding
StrigaSpp	Witch weed"Akenchera"	Maize & Sorghum		Resistant variety&hand weeding
	"Asendabo"	All Cereals		Hand weeding
Cuscutasp,	Dodder	linseed		H and weeding, sowing weed free seed
Phalarisparadoxa,	Fox tail	Wheat	Topic, Palas	Hand weeding, sowing weed free seed
Setariapumila		All Cereals		Hand weeding
Loliumtemulantum	"enkerdade"	All Cereals	Topic, Palas	Hand weeding
SnowdeniaPolystacia,	"Muja"	cereals	Topic, Palas	Hand weeding,
	"Namale"	All crops, and field side	2.4-D	Hand weeding
	"wanjali"	All crops	2.4-D	dry ploughing and hand weeding
Digitaria spp.	"ura"	All crops		
Xanthium strumarium	"ye-monyefikir"	All crops	2.4- D	dry ploughing and hand weeding
Commelinaspp	Water maker	All crops	2.4-D	
Tagetesminuta	Mexican marigold	All crops	2.4-D	
Biden spilosa	Black jack	All crops	2.4-D	

Source: from Doba Woreda &Hirna Plant Clinic.

3.7. Harvest and Postharvest Handling

Increasing production is one of the primary concerns in agriculture. A lot of effort has been made in areas related to food and cash crop production with a great success stories in Ethiopia. However, increasing yield of biological products without value addition using appropriate processing and preservation technologies will definitely lead to huge nutritional and monetary losses. Furthermore, promotion of the export market of the country's product demands standard postharvest treatments and preservation technologies. This clearly indicates the need for proper postharvest management related to all groups of food and cash crops such as fruits and vegetables, cereals, pulses, oil crops and other products, coffee and tea, milk and milk products as well as ornamental products.

Postharvest begins at the moment of separation of the edible commodity from the plant that produced it by a deliberate human act with intention of starting it on its way to the table. The postharvest period ends when the food comes into the possession of the final consumer. Plants or plant parts continue to function metabolically after harvest. However, their metabolism is not identical with that of the parent plant growing in its original environment and therefore, they are subjected to physiological and pathological deterioration and losses. "Loss" means any change in the availability, edibility, wholesomeness or quality of the food that prevents it from being consumed by people.

The type of storage varies from place to place based on the availability of local materials used for construction of storage structures, culture, climate and other factors. Among the many traditional storage systems used in the Doba Woreda, the main ones are: Gotera, underground pits, plastic sacks and animal skins. Crop losses in storage are estimated by some reports (FAO, 1990) at about 2-4% and 5% due to insects at high and low altitudes, respectively, and about 3% due to rodents at high altitudes. Grain moulds sometimes result in whole spoilage in grains stored in underground pits.

General hygiene in and outside the different traditional stores is very poor and encourages pests to multiply, and serves as a source of infection of stored grains. Few farmers use insecticides to control stored grain pests.

3.8. Livestock Husbandry

In Oromia, by far the largest proportions of the crops produced utilize livestock inputs in terms of traction power. In rural Oromia, lack of plough oxen has direct impact on the size of rainfed and irrigation land to be put under cultivation and is considered as a very strong indicator of welfare among rural households.

In Doba Woreda where mixed farming (crops and livestock production), are jointly undertaken, farmers use livestock for coping with adverse situations during crises of crop failure by selling animal products. With regard to direct food supply and/or cash income generation, livestock will play an increasingly significant role. Similarly, poultry production also supported by mixed farming agriculture. As it is summarized in below table the cattle population is high as compared to the other types of livestock population in Woreda and Kebele.

Livestock is an integral part of the farming system in the project area. Oxen are used for draft power and cows are kept for milking purposes. Sheep, goats and poultry are also reared as source of household income in addition to home consumption, usually during occasions. Livestock are mainly fed on crop residues and aftermath grazing. The scarcity of grazing land and shortage of feed resources limit the number of livestock owned by a household.

Table 16 Types and population of Livestock and number Of Hives

Type of Livestock	Doba Woreda	Jalala Kebele	Mada Talila Kebele
Cattle	177223	3332	3401
Sheep	32268	789	606
Goat	108780	1696	1715
Horses	12	00	00
Donkeys	32496	527	617
Mules	3	00	00
Camels	4348	20	00
Poultry	192828	1278	1200
Modernhives	1284	00	00
Transitional hives	48	00	196
Traditional hives	5260	00	41

Source*: From Doba Woreda Livestock & Fish Resource Development Office & Jalala & Mada Talila Kebele.*

Animal feed is currently one of the inputs that ranks top in determining livestock production. In Doba Woreda the main sources of animal feed comprises natural grass, crop residues, development of animal feed needs various strategies such as forage production and supply, expansion of improved pasture, improvement of the quality of planted grasses and trees. In addition to expansion of crops both by rain fed and irrigation, crop residue and water development to address the problem of feed availability and quality in order to utilize them efficiently for ploughing particularly during dry season when livestock feed source is limited.

Honey production also developed in connection with the expansion of rain fed and irrigated agriculture with fruits and agro-forestry development in Doba Woreda. Beekeeping is practiced in the woreda, particularly in lowland areas. Majority of the beehives in all the study areas are local. However, a few transitional and modern or frame hives were distributed to farmers.

3.8.1. Major Livestock Diseases

The major animal production constrains are animal diseases, lack of and/or limited improved feed, inadequate animal health services, low productive and reproductive performance of animals and death of honeybees due to insecticide/herbicide poisoning. The assessment result show that different animal diseases occur at different seasons in the Doba Woreda. The most important diseases are Bacterial disease, Viral, Protozoan diseases, Ricketsial diseases, Endo/Internal Parasite, Ecto/External Parasite & Toxicity are also common animal diseases.

Table 17. Livestock disease prevailing in Doba Woreda

Diseases Type	Common name	Species of animals affected
Bacterial diseases	Blackleg	Cattle
	Anthrax	Cattle, sheep, goat, camels
	Pasteurollosis	Cattle sheep, goat, camel
	B. Tuberculosis	Cattle
	Pneumonia	Cattle, sheep, goat,camel
	Brucellosis	Cattle sheep
	CCPP	Sheep Goats
Viral	PPR	Sheep, Goats
	African Horse Sickness (AHS)	Horses
	Lymphangitis	Equines
	Lumpy skin Disease	Cattle
	Pox disease	Sheep, Goat & Camel
	Rabies	Livestock & man
	Renderpest	Cattle
	New castle disease	Chicken
Protozoan	Trypanosomiasis	Cattle & Camel, Horses

Diseases Type	Common name	Species of animals affected
Diseases	Durine	Horses
	Babesiosis	Cattle,
	Anaplasmosis	Cattle & sheep
Ricketsial Diseases	Heart water	cattle
Endo-parasite	Nematodes	Cattle, sheep, goats, equines, chicken
	Liver fluke	Sheep & goats
	Ascaris	All specious
	Lung worm	Cattle, sheep goat, camel
	Coccidiosis	Mainly chicken
	Fowl Cholera	Chicken
Ecto-parasite	Tick	Cattle, sheep, goat, camel, equines
	Mange	Cattle sheep, Goat
	Lice	All species
	Mites	All Species

Source: From Doba Woreda livestock &Fishery development office

3.9. Agricultural Support Services

The woreda Agricultural office render services in introducing and providing agricultural inputs, controlling and advising in the control of crop pests, conducting agricultural and market surveys and advising on agronomic practices. The office also works with selected farmers through the extension program where various demonstrations on agronomy, input use and the likes are conducted on participatory basis.

The Oromia irrigation development authority at all level coordinates small-scale irrigation projects and programs in Oromia up to kebele level. Its main activities include irrigation water and land identification survey, detail study, design and construction of irrigation schemes.

3.10. Major Agricultural Constraints

Agriculture development in the Woreda is affected by several contraints. Among the various problems of the followings are the major onces.

a) Poor Extension Service System

Extension services in the Woreda are not well developed. Generally farmers are not yet exposed to improved farming practices. Farmers of the Project area need the establishment of demonstration on improved cropping systems. Use of agricultural inputs and post-harvest crop management is hardly implemented. The lack of adapted agronomic packages and absence of experienced development agents have partly contributed to the low performance of the extension services in the basin. Among measures that have to be taken to improve agricultural sector is strengthening extension package.

b) Unreliable Rainfall

In the Woreda, crops are produced under rain-fed condition. This causes not only unreliable single cropping in one year, but also important crop yield losses and even total crop failure. The length of the growing period of the crops and duration of the rainfall are not in harmony, i.e. rain ceases before the crops reach physiological maturity or there is deficiency of moisture at critical stages of the crop. This explains why farmers of the Woreda are not able to harvest good crops every year. To solve these problems to some extent there could be short term and long term solutions proposed. As short term solution adoption of dry land farming techniques, planting drought-resistant varieties, planting early maturing varieties, and planting low water demanding crops; and as long term solution practicing irrigation, restoration of degraded lands, better water management, and use of improve farming practices.

c) Lack of Improved Farm Implements

Improved farm implements for ploughing, seed drilling implements, light hand cultivators, harvesting & threshing are lacking throughout the woreda. Poor post harvest crop management and substantial loss of crop yields both in quantity and quality occur due to inappropriate threshing and storage conditions. A rough estimate by the farmers indicates 10 percent loss of stored grain. Crops are threshed on unclean grounds usually near or on the farmland and there are cases of adulteration of crops by weed seeds, sand, gravel and soil particles. Crops are stored in traditional and unimproved storage facilities, which are easily damaged by insects, rodents, moulds and moisture. Improved storage facilities are virtually unknown. The provision of agricultural implements to the farmers will reduce human drudgery and raise labour and farm productivity.

d) Shortage of Draught Power

Lack of adequate draught power leads to delayed and poor preparation of land and inefficient farm operations. Though, livestock population is common in most of the farmers do not have oxen in the crop producing agroecologies. Due to this, timely land preparation, sowing, and any other related farm operations are not accomplished as required. Sowing date gets delayed and this causes loss of crops by insufficient soil moisture. This means rain ceases before the crops are fully matured. In additionto this the late sown crops are also exposed to different insect pest damage.

e) Lack of Credit Service

There is no credit facility available to the farmers in most parts of the Woreda. Effective rural credit services have to be developed with due emphasis on inputs availability to the farmers like seeds, agro chemicals, oxen, farm implements, etc. Services need to cover individual farmers and have to be linked to the development of rural saving systems.

f) Shortage of Oxen

Oxen are the major source of farm power. However, due to scarcity of grazing land and other feed sources shortage of draft oxen is very much pronounced.

g) Shortage and un availability of improved seeds

.For irrigated agriculture, the shortage and timely un availability of different vegetable seeds were the major problems idetified by the beneficiaries' during data collection. Therefore, attention mus be given for this problem during project implemention**.**

h) Marketing of Agricultural products:

As farmers sale significant amount of their produce immediately after harvest ,they sale at times of low demand in the market .As a result , low price is fetched and the money is utilized for other urgent matters making them liable to lose capacity to buy agricultural inputs

3.11. Agricultural Development Potentials or Opportunities

a) Potential for Crop Production with Rain fed and Irrigation Development

Population of jobless workforce, the contribution of rainfall for increased flow of surface water sources in the upper stream and the principal sources for recharging ground water are the observed evidences in the context of potentials and/or opportunities in the woreda. Some of the areas are accessible to major road networks and proximity to local market opportunities. There are also a number of supporting institutions such as federal and regional research centers, farmer cooperatives on irrigation, universities, NGOs, and FTCs.

b) Potential for Livestock Development

If infrastructures are fulfilled, most part of the kebele is accessible to transportation having all-weather and weather road systems that helps for good market accessibility. There are aslso different support institutions such as regional research centers, universities, NGOs, FTCs, which can help in breed improvement and extension of the available resources. Availability of artificial insemination (AI) services and good experience of farmers in animal fattening activity make the suitable for livestock production and marketing.

C) Credit Facility

Rural credit facility could have an important role in sustaining agricultural production by accessing necessary inputs. Resource poor households require farm capital in credit to run their business. Microfinance institutions and credit cooperative organizations have a significant role in providing credit and saving services to smallholder farmers under existing the institutional set up, and these may require strengthening under the project in order to expand their business.

Credit facilities will be in kind or cash to run the business. Primary agricultural inputs such as fertilizer, improved seed and agrochemicals can be distributed to the farmers on credit for certain cropping seasons.

D) Improved Marketing of Agricultural Produce

Market linkages are critical to the success of the irrigated agriculture sector. They are not only important to realizing cash crops' income potential, but also critical to ensuring that farmers produce appropriately for existing demand and invest wisely in future inputs.

On the other hand, improved marketing is vital to allow farmers to profitably sell the incremental crop produce resulting from the investment in irrigation facility. Marketing constraints to be addressed by the project include lack of marketing information for farmers, low market prices and price fluctuations for most crops, storage facilities, etc.

To ameliorate these situations, things to be considered include:

- Introduction of marketing information system (i.e. market prices, dealers and outlets) through the service cooperatives (and their union) and development agents,
- Promotion of collective marketing of crops directly to wholesalers and retailers,
- Strengthening of the marketing capacity of service cooperatives and their union,
- Improvement of storage facilities to improve production quality, etc.

Besides, farmers must continuously update their knowledge of where the best place is for them to sell their produce. For marketing purpose seasonal fluctuation in prices, transportation cost and potential intermediate buyers' information have to be collected.

E) Supply of Agricultural Inputs

Improving the supply of farm inputs and credit delivery system is a crucial component in the improvement of agricultural marketing. There is a limited supply of agricultural inputs (fertilizers, improved seeds and agro-chemicals) in the woreda. The beneficiaries of the project area are agro pastoral and crop production is started in recent time and they live on food aid. Therefore, farmers' problems could be solved by improving delivery system of farm inputs on credit. To improve such system, there seems very encouraging to strengthen the existing and establish new service and marketing cooperatives.

F) Establishing Farmers Research Groups (FRGs)

One of the constraints identified while assessing the existing crop production scenarios of the project area is poor research-extension-farmers linkage. As a result, the study pointed out the need for the demonstration and dissemination of improved crop, irrigation and agricultural technologies. For this, there is a need to organize and establish Farmers' Research Groups (FRGs). FRG is group of farmers involved in joint problem identification, experiment designing, execution and monitoring and evaluation in the process of agricultural technology generation, evaluation and transfer. In case of Wagur irrigation project, Two FRGs to be established & become operational by investing at least 20 days per year recommended.

These activities help to empower farmers and build their capacity to enhance self-help and sustainable natural resource management. It is required to study the value chain of major crops as well as enterprise choice in irrigated crops. It is very pertinent to undertake adaptation/screening trial to select high yielding and disease resistance crop varieties. High emphasis needs to be given to high value crops to fill the demand- supply gap existed in the study area. Technical support and training would be given to the FRGs by subject matter specialists (SMS) from Oromia Agricultural Bureaus and Oromia Agricultural Research Center.

Integrated soil fertility management

Soil nutrient depletion is one of the issues identified while assessing soils of the study area. Hence, integrated soil fertility management is recommended to improve the soil fertility of the area. This method integrates all practices aimed at improving soil fertility and due consideration should be given to soil fertility management. The integrated soil fertility management comprises the application of well decomposed farmyard manure, use of organic fertilizer/compost, Cereal-Legumes intercropping, crop residue and use of crop rotation. The availability of farmyard manure is good in the area owing to the presence of many livestock population. Currently some farmers are applying cow dung on crops growing near their homesteads but it is not widely used.

Preparing Compost

Compost is a manure derived from decomposed plant residues usually made by fermenting waste plant materials heaped or put in a pit usually in alternate layers with a view to bring the plant nutrients in a more readily available form.

Compost is important because it:

- Contains the main plant nutrients – nitrogen (N), phosphorus (P) and potassium (K), often written as NPK;
- Improves the organic matter in the soil by providing humus;
- Helps the soil hold both water and air for plants; and
- Makes trace elements or micronutrients available to plants.

Compost can be easily prepared around homesteads or in the farmlands of each farmer. For the proposed irrigated agriculture, it is planned that every farmer is going to prepare compost pits during the dry season. Therefore, every beneficiary must prepare two composts either heap or pit composts in the irrigated farms depending on the seasons. This compost heaps are going to be prepared and used.

3.12. 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 Doba woreda and the project Kebele. As per the "without project" condition, a hectare of labor requirement is specified under the following condition.

Table 18. Existing Labour Requirement for Growing Major crops in Project area

Crops	Activities	unit	Freq	MD(Qty)	Total
Sorghum	Plowing	MD	2	16	32
	Sowing	MD	1	8	8
	Fertilizer application	‘’	1	8	8
	Weeding	‘’	3	30	90

Crops	Activities	unit	Freq	MD(Qty)	Total
	Harvesting	«	1	40	40
	Transportation	«	1	16	16
Maize	Plowing	«	3	16	48
	Sowing	«	1	8	8
	Fertilizer application	«	1	8	8
	Weeding	«	2	32	64
	Harvesting	«	1	16	16
	Transportation	«	1	16	16
Teff	Plowing	«	2	16	32
	Sowing	«	1	8	8
	Fertilizer application	«	1	8	8
	Weeding	«	1	16	16
	Harvesting	«	1	16	16
	Transportation	«	1	16	16
Wheat	Plowing	«	2	16	32
	Sowing	«	1	8	8
	Fertilizer application	«	1	8	8
	Weeding	«	2	32	64
	Harvesting	«	1	16	16
	Transportation	«	1	16	16
H. bean	Plowing	«	1	16	16

Crops	Activities	unit	Freq	MD(Qty)	Total
	Sowing	«	1	8	8
	Fertilizer application	«	1	8	8
	Weeding	«	1	16	16
	Harvesting	«	1	16	16
	Transportation	«	1	16	16

Table 19 Oxen Day used for Production Of Major Crops

Crops	Activities	Unit	Freq	OD(Qty)	Total
Sorghum	Plowing	OD	2	8	16
	Sowing	«	1	8	8
Maize	Plowing	«	2	8	16
	Sowing	«	1	8	8
Teff	Plowing	«	3	8	24
	Sowing	«	1	8	8
Wheat	Plowing	«	2	8	16
	Sowing	«	1	8	8
Haricot bean	Plowing	«	1	8	16
	Sowing	«	1	8	8

3.12.1 Extension Delivery Alternatives

Diagnostic Visits*:* Regular visits by extension agents will be carried out frequently on a predetermined date agreed with the communities. The purpose of the visit is to diagnose or identify current problems. If the development agents are unable to solve, they will consult the appropriate technical specialist at supervisor or project office level. For example if problems raise about pests and disease attack and where diagnosis is uncertain research staff and university academicians can be requested for assistance.

On Farm Practical and Demonstration Plots: As the name implies, the purpose of these plots is to practice farmers on the skills relevant to a particular crop or farm practice and observe the results. Prior to setting up the demonstration plot, plan would be drowning up, which describe the plot objective, a sketch and detail activities to be carried out. Results will be recorded and cost benefits calculated. Tasks on the plots will be demonstrated where possible with farmers practice. The observable and quantifiable results will make available to other farmers physically and in photographs.

Demonstration/Pilot Trials Site: Any agricultural production problems and/or new technologies etc anticipated in the study should be tested and resolved prior to operation of the project. Therefore, it is highly advisable to establish at least 0.5ha multipurpose demonstration site for farmers training how to practice newly introduced technologies. Oromia research institute has a responsibility of integrating the pilot issues in to the existing research program.

Training and Experience Sharing: Experts, supervisors, development agents and beneficiaries need short-term training and experience sharing to develop their technical capacity on crop management. The extension officer has great responsibility to facilitate these activities.

The training will be aimed at ensuring that all staffs are capable of carrying out their duties in a manner that will meet the objectives of the agricultural extension sector. The major functions of extension staff are dissemination of information, advice, training and evaluation and monitoring of its effect. To do this effectively they will have to know or acquire.

- The technical knowledge and skills that have to be transferred to farmers
- The skills that is necessary to be able to transfer this knowledge and its associated practice
- An understanding of the working procedures and the organizational skills, necessary to perform their duties effectively and correctly. Regular skill upgrading program should be devised accordingly at each hierarchy

Farm Tools and Equipment's: Farm tools, farm machineries and equipment, which are suitable to the area and level of technology, must be provided through appropriate credit system. This farm tools includes, fork, hoe, mower/slather, rake etc.

3.13. Proposed Irrigation Development

3.13.1 Rationale and Objectives

Population growth, shortage of farm lands, poor farming practices, declining soil fertility, low crop yields and shortage of animal feed are the major constraints for the communities of the project area. Although current situations seem not so critical, it is apparent that food supply may be greatly affected in the near future.

Therefore, harnessing available resources of the area, in time, would be more appropriate. Irrigation in general and small-scale irrigation in particular is one of the strategies that will respond to the needs of the area. This strategy should also be supported by other components including improvements in rainfed farming, soil and water conservation practices, animal feed and health services and infrastructure development (access roads, market outlets, water supply and health facilities).

The objectives of Wagur Small-Scale Irrigation development would be to:

- Develop land for irrigation and irrigate dry season crops as well as supplement wet season crops during times of early withdrawal of the rains;
- Recommend cropping pattern for irrigated farming;
- Determine input requirement for the proposed scheme;
- Realize higher crop yields and raise the household income of the beneficiaries.

3.13.2. Choice of Irrigated Crops

The choice of crops for the scheme was based on the following important factors:

- Suitability of the soils (physical and chemical characteristics);
- Adaptability to the prevailing climate (rainfall, temperature, altitude and other climatological aspects);
- Farmers' preference and experience in the production of the crop;
- Irrigability of the crop; and
- Marketability of crops.

On the basis of these factors, suitable crops were selected both for the wet season (rainy season) and the dry season (irrigation). Farmers of the area are well acquainted with most of these crops. In addition, during focus group discussions, farmers' preferences include almost all of these crops. The following are the main crop types recommended for the scheme.

These are Pepper, Tomato, Maize, Potato, Onion.

The number of crops can vary depending on water demand, agro-ecology, soil and market demand. However, for simple calculation of duty, these four crops are selected.

Table 20 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
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
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
4	Moist Kolla	500-1500	>25	900-1400	Maize, groundnut, haricot beans, sweet potato, shallot, onion, pepper, tomato, banana, papaya, citrus
5	Dry Kolla	500-1500	>25	300-900	Maize, sorghum, groundnut, haricot bean, cotton, sweet potato, shallot, onion, pepper, tomato, banana, papaya, citrus

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

3.13.3. Benefits of Wagur Small Scale Project

The implementation of the project will provide irrigation water to an area. This entails incremental production and diversification of crops by the beneficiary. The production of high value crops, especially vegetables improves cash income of the households;

Increased crop production and cash income will improve the diet and nutrition of the population. The practice of irrigation will create additional employment opportunities for the beneficiaries as well as for the people outside the command area. Apart from the scheme's beneficiaries, many other families in the surroundings will benefit from increased food crop production and possible labor opportunities in the irrigation fields. The high cropping intensity requires additional labor and provides employment opportunities throughout the year, which would have been idle otherwise. Crop yields will increase and problem of food shortage will be reduced. The project will also encourage crop diversification based on market demands in and around the area

New farming practices and improved technology will be provided through the extension services of the project. As a result, apart from the benefits that it provides to the beneficiaries, the project will also serve as demonstration of irrigation practice to the surrounding farmers.

3.14 Organization and Management Needs

3.14.1. Establishment of Water Users Association (WUA)

Water Users Association (WUA) should be established before work on construction of the scheme starts. This will enable the farmers to participate in the construction/implementation stage and a sense of ownership will flourish from the beginning. The committee shall be elected from the beneficiaries to organize, manage, co-ordinate and operate the scheme in accordance with established by laws of the association. The committee shall be composed of 5-7 elected members in the command area among which 2-3 members shall be women.

The function of the committee would be:

- Establishment and operation of irrigation water schedules,
- Distribution of irrigation water to members on set schedules,
- Organize and co-ordinate maintenance and cleaning of the canal and structure, and
- Taking measures on not abiding by WUA's laws and regulations.

3.14.2. Identification of Training Needs

Farmers should bé well oriented of irrigation practices. Training shall be given at all levels including Development Agents, Water User Association committee membres and the beneficiaries themselves.Trained DA's shall identify farmers needs interms of land preparation, crop selection, cropping patterns, crop rotation practices, irrigation scheduling and application, crop protection meaures harvesting techniques and marketing of products.

DA's will have regular training by subject matter specialists (irrigation engineers, irrigation agronomists, etc). Training materials or manuals and on-site demonstration shall support the training.

Support Institutions

The sustainability of the irrigation scheme is very much dependent upon the strength of the provision of the support services. These services include:

- **Agriculture extension service**: Thorough and continuous orientation regarding crop production in general and irrigation agriculture in particular should be given to the peasant farmers. The development agents will also be trained and take responsibility to train the farmers including the rain fed activates during the wet season.
- **Strong linkage with irrigation research**: A strong link should be formed with research centers to use improved technologies and establishment be made to carry out adaptive trials in the scheme. The most important aspects include irrigation methods, irrigation interval, water and fertilizer use efficiency, crops adaptive trial, water consumption and irrigation water management.
- **Agricultural inputs**: Crops input requirements in terms of labor, draft power, seeds etc, have been estimated based on current practices in the country. Adequate and timely supply of inputs, particularly improved seeds and fertilizers, is very important to the sustainability and productivity of the project. The full application or use of these inputs may not be attainable during the early years of the project life but should be implemented in a gradual manner through vigorous extension work, farmers' active participation, on-

farm demonstrations and trials. While the available labor of a household may be adequate for the conventional rain fed farming system, introduction of irrigation during the dry season requires increased work force and will exert higher demand on family labor. Consequently, it will not be possible for a family of average size to manage more than 0.5ha of irrigated cropland. Thus, farmers having more than 0.5ha of land in the command area may be forced to either lease out or share crop the extra area of land to others.

- **Product marketing**: Marketing of agricultural products in general and vegetables in particular require a well-organized marketing infrastructure. These include all-weather roads, efficient transport system, market centers and networks and storage facilities.

3.15. Cropping Patterns

The cropping system is based on rain fed and irrigated farming. The wet season cropping extends from April/May to October/November and that of dry season from November/December to March/April. Irrigation water will be supplemented to rain fed crops at times of early withdrawal of the rains.

In order to attain the suggested cropping intensities for the first two to three years a lot of extension work may be required in order to raise awareness among the beneficiaries to utilize the maximum possible area of the project. One has to note that the purpose of irrigation is, ultimately, to intensify agricultural production so long the resource, water and land, are adequately available.

Table. Proposed Cropping Pattern and Intensity for Wagur Project

Table 21 Full Irrigation

S/N	Proposed Crops	Area		Selected varieties	Planting/ Sowing date	Harvesting Date	Base-period (days)
		(ha)	(%)				
1	Maize	6	10	BH-543, BH-546 Shone	Nov01/11	March14/03	120
2	Potato	12	20	Jalene,Gudane,Belete	Nov10/11	March09/03	115
3	Tomato	24	40	Marglobe,Melkashola	Nov10/11	March25/03	120
4	Onion	18	30	Adama Red and Bombe red	Nov10/11	Feb12/02	90-95
	Total	**60**	**100**				

Table 22 Supplementary Irrigation

S/N	Proposed Crops	Area		Selected varieties	Planting/ Sowing date	Harvesting Date	Base-period (days)
		(ha)	(%)				
1	Sorghum	24	40	Abshir,Gobiye& Teshale	June	Nov-Dec	120
2	Haricotbean	9	15	Melkassa1 & Awash Melka	Augst	Oct-Nov	90
3	Maize	18	30	BH-543, BH-546, Shone	May	Oct	120-150
4	Teff	9	15	Kuncho, DZ-Cr 37	July	Oct-Nov	120-150
	Total	60	100				

Figure 4 Maize Crop Suitability Map

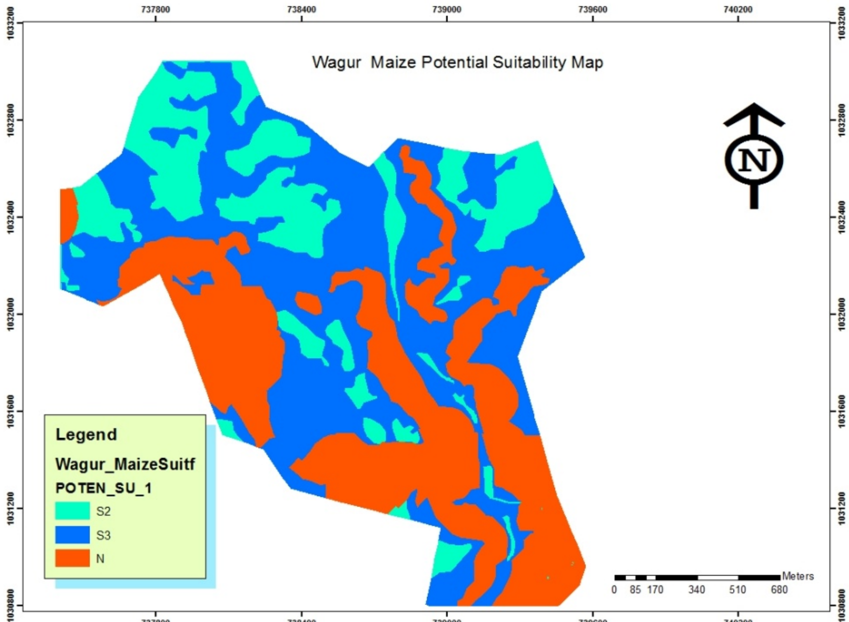


Figure 5 Onion Crop Suitability Map

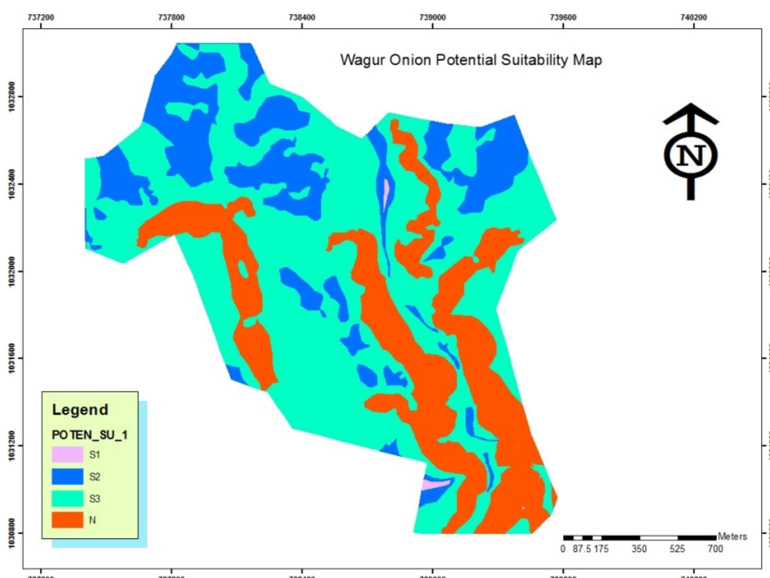


Figure 6 Potato Crop Suitability Map

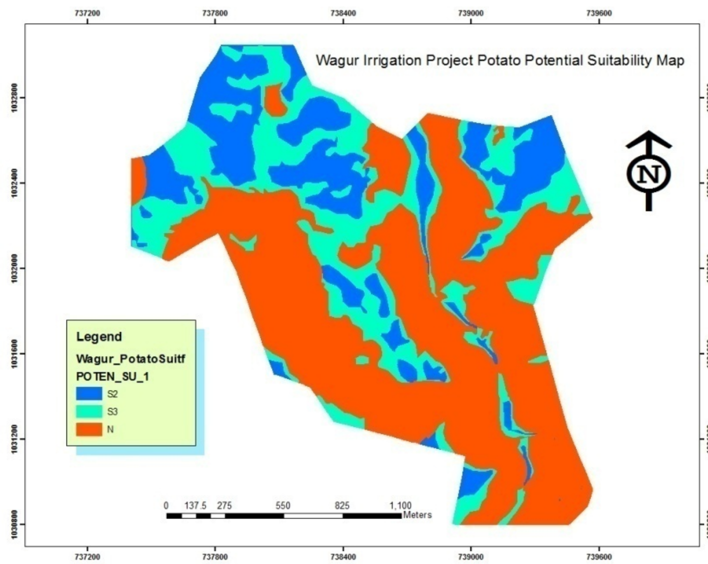
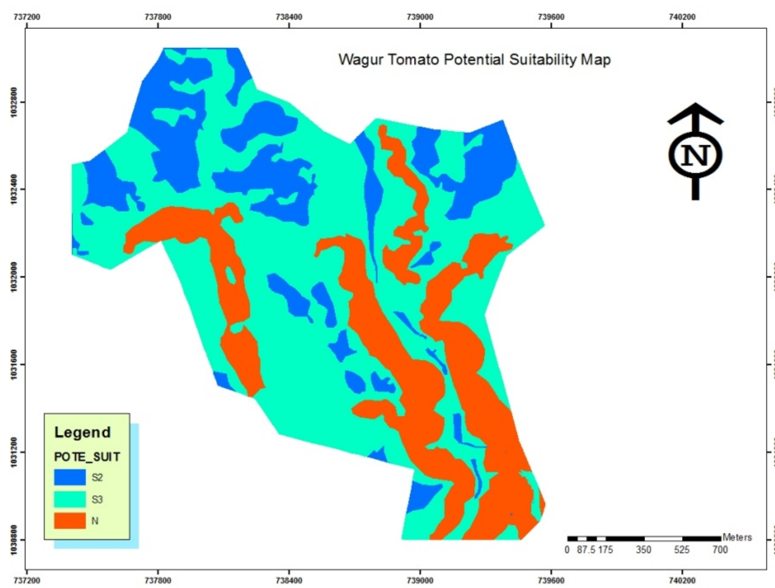


Figure 7 Tomato Crop Suitability Map



3.15.1. 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.

A) Cereals

a) Maize (*Zea mays*)

Maize is grown under a wide range of ecological conditions and is a typical crop, requires hot and humid climate; best adapted to intermediate climate. It is one of the most important food crops and also one of the major green fodders to livestock. The crop gives the best results where the growing season is more than 140 days with mean temperature around 24 degree cent grade.It is not resistant to frost, but its growing point being protected in the leaf, it could restart its growth even when outer leaves are damaged by frost. It is grown successfully even in mild temperate region at high altitude and even in hot arid plains under assured irrigation. Moisture requirement of maize is quite peculiar. It has high water requirements, but it expends the water economically and is relatively a mildly drought resistant crop. The water requirement of maize varies according to the development stage. From germination to earing stage; it could develop with very little moisture. However, the crop requires heavy amount of water supply during its inflorescence (reproductive stage). Cultivation of maize under rain fed condition needs from 600-900 mm of well distributed rainfall. It requires well structured, predicable soil with high organic matter content. Water logging can affect maize. It is fairly sensitive to salinity. Maize is an efficient user of water with regard to the production of dry matter. A seeding rates of 25-30kg/ha is required. A plant population of 44,444 per hectare is recommended. Maize could be rotated with legumes. Intercropping could also be adopted. Maize requires large amount of phosphorus and nitrogen fertilizers which should be applied as split percentage for dressing when the crop is at knee-height.

B) Vegetables

a) Tomato (Lycopersiconesculentum)

Tomato is a rapidly growing crop with a growing period of 90 to 150 days. It is a day length neutral plant. Tomato can be grown on a wide range of soils, but a well-drained light to loam soil with pH of 5 to 7 is preferred. The seed is generally sown in nursery plots and emergence is within 10 days. The seedling is transplanted in the field after 25 to 35 days. In the nursery the row distance is about 10 cm, but in the field spacing ranges from 0.3/0.60x0.6/m with a population of about 40,000 plants per ha. The crop should be grown in a rotation with crops such as maize, cabbage cowpea to reduce pest and disease, particularly nematodes.

The water requirement after transplanting, of tomato crop grown in the field for 90 to 120 days is between 400 to 600 mm depending on the climate. The plant produce flower from the bottom to top during the active development of the stem. Fruit can be harvested while the plant is still flowering at the top. In some cases three flowering periods related to three harvests can be distinguished.

Frequent light irrigation improves the size, shape, juiciness and color of the fruit, but reduces total solids (dry matter content) and acid content. However, the decrease in the solids will lower the fruit quality for processing. In selecting the irrigation practices consideration must therefore be gives to the type of end product required. Tomato is sensitive to diseases and insect pests; so apply recommended cultural and chemical control measures to control different diseases and insect pests affecting tomato production. Parasitic weed must be rouged out at earl stages before it set seeds.

b) 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, black clay textured soils are most suitable.The maximum rooting depth of the crop is 0.25m.Soil pH range is 6.6-7.3, optimum pH is 6.0-7.8.

C) Roots and Tubers

a) Potato - (solanumtuberosum)

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 5to 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.

3.16. Irrigation Seasons

Irrigation seasons are decided based on the existing climatic condition, length of growing period (LGP) of the proposed crops and capacity (efficiency) of the beneficiaries of the project. As to the proposed project condition, one time irrigation seasons as a “Dry-season” is possibly recommended. The “Dry-Season” is considered as “Full-Time” irrigation season and the second planting season is rain fed “Wet-season” as “supplementary” irrigation. The full time irrigation season is proposed starting in the month of November. This period (November) is proposed to be a starting month considering the (LGP) of crops, appropriate marketing time and the time for second rain fed production practices.

3.16.1. Proposed Crop Production and Yield

Estimates of production and yield of individual crops are based on the potential of the crop, implementation of improved cultural practices including input use and efficient irrigation management. Improvements of the farming system would be achieved through the introduction of improved locally adapted varieties, improved land preparation and soil fertility maintenance techniques and the use of environmentally sound methods of crop protection. Many of the crops proposed in this project have been successfully grown in the area and farmers do have certain experience in growing these crops. The initial yield estimates of the proposed crops are very much closer to the current production performance in the area as well as in the country. Subsequent yields are assumed to increase steadily as improvements in cultural practices including irrigation management are adapted by the beneficiaries.

3.16.2 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 below.

3.16.3 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 23 Method of Irrigation and Spacing for Selected Crops

S/N	Selected Crops	Method of Irrigation	Plant spacing (cm)		Remark
			Intra-row	Inter-row	
1	Maize	Furrow	30	75	
2	Potato	Furrow	30	75	
3	Tomato	Furrow	30	60	
3	Onion	Furrow	10	30	

3.16.3 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 24 Major Cultivation Activities in Irrigated Agriculture

S/N	Proposed crops	Seed Rate(Kg/ha)	Soil depth during Seeding/ planting (cm)	Cultivation time/Weeding
1	Maize	25	5-10	After 4-leaf stage
2	Potato	2000	4-5 (Transplanting from nursery site after 30 days)	After 20 days of planting
3	Tomato	0.5	5-10	1st 25 days and 2nd 45 days after planting
3	Onion	3-4	4-5 (Transplanting from nursery site after 30 days)	After 20 days of planting

3.16.4 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.

Table Major Cultivation Activities in Irrigated Agriculture

S/N	Proposed crops	Seed Rate(Kg/ha)	Soil depth during Seeding/ planting (cm)	Cultivation time/Weeding
1	Maize	25	5-10	After 4-leaf stage
2	Potato	2000	4-5 (Transplanting from nursery site after 30 days)	After 20 days of planting
3	Tomato	0.5	5-10	1st 25 days and 2nd 45 days after planting
3	Onion	3-4	4-5 (Transplanting from nursery site after 30 days)	After 20 days of planting

3.16.5 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 25 Method of Fertilizer Application for the Proposed Crop types

S/N	Proposed Crops	Fertilizers to be applied	Method of Application	Time of Application
1	Maize	NPS	Top/Side dressing	At the time of sowing
		Urea	Basal dressing	At 4-leaf stage
2	Tomato	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 sowing
		Urea	Basal dressing	During earthening up stage
4	Onion	NPS	Top/Side dressing	At the time of transplanting
		Urea	Basal dressing	3 to 4 weeks after transplanting

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.

3.17 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 aresummarized to be used in the future plant protection activities of the proposed project.

Table 26 Chemical and non-chemical plant protection methods for proposed crops

S/N	Proposed Crops		The Possible Pests & Diseases	Chemical Prevention Method	Non-chemical Prevention Method
1	Maize	Pests	Stalk Borer, African Ball Worm, Aphids, Army Worms, Weevil	Use different Chemicals & pesticides	Field sanitation, Crop rotation, and Insect free var., proper crop and water management.
		Diseases	GLS, TLB, Cob Rot,	Use different fungicides.	Field sanitation, Crop rotation, and Disease free var., proper crop and water management.
2	Tomato	Pests	Fruit sucking insects, Aphids, 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.
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,	Use of different	Field sanitation, crop rotation, and disease free var., proper

S/N	Proposed Crops		The Possible Pests & Diseases	Chemical Prevention Method	Non-chemical Prevention Method
			Bacterial wilt, etc.	fungicides.	crop and water management.
4	Onion	Pests	Onion trips, cut worms, Onion flies, Termite.	Use different Chemicals & pesticides	Field sanitation, Crop rotation, use of Disease free var., proper crop and water management.
		Diseases	Root rot, Purple Bloch, Downey Mildew	Use different fungicides.	Field sanitation, Crop rotation, use of Disease free var., proper crop and water management.

3.17.1 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.

- Maize ↔ potato/tomato/onion ↔ maize which helps for avoidance especially of stalk borer, and rust.
- Onion/tomato/potato ↔ maize used for avoidance, especially of nematode build up, blight and bacterial wilt; only Solanaceous crops should be avoided in the rotation system.
- Shallow rooted crops alternatively with deep rooted crops for efficient utilization of essential nutrient resources is also one of the rotational possibilities.

Labor Requirement

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

Table 27. A hectare of Labour requirement for selected Crop as a "with project" Condition

Activity	Unit		Proposed crops		
		Maize	**Tomato**	**Potato**	**Onion**
Nursery	MD	0	60	0	60
Land preparation	OD	12	12	12	12
Pre-planting operation	MD	10	12	10	12
Planting	MD	12	15	12	25
Fertilizer application	MD	8	4	4	5
Irrigation	MD	20	20	20	25
Weeding & hoeing	MD	40	40	40	60
Crop protection	MD	5	5	4	8
Harvesting	MD	30	40	20	20
Post-harvest operation	MD	20	15	20	15
Total	**MD**	**157**	**223**	**142**	**242**

3.18. 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. Accordingly, the following cropping pattern/intensity is designed for the first 5-year crop production schedule.

Table 28. A 5-year Cropping Pattern/intensity plan

S/N	Crops	Area coverage									
		1st-Year/Season		2nd-Year/Season		3rd-Year/Season		4th-Year/Season		5th-Year/Season	
		ha	%	ha	%	ha	%	ha	%	ha	%
1	Maize	6	10	9	15	12	20	12	20	12	20
2	Potato	12	20	18	30	24	40	24	40	24	40
3	Tomato	24	40	36	60	48	80	48	80	48	80
4	Onion	18	30	27	45	36	60	36	60	36	60
Intensity		**60**	**100**	**90**	**150**	**120**	**200**	**120**	**200**	**120**	**200**

3.19. 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 (rain fed) agriculture, anticipated research outputs, and other related sources are very important. Considering these parameters, the following yield projection is forecasted.

Table 29. 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	Maize	60	360	65	585	70	840	75	900	75	900
2	Potato	150	1800	160	2880	170	4080	180	4320	180	4320
3	Tomato	85	2040	90	3240	95	4560	100	4800	100	4800
3	Onion	80	1440	85	2295	90	3240	90	3240	90	3240

3.20. Postharvest 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.

f) 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.

3.21. 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.

4. 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 **50%** to obtain the gross water requirement. The project supply of the irrigation project during full irrigation is indicated for **24 hour i**rrigation and becomes ***0.98 l/s/ha*.** 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 30. Duty of Dry Season Cultivation

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation deficit												
1. Maize (Grain)	144.5	102.6	3.1	0	0	0	0	0	0	0	41.1	117.7
2. Potato	137.6	132.2	45.5	0	0	0	0	0	0	0	43.2	93.7
3. Tomato	129.6	136	92.4	0.4	0	0	0	0	0	0	51.8	87.2
4. Onion	125.6	48.8	0	0	0	0	0	0	0	0	60.5	110.3
Net scheme irr.req.												
in mm/day	4.2	3.8	1.5	0	0	0	0	0	0	0	1.7	3.2
in mm/month	131.5	105.7	46.4	0.2	0	0	0	0	0	0	51.6	98.5
in l/s/ha	0.49	0.44	0.17	0	0	0	0	0	0	0	0.2	0.37
Irrigated area (% of total area)	100	100	70	40	0	0	0	0	0	0	100	100
Irr.req. for actual area (l/s/ha)	0.49	0.44	0.25	0	0	0	0	0	0	0	0.2	0.37
Project Efficiency	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Project Duty (l/s/ha)	**0.98**	0.88	0.5	0	0	0	0	0	0	0	0.4	0.74

4.1. 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.

4.2. 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.

4.3. 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 analyzed using the modified Penman method.

4.4. 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.

4.5. 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 (Kcini) 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 31. 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
Maize	120	20	35	40	25	0.40	0.80	1.05	0.60
Potato	115	20	30	40	25	0.40	0.70	1.05	0.80
Tomato	120	25	35	40	20	0.40	0.70	1.05	0.80
Onion	95	20	30	30	15	0.40	0.70	0.95	0.85

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

4.6. 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.

4.7. 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.

4.8. 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).

4.9. 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 **50 %** 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)

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).

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

4.10. 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 Maize every **15 days**, for Tomato every **11 days,** for Potato every **9 days**, and for Onion every **8 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).

5. Conclusion & Recommendation

Production of economically important crops more than twice in a year through irrigation development is highly encouraged in the region 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 the climate and soil of the project area is suitable for some cereals, vegetables, oil crops, and has no significant limitation for implementation of the proposed irrigation project. Even though the time of dry spell from the offset to the onset of the natural rainfall is not wider, the amount and distribution of rainfall during the dry season is insufficient in the project area. This situation allows the full utilization of irrigation practices provided other factors are not limiting. Therefore, production of crops two times in a year using irrigation water and natural rainfall is recommended as full irrigation (dry period irrigation) and supplementary irrigation (wet period irrigation) seasons. 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.

6. REFERENCES

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Annex 1.1: AGRONOMY ANNEXES

Required climatic & other aerodynamic data collected from Hirna Station

Months	Min Temp	Max Temp	Humidity	Wind	Sun	Rad	Rain	Eff rain	ETo
	°C	°C	%	km/day	hours	MJ/m²/day	mm	mm	mm/day
Jan	8.2	27.3	43	90	7.3	18.4	17.6	0.6	3.76
Feb	8.7	28.8	37	91	7.4	19.7	5.7	0	4.19
Mar	10.3	28.1	40	108	7.1	20.2	90.1	48.1	4.51
Apr	11.6	27.8	54	97	6.2	19.1	108.5	62.8	4.16
May	11.7	28.5	50	111	5.9	18.2	85.4	44.3	4.24
Jun	12.2	28.5	49	147	4.8	16.2	86	44.8	4.28
Jul	12.9	27.8	57	108	4.8	16.3	184.8	123.8	3.85
Aug	12.6	26.9	60	135	4	15.4	223.4	154.7	3.8
Sep	12.6	26.9	56	97	5.7	18	145.2	92.2	3.95
Oct	11.3	27.5	49	84	7.6	20.1	52.2	21.3	4.14
Nov	8.5	27.8	44	104	8.1	19.7	19.6	1.8	4.15
Dec	7.5	26.9	45	110	8.2	19.1	8.4	0	3.94

B. 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 1: Project efficiencies

S/n	**Type of Efficiencies**		**Suggested Values, in (%)**
1	Conveyance Eff.	Ec	98 %
2	Distribution Eff.	Ed	85 %
3	Application Eff.	Ea	60 %
4	Project Eff.	Ep	50 %

C. 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 2: Irrigation depth, (d, mm)

S/n	**Crops**	**p-value**	**Sa (mm/M)**	**p.Sa**	**D (mts)**	**Ea**	**d (mm)**	**Remark**
1	Maize	0.63	200	126	0.65	0.60	136	
2	Potato	0.35	200	70	0.45	0.60	52	
3	Tomato	0.40	200	80	0.62	0.60	82	
4	Onion	0.42	200	84	0.42	0.60	58	

D. Interval (days)

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	Maize	0.63	200	126	0.65	5.46	15	Average watering days are to be from 11 to 15 days.
2	Potato	0.35	200	70	0.45	3.50	9	
3	Tomato	0.40	200	80	0.62	4.50	11	
4	Onion	0.42	200	84	0.42	4.41	8	

E. Inputs required for the Irrigation Project for one year

Crop	Dry Season (1st Irrigation)						
	Area, ha	DAP, qt	Urea, qt	Seeds, qt	Fungicide, lt	Insecticide, kg	Herbicide, lt
Maize	6	6	6	1.5	18	18	18
Potato	12	12	12	240	36	36	--
Tomato	24	24	24	0.12	72	72	--
Onion	18	18	27	0.72	54	54	--
Total	**60**	**60**	**69**	**242.34**	**180**	**180**	**18**

Crop	Wet Season (2nd Irrigation)						
	Area, ha	DAP, qt	Urea, qt	Seeds, qt	Fungicide, lt	Insecticide, kg	Herbicide, lt
Sorghum	24	24	24	2.88	72	72	72
Haricotbean	9	9	00	5.4	27	27	00
Maize	18	18	18	4.5	54	54	00
Teff	9	9	8	0.9	27	27	27
Total	60	**60**	**50**	**13.68**	**180**	**180**	**99**

Crop	**Dry Season + Wet Season**					
	DAP, qt	**Urea, qt**	**Seeds, qt**	**Fungicide, lt**	**Insecticide, kg**	**Herbicide, lt**
Maize	6	6	1.5	18	18	18
Potato	12	12	240	72	72	--
Tomato	24	24	0.12	36	36	--
Onion	18	27	0.72	54	54	--
Sorghum	24	24	2.88	72	72	72
Haricotbean	9	00	5.4	27	27	00
Maize	18	18	4.5	54	54	00
Teff	9	8	0.9	27	27	27
Total	**120**	**119**	**256.02**	**360**	**360**	**117**