The Federal Democratic Republic of Ethiopia Regional State of Tigray Bureau of Water Resource

Misrar-teli Diversion project
Agronomy Irrigation development Plan of Wereda Enderta Final Report

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Acronyms

DA Development Agent

Etc Crop Evapotranspiration

Eto Reference Evapotranspiration

EMG Enderta Misrateli Giba

FTC Farmers training center

IWUA Irrigation Water Use Association

Kc Crop Coefficient

LGP Length of Growing period

Masl Meter above sea level

P.eff Effective precipitation

P.total Mean Monthly Total Rainfall

Ra Extra terrestrial radiation

SM3 Sub moist mid high land

TA Average Temperature

TD Temperature difference

UTM Universal Transverse Mercator

EXECUTIVE SUMMARY

Agriculture in Tigray Region like in other parts of the country, is the main sector on which more than 80 % of the population is dependent. This sector is largely rain fed and characterized by mixed farming in which animal husbandry is closely integrated with crop husbandry. The current productivity per unit area in the region is very far below the average, since rain fed agriculture is very exposed to weather and climate change.

The Country and Regional development strategy attaches the highest importance to the use of agricultural inputs and vigorous extension service, which are considered essential in bring about the transformation from subsistence level of production to market led commercial production, and thereby increasing farm productivity and alleviating poverty. Therefore, improving farmers access to irrigation facility and timely supplying adequate inputs, promoting market oriented production and technical support have been given due attention.

This Irrigation Agronomy Feasibility study is developed by a client Tigray water resource bureau and studied by Tigray water works study, design and supervision Enterprise.

The objective of this feasibility study is to assess the potentials and constraints of the area for irrigated agriculture and to propose suitable and market oriented crops, efficient water management and improved practices to the area so as to increase crop production in accordance with accepted professional guidance and technical guide line of the client.

Misrar-teli is found in Enderta wereda in tabia Mahbere-genet. Mahbere-genet tabia has a population of 6905 (Male 3260, Female 3645) and the total area is 3185ha from this about 35 percent (1112ha) is cultivable land. The Tabia topography is rugged and undulating with different agro- ecology while the command area is almost lie on valley which is nearly flat found between the range of 1875 to 1885 masl.

The Tabia is highly deforested and eroded and increasingly infertile, being under the growing population pressure of scattered settlement.

The average annual rainfall varies from 293.2mm to 917.96mm.The average temperature is also varies from 11.8^0c to 30.1^0c. This irregular rainfall and drought hazard exposed crop and livestock production to periodic failures.

The command area lies and owned by Mahberegenet tabia and kushet Tsilwo. The project proposes at Dry and Wet season to irrigate annual and perennial crops through different irrigation methods to develop 50 ha. Average land holding of the farmers in the tabia is about 0.55 ha. per household.

Currently, almost all farmers follow the crop rotation of their own choices depending on the onset of rainfall which is not scientifically sound but to cop the erratic and less amount of rainfall occurred on one season. Usually mono-cropping dominates due to unavailability of supplemental irrigation facilities. seed bed preparation is mostly done by plowing the land twice or thrice using age-old tradition plowing by oxen. Mostly broad cast method of sowing is done using local seeds and the seed rate in use are also high. Both chemical and organic manures are used as per availability, composting is practically not done though it describes by extension agents. Hand weeding is most common either by family or by employed labor.

The current production of the land does not sufficient for some of the family due to continuous and progressive decline in productivity mainly due to shortage of rainfall and infertility of the soil, the farmers are trying to compensate their food deficit by sale of their livestock's and make use of family labour.

Despite, the number of agricultural constraints, there is fairly high potential that can be exploited through comprehensive integrated agricultural development program: through proper utilization of the water resource for irrigation purpose and by improving the existing traditional farming systems.

1.0. INTRODUCTION

Irrigation is the key input in crop production for drought prone areas. Full benefit of crop production technologies such as high yielding varieties, fertilizer use, multiple cropping, crop culture, and plant protection measures can be guarantee only when adequate supply of water is made available. On the other hand, optimum benefit from irrigation is obtained only when other crop production inputs and technologies are applied. For viability and profitability of new irrigation project a shift in cropping pattern and cropping system is important from the existing agricultural system. It is from this context that Irrigation Agronomy is among the different disciplines in the study team that included as part of the study.

1.1. Back Ground

Enderta Wereda is located in the South Eastern zone of Tigray. In the wereda as the result of land degradation and shortage of rainfall the farmers' leads to seasonal agricultural production and with less irrigation efficiency which leads to low productivity in Wet season (Kremti). The irrigable land in the Misrar-teli site lies in one tabia and in one kushets. Farmers in the area have traditional way of experience in utilizing the available water for irrigation purpose. The construction of this modern diversion will have tremendous benefit in alleviating food shortage for human and livestock by increasing the irrigation efficiency and productivity of the project area.

1.2. Objective of the study

The objectives of this Feasibility study are:

1. To verify potential cultivable land for irrigation purpose.
2. To study the existing farming practice and constraints.
3. To indicate improved farming practices for selected crops
4. To determine crop water requirement for proposed crops.
5. To prepare the Agronomy feasibility report.

2.0. Over View of the Area

2.1. Location

Misrar-teli Scheme is located in the Southeastern zone of Tigray, in Enderta wereda in Mahbere-genet tabia. The site is found at the western part from the center of the woreda with altitude ranges from 1802- 1812 masl.

The site is far about 10 km Asphalt road from Mekelle, and 2 km weather gravel road from Romanat. Geographical location of the site on the Axis is 545155 E, 1500009 N and 1870 masl while in the middle of the command area is 544147E, 1501183N UTM and 1809masl.

2.2. Accessibility

There is Asphalt road from the center of wereda kuiha to the site via Mekelle. The site is near to the town market Mekelle, Tikul and Hagere-selam and this creates conducive condition for the farmers to get market out let.

2.3. Farming system and Human settlement

The settlement of the farmers is mostly on the hilly sides of the areas which is less important for agriculture use. The farming system of the area is characterized by crop based livestock production, The tabia is mainly characterized by subsistence crop production. During the 'Belg' season, the rains are very rare, and farmers mostly use these rains for land preparation only. During 'Kiremti,' the main rainy season, farmers mostly grow cereal crops such as Teff, Maize, barley, Sorghum, and Pulse. The average land holding of the tabia is 0.55ha.

2.4. Climate

The rainfall data of the site is collected from Mekele Airport (AAAP) and this data shows that the mean annual rainfall of 38 years between (1980-2017G.C) is 542.7mm.Out of the total amount of 542.7 mm rainfall 77 %(418 mm) of the rain is received only in two months of the year (July and August).June and September

contribute 12% (64.6 mm) and the remaining eight months receive 11% (60.1mm) of the annual rainfall. Moreover the distribution of rainfall is not uniform throughout the season. The rainfall pattern shows that supplementary irrigation is required during the months of June, September and October in the wet season while the dry season crops (Dec. - May) crops should only be raised with full irrigation. The average mean annual temperature varies from 28.1^{0}c to 15.1 ^{0}c. The monthly maximum temperature reaches highest in June (30.9^{0}c) while the minimum temperature drops to its lowest in January (12.6 ^{0}c). Therefore, the temperature is suitable for growing variety of crops including cereals, vegetables, cash crops and fruit crops.

Table 1 Mean metrological data

Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	unit	Total
Rain mean	2.49	7.29	22.51	36.93	32.57	33.20	192.23	226.88	31.37	6.07	5.69	0.74	mm	542.7
Max.Tem.0c	26.9	28.1	29.0	29.6	30.5	30.9	27.2	26.4	28.1	27.2	26.7	26.3	oc	28.1
Min.temp.0c	12.6	13.6	14.8	15.8	17.2	17.0	16.5	16.5	15.5	14.7	13.7	12.7	oc	15.1
P.eff.	-8.5	-5.6	3.5	12.2	9.5	9.9	128.8	156.5	8.8	-6.4	-6.6	-9.6	mm	292.6
P.eff.Mod.	0.0	0.0	3.5	12.2	9.5	9.9	128.8	156.5	8.8	0.0	0.0	0.0	mm	329.2

Data taken from Mekele air port (AAAP) metrological station (NMA) while the temperature data is interpolated to Misrar-teli.

2.5. Frost hazard

There is a frost hazard in the area especially in the months of October, November, and December normally causes stress to frost sensitive crops in all growing stage particularly at seedling stage when they are on the field and nursery site.

2.6. Agro Climate

The climatic zone of the site is under /SM3/ which is Tepid Sub-moist mid-high land, since LGP is between 61-120 days and the average temperature is between 11^0**c** to 21^0**c** and the Elevation is also between 1600-2400masl. (source: Forestry, Land use and soil conservation Dep't MoANRD,July 2005 Addis Abeba.)

The total mean annual rainfall of the study area is 542.7 mm and the major crops growing in the area includes: Wheat, Barley, Teff, Maize, Sorghum, Millet, pulses ,vegetables and perennial crops.

2.7. Topography

The command area of this irrigation scheme is found downstream at the right sides of the river the gross total area of command area is 52.5ha. This command area is plain & undulating cultivated land and this Project area exhibited a slope range of nearly zero or flat in the lower and reaches up to 25% on the upper cultivable land.

Figure 1 Site map and slop rise of Misrarteli command area.

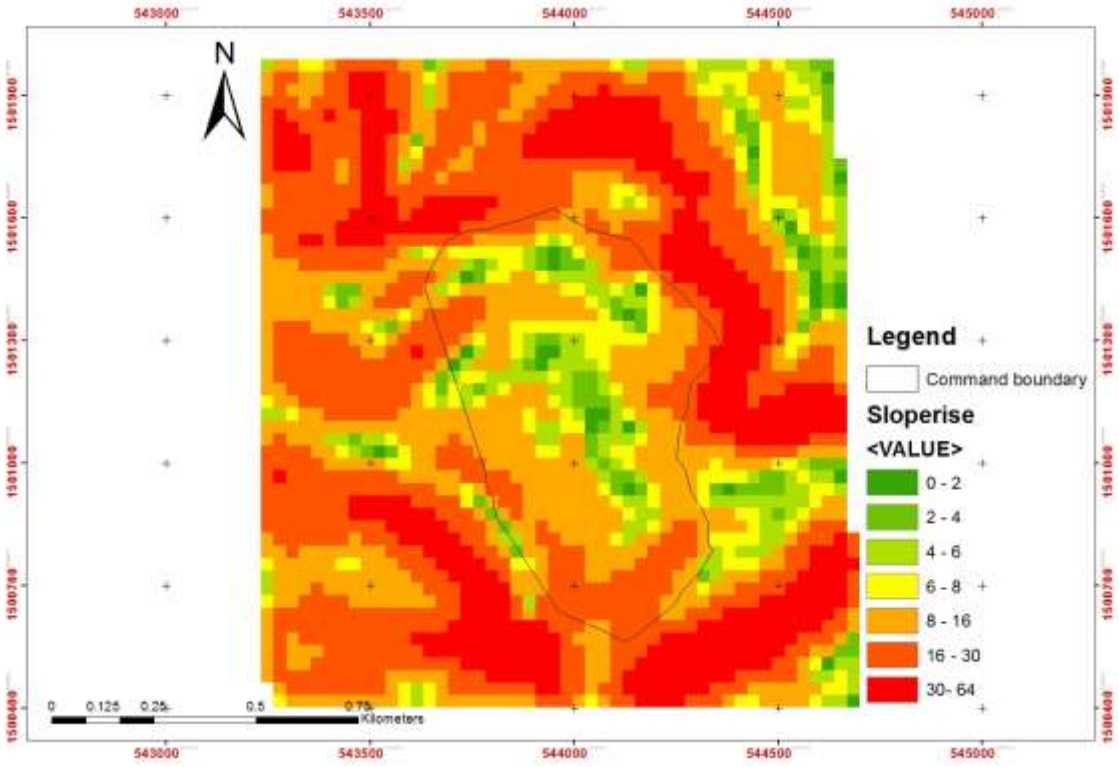

Table 2 Slope class of the command area.

S/nu.	Slope class	Slope range in percent	Area in ha	Coverage %
1	Flat or nearly level	0-2	1.6	3.2
2	Very gentle slopping very gentle undulating	2-4	3	6
3	Gentle slopping, Gentle undulating	4-6	6.8	13.6
4	Slopping undulating	6-8	7.3	14.6
5	Moderately steep	8-16	27.7	50.4
6	Very steep, hilly mountainous	16-30	6.1	12.2

from this slope gradient about 90.8% of the command area position is gentle sloping to very steep which is in class 3-6, therefore it needs applicable soil and water conservation measures, proper irrigation method and selection of alternative Agronomic management systems for the area.

3.0. Methods of Study

3.1. Agronomy

3.1.1. Interview

In agronomy interviews were made with the farmers who have land in the command area so that reliable information is obtained. In addition interviews were also made to (DAs), KI and farmers in the site.

3.1.2. Field observations

Observation were made in the study area to find out the existing crop production practices: like irrigation water management experience, crop protection measures and soil fertility management practices.

3.1.3. Literature Review

Several literatures were also reviewed to obtain additional information on different aspects of crop production such as input requirement, projected yields, disease and insect pest problems and their control measures along with soil data interpretation.

4.0. Soil

4.1. General Description of soil and land

Majority of the command area soil is deep reaches up to 150cm and these soils are sandy, Sandy loam, and clay which is deposited by water erosion and weathered rock transformation from upper part of the area. From field assessment the soil is light brown to in color.

The potential of command area with recommendable soil type is 52.5ha at river water base flow 100lt/sec.

Based on the assessment of topsoil texture, effective soil depth, topography, leveling requirement, stoniness, drainage conditions, rock out crop areas and slope majority of the command area is appropriate for irrigation purpose with some limitation on soil fertility, Effective soil depth and sheet erosion.

Thus, Soil management practices that improve soil fertility like addition of manure and artificial fertilizer, drainage systems with soil and water conservation measures are highly recommendable for the area to improve the existing productivity and sustainability of the land.

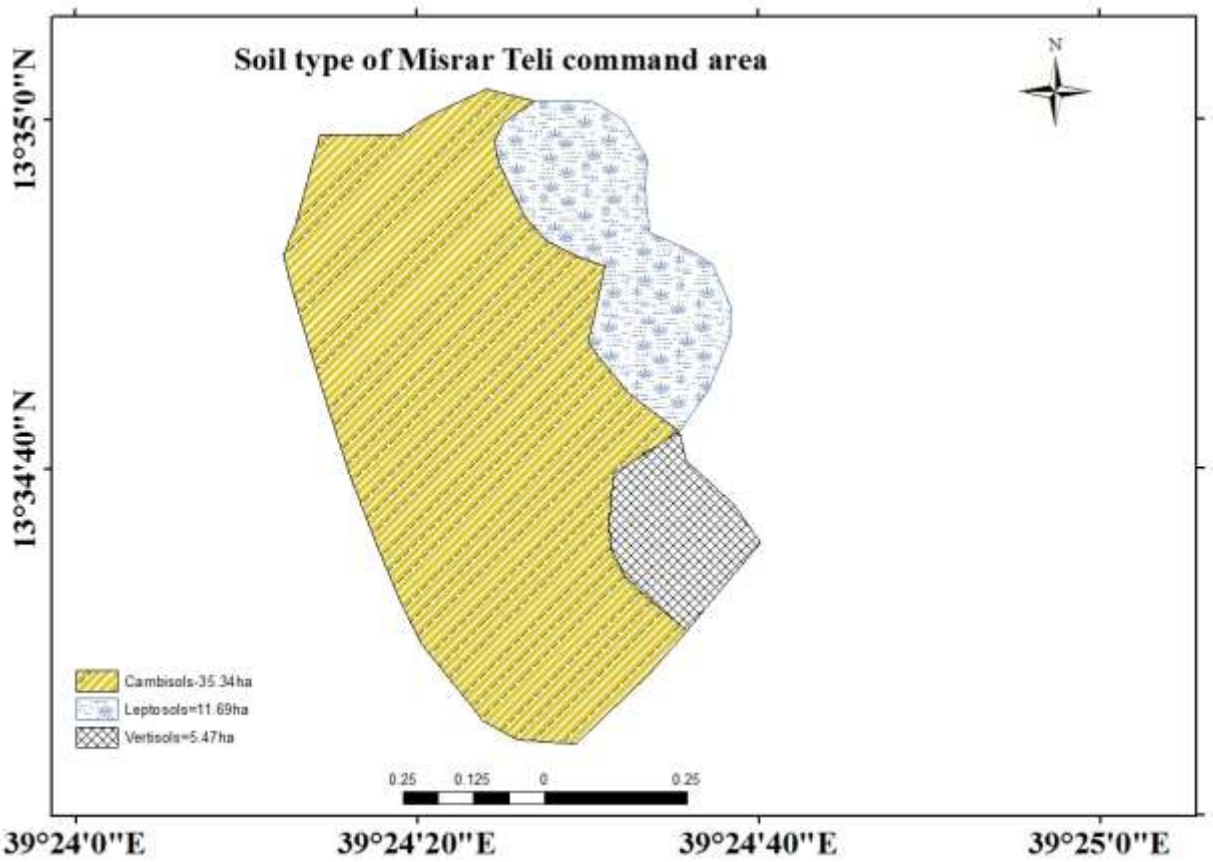

Figure 2 Map of soil mapping unit

4.2. Soil mapping units

4.2.1. General physical soil characteristics

The command area is divided in to three major soil map units mainly based on topography, depth, geology, structure, soil type and texture. The total command area surveyed is 52.5 hectare. (Refer for detail soil land unit map and classification of the command in figures, and maps on soil independent report.)

Table 3: Physical characteristics of the soil.

S/ nu.	Soil Map Unite	Soil type	Area (Ha.)	Depth (cm)	Textural class	Color (Dry)
1	EMGT01	Cambisols	35.34	0-150	Sandy loam	Dark yellowish brown
2	EMGT02	Leptosols	11.69	0-100	Loam	Light brown
3	EMGT03	Vertisols	5.47	0-150	Sandy loam	Very dark gray

Source: Soil report data for the specific Scheme.

Land unit with code EMGT01 (Cambisols) which Covers the largest part of the command with area coverage of about 67% of the total area. which is found on the upper parts of the command area. The surface texture of this land unit is sandy loam.

4.2.2. General Soil chemical properties

A. Soil reaction (pH)

The soil of the command area lay in pH ranges 7.18 - 8.32 which is high pH. The effect of soil pH is great on the solubility of minerals or nutrients. Before a nutrient can be used by plants it must be dissolved in the soil solution. Soils with a pH higher than 7.3 can cause some issues with phosphorus availability in the soil. When phosphorus fertilizer is applied to a high pH soil, a chemical reaction occurs between the phosphorus and the calcium carbonate in the soil. The result is some of the phosphorus forms compounds with calcium that are not very soluble. This reduces the amount of phosphorus the crop can get from the fertilizer applied. If we were able to lower the soil pH to less than 7.3 and neutralize all of the calcium carbonate, we would reduce the problem of phosphorus fertilizer being tied up in low solubility calcium compounds. Research April of 2005, AGVISE Laboratories established a long-term project to determine applying elemental sulfur and gypsum can lower soil pH. Thus,

micronutrient deficiency should be observed due to immobile in the presence of calcium (Alkali) therefore timely application blended fertilizer and monitoring is necessary for the field.

B. Electrical conductivity (EC)

The EC of the soil sample ranges between 0.04- 0.15 ds/m in all land units of the command area. This means that the soil of the command area is non-saline to a depth of 150cm that can not affect crop yields.

Table 4 Chemical characteristics of the soil.

S/ nu.	Soil Map Unite	Soil type	pH level		**Electric conductivity Ec (ds/m)**	
			Range	Rating	Range	Rating
1	EMGT01	Cambisols	8.32	High	0.05-0.15	Non saline
2	EMGT02	Regosols	7.2	High	0.05-0.13	Non saline
3	EMGT03	Vertisols	7.18-8.01	High	0.04	Non saline

Source: Adapted from Olsen and dean (1965) and Landon (1991).

5.0. Land evaluation

5.1. Land suitability for irrigation

The suitability of the land for surface irrigation is assessed with respect to soil texture, depth, slopes and topography, drainage, salinity, stoniness, and flood hazard. Land units with code (EMGT01, EMGP02, and EMGP03) is suitable for irrigation purpose without evident limitation to management practices.

5.2. Land suitability for crops

The suitability of the land for crop is assessed with respect to soil texture, depth, slopes and topography, drainage, salinity, stoniness, and flood hazard.

The command area is suitable for growing a variety of crops including cereals, pulses, vegetable crops and perennial crops with minor limitations. In Land unit (EMGT1, EMGT3) with total area of 41ha. is best suited for most of vegetable crops and perennial crops, but land unit (EMGT02)with area of 11.69 ha is not suited to perennial crops with apparent limitation on depth of the soil but for shallow rooted crops like cereals and vegetables can be appropriate.

6.0 Soil and land Management

6.1. Erosion

Sheet erosion and rill erosion are observed in all land units. Therefore, site specific soil and water conservation structures are essential to conserve and stabilize the command area.

6.2. Land preparation

In all land units the soil is hard when dry and friable when moist. The friability is an important quality of the soil since it makes easy during plowing and cultivation. Plowing and cultivation should be carried out when the soil is moist to reduce draft power requirement and to get fine, clod free field. The soil is suitable for plowing and cultivation if it is ploughed three to four days after irrigation or rainfall this gives a chance to release the seeds of weeds and to clean during plowing.

6.3. Drainage

Majority of the command area situated in sloppy area, so there will not be much problem of water logging during rainy season however; some pocket areas in the command need close supervision to construct drainage structures by simple agricultural implements like Broad Bed Maker (BBM).

6.4. Soil fertility

Soil fertility of the command is reduced in its fertility because it has been cultivated for decades without soil fertility management. Therefore, it is necessary to give emphasis to improve the soil fertility by different mechanisms such as use of farm yard manure, composting, green manuring and addition of sufficient dose of fertilizer by split application especially for the nitrogen containing fertilizer.

7.0. Selected crops and cropping pattern

7.1. Existing Cropping Pattern

Wheat, Barley, Sorghum, Maize, Teff, Millet, and pulses are some of the major crops grown in the area in (wet season) while Pepper, Tomato, Onion, Cabbage, Orange, Mango, Banana and Guava is well grown by traditional diversion in the area. Farmers sow Sorghum at the onset of rain mostly in the month of May and June. Maize, Faba bean, Millet, wheat, Barley and Teff are sown starting early June to mid of July. Sorghum is sown if the rain starts in May and early June, if not the land is shifted to other crops to be sown.

Harvesting is after five to six months for Sorghum, four to five months for the crops.

Agro-climatic zone of the area is favorable for growing different types of crops like cereals, pulses and Perennial crops. Thus, crops that can be grown in the project area can be listed as follows:

A. Cereals- Sorghum, Teff, Maize, Millet, Wheat, Barley
B. Pulses- Chick pea,
C. Vegetables-Pepper, Potato, Tomato, Onion, Cabbage, S.chard
D. Fruit crops-Mango, Avocado, Guava, Orange, Banana, Papaya

Table 5 Yield levels for major crops at existing condition for existing crops.

S.No	Crops	season	Coverage %	Seed Rate kg/h		Range Yield (Q/ha)		Average Yield Qt/ha
				Local	Improved	local	Improved + Fert.	
1	Barley	Wet	32	150	-	10-14	-	12
2	Wheat	Wet	30	120	100	8-12	22-28	10
3	Hanfetsi	Wet	15	150	-	8-10	-	8
4	Teff	Wet	10	30	25	4-6	6-8	5
5	Maize	Wet	6	30	25	12-16	16-20	15
6	Sorghum	Wet	4	10	-	14-18	-	16
7	Millet	Wet	2	8	-	8-10	-	8
8	F.Millet	Wet	1	9	-	6-8	-	6
9	Others	Wet	<1					

7.2 Crop selection criteria

Among the wide range of the optional crops which could be grown under the project area only limited crops are selected based on the following reasons:

- Adaptability to specific growing condition (better agro climatology suitability)
- Food habit of the people.
- Ease of crop husbandry practices required for each crops.
- The need to diversify the existing cropping system.
- Yield potential and food security program in the region
- Better market demands and shelf life of the crops.

8.0 Proposed cropping pattern

The farmers produce food grains once a year using the winter rainfall. They have traditional experience in utilizing the available perennial river for vegetable crops and other income generating crops during dry season in the area.

However, under project condition, new cropping pattern is proposed both for Dry season and Wet season conditions because of the following reasons:

- Quantity of selected crops for each growing system
- Food habit of the people
- The need to achieve food security
- Market demand and market prices
- Storage requirement and shelf life of the selected crops.

Table 6 Proposed cropping pattern

S.Nu.	Crops/ season	Percent	Sowing/ Transplanting date	Harvesting date	Growing Period (days)
I	**Dry season**				
1	Mango	0.15	Early Dec.	Perennial	-
2	Banana	0.15	Early Dec.	Perennial	-
3	Pepper	0.20	Early Dec	Early- May	160
4	Onion	0.20	Early Dec.	Late-April	150
5	Potato	0.10	Early Dec	Early-April	130
6	Cabbage	0.10	Early Dec	Early-April	130
7	Tomato	0.10	Early Dec	Mid-April	140
II	**Wet season**				
1	Mango	0.15	-	Perennial	
2	Banana	0.15	-	Perennial	
3	Wheat	0.25	Early June	Mid-Oct.	140
4	Barley	0.2	Early June	Mid-Oct.	140
5	Sorghum	0.15	Early June	Late-Oct.	150
3	Teff	0.10	Early July	Early-Nov.	130

8.1. Potential Varieties for the cropping and Crop protection.

Increasing in productivity is a function of different factors such as improved varieties, fertilization, efficient irrigation use, crop protection etc.

Therefore, the use of improved varieties should be given priority in the implementation of the new project. The following are some of the varieties that could be used in the project area.

Table 7 Potential varieties for the command area.

S.No	Crop	Varieties
1	Onion	Adama-Red,Red criole,Melkam,Bombea-red,Mermru brown
2	Pepper	Bako local,Mareko Fana,Melkazala,Bakolocal,Melka-Dima
3	Tomato	Marglobe, Roma V.F, Melkashola,Heanz-1350, Fetan
4	Potato	AAL 624, Awash,Tolcha, Wchecha.
5	Sorghum	Birmash,P9403Abshir,Dinkmash80,76t1nu.23,Seredo, 76-t-23
6	Teff	DZCr-37,DZ974(Dukem), D-Z01.358,Dz01-2053
7	Wheat	HAR1685, HAR2501,HAR2508,HAR1920,HAR1868
8	Barley	HB1307,IARH 485, AHOR 880/61, HB 42

Source: BAoNR 2003, Ethiopian Improved Seed Enterprise Crop Varieties. June 1993 EC Addis abeba

8.2. Integrated pest management

In areas developing under irrigation, weeds are very problematic due to the availability of enough moisture. Unless they are weeded timely, the weeds will cause severe yield loss. Therefore, due attention should be given to control weeds. Most weeds growing in the study area can be controlled by frequent plowing, using clean seeds, timely and frequent hand weeding and maintaining soil fertility by applying well decomposed manure and compost.

Insect pests and diseases are also very problematic in irrigated area. Especially if there is no crop rotation, diseases and insect pests will build up through time and

will cause significant yield loss. The best method to control pests is applying integrated pest management system. This system integrates all control methods aimed at minimizing pest damages and gives priority to non-chemical control methods such as using resistant varieties, crop rotation, field sanitation, using disease free seed and plants, optimum plant spacing, adjusting sowing times, and providing optimum growing condition for the crops. Chemicals are used if there are no other control possibilities.

Table 8 Potential insect pests of the command

S/nu	Crop	Pests	Chemical	Chemical dose	Mechanism of usage	Cultural protection
1	Onion/Potato/Cabbage	Onion thrips	Karate5%EC Dimethioate 40%	0.4 lt/ha 1 lt/ha	Spraying Spraying	Crop rotation, sowing tolerant crops, sanitation, deep ploughing,weeding
		Cut worm	Dursban48 %EC Diazinon60 %EC	3 lt/ha 3 lt/ha	Spraying Spraying	Crop rotation, sowing tolerant crops, sanitation, deep ploughing,weeding
		Aphids	Karate5%EC Dimethioate 40%	0.4 lt/ha 1 lt/ha	Spraying Spraying	Crop rotation, sowing tolerant crops, sanitation, deep ploughing,weeding
2	Pepper	Aphids	Karate5%EC Dimethioate 40%	0.4 lt/ha 1 lt/ha	Spraying Spraying	Crop rotation, sowing tolerant crops, sanitation, deep ploughing,weeding
		Bollworm	Diaznon 60%EC Karate5%EC	2.5 lt/ha 0.4 lt/ha	Spraying Spraying	After harvest immediate & deep ploughing, crop rotation, sanitation, sowing at a time
		Cut worm	Dursban48 %EC Diazinon60 %EC	3 lt/ha 3 lt/ha	Spraying Spraying	Crop rotation, sowing tolerant crops, sanitation, deep ploughing,weeding
3	Tomato	Bollworm	Diaznon 60%EC	2.5 lt/ha 0.4 lt/ha	Spraying Spraying	After harvest immediate & deep ploughing, crop

S/nu	Crop	Pests	Chemical	Chemical dose	Mechanism of usage	Cultural protection
			Karate5%EC			rotation, sanitation &burning of residual, sowing at a time
		Whitefly & Aphids	Krate5%EC Diazinon60%EC	0.4lt/ha 2lt/ha	Spraying Spraying	After harvest immediate & deep ploughing, crop rotation, sanitation &burning of residual,
		Blister &Pollen beetles	Malathion 50%EC Fenithrothion 50%EC	2 lt/ha 1.5lt/ha	Spraying Spraying	After harvest immediate & deep ploughing, crop rotation, sanitation, sowing at a time
		Grasshopper	Carbaryl 85%WP Malathio50%EC	1.5 lt/ha 2lt/ha	Spraying Spraying	Deep &frequently ploughing, Crop rotation, sowing at a time.
6	Wheat	Grasshopper	Carbaryl 85%WP Malathio50%EC	1.5 lt/ha 2lt/ha	Spraying Spraying	Deep &frequently ploughing, Crop rotation, sowing at a time.
		Cut worm Cricket	Diazinon50%EC Indosulfen35%EC	2. 5 lt/ha 2 lt/ha	Spraying Spraying	After harvest immediate collection of yield and destroying of moulds sowing vetiver grass
7	Barley	Cut worm Cricket	Diazinon50%EC Indosulfen35%EC	2. 5 lt/ha 2 lt/ha	Spraying Spraying	After harvest immediate collection of yield and destroying of moulds sowing vetiver grass
		Grasshopper	Carbaryl 85%WP Malathio50%EC	1.5 lt/ha 2lt/ha	Spraying Spraying	Deep &frequently ploughing, Crop rotation, sowing at a time.
8	Sorghum	Stolkborer	Karate5%EC Cypermetrine1% Gr.	0.4lt/ha 3kg/ha	Spraying Granule	Collect and burn infected after math, Deep &frequent ploughing.
		Blister &Pollen beetles	Malathion 50%EC Fenithrothion 50%EC	2 lt/ha 1.5lt/ha	Spraying Spraying	After harvest immediate & deep ploughing, crop rotation, sanitation, sowing at a time
9	Teff	Shoot fly	Trichlorofo95%SP	1kg/ha 1.5lt/ha	Spraying Spraying	Deep &frequently ploughing, Crop

S/nu	Crop	Pests	Chemical	Chemical dose	Mechanism of usage	Cultural protection
			Fenith.50%EC			rotation, sowing at a time.
		Grasshopper	Carbaryl 85%WP Malathio50 %EC	1.5 lt/ha 2lt/ha	Spraying Spraying	Deep &frequently ploughing, Crop rotation, sowing at a time.

Source: BAoNR, Potential insect pests, weeds and Disease protection manual 1989, Mekelle, Tigray.

Table 9 Potential Diseases and controlling measures of the command

S/nu	Crop	Disease	Chemical	Chemical dose	Mechanism of usage	Cultural protection
1	Onion/Potato/ Cabbage	Root & bulb rot /Mujele/	Benamol Vencalozine Dichlorine	- - -	Seed dressing or soil treatment	Sanitation, Crop rotation, Select tolerant varieties, rotation Determine seed rate etc.
		Root rot /Sur abesbis/	Tihram Bnomil Capton	250Gr./Qu. - -	Seed Dressing or Spraying/ soil treatment/	Early plowing Sowing tolerant vari.
		Rust /Himodya/	Metalaxyl Mancozeb Apron star	3 kg/ha 3 kg/ha 250 gr./qt	Spraying Spraying Dressing	Crop rotation, seeds dipping in cattle urine
2	Pepper	Root rot	Tihram Bnomil Capton	250Gr./Qu. - 3-4kg/ha	Seed dressing - Spraying	Early plowing Sowing tolerant vari.
3	Tomato	Powdery mildew	Bileton 250 EC Bileton250%wp	0.4lt/ha 0.5kg/ha	Seed dressing spraying	Early plowing Sowing tolerant vari.
		Late Blight	Metalaxyl Mancozeb Kisayd 101 wp	3kg/ha 3kg/ha 4. 5kg/ha	Spraying in 7-10 days interval Spraying	Sanitation,weeding,determining seed rate,tolerant varieties
4	Milllet	Smut	Venesit Fernasen-D Carboxyl		Seed dressing Seed dressing Seed dressing	Crop rotation,seeds dipping in cattle urine

5	Wheat/Barley	Smut	Venesit Fernasen-D Carboxyl		Seed dressing Seed dressing Seed dressing	Crop rotation,seeds dipping in cattle urine
		Rust	Manieb /Mancozeb/	20Gr.diluted in 10 lt. of H_20	Spraying in 7-10 days interval	Sanitation,weeding,determining seed rate,tolerant varieties
		Sorghum downy mildew/Shamla/	Tiram,Bnomil, Capton	250Gr./Qu.	Seed dressing	Sowing clean seed,Rougout infected ones,Rsistantvarites
6	Teff	Rust	Manieb /Mancozeb/	20Gr.diluted in 10 lt. of H_20	Spraying in 7-10 days interval	Sanitation,weeding,determining seed rate,tolerant varieties

Source: BAoNR, Potential insect pests, weeds and Disease protection manual 1989, Mekelle, Tigray.

Table 10 Controlling measures on potential weeds of the command

S/nu	Crop	Frequency of weeding	Time of weeding		Recommended Herbicides	Herbicide dose	Cultural protection
			1st	2nd			
1	Onion	2- Times HW Shallow cultiv.	21-30 days	35-40 days	2,4-D for broad leaf weeds.	1.0-1.5lt/ha	Early &deep plowing, Sanitation
2	Pepper	2-Times HW Shallow Cul.	21-30 days	35-40 days	2,4-D for broad leaf weeds.	1.0-1.5lt/ha	Early &deep plowing, Sanitation
3	Tomato	2- Times HW Shallow cultiv.	21-30 days	35-40 days	2,4-D for broad leaf weeds.	1.0-1.5lt/ha	Early &deep plowing, Sanitation
4	Potato	2- Times HW Shallow cultiv.	30-35 days	55-60 days	2,4-D at the stage of 2-3 leaf emergency for broad leaf weeds.	1.0-1.5lt/ha	Early &deep plowing, Sanitation
5	Cabbage	2-Times HW	15-30 days	45-50 days	Fusilade super12%&25EC	3 lt/ha Spraying	Early &deep plowing, Sanitation
6	Wheat/Barley	2- Times HW	21-30 days	35-40 days	2,4-D at the stage of 2-3 leaf emergency for broad leaf weeds.	1.0-1.5lt/ha	Early &deep plowing, resistant var. Sanitation

7	Teff	3- Times HW	21-30 days	35-40 days	2,4-D for broad leaf weeds.	1.0-1.5lt/ha	Early &deep plowing, Sanitation
8	Mango	2- Times HW Shallow cultiv.	As necessary	As necessary	-	-	-
9	Banana	2- Times HW Shallow cultiv.	As necessary	As necessary	-	-	-

Source: BAoNR, Potential insect pests, weeds and Disease protection manual 1989, Mekelle, Tigray.

9.0 Crop Water requirement

9.1. Reference Evapotranspiration (ET_0)

Reference Evapo-transpiration is calculated using Hargreaves's method. The formula could be given as follows:

ETo = 0.0023*Ra* Td*(TA+17.8)

Where Ra = Extraterrestrial radiation in equivalent evaporation in mm/day

Td= temperature difference (Tmax-Tmin) in ^{o}c.

Ta= Average temperature (Tmax+ Tmin)/2 in^{o}c.

9.2. Effective rainfall is calculated (Peff)

Effective rainfall is calculated using the empirical formula dependable rain method. i.e.

P_{eff} = 0.8P-25 Where P>75mm/month.

P_{eff} =0.6P-10 P<75mm/month.

Site name=	Msrarteli_Diversion	
Net water storage=	14,641.93	M^3

Table 11 Meteorological datas

Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	unit	Total
Rain mean	2.5	7.3	22.5	36.9	32.6	33.2	192.2	226.9	31.4	6.1	5.7	0.7	mm	542.7
Max.Tem.0c	26.0	27.2	28.1	28.7	29.6	30.1	26.3	27.2	27.2	26.3	25.8	25.4	oc	27.3
Min.temp.0c	11.8	12.8	14.3	15.7	16.3	16.1	15.6	15.6	14.6	13.8	12.8	11.8	oc	14.3
P.eff.	-8.5	-5.6	3.5	12.2	9.5	9.9	128.8	156.5	8.8	-6.4	-6.6	-9.6	mm	292.6
P.eff.Mod.	0.0	0.0	3.5	12.2	9.5	9.9	128.8	156.5	8.8	0.0	0.0	0.0	mm	329.2

Table 12 Eto. Computation

Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Unit	Total
Ra	12.40	13.60	14.90	15.70	15.80	15.70	15.70	15.70	15.10	14.10	12.80	12.00	mm/day	14.5
TD	14.20	14.40	13.80	13.00	13.30	14.00	10.70	11.60	12.60	12.50	13.00	13.60	oc	13.1
TA	18.90	20.00	21.20	22.20	22.95	23.10	20.95	21.40	20.90	20.05	19.30	18.60	oc	20.8
Eto.	3.94	4.49	4.96	5.21	5.40	5.53	4.58	4.82	4.77	4.34	3.94	3.70	mm/day	4.64

Table 13 Decadal values

month		Jan			feb			mar			Apr			May			June	
Decade	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3
Eto.	3.82	3.93	4.08	4.32	4.49	4.66	4.84	4.97	5.08	5.13	5.21	5.28	5.35	5.40	5.45	5.64	5.57	5.37
P.eff.	0.00	0.00	0.00	-0.17	-0.04	0.22	0.53	1.11	1.88	3.65	4.19	4.32	3.32	3.14	3.08	-2.59	1.84	10.66
P.eff.mod.	0.00	0.00	0.00	0.00	0.00	0.22	0.53	1.11	1.88	3.65	4.19	4.32	3.32	3.14	3.08	0.00	1.84	10.66

	July			Aug			Sep			Oct			Nov			Dec		
D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3
4.72	4.53	4.48	4.78	4.83	4.85	4.84	4.79	4.68	4.48	4.34	4.20	4.05	3.93	3.84	3.71	3.69	3.71
34.22	44.05	50.51	57.75	54.33	44.42	12.49	1.23	-4.90	0.54	-0.11	-0.44	0.00	0.00	0.00	0.00	0.00	0.00
34.22	44.05	50.51	57.75	54.33	44.42	12.49	1.23	0.00	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Eto	Jan	Feb	Mar.	Apr.	May	Jun.	Jul.	Agu.	Sep.	Oct.	Nov.	Dec.	Unit
100%	3.94	4.49	4.96	5.21	5.40	5.53	4.58	4.82	4.77	4.34	3.94	3.70	mm/day
50%	2.0	2.2	2.5	2.6	2.7	2.8	2.3	2.4	2.4	2.2	2.0	1.9	mm/day
30%	1.18	1.35	1.49	1.56	1.62	1.66	1.37	1.45	1.43	1.30	1.18	1.11	mm/day
10%	0.39	0.45	0.50	0.52	0.54	0.55	0.46	0.48	0.48	0.43	0.39	0.37	mm/day
Rain fall	0.1	0.2	0.8	1.2	1.1	1.1	6.4	7.6	1.0	0.2	0.2	0.0	mm

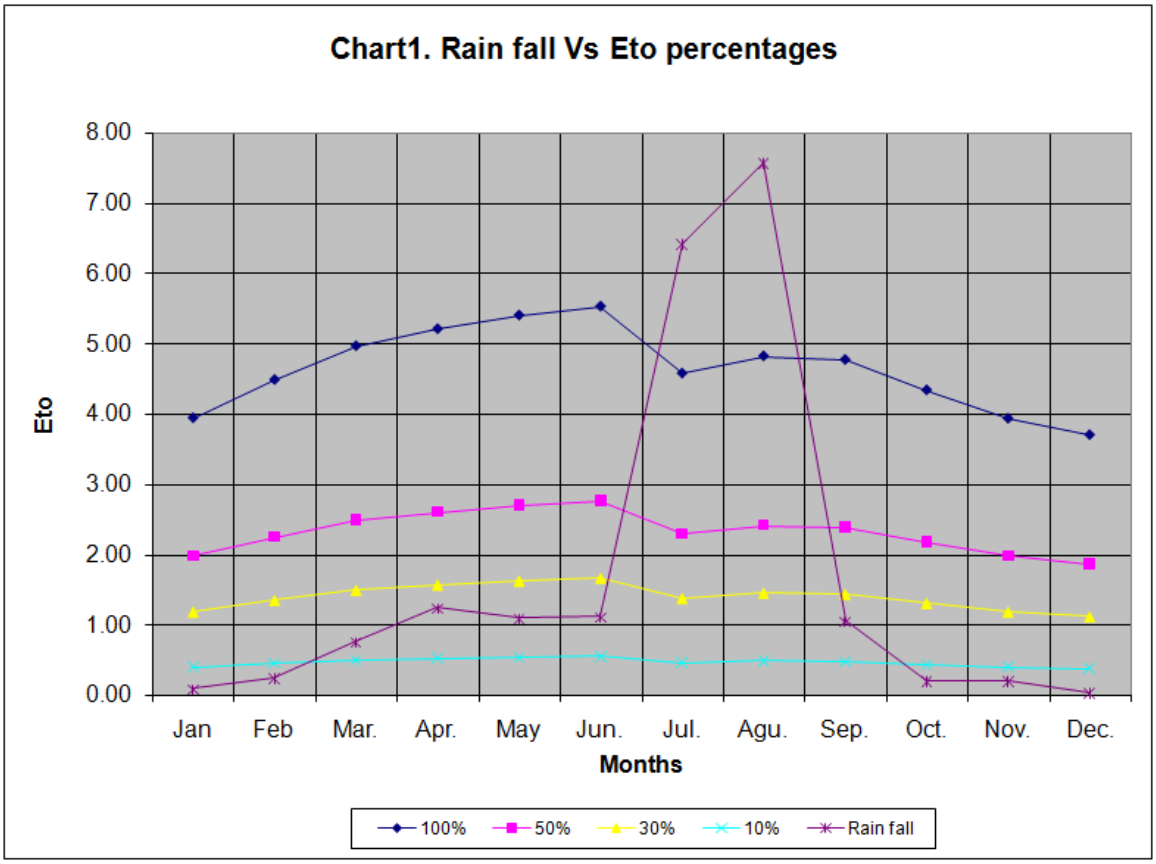

Figure 3 Rain fall verses ETo percentage graph

Table 14 Dry season irrigation crop water requirement

Table Dry season irrigation crop water requirement

Month			December			January			February			March			April			May		
Dec.			D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3
	Eto.		3.7	3.7	3.7	3.8	3.9	4.1	4.3	4.5	4.7	4.8	5.0	5.1	5.1	5.2	5.3	5.3	5.4	5.5
Crop	P.eff.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.4	0.4	0.4	0.3	0.3	0.3
1		kc	0.85	0.85	0.85	1.00	1.00	1.00	1.10	1.10	1.10	1.10	1.10	1.10	0.90	0.90	0.90	0.80	0.80	0.80
area	0.15	Etc	3.2	3.1	3.2	3.8	3.9	4.1	4.7	4.9	5.1	5.3	5.5	5.6	4.6	4.7	4.8	4.3	4.3	4.4
0.15	total	lc.	3.2	3.1	3.2	3.8	3.9	4.1	4.7	4.9	5.1	5.3	5.4	5.4	4.3	4.3	4.3	3.9	4.0	4.1
	770	irr.area	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Mango		lc.Ac.	0.5	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.8	0.6	0.6	0.6	0.6	0.6	0.6
Monthly H2o Demand		(m^3)	141.7			177.5			221.8			240.5			192.7			180.1		
2		kc	0.85	0.85	0.85	1.00	1.00	1.00	1.10	1.10	1.10	1.10	1.10	1.10	0.90	0.90	0.90	0.80	0.80	0.80
area	0.15	Etc	3.2	3.1	3.2	3.8	3.9	4.1	4.7	4.9	5.1	5.3	5.5	5.6	4.6	4.7	4.8	4.3	4.3	4.4
0.15	total	lc.	3.2	3.1	3.2	3.8	3.9	4.1	4.7	4.9	5.1	5.3	5.4	5.4	4.3	4.3	4.3	3.9	4.0	4.1
	770	irr.area	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Banana		lc.Ac.	0.5	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.8	0.6	0.6	0.6	0.6	0.6	0.6
Monthly H2o Demand		(m3)	141.7			177.5			221.8			240.5			192.7			180.1		
3		kc	0.40	0.40	0.40	0.48	0.65	0.84	1.02	1.02	1.10	1.10	1.10	1.10	1.10	1.02	1.02	0.80	0.80	0.00
area	0.2	Etc	1.5	1.5	1.5	1.8	2.6	3.4	4.4	4.6	5.1	5.3	5.5	5.6	5.6	5.3	5.4	4.3	4.3	0.0
0.20	total	lc.	1.5	1.5	1.5	1.8	2.6	3.4	4.4	4.6	5.1	5.3	5.4	5.4	5.3	4.9	5.0	3.9	4.0	0.0
	655	irr.area	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.0
Pepper		lc.Ac.	0.3	0.3	0.3	0.4	0.5	0.7	0.9	0.9	1.0	1.1	1.1	1.1	1.1	1.0	1.0	0.8	0.8	0.0
Monthly H2o Demand		(m3)	88.9			156.3			281.6			320.7			302.6			159.1		
4		kc	0.40	0.40	0.40	0.49	0.67	0.85	1.02	1.02	1.10	1.10	1.10	1.10	1.10	1.04	0.91	0.00	0.00	0.00
area	0.2	Etc	1.5	1.5	1.5	1.9	2.6	3.5	4.4	4.6	5.1	5.3	5.5	5.6	5.6	5.4	4.8	0.0	0.0	0.0
0.20	total	lc.	1.5	1.5	1.5	1.9	2.6	3.5	4.4	4.6	5.1	5.3	5.4	5.4	5.3	5.0	4.4	0.0	0.0	0.0
	571.89	irr.area	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.0	0.0	0.0
Onion		lc.Ac.	0.3	0.3	0.3	0.4	0.5	0.7	0.9	0.9	1.0	1.1	1.1	1.1	1.1	1.0	0.9	0.0	0.0	0.0
Monthly H2o Demand		(m^3)	88.9			159.5			281.6			320.7			293.1			0.0		
5		kc	0.45	0.45	0.57	0.69	0.75	1.05	1.05	1.05	1.05	1.05	1.00	0.90	0.90	0.00	0.00	0.00	0.00	0.00
area	0.1	Etc	1.7	1.7	2.1	2.6	2.9	4.3	4.5	4.7	4.9	5.1	5.0	4.6	4.6	0.0	0.0	0.0	0.0	0.0
0.10	total	lc.	1.7	1.7	2.1	2.6	2.9	4.3	4.5	4.7	4.9	5.0	4.9	4.4	4.3	0.0	0.0	0.0	0.0	0.0
	479.63	irr.area	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Cabbage		lc.Ac.	0.2	0.2	0.2	0.3	0.3	0.4	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.0	0.0	0.0	0.0	0.0
Monthly H2o Demand		(m^3)	54.5			98.7			141.1			142.8			42.6			0.0		
6		kc	0.45	0.45	0.45	0.62	0.79	0.97	1.14	1.15	1.15	1.15	1.15	1.01	0.87	0.80	0.00	0.00	0.00	0.00
area	0.1	Etc	1.7	1.7	1.7	2.4	3.1	4.0	4.9	5.2	5.4	5.6	5.7	5.1	4.5	4.2	0.0	0.0	0.0	0.0
0.10	total	lc.	1.7	1.7	1.7	2.4	3.1	4.0	4.9	5.2	5.3	5.5	5.6	4.9	4.1	3.7	0.0	0.0	0.0	0.0
	537.67	irr.area	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Tomato		lc.Ac.	0.2	0.2	0.2	0.2	0.3	0.4	0.5	0.5	0.5	0.6	0.6	0.5	0.4	0.4	0.0	0.0	0.0	0.0
Monthly H2o Demand		(m^3)	50.0			94.3			154.1			160.7			78.5			0.0		
7		kc	0.40	0.40	0.52	0.79	0.98	1.10	1.10	1.10	1.10	1.10	1.02	0.84	0.60	0.00	0.00	0.00	0.00	0.00
area	0.10	Etc	1.5	1.5	1.9	3.0	3.9	4.5	4.7	4.9	5.1	5.3	5.1	4.3	3.1	0.0	0.0	0.0	0.0	0.0
0.10	total	lc.	1.5	1.5	1.9	3.0	3.9	4.5	4.7	4.9	5.1	5.3	5.0	4.1	2.7	0.0	0.0	0.0	0.0	0.0
	480.67	irr.area	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Potato		lc.Ac.	0.1	0.1	0.2	0.3	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.4	0.3	0.0	0.0	0.0	0.0	0.0
Monthly H2o Demand		(m^3)	48.9			113.6			147.8			143.1			27.2			0.0		
Total command Area(ha)	1.0																			
NIR(mm/day)			2.0	2.0	2.1	2.7	3.2	3.9	4.6	4.8	5.1	5.3	5.3	5.1	4.5	3.6	3.2	2.0	2.0	1.2
NIR(Lt./se./ha)			0.2	0.2	0.2	0.3	0.4	0.4	0.5	0.6	0.6	0.6	0.6	0.6	0.5	0.4	0.4	0.2	0.2	0.1
Project. Efficiency(%)	0.60																			
Total Irr.Req.(lt./sec/ha)			0.4	0.4	0.4	0.5	0.6	0.7	0.9	0.9	1.0	1.0	1.0	1.0	0.9	0.7	0.6	0.4	0.4	0.2
Net Irr. Area(hectare)			1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.8	0.7	0.5	0.5	0.3
Proj.supply Requirement			0.4	0.4	0.4	0.5	0.6	0.7	0.9	0.9	1.0	1.0	1.0	1.0	0.9	0.6	0.4	0.2	0.2	0.1
Ratio of Hrs of operation	0.54																			
Actual proj.sup.requirement			0.7	0.7	0.8	1.0	1.1	1.4	1.6	1.7	1.8	1.9	1.9	1.8	1.6	1.0	0.8	0.4	0.4	0.1
Duity(litre/sec/hectare)			0.7	0.7	0.8	1.0	1.1	1.4	1.6	1.7	1.8	1.9	1.9	1.8	1.6	1.0	0.8	0.4	0.4	0.1
Max.duity for dry seas. (lt/sec/ha)	1.9																			
Seas.Month.H2o Demand(m^3/month)			614.67			977.44			1,449.88			1,568.96			1,129.30			519.26		
Dry Seasonal H2o Demand(m^3/growing season)			6,259.5																	

Table 15 Supplementary irrigation crop water requirement

Table Supplementary irrigation crop water requirement

Month			June			July			August			September			October			November		
Dec.			D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3
	Eto.		5.6	5.6	5.4	4.7	4.5	4.5	4.8	4.8	4.8	4.8	4.8	4.7	4.5	4.3	4.2	4.0	3.9	3.8
Crop	P.eff.		0.0	0.2	1.1	3.4	4.4	5.1	5.8	5.4	4.4	1.2	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0
1		kc	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.60	0.60	0.60
area	0.15	Etc	3.1	3.1	3.0	2.6	2.5	2.5	2.6	2.7	2.7	2.7	2.6	2.6	2.5	2.4	2.3	2.4	2.4	2.3
0.15	total	lc.	3.1	2.9	1.9	0.0	0.0	0.0	0.0	0.0	0.0	1.4	2.5	2.6	2.4	2.4	2.3	2.4	2.4	2.3
		irr.area	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Mango	285.62	lc.Ac.	0.5	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.4	0.4	0.4	0.3	0.4	0.4	0.3
Monthly H2o Demand		(m^2)	118.0			0.0			0.0			97.5			106.6			106.3		
2		kc	0.40	0.40	0.40	0.40	0.40	0.40	0.45	0.45	0.45	0.50	0.50	0.50	0.60	0.60	0.60	0.70	0.70	0.70
area	0.15	Etc	2.3	2.2	2.1	1.9	1.8	1.8	2.2	2.2	2.2	2.4	2.4	2.3	2.7	2.6	2.5	2.8	2.8	2.7
0.15	total	lc.	2.3	2.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	1.2	2.3	2.3	2.6	2.6	2.5	2.8	2.8	2.7
		irr.area	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Banana	271.92	lc.Ac.	0.3	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Monthly H2o Demand		(m3)	80.7			0.0			0.0			86.8			116.4			124.0		
3		kc	0.35	0.35	0.35	0.35	0.39	0.69	1.03	1.20	1.20	1.20	1.14	0.73	0.37	0.37	0.00	0.00	0.00	0.00
area	0.25	Etc	2.0	1.9	1.9	1.7	1.8	3.1	4.9	5.8	5.8	5.8	5.5	3.4	1.7	1.6	0.0	0.0	0.0	0.0
0.25	total	lc.	2.0	1.8	0.8	0.0	0.0	0.0	0.0	0.4	1.4	4.6	5.3	3.4	1.6	1.6	0.0	0.0	0.0	0.0
		irr.area	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0
Wheat	227.92	lc.Ac.	0.5	0.4	0.2	0.0	0.0	0.0	0.0	0.1	0.3	1.1	1.3	0.9	0.4	0.4	0.0	0.0	0.0	0.0
Monthly H2o Demand		(m3)	113.8			0.0			43.5			332.4			80.1			0.0		
4		kc	0.35	0.35	0.44	0.61	0.79	0.96	1.05	1.05	1.05	1.00	0.85	0.68	0.68	0.37	0.00	0.00	0.00	0.00
area	0.2	Etc	2.0	1.9	2.4	2.9	3.6	4.3	5.0	5.1	5.1	4.8	4.1	3.2	3.0	1.6	0.0	0.0	0.0	0.0
0.20	total	lc.	2.0	1.8	1.3	0.0	0.0	0.0	0.0	0.0	0.6	3.6	3.9	3.2	3.0	1.6	0.0	0.0	0.0	0.0
		irr.area	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0
Barley	210.04	lc.Ac.	0.4	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.1	0.7	0.8	0.6	0.6	0.3	0.0	0.0	0.0	0.0
Monthly H2o Demand		(m^2)	100.7			0.0			13.0			214.5			91.9			0.0		
5		kc	0.40	0.35	0.35	0.47	0.70	0.93	1.12	1.15	1.15	1.15	1.15	1.05	0.85	0.65	0.35	0.00	0.00	0.00
area	0.15	Etc	2.3	1.3	1.3	1.8	2.7	3.8	4.8	5.2	5.4	5.6	5.7	5.3	4.4	3.4	1.8	0.0	0.0	0.0
0.15	total	lc.	2.3	1.1	0.2	0.0	0.0	0.0	0.0	0.0	0.9	4.3	5.6	5.3	4.3	3.4	1.8	0.0	0.0	0.0
		irr.area	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.0	0.0	0.0
Sorghum	293.03	lc.Ac.	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.6	0.8	0.8	0.6	0.5	0.3	0.0	0.0	0.0
Monthly H2o Demand		(m^3)	54.0			0.0			13.7			228.7			143.2			0.0		
6		kc	0.00	0.00	0.00	0.40	0.40	0.51	0.73	0.94	1.05	1.05	1.05	1.05	0.96	0.77	0.59	0.40	0.00	0.00
area	0.1	Etc	0.0	0.0	0.0	1.9	1.8	2.3	3.5	4.5	5.1	5.1	5.0	4.9	4.3	3.3	2.5	1.6	0.0	0.0
0.10	total	lc.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	3.8	4.9	4.9	4.2	3.3	2.5	1.6	0.0	0.0
		irr.area	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
Teff	259.89	lc.Ac.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.5	0.5	0.4	0.3	0.2	0.2	0.0	0.0
Monthly H2o Demand		(m^3)	0.0			0.0			6.5			136.6			100.7			16.2		
7		kc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
area	0	Etc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.00	total	lc.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		irr.area	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.00	lc.Ac.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Monthly H2o Demand		(m^3)	0.0			0.0			0.0			0.0			0.0			0.0		
NIR(mm/day)			2.0	1.7	0.9	0.0	0.0	0.0	0.0	0.1	0.7	3.3	4.2	3.5	2.8	2.3	1.2	1.0	0.8	0.7
NIR(Lt./se./ha)			0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.5	0.4	0.3	0.3	0.1	0.1	0.1	0.1
Total Irr.Req.(lt./sec/ha)			0.4	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.1	0.6	0.8	0.7	0.5	0.4	0.2	0.2	0.1	0.1
Net Irr. Area(hectare)			0.9	0.9	0.9	0.0	0.0	0.0	0.0	0.3	0.7	1.0	1.0	1.0	1.0	1.0	0.6	0.4	0.3	0.3
Proj.supply Requirment(lt/sec)			0.4	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.1	0.6	0.8	0.7	0.5	0.4	0.1	0.1	0.0	0.0
Actual proj.sup.requirement(lt/sec)			0.7	0.5	0.3	0.0	0.0	0.0	0.0	0.0	0.2	1.2	1.5	1.3	1.0	0.8	0.2	0.1	0.1	0.1
Duity(litre/sec/hectare)			0.65	0.55	0.30	0.00	0.00	0.00	0.00	0.01	0.17	1.17	1.49	1.26	1.01	0.83	0.25	0.14	0.08	0.08
Max.duity for wet seas.(lt/sec/ha)			1.5																	
Seas.Month.H2o Demand(m^3/month)			467.2			0.0			76.6			1,096.47			638.79			246.57		
Maximum duity for design (lt/sec/ha)			1.9																	
Wet Season H_2O Demand(M^3/wet season)					2,525.6															
Total Seasonal H2o Demand(m^3/growing season)						8,785.16														

Table 16 Volume of water required per crop per hectare

		Dry Season Irrigation				Supplementary Irrigation		
S.no	Crop	Area (ha)	Growth Period (days)	Water req. (mm)	Water Req M3	Area (ha)	Water req. (mm)	Water Req M3
1	Mango	0.15	Perennial	769.51	1154.27			
2	Banana	0.15	Perennial	769.51	1154.27			
3	Pepper	0.20	170	654.61	1309.22			
4	Onion	0.20	150	571.89	1143.79			
5	Cabbage	0.10	150	479.63	479.63			
6	Tomato	0.10	130	537.67	537.67			
7	Potato	0.10	150	480.67	480.67			
8	Mango		Perennial			0.15	285.62	428.44
9	Banana		Perennial			0.15	271.92	407.89
10	Wheat		130			0.25	227.92	569.80
11	Barley		130			0.20	210.04	420.09
12	Sorghum		140			0.15	293.0	439.5
13	Teff		140			0.10	259.89	259.89
14	0		150			-	-	-
Seasonal Area ratio		1	Water DM without Pro.Eff (M3/ha/Season)		6,259.51	1		2,525.64
Project efficiency		0.60	Water DM+Pro.Eff (M3/ha/Season)		10,432.52			4,209.41
Grand Water Demand(M^3/year/ha)								14,641.93
					Reservoir storage($M^{3)}$			14,641.93
					Water Demand(M^3/year/ha)			14,641.93
					Area to be irrigated (ha)			1.00

Table 17 Irrigated Crop per hectare

Dry season	
Crops	**Area**
Mango	0.15
Banana	0.15
Pepper	0.20
Onion	0.20
Cabbage	0.10
Tomato	0.10
Potato	0.10
sum	**1.00**

Wet season	
Crops	**Area**
Mango	0.15
Banana	0.15
Wheat	0.25
Barley	0.20
Sorghum	0.15
Teff	0.10
0	0.00
Sum	**1.00**

Table 18 Water Budget required per hectare

		Dry Season Irrigation				Supplementary Irrigation			Water Req(m^3)
S.no	Crop	Area (ha)	Growth Period (days)	Water req. (mm)	Water Req with out pro.eff (m3)	Area (ha)	Water req. (mm)	Water Req with out pro.eff (m3)	with project efficiency
1	Mango	0.15	Perennial	769.51	1,154.27				1,923.78
2	Banana	0.15	Perennial	769.51	1,154.27				1,923.78
3	Pepper	0.20	110	654.61	1,309.22				2,182.03
4	Onion	0.20	120	571.89	1,143.79				1,906.31
5	Cabbage	0.10	120	479.63	479.63				799.38
6	Tomato	0.10	120	537.67	537.67				896.12
7	Potato	0.10	100	480.67	480.67				801.12
8	Mango		Perennial			0.15	285.62	428.44	714.06
9	Banana		Perennial			0.15	271.92	407.89	679.81
10	Wheat		110			0.25	227.92	569.80	949.67
11	Barley		110			0.20	210.04	420.09	700.15
12	Sorghum		110			0.15	293.03	439.54	732.57
13	Teff		80			0.10	259.89	259.89	433.15
14	0		120			0.00	0.00	-	-
Seasonal water demand (with out pro.eff)					6,259.51			2,525.65	14,641.93
Project Efficiency (%)					0.60				
Seasonal water demand(with pro.eff)					10,432.52			4,209.41	
Grand Total water demand of the project.					14,641.93				
Balance between Demand and Supply					0.0				
Maximum duty for design (lit/sec/ha)					1.9				

Table 19 Monthly Water Demand and Duty

No	Months	Monthly water Demand with out Project efficency(m3)	Monthly water demand with project efficency (m3)	Monthly Max. duty (lit/s/ha)
1	December	615	1,024	0.8
2	January	977	1,629	1.4
3	February	1,450	2,416	1.8
4	March	1,569	2,615	1.9
5	April	1,129	1,882	1.6
6	May	519	865	0.4
7	June	467.2	779	0.7
8	July	0.0	0.0	0.0
9	August	76.6	128	0.2
10	September	1,096	1,827	1.5
11	October	639	1,065	1.0
12	November	247	411	0.1
Total Monthly Water Demand(m3)		8,785.2	14,642	
Project Efficiency used(%)		0.60		
Maximum duty for design (lit/sec/ha)		1.9		

10.0. Irrigation Scheduling

Irrigation scheduling (determination of the depth and interval of irrigation) is important if water has to be used efficiently and moisture stress has to be reduced so as to increase productivity. Timely application of water according to the demand of crops is essential for the vigourity of plant and to use it the delivered water efficiently by accumulating moisture around the root zone of the plant besides of the selected method of irrigation.

10.1. Pepper

Root depth can extend up to 1m but under irrigation roots are concentrated mainly in the upper 0.3m.Due to low depletion level light irrigation application is required. Irrigation frequency 4 to 7days is common. For optimum yield of the crop 600-900 mm of water is required. Pepper is most sensitive to water stress during transplanting and flowering. The most common irrigation methods are furrow.

10.2. Onion

Onion has shallow root system with roots concentrated in the upper 30cm depth. Thus the crop requires frequent and light irrigation in every 2 to 4 days. The crop is most sensitive to water stress during transplanting and yield formation (rapid bulb formation) after 60 days from transplanting. For optimum yield onion requires 350-580mm of water. Irrigation should be discontinued 15 to 25 days before harvest to allow the tops to dry out, and also to prevent flush of root growth. The most common irrigation methods are furrow.

10.3. Potato

Potato requires a good amount of water and a large part of it is transpired. Total water requirement after planting, of a potato crop grown in the field is between 500-700 mm depending on the climate and varieties. Potato being a shallow rooted crop requires frequent irrigation of shallower depth rather than a few heavy irrigation. On an average, 6 to 7 days irrigation is applied to early maturing varieties and 9-11 irrigation to late varieties. The common irrigation method is surface irrigation by furrow is practiced.

10.4. Cabbage

Total water requirement for cabbage crop is 380mm-500mm. The seedling should be watered immediately after transplanting and thereafter irrigation is at interval of 3-12 days would adequate. At the time of maturity watering should be avoided since this will cause splitting of heads. However high soil moisture levels during vegetative growth improved leaf growth but not necessarily increased yield level. The common irrigation method is surface irrigation by furrow is practiced.

10.5. Tomato

Total water requirement after transplanting, of a tomato crop grown in the field for 90 to 120 days, is between 400-600 mm depending on the climate. On average 7-15 days irrigation applied. The plant produces flowers 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. The crop has a fairly deep root system and in deep soils roots penetrate up to some 1.5m. The maximum rotting depth is reached about 60 days after transplanting. Excessive watering during the flowering period has been shown to increase flower drop and reduce fruit set. Also this may cause excessive vegetative growth and a delay in ripening. Water supply during and after fruit set must be limited to a rate which will prevent

stimulation of new growth at the expense of fruit development. The common irrigation method is surface irrigation by furrow is practiced.

10.6. Teff

The total water requirement for teff crop is with a range of 300-2500 mm. Teff is extraordinarily drought resistant compared to some other cereal crops, but water is essential for proper plant development, especially during early stage of growth most cultivars require at least three good rains during their early growth, a total of 200-300mm of water is required for a fully productive life cycle of three to four month. Plant growth ceases because of shallow root system. In some parts of Ethiopia irrigation is practiced, but this is insignificant. Irrigation methods used are furrow and boarder irrigation.

10.7. Sorghum

The water requirement of the crop varies between 450-650mm depending on the climate. Irrigation interval 21-30 days is adequate. Because of its extensive root system the crop is more drought resistant than most of the crops.Physiollogically the plant is able to with stand desiccation and recover rapidly after water stress. Timing of water supply should be planned to reduce water deficits to a minimum during the periods of crop establishment, flowering and early yield formation. Irrigation is by surface methods, boarder and furrow.

10.8. Barley

Barley is grown during rainy season. The water requirement of the crop varies between 400-800 mm depending on the climate. Irrigation interval 14- 21 days is adequate. Because of its extensive root system for it is relatively drought resistant than other crops. Timing of water supply should be planned to reduce water deficits to a minimum during the periods of crop establishment, flowering and

early yield formation. Irrigation can apply by boarder and furrow irrigation methods.

10.9. Wheat

Wheat crop thrives well in those are where annual rainfall ranges between 250-1800mm.However, low as well as high rainfall is detrimental to wheat yield. Irrigation interval 7-14 days is adequate. The total crop water need mm/total growing period is 500-800 mm. The crop may be irrigated by either border strip or check method. The border and furrow method of irrigation is preferable.

10.10. Banana

The Banana plant has a sparse, shallow root system. Most feeding roots are spread laterally near the surface. Rooting surface not exceed 0.75m.In general 100% water of the water is obtained from the first 0.5 to 0.8m soil depth. Since a depletion of total available soil water in excess of about 35% during the total growing period is harmful to good fruit production, frequent irrigation is important. Mostly surface namely basin and furrow irrigation are practiced.

10.11. Mango

Irrigation during blossoming is highly detrimental, since it injures the unproduced pistil. A mango tree can give a good performance in some arid regions with an annual rainfall of 600-800mm in humid rainy season with 350-700mm. In the period (up to 2 years) require irrigation frequently. The amount and timing of irrigation vary depending on the soils and climatic conditions. Heavy irrigation is usually applied in heavy soils with less frequency and light irrigation is given in light soils with high frequency. The interval between irrigation may be from 3 to 4 days in summer when the plants are young and 15 days in winter. Mostly surface namely basin and furrow irrigation are practiced.

11.0. Agricultural Development Plan

11.1. Objectives of the agricultural development plan

This agricultural development plan is prepared to endeavor at, improving the existing crop production and productivity of the study area, and hence securing food self sufficiency and benefit of the farmers in study area. The plan is prepared together with the agronomy feasibility reports of the scheme during site field works, in-depth discussion with the beneficiary farmers, and administration body of the tabia, and wereda's pertinent offices.

11.2. Expected output of the ADP

The anticipated outcome of ADP is to improve the skill of the beneficiaries at all level of experts mainly farmers on how to use the existing resource efficiently and to get familiarize with better recommended irrigation benefits, building strong structures of water users, and support services so as to increase yields and benefits, and living standards of the farmers on this new irrigation schemes.

12.0. Existing potential of the area for Irrigation development

12.1. Land and water resources

The study area is suitable for irrigation development. This area is capable of producing sustained and relatively high yields of a wide range of crops. The water resource potential of the study area is also highly promising. This irrigation scheme is expected to develop the proposed command area sustainably.

12.2. Agricultural support services

The tabia is found near the project area. The distance from the tabia center to the project area is about 6 km. Hence, the services provided by the tabia (extension service and others) are at the reach of the farmers. The services provided by the wereda agricultural office is wel structured by multi discipline development agents that deliver technical support to the farmers. Regular supervision and technical support are also executed by wereda as in SMS team.

12.3. Human Resource

There is enough human resources to implement the envisaged irrigation development. Moreover, this irrigation scheme is expected to create job opportunities especially for the landless young farmers.

12.4. Experiences from existing irrigation

There are existing traditional irrigation and pumps around the boarders of the river that develops small plots of irrigation. Hence, the farmers of the study area have gained experience from those schemes. So, those experiences could be easily scaled up to the project area.

12.5. Access road and transport service

There is asphalt road from the project area to Hagereselam, Mekelle, Romanat, and Tikul: and this creates good condition to market outlet. Additionally, the expansion of irrigated agriculture by itself will invite wholesalers to the area.

12.6. Favorable Policies

The Ethiopian water resources management policy was issued in 1998. This policy sets guidelines for water resources planning, development and management. Irrigation is one of the subsectors included in this policy. One of the detail objectives of the irrigation policy is development and enhancement of small, medium- and large-scale irrigated agriculture. The irrigation developments are to be integrated with agricultural development led industrialization strategy.

Accordingly, in Tigray region, several irrigation projects are constructed in the last twenty five years. Still there is strong commitment of the government of this region to enhance irrigation developments. The farmers are also well organized and devoted to implement such projects.

12.7. Scope for Crop Diversification and Requirements

The study area has favorable climate and soil for the growth of many crops. Hence, there is wide possibility for crop diversification. At the existing condition several crops are growing under rainfed condition and traditional irrigation. These crops include cereals (Wheat, Barley, Maize, Sorghum Millet, and Teff), and vegetables (Onion, Garlic, Shallot, Tomato, Potato, Cabbage, Lettuce, Swiss chard and Carrot) and many of the fruit crops.

13.0 Major constraints of the existing Agricultural crop production

The existing crop production is characterized by subsistence and traditional agriculture with low inputs and poor cultural practices.

Several factors such as the soci-economic condition, market accessibility, extension weather condition etc. have contribution for the existing low yields in the study area. The major Agricultural constraints are listed below.

13.1. Rainfall /Moisture/ Deficiency

There is available perennial river that can be used for irrigation purpose in the area. Though there is little practice of using water for irrigation by pump, majority of the farmers are not using the water. The Command area faces water shortage at time of Kremti during June and September while the dry season are not developed as a whole.

13.2. Reduced soil Fertility Condition

The land has been cultivated for decades at less soil fertility management. The existing cropping pattern is also cereal dominated and don't have the practice to rotate with pulses more over present use of commercial fertilizers, compost and animal manure is also very low.

13.3. Traditional crop husbandry system

Land preparation especially in selection appropriate time and maintaining frequency of plowing is poor. Planting and sowing in most cases is delayed. Seed rate is beyond optimum due to use of poor quality of seed, poorly prepared seedbed and insufficient moisture condition.

Hoeing and weeding operation are given little attention and some farmers harvest the crop even without single weeding.

There is no practice of timely harvesting and threshing the crop stays long in field after maturity contributing to yield reduction by shedding and falling to the ground as well as damage by animals, rats and termites.

The storage condition for the grains also does not allow the grains to stay for longer period of time and this causing deterioration in quality.

13.4. Disease and pest problems

Disease and pests attack crops in the field and after harvest in the area. Farmers has less tendency to protect the pests due to less awareness, for this reason yields exposed to damage both in quality and quantity.

13.5. Lack of improved crop varieties at reasonable price

Improved crop varieties are not easily available if available their prices are high and farmers don't want to buy at higher price because of their lower purchasing power. Farmers in the area use local seeds as source of planting materials. Local varieties are low yielding and repeatedly affected by various pests. The use of low yielding local varieties which are neither cleaned, chemically treated nor improved have contributed to the current low crop production in the area.

13.6. High price of fertilizer

Most of the farmers complain the high price of the fertilizer even though they are aware of its importance. They hesitate to invest on fertilizer especially for rainfed crops because the rainfall is not reliable resulted failure in crops. They are trying to avoid a risk. However in irrigation needs close supervision in selection of feasible crops with market which can return the cost.

13.7. Weak extension service

Most of the extension workers focus on the distribution of seeds and fertilizer for the target farmers they did not pay enough time how the farmers can fertilize

and sowing the inputs taken for this reason the farmers cannot observe clearly the difference in yield by adding cost.

13.8. Traditional post harvest management

The study area has very conducive climate for the growing a variety of crops. Currently, thus crop in the study area has a problem in collection and storing. It is studied that, greater than 30% yields lost because of poor management for most cereal crops and Vegetables specially, potato is easily spoiled.

14.0. Improved Agricultural crop husbandry.

Once sustainable irrigation is proposed in the area farmers should focus on improved crop husbandry practice and proper agricultural development plan thus, productivity and quality of production could improve.

The major components of Agricultural development plan are briefly given below:

14.1. Plowing

Plowing is better done at the time just after harvesting the crop when the soil has some moisture. It should be plough at least to a depth of 30cm.using improved (plough) maresha. The frequency of plowing should be to the range up to minimum of clods in the field or fine bed is prepared. Early start of plowing will also expose the eggs and larva to sun light and unfavorable weather condition of the insect pest which helps in reducing pest.

14.2. Application of farm yard manure and compost.

Farm yard manure or compost should be prepared and mixed with seed bed or field before sowing. Addition of large quantities of farmyard manure and compost is important to improve the organic matter there by improve the soil nutrient holding capacity.

Farmer should also be encouraged to green manure their field using nutrient fixing (leguminous) species such as pulses, suspania and lusunnia.Varieties with high green manure yield should be selected for this purpose.

14.3 Crop rotation

Crop rotation has a potential to increase crop yields in the area. Present practice of monoculture agricultural system need to be replaced by proper crop rotation practices. Thus Pulses, horticultural crops, vegetables and need to be shifted with cereal crops from concept of soil fertility, integrated soil plant nutrient, Implementing integrated pest management.

14.4. Forming of Ridges and Furrows

Ridges and furrows should be properly made for row crops and beds for Vegetables and other grain crops. These rows and beds helps for easy management of crops and conserving soil moisture in the field.

14.5. Application of fertilizers

The recommended dose of fertilizers should be applied on time**.** Farmers have to apply recommended fertilizer rates for each crop. Timely and adequate supply of fertilizer is quite crucial for promotion of effective fertilizer use under irrigation. Nitrogen fertilizer should be applied in splite form while phosphorous can be applied as basal.

14.6. Maintain optimum plant population

Farmers should be advised to use the optimum seed rate to insure optimum plant population in the field. Seeds should be of good quality to get high emergency and establishment.

The recommended spacing and seed rate should be adopted to avoid excess population or insufficient population in the field. Crop yield could be significantly increased by keeping optimum and acceptable planting seed densities.

14.7. Sowing/planting transplanting

Farmers should plan to timely sowing/planting transplanting using the advices of the extension workers. Farmers should encourage to their crops as early as possible and preferably just after the first shower. Early sowing allows the crops to get extended growing period and get well matured. Delay in sowing or planting time always decreases the yield of the product.

14.8. Proper pest control Measures

Crop pests such as weeds, diseases and insects have to be timely and effectively controlled under cultural and chemical methods. Due to warm and moist condition of the irrigated area pest damages could be aggravated and causes great damage on the yield if they are not properly controlled. Crop yields could be increased in the order of 20-35%, if pests are timely and effectively controlled.

14.9. Gap Filling

Gap filling should be done with in less than a week time to efficiently utilize the land and to increase yield per hectare. Delayed in filling of gaps (space left by wilt out plants) may not bring much change on yield because of shadowing effect of taller plants especially on crops like maize.

14.10. Top dressing of Nitrogen Fertilizer

Top dressing of urea should be carried out as recommended especially when the crop is at active stage of growth. N fertilizer should be applied in 2 splits. The final top dressing should be done before flowering in case of cereals.

14.11. Irrigation

Irrigation scheduling of the different crops chosen should be followed to avoid moisture deficiency as well as excess irrigation.

14.12. Harvesting

Timely harvesting of the crops is important to reduce loss in field. For perishable crops the produce should be harvested and packed at normal ripening stage and should be transported to market as early as possible.

14.13. Diffused-light stores

The study area has very favorable climate for the growth of potato. Currently, this crop is growing around the study area in small plots where there is irrigation. Hence, construction of one communal diffused-light store is important for the purpose of storing seed potatoes.

14.14. Establishing Farmers' Research Group (FRG)

Establishing farmers research group (FRG) is also proposed. In the irrigation scheme, two groups each consisting of 20 farmers are planned to be established. These research groups will be established during the construction phase of the project. Site specific irrigation packages will developed for the site through adapted and verification trials: on water requirement, time of irrigation, adaptation of new varieties, on local versus improved varieties, row planting versus broadcasting, furrow irrigation versus flooding, trials on integrated soil fertility management, and IPM. On-farm demonstration will be organized in the area in order to expose farmers to new irrigation practices and the responsibility is taken by the wereda Agricultural office, DAs and zonal research centers.

14.15. Improved seed production and multiplication.

Where reliable commercially produced improved seeds are available, the farmers are advised to use these seeds rather than using locally produced seeds. This is because commercial seeds, produced under controlled conditions, are likely to be high yielding and less likely to harbor pathogens than locally produced seed. Sometimes, however, commercially produced improved seeds may not be easily available or the source of the seeds may not be reliable. In such cases the farmers should opt to produce their own seeds. From the proposed crops, based on interest of the group crops will be selected and multiplied on 0.5 ha of land that is on communal nursery. The farmers will be provided with training, starting

seed and other necessary equipments. Concurrently with the construction phase, details of the plan will be worked out in consultation with the community and the FRGs.

14.16. Establishing communal vegetable nursery.

The experience from previously constructed irrigation schemes of the region shows that farmers are producing seedlings of vegetables on their own farms and in unorganized manner. Such practice leads to production of poor quality seedlings and irrigation water loss. To avoid these problems, the beneficiary farmers of this scheme have consented to establish communal vegetable nursery at the upper reach of the command area. 1 ha of land will be allocated for the nursery site and seedlings of the proposed vegetables will be produced on this nursery site. The produced seedlings will be sold to the beneficiary farmers on fair price. The money that is going to be collected from selling the seedlings will be used to buy seeds of the vegetables for the next season. Details of this plan will also be worked out in consultation with the community and the FRGs during the construction phase of the scheme.

As for the fruit crops, wereda, and regional Agricultural office are responsible to deliver seedlings from the nearest nursery sites available.

14.17. Strengthen Agricultural support services

14.17.1. Irrigation Water Users Association/IWUA/

Efficient water users association should be established at the site in order to help farmers under take faire and equitable water distribution, land distribution, in put supply. Moreover the association will facilitate regular maintenance of irrigation structures. Specially, in new irrigation project area, there should be urgent set sufficient material and training for Beneficiary farmers, IWUA boards, DAs, wereda farmers cooperatives, and wereda irrigation expert valued NGOs /IFAD/.

14.17.2. Extension

The extension service should be strengthening in man power, training and logistics. Unless effective extension system is developed, it will be less likely to achieve the required targets from the site. More over the extension system will have more acceptable extension approach and develop its linkage with other research and development institutions.

14.17.3. Marketing

Currently they supply their produce to near towns however, Efficient marketing services need to be established in order to help farmers sell their product at acceptable prices. Since most vegetables and horticulture products are easily perishable it is quite essential to develop such services which otherwise make farmers easily discouraged and disappointed from crop intensification efforts.

14.17.4. Credit Service

Farmers in the study area get credit from Dedebit credit and saving institution. Dedebit credit and saving institution gives credit in cash; whereas the farmers' cooperatives give credit in kind (improved seeds, chemical fertilizer, water pumps, drip irrigation equipments and other inputs).

The rural saving and credit cooperative is established recently. Currently it is giving credit to member farmers. The expansion of this service will benefit more farmers.

Table 20 Cultural practices and labor requirement for the proposed crops.

S/n.	Crops	Land preparation (No. of plowings)	Seed rate (KG/ha)	Weeding /cultivation/ Herbicide	In-put & Labor requirement man days/ha.		
				N(urea)	NPKSFeZnB	Lab.	(Pair) Oxen
1	Pepper	3	0.6	3shall.cult	100	100	280 (12)
2	Onion	3	3	Shallow cultivation 3 times	100	100	315 (12)
3	Potato	3	2200	3shall.cult	100	100	280 (12)
4	Cabbage	3	0.75	3shall.cult	100	100	355 (12)
5	Tomato	3	0.25	3shall.cult	100	100	421 (12)
6	Teff	4	30	3 HW 2,4-D	100	100	130 (20)
7	Sorghum	3	8	1HW,1SC	100	200	64 (12)
8	Wheat	3	100	2 H.W	100	100	93 (20)
9	Barley	3	100	2 HW 1 SC	100	100	120 (20)
10	Mango	Pits(100)	100 seedling	4 HW	200	82	480 -
11	Banana	Pits(400)	400 suckers	4 HW	50	150	350 -

Source: (Tigray Bureau of Agriculture &Natural Resource Guideline on Irrigation Agronomy of SSIP and ATA, Tigray soil fertility status and fertilizer recommendation Atlas.)

15.0 Yield build up pattern

Yield projection is important to evaluate the feasibility project. It helps in the computing of the benefit cost ratio of the project.

Once improved method of irrigation is introduced and improved varieties used the yield level starts to increase but takes some years until it reaches optimum achievable yields. The adoption rate of the farmers for improved technologies, availability of the agricultural inputs (seeds, fertilizers, chemicals etc), the socio economic condition of the farmers, efficient management of the water etc affect the time needed to reach optimum yields.

Generally five year period is taken as a norm to achieve the optimum yield for cereals and vegetable for perennial crops an average of seven years is taken. For the assessment of the ultimate yields for the various crops references were made to the following factor:

- Present yield levels of farmers
- Yield obtained by research stations
- The anticipated management levels
- Climate and soil conditions
- Type of production system (rain fed/irrigated)
- Crop yield in similar agro ecology
- Yield projection adopted by similar studies

In view the above facts crop yield in the project area could be substantially increased with the project condition and through the individuals or collective impact of the following interventions:

- Shift from traditional to improved crop husbandry practices
- The use of external agro inputs
- The shift from rainfed to irrigated production system
- Effective implementation of post harvest crop management

- Positive impact from the soil and water conservation practice

Table 21 Attainable Yield level (Q/ha) with irrigation, improved varieties and fertilizer.

S/n.	Crops	1st year	2nd year	3rd year	4th year	5th Year	6th Year	7th Year
1	Pepper	16	18	20	25	30	32	35
2	Onion	180	200	210	220	250	280	300
3	Potato	200	220	260	280	300	310	320
4	Cabbage	140	160	180	200	210	220	230
5	Tomato	180	210	230	250	280	300	320
6	Wheat	25	35	40	45	50	52	52
7	Barley	25	30	35	40	50	52	52
8	Sorghum	25	30	35	45	50	50	50
9	Teff	10	12	15	20	25	25	25
10	Mango /Onion1-3 years/	- 140	- 120	- 100	180 -	200 -	210 -	220 -
11	Banana/Pepper1-2 years/	- 12	90 -	130 -	150 -	180 -	200 -	210 -

Source: Guideline on Irrigation Agronomy SSIP

16. Budget

In the previous page, under Agricultural support Service, urgent interventions proposed to deliver enough training and materials to the stake holder in all level of experts and farmers by valued NGOs /IFAD/ in new irrigation projects. So, the budget necessary for the key interventions is tabulated below.

Table 22 Budget required for training and demonstrations

S/N	Activities	Unit	Quantity	Unit cost/day/ pers.	Total cost	Responsibility For activity	Time frame
1	**Training**						
1.1	DAs training	Nu.	5	158	7900	Wereda Exp.	10
1.2	Farmers	Nu.	76	120	45600	DA' & WE	5
1.3	IWUA	Nu.	10	158	15800	Wereda Exp.	10
1.4	IWUA board	Nu	5	158	3950	DA' & WE	5
2	**Equipment for FTC**						
2.1	Sprayer(20lt)	Nu.	2	1200	2400	Board & DA's	-
2.2	Balance (pendulos15--20kg)	Nu.	1	800	800	Board & DA's	-
2.3	Watering cane (15lt)	Nu.	10	120	1200	>>	-
2.4	Spade	Nu.	10	80	800	>>	-
2.5	Rake	Nu.	10	60	600	>.	-
2.6	Digging hoe	Nu.	10	100	100	>>	-
2.7	Pick axe	Nu.	4	100	400	>>	-
2.8	Sickle	Nu.	10	80	800	>>	-
2.9	Tape meter (50m)	Nu.	3	120	360	>>	-
2.10	Plastic rope (200m)	Nu	3	100	300	>>	-
3	**Training Equipments**						
3.1	TV se(42")	Nu.	1	20000	20000	>>	-
3.2	DVD player	Nu.	1	3000	3000	>>	-
3.3	Over head projector	Nu.	1	16000	16000	>>	-
3.4	White board (90*120cm)	Nu.	1	1600	1600	>>	-
3.5	Stationary material	Nu.	100	20	2000	>>	

S/N	Activities	Unit	Quantity	Unit cost/day/ pers.	Total cost	Responsibility For activity	Time frame
4	**Demonstration material/FTC/**						
4.1	Improved seed(1250m^2)	kg	15	36	540	BoANRD	Wheat
4.2	Fertilizer	Qt	1	1300	1300	>>	
4.3	Chemical	kg	2	500	1000	>>	
4.4	Labor	Nu	50	100	5000	>>	
5	**Improved seed multiplication /0.5ha/**						
5.1	Improved seed(5000m^2)onion	kg	1.75	2000	3500	DA's,BoANR	
5.2	Fertilizer	Qt	1	1300	1300	>>	
5.3	Chemical	Lt.	2	500	1000	>>	
5.4	Labor	pd	100	100	10000	>>	
5.5	Fencing	m	340	85	28900	>>	
6	**Vegetable nursery/ 1ha./**						
6.1	Improved seed(5000m^2)	kg	6	2000	12000	DA's,BoANR	
6.2	Fertilizer	Qt	2	1300	2600	DA's,BoANR	
6.3	Chemical	Lt.	4	500	2000	DA's,BoANR	
6.4	Labor	pd	200	100	20000	DA's,BoANR	
6.5	Fencing	m	440	85	37400	DA's,BoANR	
7	**Farmers research group/ FREG /**						
7.1	Demonstration in Irrigation. Agronomy (625m^2) each 8 farmers	person	16	3670	58720	DA's,Zonal Research	
7.2	Provision of demonstration material	FRG	2	5000	10,000	>>	
7.3	Training and demonstration conducted to farmers.					>>	
7.3.1	Demonstrations in Irrigation agronomy	Nu.	16	120	1920	Resease. &DA	1 day
7.3.2	Irrigation agronomy	Nu.	16	120	1920	>>	1 day

S/N	Activities	Unit	Quantity	Unit cost/day/ pers.	Total cost	Responsibility For activity	Time frame
7.3.3	Water management	Nu.	16	120	1920	>>	1 day
7.3.4	Soil and water management	Nu.	16	120	1920	>>	1 day
7.3.5	Improved soil fertility	Nu.	16	120	1920	>>	1 day
7.3.6	Integrated pest management (IPM)	Nu.	16	120	1920	>>	1 day
7.3.7	Stationery materials	Nu.	16	20	**320**	>>	
Total					**330,710**		

17.0 Conclusion and Recommendation

The study of the soil resource in Misrar teli showed that the command area is suitable for irrigation with no apparent limitation though, there is some pocket area limitations in depth and texture of soil for some of vegetable crops and perennial crops that needs selection and improvement of the soil structure.

A range of crops are suitable to be grown in the area. These include Wheat, Barley, Teff, Sorghum, Maize, Onion, Pepper, Tomato, Potato, Cabbage, S.chard and perennial crops can also be grown provided sufficient training of beneficiaries and market outlet is improved for the area.

Soil management practices that improve soil fertility like addition of manure and artificial fertilizer, drainage system for pocket area, soil and water conservation measures are also recommendable. From Tigray soil fertility status Atlas studied by Agricultural transforming Agency /ATA/ and from field observation the soil lacks some essential nutrients and Hence application of adequate dose of P and N containing fertilizer is important. The deficiency of micro nutrient could be expected as the study indicates, thus application of the blended fertilizer has a paramount importance in the field while the crops are actually growing and show symptoms on the crops. Trials and demonstration need to be carried out on the use of improved seeds, fertilizer dose, timely application of pesticides and disease control methods. For new crop variety adaptability trial of the recommended crops should also be carried out to select the most promising ones.

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