AMHARA NATIONAL REGIONAL STATE
BUREAU OF WATER RESOURCES DEVELOPMENT

FEASIBILITY STUDY & DETAIL DESIGN

OF

GOBU 3 SMALL-SCALE IRRIGATION PROJECT

GOBU 3 SPATE IRRIGATION AGRONOMY FEASIBILITY STUDY FINAL REPORT

VOLUEM III :IRRIGATION AGRONOMY

AMHARA DESIGN & SUPERVISION WORKS
ENTERPRISE
(ADSWE)

Amhara National Regional State

Water Resources Development Bureau

(BOWRD)

Feasibility Study and Detail Design

of

Gobu 3 Spate Irrigation Project

Volume III: Irrigation Agronomy Final Report

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FEASIBILITY STUDY & DETAIL DESIGN REPORT STRUCTURE

- Volume I: Watershed Management
- Volume II: Engineering Geology
- **Volume III: Irrigation Agronomy**
- Volume IV: Engineering Design
- Volume V: Socio Economy
- Volume VI: Environmental Impact Assessment

Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF ANNEXES

ACRONYMS

ADSWE	:	Amhara design and supervision works enterprise
ADO	:	Agricultural development offices
BoFED	:	Burea of Finance and Economic Development
CEC	:	Cation exchange capacity
Cm	:	Centimeter
DA	:	Development agent
EC	:	Electrical conductivity
Ep	:	Project efficiency
ETc	:	Evapotranspiration of crop
ETo	:	Potential evapotranspiration
FAO	:	Food and Agriculture Organization
GIWR	:	Gross irrigation water requirement
Ha	:	Hectare
HABP	:	Household asset building program
Hr	:	Hour
IPM	:	Integrated pest management
Kc	:	Crop coefficient
Kg	:	Kilo gram
Km/hr	:	Kilometer per hour
Lt	:	Liter
L/S/H	:	Litter per second per hectare
LGP	:	Length of growing period
MASL	:	Meter above sea level
M/S	:	Meter per second
MM	:	Millimeter
M	:	Meter
NIWR	:	Net irrigation water requirement
NGO	:	Non-governmental organization
NMSA	:	National meteorology service agency
OC	:	Organic carbon
OM	:	Organic matter
PCA	:	Proposed command area
PPM	:	Parts per million
QT	:	Quintal
RF	:	Rainfall
RH	:	Relative humidity
SWC	:	Soil and water conservation
Sec	:	Second
S/N	:	Serial number
UTM	:	Universal Transverse Mercator

SALIENT FEATURES OF THE IRRIGATION PROJECT

Name of the Irrigation Project: Gobu 3 Spate Irrigation Project

Location: Amhara Region, North Wollo Zone, Raya Kobo Woreda, Jarota (04) Kebele

Project site (command) elevation:	1426.7 – 1461.6masl
Soil texture:	Loam
Net irrigable land for full irrigation farming:	300 ha
Net irrigable land for supplementary irrigation farming:	300 ha
Water abstraction system:	Spate Irrigation
Client:	ANRS BoWRD
Consultant:	ADSWE

1. INTRODUCTION

1.1 General

Amhara National Regional State (ANRS) is one of the nine regions of the country, located in the northern part of Ethiopia, extending from 9° to 14°N and 36° to 40°E and covers a total land area of 1, 61828.4 square kilometers or 16,182,840 hectares which makes up 11% of the size of the country; and inhabited by with an estimated population of 19.24 million people (ANRS BoFED, 2013 population projection).

Interms of spatial distribution of the Region's population, close to 90 % lives in the rural areas whose economy is mainly based on agriculture. Hence the agricultural sector is the main sources of income and employment for the bulk of the population. It also accounts a great share for the country's total GDP and foreign/export earnings. Although the region is within the high agricultural potential of the country, agricultural productivity remains low, mainly due to unreliable rainfall and backward agricultural systems; its growth has not been rapid enough to meet the challenges that it has faced. The dependency of the sector on rain-fed production, the low utilization of modern agricultural inputs, inadequate infrastructural development, poor marketing, etc, are some of the critical factors that impedes the rapid growth of the sector. These constraints coupled with high population growth have exposed the region to the problems of food shortage and mass poverty.

Farmers in the region largely practices mixed farming where they grow crops and rear animals. Especially crop production is highly dependent on rainfall and is the predominant activity of the region. However, the production capacity of the sector is lagging behind the actual demand of the region. Especially in drought prone woredas of the region food self-sufficiency, at household level, is not assured.

In terms of economy, the sector faces at least two major challenges. The first challenge is that being unable to produce the volume of grain crops required to meet the food demand of the rapidly growing population of the region. The second challenge is the limitations to produce the raw materials and savings required to enhance the growth of the industrial sector and the urban economy as a whole in order to generate the employment opportunities that will absorb the excess labour engaged in agriculture and also to alleviate both urban and rural poverty.

On the other hand, the region has plenty of natural resources such as water potential and suitable irrigable land areas. The total irrigation potentials of the region have estimated to be about 1,200,000 ha, out of which 620,428 hectare (51.7%) is under utilization (ANRS BOA, 2012). Thus, strong effort and commitment is highly required to bring these potentials into use. The development of irrigation at all levels facilitates increment of agricultural production in sustainable manner and assist in overcoming of the problem of depending only on natural rainfall for smallholder farmers. In order to mitigate these gaps of production, the Amhara regional government has designed a strategy of sustainable irrigation development and environmental rehabilitation inline with the national government irrigation development polices and strategies. This strategy is designed to alleviate the problems of erratic and uneven distribution of rainfall occurrences through supplemental (wet season) and full irrigation (dry season) thereby sustainable and increased crop yields can be obtained.

Hence, as parts of regional strategy, the ANRS Bureau of Water Resources Development (BOWRD) has planned to undertake Intake irrigation project study in North Wollo Administrative Zone, Raya Kobo Woreda of Jarota (04) Kebele. Amhara Design and Supervision Works Enterprise (Consultant), has been commissioned to undertake the study. Thus, this agronomy report is prepared as per the consultancy agreement made between the two parties.

The present agronomy feasibility study report contains: introduction, objectives, study methodology, the project area profile, existing rainfed and irrigated crop production systems, existing agronomic practices, major crop pests and their controlling measures, inputs requirements and utilizations, proposed crops and cropping patterns, crop water requirements, irrigation duty, irrigation schedules, supporting services, conclusion, recommendations, etc.

The feasibility study report also includes references and annexes. In general, the study report can serve as the baseline or guideline for the implementation and development of the Gobu River as Spate Irrigation Project (GRSIP), particularly for agronomy part.

1.2 Objectives

1.2.1 General Objective

The general objective of the project is to bring food self-sufficiency of the beneficiaries and to produce marketable surplus through the provision of irrigation water and modern crop production techniques both in wet and dry seasons.

1.2.2 Specific Objective

The specific objectives of the Agronomy study is to make inventory on the existing agricultural practices (farming and cropping systems, cropping pattern, crop calendar, crop rotation, etc), level of support services (agricultural extension, finance and credits, research and development, agricultural inputs requirements and utilization and crop protection), existing physical features in the study area (i.e. agro-climatic zones, soil conditions, land use, etc.), both traditional and modern irrigation schemes, assess the potentials and constraints that exist in the project area so as to:

- Study the existing physical features and agricultural situations in the study area /agro-ecology, land use, soil conditions, farming system, cropping systems, etc. /
- Assess the existing crop production situation (cropping pattern, crop calendar, etc);
- Assess the present situations, crops and level of production, cropping systems and rotations, and support services such as extension, finance and credit, research and development, level of agricultural inputs requirements and utilization, crop protection level, etc.
- Identity the potential and main constraints in the project area and propose suitable development interventions;
- Propose the necessary interventions measures and thereby ensure the possible increase in crop productivity;
- Propose measures to upgrade for the community based small-scale crop farming;
- Improve crop production and productivity on sustainable base by use of appropriate technologies;
- Develop socially acceptable, environmentally friendly, technically feasible and economically viable crops;
- Create employment opportunities in the project area through intensive farming system;

- ≡ Develop high yielding, diversified and market-oriented cash crops to replace in the long-run existing subsistence cropping system;
- ≡ Compute and analyze the proposed crops water requirement and propose faire irrigation intervals for the understudy project.

1.3 Methodology

In the project area agronomic survey was carried out during the month of March 2014. The field survey study was carried out through field observation of the proposed command, interview of key informants and individual farmers, primary and secondary data collection and conducting direct discussions with the concerned development agents (DAs) and consultation of relevant woreda offices particularly the agricultural development office.

Observation of gross command area, assessment of cultivated land, traditional irrigation practices and cropping mixes are some of the first tasks carried out during the field study.

Primary data sources are directly taken from key informants and individual farmers in their farmland using prepared checklist/formats. Assumption and parameters are based on the result of observation and discussion carried out among the informants and Development Agents (DAs). During discussion, different crop production system and other detail environmental situation of the area has been identified.

Technical data (number of households, land use type, existing cropping pattern, input use, pest occurrence and control measures, etc), which are beyond the scope of beneficiaries, are collected from DA's and woreda agriculture development offices. Furthermore, climate, topography, agro-ecology, land holding size, cropping calendar, agricultural extension services, draft power (oxen) possession, traditional irrigation practices and technical support, man and oxen day requirements, general production constraints and mitigating measures are the major areas given much attention. Finally, primary and secondary data are cross checked and the summary of the two data are incorporated in to this report.

2. DESCRIPTION OF THE PROJECT AREA

2.1 Location and Access

Gobu 3 Spate Irrigation Project is found in Amhara National Regional State, North Wollo Administrative Zone, Raya Kobo Woreda, specifically within Jarota (04) Kebele. The site is located about 18.5 km far from Kobo town (Capital of Raya Kobo Woreda). Of which about 14km is Asphalt road access and the rest (4.5km) is dry season road. The geographical coordination of the command area lies at 566619.239 - 570269.104 UTM East longitudes and 1357289.116 - 1359392.94 UTM North latitude and an elevation range of from 1426.7 - 1461.6 meters above sea level (masl). Based on the survey data and the computation result of the proposed command area (using ArcGIS 10.1 software) slope gradient of the command is 98.2% (0-3% slope) and 1.8% (3-5% slope). This result indicates that most of the command area is found in 0-3% slope gradients. Generally, the slope gradient class ranges from level to gently sloping. Hence, it has identified that the command area is highly suitable for spate irrigation.

2.2 Agro-Ecology and Climate Condition

2.2.1 Agro-Ecology

According to the traditional Ethiopian agro-ecological zones classification (MOA, 2001) the proposed irrigation project area is basically categorized under Dry Kolla (dry-hot) agro-ecology which is comparatively conducive to the production of tropical and sub-tropical lowland crops. The elevation of the command area also ranges from 1426.7 to 1461.6masl.

2.2.2 Climate Conditions

Climate has an important influence on the nature of the natural vegetation, the characteristics of the soil, the crops that can be grown and the type of farming that can be practiced in any region. The climate of an area is highly correlated with its vegetation and, by extension, the type of crop that can be cultivated. The following are the major elements of climate.

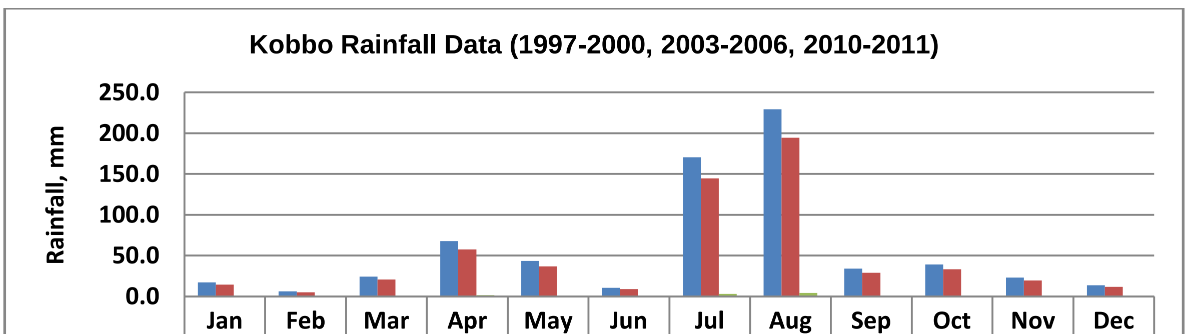
2.2.2.1 Rainfall pattern

The project area has unreliable and partially bimodal pattern of rainfall. The main rain season (locally known as Meher or *Kiremt*) occurs from End-June to after mid of September, yielding average annual rainfall of 679.3 mm. About 34.6% of the annual rainfall occurs during the dry season from October to May (*Belg*). The dependable rainfall during the wet season of June to September varies from a minimum monthly value of 9 mm (June) to a high value of 194.3 mm (August).

In the project area, the main bottle neck for the successful crop production is the nature of unreliable/erratic and uneven distribution of rainfall. The highest rainfall occurs in the months of July and August with better intensity and spatial distribution. Had the annual amount of rainfall been well distributed throughout the wet seasons, the amount of rainfall would have been sufficient for the crops grown in the wet seasons where Maher crops are grown.

Generally, the area is characterized by inconsistent and uneven rainfall distribution. The current unreliable rainfall and uneven distribution makes traditional rainfed crops production difficult. As a rule of thumb, the amount and duration of rainfall affects the moisture content and nutrient status of soil, which in turn determine the growing periods and type of crops to be cultivated in wet seasons.

Kobo meteorological station rainfall data has taken to represent the project area (see Annex II). Ten years rainfall recorded data was used for the computation and analyses of irrigation water requirements. The monthly total rainfall data recorded from year 1997 - 2011 was used (Figure 1). The 10 years average amount of annual rainfall at Kobo meteorological station is about 679.3mm.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ave	17.1	6.2	24.5	67.8	43.5	10.6	170.5	229.1	34.3	39.2	23.1	13.7
80% Dep	14.5	5.2	20.7	57.4	36.9	9.0	144.5	194.3	29.1	33.2	19.5	11.6
RF CV	0.3	0.1	0.4	1.2	0.8	0.2	3.0	4.0	0.6	0.7	0.4	0.2

Figure 1: Average and 80% dependable rainfall at Kobo station

The monthly rainfall has a partially bi-modal characteristic with better rainfall distribution from July to August (Figure 1) and more than 65.4% of the annual rainfall occurs from June to September.

The pattern of the seasonality of rainfall in the project area is determined by computing mean monthly rainfall ratio with that of rainfall module as rainfall coefficient according to Daniel Gemechu classification shown below:

Rainfall Coefficient	Designation/Representation
<0.6	Dry (represent a dry season/month)
≥ 0.6	Rainy (represent a rainy season/month)
0.6 to 0.9	Small Rains (represent small rain season/month)
≥ 1	Big rains
1.0 to 1.9	Moderate (represent big-rains with moderate concentration)
2 to 2.9	High (represent big-rains with high concentration)
3.0 & over	Very high (represent big-rains with very high concentration).

Rainfall coefficient (RF CV) which is defined as the ratio of mean monthly rainfall to rainfall module (one-twelfth of the annual total) has presented in Table 1a for Kobo meteorological station and Table 1b for Muja station.

Table 1-a: Monthly and Dependable Rainfall patterns & Rainfall coefficients of Kobo Station

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average RF	17.1	6.2	24.5	67.8	43.5	10.6	170.5	229.1	34.3	39.2	23.1	13.7	679
80% Dep. RF	14.5	5.2	20.7	57.4	36.9	9.0	144.5	194.3	29.1	33.2	19.5	11.6	576
Rainfall CV	0.3	0.1	0.4	1.2	0.8	0.2	3.0	4.0	0.6	0.7	0.4	0.2	12

Accordingly, September, October and May represents small rains; while April represents big-rains with moderate concentration. July and August represents big-rains with high very high concentration. The rest (November, December, January, February, and June) are known as dry months. Irrigation is required if crop production is envisaged in the long period of October to June. In addition, the following tabulated values illustrate Muja station RF CV; and it is also this station rainfall data that indicates us the spate irrigation water sources and months for the project which is understudy now.

Table 1-b: Monthly and Dependable Rainfall patterns & Rainfall coefficients of Muja Station

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average RF	6.4	7.1	40.4	50.0	36.2	37.0	229.9	234.7	37.9	11.1	12.8	8.4	711.8
80% Dep. RF	5.5	6.2	35.1	43.4	31.5	32.1	199.6	203.8	32.9	9.6	11.1	7.3	618.0
Rainfall CV	0.1	0.1	0.7	0.8	0.6	0.6	3.9	4.0	0.6	0.2	0.2	0.1	12.0

2.2.2.2 Temperature, Relative Humidity, Wind Speed & Sunshine Hour

Average daily temperature variations throughout the year are somewhat wider (19.2°C in December to 26.8°C in June), whereas humidity values vary from 32% in June to 61% in August. Maximum temperatures over the year vary within a range of 34.7°C (June) to 26.5°C (January), and the minimum temperatures vary with a range of 11.5°C (December) to 18.9°C (June). Wind speeds are relatively high and varies from 97 (in September) to 188 (in March) km/day. Sunshine duration is reduced due to cloud cover; and values vary from 5.6 (in July) to 10 (in May) hours during over the year.

2.3 Topography

The nature of topography can influence soils of an area in many ways. In irrigated agriculture, topography influences the choice of irrigation method, the labour requirement, the irrigation efficiency, the cost of land development, the problems of drainage, the hazards of erosion, the range of possible crops that can be grown and the size/shape of fields to put under cultivations. Furthermore, the suitable soils occur on a range of slopes up to 12%. A slope of land greater than 12% is considered permanently unsuitable for irrigation for all land use types (LUTs). Based on secondary data obtained from Jarota (04) Kebele Agricultural Development Office, the topography feature of the kebele contains 100% plain. On the other hand, based on slope gradient classes which have developed from topographic survey data of the command area, using ArcGIS 10.1 Software, the command area has consisted of level to gently sloping topographic feature. In general, the slope gradient classes of the command area range from 0.2% to 5%.

From the abovementioned evidences and the agro-ecological suitability of the area, development of modern spate irrigation scheme is believed to be encouraging for the production of drought tolerant crops and bring about rapid and sustainable development in the project area.

2.4 Land Use System and Soil Characteristics

2.4.1 Land Use System

As there are no technically supported land use systems from the grass root up to regional level, for this reason, the land use data of Jarota (04) kebele is more of approximate. The data obtained from Jarota (04) kebele agricultural development office has showed that the total area of this kebele is estimated to be 2,921 hectares. Out of which the share of cultivated land is 2,006ha (68.7%) covered with different crops, forest & bush lands 85ha (2.9%), grazing 212ha (7.3%), construction 558ha (19.1%) and waste & others lands 60ha (2%). The existing land use pattern/practice of the command area and 04 kebele where the project is found has presented in Table 2.

The existing land use pattern of the command area is mainly under cultivation; that is under intensive cultivation of field crops in wet seasons (sorghum, teff, maize, and chick pea) and horticultural & field crops (onion, pepper, tomato, and maize) in dry seasons by smallholder farmers.

Table 2: Existing land use pattern of Jarota kebele and the project command area

Land use type	Command area		04 Kebele	
	Area in (ha)	% cover	Area in (ha)	% Cover
Cultivated land	300	100	2,006	68.7
Grazing land	0	0	212	7.3
Forest lands	0	0	85	2.9
Bush lands	0	0		
Construction land	0	0	558	19.1
Gullies & Others	0	0	60	2.0
Total	300	100	2,921	100

Source: Jarota (04) Kebele Agricultural Development Office & Field Observation.

2.4.1.1 Land tenure system, land holding size and share cropping

Based on information obtained from DAs and the local farmers, different land tenure systems exist in the project area. Some of them are: regular land use right, sharecropping, renting and exchange of human labour by oxen power, respectively.

The average farmland holding size of individual households (HH) is about 0.875 hectare and cultivated annually as there are land shortages in the area. In addition, most of the HHs found in the project area has fragmented lands on average from three places. In general, the individual households' average land holding size is decreasing through years owing to population number increase. In such situations, to satisfy the needs of additional food requirements, crop yields has to be increased by employing agricultural intensification approaches such as application of irrigation water, introduction of improved farmland inputs, use of appropriate farm managements, employing better cultivation techniques, etc.

In general, land is the property of the State and Ethiopian nation and nationalities. The farmers have a use right for their land and may rent out their land for not more than 25 years. The holding right to farmland is unlimited. The Federal Land Use Right Proclamation prohibits the cultivation of annual crops on land with greater than 60% slope, however the user can use steeper land if appropriate conservation measures are applied and/or perennial crops and forest trees are planted.

As stated in the revised Amhara National Regional State Rural Land Administration and Use Proclamation (2007): "any land to be cultivated by modern irrigation, causing the acquisition of the proper share of the previous landholder, can be distributed." This implies that construction of an irrigation scheme will involve re-distribution of the irrigated area between the existing land holders.

2.4.2 Soil Characteristics

Soil properties (physical, chemical, etc.) greatly influence the growth and thereby yield of crops which is grown. For the determination of important micro/macro elements for the required fertilizer application purposes a composite nature of sampling has been made with 0 - 30 cm and 30 - 60 cm soil depths. The laboratory results of physical and chemical analysis of the composite soil samples has presented in Table 3.

Table 3: Summary of physical and chemical analysis of soils of the command area

Soil auger composite sample no	Soil depth (cm)	% Sand	% Clay	% Silt	Textural Class	pH (H_2O) (1:2.5)	ECe, (dS/m)	% OC	% OM	% N	Av. P (mg/kg, ppm)
A-1	0-30	44	10	46	Loam	7.9	0.179	0.95	1.64	0.08	5.83
A-2	30-60	42	8	50	Loam	7.1	0.126	0.99	1.71	0.09	2.07
B-1	0-30	34	12	54	Silty loam	7.7	0.164	0.84	1.44	0.07	6.74
B-2	30-60	36	14	50	Loam	8.1	0.128	0.95	1.64	0.08	1.51
C-1	0-30	42	10	48	Loam	7.7	0.122	0.95	1.64	0.08	46.01
C-2	30-60	46	10	44	Loam	8.3	0.135	0.91	1.57	0.08	2.77

Note: At field condition, it has estimated that about 85% of soils of the command area are loam textured.

2.4.2.1 Soil physical properties

a) Texture

Soil texture refers to the relative proportion of sand, silt and clay in a mass of soil. Texture is important in that it helps to determine the capacity of the soil to retain moisture and air as both are necessary for plant growths. Soils with greater proportion of large particles are well aerated and allow water to pass through the soil more quickly.

Based on field observations and soil laboratory results, from soil samples collected from command area and submitted to ADSWE soil lab, the command area has predominantly loam textured soil which can be classified as well drained soil.

b) Effective soil depth

According to FAO, soil depth is categorized as follows:

Very shallow	< 30 cm
Shallow	30 – 50 cm
Moderately deep	50 – 100 cm
Deep	100 – 150 cm
Very deep	> 150

The effective soil depth of the command area was measured during field working period; and hence, all the study area soils are categorized as very deep soils (>1.5 meters).

2.4.2.2 Soil chemical characteristics

a) Soil reaction (pH)

The pH of soils can provide overall information of soils condition for crop growth and for crop selection. For these purposes soils reaction was measured in a 1:2.5 (H_2O) soil suspension.

Table 4: General rating for soil pH

Rating	pH	General Interpretation
Very high	>8.5	Ca and Mg unavailable, may have high Na, possible B toxicity otherwise as below
High	7.0-8.5	Decreasing availability of P and B above 7.0 increasing liability of deficiency of Co, Cu, Fe, Mn, Zn.
Medium	5.5-7.0	Preferred range for most crops
Low	< 5.5	Acidic soil. Possible Al toxicity and excess Co, Cu, Fe, Mn, Zn. Deficiency in Ca, K, N, Mo, P, S

The pH values of soils of the command area ranges from 7.1 to 8.3 for pH (H_2O) soil suspension test in the top 0-60cm soil depth. Based on the soils Lab result (Table 3) and pH rating (Table 4) the soils of the command has found at high pH levels. Accordingly, soils of the command area is moderately suitable for most of the selected crops to be grown. Hence, it needs to grow hight pH tolerant crops. Generally, most crops grow satisfactorily on soils with a pH ranging from 6.2 to 8.3. Where, soils with a pH of 8.3 or greater than these values usually have high sodium contents. Conversely, soils with a pH below 5.5 are strongly acidic soils and limit the availability of essential elements (N and P).

b) Electrical conductivity (ECe)

The best method for assessing soil salinity is to measure the electrical conductivity of the saturated soil extract, the ECe. Salinity effects on plants, as measured by the electrical conductivity of the saturated extract, ECe, in decisiemens per meter, dS/m, are indicated in Table 5.

Table 5: Electrical conductivity expressed in dS/m

Rating	EC (dS/m)	Crop Reaction
Non-saline	< 2	Salinity effects mostly negligible
Slightly saline	2- 4	Yields of very salt-sensitive crops may be restricted
Moderately saline	4 - 8	Yield of many crops restricted
Strongly saline	8 - 16	Only salt-tolerant crops yield satisfactorily
Very strongly saline	> 16	Only a few very salt-tolerant crops yield satisfactorily

Source: Based on Fundamentals of Soil Science, 8th Edition.

The effect of salts on plants is mainly indirect, that is, the effect of salt on the osmotic water potential. Decreasing water potential due to salt reduces the rate of water uptake by roots and germinating seeds.

Based on the soil lab result (ADSWE, 2014), soils of the command area has ECe values ranging from 0.122 to 0.179 dS/m, which indicates a non-saline effect on the selected crops as presented in Table 3 and 5.

c) Total Nitrogen

The general rating for the total nitrogen according to the Kieldahl’s method is as indicated in Table 6.

Table 6: Interpretation of total Nitrogen

N (%)	Rating
> 1.0	Very high
0.5 - 1.0	High
0.2 - 0.5	Medium
0.1 - 0.2	Low
< 0.1	Very low

Total nitrogen values of the command area soils ranges from 0.07 to 0.09% in the top 0-60cm soil depths, which indicates very low level of N in the soil profile. Thus, N source fertilizers response is very high (see Table 3 and 6).

d) Available phosphorus

Available phosphorus (P) has been determined by the Olsen method of bicarbonate extraction. Thus, soils of the command area have showed high available P values. The available P range for the command soil is from 1.51 to 6.74 mg/kg or PPM in the top 0-60cm soil depths. Therefore, the soil lab result has indicated that soils of the command area are low to medium in available P and hence P source fertilizers response may not be more likely (Table 3 and 7).

Table 7: Interpretation of phosphorus by Olsen's method

Available P (ppm)	Value	Comment
> 15	High	Fertilizer response unlikely
5 –15	Medium	Fertilizer response probable
< 5	Low	Fertilizer response most likely

e) Organic matter (OM) and organic carbon (OC) content

Organic matter is a good reserve for plant nutrition. Almost all life in the soil is dependent on OM for nutrients and energy. The importance of OM for plant growth is so vital. The primary or original source of soil OM is the production of the primary producers (the higher plants). This organic material is subsequently consumed and decomposed by soil organisms. The result is the decomposition and the accumulation of OM in soils that has great diversity and a highly variable composition.

During decomposition of plants and animals residues, there is a loss of carbon as carbon dioxide and the conservation and reincorporation of nitrogen into microbial products, which eventually are incorporated into humus. As a consequence, humus contains about 50-60% carbon (C) and 5% nitrogen (N) producing a C: N ratio of 10 or 12 to 1. The more decomposed the humus is the lower or narrower will be the C: N ratio. Humus is a good source of biologically available nitrogen. Humus is also a significant source of sulfur and phosphorus.

Based on the soil lab results, soils of the command area OC content ranges from 0.84% to 0.99% (average 0.915%) in 0-60cm soil depths, which indicates a very low contents of OC; whereas the OM content ranges from 1.44% to 1.71% (average 1.575%) in the same depths of soils, which is indicating low contents of OM (Table 3 and 8). The ratio of OC to OM content, for soils of the project area, is nearly 1:1.721, which is in the optimum ratio and this ratio can also matches to that of FAO's. According to FAO, the optimum ratio of OC to OM content is 1:1.7–2.

Table 8: Interpretation of OM and OC contents

Parameter	Range	Rating
Organic matter (%)	>6	Very high
	4–6	High
	2–4	Medium
	1–2	Low
	<1	Very low
Organic carbon (%)	> 20	Very high
	10-20	High
	4-10	Medium
	2-4	Low
	<2	Very low

2.5 Water Resources

Considering surface water resource only one seasonal river (i.e., Gobu) is crossing through the kebele where the project area is found. Thus, about 1,006 hectares of land is under cultivation using flood water from the wadi of Gobu, mainly using community spate irrigation. Moreover, modern ground water irrigation project is under way of expansion in the project area and hence about 201 hectares of land is under irrigation so far. In general, due to erratic rainfall distribution and production shortfalls in the area a thorough assessment and development support for existing spate irrigation potential is critical.

2.6 Natural Vegetation Cover

With regard to the vegetation cover of the kebele, the major forest trees naturally and artificially grown are: Kurkura, Bedena, Wacho, Kinchib, Moringa, and Girar; and bushes are: Kinchib, Kurkura, and Girar. However, Kinchib is the dominant tree and bush plant found in the vicinity of the command area.

3. PRESENT AGRICULTURAL SITUATION

3.1 Farming System

The livelihood of the rural communities within the project area and its surroundings is almost entirely dependent on agriculture and its related sectors. Kolla mixed farming is the common agricultural practices being carried out in the project area where livestock production is undertaken complementary to crop production (i.e., crop and livestock productions run side by side) and almost all the farming society practice this activity. In general, the main agro-economic base of the area is mixed-farming of field crops and rearing of livestock, especially rearing of cattle, goats, sheep, equines (donkey), and camel.

The farming system, which accounts for the bulk of food production in the area, is characterized by subsistence farming with its typical feature of low input-low output productivity. Crop production is predominantly carried out under rainfed conditions and is frequently vulnerable to natural vagaries such as unreliable/erratic and uneven distributions of rainfall, recurrent drought and prevalence of crop pests attack. Irrigated agriculture production has not started in recent years in the area.

At present, the command area is being cultivated entirely by smallholder farmers. Farmers use their land predominantly for rainfed subsistence cropping; and almost all of their staple food production comes from this system. Irrigated farming is not a new phenomenon in the project area; and it is practicing on small scales mainly by using water from river diversions and perennial springs.

3.2 Cropping System

The market situation and the physical environments are among the major factors that influences on the types of crops grown; and it is also the causes of farmers to grow similar mixes of crops. When we come to the project area the following cropping systems are being practiced.

3.2.1 Mono-cropping:

Mono-cropping: although this system is not appropriate from scientific point of view, i.e. mostly cereals are rotated with cereals and so on. Some farmers also do practice mono-cropping of same crops such as sorghum after sorghum is grown in the area. This system is carried out traditionally using low input and poor management practice such as land preparation and weed control.

3.2.2 Intercropping:

Intercropping: no intercropping practices are carried out in the project area for rainfed crops.

3.2.3 Crop rotation:

Crop rotation: Farmers of the project area commonly rotate cereals with cereals (such as sorghum with teff and vice versa); whereas, cereals with pulses rotation practices infrequently in the project area as long as no more pulse crops are grown there except chick pea. However, farmers sometimes rotate shallow rooted crops with deep-rooted crops. The typical crop rotation trend of the project area has illustrated in Table 9.

Table 9: The existing crop rotation patterns of the project area

Meher/Wet Season (1st)	Meher/Wet Season (2nd)
Sorghum	Sorghum/teff
Teff	Sorghum/chick pea
Chick pea	Teff/sorghum
Maize	Teff/chick pea/sorghum
Meher/Wet Season (1st)	Irrigated/Dry Season
All crops	Vegetables(onion), maize, teff

Source: Farmers of the project area during agronomy survey.

3.3 Crops Production and Yields

3.3.1 Rainfed Crops, Cropping Patterns and Crop Calendar

The rainfed agriculture is mainly based on wet season (*Meher*) rainfall. In the project area, the longer rainy season (*kiremt*) occurs from Late-June to Late-September; however, sometime the rain ends at the end of August. During this time of span some crops are grown. Depending on the climatic factors, late or early start of *Meher* rainfall, cropping pattern vary from year to year. Furthermore, farmers' preferences, market values, quality of land preparation, pest incidences, input availability, length of growing period (LGP), food values of the crops and so on also determines the cropping pattern.

As altitude governs the temperature, rainfall and types of crops grown, the project area is suitable for the production of lowland crops. The major crops that grow in kebele 04, where the project site is found, in wet seasons includes: sorghum, teff, maize, chick pea, etc. Based on the crop yield assessment data of kebele 04 for the cropping years of 2013, sorghum is the major crop that accounts more than 48% of the total area coverage followed by teff (46%). Generally, sorghum is the dominant crop commonly produced for consumption and rarely for sale. It also accounts more than 48% of the total production in same cropping year (see Table 10). Sorghum, maize, teff and chick pea are the major crops produced for home consumption. Other crops, such as: onion, pepper, tomato are mainly produced for sale and cash income; and also to supplement home consumption. The growing season varies from crop to crop and even from place to place based on agro-ecological variation. However, the general period of growing season ranges from Earl April to November for wet season crops production and from December to May for irrigated crops.

The data for crops grown, area coverage, productivity and production of year 2013 in Jarota (04) Kebele has presented in Table 10.

Table 10: Existing cropping pattern & rainfed crop production of kebele 04, in 2013 cropping years

S/N	Crop types	2012			2013		
		Area (ha)	Productivity (qt/ha)	Production (qt)	Area (ha)	Productivity (qt/ha)	Production (qt)
1	Sorghum	1005	Na	Na	1005	27	27135
2	Teff	954	"	"	954	16	15264
3	Maize	39.5	"	"	39.5	24	948
4	Onion	80.5	"	"	80.5	160	12880
	Total	2079		"	2079		56227

Source: Kebele 04 Agricultural Development Office

The crops operational calendar of Jarota (04) Kebele has illustrated in Table 11 here below.

Table 11: Existing operational calendar for different farming activities of rainfed crops

S/N	Crop types	Land preparation	Sowing	Weeding /cultivation	Harvesting	Threshing
I	Rainfed crops					
1	Sorghum	Jan-Apr	Early Apr - End May	Jul-Mid Aug	Mid Nov-Late Dec	Dec-Jan
2	Teff	Jun-Earl Jul	Mid Jul-Mid Aug	Aug-V/Earl Sept	Mid Sept-Oct	Nov-Jan

S/N	Crop types	Land preparation	Sowing	Weeding /cultivation	Harvesting	Threshing
3	Maize	Jan-End Apr	May-Earl Jul	Jul-Mid Aug	Mid Aug-End Oct	Oct-Nov
4	Chick pea	Jun-Mid Aug	Mid Aug-V/Earl Sept	Sept	Mid Oct-Nov	End Oct-Nov
II	Irrigated crops					
1	Onion	Oct-Jan	Feb-Apr	Feb-May	Apr-Jun	-
2	Tomato/pepper	Oct-Jan	Feb-Apr	Feb-May	Apr-Jun	-
3	Maize	Nov-Jan	Jan-Mar	Feb-Apr	Apr-Jun	-

Source: Farmers of the project area during agronomy survey.

3.3.2 Existing Irrigated Agriculture and Practices

The existing low productivity or production capacity of crops enforced farmers to develop traditional irrigation practices in the project area (i.e., primarily due to erratic/unreliable nature of rainfall, uneven distribution of rainfall, crop pests attack, and population pressure). Therefore, irrigated agriculture has gradually developing following rainfall abnormalities and scarcity of farmlands. In the project area irrigated crop production has been practicing using water from the wadi Gobu by constructing traditional Intake structures. Accordingly, the project area is practicing two seasons crops production. The first is rainfed crop production which is the main income base and constitutes about 93% of the annual cultivated land and about 66% of the annual income; and the second is irrigated crop production (traditional) that accounts about 7% of the whole cultivated land area and 34% of the annual gross production.

According to the 2013 annual irrigated crops area and yield estimation data, obtained from Jarota (04) Kebele Agricultural Development Office, a total of 153.5 hectares of land was covered by irrigated crops and about 29,282 quintals was produced in the kebele. From the woreda total irrigated land area it accounts about 1.8% area coverage (see Table 12). However, the existing traditional irrigation is not diversified because of different technical and social reasons. Accordingly, the productivity of crops is comparatively low due to traditional management practice and low input uses (see Table 12). In the project area the widely used methods of irrigation are furrow and flooding for almost all crops.

Table 12: Existing traditional irrigated crop production data for year 2013

S/N	Crop type	Kebele 04 in 2013			Raya Kobo Woreda in 2013		
		Cropped Area (ha)	Production (qt)	Productivity (qt/ha)	Cropped Area (ha)	Production (qt)	Productivity (qt/ha)
1	Onion	131.5	28930	220	3309.5	728090	220
2	Pepper	0	0	0	320	4200	15
3	Cabbage	0	0	0	442.2	39982	150
4	Tomato	0	0	0	504.6	100920	200
5	Carrot	0	0	0	79.35	634.8	8
6	Lettuce	0	0	0	79.35	7141.5	90
7	Barley	0	0	0	11	275	25
8	Wheat	0	0	0	14.5	290	20
9	Maize	0	0	0	406.5	27080	80
10	Teff	0	0	0	2601	39866	14
11	Chick pea	22	352	16	397	6352	16
12	Lentil	0	0	0	29	261	9
13	Field pea	0	0	0	11	121	11
14	Avocado	0	0	0	3	450	150
15	Papaya	0	0	0	12	3000	250
16	Orange	0	0	0	10	1500	150
17	Mango	0	0	0	94	18800	200
18	Banana	0	0	0	35	5250	350
19	Sugarcane	0	0	0	158	197	1250
20	Hops	0	0	0	5	750	150
	Total	153.5	29,282		8,522	985,160.3	

Source: Jarota (04) Kebele and Raya Kobo Woreda Agricultural Development Offices.

Concerning the irrigation development supporting services, alike other woredas of the region, irrigation and drainage work process has already established under Raya Kobo Woreda Agriculture Development Office. Moreover, irrigation expert has assigned in the project kebele.

During public meeting, carried out at time of field survey, farmers of the project kebele have showed keen demand/interest on the proposed Gobu 3 Spate Irrigation Scheme.

3.3.3 Experience of Private and State Agricultural Enterprises

There is no notable private investment farming companies and state agricultural enterprises within the kebele where the project area is found. However, there are private agricultural investors (e.g. Getahun, KIWO, etc) and state owned agriculture enterprise (Zeleke farm) within the woreda.

3.4 Cropping Practices and Use of Technologies

Analysis of existing agricultural practices must be one of the important elements in agricultural development planning. This includes both pre- and post-harvest practices (tillage, land preparation, seed bed preparation, planting methods and date of planting, transplanting, irrigation, application of fertilizers and/manure, cultivation, disease and pest control, crop rotation, harvesting, threshing and winnowing, transport, storage, marketing, etc). These practices had been done by all farmers in the area even though the degree of implementation varies and not as required.

3.4.1 Pre-Harvest Practices

3.4.1.1 Tillage and land preparation

In the project area land preparation commences from land clearing, i.e., clearing of shrubs, weeds and plant residues. Stirring the soil for the benefit of domesticated plants is known as tillage. Annual weeds are controlled more effectively by tillage than are perennials. Tillage for seedbed preparation is intended to destroy existing weeds and to stimulate germination of weed seeds in the topsoil layer. Seedbed preparation in the project area has been carried out using animal drawn local plough called "*Maresha*”. This practice has been used since ancient times and is still in use without any improvement. Farmers prefer this plough since it is cheaper, versatile, lighter and easily maneuverable.

Tillage also enables farmers to control weeds which would otherwise compete with their crops for soil moisture, nutrients and light. Furthermore, it assists in the mixing and burying of previous crops residues into the soil, controlling of certain insect pests and plant diseases.

Ploughing is the basic tillage operation in that it’s main purpose being to loosen, turn and mixes the soil, burying crop residues, vegetation or manure. It also brings to the surface a layer of soil from below and exposing it to weathering. Subsequent tillage operation, normally called secondary tillage, is harrowing, clod crushing, leveling and weed control (cultivation) in the standing crops. The frequency of ploughing in the project area varies with soil types and crops to be grown. The highest frequency of ploughing is done for sorghum, maize, teff and horticultural crops like pepper, onion, tomato, etc. In general, the frequency of ploughing varies from three to five (see Table 13). Likewise, the time and labour required for primary land preparation is greater than planting (sowing) operations.

Table 13: Average existing land preparation practices

No.	Crop type	Plowing frequencies
I	Rainfed crops	
1	Sorghum	3-4 (average 3)
2	Maize	3-4 (average 3)
3	Teff	3-5 (average 4)
4	Chick pea	3-4 (average 4)
II	Irrigated crops	
1	Onion	3-5 (Average 4)
2	Pepper	3-4 (Average 3)
3	Tomato	3-4 (Average 3)
4	Maize	3-5 (Average 4)

Source: Farmers of the project area during agronomy survey.

3.4.1.2 Planting/Sowing

Following land preparation sowing (planting) operation starts in the month of Early April for sorghum and extends up to the mid of August for chick pea. Farmers sow teff seeds after the final ploughs and trembling by animals (for black cotton soils) to make the land surface smooth. Other crops, such as sorghum, chick pea, maize, etc are broad casted and then under ploughed. In general sowing begins shortly after the first rain shower for rainfed crops and usually done by broad casting. Row planting is being practiced for horticultural crops (like onion). Farmers sow/plant sorghum, teff, maize, etc, seeds by broad cast and then under plow it. Most of the farmers use local seeds for planting unless and otherwise they are told and forced by governmental structures/bodies to take and use improved seeds. The local varieties are not uniform and some of are low in yield potentials.

3.4.1.3 Crop protection practices

Every year a significant amount of crop yield is lost due to crop pest infestation. In this day, in most farming systems, natural mechanisms of regulating the population of crop pests and other organisms have been disturbed or partially replaced by artificial mechanisms such as chemicals and drugs. Under such unnatural conditions, if not using chemicals it will lead to considerable production losses. Hence, instead of direct/primarily use of chemicals, other alternative pest control measures are growing such as application of integrated pest management (IPM) method.

In IPM, in the context of farmers environment and the population dynamics of the pest species, all suitable techniques and methods are used in the most compatible manner possible so as to maintain pest population at level below those causing economic injury.

Generally, chemical pest control measures are recommended only if all the mechanical, biological and physical measures are ineffective to bring the losses caused by the pest below economic injury level. In the project area there are economically important insect pests, weeds, and diseases of crops as it has explained here below.

a) Insect pest

Agro-ecologically the area is more suitable for multiplication of various insect pests. Some of the important insect pests that commonly occurring and causing extensive damages to different crops are presented in Table 14.

Table 14: Common insect pests and crops infested

S/N	Insect pests		Crops infested	Extent of Damage
	Common name	Scientific name		
1	Ball worm	Heliothis armgera	Chick pea, pepper	High
2	Stalk borer	Buseola fusca	Sorghum	High
3	Cut worm	Agrotis segetum	Chick pea	Medium
4	Grass hopper	Different spp.	Teff, sorghum	Medium
5	Beetles		Cane crops	High
6	Shoot fly	Delia sp.	Teff	High
7	Termites	Different types	All crops	High
8	Weevils (storage pest)	Sitophlus spp.	Sorghum, maize, pulses	High

Source: Jarota (04) Kebele Agricultural Development Office.

b) Weeds

Weeding is the next operation immediately after sowing, and even sometimes sowing overlap with weed control and it is at this time that more labour required. Especially July and August are the months that need more labour.

Weed flora is one of the most important pests known to cause great crop yield loss and quality reductions. The control mechanism used by farmers is hand weeding for most crops and hoeing for some other crops like maize and other horticultural crops. However, the quality of weeding, time of weeding and its frequency affects the yield below its standard quality. Some of the most common weeds found in the project area, crops infested and extent of damage are illustrated below in Table 15.

Table 15: Major weed species and crops infested

S/N	Common Name	Scientific Name	Crops infested
1	Double thorn (Akakima-Amharic)	Oxygonum sinuatum	All crops
2	Mexican popi (Netch Lebash-Amharic)	Argemone mexicana	All crops
3	Cocklebur (Banda-Amharic & Megale-local)	Xanthium strumarium	All crops
4	Congress weed (Kinche-local)	Parthenium hysterophorus	All crops
5	Spiny cocklebur (Yeset Milas=Amharic)	Xanthium spinosum	All crops
6	Yewof teff (Tefatef = local)	Eragrostis cilianensis	All crops
7	Purpl Sedge (Engicha)	Syprus spps	All crops
8	Coach/Star/Bermuda grass (Serdo-Amharic)	Cynodon niemfuensis	All crops
9	Water maker (Wof Ankur-Amharic)	Commelina spp.	All crops
10	Blue coach grass (Wariat-Amharic)	Digitaria abyssinica	All crops
11	Witch weed (Akenchira - Amharic)	Striga hermonthica	Sorghum, maize

Source: Jarota (04) Kebele Agricultural Development Office & Field Observation.

Hand weeding and hoeing for horticultural crops and maize are the practices used for the weed control of broadcasted crops. The number of weeding/hoeing varies from one (for chick pea) to four for horticultural crops, such as onion (see Table 16). The noxiousness of weeds, seedbed preparation and quality of primary weeding determine the frequency of weeding. The time and quality of land preparation also have wide contribution for weed management. Weeding and cultivations are done by men and women including families who have reached for working.

Table 16: Existing weeding practices and frequencies

No.	Crop type	No of weeding and/or hoeing commonly practiced
I	Rainfed crops	
1	Sorghum	1 Shilshallo + 2 hand weeding
2	Maize	2 hoeing + 2 hand weeding
3	Teff	2 hand weeding (depending the land condition)
4	Chick pea	1 hand weeding with hoeing
II	Irrigated crops	
1	Onion	3 hoeing + lastly 1 hand weeding
2	Tomato/pepper	3 hoeing + " 1 hand weeding
3	Maize	1 Shilshallo + " 1 hand weeding

Source: Farmers of the Project Area during Agronomy survey.

c) Crop disease

Farmers in the project area do not have the concept of crop diseases. For this reason, farmers don't practice direct control measures. They usually relate the effects with insect pests or natural hazards. Diseases are not scientifically diagnosed by expertise in the area thus shortfall of clear understanding of diseases is another problem. The most common crops diseases identified and cause crop yield reduction in the project area are: smut (locally called *Areguaso*) on sorghum, root rot on chick pea, pepper, etc (see Table 17). The crops attacked and the extents of damage are not all well known.

Table 17: Major crop diseases and crops affected

S/N	Types of diseases		Craps attacked	Extent of Damage
	Common Name	Scientific Name		
1	Smut	Sphacelotheca spp.	Sorghum	Medium
2	Bulb rot (damping-off)	White rot	Onion	High
3	Root rot & wilt	Rhizoctonia, phythophtra, and pithium spp.	Pepper	High
4	Root rot & wilt	Fusarium spp.	Chick pea	Medium

Source: Jarota (04) Kebele Agricultural Development Office.

d) Vertebrate pest

Regular Birds, Rats, and Porcupines from wild lives are some of the most important vertebrate pests that affect crop production in the area. Porcupines attack sorghum and maize. Bird pests also attack sorghum in the field. In addition, rodents attack different types of crops both in the field and storages.

The traditional control measures taken in the area are not exclusively effective. Therefore, significant amount of yields are lost yearly. The regulation of wild life is also another production constraint that protects the life of some vertebrates. In general, farmers are currently suffering from these pests attack; and they affect all crops at all levels of their growth stages.

3.4.2 Post-Harvest Practices

3.4.2.1 Harvesting and threshing

Harvesting and threshing are the final operations and are the most labour intensive and time consuming operations and are done in a traditional manner in the project area. Harvesting is carried out by human labour using local hand tool 'Sickle' and then the harvested crops are pile up until the time of threshing.

Cereal and pulse crops are left on the ground for some time to get dry after harvest and piled up for a while, one day up to one month. For horticultural crops after harvest they are taken soon to the market for sale. The harvested crops are threshed by human labour and animal power after a threshing ground '*Awudma*' has selected, cleaned and compacted. Crops like sorghum and chick pea are threshed on the prepared ground and threshing is carried out mostly by oxen and trampling on it. Farmers continuously turn the straw with a forked stick, locally call it '*Mensh*', to get the panicles exposed to the oxen hooves and the grain get loosen and then separated. The straw and chaffs are separated from the grain by the process of winnowing.

3.4.2.2 Storage

After cleaning the grain farmers pack the produces by plastic bags and transport to their home by loading on donkeys or camel backs for storage. The produces are stored in different storage structures. Teff, maize, and chick pea are commonly stored in *Gotta* and also with bags (*Kesha*) while sorghum is stored in underground pits. The storages are placed indoor and outdoor including underground pits. Regardless of the types of structures used and the precautionary measures taken, the overall annual losses of stored grains (by rodents, birds and insect pests like weevils) are high. As studies suggested by FAO and others, the losses due to poor storage of grains has estimated to be as high as 15–20%. In the project area the post-harvest losses are estimated to be about 3% (based on information gained from kebele 04 DAs).

3.5 Farm Inputs Supply and Utilization Experiences

The two essential agricultural inputs (fertilizers and improved seeds) are supplied by cooperatives & union in the project area; and the other essential input, agro-chemicals, are purchased from private traders in the free market by individual farmers. Fertilizers and improved seeds of maize, sorghum and teff are supplied through farmers' service cooperatives from respective union. The supplies of fertilizers are summarized in **Error! Reference source not found.**. About 525.26 quintals of chemical fertilizers are supplied to Jarota (04) kebele where the project area is found in 2013 cropping year.

Jember Union and Service Cooperative are community based organization involved in input supply. Despite weak organizational set up of service cooperatives in the project area the respective union is providing inputs supply services to the required members. Improved seeds of maize, sorghum, teff and vegetables are the dominant seeds used by smallholder farmers. Vegetable seeds are mostly purchased by farmers from private traders.

Regarding agro-chemicals, mainly herbicides are available from private dealers. The aforementioned major suppliers are not involved in the distribution of agro-chemicals; however, during the outbreak of major regular pests like ball worm the government office will supply the required chemicals.

The physical, chemical and biological processes in the soil are strongly influenced by climate, plants & animals' life and human beings activities. Generally, inputs are added to improve the capacity of the soil to supply plant nutrients for the plants/crops.

3.5.1 Organic Input Use

As most parts of the region, animal dung is used for fuel wood and hence very few farmers are using for soil management. Even though many-trainings have been given for many of the local farmers, on compost preparation and its uses, due to poor awareness of it, no or few farmers have started preparing this organic input (based on data obtained from Jarota (04) kebele agricultural development center). Generally, compost preparation and utilization by local farmers of the project area is at low level and it has not well adapted inorder to modify the existing soil fertile status. Nonetheless, manure utilization has adapted by farmers of the area at a better level.

3.5.2 Commercial input

Modern inputs such as chemical fertilizers (DAP and UREA), improved seeds, and agrochemicals are introduced into the area through agricultural extension systems. However, farmers of the area are not in active use of inputs. The reasons explained by the interviewed local farmers for its low use are: high price of inputs and a fear of natural hazards (shortages of rainfall), late arrival/supply of inputs for consumer farmers. Moreover, demand based supply of inputs is not practicing in the area and farmers' poor economic base to return the loan. Therefore, strong credit facilities and agricultural extension supports should have to be intensified to improve the existing low input use in the project area; otherwise, the level of inputs use will become low in the coming years and hence production becomes lower than the present. The types and amounts of inputs, improved seeds, agro-chemicals and farm tools, distributed and used in 2013 cropping year in Jarota (04) kebele and Raya Kobo Woreda has presented in Table 18.

Table 18: Inputs used in the project area in Meher, in 2012 & 2013 cropping yeas

Types of Inputs	Unit	Jarota (04) Kebele		Raya Kobo Woreda	Variety
		2012	2013	2013	
Chemical fertilizers		3.0	525.26		
DAP	Qt	1.5	318.88	4083.7	
UREA	"	1.5	206.38	2629.89	
Lime	"	0	0	0	
Bio-fertilizer	PCs	0	0	507	
Improved seeds					
Sorghum	Qt	0	0.48	26	Girana-1, Gobye, Abshir
Maize	"	0	4	19.5	Melkasa-II
Teff	"	Na	0	165	Quncho, Dz-Cr-37
Wheat	"	0	0	284.5	HAR-1685 & Pica flora
Chick pea		0	0	36.5	Arerti
Vegetables		0	0	12.72	Red Bombay, Marko Fana
Coffee seedlings	No	0	0	Na	
Mango seedlings	"	0	0	“	
Avocado seedlings	"	0	0	“	
Agro-chemicals					
Insecticides	Lt/kg	Na	Na	1818/813	
Herbicides	"	“	“	Na	
Fungicides	"	“	“	“	
Rodenticide	Lt/kg	“	“	“	
Farm tools					
BBM	No	0	0	0	
Tie Ridger	"	0	20	Na	
Water pumps	"	0	0	11	
Geo-membrane (lined)	"	Na	10	Na	
Drippers (farmers level)	"	0	0	0	
Pedal pumps	"	0	0	0	
Rope pump	"	0	0	0	

Na=data not available

Source: Jarota (04) kebele and Raya Kobo Woreda Agricultural Development Offices.

Based on data obtained from DAs of Kebele 04 and information gathered from local farmers, artificial fertilizers (DAP & Urea) are applied at different rates for maize, sorghum, and teff for Meher season crops and onion, tomato, pepper, etc for irrigated-horticultural crops.

Nonetheless, no artificial fertilizes has been used in year 2014 for irrigated crops (Based on data obtained from kebele 04 agricultural development center).

3.6 Labour and Draught Power Conditions

As most parts of the country, the main power source of production in Amhara region in general and the project area in particular is human labour and oxen power. Almost all-rural populations of the region in general and project area in particular earn their living by manual labour. As compared to mechanized agriculture, manual labour requires mobilization of more human labour at a time for seasonal farm operations. Oxen power is the most important power source of the area next to human labour. However, camel power is becoming the next power source of the area since recent years. This unskilled labour has been used for the last centuries and is still in use without any modification.

3.6.1 Labour Power

The rural populations are directly dependent on human labour for their livelihood within the region in general and the project area in particular. No farming activities can be carried out without direct involvement of human labour. All agricultural production processes from primary land preparation up to final consumption levels are carried out using this unskilled labour. This labour is readily available and relatively cheap in some months of the year except from June to November where critical farming operation activities take place.

Furthermore, when farmers are facing a problem of shortage of labour during crop production processes they use group working systems. Such type of group working system is common in the project area and they locally call it '*Wonfel*'. The major agricultural activities and time where community labour are needed and used are in wet seasons during weeding, harvesting, and threshing times, especially for teff from land preparation up to threshing and for sorghum during harvesting. As to the existing labour requirements of the project area per hectare basis it has presented in Table 19.

3.6.2 Draught Power

Draught animals make an important contribution to Ethiopian agriculture and rural economy. Generally, draught animals, such as oxen are the main power sources of traction and for threshing in Amhara region in general and the project area in particular. Cows are mostly used for milking and replacement of oxen. In the project area, camels carry out transportable materials, including farm produces. The main constraint encountered in rearing of animals is the shortage of feeds. Grazing animals in over grazed lands and collecting and providing hay and/or straws as a supportive feeds is the animal feeding system in the project area. However, the feed sources are not sufficient enough for existing cattle; and hence the traction power of draught animals and the milking potential of cows are lower than their potential.

Oxen are the major source of draft-power in the project area. The total numbers of oxen and households (HHs) found in the project kebele are: 1,061 oxen & 161 camels and 1,480HHs (based on data obtained from DAs of kebele 04). The numbers of oxen-less HHs, in the project kebele, are about 862. Furthermore, there is tractor rent access at Kobo town and Aramo kebele. Based on information gathered from the local people there are about 8 to 10 tractor renters at Kobo town and its surroundings; and the rate of tractor rent per hectare base is two thousand ETH birr (2000 birr/ha). Farmers of the project area have already started to get tractor rent accesses from Kobo town.

Farmers, who have no farm oxen, grow crops using the following traditional renting agreements:

≡ Renting their farm-lands to those who have oxen; and hence the produce is shared equally 50% share between the land renter and the sharecropper (after consideration of inputs cost incurred by the sharecropper). All the inputs and labour costs are covered by the sharecropper.
≡ Renting farmlands by money: for Meher season, renting of one hectare of land for 1500-2000 birr/year; for irrigated land, renting a quarter of (¼) hectare land for 3000-4000 birr/year.
≡ The other option is renting tractor power from Kobo town for 2000 birr/ha rate.
≡ Another option is employing farmer as a share owner of 25% produces, and;
≡ Renting oxen-power (1 *Timad* /OD) for about 500birr.

The existing labour and oxen requirements of the project area for various farm-operations and major crop types on one hectare basis are presented in Table 19.

Table 19: Existing labour and oxen requirements for major crops and various farm operations

Crop type	Man & Oxen Days	Land Preparation	Sowing	Weeding & cultivation	Irrigation	Harvesting	Threshing
Teff	M	11	4	56	0	26	14
	O	15	4	0	0	0	3*
Sorghum	M	11	4	26	0	24	6
	O	11	4	2	0	0	3*
Maize	M	11	4	18	0	36	12

Crop type	Man & Oxen Days	Land Preparation	Sowing	Weeding & cultivation	Irrigation	Harvesting	Threshing
	O	11	4	2	0	0	0
Chick pea	M	11	4	28	0	16	6
	O	11	4	0	0	0	3*
Tomato (Irrigated)	M	11	4	156	36	48	0
	O	11	4	0	0	0	0
Onion (Irrigated)	M	15	4	156	48	48	0
	O	15	4	0	0	0	0

M=Man days; O=Oxen days ***=folded by 4 times**

Source: Farmers of the project area.

3.7 Agricultural Support Services

3.7.1 Agricultural Extension and Training

Agricultural extension is the technology dissemination service to potential producers (i.e., smallholder farmers, private investors, etc). To facilitate the technology dissemination process and the information transfer four development agents are assigned in the kebele who have trained in and working in different disciplines, i.e., crop production, livestock production, natural resource management, and irrigation agronomy. Agricultural development center head person has also assigned to lead and manage all the activities carried out within the kebele.

In addition, one animal health technician and one cooperative expert are assigned to provide extension services in their fields of work for 3 kebeles. In the project kebele, there are also a number of governmental teams or development teams (in Amharic=Yelmat budin); and each team contains from twenty to thirty member farmers and each teams has also group leader that would usually be a model or a front line farmer.

Furthermore, there is an extension team (work process) under the Woreda ADO level. Technical staffs from the woreda agriculture development office (ADO) provide technical supports to development agents as required. In-service trainings are also given to development agents to improve their skills and introduce extension package programs.

Raya Kobo Woreda Agricultural Development Office carries out agricultural extension activities generally within the woreda and particularly at the development center level (kebele). Currently a participatory extension system is being exercised not only in the project area but also in Amhara

National Regional State as a whole. The system is based on demonstrating and training of farmers in proven technologies in a participatory manner. Farmers training centers (FTCs) has constructed for the above mentioned purposes and furnished with necessary training furniture but are not well functioning because of different reasons. New agricultural technologies are not being demonstrated to farmers in the FTC site due to that no suitable land at the FTC site.

Close follow up and seasonal supervision is highly essential to give the local farmers equal chance of technical support. The major supports provided by the development agents include:

- Close follow up of the packages, crop production & protection activities, livestock production and health, soil and water conservation activities, aforestation, and other integrated food security Programme.
- Controlling of inputs supply and distributions
- Technically training and support in the preparation of compost.
- Demonstration of new agricultural technologies such as motor/water pumps and pedal pumps for irrigation, modern bee keeping using modern bee hives, etc
- Forage development activities and reporting of animal diseases to the veterinarian and other extension activities to the supervisors.

Improved seeds of crops, farm implements and equipments before disseminated for farmers have to be tested for its adaptability and acceptance on farmer's field. Basic and improved seeds demonstration and multiplication sites were not observed except on teff, cereals, pulses and vegetables.

3.7.2 Agricultural Research

Agricultural research in the area is mainly undertaken by Sirinka Agricultural Research Centre (SARC). SARC is centrally located about 80km far from the project area; and has an opportunity to increase the productivity of Mid-highland crops through improved technology. Sirinka agricultural research center which was established in year 1987 and since then made available quite a lot of useful agricultural technologies in fields of crops (low land pulses; highland pulses; highland oil crops; lowland oil crops, vegetables, fruit crops, fiber crops, etc), soil/soil fertility management, forestry and agro-forestry, soil and water conservation, agricultural water management, cattle; sheep; goat; fisheries

& aquaculture; bee; animal feed and nutrition, agricultural economics, etc. Hence, the center of excellence of SARC is mainly concentrated on low land, mid-highland and highland crops.

SARC has developed and released different productive and disease resistant/tolerant crop varieties for the region. The agricultural research activities are carried out with the participation of the end users that allows communities to become involved in on-farm adaptation trial activities. Moreover, SARC has sub-center site near Kobo town and working on irrigated crop research. Kobo agricultural research sub-center is comparatively nearer to the project site.

3.7.3 Credit Facility

Few credit suppliers/Institutions are found in the project area, such as: HABP, ACSI and Farmers' Service Cooperative & Jember Union. The supplied credits are used for different purposes and inputs purchase.

3.8 Constraints and Opportunities of Agriculture and Irrigation Development

3.8.1 Agricultural Development Constraints

Agricultural development in general and crop production in particular usually exhibit a number of constraints which mainly relate to climatic and edaphic factors, socio-economic conditions, bio-physical situations, market access and availability, technological development, etc. Crop production is an agricultural activity carried out in the external environment and easily exposed for environmental hazards. The hazards hinder the full exploitation of available resources such as land, water and labour.

Of the various bio-physical and socio-economic problems that affect crop production in the project area in particular and within the region in general are: erratic nature and uneven distribution of rainfall, poor management practice, crop pest occurrence and insufficient controlling mechanisms, low level of agricultural inputs' use by farmers, lack of use of improved farm implements, poor cropping system, inadequate extension service, and back ward irrigation practices are the most serious factors that lags behind the sector.

Based on discussions made with the local farmers and DAs of Jarota (04) kebele and also confirmed by visual observation, during field study, the major constraints for the growths of crop production and productivity are categorized under three main groups and are listed in detail here below:

3.8.1.1 Social constraints

- Farmers doubt on the use of new technologies and improved practices as well as lack of clear awareness among the local farmers about use of new technologies and improved practices.
- Continuous increase of agricultural inputs' price from year to year (i.e., fertilizers, improved seeds, agro-chemicals, etc). Because of this, farmers use local seeds and low amount of inputs, especially low rate of artificial fertilizers per hectare basis.
- The local farmers' sentiment is that soils of the project area is long years transported and deposited soils from highlands and hence no need to use chemical fertilizers.
- Development of deep rooted dependency syndromes among the local farmers (free need for supply of inputs).
- Poor working culture of local farmers (i.e., laziness habit of farmers, satisfaction with minimum incomes, looking dry season works as a tiresome).

3.8.1.2 Institutional constraints

- Slow development of agricultural research; and also existence of poor linkages among Research - Extension and farmers system.
- Poor/loose agricultural extension services and trainings, especially on irrigation at woreda and kebele level.
- Input suppliers' late supply of inputs, especially late arrival of improved seeds, i.e., after farmers has covered his farmland with his local seeds.
- No agro-ecology based improved seeds supply; and lack of access for early maturing crop varieties.
- No agricultural inputs supply for irrigated crops in dry seasons other than the left over ones from Meher seasons.
- Farmers cooperatives are not strong enough institutionally and hence their services supply and managements are poor.

- No sufficient number of credit supplier institutions and credit accesses in the area; and also no timely credit supplies for farmers too.
- Lack of strong value-chain systems (agro-businesses) in the project area and the surrounding kebeles as well as woredas to consume excess productions of different crops.
- Insufficient amount credit supplies for the purchase of agricultural inputs and imposition of inputs direct purchase system (by cash).
- Light power interruptions and maintenance problems occurred for the established modern ground water irrigation project system.

3.8.1.3 Agronomic and environmental constraints

- Moisture stress problems due to erratic nature and uneven distribution of Meher & Belg rains.
- Flood hazards coming from upstream hillsides and high land areas in wet & Belg seasons.
- Use of low amount of chemical fertilizers per hectare basis to improve soil fertility status.
- Low level of composting and manure utilization practices of local farmers.
- Occurrences of crop pests' (insect pests, crop diseases, noxious weeds, etc) and their severe attacks on different crops and insufficient controlling mechanisms.
- Lack of good quality agro-chemicals and shortage of chemical sprayers supply.
- Wastage of irrigation water due to poor conveyance structures and unwise utilization (such as, practicing flood irrigation).
- Lack of drought tolerant and early maturing varieties of crops.
- Market price declines when production is simultaneously produced in all areas.

In order to boost up the existing low production and productivity, the aforementioned constraints has to be solved at least step by step through strong extension provision and close supervision.

3.8.2 Development Opportunities for Irrigated Agriculture

Assessing the available resources in the project area and estimating the gaps that requires from outside is an essential parameter to determine the success or failures of any project. Based on field survey study, on potentials of the project area, it has suitable agro-ecology, deep soil profile and ideal soil texture, modern ground water irrigation project establishment. Furthermore, availability of all weather road accesses from kebele 04 to Waja, Kobo, Woldia, Dessie, Addis Ababa and Mekelle. The water resource management policy of the country, presence of government development policies and strategies, availability of agricultural support services, cash crop production systems, keen interest of the society in the project area, very suitable topography of the command, and traditional labour availability are the main potentials and/or opportunities for the development of irrigation projects.

The institutions found in the area are other potentials for the agriculture development. These institutions include extension center of the kebele including FTC, farmers' cooperative and Union, Credit and Saving Institution at Kobo.

3.8.3 Development Strategy for Irrigated Agriculture

To achieve the goals of the project (i.e., to attain the food demand of the beneficiaries and produce cash crops for domestic and export markets, to generate/improve household incomes) and based on the existing production and market conditions, the project can combine/integrate the here below mentioned alternative strategies to attain higher farm return.

a) Crop specialization፡

Crop specialization is one of the crop production improvement option focused on single crop or a group of crops. For this project it has focused on very few crops such as teff, sorghum, maize, haricot bean, chick pea, pearl millet, mung bean, and cow pea to attain higher income.

b) Crop diversification:

Different crop groups like cereals, pulse, and forage crops could be selected. Hence, diversified crops have to be and has selected from the crop basket of the area to grow for food and market purposes.

c) Domestic market oriented:

This project relies entirely on domestic market opportunities mainly found in the vicinity of the project area and far the project area markets, such as: Waja, Alamata, Kobo, Woldia, Dessie, Kombolcha, Addis Ababa, Mekelle, etc.

4. AGRICULTURAL DEVELOPMENT PLAN (WITH-PROJECT)

4.1 Project Rationale and Objectives

The needs for survival and additional food supplies to meet the demands of the increasing population pressure are necessitating a rapid expansion of irrigation schemes throughout the world. Consequently, irrigated agriculture has becoming a fundamental part of well developed agriculture throughout the world.

Due to uneven distribution and unreliable/erratic nature of rainfall, problems caused by crop pests (insect pests and diseases), etc, farmers of the project area in particular and Raya Kobo Woreda as a whole are suffering from low level income and low standard of livings.

Although the project area hasn't blessed with perennial rivers for irrigation purposes, flashy spate floods are running off from mountainous catchments to dry wadis or ephemeral rivers. Of the wadis found in the project area Gobu is the one that has to be employed for improved spate irrigation purposes, especially during Belg season. Thus, design study of improved water diversion structures and canals in spate scheme is now underway from the wadi Gobu.

The present feasibility study on spate irrigation project would contribute towards the supply of additional food and cash incomes as well as livestock feeds in the project area for the beneficiary farmers who are suffering from very low standard of livings. In view of that, food self-sufficiency could be assured and household incomes would be improved.

In respect of the Gobu 3 Spate Irrigation Project, the main objectives of the present agricultural development planning are:

- ≡ To increase crop yields through spate irrigation and cropping systems among the beneficiary households in the project area.
- ≡ To bring about sustainable development and food self-sufficiency among the farming families in the project area and increase their incomes from modern spate irrigation systems.
- ≡ To calculate with-project cultivated area of smallholder farms on different land suitability types
- ≡ To calculate present, without-project and with-project benefits from smallholder farms on farmlands of different suitability.

The proposed project has designed to irrigate a net area of 300 hectares under both dry and wet seasons at 200% crop intensity which is expected to benefit about 280 households with an average of about 1.0ha of land per household. Land distribution of the area has done before and re-allocation is impossible; hence an individual may have less than 1ha.

The project area of the smallholder farms have been taken as 300 hectares and about 100% are assumed to be loam textured soil.

Figure 2: Partial view of the command area at Jarota kebele

4.2 Selection of Crops

4.2.1 Crop Basket Determination

Before the start of the selection of potential crops for the proposed irrigation project, the crop basket or list of crops growing in the project area has prepared and presented in Table 20. The crop basket not necessarily includes only the list of crops currently growing in the project area rather based on the agro-climatic and soil conditions. All possible crops are incorporated in the crop lists because there are potential and suitable crops which are not currently found in the cropping patterns of the project area and need to be considered in new development intervention.

Table 20: The possible list of crops for irrigated agriculture

Crop group	Type of crops
Cereals	Sorghum, maize, millet, teff
Pulses	Soybean, haricot bean, mung bean, chick pea
Oil crops	Sunflower, safflower, noug , ground nut
Vegetables	Onion, cabbage, tomato
Spices	Pepper, fenugreek,
Fruits	Mango, avocado, banana, papaya, guava
Other perennial crops	Sugarcane
Fiber crops:	Cotton
Stimulant crop:	Coffee

4.2.2 Crops Selection Criteria

In the project area the smallholder farmers have two major objectives to carry out irrigation agriculture on their plots of land; the primary objective is attaining the food demand of the family members, while the second important objective is growing cash crops to generate household income. Under small-scale irrigation the crops selection should take into account the optimum utilization of water, land and labor to attain the objective of the project. Crop selection is a main and determinant process to ensure the sustainable development of irrigation projects, because the overall goals of the irrigation project are screwing to the improvement of crop outputs.

The criteria for selecting the potential crops should follow multidimensional approach to cover various issues. The criteria could categorize into agronomic, social, environmental, cultural, and business sectors to simplify the determination of the selection criteria. Three major targets of the criteria are: increased crop production, high income generation and restoration of soil fertility.

The criteria considered for the choice/selection of crops are:

- Growers' preference and existing cropping experience in commercial farms (farmers existing knowledge and experiences in irrigated agriculture);
- Suitability to the given agro-ecology (soils, agro-climate) and to irrigation technology
- Yield potential of the crop (high productivity);
- Market opportunity in local and export markets
- Crop potential for irrigated agriculture (irrigation characteristics of the crop);
- Length of growing period (LGP) of the crops (early maturing type).
- Farmers potential attitude to the introduction of new crops;
- Potential of the irrigation water source
- Soil types and soil characteristics
- Availability of high yielding variety with adequate supply and other improved inputs;
- High market value and potential for export market (marketability);
- Potential for maintenance of soil fertility
- Cropping intensity
- Recurrent prevalence of pest infestation
- Consumption habit of the community
- Government policy and development strategies.

4.2.3 Proposed Crops and Cropping Pattern

Based on the aforementioned selection criteria the proposed crops for Gobu 3 Spate Irrigation Project includes: teff, sorghum, maize (grain), haricot bean, and chick pea for wet season; chick pea, pearl millet, mung bean, teff (local), cow pea for dry season. The texture of the command soil is predominantly loam textured. Therefore, the suitability of loam textured soil type for specific crops is the starting point to determine the cropping pattern for small-scale farms. The total area of 300ha will be covered by those crops, to provide food crops for beneficiary farmers and for sale. Thus, the proposed smallholder farm cropping patterns has indicated in **Error! Reference source not found.**.

Table 21: Cropping patterns for small scale farms

Crop	Wet season				Crop	Spate (dry) season			
	Area, %	Area, ha	Planting date	Harvest date		Area, %	Area, ha	Planting date	Harvest date
Teff	20	60	16-Jul	22-Nov	Chick pea	25	75	14-Mar	21-Jun
Sorghum	40	120	06-Jun	03-Oct	Pearl millet	25	75	16-Mar	13-Jun
Maize (grain)	15	45	26-Jun	12-Nov	Mung bean	30	90	20-Mar	23-May
Haricot bean	10	30	01-Jul	08-Oct	Teff (local)	10	30	16-Mar	18-Jun
Chick pea	15	45	10-Aug	27-Dec	Cow pea	10	30	14-Mar	16-Jun
Total	100	300			Total	100	300		

4.3 Agricultural Input Requirements

4.3.1 Seed Requirements

Improved Seeds Requirements: Smallholder farmers are intended to utilize high yielding crop varieties under irrigated agriculture. Crop varieties that have been released from agricultural research centres and are tested in similar agro-ecologies are essential inputs. Shortage of certified crop seeds are identified as one of the major bottlenecks facing farming communities in the project area as it is elsewhere in the country (e.g., improved mung bean seeds). To establish reliable seed sources, the smallholder farms' fields shall be involved in seed multiplication activities in order to fulfil their requirement and sell to surrounding smallholder farmers. An estimate of improved seed requirements is given in **Error! Reference source not found.**.

Table 22: Summary of seed requirement format

Crops	Seed rate, kg/ha	Requirement, qt	Annual total seed requirement, qt	Potential sources
Wet season		117	117	Seed Agency
Teff (Gerado, Lakech, DZ-Cr-37, Gola,)	30	18		
Sorghum (Miskir, Girana 1, Hormat,best local)	10	12		
Maize (grain) (BH-140, BH-540, Melkassa I)	30	13.5		
H/Bean (Awash-1, Wedo, Lehode, AR04GY)	95	28.5		
Chick pea (Kutaye and Yelbey , Habru, Arerti)	100	45		
Spate (dry) season		123.75	123.75	Seed Agency
Chick pea (best local)	100	75		
Pearl millet (Kolla 1)	15	11.25		
Mung bean (M61, M76, M140,best local)	25	22.5		
Teff (local)	30	9		
Cow pea (Black-eye-bean, Bole)	20	6		
Total		240.75	239.25	

4.3.2 Fertilizer Requirements

Fertilizer is an important input to ensure high production under improved irrigation agriculture. Therefore, use of fertilizers will be one part of the interventions in the cropping system. Based on the proposed cropping patterns and the recommendations given by the research institutions (ARARI & EIAR) the following requirements are computed and has shown in **Error! Reference source not found.**.

Table 23: Seasonal & annual fertilizer recommendation for full & supplementary irrigated crops

Crop	Area (ha)	DAP (qt)	DAP Sub total	Urea (qt)	UREA Sub total	Total requirement (qt)
Supplementary irrigated	300		225		135	360
Teff	60	1	60	0.5	30	90
Sorghum	120	1	120	0.5	60	180
Maize (grain)	45	1	45	1	45	90
Haricot bean	30	0	0	0	0	0
Chick pea	45	0	0	0	0	0
Spate irrigated	300		0		0	0
Chick pea	75	0	0	0	0	0
Pearl millet	75	0	0	0	0	0
Mung bean	90	0	0	0	0	0
Teff (local)	30	0	0	0	0	0
Cow pea	30	0	0	0	0	0
Total	200%		0		0	0

4.3.3 Agro-Chemicals Requirements

Agro-chemicals: the estimate of the seasonal and annual required pesticides/agro-chemicals for the project and its costs has presented below in **Error! Reference source not found.** & 25. The approach to the estimation here is by considering the area likely to require agro-chemical treatments in each season and annually, rather than to provide a more expensive "prophylactic" costing. Because all proposed crops grown in the command area may not be infested by crop pests every season and each year. In addition, a single proposed crop may be infested by same types of crop pests twice or tries or can be infested by different pests within a season.

Table 24: Estimation of seasonal & annual agro-chemicals requirement & costs

Crop	Area in wet/dry cropping season (ha)	Area considered (ha)	Rate of application (lt/kg/ha)	Pesticides required (lt/kg)	Price, birr /unit	Total cost, birr
Wet season	300	300		600		135,000
Teff	60	60	2	120	200	24000
Sorghum	120	120	2	240	200	48000
Maize (grain)	45	45	2	90	200	18000
Haricot bean	30	30	3	60	450	27000
Chick pea	45	45	2	90	200	18000
Spate (dry) season	300	240		525		105,000
Chick pea	75	75	2	150	200	30000
Pearl millet	75	75	2	150	200	30000
Mung bean	90	45	2	90	200	18000
Teff (local)	30	30	3	90	200	18000
Cow pea	30	15	3	45	200	9000
Total	200%	540		1125		240,000

Table 25: Summary of seasonal & annual agro-chemicals requirement and costs

Crop	Annual requirement		Potential supplier
	Quantity, qt	Cost, birr	
Wet season	600	135,000	WUA, Cooperative and Union
Teff	120	24000	
Sorghum	240	48000	
Maize (grain)	90	18000	
H/Bean	60	27000	
Chick pea	90	18000	
Spate (dry) season	525	105,000	WUA, Cooperative and Union
Chick pea	150	30000	
Pearl millet	150	30000	
Mung bean	90	18000	
Teff (local)	90	18000	
Cow pea	45	9000	
Total	1125	240,000	

4.3.4 Human Labour and Machinery Requirements

As most parts of the region, human labour and oxen power is the main source of power for any agricultural development. No development is expected without the direct involvement of human labour. Human labour is a driving force to facilitate and organize any farm operation. As compared to mechanized agriculture, manual labour requires mobilization of more human labour at a time for seasonal farm operations. Oxen power is the most important power source of the area next to human labour. This unskilled labour has been used for the last centuries and is still in use without any modification. Based on interview result and experiences the labour and oxen power requirement of the proposed crops to be grown in the project area per hectare bases are presented in Table 26.

Table 26: Labour requirements in Man-days and Oxen-days

Crop Type	Labor Requirements (man-day/ha)	draught or oxen power Requirements (man-day/ha)
Teff	110	22
Sorghum	70	20
Maize (grain)	100	18
Haricot bean	80	18
Chick pea	80	18
Chick pea	70	18
Pearl millet	70	18
Mung bean	70	18
Teff (local)	90	18
Cow pea	60	18

Source: Interviewed farmers and consultant estimates

Note: Labour and oxen requirements includes from nursery site preparation up to threshing activities

- Average oxen rent per day = 300 birr
- Average human labour rent/day/person = 50 birr

4.4 Calculation of Crop Water Requirement

The calculation of crop water requirement is a very important aspect for planning of any irrigation project. Several methods and procedures are available for this. The Food and Agriculture Organization (FAO) of the United Nations has also made available several publications on this subject and other issues related with this. The computer program available in FAO Irrigation and Drainage Paper No. 56

"CROPWAT" has been used for the calculation of crop water requirement. This program is based on Penman-Monteith approach and procedures for calculation of crop water requirements and irrigation requirements are mainly based on methodologies presented in FAO Irrigation and Drainage Paper No. 24 "Crop Water Requirements" and No. 33 "Yield Response to Water". As recommended in FAO Publications three steps (procedures) are involved in the calculation of the crop water requirement.

4.4.1 Reference Evapotranspiration (ETo)

The Reference Evapotranspiration (ETo) represents the potential evaporation of a well-watered grass crop. The water needs of other crops are directly linked to this climatic parameter. Although several methods exist to determine ETo, the Modified Penman-Monteith Method has been recommended as the appropriate combination method to determine ETo from climatic data, on a monthly basis, on: temperature, humidity, sunshine, and wind speed.

Based on this calculation the value of ETo varies from 3.7 mm/day (in December & January) to 5.9 mm/day (in May & June); and the average reference evapotranspiration is 4.7mm/day. All climatic data required for ETo calculation and calculated ETo has tabulated in Annex 1.

4.4.2 Climate Data Collection

The methods of calculating evapotranspiration from meteorological data require various climatological and physical parameters. The meteorological factors determining evapotranspiration are weather parameters which provide energy for vaporization and removal of water vapour from the evaporating surface. The evapotranspiration process is determined by the amount of energy available to vaporize water. Solar radiation is the largest energy source and is able to change large quantities of liquid water into water vapour. The principal weather parameters are: rainfall, temperature, relative humidity, wind speed, and sunshine hour.

The ETo estimation for Gobu 3 Spate Irrigation Project is dependent on Kobo meteorological station data. At Kobo the station is 1st class and hence all climatic data were recorded (rainfall, minimum & maximum temperature, relative humidity, wind speed, and sunshine). Climate (rainfall) data were also collected from Muja station to represent the spate irrigation water sources. The FAO CropWat version 8.0 Software has been used to estimate the evapotranspiration by using data obtained from Kobo meteorological station. The monthly ETo for the reference crop has presented in Annex 1.

The proportion of rainfall that can enter and support plant evapotranspiration is said to be effective rainfall (Peff). Of the various methods used for CWR calculation, the USDA soil conservation service method has been used to estimate the effective rainfall for this project, that is:

- Peff = (P* (125 - 0.2 * P))/125 ………………for P ≤ 250 mm
- Peff = 125 + 0.1 * P ………………………….for P > 250 mm

Where, Peff = Effective rainfall,

P = Total rainfall

As the rainfall amount in the project area is somewhat medium, the effective rainfall has been accounted for the present irrigation scheme crop water requirement's calculation, especially for wet season (see Annex 2). Kobo station rainfall data was used for the dependable rainfall computation. Hence, Kobo meteorological station data was directly used to calculate Irrigation Water Requirement (IWR) for the supplement of the rainfed proposed crops of this project. On the other hand, Muja station rainfall data has recorded and considered to represent the spate water sources for Gobu 3 Spate Irrigation Scheme.

4.4.3 Crop Coefficient (Kc) and Crop Evapotranspiration (Etc)

The effect of crop on its water requirement is represented by crop coefficient (Kc). This is presented by the relationship between reference Evapotranspiration (ETo) and crop evapotranspiration (ETc) as ETc = Kc × ETo. The values for crop coefficient vary with the crop, its stage of growth, growing season and prevailing water condition. The second step required is to select suitable values for crops coefficient. Based on the recommendation of FAO Irrigation and Drainage Paper No. 56 and No. 33 Yield Response to Water (ky), crop coefficients (Kc values) and other factor or aspects have been used for the selected crops in the calculation as presented in Annex 3.

4.4.4 Effect of Agricultural Practice and Local Conditions

This requires evaluating the effect of climate and its variability over time and area; and also requires to evaluate the effect of soil water availability and agricultural and irrigation practices.

4.4.5 Calculation of Irrigation Water Requirement (IWR)

4.4.5.1 Supplementary Irrigation Water Requirement for Rainfed Crops

The crops irrigation water requirement for Gobu 3 spate irrigation project command has calculated and presented in annex 4 for wet season crops as supplementary irrigation systems. The detail NIWR for the proposed wet season crops has presented in Annex 4.1 to Annex 4.5.

For the wet season proposed crops and cropping pattern of Gobu 3 spate irrigation project maize has showed maximum net irrigation water requirement (NIWR) of 4.99 mm/day in the month of September. The maximum gross irrigation water requirement (GIWR):

$$GIWR = NIWR/Efficiency = 4.99/0.49 = 10.18 \text{ [mm/day] for supplementary irrigation}$$

The duty is calculated as: $D = GIWR \times 1000 \times 10 / (t \times 60 \times 60)$ formula

Where; D = Duty [l/s/ha]

GIWR = Gross Irrigation Requirement [mm/day]

t = Daily irrigation or flow hours [hrs]

Thus, duty for 14 irrigation hours of wet season proposed crops as a supplementary irrigation has computed as: $D = (10.18 \times 10 \times 1000) / (14 \times 3600) = 2.0$ l/s/h.

4.4.5.2 Spate Irrigation Requirements and Systems

The source of water for the understudy spate irrigation project is the Wadi Gobu since the Belg rainfall floods coming from the highland areas (especially from mountain Abuhay Gara) and flows down to the Kobo plain areas. The flood water should have to be led to farmers' fields that have soil bunds in their borders. In field-to-field irrigation there are no secondary or tertiary canals; and all flows in a canal is diverted to bunded fields.

Spate irrigation is a subsistence activity, with low returns, generating highly variable incomes between good and bad years, and requires very high inputs of labour to maintain intakes, canals and field systems. A total of 300 hectares would be covered in this spate irrigation system in the dry (Belg) season. The soil and water management and moisture conservation aspect of this spate irrigation system has described in depth as follows.

4.4.5.2.1 Soil and water management

According to Lawrence and van Steenbergen (2005), soil and water management in spate irrigation system is vital for two major reasons:

- The soils are largely induced by human activity (in spate irrigation systems). They are built up from the sediments transported with the spate flood flows that settle when water is ponded on bunded fields. The water holding capacity and fertility of these transported soils is usually excellent, but soil management is required to counter land rise, maintain fertility, and to avoid soil crusting and compaction.
- The importance of moisture conservation in crop production. In spate irrigation systems irrigation before planting provides the main source of crop moisture. Conserving this moisture is essential to crop production; and good moisture conservation can have an impact on production often greater than improvements to the water diversion systems.

a) Soil management

i) Development of spate soils

In spate areas soils are largely built up from sedimentation in the early years of development of a spate system. Spate soils are influenced by irrigation practices, climate, conditions from the source catchments, the underlying material, vegetation and time.

Large sediment particles tend to settle out in the canals near to the wadi intakes. Whereas, sand may be transported to and be deposited on fields close to wadi intakes to form coarse sandy soils. Finer sediments, like silts and clays, are mostly transported in suspension and travel with the water through the canal systems and are deposited on the fields. As a result, soil textures and water retention capacity varies within the spate systems.

The average siltation rates on spate irrigated fields in spate irrigation systems in Yemen, Eritrea, Sudan and Pakistan ranging between 6mm to more than 50mm/year (Lawrence and van Steenbergen, 2005).

The constant sedimentation of spate irrigation systems can turn from a blessing into a curse, as over the longer term it causes field levels to rise up, and for fields to go out of command.

In traditional spate systems, to mitigate land rises, what farmers do is: a) They move soil to the field -bunds while leveling their lands; b) by moving intakes further upstream; c) by constructing higher bunds in flood canals to raise water levels.

Too large variations in the levels, within fields, leads to over-watering and leaching of plant nutrients at lower levels and under watering at higher levels. These results in poor water use efficiency and uneven crop growth and yields within the same field (Williams, 1979 and Mu'Allem, 1987).

In Gobu 3 spate irrigation project area such practices are not common still now. However, during project implementation phase field level rise problems due to transported sediments need to be controlled or reduced by moving soils to the field bunds and/or closing weir/canals gates during first flood time. Furthermore, to avoid the large variations of field surface, farmers should have to level their plots prior to irrigation so as to enable the fields to receive flood water equally.

ii) Soil management

Soils in spate irrigation systems have generally good water holding capacities, such as loams, silty loams, sandy loams and sandy clays are common. Infiltration rates, in irrigated soils, vary with soil texture, density and soil management practices (Williams, 1979). Thus, pre-irrigation ploughing can significantly increase infiltration rates. Indeed, the present soil texture of the project site is clay loam type and has almost related characteristics with silty loam texture and better water holding capacity.

In spate areas soil fertility is not generally a major issue. Fertility is ensured by the regular replenishment of fine silts, carrying organic material eroded from the catchments. Hence, application of mineral fertilizers may not be necessary for the project site, specifically for dry season spate irrigated crops.

The most common soil fertility problems are the low availability of phosphate and unavailability of some micro-nutrients (Tesfai, 2001). As the flood water deposit sediments with each irrigation there is no time for weathering and pedogenetic processes to take place, (Tesfai, 2001). Some deep soils may restrict root growth (particularly tap roots) because of stratification caused by frequent textural changes in the soil profile, (Mu'Allem, 1987).

Organic matter is one of the major sources of soil fertility particularly for nitrogen and phosphorus. The low organic matter content of the soils is often related to the sparse natural vegetation in the catchments. Hence, soil fertility could be improved by incorporating organic fertilizers and crop residues into the soil. It can also be improved by growing leguminous crops and by practicing crop rotation Tesfai (2001).

Soil fertility improving practices, such as compost application, crop rotation with leguminous crops, and incorporating crop residues, are added in this project study. In addition, breaking hard pans and soil strata by deep tillage using improved farm tools, such as Arm Strong need to be adopted and practiced during project implementation phase.

b) Field water management and moisture conservation

As Lawrence and van Steenbergen (2005) pointed out, in spate irrigation systems, field water management and moisture conservation are as important as effective water diversion. The floodwater should be spread in a controlled, non-erosive manner as much as possible.

In spate irrigation systems, moisture conservation is important because crop yields can be severely depressed by moisture deficit. Research result (in Yemen) also showed that up to 30-40 % of moisture was lost due to that land was not ploughed within two weeks after irrigation.

i) Field water distribution strategies

The nature of spate irrigation is that farmers cannot follow a predetermined irrigation schedule where water quantities are applied to a crop when it is needed from permanent water source. Nonetheless, this does not mean that water distribution within the command area is haphazard or unplanned. Rather, water distribution is regulated by the following general principles:

- Rapidly spreading the available flood flows and preventing spate water rapidly disappearing in low-lying areas.
- Dividing and distributing the floods in manageable quantities/proportions so as to avoid erosive flows and gully formation.
- Ensuring large enough water volumes to reach and irrigate the downstream areas are conveyed in the short time that spate flows are available.

Therefore, these general principles are fully adopted for Gobu 3 spate irrigation project for the additional spate system and would be applicable during the project implementation phase on 300 hectares.

Furthermore, water distribution within the command area has to be determined that whether water is distributed field-to-field or each field has its own inlet from a canal, which is a controlled system. Their advantages and/or disadvantages are described as follows:

- **Field-to-field or individual field off-takes**

As Lawrence and van Steenbergen (2005) presented field-to-field systems are sometimes considered less efficient than controlled systems that use gated water control structures and secondary or even tertiary water distribution systems and individual field outlets. In field-to-field irrigation there are no secondary or tertiary canals and all flows in a canal is diverted to bunded fields. The process of moving flood water from field-to-field leads to irregularities on the land surface unless water distribution structures that prevent or limit scour are used. Field-to-field system has also erosion hazards. However, field-to-field irrigation system allows large volumes of water to be applied to fields rapidly in the short time periods that spate floods flow.

In regard to Gobu 3 spate irrigation project, since it is a combination of modernize base flow and spate scheme, the water distribution option is that each field will have its own inlets on secondary or tertiary canals; such controlled system of water distribution strategy has selected to be designed.

- **Extensification or intensification**

A second factor in spate water distribution strategies is that whether irrigation is spread widely or concentrated in a small area. The choice for intensive or extensive system is mainly related to the flood pattern. Concentrating spate flood supplies on a small area will make it easier to plough prior to the spate season, with the aim to improve infiltration rates. In this case, the project command area cannot be considered as large or extensive (300ha).

ii) Field water application

According to Mehari and van Steenbergen (2008), soil water simulations have shown that for silt loam and sandy loam soils, a single spate irrigation turn of 1000 mm can result in a net soil moisture equivalent to that obtained from two irrigation turns of 500 mm each provided the timing of the last irrigation turn is the same. Thus, a single watering of 1000 mm could sufficiently support the optimum yield of sorghum and maize. They also described that, if two irrigation turns or 1000 mm of gross irrigation depth is to result in net soil moisture of 700 to 750 mm and produce an optimum yield of some of the major crops in spate irrigated agriculture, the soil profile must have a good water holding capacity as well as good infiltrate rate.

In most spate systems, the soil profiles are a result of successive alluvial silt loam and sandy loam deposition. These soil profiles have high water holding capacity at 300 to 350 mm m^{-1}; their basic infiltration rate (20 to 25 mm hr^{-1}) is categorized as moderately rapid. Such high water holding capacities and infiltration rates of soil profiles would have to be enhanced or at least maintained if spate irrigation systems are to have high land and water productivity at a sustainable manner.

It is generally assumed that spate irrigation application should result in an average of 400 mm net stored in the soil, (Camacho 1987). According to Mu'Allem (1987) the application of 600 -1,000 mm of water in a single pre-planting irrigation is sufficient to raise all spate irrigated crops, provided that the moisture holding capacity of the soil is satisfactory. In other countries the preference is for several spates. Lawrence and vas Steenburgen (2005) showed that in Eritrea arable fields are flooded using several spates; and fields are also flooded to a depth of about 0.5 - 1m giving a wetting depth of about 2 - 2.4m in the soil profile.

In this regard, there is a relationship between the height of field bunds and the availability of water. Bund heights may easily reach two meters. High bunds are needed to allow for the large plots; and the security of irrigation is also very much a function of the strength of the field bunds. Thus, to make strong bunds moist soils should be compacted and rat proofed.

In spate irrigation systems, farmers should have to construct and maintain their field bunds as this affects the supply of water. The depth of water that can be impounded in a bunded filed during particular irrigations often affects the choice of crop grown.

In Pakistan, if 300mm are impounded (water soaked into the soil) then guar (cluster bean) alone is sown, mainly as a fodder. If 750 - 900mm is stored in the soil then castor is sown. Otherwise a mix of sorghum, mung bean and sesame/guar is sown. Mustard is only planted when two or more floods can be impounded on the same plot, prior to cultivation, (MacDonald 1987a).

Based on the above mentioned evidences and facts Gobu 3 spate irrigation project (specifically spate system) needs to adopt the following field water application standards:

- Two irrigation turns or 1000mm of gross irrigation depth (water soaked into the soil) before planting/seeding, to result in a net soil moisture of 700 - 750mm, is adopted since the command area soil texture is clay loam and has better water retention capacity.
- Adopt a standard height of 1m field bunds which is rat proofed.
- Construct field bunds before irrigation and during land preparation.
- Flooding fields to a depth of about 1m to wet more than 2m depths.
- Enhance or maintain soil profiles to increase infiltration rates of flood water

a) Moisture conservation/Soil moisture management/

In spate irrigation systems, of the several techniques to conserve soil moisture, the following are considered as major ones and are also adopted in this agronomic feasibility study of Gobu 3 spate irrigation project.

- Ploughing prior to irrigation
- Ploughing after irrigation
- Conservation tillage
- Breaking soil crusts.

Breaking the topsoil through ploughing land prior to irrigation greatly increases infiltration rates. In pre-irrigation ploughing, breaking down the top soils to increase infiltration rate is the major objective. Pre-irrigation ploughing also makes cultivation much easier and quicker to carry out once the flood waters arrive, which is important as a lot of labour is required to cultivate the land after irrigation.

The topsoil should also be ploughed loosely after-irrigation or rainfall in order to conserve water, (Williams 1979). The common recommendation is not to delay ploughing for more than 2 weeks, to avoid water loss through evaporation or deep percolation. Extending the post-irrigation period beyond that time may cause a moisture loss of 40% in the area. In the ploughing after irrigation practice, which is commonly called conservation tillage, the top soil is tilled loosely to break soil crusts and fill large cracks thereby reducing evaporation losses. This tillage practice is done 2 - 3 weeks after irrigation. It would be better if it is done within the first week after irrigation so as to reduce any soil moisture losses.

Soil mulching technique is practiced after the conservation tillage in the two week period between the irrigation and planting period. Generally, timely ploughing and mulching improve the capacity to maintain soil moisture. Mulching can be done by either traditional or improved soil mulching farm tools. During mulching operation farmers should have to scoop thin layer of soil surface to mulching soil pores. Farmers can even cover the land with sorghum stalks and other available mulching materials to further reduce evaporation losses.

Another technique is application of conservation tillage. Conservation tillage aims at creating a suitable environment for growing a crop in a way that conserves soil, water and nutrients. Conservation tillage involves tillage practices that leave plant residues in the field. There is a broad spectrum of intermediate stage to conservation tillage. These include practices like tied ridging, reduced or minimum tillage, mulching, and zero or no tillage systems.

It is practiced in the approximately 10 day period between the last flooding/irrigation and the sowing of seeds. Farmers plough the fields about 0.15m deep to create a tilth, which conserves the soil moisture by reducing the evaporation losses from the soil surface. At sowing time, the tilth layer is broken down by shallow tillage followed by drilling the seeds in rows, (Tesfai 2001).

Particularly in areas with silt soils or calcareous soils, soil crusting can be affect water use efficiency and special measures are required. Clayey soils, including silty clays, clays and silty clay loams, are generally more difficult to till and are prone to surface cracking. The soil crust, that develops, reduces the infiltration rate, increases runoff, restricts seedling emergence and reduces crop yield (Nizami and Akhtar 1990).

Appropriate management and agronomic techniques include appropriate tillage practices, surface mulching, increasing the soil organic material (by applying manure and incorporating crop residues, where possible), seeding at appropriate depth, planting on ridges and use of mechanical crust breakers, (Tesfai, 2001).

Silt soils are also prone to compaction, if they are cultivated when wet with machines. Soil compaction slows down root penetration. Soil water and nutrients become less accessible to the plant and crops on compacted soils and will show the effects of drought stress first. Clay particles carried in the flood water are washed down the profile making it difficult for plant roots to reach water, leading to a reduction in productivity. According to Mu'Allem (1987) the hard pan should be broken up by chiseling using a heavy power unit every 2–3 years.

Generally, in spate irrigation agriculture, the soil moisture management package include: avoid overstretching the command area, limiting the number of irrigation turns to two or an irrigation gift of 1000 mm; avoiding field bund heights of more than 1m, reducing the command area irrigated by a single inlet to about 20 to 30ha (some systems have more than 100 ha), opting for water rights, minimizing evaporation losses through pre-and post-irrigation tillage, and soil mulching (Mehari and van Steenbergen, 2008).

b) Irrigation turns/schedule in spate system

Of the total command area of Gobu 3 spate irrigation project 300 hectares of the farmlands would be covered with spate irrigation system in dry seasons. However, prior to irrigation applications soil bunds should have to be constructed around individual farmers' fields. Following the bund construction farmers should have to irrigate or flood their fields before planting/seeding using basin or flood irrigation methods. Controlled system of water distribution will also be employed during spate irrigated system.

According to Lawrence and van Steenbergen (2005), in spate irrigation systems, given the unpredictable nature of floodwater to have in place fixed irrigation turn is a near impossible task. However, "Irrigation scheduling" is possible in spate irrigation through systems of storing maximum soil moisture (usually ranges from 500 to 1000 mm of water depth).

However, in spate irrigation systems several crops give significantly higher yields when the fields are irrigated more than once and sufficient moisture is stored in the soil profile. The water turns are particularly important in systems that receive a series of spates in a normal year.

Regarding Gobu 3 spate irrigation project, specifically the spate system for 300 hectares, the irrigation schedule in the belg flood period (dry season) will not have normal irrigation interval; and spate irrigation could be done through systems of storing maximum soil moisture (usually 1000 mm of water depth) with at least two irrigation turns before planting.

In the project area, the Belg or dry season main flood periods are in the months of March, April and May (based on Muja rainfall data analysis). Basing this information, at least a single floodwater is expected to be existed in each of these months. While the main rain season or kiremt flood period is starting from late June to September.

The critical stages of crops are at which moisture stress adversely affects the growth, flowering, seed formation and development, and ultimately the yield. At these stages care has to be taken with the intention that crops are adequately irrigated. Hence, the proposed crops critical stages has presented in Table 27.

Table 27: The most critical moisture sensitive crop growth stages for proposed crops

Crop	Growth stages
Teff	Boot to heading stage
Sorghum	Flowering , yield formation, vegetative period less sensitive when followed by ample water supply
Maize	Flowering, grain filling, vegetative period; flowering is very sensitive if no prior water deficit
H/Bean	Flowering, pod and seed setting
Chick pea	Relatively less sensitive to moisture stress
Pearl millet	Flowering , yield formation, vegetative period less sensitive when followed by ample water supply
Mung bean	Relatively less sensitive to moisture stress
Cow pea	Flowering and yield formation > vegetative, ripening for dry peas

4.4.6 Organizational Aspects of Irrigation Schemes

Administrative and technical problems cause great failure of crops yield and irrigation extension, in irrigated agriculture, unless they are solved as quickly as possible. Thus, water users association has to be established; and due attentions should have to be given by the woreda administrative councils and development sectors in solving both social and technical problems.

The project beneficiaries, who organize under the water users association, would have the following advantages:

- Problems of local administration will be solved.

≡ Damaged irrigation weir and canal structures could be maintained easily and sooner after close supervisions are made by the members of the association and irrigation water managing bodies of the project.

≡ The organization could construct common storage facilities so that they could store their surplus and low costly productions and sells when the price rises up.

≡ When the association get the by-Laws can take credits of agricultural inputs, farm tools and equipments for its members.

≡ The association controls the whole irrigation structures, irrigation water distribution and management operation and maintenance of the weir and canals.

Therefore, the woreda agricultural development office and the woreda cooperative promotion agency should have to take the lion share to carry out the organization of the water users association and its structural set up.

4.5 Crop Yield Estimate and Projection

4.5.1 Crop Yield Estimation

Estimates of with-project crop yields consider the existing yields which are attained with presently available technology. Projected yields are targeting crop productivity under improved agricultural practice. The number of production years that are required to attain the planned optimum yields depends on suitability of the area, level of farmers' exposure to given technologies and efficiency of supporting institutions.

The following assumptions are made to estimate achievable yield and yield projection: appropriate input supply system, proper irrigation application, appropriate farm management, and provision of consistent agricultural support by competent institutions. Based on the research findings on farmers' fields and farmers' experience the following crop yields are used to compute the expected crop production.

Yield projections are normally required in order to determine the feasibility of the irrigation project. Yield projections are usually made for the first three years of the project over which time the exploitable genetic potential of the different crops is captured. Then the yields stabilize at the same rate for following years provided all other conditions, such as proper use of inputs, viability of the seeds, efficient use of water and good management practices are maintained. Such projections are made for smallholders in Nonetheless, the yield projections (see Table 28) are rough estimates and can be treated with same degrees of flexibility until determined by trials.

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For the estimation of yield build-up/projection, it is expected that the with-project yields will be improved due to the following favourable conditions:

- Access to full irrigation in the dry season and supplementary irrigation as required during the wet season;
- Reduced flooding and water logging due to drainage works;
- Farmers acquiring necessary agricultural skills and knowledge due to the provision of trainings and strong agricultural extension services;
- Improved access to improved seed varieties and other farm inputs, including fertilizer and agro-chemicals;
- Improved access to improved equipment, credit services;
- Reduced crop losses due to better control of insect pests, diseases and weeds;
- Present average yields obtained by farmers and research institutes.

Nonetheless, the yield projections (see Table 28) are rough estimates and can be treated with same degrees of flexibility until determined by trials.

Table 28: Yield estimation and projection for smallholder farmers' crops, qt/ha

Crops Type	Without project		With project			
	Current local average yield estimate [1]	Amhara Region, CSA data, 2004 EC) [2]	Future [3] (Projected yields (qt/ha))			Ratio [4]
Wet season	Year 0 (50%)		Year 1 (80%)	Year 2 (90%)	Year 3 (100%)	
Teff	12	14	18	20	22	180%
Sorghum	24		28	32	35	150%
Maize (grain)	20		40	45	50	250%
Haricot bean		10.6	18	20	22	200%
Chick pea	20	16.9	19	22	24	120%
Spate (dry) season	**Year 0 (45%)**		**Year 1 (80%)**	**Year 2 (90%)**	**Year 3 (100%)**	
Chick pea		16.9	20	11	12	
Pearl millet	6.9		12	14	15	

Mung bean			8	9	10	
Teff (local)			9	10	11	
Cow pea			52	59	65	

1 Present study estimate of rainfed & irrigated yields based on kebele survey data, regional data and agronomic assessment

2 CSA STAT database (Amhara, 2011/12)

3 Future yield development rate based on management system (rainfed with supplementary and irrigated)

4 Ratio between present and maximum expected yield

4.5.2 Production Projection

Taking into account the above yield estimates and the proposed cropping patterns for smallholder farmers, crop production is estimated for both the wet and dry cropping seasons. It is assumed that farmers will use inputs properly and they will receive appropriate technical supports. The crop production estimates at full development stage of the project has presented in Table 29*: Estimated with-project of smallholder farmers' crops production*

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Table 29: Estimated with-project of smallholder farmers' crops production

Crops	Area, ha	Production, tons	Annual production, tons
Wet season		951	951
Teff	60	132	
Sorghum	120	420	
Maize (grain)	45	225	
Haricot bean	30	66	
Chick pea	45	108	
Dry Season		610.5	610.5
Chick pea	75	180	
Pearl millet	75	112.5	
Mung bean	90	90	
Teff (local)	30	33	
Cow pea	30	195	
Total	200%	1561.5	1561.5

Source: Consultant’s estimates

4.6 Crop Budget and Expected Gross Return of the Project

4.6.1 Without and With Project Crop Budget

Taking existing farm gate and improved input price from local information, the total cost of the project and its gross return is estimated (Table 30 & Table 31). The estimation considers only agronomic cost and return.

Table 30: Crop budget for proposed project per hectare basis

Description	Crop Types										Total Costs (birr)
	Wet season					Spate (dry) season					
	Teff (Improved)	Sorghum	Maize (grain)	H/bean	Chick pea	Chick pea	Pearl millet	Mung bean	Teff (local)	Cow pea	
Labour (MD)	110	70	100	80	80	70	70	70	90	60	
Unit cost (birr)	50	50	50	50	50	50	50	50	50	50	
Total cost (birr)	5500	3500	5000	4000	4000	3500	3500	3500	4500	3000	40000
Oxen power (OD)	22	20	18	18	18	18	18	18	18	18	
Unit cost (birr)	300	300	300	300	300	300	300	300	300	300	
Total cost (birr)	6600	6000	5400	5400	5400	5400	5400	5400	5400	5400	55800
Fertilizer (qt)											
DAP	1	1	1	0	0	0	0	0	0	0	
Unit cost (birr)	1375	1375	1375	1375	1375	1375	1375	1375	1375	1375	
Total cost (birr)	1375	1375	1375	0	0	0	0	0	0	0	4125
UREA	0.5	0.5	1	0	0	0	0	0	0	0	
Unit cost (birr)	1148	1148	1148	1148	1148	1148	1148	1148	1148	1148	
Total cost (birr)	574	574	1148	0	0	0	0	0	0	0	2296
Seed (qt)	0.3	0.1	0.3	0.95	1	1	0.15	0.25	0.3	0.20	
Unit cost (birr/qt)	2233	1300	1735	1200	1240	988	984	1600	1300	800	
Total cost (birr)	669.9	130	520.5	1140	1240	988	147.6	400	390	160	5786
Pesticides (lt/kg)	2	3	3	2	3	3	2	2	2	2	
Unit cost (birr)	200	200	200	200	200	200	200	200	200	200	

Description	Crop Types										Total Costs (birr)
	Wet season					Spate (dry) season					
	Teff (Improv ed)	Sorghu m	Maize (grain)	H/bean	Chick pea	Chick pea	Pearl millet	Mung bean	Teff (local)	Cow pea	
Total cost (birr)	400	600	600	400	600	600	400	400	400	400	4800
Grand total cost (birr/ha)	15118.9	12179	14043.5	10940	11240	10488	9447.6	9700	10690	8960	112807
Annual estimated crop budget for double cropping of net command area (300ha + 300ha = 600ha)											
Grand total cost (birr/ha)	15118.9	12179	14043.5	10940	11240	10488	9447.6	9700	10690	8960	112807
Total area (ha)	60	120	45	30	45	75	75	90	30	30	600
Annual cost (birr)	907134	1461480	631957.5	328200	505800	786600	708570	873000	320700	268800	6,792,241.5

Table 31: Gross return of the proposed project

Crop Type	Description	Year I	Year II	Year III
Teff	Yield (qt/ha)	18	20	22
	Area (ha)	60	60	60
	Total produce	1080	1200	1320
	Unit price (birr)	1309	1309	1309
	Gross return	1413720	1570800	1727880
Sorghum	Yield (qt/ha)	28	32	35
	Area (ha)	120	120	120
	Total produce	3360	3840	4200
	Unit price (birr)	1107	1107	1107
	Gross return	3719520	4250880	4649400
Maize (grain)	Yield (qt/ha)	40	45	50
	Area (ha)	90	90	90
	Total produce	3600	4050	4500
	Unit price (birr)	672	672	672
	Gross return	2419200	2721600	3024000
H/bean	Yield (qt/ha)	18	20	22
	Area (ha)	60	60	60
	Total produce	1080	1200	1320
	Unit price (birr)	1000	1000	1000
	Gross return	1080000	1200000	1320000
Chick pea	Yield (qt/ha)	19	22	24
	Area (ha)	90	90	90
	Total produce	1710	1980	2160
	+Unit price (birr)	988	988	988
	Gross return	1689480	1956240	2134080
Chick pea	Yield (qt/ha)	10	11	12
	Area (ha)	75	75	75
	Total produce	750	825	900
	Unit price (birr)	988	988	988
	Gross return	741000	815100	889200
Pearl millet	Yield (qt/ha)	12	14	15
	Area (ha)	75	75	75

Crop Type	Description	Year I	Year II	Year III
	Total produce	900	1050	1125
	Unit price (birr)	984	984	984
	Gross return	885600	1033200	1107000
Mung bean	Yield (qt/ha)	8	9	10
	Area (ha)	90	90	90
	Total produce	720	810	900
	Unit price (birr)	1600	1600	1600
	Gross return	1152000	1296000	1440000
Teff (local)	Yield (qt/ha)	8	9	10
	Area (ha)	30	30	30
	Total produce	240	270	300
	Unit price (birr)	1155	1155	1155
	Gross return	277200	311850	346500
Cow pea	Yield (qt/ha)	40	45	50
	Area (ha)	30	30	30
	Total produce	1200	1350	1500
	Unit price (birr)	100	100	100
	Gross return	120000	135000	150000
Grand Total Return/year		13,497,720	15,290,670	16,788,060

4.7 Supporting Interventions

4.7.1 Extension

The success of any project will be measured by the ability to meet designed objectives and targets. Extension support has mainly designed to achieve the following:

- Increasing the agricultural returns, there by improve living standard and alleviate poverty.
- Improving the farmers' capacity to develop agricultural production so that schemes achieve its economic potential.

The achievement of successful schemes and viable project therefore obtained with strong endeavor of the beneficiaries and should not end on completion of the infrastructure. For the farmers to be able to increase the total value of their input, they need not only regular access to markets, credit and on farm inputs but also exposure to technological improvements and an opportunity to learn new skills. It is necessary to ensure that, the level of extension, remains high enough especially during the first three to five years of cropping as this is the time when farmers will need to adopt changes in the cropping pattern, increasing intensity and agricultural practices that can be expected from introduction of development projects. Therefore, it is important to note that, the extension services are in place and prepared prior to the onset of the project

4.7.1.1 Extension delivery alternatives

Extension services can be delivered in one or more of the following alternatives as appropriate.

a) 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 DAs are unable to solve the problem, they will consult the appropriate technical specialist at supervisor 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.

b) 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 drawn 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.

c) 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 2ha multipurpose demonstration site for farmers training how to practice newly introduced technologies. The regional agricultural institute through its closest research station (Kobo & Sirinka) has a responsibility of integrating the pilot issues in to the existing research program.

d) Field days

Field days will be needed when scheme awareness is required of a particular topic or theme and will generally be focused around demonstration plots and farmers. The activity may range from modest demonstrations with short technical talks, to a campaign with several presenters, audiovisual aids and displays. In certain cases, the event will permit the inclusion of some social activities which will usually encourage attendance and help foster community spirit. It is also encouraging to prepare an award for merit jobs.

e) Farmers meeting

Meeting and making open discussion on different development agendas are a traditional way of disseminating extension messages. Information is often exchanged among beneficiaries. Farmers are usually enthusiastic to get the best way they can. This is not appropriate at early time, where new practices are being introduced. The meetings will play an important role as the discussion forum focused on opinions and consensus, on programs and plans, marketing, credit and repayment, farm inputs and provision of services.

f) Farmers group visits and farm transect walks

Visits could be arranged when it is of particular advantage for farmers to see and discuss the activities with others or of particular benefit to visit farms, research and field stations.

g) Audiocassette, tapes and radios

A recorded newsletter, case histories, interviews made available for circulation to the irrigation schemes and beneficiaries. It is intended that the content should include a mix of technical subjects, timely reminders, women features, music and other agricultural and socio-economic affairs.

h) Study tours

Regional and national study tours can be arranged for group of farmers to enable them learn the new technologies. Study tour has to be arranged to visit areas where there is a good irrigation management practice and other improved farming practices. If conditions are allowable, International study tour can also be arranged in advanced countries.

i) Notice board

Notice board or sheltered glassed wall, at conventionally central location where members regularly pass, can be used to display items of general information and be kept updated with seasonal topics. It can be in written form, photographs, cartoons, talks, questions, folk talks, poems…etc as appropriate

j) Schools and youth students

Liaison activities with schools should be encouraging, as farmers’ sons and daughters are the major source of disseminating the information and skills to their parents. This can be include the practice as inputs in to the classroom subject or facilitate to involve as school project.

4.7.1.2 Training and experience sharing

Experts, supervisors, DAs and beneficiaries need short-term training and experience sharing to develop their technical capacity on crop management. 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 Equipments Farm tools, farm machineries and equipment, which are suitable to the area and level of technology, have to be provided through appropriate credit system.

4.8Agronomic Practices and Crop Requirements for Selected Crops Grown Under Irrigation

Sorghum

- Grows well at altitudes ranging from 500 -2000m.a.s.l. But the optimum altitude level is between 1,000 and 1600m.a.s.l. It grows well on moist, light to medium textured, well drained and aerated soils of pH 6-8. The crop survives and grows successfully under inadequate and erratic rainfall conditions.
- Field Preparation: 2 to 3 ploughings are required to prepare the seedbed reasonably well.
- Time of Planting & Seed Rate: Depending on the start of the rains and the variety, sorghum should be planted between April and May in Woina Dega and between May and June in Kolla agro-climates. The crop is row planted (spacing of 20x75cm) at the rate of 5-10 kg/ha.
- Fertilizer: Recommended rates of fertilizers vary with different soil types and agro-ecological conditions. However, the general recommendation is 100kg DAP and 50kg Urea per hectare.
- Weed Control: Sorghum should be weeded twice; the first 20-25 days after germination and the second 45-50 days after planting. Striga spp. is the most noxious weed in sorghum fields and control of this

weed is through crop rotation (with pulse crops) and pulling out the weed after flowering, just before fruiting.

- Insect Pests: Stalk borer, African bollworm and army worm are the major insect pests of maize. Destroying the previous crop residues controls stalk borer infestation. Application (inside each leaf funnel of the plant) of Cypermetrin 1% granular or Endosulfan 3% granular or Diazinon 5% granular controls stalk borer. For the other pests, Endosulfan 35% E.C. can be applied.
- Diseases: Smut, grain moulds and foliar diseases are common in sorghum. For the control of smuts, seed treatment using Fernesan D at the rate of 300g/quintal is recommended. Cultural practices including use of resistant varieties, crop rotation and removal of smut infested heads controls foliar diseases and grain moulds.

Cow pea

- The optimum altitude for Niger seed growth ranges from 0 - 2200 masl.
- Land preparation: Two to three times plowing is important for sesame seed growth.
- Seeding rate: For broadcasting 20 kg seed per hectare is required.
- Fertilizer: No recommended rate.
- Weed control: Hand weeding within 30-35 days after planting is recommended.
- Irrigation: minimum Water requirement of cow pea is 400mm, depending on the agro climatic condition of the area. Excessive irrigation can be harmful since the crop is very sensitive to water logged conditions.

Mung bean

- The crop is well adapted at elevation up to 2000m.a.s.l. It is ‘warm season’ crop. Cool temperatures adversely affect growth and plants are killed by frost. An optimum mean temperature for green gram is in the range of 28 - 30 0C. In general, warmer temperatures hasten development, so that flowering is most rapid and crop duration is shortest in warm-temperature, short-day conditions. Green gram has a reputation of being ‘drought resistance’. This crop is sensitive to water logging, which may affect nodules development, and leading to nitrogen deficiency which ultimately reduce growth. it is grown primarily as rainfed crops on vary wide range of soils.
- Land preparation: Two to three times plowing is important for sesame seed growth.
- Seeding rate: 30 kg seed per hectare is required for broadcasting. During row planting, 30cm between rows and 5 cm b/n plants.
- Fertilizer: 25 kg DAP/ha at planting.

- Weed control: Hand weeding according to the weed infestation is very crucial (Once to twice).

Teff

- Grows well b/n 1,600 to 2,700m.a.s.l.
- Ploughing frequency: on average 4 times
- See rate: 25 kg/ha
- Sowing method: broad casting after stepping with animals' hoofs or pulling/rolling trunks on the field for leveling
- Fertilizer application:
  - DAP 100 kg/ha all at time of sowing
  - Urea 50 kg/ha (half at time of sowing and half during plant tillering.
- Weed control: needs at least two hand weeding
  - 1st weeding 25-30 days after sowing
  - 2nd weeding 50-55 days after sowing

Maize

- Grows well b/n 1,800 to 2,500m.a.s.l.
- Ploughing frequency: on average 3-4 to ensure fine and weed free seedbed.
- Seed Rate: 25-30kg/ha.
- Sowing method: row planting
- Spacing: 75cm b/n rows and 25cm b/n plants.
- Fertilizer application:
  - DAP 100 kg/ha all at time of sowing
  - Urea 100 kg/ha (Urea should be applied in split applications).
- Weed Control: at least one hoeing and one hand weeding are recommended
  - 1st at 4 leaf stage: hoeing or inter row cultivation
  - 2nd at knee height stage: hand-weeding
  - 3rd weeding: up to flowering stage

Haricot bean

- Grows well at altitudes ranging from 1,400 to 1,800m.a.s.l.
- Ploughing frequency: 2 - 3 ploughing are adequate.
- Sowing method: row planting/seed drilling
- Seed rate: 40 to 60kg/ha depending on agro-climate and variety.
- Spacing: 40 - 60cm b/n row and spacing 5-10cm b/n plants.
- Fertilizer application:
  - DAP 100 - 150 kg /hectares.

- Weed control: One to two hand weeding are required.
  - 1st weeding is b/n 2nd to 3rd weeks after planting.
  - 2nd weeding: hoeing up to the start of flowering, i.e., after 4-5 weeks of planting

Chick pea

- Grows well between altitude ranges of 1500-2600m.a.s.l.
- Ploughing frequency: on average 3 times
- Sowing method: row planting/seed drilling
- Recommended spacing for row planting: 30cm b/n rows × 10cm b/n plants
- Seed rate: 120kg/ha
- Fertilizer application:
  - DAP: 100 kg/ha and all apply at time of sowing.
  - Weeding: needs at least one hand weeding: 25-30 days after sowing

4.9 Agricultural Development Scenarios and Options

4.9.1 General

The major target of the irrigation development study at any level is to prepare a developable, feasible, fundable and above all sustainable project to the planners and decision makers for implementation. After formulating cropping pattern, farm inputs, yield estimation and build up crop water requirements in pervious sections, etc the next decisive step of agricultural development planning is to provide at most possible scenarios, options and alternatives.

Agricultural Development Scenarios and Options should give the choice of possible crop mix and farming enterprise available. Justifications for those scenarios and options have to be in place.

4.9.2 Basis of agricultural development scenarios and options

Basis for formulation of scenarios could be: crop types and cropping pattern, settlement and land consolidation, land allocation and re-allocation, development of agro-processing industries and raw materials, integration of livestock with irrigation (such as, livestock & irrigated pasture), fishery and tourism (i.e., creation of a reservoir for development of irrigation could stimulate fishery and lake tourism)**,** irrigation and apiculture (i.e., their compatibility), etc.

On top of the above exemplary basis for the formulation of agricultural development scenarios and from the nature of the present irrigation project site and localities, “integration of livestock with irrigation (such as, dairy and fattening with irrigated pasture)", has been proposed for this project. Justifications for this scenario are:

- ≡ The agro-ecology of the project area is suitable for pasture production
- ≡ Farmers experience on dairy and fattening is somewhat good
- ≡ Development and expansion of irrigation schemes (surface & ground water source irrigations schemes) in the surrounding areas of the project, i.e., in Kobo Woreda.
- ≡ Proximity to towns or big market centers such as, Alamata, Woldia, Dessie, Combolcha, Addis Ababa, etc.
- ≡ The project command is located at the backyards of farmers' houses and ease to work and supervise the project closely.
- ≡ Presence of good road (asphalt) facility to transport the produce (milk and/or fattened sheep or oxen) to big and better market places.
- ≡ Farmers can obtain improved fodder planting materials from Sirinka Agricultural Research Center easily and also can get technical advisory services from the center.
- ≡ The demand for milk and/or meat for food purposes is high in over all the country, especially in large cities (like, Dessie, Combolcha, Addis Ababa, Mekelle, Bahir Dar, Gondar, etc)

4.9.3 Pilot scheme and/or research

The recommended cropping patterns and scenarios/options have to be tested on a pilot basis before it is extensively adopted on the whole project area. A pilot scheme serves, for example, to adopt new and presently untried varieties of selected crops including hybrid varieties and pasture crops, to display new agro-technologies and agricultural practices, etc.

Based on the aforementioned facts, some of the recommended crop varieties for this development irrigation project are new for the project area and farmers too. Of the recommended crop varieties which are new for the area and local farmers are: haricot bean varieties (Awash-1, Wedo, Lehode, and AR04GY), chick pea varieties (Kutaye, Yelbey and Arerti), and pearl millet (Kolla 1) and cow pea varieties (Bole, black-eye-bean), mung bean varieties (M61, M76, M140).

5. Agribusiness Linkage and Market Access

Agribusiness linkages and market access covers the services involved in moving an agricultural product from the farm to the consumer. Numerous interconnected activities are involved in doing this, such as planning production, growing and harvesting, grading, packing, transport, storage, agro- and food processing, distribution, advertising and selling.

Marketing systems are dynamic; they are competitive and involve continuous change and improvement. Businesses that have lower costs, are more efficient, and can deliver quality products, are those that prosper. Those that have high costs, fail to adapt to changes in market demand and provide poorer quality is often forced out of business. Marketing has to be customer-oriented and has to provide the farmer, transporter, trader, processor, etc. with a profit. This requires those involved in marketing chains to understand buyer requirements, both in terms of product and business conditions.

The farmers in the project area sales their produces in the near town market for local traders. They lack market information, low business and negotiating experience, lack of farmers' organizations like cooperatives which encourage producers to produce adequate quantity and quality and fetch better price for their produces. The farmers couldn't have direct linkage with processers, super markets, government institutions and hence most of the markets have been mobilized by brokers and local traders. Business and marketing support services are not well developed to improve their marketing performances.

To solve the existing gaps, it needs to strengthen farmers' groups and cooperatives, the development of agribusiness linkages and access to financial services. Supports will be provided to improve participation, awareness, knowledge and skill and business linkages of the private business enterprises (such as small farmers, cooperatives/unions, processors, wholesalers, retailers, exporters and relevant public agencies). Focus will be given to Farmers' groups, primary cooperatives, unions, and private sectors (such as traders, agro-processors and exporters) who are involved in the development of agribusiness. Mobilizing, organizing and strengthening of farmers' groups, irrigation users marketing cooperatives and multipurpose cooperatives will be the key activities as they are the main vehicle for application of the principles and practices of irrigation farming as a business

It will be expected to facilitate the establishment of agribusiness linkages among small farmers, relevant private and public stakeholders through market access alliances (MAA). The MAA would be established as voluntary platforms. The main purpose of the MAA will be facilitating emergence of agribusiness linkages between organized farmers and other marketing chain stakeholders and service providers. The MAA will comprises of membership of farmers groups, farmers cooperatives, inputs suppliers, primary processors and aggregators, exporters, etc), and key service providers such as micro finance institutions, rural saving and credit cooperatives, banks, transporters as well as relevant Woreda level public institutions.

Furthermore, private-public dialogue is always crucial in business and market development, particularly regarding policy and intuitional supports. The farmers' cooperatives and private sector have a central role to play in identifying and advocating policy, legal and institutional supports that will help government to take directives. Using market access alliances as a plat form, public and private dialogue will be facilitated to create common understanding and collaboration among private and public stakeholders to promote market and agri-business development. Stakeholders in the various value chains will be assisted to identify policy, legal and institutional constraints and articulating impact on actors and functions of the market and agribusiness, and to develop a strategic intervention plan that prioritizes actions and investments for greatest effect.

There are also government institutions which have potential sources of demand for agricultural food products and improve seed. Therefore, it will be facilitated to link farmers to universities/colleges, hospitals and correction centers which involve in the purchase of food items in a regular manner for their communities members as well as seed enterprises like Amhara and Ethiopian seed enterprises which involve in the contractual agreements with the farmers directly for the multiplication of improved seed. These type of agreements have to be watched carefully for sake of "Win-win'' relationship among parties. To smooth the demand and supply, contractual farming system will be promoted with defined quantity and quality of the product and specified price.

Benefit description market access farmers can access markets that were formerly out of reach for them. Increased incomes contract farming promotes production of commodities that are sold for a higher price and may be grown without significant extra effort. Reduction in the risk of price fluctuations binding product prices are normally specified in the contract before production, thereby cushioning both the farmer and the contractor against price fluctuations. Credit and financial intermediation contracting offers opportunities for lending to farmers who would otherwise be ineligible for credit. Timely provision of inputs contracting enables timely delivery of inputs and products to markets, even in areas that have poor road networks. Monitoring and labor incentives contract farming is a more efficient way of managing the productivity of labor since efficiency is directly related to return. Reduction of production risk contract farming allows farmers to significantly reduce their risk in the event of crop failure because losses are shared by the contracting parties. Introduction of higher-value crops through contract farming, farmers can start growing new crops that they would otherwise not produce under conventional farming arrangements. Improved collective bargaining contract farming results in improved awareness of the need for collective efforts for farmers' common good and promotion of group and farmer association development. Household spill-over benefits include improved food security, which results from adoption of improved husbandry methods. Improved access to extension many contracting companies provide extension advice and other technical assistance that would, otherwise, not be available to farmers under normal circumstances.

The overall aim of linking farmers to the market is "To provide market linkage innovations and empower smallholder producers to choose what commodities to produce, what technologies to apply for production, when to produce, for whom to produce and when and at what price to sell". Market linkage innovations will enable smallholder producers to sell their produce or purchase needed inputs on time and at competitive prices. There are several ways of linking small farmers to market. The most important ones include linking through growers' association, cooperatives and contract farming. The market linkage is to be done with domestic traders, retailers, agro-processors, exporters and buyer institutions. Therefore, it needs to first mobilize and organize small farmers in groups, cooperatives, association, etc, then to identify most effective ways of linking them to market.

6. CONCLUSION AND RECOMMENDATION

6.1. Conclusion

The current crop production of the project area has been constrained by technical/social, institutional, agronomical and environmental factors, which contribute for unattractive development of the sector. The productivity of crops are not at a promising stages due to: unreliable and uneven distribution of rainfall, low level of soil fertility, crop pests attack, traditional farming practice and other extension associated problems. Majority of the farmers in the project area are not acquainted to improved technologies that influence the existing backward farming practices so as to transform to modern production systems. Moreover, agricultural support services are not strong enough, i.e., loosened. As a result of these, the current crop production shows neither sustainable growth nor modern technology based production system.

Conversely, following the present production uncertainty, farmers of the project and the vicinity area have developed traditional irrigation agriculture/practices. The existing practices are highly encouraging and have started to register significant results. Thus, introduction of modern irrigation is a shortcut solution for sustainable development. The regional government has also tired to implement small-scale modern irrigation technologies at household levels. Despite the fact that, the effort that has been done is very promising, it lacks close supervision and technical supports. To attend sustainable development, existing traditional production systems of rainfed agriculture has to be complemented by modern irrigation. Therefore, transferring the existing traditional irrigation practices into modern system will be a cross cutting issues to bring about a sustainable development. In view of that, it is highly valuable to implement the proposed development project with proper application of the following recommendations.

6.2. Recommendation

The major problems observed in many of the irrigation intervention areas are poor agronomic practice. Therefore, it is valuable to implement the present project instantly to take the advantages of current market prices; and also greatly advised to use recommended practices to deserve the intended project objectives. The following points are recommended for the success full implementation of this project:

- The project Water Users Association (WUA) should be established.
- Training on irrigation agronomy and management should be provided to DAs and beneficiary framers to equip them with sufficient techniques and skills on irrigation methods, utilization of agricultural inputs (specifically improved seeds), improved crop management practices, etc.
- It is quite important to implement the irrigation project in accordance with the proposed cropping pattern and calendar so as to avoid irrigation water management related problems.
- It is also important to strengthen input and credit's supplying institutions in the area
- Different demonstration and adaptation trials should be adopted on farmers' fields for recommended new crop varieties.
- As spate irrigation is mostly a subsistence activity achieving reliability of cropping, even if yields are low, is more important than introducing using new crop varieties that achieve high yields in good years if this at the expense of the risk of a complete crop failures in bad years.
- To increase yields and the returns from spate irrigated agriculture: it is important to improve the link between research and extension; where possible research needs to be carried out with farmers, in farmer led trials and experiments on working spate systems and farmer to farmer demonstration activities so as to get away from the "research farm" approach.

Note: The proposed cropping pattern for Gobu 3 spate irrigation scheme is based on the existing knowledge of the local farmers, market accesses, environmental adaptability, productivity, etc. conditions. However, the proposed pattern is flexible and can be revised according to the prevailing market demand and changes in production objectives of the farmers.

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8. ANNEXES

Annex 1: Monthly reference evapotranspiration using modified Penman-Monteith method

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Country: Ethiopia Station: Kobo

Kobo: Alt: 1470; Lat: 12.08^0; Long: 39.38^0

Month	Min Temp	Max Temp	Humidity	Wind	Sun	Rad	ETo
	°C	°C	%	km/day	hours	MJ/m²/day	mm/day
January	13.8	26.5	60	158	8	18.7	3.7
February	13.8	29.1	54	175	8.3	20.5	4.4
March	15.5	29.9	49	188	9.1	23	5.2
April	16.4	31	50	174	9.6	24.3	5.5
May	17.1	33.2	42	181	10	24.6	5.9
June	18.9	34.7	32	184	7.6	20.6	5.9
July	18.4	32	50	180	5.6	17.7	4.9
August	17	30.5	61	131	6.6	19.5	4.4
September	15	30.7	56	97	8.2	21.7	4.5
October	13.3	29.7	48	104	9.7	22.8	4.5
November	12.1	28.4	46	119	9.5	20.9	4.1
December	11.5	26.9	54	125	9	19.5	3.7
Average	15.2	30.2	50	151	8.4	21.2	4.7

Annex 2: Rainfall data of the study area

Station: Kobo

Kobo: Alt: 1470 masl; Lat: 12.08^0; Long: 39.38^0

Month	Average Rainfall (mm)	80% dependable Rain (mm)	Eff. rain (mm)
January	17.1	14.5	14.2
February	6.2	5.2	5.2
March	24.5	20.7	20
April	67.8	57.4	52.1
May	43.5	36.9	34.7
June	10.6	9	8.9
July	170.5	144.5	111.1
August	229.1	194.3	133.9
September	34.3	29.1	27.7

October	39.2	33.2	31.4
November	23.1	19.5	18.9
December	13.7	11.6	11.4
Total	679.6	575.9	469.5

Annex 3: Length of growing period (LGP), crop coefficient (Kc) and others data for irrigated crops

Crops proposed	**LGP**	**Initial**	**Dev.**	**Mid**	**Late**	**Planting Date**	**Harvest date**	**Land share %**	**Yield response**					**Critical depletion (P)**			**Root depth (m) (stages)**		**crop max.ht (m)**
Wet Season								**100**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**Initial**	**Late**	
Teff	130	20	25	55	30	16-Jul	22-Nov	20	0.20	0.60	0.50	0.20	1.00	0.45	0.50	0.50	0.15	0.50	0.8
	Kc	0.7		1.0	0.3														
Sorghum	120	20	35	40	25	06-Jun	03-Oct	40	0.20	0.55	0.45	0.20	0.90	0.50	0.55	0.55	0.20	1.00	1.5
	Kc	0.65		1.05	0.55														
Maize	140	25	40	45	30	26-Jun	12-Nov	15	0.40	1.25	0.50	0.20	1.25	0.50	0.55	0.55	0.25	1.00	2.0
	Kc	0.7		1.2	0.6														
Haricot bean	100	25	25	30	20	01-Jul	08-Oct	10	0.20	0.80	1.00	0.30	0.85	0.40	0.45	0.45	0.25	0.60	0.4
	Kc	0.4		1.2	0.35														
Chick pea	140	25	40	45	30	10-Aug	27-Dec	15	0.30	0.55	0.60	0.20	0.80	0.45	0.50	0.50	0.25	0.60	0.4
	Kc	0.4		1.0	0.35														
Dry Season								**100**											
Chick pea	100	20	30	35	15	14-Mar	21-Jun	25	0.30	0.55	0.60	0.20	0.80	0.45	0.50	0.50	0.25	0.60	0.4
	Kc	0.4		1.0	0.35														
Pearl millet	90	15	25	30	20	16-Mar	13-Jun	25	0.20	0.55	0.45	0.20	0.90	0.45	0.50	0.50	0.15	0.90	1.5
	Kc	0.65		1.1	0.55														
Mung bean	65	15	20	20	10	20-Mar	23-May	30	0.20	0.80	1.00	0.30	0.85	0.40	0.45	0.45	0.25	0.60	0.4
	Kc	0.4		1.1	0.35														
Teff (local)	95	15	20	35	20	16-Mar	18-Jun	10	0.20	0.60	0.50	0.20	1.00	0.45	0.50	0.50	0.15	0.50	0.5
		0.7		1.0	0.3														
Cow pea	95	20	30	30	15	14-Mar	16-Jun	10	0.2	1.10	0.75	0.20	1.15	0.40	0.45	0.45	0.20	0.40	0.4
		0.4		1.05	0.6														
G/Total								**200**											

Annex 4： Net crop water requirements for Gobu 3 Spate Irrigation Project

- ***Wet season crops***

Annex 4.1: Net Crop Water Requirements of Teff

Month	Decade	Stage	Kc	ETc	ETc	Eff rain	Irr. Req.
			coeff	mm/day	mm/dec	mm/dec	mm/dec
Jul	2	Init	0.7	3.45	17.2	20.4	0
Jul	3	Init	0.7	3.33	36.7	42.1	0
Aug	1	Deve	0.72	3.34	33.4	46.2	0
Aug	2	Deve	0.84	3.72	37.2	50.7	0
Aug	3	Mid	0.96	4.28	47.1	36.9	10.2
Sep	1	Mid	1	4.48	44.8	17.6	27.2
Sep	2	Mid	1	4.51	45.1	4	41
Sep	3	Mid	1	4.5	45	6.2	38.8
Oct	1	Mid	1	4.5	45	10.6	34.4
Oct	2	Mid	1	4.5	45	11.2	33.7
Oct	3	Late	0.92	4.03	44.3	9.6	34.7
Nov	1	Late	0.68	2.9	29	7.6	21.4
Nov	2	Late	0.45	1.85	18.5	6.1	12.4
Nov	3	Late	0.31	1.23	2.5	1.1	2.5
Total					490.7	270.2	256.5

Annex 4.2: Net Crop Water Requirements of Sorghum

Month	Decade	Stage	Kc	ETc	ETc	Eff rain	Irr. Req.
			coeff	mm/day	mm/dec	mm/dec	mm/dec
Jun	1	Init	0.65	3.89	19.4	1.1	18.4
Jun	2	Init	0.65	3.91	39.1	0	39.1
Jun	3	Deve	0.67	3.77	37.7	6.9	30.8
Jul	1	Deve	0.77	4.03	40.3	28.2	12.1
Jul	2	Deve	0.88	4.32	43.2	40.8	2.4
Jul	3	Mid	0.99	4.73	52	42.1	9.9
Aug	1	Mid	1.04	4.78	47.8	46.2	1.6
Aug	2	Mid	1.04	4.61	46.1	50.7	0
Aug	3	Mid	1.04	4.64	51	36.9	14.1
Sep	1	Late	1.03	4.64	46.4	17.6	28.8
Sep	2	Late	0.89	4.02	40.2	4	36.2
Sep	3	Late	0.69	3.13	31.3	6.2	25.1
Oct	1	Late	0.56	2.54	7.6	3.2	2.3
Total					502.2	283.7	220.9

Annex 4.3: Net Crop Water Requirements of Maize (Grain)

Month	Decade	Stage	Kc	ETc	ETc	Eff rain	Irr. Req.
			coeff	mm/day	mm/dec	mm/dec	mm/dec
Jun	3	Init	0.7	3.96	19.8	3.4	16.4
Jul	1	Init	0.7	3.68	36.8	28.2	8.6
Jul	2	Init	0.7	3.45	34.5	40.8	0
Jul	3	Deve	0.77	3.69	40.6	42.1	0
Aug	1	Deve	0.9	4.16	41.6	46.2	0
Aug	2	Deve	1.03	4.57	45.7	50.7	0
Aug	3	Mid	1.15	5.16	56.7	36.9	19.8
Sep	1	Mid	1.19	5.37	53.7	17.6	36.1
Sep	2	Mid	1.19	5.4	54	4	49.9
Sep	3	Mid	1.19	5.4	54	6.2	47.8
Oct	1	Mid	1.19	5.39	53.9	10.6	43.3
Oct	2	Late	1.14	5.14	51.4	11.2	40.2
Oct	3	Late	0.94	4.11	45.2	9.6	35.6
Nov	1	Late	0.73	3.11	31.1	7.6	23.5
Nov	2	Late	0.61	2.52	5	1.2	5
Total					623.8	316.2	326.3

Annex 4.4: Net Crop Water Requirements of Haricot bean

Month	Decade	Stage	Kc	ETc	ETc	Eff rain	Irr. Req.
			coeff	mm/day	mm/dec	mm/dec	mm/dec
Jul	1	Init	0.4	2.1	21	28.2	0
Jul	2	Init	0.4	1.97	19.7	40.8	0
Jul	3	Deve	0.46	2.19	24.1	42.1	0
Aug	1	Deve	0.76	3.52	35.2	46.2	0
Aug	2	Mid	1.08	4.8	48	50.7	0
Aug	3	Mid	1.19	5.33	58.7	36.9	21.8
Sep	1	Mid	1.19	5.36	53.6	17.6	36.1
Sep	2	Late	1.18	5.34	53.4	4	49.3
Sep	3	Late	0.88	3.96	39.6	6.2	33.4
Oct	1	Late	0.5	2.25	18	8.5	7.4
Total					371.3	281.1	148

Annex 4.5: Net Crop Water Requirements of Chick pea

Month	Decade	Stage	Kc	ETc	ETc	Eff rain	Irr. Req.
			coeff	mm/day	mm/dec	mm/dec	mm/dec
Aug	1	Init	0.4	1.84	1.8	4.6	1.8
Aug	2	Init	0.4	1.78	17.8	50.7	0
Aug	3	Init	0.4	1.79	19.7	36.9	0
Sep	1	Deve	0.44	1.99	19.9	17.6	2.3
Sep	2	Deve	0.59	2.66	26.6	4	22.6
Sep	3	Deve	0.74	3.34	33.4	6.2	27.2
Oct	1	Deve	0.89	4.02	40.2	10.6	29.6
Oct	2	Mid	1	4.51	45.1	11.2	33.8
Oct	3	Mid	1	4.39	48.3	9.6	38.7
Nov	1	Mid	1	4.26	42.6	7.6	35
Nov	2	Mid	1	4.12	41.2	6.1	35.1
Nov	3	Late	0.99	3.92	39.2	5.3	33.9
Dec	1	Late	0.82	3.12	31.2	4.3	26.8
Dec	2	Late	0.6	2.2	22	3.3	18.6
Dec	3	Late	0.42	1.53	10.7	2.4	6.9
Total					439.6	180.5	312.5

- ***Dry season crops***

In general, dry season irrigation will be practiced using spate irrigation system

Annex 5： Irrigation schedule of Gobu 3 Spate Irrigation Project

- ***Wet season crops***

Annex 5.1: Irrigation Schedule of teff

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
16-Jul	1	Init	0	0.91	91	63	15	0	0	21.4	2.48
20-Jul	5	Init	0	1	100	49	13.8	0	0	19.7	0.57
01-Aug	17	Init	0	1	100	47	20	0	0	28.6	0.28
09-Sep	56	Mid	0	1	100	52	39	0	0	55.7	0.17
18-Sep	65	Mid	0	1	100	52	38.8	0	0	55.5	0.71
28-Sep	75	Mid	0	1	100	54	40.2	0	0	57.4	0.66
09-Oct	86	Mid	0	1	100	51	38.4	0	0	54.8	0.58
20-Oct	97	Mid	0	1	100	50	37.6	0	0	53.7	0.57
02-Nov	110	End	0	1	100	53	40.1	0	0	57.2	0.51
22-Nov	End	End	0	1	0	44					

Annex 5.2: Irrigation Schedule of Sorghum

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
06-Jun	1	Init	0	0.9	90	66	21.2	0	0	30.3	3.51
11-Jun	6	Init	0	1	100	59	25.5	0	0	36.4	0.84
17-Jun	12	Init	0	1	100	55	30.7	0	0	43.9	0.85
26-Jun	21	Dev	0	1	100	55	41.6	0	0	59.4	0.76
20-Sep	107	End	0	1	100	57	85.4	0	0	122	0.16
03-Oct	End	End	0	1	100	17					

Annex 5.3 Irrigation Schedule of soybean Maize (Grain)

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
26-Jun	1	Init	0	0.9	90	64	25.2	0	0	35.9	4.16
01-Jul	6	Init	0	1	100	50	24.1	0	0	34.4	0.8
15-Sep	82	Mid	0	1	100	55	82.9	0	0	118.4	0.18
02-Oct	99	Mid	0	1	100	57	86.1	0	0	122.9	0.84
22-Oct	119	End	0	1	100	57	85.3	0	0	121.9	0.71
12-Nov	End	End	0	1	0	38					

Annex 5.4 Irrigation Schedule of Haricot bean

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
01-Jul	1	Init	0	0.92	92	50	19.3	0	0	27.5	3.19
05-Sep	67	Mid	0	1	100	47	42.1	0	0	60.2	0.11
14-Sep	76	Mid	0	1	100	47	42	0	0	59.9	0.77
23-Sep	85	End	2.4	1	100	45	40.7	0	0	58.1	0.75
08-Oct	End	End	5.6	1	100	33					

Annex 5.5 Irrigation Schedule of Chick pea

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
10-Aug	1	Init	0	0.91	91	54	20.8	0	0	29.8	3.44
21-Sep	43	Dev	0	1	100	50	36.2	0	0	51.7	0.14
06-Oct	58	Dev	0	1	100	52	43.8	0	0	62.6	0.48
20-Oct	72	Mid	0	1	100	55	49.3	0	0	70.4	0.58
02-Nov	85	Mid	0	1	100	52	46.8	0	0	66.8	0.59
15-Nov	98	Mid	0	1	100	53	47.6	0	0	68	0.61
29-Nov	112	End	0	1	100	53	47.3	0	0	67.6	0.56

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
19-Dec	132	End	0	1	100	52	47.1	0	0	67.3	0.39
27-Dec	End	End	0	1	0	8					

Annex 6：Irrigation Scheme of Gobu 3 Spate Irrigation Project

Precipitation deficit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1. Teff	0	0	0	0	0	0	0	10.4	107.8	103.6	36.5	0
2. Sorghum	0	0	0	0	0	88.3	25.8	17.2	92	2.5	0	0
3. Maize	0	0	0	0	0	16.4	8.6	20.3	135.3	120.4	28.7	0
4. Haricot bean	0	0	0	0	0	0	0	22.1	119.7	7.4	0	0
5. Chick pea	0	0	0	0	0	0	0	1.8	52.1	102.2	104.1	52.4
Net scheme irr.req.												
in mm/day	0	0	0	0	0	1.3	0.4	0.5	3.3	1.8	0.9	0.3
in mm/month	0	0	0	0	0	37.8	11.6	14.5	98.4	55.9	27.2	7.9
in l/s/h	0	0	0	0	0	0.15	0.04	0.05	0.38	0.21	0.1	0.03
Irrigated area (% of total area)	0	0	0	0	0	55	55	100	100	100	50	15
Irr.req. for actual area (l/s/h)	0	0	0	0	0	0.27	0.08	0.05	0.38	0.21	0.21	0.2