SSIGL 2

NATIONAL GUIDELINES

For Small Scale Irrigation Development in Ethiopia

Site Identification and Prioritization

November 2018

Addis Ababa

MINISTRY OF AGRICULTURE

National Guidelines for Small Scale Irrigation Development in Ethiopia

SSIGL 2: Site Identification and Prioritization

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DISCLAIMER

Ministry of Agriculture through the Consultant and core reviewers from all relevant stakeholders included the information to provide the contemporary approach about the subject matter. The information contained in the guidelines is obtained from sources believed tested and reliable and are augmented based on practical experiences. While it is believed that the guideline is enriched with professional advice, for it to be successful, needs services of competent professionals from all respective disciplines. It is believed, the guidelines presented herein are sound and to the expected standard. However, we hereby disclaim any liability, loss or risk taken by individuals, groups, or organization who does not act on the information contained herein as appropriate to the specific SSI site condition.

FORWARD

Ministry of Agriculture, based on the national strategic directions is striving to meet its commitments in which modernizing agriculture is on top of its highest priorities to sustain the rapid, broad-based and fair economic growth and development of the country. To date, major efforts have been made to remodel several important strategies and national guidelines by its major programs and projects.

While efforts have been made to create access to irrigation water and promoting sustainable irrigation development, several barriers are still hindering the implementation process and the performance of the schemes. The major technical constrains starts from poor planning and identification, study, design, construction, operation, and maintenance. One of the main reasons behind this outstanding challenge, in addition to the capacity limitations, is that SSIPs have been studied and designed using many ad-hoc procedures and technical guidelines developed by various local and international institutions.

Despite having several guidelines and manuals developed by different entities such as MoA (IDD)-1986, ESRDF-1997, MoWIE-2002 and JICA/OIDA-2014, still the irrigation professionals follow their own public sources and expertise to fill some important gaps. A number of disparities, constraints and outstanding issues in the study and design procedures, criteria and assumptions have been causing huge variations in all vital aspects of SSI study, design and implementation from region to region and among professionals within the same region and institutions due mainly to the lack of agreed standard technical guidelines. Hence, the SSI Directorate with AGP financial support, led by Generation consultant (GIRDC) and with active involvement of national and regional stakeholders and international development partners, these new and comprehensive national guidelines have been developed.

The SSID guidelines have been developed by addressing all key features in a comprehensive and participatory manner at all levels. The guidelines are believed to be responsive to the prevalent study and design contentious issues; and efforts have been made to make the guidelines simple, flexible and adaptable to almost all regional contexts including concerned partner institution interests. The outlines of the guidelines cover all aspects of irrigation development including project initiation, planning, organizations, site identification and prioritization, feasibility studies and detail designs, contract administration and management, scheme operation, maintenance and management.

Enforceability, standardization, social and environmental safeguard mechanisms are well mainstreamed in the guidelines, hence they shall be used as a guiding framework for engineers and other experts engaged in all SSI development phases. The views and actual procedures of all relevant diverse government bodies, research and higher learning institutions, private companies and development partners has been immensely and thoroughly considered to ensure that all stakeholders are aligned and can work together towards a common goal. Appropriately, the guidelines will be familiarized to the entire stakeholders working in the irrigation development. Besides, significant number of experts in the corresponding subject matter will be effectively trained nationwide; and the guidelines will be tested practically on actual new and developing projects for due consideration of possible improvement. Hence, hereinafter, all involved stakeholders including government & non-governmental organizations, development partners, enterprises, institutions, consultants and individuals in Ethiopia have to adhere to these comprehensive national guidelines in all cases and at all level whilst if any overlooked components are found, it should be documented and communicated to MOA to bring them up-to-date.

Therefore, I congratulate all parties involved in the success of this effort, and urge partners and stakeholders to show a similar level of engagement in the implementation and stick to the guidelines over the coming years.

H.E. Dr. Kaba Urgessa
State Minister, Ministry of Agriculture

SMALL SCALE IRRIGATION DEVELOPMENT VISION

Transforming agricultural production from its dependence on rain-fed practices by creating reliable irrigation system in which smallholder farmers have access to at least one option of water source to increase production and productivity as well as enhance resilience to climate change and thereby ensure food security, maintain increasing income and sustain economic growth.

ACKNOWLEDGEMENTS

The preparation of SSIGLs required extensive inputs from all stakeholders and development partners. Accordingly many professionals from government and development partners have contributed to the realization of the guidelines. To this end MOA would like to extend sincere acknowledgement to all institutions and individuals who have been involved in the review of these SSIGLs for their comprehensive participation, invaluable inputs and encouragement to the completion of the guidelines. There are just too many collaborators involved to name exhaustively and congratulate individually, as many experts from Federal, regional states and development partners have been involved in one way or another in the preparation of the guidelines. The contribution of all of them who actively involved in the development of these SSIGLs is gratefully acknowledged. The Ministry believes that their contributions will be truly appreciated by the users for many years to come.

The Ministry would like to extend its appreciation and gratitude to the following contributors:

- Agriculture Growth Program (AGP) of the MoA for financing the development and publication of the guidelines.
- The National Agriculture Water Management Platform (NAWMP) for overseeing, guidance and playing key supervisory and quality control roles in the overall preparation process and for the devotion of its members in reviewing and providing invaluable technical inputs to enrich the guidelines.
- Federal Government and Regional States organizations and their staff for their untiring effort in reviewing the guidelines and providing constructive suggestions, recommendations and comments.
- National and international development partners for their unreserved efforts in reviewing the guidelines and providing constructive comments which invaluably improved the quality of the guidelines.
- Small-scale and Micro Irrigation Support Project (SMIS) and its team for making all efforts to have quality GLs developed as envisioned by the Ministry.

The MOA would also like to extend its high gratitude and sincere thanks to AGP's multi development partners including the International Development Association (IDA)/World Bank, the Canada Department of Foreign Affairs, Trade and Development (DFATD), the United States Agency for International Development (USAID), the Netherlands, the European Commission (EC), the Spanish Agency for International Development (AECID), the Global Agriculture and Food Security Program (GAFSP), the Italy International Development Cooperation, the Food and Agriculture Organization (FAO) and the United Nations Development Program (UNDP).

Moreover, the Ministry would like to express its gratitude to Generation Integrated Rural Development Consultant (GIRDC) and its staff whose determined efforts to the development of these SSIGLs have been invaluable. GIRDC and its team drafted and finalized all the contents of the SSIGLs as per stakeholder suggestions, recommendations and concerns. The MoA recognizes the patience, diligence, tireless, extensive and selfless dedication of the GIRDC and its staff who made this assignment possible.

Finally, we owe courtesy to all national and International source materials cited and referred but unintentionally not cited.

Ministry of Agriculture

DEDICATIONS

The National Guidelines for Small Scale Irrigation Development are dedicated to Ethiopian smallholder farmers, agro-pastoralists, pastoralists, to equip them with appropriate irrigation technology as we envision them empowered and transformed.

LIST OF GUIDELINES

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

AGP	Agricultural Growth Program
ANRS	Amhara National regional State
CA	Command Area
CBL	Canal Bed Level
CBO	Community Based Organization
CWR	Crop Water Requirement
DD	Detail Design
DEM	Digital Elevation Model
EMA	Ethiopian Mapping Agency
EPA	Environmental Protection Authority
ESIA	Environmental and Social Impact Assessment
ETo	Reference Evapotranspiration
FAO	Food and Agriculture Organization
FS	Feasibility Study
GIR	Gross Irrigation Requirement
GIS	Geographic Information System
GPS	Global Positioning System
HIV	Human Immunodeficiency Virus
HW	Head Work
ID	Identification
IR	Irrigation Requirement
IWUA	Irrigation Water Use Association
LGP	Length of Growing Period
MCA	Multiple Criteria Analysis
MoA	Ministry of Agriculture
MOWIE	Ministry of Water, Irrigation and Electricity
NIR	Net Irrigation Requirement
OBL	Original Ground Level
PIDM	Participatory Irrigation Development and Management
RBL	River Bed Level
SMISS	Small Scale and Micro Irrigation Support Project
SNNPR	Southern Nations, Nationalities and Peoples' Region
SSI	Small Scale Irrigation
SSID	Small Scale Irrigation Development
SSIGL	Small Scale Irrigation Guideline
SSIP	Small Scale Irrigation Project
SSIS	Small Scale Irrigation Scheme
USBR	United States Bureau of Reclamation

PREFACE

While irrigation development is at the top of the government's priority agendas as it is key to boost production and improve food security as well as to provide inputs for industrial development. Accordingly, irrigated land in different scales has been aggressively expanding from time to time. To this end, to enhance quality delivery of small-scale irrigation development planning, implementation and management, it has been decided to develop standard SSI guidelines that must be nationally applied. In September 2017 the Ministry of Agriculture (MoA) had entrusted Generation Integrated Rural Development Consultant (GIRDC) to prepare the National Small-scale Irrigation Development Guidelines (SSIGLs).

Preparation of the SSIGLs for enhancing development of irrigated agriculture is recognized as one of the many core initiatives of the MoA to improve its delivery system and achieve the targets in irrigated agriculture and fulfill its mission for improving agricultural productivity and production. The core objective of developing SSIGLs is to summarize present thinking, knowledge and practices to enable irrigation practitioners to properly plan, implement and manage community managed SSI schemes to develop the full irrigation potential in a sustainable manner.

As the SSIGLs are prepared based on national and international knowledge, experiences and practices, and describe current and recommended practice and set out the national standard guides and procedures for SSI development, they serve as a source of information and provide guidance. Hence, it is believed that the SSIGLs will contribute to ensuring the quality and timely delivery, operation and maintenance of SSI schemes in the country. The SSIGLs attempt to explain and illustrate the important concepts, considerations and procedures in SSI planning, implementation and management; and shall be used as a guiding framework for professionals engaged in SSI development. Illustrative examples from within the country have been added to enable the users understand the contents, methodologies presented in the SSIGLs.

The intended audiences of the SSIGLs are government organizations, NGOs, CSOs and the private sector involved in SSI development. Professionally, the SSIGLs will be beneficial for experienced and junior planners, experts, contractors, consultants, suppliers, investors, operators and managers of SSI schemes. The SSIGLs will also serve as a useful reference for academia and researchers involved and interested in SSI development. The SSIGLs will guide to ensure that; planning, implementation and management of SSI projects is formalized and set procedures and processes to be followed. As the SSIGLs provide information and guides they must be always fully considered and applied by adapting them to the local specific requirements.

In cognizance with the need for quality SSIGLs, the MoA has duly considered quality assurance and control during preparation of the guidelines. Accordingly, the outlines, contents and scope of the SSIGLs were thoroughly discussed, reviewed and modified by NAWMP members (senior professionals from public, national and international stakeholder) with key stakeholders in many consultative meetings and workshops. Moreover, at each milestone of SSIGL preparation, resource persons from all stakeholders reviewed and confirmed that SSIGLs have met the demands and expectations of users.

Moreover, the Ministry has mobilized resource persons from key Federal, National Regional States level stakeholders and international development partners for review, validation and endorsement of the SSIGLs.

Several hundreds of experienced professionals (who are very qualified experts in their respective fields) from government institutions, relevant private sector and international development partners have significantly contributed to the preparation of the SSIGLs. They have been involved in all aspects of the development of SSIGLs throughout the preparation process. The preparation process included a number of consultation meetings and workshops: (i) workshop to review inception report, (ii) workshop on findings of review of existing guidelines/manuals and proposed contents of the SSIGLs, (iii) meetings to review zero draft SSI GLs, (iv) review workshop on draft SSI GLs, (v) small group review meetings on thematic areas, (vi) small group consultation meetings on its final presentation of contents and layout, (vii) consultation mini-workshops in the National States on semi-final versions of the SSIGLs, and (viii) final write-shop for the appraisal and approval of the final versions of SSIGLs.

The deliberations, concerns, suggestions and comments received from professionals have been duly considered and incorporated by the GIRD Consultant in the final SSIGLs.

There are 34 separate guidelines which are categorized into the following five parts concurrent to SSI development phases:

Part-I. Project Initiation, Planning and Organization Guideline which deals with key considerations and procedures on planning and organization of SSI development projects.

Part-II. Site Identification and Prioritization Guideline which treats physical potential identification and prioritization of investment projects. It presents SSI site selection process and prioritization criteria.

Part-III. Feasibility Study and Detail Design Guidelines for SSID dealing with feasibility study and design concepts, approaches, considerations, requirements and procedures in the study and design of SSI systems.

Part-IV. Contract Administration and Construction Management Guidelines for SSI development presents the considerations, requirements, and procedures involved in construction of works, construction supervision and contract administration.

Part-V. SSI Scheme Management, Operation and Maintenance Guidelines which covers SSI Scheme management and operation.

Moreover, Tools for Small Scale Irrigation development are also prepared as part of SSIGLs.

It is strongly believed and expected that; the SSIGLs will be quickly applied by all stakeholders involved in SSI development and others as appropriate following the dissemination and familiarization process of the guidelines in order to ensure efficient, productive and sustainable irrigation development.

The SSIGLs are envisioned to be updated by incorporating new technologies and experiences including research findings. Therefore, any suggestions, concerns, recommendations and comments on the SSIGLs are highly appreciated and welcome for future updates as per the attached format below. Furthermore, despite efforts in making all types of editorial works, there may still errors, which similarly shall be handled in future undated versions.

UPDATING AND REVISIONS OF GUIDELINES

The GLs are intended as an up-to-date or a live document enabling revisions, to be updated periodically to incorporate improvements, when and where necessary; may be due to evolving demands, technological changes and changing policies, and regulatory frameworks. Planning, study and design of SSI development interventions is a dynamic process. Advancements in these aspects are necessary to cope up with the changing environment and advancing techniques. Also, based on observation feedbacks and experiences gained during application and implementation of the guidelines, there might be a need to update the requirements, provisions and procedures, as appropriate. Besides, day-by-day, water is becoming more and more valuable. Hence, for efficient water development, utilization and management will have to be designed, planned and constructed with a new set up of mind to keep pace with the changing needs of the time. It may, therefore, be necessary to take up the work of further revision of these GLs.

This current version of the GLs has particular reference to the prevailing conditions in Ethiopia and reflects the experience gained through activities within the sub-sector during subsequent years. This is the first version of the SSI development GLs. This version shall be used as a starting point for future update, revision and improvement. Future updating and revisions to the GLs are anticipated as part of the process of strengthening the standards for planning, study, design, construction, operation and management SSI development in the country.

Completion of the review and updating of the GLs shall be undertaken in close consultation with the federal and regional irrigation institutions and other stakeholders in the irrigation sub-sector including the contracting and consulting industry.

In summary, significant changes to criteria, procedures or any other relevant issues related to technological changes, new policies or revised laws should be incorporated into the GLs from their date of effectiveness. Other minor changes that will not significantly affect the whole nature of the GLs may be accumulated and made periodically. When changes are made and approved, new page(s) incorporating the revision, together with the revision date, will be issued and inserted into the relevant GL section.

All suggestions to improve the GLs should be made in accordance with the following procedures:

I. Users of the GLs must register on the MOA website: Website: www.moa.gov.et
II. Proposed changes should be outlined on the GLs Change Form and forwarded with a covering letter or email of its need and purpose to the Ministry.
III. Agreed changes will be approved by the Ministry on recommendation from the Small-scale Irrigation Directorate and/or other responsible government body.
IV. The release date of the new version will be notified to all registered users and authorities.

Users are kindly requested to present their concerns, suggestions, recommendations and comments for future updates including any omissions and/or obvious errors by completing the following revisions form and submitting it to the Ministry. The Ministry shall appraise such requests for revision and will determine if an update to the guide is justified and necessary; and when such updates will be published. Revisions may take the form of replacement or additional pages. Upon receipt, revision pages are to be incorporated in the GLs and all superseded pages removed.

Suggested Revisions Request Form (Official Letter or Email)

To: ---
From: --
Date: --
Description of suggested updates/changes: Include GL code and title, section title and # (heading/subheading #), and page #.

GL Code and Title	Date	Sections/ Heading/Subheading/ Pages/Table/Figure	Explanation	Comments (proposed change)

Note that be specific and include suggested language if possible and include additional sheets for comments, reference materials, charts or graphics.

GLs Change Action

Suggested Change	Recommended Action	Authorized by	Date

Director for SSI Directorate**:** _________________________**Date:** _________________

The following table helps to track initial issuance of the guidelines and subsequent Updates/Versions and Revisions (Registration of Amendments/Updates).

Revision Register

Version/Issue/Revision No	Reference/Revised Sections/Pages/topics	Description of revision (Comments)	Authorized by	Date

1 SCOPE AND OBJECTIVES OF THE GUIDELINE

1.1 OBJECTIVES

The general objective of site identification and prioritization guideline is to prepare procedural guideline to undertake appropriate site identification for successive study and design phases of small-scale irrigation projects (SSIPs) and their associated irrigation infrastructures to enhance the utilization of the available/potential water resources for irrigation development and thus improve agricultural productivity of the beneficiaries farmers of the study area.

The specific objectives include: prioritization

- Conduct preliminary investigation from previous studies, topo-map reading, and GIS software.
- Demonstrate the role of community participation in site identification process
- Identify appropriate site identification and evaluation criteria
- Select most appropriate potential small-scale irrigation site
- Recommend the required technical staff, materials and other logistics
- Prepare tentative work schedule for site identification

1.2 SCOPE OF THE GUIDELINE

The guideline focuses on major activities need to be undertaken during site identification of small scale irrigation project. It illustrates all possible options being used to assess the irrigation potential of given site through resource potential analysis, catchment capacity analysis, cost-benefit analysis, social acceptance and environmental sensitivity analysis. The guideline is developed to practice the recommended procedures and methods at grass root level (ex woreda and site level) where technical staff entirely responsible for execution of the site identification and prioritization assignments. The guideline has two major components i.e. site identification and prioritization of identified SSI sites for further feasibility study and investments. Accordingly the guideline users can apply only to identify potential irrigation site(s) without prioritizing or the user could apply for potential site identification and prioritizing them in order of their importance.

The prioritization criteria recommended in this guideline might not be fully appropriate for ranking of SSIPs at country, regional and zonal levels because the issues most likely considered for prioritization have slightly different nature and objectives than of grass root level. At higher administrative levels the most of prioritizing criteria are mainly rely on non-technical parameters like equity, location, national strategy and others

The guideline is users friendly, simple and applicable in all agro-ecological conditions with participation of community.

The guideline is proposing the sectors to be involved in this study phase and identify guiding sectoral site identification and evaluation criteria analyze accordingly the appropriateness of the SSIP site.

The guideline develops lists of the required human resource, materials and other logistics important for undertaking the site identification. Moreover the guideline prepared checklists and data compiling formats necessary during site identification process.

2 METHODOLGY OF SITE IDENTIFCATION AND PRIORITIZATION

2.1 GENERAL

Small-scale irrigation development study from project initiation to detail design requires multi-disciplinary expertise from different sectors. This ensures the reliability and sustainability of the irrigation projects.

The site identification phase should not be complicated and time consuming; the tasks shall be carried out with experts in relatively short period of time. Currently the assignment might take extended period of time to identify many sites at a time. Therefore undertaking the assignment by key sectors is imperative without compromising the output quality towards the objectives. The following principal methodologies are recommended for this phase.

2.2 REVIEW OF POLICIES AND PREVIOUS WORKS

Review of relevant policies, development strategies, previous studies such as master plan, natural resource development, agricultural potential and development, watershed development and conservation, soil and land suitability, land us land cover, water resource potential studies periodical reports of Woreda and kebele offices should be reviewed as per their availability and specific to small-scale irrigation development and community participation.

2.3 PREPARATION OF BASE MAP FOR SSIP SITE IDENTIFICATION

The base map of the project area should indicate alternative potential command areas, administrative boundary, town or city, social infrastructures like road network settlements, stream drainage, possible abstraction points including source of irrigation water supply.

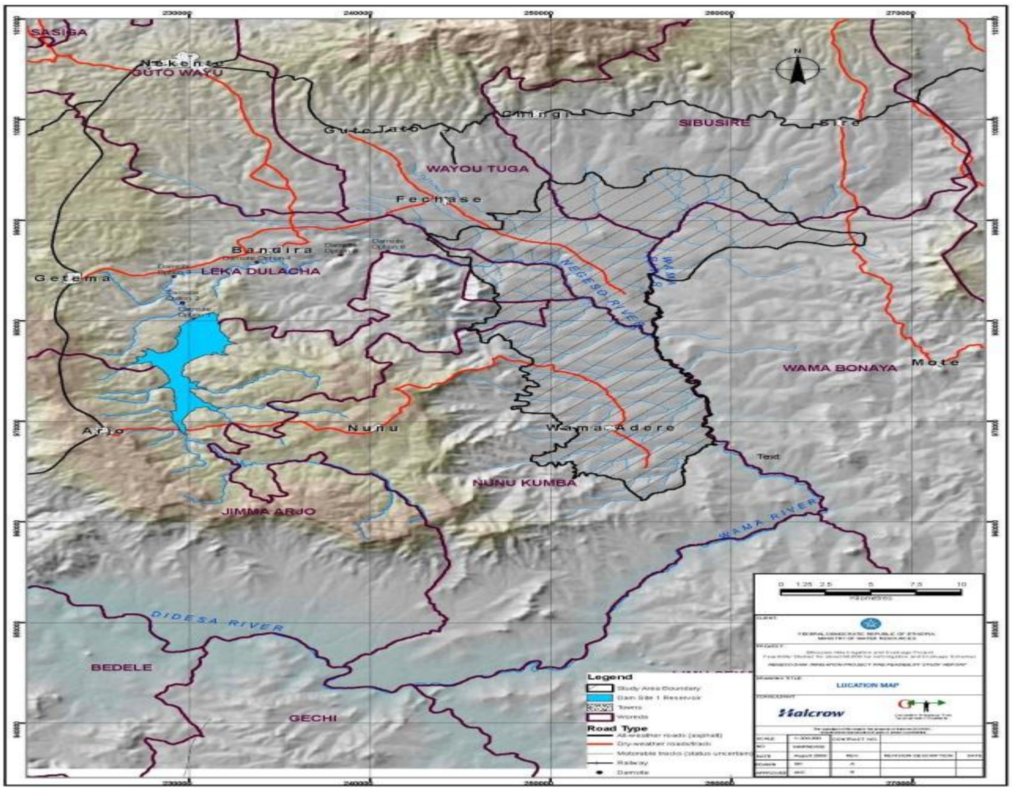


Figure 2-1: Sample indicative base map

In addition to the base map, the study team requires different maps of the project area facilitating the site identification and prioritization process which are expected to produce before the commencement of the fieldwork. All maps should be updated and checked during fieldwork by reconciling with actual ground conditions. The maps can be produced from national technical maps like Ethiopian Topographic map, Geology map, land use/cover map and soil map. Moreover, they can develop from digital imagery and aerial photographs accessible from digital datasets and software.

The maps are:

- Watershed map: can be develop using topographic map of Ethiopia and DEM & Arc GIS/ SWAT software
- Land use/cover map: this map should indicate current land cover of both the command area and the watershed. The source could be the recent land use/cover map developed by EMA, 2013, regionally developed land use/cover and other imageries
- Soil map: major types of soils of the project area including the watershed should be indicated
- Geological map: it gives highlight on the geological features of the project area which further need verification at field level. It can be developed from Ethiopian geological map

2.4 COMMUNITY AND STAKEHOLDER CONSULTATION

2.4.1 Stakeholder consultation

In order to make the site identification and prioritization work participatory; the study team should made consultations with relevant stakeholders such as regional stakeholders, woreda Administrative Councils, woreda level Offices, kebele administration offices. The consultation points should follow Participatory Irrigation Development (PIDM) approach guideline:

Some of the discussion points are:

- Five-year regional plan for agricultural development and specific to SSIP development indicating irrigation development zones and their objectives or specialization
- Overview of Small-scale irrigation development project initiation process (if already undertaken)
- Criteria set by the region, zone and woreda to prioritize the SSIP Sites;
- Socio-economic and market conditions
- Land, water and agricultural potentials of the area for rain fed and irrigated agriculture;
- Existing and future development opportunities of the project area
- Attitudes of stakeholders towards SSIP development and alternatives,
- Potential areas for irrigated agriculture those can be pre-determined by agriculture and /or water resource development related offices
- Suitable crops for irrigated agriculture;
- Potential adverse and positive impacts of the project;
- Attitude of the farmers towards irrigation development;
- Existing use of potential rivers and irrigable lands.

The consultation should be undertaken in group with representatives of the above-indicated stakeholders. At woreda level the consultative meeting should be conducted by inviting relevant offices and departments through woreda administrator or representative. The meeting should be led by the administrator and the minutes recorded by representative of agriculture or water resource development office.

2.4.2 Community consultation and participation

Community consultation is important information or data collection tool at grass root level to get reliable first-hand information from direct beneficiaries. Accordingly meetings should be carried out with small group of communities and kebele councils. Moreover the experts can organize focus group discussion session with selected informants to deal with specific issues. These groups could be traditional irrigation users' group, potential beneficiary group, women and youth groups. Checklists for community consultation need to be prepared before the fieldwork

The consultation can be undertaken by group of study team or by individual expert depending on the issues to be discussed and work schedule

The tentative consultation issues at this level of study are:

- The availability of alternative SSIP sites,
- Community attitudes towards the irrigation development
- Opinion on the identified SSIP and headwork sites,
- Experience of modern and traditional irrigation agriculture,
- The existence of other water users that could be affected by the implementation of the project,
- Possible impacts of the project upon the existing socio economic conditions,
- Readiness and willingness of the people to form IWUA and to participate in the project etc.
- Preferable irrigable crops suitable for project site(s)
- Community perceptions on communally owned lands to be affected by the project (if any)

It is believed that all field investigation in the project sites should be conducted with participation of the communities. They should involve in identifying water source, alternative intake points; construction material sites, physical resource investigation, agriculture experience sharing, describing the bio-physical features and providing their perception on irrigation potential of the selected sites.

2.5 FIELD OBSERVATION AND ASSESSMENT

In reference with the activities of each sector indicated in Appendix I, field level assessments should be undertaken for potential SSI project sites by employing different field physical assessment or survey methods.

Site observation should be conducted with support of the local people to get additional information about the project area. Transect walk across the command area is important to address representative bio-physical situations; and depending on the feature of the project sites additional visit might require to have better information.

Some of the features requiring field observation are but not limited to: slope of the command area, soil conditions, crop performance, river morphology, geological features, watershed vegetation coverage and degradation, appropriateness of headwork sites, appropriateness of night storage site and delivery system (if any), settlement pattern, environmentally sensitive sites e.t.c.

Field assessments should be undertaken by all experts in integrated manner respective to their assignment. In general the field assessment should be carried out within the command area boundary, however for some disciplines such as geology, watershed, ESIA, and socio-economy might require investigating the surrounding areas.

The field assessment is starting after identifying the most potential sites those require preliminary assessment for site prioritization. These sites can be determined from secondary data or sources; base map and/or resource maps developed by study team or secondary data from woreda archive.

The results of field observation should be presented and discussed in in-house meeting organizing by the team leader each or every two days during field survey period.

2.6 SECONDARY DATA COLLECTION

Secondary data will be collected from different stakeholders to augment the primary data and use as a basis for site specific characterization. The data are available from regional, zonal, woreda and kebele offices; Ethiopian Mapping Agency, meteorology centres, Central Statistics Agency, and relevant websites.

List of maps, data and information to be collected from the secondary sources:

- Topographic map of the project area or sites (hard or soft copy)
- List of watersheds and their maps/sketch at Woreda and kebele level (available for most woredas)
- Potential irrigation sites in the Woreda and kebeles
- Land use/cover map of the project area and kebele
- Number and types of irrigation schemes in the project area or woreda
- Number of beneficiaries of existing irrigation schemes
- Number of households and population by kebele
- Social and public infrastructures in the Woreda and kebele
- List of major crops grown under irrigation and rainfed agriculture
- Crop production data and farm gate price
- Soil type and distribution in the Woreda and kebele
- Location of environmentally sensitive places
- others

2.7 ESTABLISHMENT OF SITE SELECTION AND RANKING CRITERIA

Appropriate site selection criteria are required to select and analyze the appropriateness of the sites for irrigated agriculture. The criteria should be developed in consultation with stakeholders depending on the objective of the project and socio-economic conditions of the project area. The criteria should be flexible to reflect the project area reality and subject to revision to consider the diversity of farming system like for agro-pastoral and sedentary communities; land topography and water resource availability; and project objectives like for commercial and food security projects and so on.

Basic criteria for each sector are recommended in this guideline and further revision might require depending on the above-mentioned conditions of the project area.

2.8 DATA COMPILATION AND ANALYSIS

The collected data should be compiled by sector and sites for analysis. The detail sectoral data like climate data have to be compiled monthly to get average values representing the project sites. The water balance of a given project area is a special tool that confirm the upstream-downstream relationship of the project sites, which is based on the continuity, momentum, and energy equations for various hydrologic processes (Chow et al. 1988). Water balance at scheme level will be analysed considering the upstream, downstream and scheme water demands.

Different software such as CROPWAT 8.0, New Loc Clim V10.1 for area where climate data is unavailable; Arc GIS, and SWAT will be used for data analysis.
This guideline provided data compiling formats for each sector

Digital Elevation model (DEM) and outlet point location are the only inputs data for catchment delineation and drainage features analysis. The DEM with 30m resolution or possible smaller resolution can be accessed from Ethiopian mapping agency, or from Ethio GIS dataset or SRTM web site or ASTER web site. The location of outlet points can be set from GPS reading of field observation, 1:50,000 Topographic map from Ethiopian mapping Agency, or Google Earth site view.

2.9 EVALUATION, RANKING AND PRIORITIZATION

Based on collected data, the study team should analyze, prioritize/screen out using matrices of viability of irrigation schemes after investigating from technical appropriateness, social acceptance, project economic benefits, institutionally easily manageable, and environmentally sound and come up with the best project from any one of them for successive study. Multiple Criteria Analysis (MCA) is a method recommended to evaluate and prioritize multiple options across a multiple set of criteria. Accordingly the selected potential irrigation sites shall be analyzed and the best site will be recommended for further feasibility study.

2.10 PREPARATION OF FS & DD WORK ACTIVITIES AND SCHEDULE

Finally we prepared detail work activities and schedule of the prioritized SSIP for FS & DD including, lists of physical activities, time required, work flows and internal budget required etc.

3 TECHNICAL STAFF AND ORGANIZATION

3.1 HUMAN RESOURCE REQUIREMENT AND RESPONSIBILITIES

The study team would have three professional groups; Engineering, Natural resource; and socio-economy sectors. Each group expected to have close contact and frequent discussions to manage the data collection and intra-group data exchange. In most cases, the stakeholder and community consultation could be convenient to conduct the experts together within the group because the sectors have most issues in common. The assigned engineer is a team leader of the site identification and prioritization study.

Engineering group includes four sectors such as engineering and drainage; geology, hydrology and climate; and topography survey

Natural resource group comprises, Agronomist, Soils/land evaluation study and Watershed management.

Socio-economy includes Socio-economy, Environmental Impact assessment and Irrigation agronomy

The followings are being part of the study team for site identification and prioritization phase. These are listed below:

No	Sector	Requirement level
1	Watershed study expert	As required
2	Engineering and drainage	Mandatory
3	Topographic surveyor	Mandatory
4	Geologist	As required
5	Hydrologist	
6	Socio-economist	Mandatory
7	Irrigation agronomist	Mandatory
8	Soils and land suitability evaluation expert	
9	Environmentalist	As required

The responsibilities of the above indicated professionals are presented in detail In SSIGL 1: SSIP project Initiation, Planning, organization and Management under Appendix II TOR for site identification and prioritization.

3.2 ORGANIZATIONAL SET-UP OF THE TEAM

For small-scale irrigation project the indicated professionals from nine sectors will be organized in a study team to work together, exchange data, analyse the situation and identify the most appropriate site for irrigation development. Preliminary characterization of the sites in terms of engineering, physical, agronomic, social and environmental conditions give important evaluation data for comparison and prioritization which thoroughly handled by professionals with intensive participation of communities and stakeholders at grass root level. Considering the above noted preconditions the following organization of the Team is proposed.

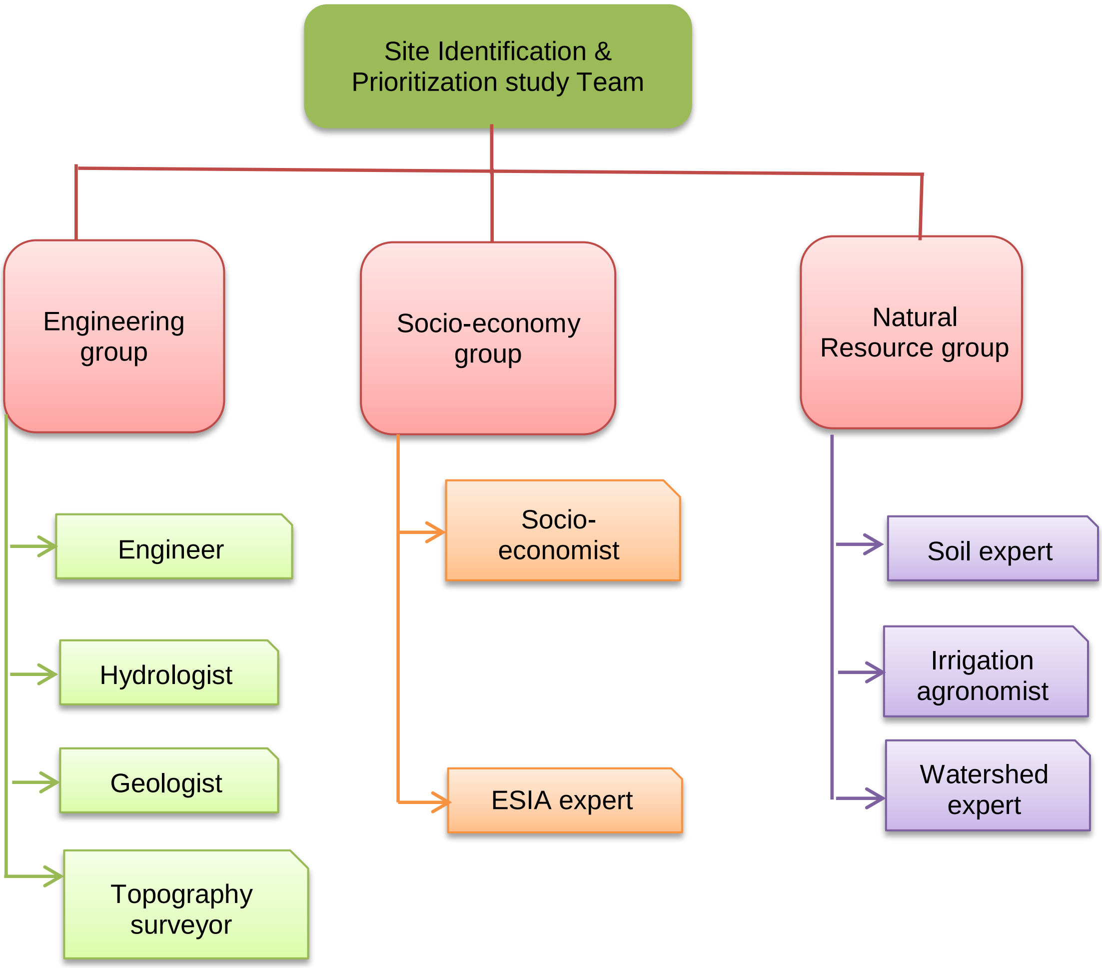


Figure 3-1: Organization chart for site identification and prioritization

4 PRELIMINARY IDENTIFICATION OF POTENTIAL SSI SITES FOR SCREENING

Potential SSI site identification procedures should follow watershed approach for sustainability of the project. At initial stage, numbers of potential sites can be identified from bio-physical map; previous studies or other secondary sources to have as many potential sites for screening to focus on limited potential sites.

Example 4-1; List of potential sites compiled from topographic 1:50,000 map and Yeki woreda database for screening in consultation with wereda administration and technical staff. The Yeki woreda site identification assignment applied identification method 4-1 and 4-2

Table 4-1: Example for preliminary potential site identification for first level screening

S/N	Water source	Kebele	River discharge (l/t)	Estimated gross command area, (ha)	Geographic Coordinate of Headwork site		Altitude (masl)
					Easting (UTM)	Northing (UTM)	
1	Bubi River	Alemo	150	75	794724	800165	1305
2	kashi River	Komi	200	190	785162	800097	1197
3	Achani River	Gobita	1700	70	763445	800303	1310
4	Dembi River	Depi	300	50	766305	800592	1267
5	Shay river	Yeki	500	80	755691	800898	1270
6	Shosha River	Fide & Shoda	155	123	772515	801425	1183
7	Bukun Hora	Alemo & Gelecha	100	170	7887609	797695	1182
8	Oda	Alemo	130	105	790233	798466	1225
9	Dsasay	Alemo	200	140	792121	798080	1200
10	Dunchay	Dunchay	330	120	760736	794807	1164

Source: Site identification & prioritization report of Bubi SSIP in SNNPR, 2017

The following methods are recommended to be employed depending on resource availability, simplicity and level of stakeholder participation. The preliminary potential sites identification could be undertaken from bio-physical map, review of previous studies and computer based assessment.

4.1 IDENTIFYING FROM AVAILABLE BIO-PHYSICAL MAPS

The irrigation potential sites can be identified from 1;50,000 topographic map or other digital maps showing the natural resource features of the project area or within the boundary. The procedures to investigate the potential sites on available maps are:

Steps:

- Search and identify potential watersheds with good drainage network of rivers and/or streams
- Investigate alternative and potential headwork sites from topographic features and morphology of the rivers or streams
- Investigate the land resources availability considering the slope (flat to 15%), land cover and type of soils
- Delineate potential gross command area on the map and estimate the area coverage
- Prepare a summary table indicating the salient features such as, location of the sites, type of headwork, command area size, slope ranges,

4.2 IDENTIFYING POTENTIAL SITES WITH STAKEHOLDER CONSULTATION

Potential sites can be identified from previous studies or database relevant to the project area. If the woreda offices such as water resource and agricultural office, have extended list of irrigation sites with some basic information, then the study team should utilize the available information.

Further discussion need to be undertaken on major features of the identified irrigable sites to enrich the basic data/information for further screening

Steps:

- During woreda/ kebele consultation meeting try to analyze the irrigation sites from the following aspects :

  Reliability and adequacy of water resource potential
  Command area size and topographic features
  Number of potential beneficiaries
  Potential for resource and social conflicts
  Possible environmental impacts
  Responsiveness to Woreda development plan
  Accessibility for technical support and marketing

- Select the most appropriate SSI sites based on the above-indicated preliminary selection considerations for further discussion with stakeholders
- Make de-briefing to Woreda agricultural or water and irrigation offices on the site observation findings for re-confirmation of their appropriateness and agree on certain manageable number of irrigation sites (recommended at least 3 sites) .

4.3 GIS AND OTHER SOFTWARE'S BASED IRRIGATION POTENTIAL AREA ASSESSMENT

The physical irrigation potential of a project area can be delineated using GIS based desk work analysis. The three input layers; land suitability, gross water requirement for project area and the water availability at abstraction point, should be organized in aerial and point GIS layers.

- **Land suitability mapping**

  Add the suitability classified grid in Arcmap
  Removed all non-suitable cells from the grid data set
  Filter it with majority filter to removed dissected cells

- **Irrigation water Requirement**

  Compute mean monthly ETo using different computation methods
  Compute mean monthly rainfall
  Compute the monthly Net Irrigation requirement by subtracting rainfall from ETo
  Select the high NIR for each grid station
  Divided with efficiency value (0.5)
  Organize the grid stations name and GIR in one excel sheet
  Add the Grids point feature and the excel sheet with GIR in Arcmap and join them
  Convert the point data to surface using any of interpolation method (ex. IDW)

- **Water Availability**

  Water Availability computes the flow for selected outlet in SWAT model
  Get the monthly time series outflow from the 'rch' table in the SWAT output database
  Compute the annual minimum flow for each sub basin
  Compute long term average of minimum flow for each outlet point
  Organize the excel sheet that has outlet ID and minimum flows for each outlet

Add the outlet point features and the excel sheet in ArcMap
Join them to have minimum flow

- **The three layers in one**

Add the filtered land suitability surface layer, GIR surface layer and minimum flow point features in ArcMap
Filter the outlets which has sufficient water for the possible suitable irrigated land with visual comparison
Aggregate the suitable land under selected outlets in one polygon with different suitable class
Intersect the GIR layer to have the area and water requirement attributes for aggregated polygon
Compute the volume of water requirement for each aggregated suitable land
Compare it with the minimum flow at the upstream outlet points and confirm the amount of area that can be irrigated with the minimum flow at outlet.
Map them in one map to show
Screening most preferable sites in watershed or project woreda/kebele
Sites with larger area of S1 and S2
Command area size
Accessibility to beneficiaries
Appropriateness to cost effective type of headwork and distribution system
Exposure for severe flooding, erosion/land degradation, and frost hazard
Potential for resource and social conflicts
Woreda development priority areas

At this stage at least selected irrigation potential sites are known and preliminary site visit need to be conducted by the study team with woreda partners. After site visit of potential sites the observation results need to be forwarded for woreda administration and technical staff to reach on consensus for better **POTENTIAL SITES** based on woreda development priority and other selection factors

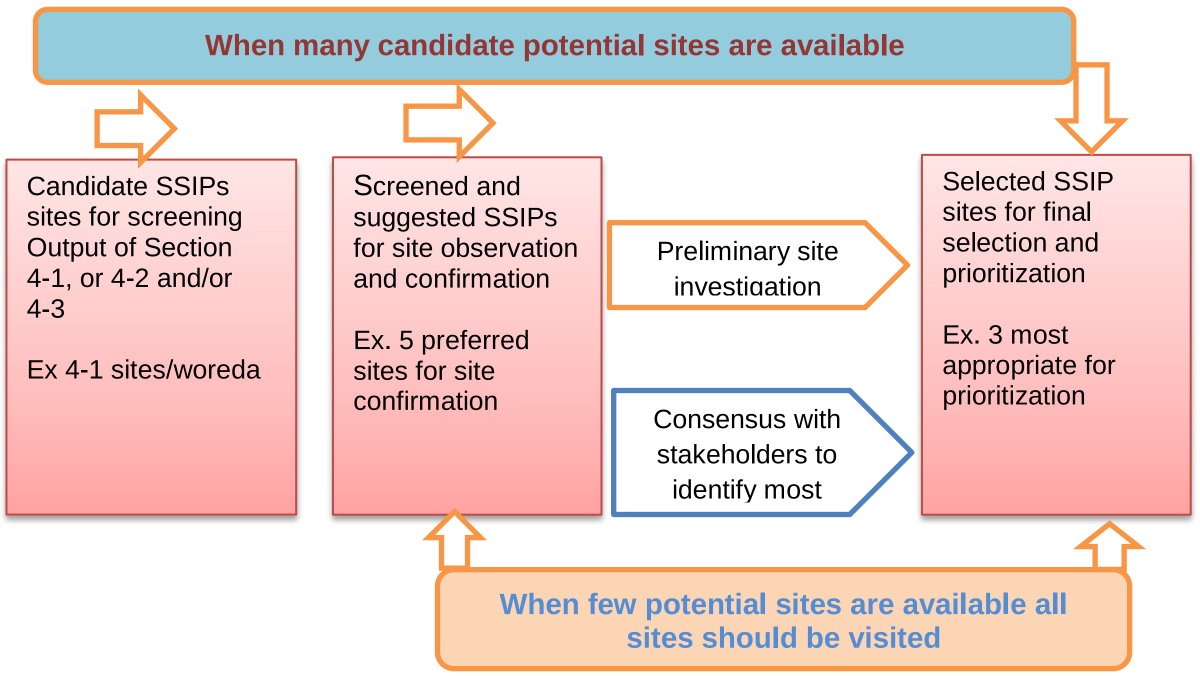


Fig 4-1: Diagram Illustration for steps to select most preferable SSIPs for final prioritization

5 CRITERIA FOR SEMI-DETAIL POTENTIAL SSIP SITE IDENTIFCATION

5.1 GENERAL

The potential sites which are screened and proposed in chapter 4 should be assessed and analyzed with the following sector criteria for final selection and prioritization.

Site identification criteria should be a multi-sectoral and interdependent evaluation tools in determining the potential of the area for irrigation development. Irrigation potential site identification in this context is a function of physical, social and environmental factors those require intra and inter sector analysis based on preliminary assessment findings. To manage the site identification assignment the following criteria need to be considered for selection and prioritization process.

5.2 HYDROLOGY & WATER RESOURCE POTENTIAL

Based on the information of stakeholder meeting and site observation in sites screening, The hydrologist should assess and characterize the watershed or water resource conditions by delineating on topographic or digital maps to quantify the discharge at different water course points in consultation with the irrigation engineer

- Extent of catchment cover is used to reflect conditions of land use and land cover of that catchment, thus plays roles in yield of that catchment.
- Monthly minimum water flow in the stream.
- Water balance considering upstream and downstream water use and allowing for environmental flow
- Climate condition in related with evapo-transpiration

5.3 TOPOGRAPHIC CHARACTERISTICS OF THE COMMAND AREA

- Topographic features such as slope length; extent of undulation, gully intensity and other
- Slope range depending on the type of irrigation as recommended 0-8 surface irrigation, 8-15 surface irrigation with bench terrace or pressurized system, 15-30% pressurized for perennial crops

5.4 LAND RESOURCE AND SUITABILITY FOR IRRIGATION

- Soil type and Soil physical characteristics such as texture, effective, depth, color, workability/compactness
- Soil drainage
- Soil salinity and acidity
- Land suitability for irrigated farming and planned crops

5.5 WATERSHED CHARACTERISTICS

- Drainage pattern, watershed shape, extent of land use/land cover
- (vegetation with Forest and /or perennial crop coverage as indication of capacity of the catchment to protect the irrigation scheme, to ensure sustainability of the water flow for the project and environmental flow)

- Vulnerability to natural resource degradation and erosion
- Community experience and interest in watershed conservation

5.6 ENGINEERING CRITERIA

5.6.1 Headwork type & sites

To suit to nature of the project,, headwork types need to be such that they are simple or small structures that can be managed by beneficiaries' themselves. Thus, selections of such headwork structure types are approached in the order of spring development/protection, free intake headwork structure, river diversion headwork structure, small-scale pump headwork installation, and micro dam headwork structure.

In general, the study should use the following points as criteria for selection of appropriate headwork sites:

- Suitability to deliver both left and right banks of the river; and at least one-side
- Ability to maximize the command area
- The narrowest cross section of the river for economizing the structure; (optional)
- Reach of the river that can accommodate expected return period design flood;
- Straightness of reach of the river to minimize turbulence of flow, and approach flow conditions are uniform;
- Minimum backwater effect i.e. submergence of upstream farmland would be minimum as a result of introduction of such structure;
- River stability, meandering, causing degrading or aggrading;
- The project would not result in displacement of communities already residing in and around the project area;

5.6.2 Flow condition

Condition of flow i.e. whether it carries too much sediment with boulders or other ingredients like mixture of gravel and sand at a definite reach of a river indicates type of diversion headwork to be recommended at that particular cross section, e.g. ogee type of weir is preferred if high flood carrying huge boulders is expected thus expensive otherwise broad crested weir which is less expensive but manageable is recommended.

5.6.3 Intake arrangement

Conditions for supplying irrigation water can be of two types: single side intake i.e. on left or right side of the river or double side intake i.e. on both left and right side of the river depending on availability of command area and topographic feature of headwork site.

5.6.4 Channel stabilization works requirement

Location of appropriate site for river diversion can play great role in requirement of channel stabilization works or not on the upstream or downstream or both. Thus, it incurs additional cost to the project if appropriate site does not exist in the reach of that river.

5.6.5 Complexity of the system

The structures should not be complex or it shall be easily manageable by beneficiaries and gender responsive.

5.6.6 Drainage condition in the command

Gentle slope of the command area is necessary to avoid water logging on it. However, very flat land requires dense drainage network thus, incurs additional cost to the project.

5.6.7 Type and no of structure requirements of main canal

If the natural drainage networks along a proposed main canal is dense as well as command area is of steep topography, then it definitely requires a huge number of crossing and energy dissipater structures than command area of flat slope. Thus, structural requirements have been identified on topographic maps and confirmed/observed on the site.

5.7 GEOLOGY AND GEOTECHNICAL CRITERIA

- Geological condition of the head work, Stable bed i.e. rocky foundation material, Stable banks, Non-existence of Faults
- Availability of construction materials in the nearby area
- Soil material conditions of the main and secondary canal alignments, an don structures sites

5.8 IRRIGATION AGRONOMY CRITERIA

- Agro-climate condition suitability
- Irrigation water demand
- Potential to grow diversified cash and high value crops
- Potential for growing perennial crops for hillside irrigation if the area intend to include sloppy lands
- Conducive soil- crop and water management
- Current accessibility of improved technologies (improved seed, chemicals, equipment's and machineries. etc)
- Existence of agricultural support system (extension, research, demonstration)
- Accessibility to market centers and agro-processing area

5.9 ENVIRONMENTAL FACTORS

- Impacts on social and physical infrastructures places (if the project site tend to affect cultural, heritage, and historical places then the site should be rejected at screening level)
- Exposure of the project area to environmental hazards like frequent hazardous flooding, landslides
- Occurrence of water use conflicts between up and down stream users
- Susceptibility of the command area to land degradation, and water pollution,

5.10 SOCIAL AND ECONOMIC ASPECTS

- Number of Existing Beneficiary Households
- Availability of Farm labour (family labour and hired labor) ;
- Number of potential affected people
- Project impact upon other water users
- Level of food insecurity
- Equity and Priority
- Responsiveness to cross cutting issues such as women and youth, poverty reduction, climate change, nutrition, HIV and other communicable disease,

- Community participation, attitude and willingness for cost sharing in implementation and; operation and maintenance
- Market, value chain and agribusiness potential (Availability of market infrastructure, Size of market catchment or extent of existing and future market network, accommodation capacity of perishable crops for marketing, location advantage for export markets,)
- Cost benefit and financial viability
- Vulnerability to social conflicts due to water utilization, inefficient and/or overutilization of water resource for irrigation
- Availability of community organizational structure or willingness of the people to form IWUA,
- Community Responsibility for Project Operation & Maintenance
- Strength of implementing and supporting stakeholders to support during planning, studying, construction and implementation periods

6 SSI POTENTIAL SITE ASSESSMENT

Interdisciplinary field assessments need to be undertaken by study crew using respective survey methodologies (Chapter 2) with intensive community and stakeholder consultations. The main assessment areas are watershed condition, hydrology and climate; land resource assessment, irrigation water supply or resource, crop potential assessment, water demand, socio-economic conditions and environmental impacts.

6.1 CLIMATE & HYDROLOGY

6.1.1 *Climate condition analysis and description of the project sites*

The availability of climate and hydrology data should be accessed from different sources including National Meteorology Agency and climate forecast software or satellite based verified datasets that could be used for climate description and preliminary analysis of the project area. The monthly data of climate and flow data including rainfall, temperature, humidity, wind speed, sunshine hour, and stream flow of rivers should be collected and analyzed for identification.

Moreover the ETo values can be computed from climate data or accessed from Class 1 meteorological station that simplify the crop water requirement calculation at this level of study. The hydrologist should provide the climate data for agronomist to compute preliminary water demand for site comparison.

6.1.2 *Stream flow analysis*

Stream flow is an important factor in irrigation project in two aspects, one to determine the design flow through the peak flow analysis and secondly to determine dependable flow that required to compute the amount of available water to deliver to the irrigated field and help to fix the size of the irrigation

The water resource potential of the project area could be assessed through determination of the stream flow or water discharge (Q). The stream flow of identified source could be estimated from gauged station records if the river has gauged station, otherwise it will estimate by catchment transfer or by direct flow measuring. For site identification level of study the stream flow can be estimated by float method for rivers and streams and bucket and watch method for spring.

Float method: The float method measures the surface velocity of flowing water, and the mean velocity is obtained using a correction factor. The basic idea is to measure the time taken to float an object over a specified distance.

$$\text{V surface} = \frac{\text{Travel distance (m)}}{\text{Travel time (t)}} \qquad [1]$$

Because surface velocities are typically higher than mean or average velocities,
V mean = k Vsurface; where k is a coefficient that generally ranges from 0.65 for rough beds to 0.75 for smooth beds.

The coefficient can be determined based on the depth of water as indicated in table 6-1

Table 6-1: Coefficient for converting float velocity to mean channel velocity

Avg. Depth of water(m)	Correction Coefficient (K).
< 0.3	0.66
0.6	0.68
0.9	0.7
1.2	0.72
1.5	0.74

Source: USBR Water Measurement Manual (1997) referred from SMISS, 2017

Required material: Tape measure; stop-watch (available in mobile phone); straight rod, or gauged stick; buoyant object such as wood

The procedures for discharge measurement are as follows:

- Choose a suitable straight reach with minimum turbulence (minimum distance should be 5-20 m depends on the size and nature of the stream, reach length and riverbed stability);

  Mark the start and end points of the chosen reach;
  If possible, travel time should exceed 20 seconds but be at least 10 seconds;
  Drop your object into the stream bit upper of the upstream marked point;
  Start the watch when the object crosses the upstream marker and stop the watch when it crosses the downstream marker;
  Repeat the measurement at least 3 times and use the average in further calculations;
  If you only do the float method, you need to measure the cross-sectional areas at the start and end point of your reach;
  Compute the average cross-sectional areas;

- Using the average area and corrected velocity, you can now compute discharge

  $Q = AV_{mean}$

  Where Q is discharge, A is cross sectional area, V mean is mean velocity

Bucket and Watch method: The bucket and watch method is a simple volumetric measurement of water at the given time period. This method is applicable for **spring sources** with a discharge less than 1 lt/s. The volume of water can be measured by diverting the entire flow into a measuring vessel of known capacity (for example, a plastic bucket). The time taken to fill the vessel is noted. At least three to five readings are necessary for the measurement of the water and average value is computed. The discharge calculation may be carried out using the following format (Table 6.1).

$Rate\ of\ flow = Volume\ (lt)$

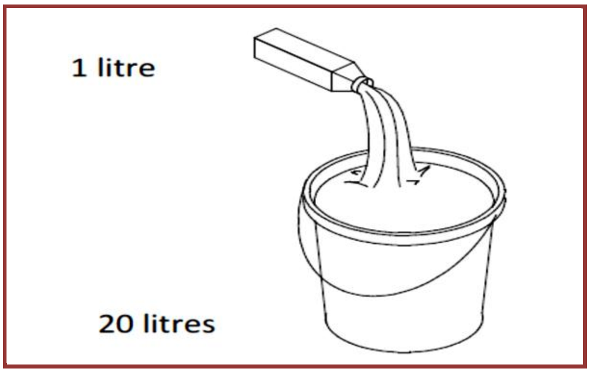


Fig 6-1: Illustration for bucket and watch method measurement

The material needed for this measurement include:

- Bucket (of known volume);
- Watch/stopwatch (Smart/Cell phone can be used);
- Pipe, plastic sheet, corrugated iron sheet, etc. (to direct the flow to the bucket)

Table 6-2: Discharge measurement with bucket-watch method

Project Name---------------		**Location :**				
Source Name:		**Date of Measurement :**				
Description:		**Measurement No**				
		1	2	3	4	5
A	Vessel capacity(litre)					
B	Time to fill the vessel(sec)					
C	Discharge (l/s)=A/B					
D	**Average Discharge Q (l/s)**	**Q=(C1+C2+C3+C4+C5)/5**				

Example 6-1 (source: SMISS *Watershed based approach to SSI Identification and Selection tool, 2017)*

Chacha is a very small stream that is not suitable for float method discharge measurement. A district expert decided to use volumetric discharge measuring method. S/He prepared all the materials required (watch, 20-liter bucket, spade, flow guiding material) and directed the stream to collection point. Filled the bucket five times and the time was recorded as 10, 12, 11,10, and 10 seconds. During the measurement the estimated un collected water to be about 5%.
Estimate the discharge?

Analytical procedure

Step-1 Determine the average time

- T_{avg} = (10+12+11+10+10)/5 = 10.6 sec

Step-2 Calculate the actual volume

- Va = Vm + (Vm X 5%)
- Va = 20 +(20x 0.05) =21 Liter

Step-2 Calculate the discharge

Q = Va/ Tavg = 21/ 10.6 = 1,98 Lit/sec

6.1.3 Flood estimation

The rational method, SCC method and transferring gauged data method can be applied for flood estimation in ungagged watersheds

a. Rational method

The Rational Method is a widely used for design flood estimation of small catchments. This method considers the entire catchment area as a single unit assuming uniform rainfall distribution. This method is suitable for small catchments with an area of less than 25 km2.

The rational method formula is as follows:

$Q = 0.278CI\,A$
Where, Q is the peak discharge in m^3/s,

C is the runoff coefficient (roughly defined as ratio of runoff to rainfall),
I is the rainfall intensity in mm/h,
A is the catchment area in km^2

The most widely used method for the calculation of the time of concentration is the Ramser-Kirpich method, which is expressed as follows:

$$Tc = 0.0195L^{0.770}S^{-0.385}$$

Where, L is the length of the main stream in m and S is the weighted slope of the main stream.

Rainfall intensity (I) is computed from the rainfall intensity-duration curves of a known location based on the time of concentration (Tc) of the stream in hours. The average rainfall intensity (I) has duration equal to the critical storm duration, normally taken as a time of concentration (Tc).

b. SCS Method

A relationship between accumulated rainfall and accumulated runoff was derived by SCS (Soil Conservation Service). The SCS runoff equation is therefore a method of estimating direct runoff from 24-hour or 1-day storm rainfall. The equation is:

$Q = (P - Ia)^2 / (P - Ia) + S$
where
Q = accumulated direct runoff, mm
P = accumulated rainfall (potential maximum runoff), mm
Ia = initial abstraction including surface storage, inception, and infiltration prior to runoff, mm
S = potential maximum retention, mm

The relationship between Ia and S was developed from experimental catchment area data. It removes the necessary for estimating Ia for common usage. The empirical relationship used in the SCS runoff equation is:

$$Ia = 0.2xS$$

Substituting 0.2xS for Ia in equation ---, the the SCS rainfall-runoff equation becomes:

$$Q = (P - 0.2S)^2 / (P+0.8S)$$

S is related to soil and cover conditions of the catchment area through CN. CN has a range of 0 to 100 (can be obtained from Annex C3 and ERA 2002), and S is related to CN by:

$$S = 254x[(100/CN) - 1]$$

Conversion from average antecedent moisture conditions to *wet* conditions can be done by multiplying the average CN values by Cf [where $Cf= (CN/100)^{-0.4}$]

c. Catchment transformation method

When the diversion site in un gauged catchment/watershed is located near the gauged site, the monthly flows at the diversion site is calculated using an area ratio.

Qd= Qg* (Ad/Ag)^7

Where,

Qd= Daily discharge at diversion site in m3/s,

Qg= Daily discharge at gauged site in m^3/s,

Ad = catchment area at diversion site in km^2,

Ag = catchment area at gauged site in km2

Moreover, gauged data may be transferred to un-gauged site of interest provided such data are nearby (i.e., within the same hydrologic region, and there are no major tributaries or diversions between the gage and the site of interest)

d. Flood Estimation from flood marks

The trash mark method is one of the conventional methods of estimating flood flow which is used when other data and information are unavailable. This method is based on the slope area survey of the particular river stretch where past flood levels can be recorded with the help of old inhabitants and/or local informants. It may be possible to find debris indicating a past flood level or to have a level on a tree or building pointed out. Trash mark levels are more accurate than remembered levels.

A river cross sectional survey is needed at two or three sites where flood levels can be obtained and the hydraulic calculation is carried out using Manning's formula

$$Q = \frac{A \times R^{2/3} \times S^{1/2}}{n}$$

Where, A is the area of river cross section up to trash level in m^2,

R is the hydraulic radius = A/P, S is the water surface slope

n is the Manning's roughness coefficient and is given in a standard table (V. Chow, 1959)

P is the wetted meter in m,

The water surface slope is that obtained from the trash marks at three different sites. The flood flow can be estimated for two or three sites and then averaged.

6.1.4 Water balance analysis

a. Catchment water balance

Catchment/watershed water balance governs the principles of conservation of mass in a closed system, whereby any water entering a system (via precipitation), must be transferred into either as evaporation, surface runoff (eventually reaching the channel and leaving in the form of river discharge), or stored in the ground as storage. Therefore, it is expressed in a general water balance equation given as,

$$P = R + E + \Delta S$$

Where, P is precipitation, E is evapo-transpiration, R is stream flow, and ΔS is the change in storage (in soil or as ground water)

As indicated in the Hydrology and Water Resources Guideline, option is provided to enable and consider the water resources availability for a specific study area as well as the existing and potential developments both in the upstream and downstream part of the proposed scheme. It is keen to make the water balance analysis, upstream and downstream water abstraction for different uses (e.g., domestic and non-domestic, animal watering, irrigation uses) as well as the estimated water uses by the proposed scheme and future development aspects persevering the environmental flow.

b. Scheme water balance

Based on the development of the proposed irrigation scheme, the water balance analysis can be carried out and confirm the availability of water resources for the command area say considering the 70% dependable monthly flow of the stream. In this analysis, the amount of diverted water, allocated water for irrigation water requirement and the return flow that accounts for the downstream uses shall be analyzed and quantified. If the amount of diverted water (at headwork site) satisfies the gross irrigation demand and significant amount of water returned back to the river system (additions to the downstream flow) and no negative impacts in the downstream, the project can be admitted for development. Please refer Table 6-3 indicated the water balance analysis at scheme level for Shew SSI project.

Table 6-3: Example for scheme water balance

Example from Shew SSI Project at Bench Maji Zone SNNP (lt/sec)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Diverted water	100	70	90	210	370	920	1960	1810	1660	730	310	180
Allocated water	54.2	59.2	40.6	13.5	0	0	1.7	0	0	3.4	13.5	45.7
Return water	45.8	10.8	49.4	196.5	370	920	1958.3	1810	1660	726.6	296.5	134.3

Table 6-4: Summary of hydrology assessment findings

S/N	Hydrology parameter	Site 1	Site 2	Site 3
1	Stream flow availability			
2	Water balance condition/ effect			
3	Rainfall sufficient or not			
4	Catchment features (e.g., shape, size, slope)			

Water balance condition: shortage, sufficient or insufficient for downstream uses**; Rainfall** sufficiency in relation with ETO (adequate, marginal or shortage).

6.2 ENGINEERING SECTOR ASSESSMENT

Engineering related assessments need to be carried out to indicate major structure requirement for recommended type of irrigation system in turn it tentatively shows potential irrigable land and cost-effectiveness of water storage, distribution and drainage structures. In order to compare and prioritize the project sites, the following relevant factors should be defined.

6.2.1 Selection of irrigation type (surface, drip, sprinkler, and spate.)

The type of irrigation system reflects the operation and investment cost of the system, complexity of the system, labour requirement and water use efficiency which are conditions to make comparison between the potential sites.

The choice of type of irrigation system for a particular project is depending on a number of factors. Some of the major factors which influence the choice of the right method of irrigation system are: available water supply, type of soil, topography of the land, investment costs, skilled man-power requirement; the type of crop to be irrigated and so on.

Accordingly the engineer should select appropriate irrigation system type for each of the potential site for comparison.

See the summarized criteria and qualification for each type of irrigation system presented below:

Table 6-5: Consideration in selection of irrigation type

S/N	Factors	Surface	Sprinkler	Drip
1	Soil type	Clay, Loam, medium to low infiltration rate upper limit of 30mm/hr	Sandy, clay, loam High infiltration rate,	Sandy, clay, loam High infiltration rate,
3	Soil depth	Minimum of 2 meter	Minimum of 1 meter	Minimum of 1 meter
2	Slope	Plain and steeper areas with conservation structure	Steeper, unevenly sloping lands	Steeper, unevenly sloping lands
3	Local weather pattern	Possible in strong wind area	Less desirable in high windy area and in low humid area because of high evaporation	Possible in strong wind area
4	Water availability	Abundant water	Water in short supply	Water in short supply
5	Water quality	Possible water with sediment	Sediment free	Sediment free
6	Crop	All crops	High value crops	High value crops
7	Investment cost	Less expensive	High investment and maintenance costs.	High investment and maintenance cost.
8	Labour requirement	Much higher labour input	Less labour intensive; Skilled manpower required	Less labour intensive; Skilled manpower required

FAO, website: www.fao.org/docrep/S8684e/S8684e08.htp; and Technical guideline for SSI surface irrigation system planning & Design, 2017

6.2.2 Potential headwork site assessment and identification

Headwork site determination: During site identification field work, the engineers should identify appropriate cost effective headwork site together with geologist and hydrologist team members.

Potential site assessment for a headwork type is based on criteria in which some of the mains are narrow section of the river reach, nearest site to the irrigable area, and elevated site than the command area, otherwise it needs another lifting mechanism like pump, and stable foundation of the site or of rock material.

Small dam headwork site shall be in narrow valley, enable irrigation of considerable potential command area; the river is stable, not meandering and neither degrading or aggrading; impervious and strong foundation condition; strong, stable and water tight abutments/banks; the contoured main canal expected having minimum excavation and fill with minimum possible length; and the site shall be environmentally friendly, socially and culturally acceptable, and economically feasible

Alternative potential headwork sites for potential stream shall be selected and analyzed with participation of the communities those have extended knowledge about the resources of the project area. Experts from the study team including geologist and topographic surveyor; and woreda/kebele experts should accompany the irrigation engineer to contribute their expertise.

Selection of headwork type: Each of the selected project sites would have at least 3 or more alternative headwork sites to choose the most appropriate. The type of headwork will be determined depending on water discharge value, command area size, river and cannel bed levels to be measured at field level during site assessment or on a map.

The irrigation engineer should take into consideration the following criteria to recommend the headwork type for optimum utilization of available water and land resources.

Table 6-6: Comparison and selection of headwork type

Criteria\HW Type	Intake	Weir	Pump	Dam
Relative location of RBL and CBL at its head reach	This is selected when CBL at its head reach < RBL	This is selected when CBL at its head reach > RBL	This is selected when command OGL > RBL & for pressurized system	Not critical
Amount of base flow and Size of command area	Base flow is Critically required otherwise it needs NSR structure	Base flow is Critically required otherwise it needs NSR structure	Base flow is Critically required	Selected when CA is larger in relation to available flow i.e. when flow is in scarce
Locally availability of construction material	Not critical, as its requirement is relatively smaller	Critical as it has direct implication on cost of the structure	Not critical, as its requirement is relatively smaller & most of the materials are imported	The most critical as it has direct implication on cost of the structure
Easiness of construction	This is the simplest & preferred where skilled manpower is limited	This is a bit harder & preferred where there is enough skilled manpower	Needs relatively smaller skilled manpower	Needs huge number of skilled manpower
Foundation condition	Foundation condition is not critical as it can be treated easily.	Needs stronger foundation condition	Needs relatively strong foundation condition	Needs the strongest foundation that can bear forces acting on the structure
Operation	This is the easiest to operate	Relatively easier to operate	Needs especial technical to operate based on demand	Needs especial technical to operate based on demand
Maintenance	Needs regular follow-up & maintenance	Needs seasonal follow-up & maintenance	Needs day-to-day follow-up & maintenance	Needs regular inspection & occasional maintenance
Investment Cost	The cheapest	Relatively cheaper	Relatively expensive	The most expensive
Environmental impact	Relatively smaller impact	Relatively wider impact	Relatively smaller impact	The most environmental impact

Note: CBL= Canal Bed Level; RBL= River Bed Level; OBL= Original Ground Level; CA= Command Area; HW= Headwork

<u>**Recommendation**</u>: Selection of headwork type in the order of priority shall be first Intake, then Weir, then Pump and then Dam if all options exist.

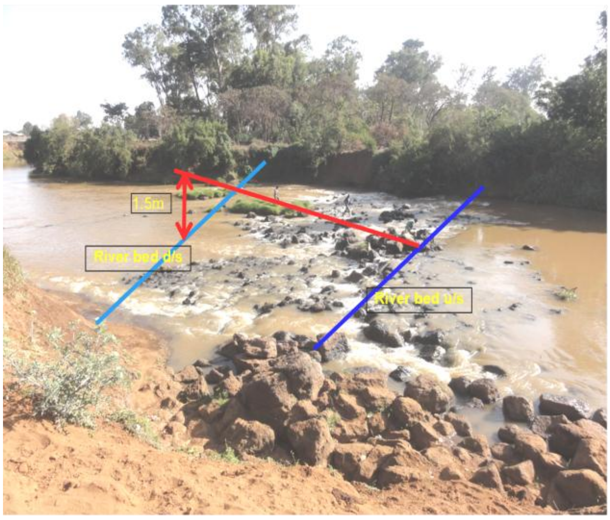


Figure 6-1: One of the headwork site options of Abay Chimba SSIP, in ANRS West Gojam

Figure 6-2: HW site for Meenit Goldya SSIP in Bench Maji zone

6.2.3 Delineation command area and preliminary layout

6.2.3.1 Delineation of command area

The command area can be delineated and estimated for the selected headwork sites on 1:50,000 topographic maps, and recent high resolution satellite imageries; and should be checked with additional information from woreda irrigation experts, and the local people.

Primarily the command area should be delineated on the map in reference with the elevation of the intake point to identify the potential land to be covered from the water supply point. This preliminary command area boundary should be verified at filed level with team members and other experts. It is highly recommended to develop this map in soft and hard copies before the commencement of potential site visit.

The boundary of the command area should be defined based on (i) possible head work site (ii) nature of existing terrain and (iii) a preliminary contour alignment for the main canal based on satellite imagery data and physical field observation.

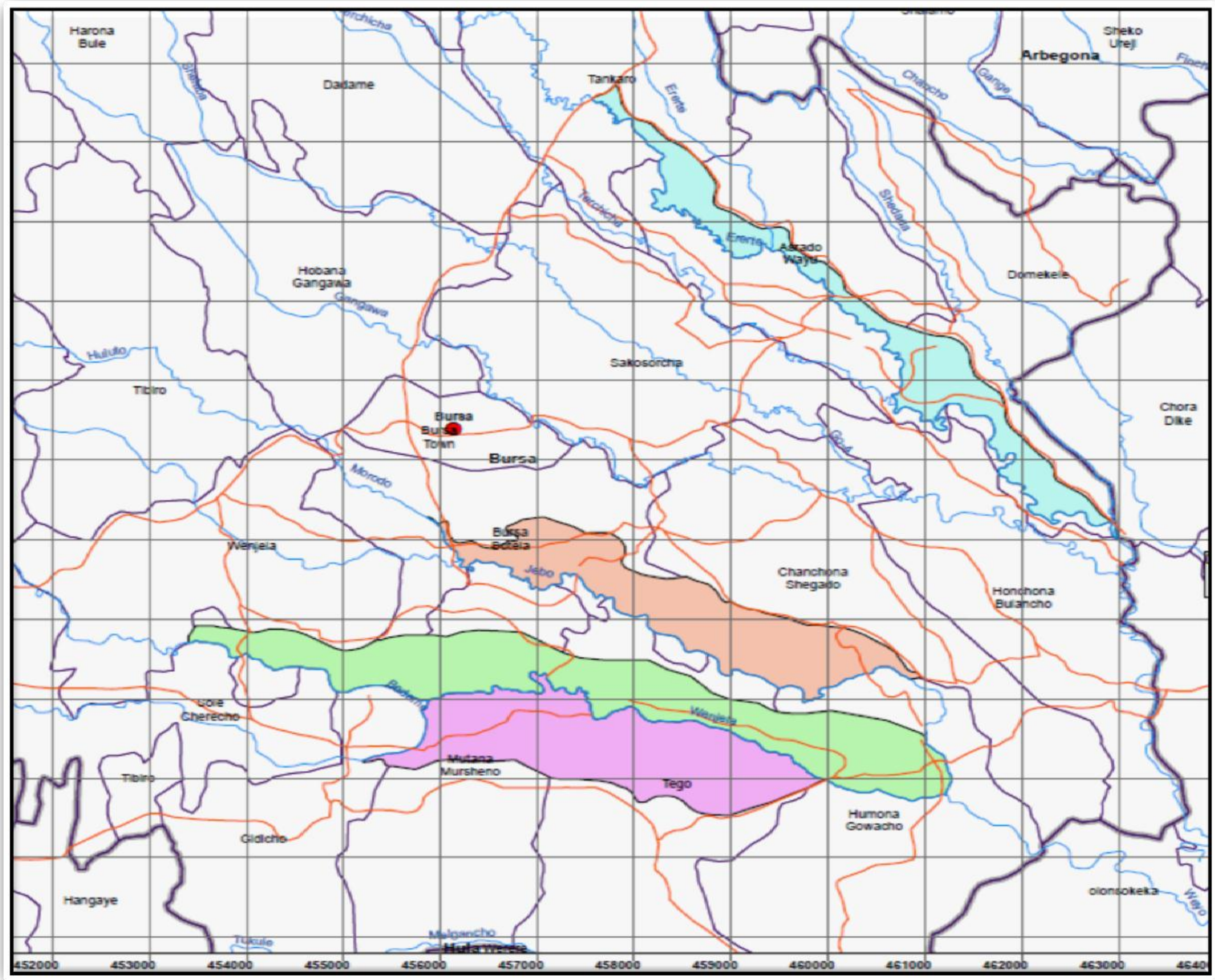


Figure 6-3: Alternative command areas delineated during site identification stage in Bursa woreda, Sidama zone, SNNPR

6.2.4 Preliminary layout

The preliminary layout indicates the command area boundary, primary canals, and crossing points from DEM (Digital Elevation Model). In identifying water distribution routes the communities and woreda/kebele experts should participate in showing and commenting the most optimum routes for each project sites considering the water supply efficiency, economic aspects, social and environmental impacts.

Preliminary main canal routes, (pressure line and delivery pool if any) need to be proposed during site identification to verify their appropriateness and to evaluate possible social impacts due to the scheme infrastructure for comparison.

6.2.5 Estimating indicative engineering costs

At this level of study, the engineering cost estimate shall be indicative mainly cost per hectare that represents the project site irrigation scheme. Secondary data from regional, zonal and woreda water and irrigation development offices might provide the engineering cost per hectare for projects have been studied and documented; for SSIPs under-construction; and for operational small-scale irrigation projects having similar type of headwork site an command terrain.

Table 6-7: Summary of engineering sector assessment findings

S/N	Engineering	Site 1	Site 2	Site 3
1	Type of irrigation system (Table 6-5)			
2	Type of headwork (Table 6-6)			
3	Site appropriateness for selected headwork			
4	Accessibility of headwork sites			
5	Command area size			
6	River stability			
7	Site location appropriateness for maximum water harvesting			
8	Engineering cost estimate (ETB/ha)			

6.3 GEOLOGY SECTOR ASSESSMENT

The geologist primarily should review the geological and hydrogeological condition of the project area from secondary sources like Ethiopian geological survey map, satellite images; previous studies conducted in and around the project area similar to the project sites. Before the field work the geologist can review the geological features of the project woreda and the review will continue after the identification of the irrigation potential sites during the field work.

At this level of study, the geologist expected to undertake the physical assessment of the project sites in particular the headwork sites and potential construction material areas for:

- Identification of general geologic conditions of the headwork cross section i.e. weir axis geomorphology, geology, hydrogeology and engineering geology
- Check profile of canal routs and structures
- Study source of irrigation water supply river's/spring's profile around the headwork site from visual observation.
- Identification of stability conditions and potential geologic failures at the same sites which will be confirmed during feasibility study.

6.4 TOPOGRAPHY SURVEY

Topographic survey of the potential sites at this level of study is limited on headwork sites cross sections and terrains of the command area. Together with irrigation engineer and soil expert using the topo-map or DEM contour map of the potential sites have to be developed and classified the survey area in slope gradient ranges (0-3%; 3-5%, 5-8%, 8-15%, 15-20%; 20-30%, 30-60% and >60%) appropriate for recommendation of conservation measures as required like for hillside cultivation.

- Cross-sectional survey of the source river and its flood-plain up to 5m above the floodplain (on both right and left banks) 50-100m on u/s, d/s & along axis of headwork.
- Cross-sectional survey to determine flood embankment requirements along some ±1 km of the River and its floodplain,

6.5 SOILS AND LAND SUITABILITY ASSESSMENT

6.5.1 Preparation of base map

Purpose of base map: Soil maps rely upon accurate base maps, both for positional reference and to provide bio-physical data that can assist in the prediction of soil properties. The availability of geographic technology for producing base maps has both constrained and directed the geographic study of soil. Base maps are used as parameters in soil-landscape models for predicting the spatial distribution of soil properties and classes.

Steps for base map preparation

- Generate Slope map using Digital Elevation Model (DEM) and classify the slopes based on the guideline (SSI-GL5)
- Interpret Land Use/cover from satellite imageries (Land sat, spot or the likes)
- Overlay soil and land suitability maps from previous studies and other related data sources if available
- Combine the outputs of the above maps and delineate preliminary homogenous land unit boundaries
- Predict possible soil grouping and name the land unit.
- Plan a systematic transects on produced map which cover the preliminary land units and locate points for auger-hole soil description with site codes and download these co-ordinates to a hand-held GPS (Use GPS application software)
- Organize the required field survey equipment, field survey checklists and guidelines for field investigation (See SSI-GL5).
- Use National topographic map at 1:50,000 scale as reference

In addition to the determination of the Land Unit, the expert will have information about land use/cover, topography, soil type, and other land features like river, streams, terrain, waterlogged areas, rocky surfaces and etc

6.5.2 Auger observation

At this level of study soil auger observation is required to assess randomly the physical features of the soil to characterize the site(s) for suitability and make comparison analysis for prioritization. The observation will take one observation auger to 25 ha depending on the homogeneity features of the area. Make the auger-hole observation to 1.2m deep or shallower when hindered by a rock.

Procedures for auger observation:

- Check the base map with the ground truth and make notes for any variation prior to augering
- Describe the following site features while augering:

  Location (Geographic Co-ordinates)
  Landform (plain, valley, hill, ridge etc)
  Topography (Gradient, form, orientation and position) see Appendix IV
  Land use/ Land Cover (including human influences)
  Surface characteristics (Rock outcrops, Coarse fragment, Erosion, Surface sealing and Surface Cracks)
  Drainage class (use indicates like mottling, Fe-Mn nodules…)

- From the soil auger

  Effective soil depth
  Depth of water table (if it is above 1.2m)
  Texture class
  Coarse fragments
  Soil color
  Top soil structure

After description collect soil samples from the first two horizon for in-situ soil pH analysis.

Figure 6-4: Auger-hole samples arranged based on layers & soil depth

6.5.3 Visual site observation

Apart from the soil auger descriptions the expert should note and geo-reference relevant features along the soil survey traverses. These features include: slope and slope changes; gullies and streams; soil boundaries; rock outcrops; shallow, stony or eroded areas; wet depressions; wells; land use' cover and settlements.

6.5.4 Land evaluation for irrigation

The physical land evaluation focuses on permanent factors to identify project areas. It considers the costs based changeable factors to prioritize the potential areas, particularly the suitability become conditional suitable.

Table 6-8: Land evaluation criteria

Code value	Soil Depth (cm)	Slope (%)	Drainage Condition	Stoniness (%)	Texture
1	>200	0-3	well	< 1	Silt loam, sandy clay, and clay loam
2	120-200	3-5	moderate	1-3	sandy loam, loam, silty clay loam, silty clay
3	60-120	5-8	Imperfect	3-15	loamy sand - clay
4	30-60	8-15	Excessive	15-50	sand, clay
5	<30	> 15	Poor	> 50	sand, gravel

Range of codes for the conditional Assessment of Suitability Land for irrigation										
Texture	1	1-2	1-3	1-3	1-3	1-3	4	4	5	5
Drainage	1	1-2	1-2	1-2	1-3	4	1-4	1-4	1-4	5
Soil Depth	1-2	1-2	1-3	1-3	1-4	1-4	1-3	1-4	1-5	1-5
Stoniness %	1-3	1-3	1-3	1-4	1-4	1-4	1-3	1-4	1-5	1-5
Slope	1-2	1-3	1-4	1-4	1-4	1-4	1-3	1-4	1-5	1-5
Land Suitability Class	S1	S2	S3	CNS				NS		

The above indicated land and soil characteristics can be determined by soil expert from field observation and secondary data, ATA soil fertility performance and fertilizer recommendation Atlas, Master plan studies, and other studies might help. The soil expert should determine the soil depth, slope, drainage condition, stoniness and texture from auger observation to qualify the land suitability which is the most essential inputs for site selection and prioritization.

6.5.5 Matching of site specific land quality and requirement

The expert should match the land qualities determined from site survey preliminary mapping unit (Table 6-8) with land suitability criteria indicated in Table 6-9 as shown in table below.

Estimate and indicate areal coverage of each PMU on the matching table in %

Table 6-9: Land quality matching results for potential site

Mapping Code	Depth	Slope	Drainage	Stoniness	Texture	Suitability Order	Estimated coverage,
PMU 1	S1	S1	S2	S1	S2	S	60%
PMU 2	S2	S3	S1	S1	S3	S	10%
PMU 3	NS	S1	S3	S2	S2	N	15%
PMU 4	S1	S1	S1	S1	S1	S	15%
PMU n							
							100%

As the result of matching procedures quantify the land area coverage of suitable land “S” in percentage in order to evaluate the level of land suitability for further prioritization. Then rate the suitability conditions of the site based on the rating table (Table 6-11) to classify the potential site in high or medium or low rates. Refer the table below for rating:

Table 6-10: potential site rating from land suitability aspects

No.	Suitable land % coverage	Rate	Example for Scoring (out of ten)	Remarks
1	>80	High	8-10	Base on the combination of S1, S2 & S3
2	50-80	Medium	5-8	Base on the combination of S1, S2 & S3
3	25-50	Low	0-5	Base on the combination of S1, S2 & S3

The land area coverage with land suitability levels for each of the potential irrigation sites have to be investigated and summarized for site characterization and prioritization purpose to be compiled in prioritization matrix table.

The expert should score subjectively using the combination of coverages by suitability classes.

6.6 AGRICULTURAL PRODUCTION POTENTIAL ASSESSMENTS

Preliminary agricultural potential assessment should be undertaken to provide inputs for project site selection and prioritization. At this level of study, preliminary estimated figures, descriptions and analysis are adequate to characterize the project sites and compare for their potential.

There are four major factors or indicators to be considered for agricultural potential assessment such as climate factor, water resource availability, land suitability and human factors. Agro-Climate and crop production related analysis including agro-climate suitability analysis, length of growing period analysis, vulnerability analysis need to be undertaken to propose appropriate crops for tentative estimation of irrigation water requirements and yield estimates. Each of the above-mentioned assessments and analysis are briefly discussed below:

6.6.1 Existing crop production experiences

a. Crops grown in the project area

The agronomist has to collect information on the type of major crops by growing season. The following table format will be used for collection of crops grown

Table 6-11: List of crops grown in the project area

Cropping season	Crop
Belg	
Meher	
Irrigated farming	
Recession farming season	

* recession farming season need to be treated as separate season to have clear information about the irrigated farming and recession farming because in some areas they describe interchangeably

b. Cropping calendar of rainfed and irrigated crops

Collect data on time schedule for land preparation, sowing, weeding and harvesting of major crops listed in Table 7-10. Take the most common cropping schedule prominent in the area

Table 6-12: Cropping calendar of crops grown under rainfed farming

Crop	Land preparation	Planting date	Weeding	Harvesting	Irrigation interval, days
Rainfed crops					X
Crop 1					X
Crop 2					X
Crop n					X
Irrigated crops					
Crop 1					
Crop 2					
Crop n					

c. Assessment of major constraints of crop production system

During site identification and prioritization study phase basic and main constraints of the agricultural activities in project site(s) should be listed and rated their effects on production system. Therefore we can evaluate the problems in terms of high, medium, and low rates in order to compare and contrast different sites with their level of vulnerability to crop production limiting factors. The number of constraints should not be limited to the given rows in the table below use as template for assessment

Table 6-13: Identified agricultural production constraints of the project site(s)

Major Constraints	Impacts on agricultural production		
Constraints of rainfed agriculture	High	Medium	Low
1.			
2			
3			
4+			
Constraints of irrigated agriculture			
1.			
2			
3.			
4+			

Make a «X» mark in impact rating ; the irrigated agriculture could be traditional or/and modern irrigation system and the location could be in or out of the project sites

6.6.2 Agro-climate suitability analysis

The climate factors should be assessed after receiving climate data from hydrologist or other reliable sources. At this level of study, the agronomist can analyse the agro-climate suitability for few crops selected from different potential crop groups for irrigated agriculture.

The following grouping can be used for suitability analysis: Cereals, pulse, oil seed crops, vegetables, root crops, fruit crops, fruit tree crops,. The agronomist should concentrate on few individual crops representing different potential crop groups based on their climatic requirements

The following data should be filled based on farmers' experience about the occurrence, frequency and hazard incidence of agro-climate conditions. Therefore key informants those have knowledge on long history of the project area are preferable to do the analysis. The outputs of the analysis will help to select appropriate and tolerant crops or to make adjustment on cropping calendar

Table 6-14: Project area climate conditions

Climate factor			
Rainfall pattern	Bi-modal	Mono-modal	
Rainfall distribution	Dry months	Small rain	Big rain
Months in range			
Mean Temperature	Max average	Mean average	Min average
^{o}C			
Frost occurrence	Frost free months	harmful frost occurrence	Slight with no harm
Months in range			
Wind	High wind	Moderate	Light wind
Months in range			

Optimum and tolerable temperature ranges for different crops are attached as annex in "SSIGL 8: Guideline for Feasibility study of Irrigation agronomy" to identify suitable crops for given temperature ranges.

Procedure for climate matching analysis

Step 1: list type of potential irrigable crops can be grown in the project area from farmers, development agents and your professional suggestions

Step 2: Match climate (rainfall, temperature and humidity) requirements of selected crops with the climate conditions of the project sites.

Step 3: Select and list most suitable crops from agro-climate condition

If the area is found frost prone area then focus on crops tolerant to frost (refer from Annex 1 of this guideline). If the area has a history of frost hazard then we have two alternatives; the first option is selecting frost tolerant crops otherwise the second option is readjusting the cropping calendar in frost free months.

6.6.3 LGP description and compatible analysis

The LGP information will help to analyse the adequacy of dry season period for 1 or 2 round irrigation faming. Depend on the LGP of the project area appropriate crops can be recommended for further analysis

The LGP can be investigated in two ways such as by interviewing farmers and key stakeholder; or by calculating simple water balance from monthly ETo and rainfall.

Option 1: Farmers and key stakeholders interview

Collect data from farmers or elders or development agents or secondary data from kebele agricultural office. Try to get the most common and representative date for starting and ending of rainfall.

Table 6-15: Cropping season of the project area, in months

Cropping season	Starting date of rain	End of the rain	Harvesting season
Belg			
Meher			
Dry season in months	From to		

Note: specify the date in early/middle/late days of month

Option 2: Using the excel spread sheet

Steps:

- Calculate the monthly Potential Evapo-transpiration of the area using Pen-manteith method or it can be available from Class I Meteorology station; or New-LocClim V1-10 software. However it's advisable to calculate the ETo with site specific climate data.
- Calculate 50% of ETo monthly values
- Insert the mean monthly rainfall data
- Calculate simple water balance by subtracting 50% of ETo values (crop water demand) from monthly Rainfall (water availability), and identify the months with deficits (-)
- Determine the number of days with surplus water balance months and add-up that gives length of growing period of the project suitable for crop production under rainfed conditions

Table 6-16: LGP determination for Pawi Area SSIP area

	Month	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	ETo, mm	116	127	154	147	142	117	99.9	93.3	102	104	104	104.7
2	ETo*0.5	57.9	63.45	77.1	73.5	70.95	58.65	49.95	46.65	51	51.75	51.9	52.35
3	Rainfall, mm	1.2	0.8	6.9	22.7	106.7	291.2	354.7	415	243.2	130.5	13.5	1.2
4	(3-2)	-56.7	-62.65	-70.2	-50.8	35.75	232.55	304.75	368.35	192.2	78.75	-38.4	-51.15
5	LGP, days					31	30	31	31	30	31		
	LGP Period					**~184 days**							

In the next step make sure that the selected crops and their varieties are compatible with project area length of growing period and for the anticipated irrigated agriculture intervention. If the area has adequate dry season period for cultivation of irrigable crops then identify the months to considered for full irrigation. Moreover, if the area is characterized by erratic rainfall and frequent drought during rainfed agriculture then supplementary irrigation would be important to support the rainfed agriculture. From these and other crop growing factors, the agronomist can identify the preliminary list of crops for the project

6.6.4 Vulnerability assessment

Vulnerability assessment mainly focused on major environment and climate induced calamities on crop production. Less prone project sites should have better opportunity to be selected for irrigated agriculture. Therefore the evaluation can be undertaken with the help of farmers and development agents to rate the occurrence and intensity. The agronomist can modify the evaluation template presented in Table 6-17, according to the specific conditions of the project sites to be more flexible and incorporate additional environmental and human induced causal factors.

Table 6-17: Existing level of crop vulnerability to different calamities

Causes of vulnerability	Site 1	Site 2	Site 3
Crop insect infestation			
Crop disease			
Frost hazard			
Harmful flooding			
Sever erosion			
Extensive termite damage			
Others if any (list them)			

Vulnerability Level: High, medium and Low

6.6.5 Crop proposal and cropping pattern recommendation

The crops at this level should not be more than 6 crops (3 crops for full irrigation and 3 crops for supplementary irrigation) considering the above mentioned results in section 6.6.2, 6.6.3, and 6.6.4.

Table 6-18: Proposed crops and cropping calendar

Full irrigation				Supplementary irrigation			
Crop	Cropping pattern %	Planting date	Harvesting date	Crop	Cropping pattern %	Planting date	Harvesting date
Crop 1				Crop 1			
Crop 2				Crop 2			
Crop 3				Crop 3			

6.6.6 Irrigation water requirements computation for selected sites

Crop and irrigation water requirements can be calculated with simple method considering the level of precision for this phase. After the identification of suitable crops, apply the following procedures:

Step 1: Calculate Potential evapotranspiration

The reference evapotranspiration of the project area could be estimated from climate data. The Potential evapotranspiration of the project area to be used for Excel based computation of CWR and IR can be computed by Climate Module of CROPWAT 8 software as presented in Appendix V. If the project sites are found in the same agro-ecology and the utilized climate data represents all potential sites then the calculated ET_o can be used for all sites with the same agro-ecology and proxy.

Step 2: Calculate the Crop water requirement

Crop water requirement (ETc) of each selected crop is computing by multiplying the monthly ETo with adjusted crop coefficient (Kc) (refer the detail Kc estimation in Appendix v of this guideline)

Step 2: Calculate the effective rainfall

Calculate the effective rainfall of the project area from long term average rainfall obtained from hydrologists or available from meteorology center / satellite verified climate datasets by empirical formula. Insert the data for each months in excel where the CWR and IR are going to estimate (see sample format in Table 6-20)

Peff = 0.6*P-10 for P month <= 70 mm; Peff = 0.8* P -24 for P month > 70 mm

Step 3: Estimate the monthly irrigation requirement

Compute the irrigation requirement by subtracting the effective rainfall from actual evapotranspiration ETc or crop requirement. (see Appendix V)

Please refer the attached appendix V for CWR and IR computation.

Table 6-19: Example for Crop and Irrigation Water Requirement Computation

	Month	Unit	Jan	Feb	Mar	April	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
	Climate Data													
1	ETo (mm)	mm	111	113	136	147	125	100	82	82	101	109	102	96
2	Rainfall mm	mm	11.0	44.0	1.0	23.0	151.0	302.0	358.0	490.0	320.0	184.0	13.0	6.0
3	Effective rainfall (Pe)	mm	**0.0**	**16.4**	**0.0**	**3.8**	**66.6**	**157.2**	**190.8**	**270.0**	**168.0**	**86.4**	**0.0**	**0.0**
	Crop water Requirement													
	Tomato													
4	Kc values		0.93	0.94	0.65								0.4	0.63
5	ETc (mm) (1X4)	mm	**103.2**	**106.2**	**88.4**								**40.8**	**60.5**
	Maize													
6	Kc values		0.95	0.88	0.8								0.3	0.7
7	ETc (mm) (1X6)	mm	**105.3**	**99.5**	**108.8**								**30.6**	**67.2**
	Potato													
8	Kc values		1.02	0.95	0.8								0.4	0.66
9	ETc (mm) (1X8)	mm	**112.8**	**107.6**	**108.8**								**40.8**	**63.5**
	Haricot bean													
10	Kc values		0.90	1.01	0.70									0.25
11	ETc (mm) (1X10)	mm	**99.4**	**114.4**	**95.2**									**24.0**
	Net Irrigation Requirement (CWR-Pe), mm/month													
12	Tomato (5-3)	mm	103.2	89.8	88.4								40.8	60.5
13	Maize (7-3)	mm	**105.3**	**83.1**	**108.8**								**30.6**	**67.2**
14	Potato (9-3)	mm	112.8	91.2	108.8								40.8	63.5
15	Haricot bean (11-3)	mm	99.4	98.0	95.2								0.0	24.0
16	Total net irr mm/month/ha	mm	106.2	89.9	102.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.6	56.2
17	Project irrigation efficiency (Ep)		**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**
18	Gross Irrigation Requirement (16/17)	mm	**212.4**	**179.8**	**205.2**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**59.2**	**112.4**
19	Project irrigation supply lt/s/ha (18/259.2)		**0.82**	**0.69**	**0.79**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.23**	**0.43**
20	Actual irrigated area %		**100.0**	**100.0**	**100.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**80.0**	**100.0**

6.6.7 Estimate Yields and Crop budget

The yield estimates of the proposed crops will be used for computing the potential farm returns and to use as input for cost-benefit analysis. The optimum yield of the proposed crops shall be for production estimates. The optimum yield data for different crops can be obtained from reliable sources or Annex 10 of the "GL 6: Irrigation Agronomy Feasibility study guideline for SSID".

Crop budget estimation is an important input for computing production costs of the proposed crops which further will be analysed against the benefits of the crops under irrigated agriculture. See the format for crop budget preparation

Table 6-20: Formats for crop budget calculation

	Input	Calculation	Unit	Qty/ha	Unit Rate (Birr)	Annual cost (Birr)
1	**Labour**		Man-days			
2	Oxen power		Oxen-days			
3	Seed		Kg			
	Fertilizer					
4	NPS		Kg			
5	Urea		Kg			
6	Pesticide		Lump sum	xxx	xxx	
7	Herbicides		Lump sum	xxx	xxx	
8	Lime		kg			
9	Packing materials		No			
10	Land tax		LS			
11	Total cost	(1+2+3..10)	ETB			
12	Miscellaneous (5%)	(5% x 11)	ETB			
13	Grand total cost	(11 +12)	ETB			
14	Yield		Qt			
15	Price		ETB	xx		
16	Gross Income	(14 x 15)	ETB			
17	Farm return	(15 – 13)	ETB			

Most of the crop requirements useful for computing the budget are available in Irrigation agronomy feasibility study guideline for SSID, however other inputs like Labour and Oxen power, unit rates should be collected from the project area or consult the socio-economist.

6.7 SOCIO-ECONOMIC ASSESSMENTS

6.7.1 Settlement patterns of the beneficiaries in the command area

Identify the settlement patterns of the beneficiaries whether they are confined in one place, clustered in different places, scattered and no settlement. To conduct this assessment, search for imageries from recent Google earth imagery or aerial photos indicating the settlement patterns. Further consultation is required with administration and communities to define the settlement pattern

6.7.2 Demographic features assessment

The main demographic characteristics to be considered at site identification and prioritization phase are population, household, average family size, age composition, and sex composition.

Prepare list of Sub-village(s) included in the command area and estimate the number of households found in the delineated gross command area, then calculate the population with average family size in identified sub-villages or kebele average family size. The avaergae family size can be obtained from kebele secondary data or in consultation with key informants

6.7.3 Economic conditions assessment

The livelihood basis of the communities or income sources reflects the prevailing economic conditions and income diversity of the area. Therefore at this level identify the primary and secondary income sources of the community to describe the economic basis of the community and opportunities for development.

6.7.4 On-going or planned investment projects identification

During stakeholders and community consultation the list of on-going rural based projects including irrigation scheme, road, market infrastructure, social service facility construction, agricultural support institution establishment and etc. should be identified to consider the capacity building improvements for the potential site. Besides, the planned investment projects by region, zone, woreda and kebele in area of the above indicated services have to be collected from relevant offices.

6.7.5 Assessment of availability of human resource for irrigated agriculture development

Human capital or resource is one the fundamental requirements for implementation and sustainability of irrigated agriculture which need to be assessed its availability and accessibility in the project sites. The availability can be assessed by

a) Demographic data of the project kebele (s) available from secondary data. Take the number of active age groups those within 14 to 60 age group ranges
b) Estimate potential human labour from average family size and number of household beneficiaries of the project. In consultation with communities quantify the number of family members per household those who are within 14 – 60 age interval and multiply by the number of beneficiary households
c) extra labour availability can be assessed in consultation with key informants on community experience of hiring extra labour, and using labour exchange arrangement for agricultural activities

6.7.6 Assessment of stakeholders attitude towards irrigated agriculture development

Short and precise consultation session is required to confirm about the attitude of the stakeholders including woreda and kebele administrations, woreda sector offices, primary cooperatives and UNION and traders. Conduct the consultation meeting with other team members at woreda and kebele centers.

Ask their opinion on the appropriateness of the planned irrigated agriculture development in identified particular site(s) and willingness/commitment to involve in all project levels such as study, construction, implementation, monitoring and evaluation of the project

The stakeholders mainly the sector offices and CBOs should confirm their commitments with letters or minutes of meetings. In here the main output is reaching consensus through confirmation letter from woreda and kebele offices including minutes of meetings

6.7.7 Community attitude assessment

During site identification phase, the willingness of the communities in the intended command area or project kebele has to be checked whether they are interested to own and manage the proposed agricultural development. In order to assess their attitude either of the following process needs to be carried out

- Collect a copy of application or request letter for development of SSIP written from project kebele on behalf of the communities submitted to woreda administration office. It shall indicate that the kebele administration and the communities are requesting the woreda administration to build a small-scale irrigation project in their kebele or to include their interest in annual or five-year development plan.
- Carry out consultation session with kebele council and community representatives on their interest towards the intended irrigation development. The expert should give briefing about the benefits of the intervention on the improvement of their livelihood through improved irrigated agricultural system. Keep the signed consultation session minute to attach in the report.

Make sure that the communities in and around the potential small-scale irrigation sites are willing to own and manage the intended irrigation project in written form to precede to next study phase

Due to different reasons the communities might reject or not give priority for this irrigation development plan, the expert should clearly pointed out their explanation and support with official letter from kebele administration afterward to attach in the site identification and prioritization report.

If there is a rejection by the communities, the information need to be immediately circulated to all study team members to revise their work and schedule.

Output: letter of request for SSIP development from community or kebele administration; or Minutes of meeting

6.7.8 Preliminary assessment of social infrastructure

The main objectives of this assessment are identifying the available social infrastructures and their accessibility; and identify potential resource use conflicts might raise due to the implementation of the irrigation project that might affect the routine service given by the providers.

List of social infrastructure: in the context of irrigation project development, the social infrastructures are: schools, health center, water supply points, religion centres, administration office, market centers, road, community based organization service center and telecommunication center, electricity if any.

Issues to be considered: at this level of study, the expert has to assess accessibility and their contribution in all project phases. The accessibility of the social infrastructure can be expressed in distance (km) from major settlement area of the beneficiaries or time taken to reach the service providing center. For instance the site with better road network and market facilities could have priority than the remote sites.

Resource use conflict: there may be water supply scheme or points sharing the water resource and such conditions need to be investigated and discussed its level of impacts with the communities and service providers. On the other hand the water distribution canal may cross the schools or health center compounds, therefore consultation have to be undertaken to perceive their comments

Table 6-21: Format for assessment of social infrastructure accessibility

Social infrastructure	Site 1		Site 2		Site 3	
	Km or hr*	In command area (√)	Km or hr	In command area (√)	Km or hr	In command area (√)
1 Health centre						
2. Schools						
3. Water supply facility						
4. Religion centre						
5. Main market						
6 CBO service centre						
7. Administration office						

* Distance from main settlement centre (in km or hr)

6.7.9 Preliminary assessment of agricultural support service

The agricultural support service is an important institutional support to attain the objectives of the irrigation development intervention. The availability and efficiency of the agricultural support institutions would have substantial role for site identification and prioritization. The expert should have information on their services currently provided to the communities in the project sites. The assessment can be undertaken by interviewing the kebele administration, development agents and representatives of the community.

Check the availability of:

- Extension service provider institution or kebele agricultural development office
- Credit provider institutions
- Research intervention areas proxy to the project area and
- Agricultural inputs supplier
- Water users' association

Undertake Performance assessment

During consultation of the communities for site identification, collect their opinion on the efficiency of the indicated institutions to overview their current performance. Please fill the following evaluation table which should entirely reflect the community perception.

Table 6-22: preliminary performance evaluation of agricultural support institutions

Agricultural support service institution	Site 1	Site 2	Site 3
Agricultural extension service			
Rural credit and saving institution			
Private agricultural input supplier			
Irrigation Water Users' Association			
Primary cooperatives and UNION			
Farm machinery rental service providers			
Research centres involvement in development			

Evaluation rate: Not satisfactory; Fair enough; and very good

6.7.10 Existing community based organization assessment

The existing community based organizations includes IWUA, primary cooperative, and cooperatives' Union. Primary assessment of these community institutions is required to obtain information on their availability and performance in achieving their institutional objectives. The project site with well performing water users' association and cooperatives would have better opportunity to be nominated for development intervention. Their performance in each project site should be evaluated by the beneficiaries and summarized in Table 6-21.

Table 6-23: Capacity of existing community based organizations

No	Name of CBO	HH Members		Capital, ETB	Office facility
		Male	Female		
I	**Site 1**				
1	IWUA				
2	Primary cooperatives				
3	Cooperatives' Union				
II	**Site 2**				
1	IWUA				
2	Primary cooperatives				
3	Cooperatives' Union				
III	**Site 3**				
1	IWUA				
2	Primary cooperatives				
3	Cooperatives' Union				

6.7.11 Marketing conditions

The existing market facilities in and around the project sites required a preliminary assessment to identify the type of market, location from the village and accessibility. Market centres can be classified into primary and secondary level depending on the chain of the marketable products. The existing conditions including potential, facilities, networking and accessibility of market centres need to be investigated and described.

Primary and secondary markets in terms of types of participants (whole sale and retail traders, producers, and consumers), size of participants i.e. large and small, marketing volumes, distance and frequency per week should be discussed and summarized for each site as follows:

Table 6-24: Summary of market potential and accessibility assessment

No	Description	Site 1		Site 2		Site 3	
		Primary	Secondary	Primary	Secondary	Primary	Secondary
1	Participants						
2	Market size						
3	Distance , km						
4	Frequency, Per week						
5	Big storage structure						
6	Means of transportation						

Participants: consumers = c, whole seller = w, retail traders = r, producers = p; Market size: Small, Medium, large

Big storage structure available or not = Yes/No; Transportation: Animal back = AB; Animal cart or "gari" = AC; Own labor= OL; vehicles = V
Market related constraints those have capacity hindering the irrigation development interventions should be assed and listed in order of importance.

6.8 ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

6.8.1 Screening of the project

Screening is the processes of determining whether or not a project requires EA and the level at which the assessment should occur. According to the guideline issued by former Ethiopian Environmental Protection Authority, 2003 (current Ministry of Environment Protection and Forestry) the small-scale irrigation projects require full Environmental Assessment studies because they are sensitive to environmental effects and social conflicts.

6.8.2 Scoping

The scoping report is a requirement for small-scale irrigation project which need to be submitted separately with its own table of content for each of the identified potential sites. The scoping report expected to be precise and self-explanatory. In reference with EPA, 2003 guideline the purposes of scoping are to:

- Involve potentially affected groups,
- Consider reasonable alternatives,
- Evaluate concerns expressed,
- Understand local values,
- Determine appropriate methodologies, and
- Establish the terms of reference,

The outcome of scoping is a scoping report or Terms of Reference for undertaking full scale ESIA. Both of them require passing through reviewing process.

6.8.3 Brief description of the project and environmental influence area

Each of the identified small-scale irrigation project at site identification and prioritization phase should be described in terms of its administrative and geographical location obtained from the irrigation engineer. Moreover, indicate the project components which recommended at preliminary levels such as type of irrigation system and headwork, storage facility (if any), social infrastructure, number of beneficiaries and command area size.

The influential area or potential impact zones of the irrigation projects tend to be identified in upper and downstream of the project. The impact zones can be classified into primary and secondary or direct and indirect impact zones which highlights the extent of exposure to environmental impairment due to the construction and implementation of the small-scale irrigation project. For example, water bodies closer to the scheme drainage system (downstream) of a project is usually taken as primary impact areas.

The watershed of the project site shall be included in the environmental influential areas that may have positive and/or adverse impacts on irrigation development.

The location of the impact areas can be sketched on a map for better illustration and description.

The data and information for description and identification of the project influential area will be collected from site physical investigation, community and stakeholder consultation, key informant interview, review of secondary data sources.

6.8.4 Alternative consideration for the project

The alternatives to be considered for planning of economically, socially and environmentally sustainable small-scale irrigation project should be identified in consultation with other study team members mainly the engineering group; stakeholder and community. For instance in the context of the small-scale irrigation projects the followings could be possible alternatives depending on the features of the project area and availability of the resources:

- ***Type of irrigation system/technology***: different irrigation applications such as surface, pressurized and spate could be possible alternatives for a water abstraction point. The environmental impacts for each alternative irrigation system can be anticipated.
- ***Type of Headwork*** such as intake, diversion weir, pump, micro-dam, and barrage are possible options to be considered as alternative for small-scale irrigation project. They have different comparative advantage in terms of economic return, investment cost, environmental impacts and technical applicability,
- ***Location of headwork sites***: the potential area to be commanded and environmental impacts from different headwork sites of a river/stream could be significantly varied and the study team could propose as alternative for further analysis.
- ***Command area size:*** in combination with some of the above-indicated factors, the variation in command area size will be taken as an alternative for a given project.

Finally the environmentalist should prioritize the most preferable alternative in consultation with other staff. See the example from Abay Chimba SSIP located in ANRS, North Achefer woreda in Chimba kebele

Table 6-25: Example for description of alternative and environmental comparison

	Alternative 1	**Alternative 2**	**Alternative 3**
Irrigation method	**d/s Diversion**	**u/s Diversion**	**Pump**
Geographic location of headwork	299716 Easting and 1294306 Northing	296756 Easting and 1292566 Northing	301690 E and 1294877 Northing
Gross Command area (ha)	1359	1953	2810
Change in river water regime	Moderate	Moderate	High
Erosion land degradation	High	Moderate	Low
Loss of land subproject land acquisition	Moderate	Moderate	Low
Destruction of swamp/wetland	Moderate	High	Low
Irrigation water quality high sediment load	Moderate	Moderate	High
Water pollution from residual agrochemicals	Medium	Medium	Medium
Clearing of vegetation	Moderate	Moderate	Moderate
Preference by local community and administration	Medium	Medium	High
Environmentally preferred option rank	**2**	**3**	**1**

d/s = downstream; u/s = upstream

6.8.5 Environmental and social sensitive issues

To determine the scope of ESIA feasibility, main environmental and social issues have to be identified through project site observation and consultation. The field assessment and secondary data collection from woreda and kebele offices should be carried out to specify the major environmental sensitive issues. Some of the main issues in respect with small-scale irrigation projects are:

Bio-physical environment: land use/cover change, soil erosion, eco-system depletion; flora and fauna bio-diversity degradation,

Social issues: effects on upstream and downstream communities, water and land resource conflicts, impacts on social infrastructure, displacement, encountered health problems, historical and cultural sites; and so on.

The findings of the assessment tend to help in identifying environmental protection areas, to design appropriate methodology for further assessment during feasibility study, to plan proper working schedule.

6.8.6 Preliminary environmental and social impact assessment of SSIP

Environmental and social impact assessments will be undertaken to meet the data requirement for project scoping and for semi-detail investigation of impacts and mitigation measures.

6.8.6.1 Reviewing environmental policy, legal and institutional framework

Environmental and Social Impact Assessment (ESIA) is supported by policy, legal and institutional frameworks of the country and funding agency. The small scale irrigation project activities shall be undertaken within these frameworks. Therefore, the environmental expert should review issues related to irrigation development activities and briefly describe the legal bound of environmental and social aspects as per legal issues. The environmental expert should also review additional materials on which agreement has been made with funding agencies. Please refer the SSIP Technical guideline of ESIA for feasibility study" for detail information

6.8.6.2 Identification of project main features

The main components of small-scale irrigation project in each potential site should be indicated and briefly described. At this level of study only limited components can be identified for site identification and prioritization purposes. The data will be obtained from the irrigation engineer and other staff of the study team as appropriate.

The following features may be considered for this section: type of headwork, headwork dimensions, river protection structure and its dimension (if any), type of irrigation application, command area size, topographic features of the command area, type of related social infrastructure, number of beneficiaries.

6.8.6.3 Investigating watershed main characteristic

The expert should emphasis on main hydrological, bio-physical and social characteristics of project watershed for each of the three identified potential site. Main features of the watersheds should be considered are: watershed area, shape, drainage pattern, vegetation cover, stream density, settlement pattern, land degradation status and accessibility.

The information for watershed description can be obtained from watershed expert and hydrologist of the study team

6.8.6.4 Bio-physical assessment

At this level of study will be carried out by physical observation of the three potential sites, consultation with community and stakeholders and secondary data sources. Regional, woreda and kebele agricultural and natural resource offices; and bureau of environment and forestry are the main sources of information. The bio-physical data including type of soil, topography, land cover, land degradation situation, bio-diversity endowments and other important features can be collected and compiled from ESIA own assessment, and in addition, findings of soils and land suitability evaluation study, socio-economic and crop production studies will help to develop site specific baseline data for analysis of the preliminary potential impacts of the irrigation project. The assessment, consultation and discussion should oaslo give emphasis on the downstream impacts by identifying sensitive eco-system, water body, wetlands, sanctuary, cultural sites and others. Simultaneously collect potential mitigation measures during discussion. Some of indicative bio-physical impacts are

- Biodiversity disturbances (forest clearing, wildlife disturbances,)
- Water pollution
- Nitrification
- Land use change to cultivated land
- Loss of wetlands and their inhabitants
- Project induced land degradation

6.8.6.5 Socio-economic baseline data

Small group of community consultation comprises elders, youth, women, vulnerable group are enough to investigate the existing and possible future environmental impacts might be induced by the intended irrigation project. Similarly the adverse and benefits of the project on socio-economic status of the beneficiaries need to be analyzed to provide highlights for site characterization and selection purposes.

6.8.6.6 Stakeholder and public consultation

Consultation is most important tool to identify and analyse the potential multi-faceted impacts of the SSIP. The ESIA expert expected to handle the stakeholder and community consultations on basic environmental issues and assessing the beneficiaries' attitude towards the sustainability of the project and surrounding environment.

The stakeholders from different regional, zonal, woreda, and kebele government offices should be consulted together with other study team members. More importantly all levels of bureau of environmental protection and forestry should be consulted by environmentalist.

6.8.6.7 Preliminary impact identification and analysis

- The social preliminary impacts could be identified from project area site visit, community and stakeholder consultations, review previous studies and documents.
- Potential social impacts relevant for small-scale irrigation projects are but not limited to:

  Loss of lands and assets including perennial crops,
  Community and its livestock movement restrictions to water sources and/or grazing areas
  Prevalence of waterborne and communicable diseases,
  Vector borne diseases prevalence as a result of unintentional disease vectors breading site or conditions habitat creation such as stagnant water formation in borrow pits left without rehabilitation, etc. during different project activities,
  Possible damage of valuable historic, religious, cultural and/or archaeological sites

6.8.7 Methodologies for feasibility study ESIA

By taking into account the above-mentioned area specific environmental and social issues; and other determinant issues, the methodologies have to be set and proposed for feasibility level ESIA study. Further the client will evaluate the appropriateness of the recommended methodology tools and approve for next phase.

Data collection and analysis tools for ESIA study will be

- Review of national and regional policies, strategies, and regulations; similar studies, and periodical reports
- Physical assessment of the project area through field visit and observation
- Community and stakeholder consultation
- Focus group discussion for small target groups
- Key informant interview
- Water quality analysis

Outline of a Term of Reference:

- background to the proposal,
- setting the context of the problem,
- consideration of alternatives,
- institutional and public involvement,
- required information regarding project and location,
- analysis of impacts,
- mitigation and monitoring, and
- conclusions and recommendations,

7 COST BENEFIT ANALYSIS

Cost-benefit analysis of each irrigation project in three identified sites is required to compute the crude potential return that provide indicative figure for prioritization assessment. The data will be available from different sectors those contribute various costs for development of the project.
Type of costs to be collected and organized for analysis are: Engineering cost, crop production cost, and environmental costs (for conservation within the command area for production sustainability)

The engineering cost will be estimated based on average cost per hectare value by irrigation engineer and other concerned staff

Watershed cost: the watershed cost is estimated for 1-2 micro-watersheds closest to the headwork site that has immediate effect on the structure identified to be **hot spot watershed areas** .

Command area conservation cost: this cost has to be estimated by soil expert in land development section. Usually this cost will be considered for hillside irrigation requiring huge land development works

Production cost: it applies to the costs for production of the crops in the project. Production cost will be estimated in crop budget calculation handled by the agronomist. The estimated per hectare production cost will be multiplied with the crop area to get the production of each proposed costs.

Environmental cost: Costs require for mitigating the impacts induced by the project are taken for computing environmental cost. This cost might be considered only if the costs can be determined at this level of assessment.

Table 7-1: Project costs and benefit estimation

No.	Description	Estimate In Birr
I	**Investment and operation costs**	
1	Engineering cost	
2	Watershed cost (closest micro-watershed)	
3	Crop production cost	
4	Environmental cost	
5	Command area conservation cost (if any)	
	Cost Benefit	

8 PRIORITIZATION OF POTENTIAL SITES

In order to identify the best SSIP from the three potential SSI schemes in the given assignment area (woreda) for feasibility study, Detail Design; each of them has to be evaluated using a wide range of multi-sectoral criteria such as Engineering, topography, water resource, geology, land suitability, agronomic, socio-economics, institutional capacity, watershed characteristics, environmental sensitivity, project benefits. Ranking using these criteria will be based on an objective assessment of each sector using both qualifying and quantified indicators/criteria's.

Weighted factor system is applied where by a weighted score is given for each criterion based on a total of given point mark. The cumulative values would determine the priority rank of the project. The value should only be taken as an indicative, since there are other intangible benefits, forward and back ward linkages. Analysis of these multi-sectorial criteria and weighted system result are given in Table 8.1

8.1 MULTI SECTORIAL CRITERIA AND WEIGHTED SYSTEM

Multi criteria analysis (MCA) provides a structured framework for comparing a number of irrigation sites across multiple criteria. A major benefit of using MCA for prioritizing SSIP potential sites is the ability to include sectoral selection factors assessed and analyzed at field level and in consultation with communities and stakeholders. All selection criteria not necessarily used for prioritization while some of the criteria could be combined. This method is simple to use for quantitative criteria analysis.

The steps for undertaking the MCA follows the approach as summarized in Dodgson et al. (2009):

Steps:

I. Establish the decision context. What are the aims of the MCA?

The main aim of the MCA is to identify the most appropriate and needy project site from three proposed and assessed irrigation potential sites

II. Identify the options (three irrigation sites)

Three SSI potential sites to be analyzed and prioritized

III. Identify the criteria

The sectoral criteria for site prioritization need to be determined for comparison. The professionals from each sector should apply appropriate prioritization criteria from the identified site selection criteria. Do not take all selection criteria for prioritization purpose because some of the criteria can be combined for evaluation. Please try to minimize the number of criteria to be used for prioritization and do not miss the major factors which have critical importance for irrigation site selection.

This guideline proposed sectoral criteria to be used for site selection and prioritization purposes. However, depending on the peculiar condition of the irrigation projects or sites the criteria are subject to modification

IV. Describe the expected performance of each option against the criteria.

Based on the prioritization criteria set for each sector will be applied to qualify the options or irrigation potential site

V. Weighting each main and sub criteria

- Assign weights for each of the criteria to reflect their relative importance to the decision
- Two stages weighting of factors are required where numbers of sub-criteria are considered for evaluation. In our context there are 3-6 sub-criteria in each sector those need to be weighted to each other to consider their level of impacts or importance in evaluation of the site preferences.
- Primarily give weighting value from 0- 30 for each sector and sub sector depending on their significance which their sum total should be 100
- Secondly the sub-criteria in each of the sector separately should be weighted and their summation should be 100 (see example in table 8-2)

VI. Weight each potential SSIP site

Score of evaluation point to be given for each potential irrigation site against each sub-criterion independently. The scoring should follow the score level proposed in table 8-1.

VII. Examine the results

Identify determinant and critical criteria that have a strong decision power to the establishment of irrigation projects. These critical or basic criteria for any of the irrigation intervention need to give special priority in examining the results. For example the site with very low base flow is chosen in prioritization process due to highest scores in other factors. This critical (low base flow) factor has to take into consideration when the team re-analyzes the results of evaluation matrix (Table 8-2). For your reference some of critical criteria need special attentions for further analysis are highlighted in Table 8-3 below.

Table 8-1: Descriptions for recommended of evaluation

Score	Description
0	Used when information on a site does not apply to the particular criteria
1-20	Extremely weak performance, strongly unfavourable
21-40	Poor performance, major improvement needed
41-60	At an acceptable or above level
61-80	Very favourable performance, but still needing improvement
81-100	Clearly outstanding performance

Combine the weights and scores for each of the sub-criteria in a sector and then for overall potential sites to derive and overall value.

Table 8-2: Proposed prioritization criteria & Evaluation matrix for selected of potential site

S.N	Criteria's for prioritization	Score	SSIP sites		
			S1	S2	S3
C1	**Water and Land resource potential (30)**	30			
	Water potential & balance including Env flow	10			
	Topographic condition /Steepness and terrain characteristics	5			
	Land suitability for irrigated farming and planned crops indicated by Soil type and Soil characteristics indicated by texture, effective, depth, color, workability/compactness, soil salinity and acidity	10			

S.N	Criteria's for prioritization	Score	SSIP sites		
			S1	S2	S3
	Watershed Drainage pattern, shape, land use land cover	5			
	Sub Total	**30%**			
C2	**Engineering Criteria (30)**	**30**			
	Head work Type & Sites condition	10			
	Type and no of Structure Requirements of MC, SC Canals & drainage system	5			
	Geological condition of the head work, Stable bed i.e. rocky foundation material, Stable banks, Non/Existence of Faults, main and secondary canal alignments, and on structures	5			
	Availability of construction materials in the nearby area	5			
	Cost per ha	5			
	Sub Total	**30%**			
C3	**Irrigation Agriculture**	**10**			
	Agro-climate condition suitable for diversified cropping patterns	3			
	Potential to grow cash and high value crops	2			
	Irrigation water requirement or demand	2			
	Existence of improved technologies accessibility (improved seed, chemicals, equipment's and machineries..etc)	2			
	Existence of support system (extension, research, demonstration)	1			
	Sub Total	10%			
C4	**Social and economic aspects (20)**	**20**			
	Nr of Existing Beneficiary Households	2			
	Equity and Priority	3			
	Responsiveness to cross cutting issues,	3			
	Community participation, Attitudes and willingness for cost Sharing in implementation and operation and maintenance	5			
	Market, value chain and agribusiness potential	5			
	Cost benefit and financial viability	2			
	Sub Total	20%			
C5	**Environmental Factors**	**10**			
	Impacts on social and physical infrastructures places	3			
	Positive impacts	2			
	Existence of alternative project options	1			
	Occurrence of water use conflicts between up and down stream users	2			
	Sub Total	10%			
	Grand Total	100%			
	Rank				

Note: If the project expected to have impacts on cultural heritage, historical places, and religious centers then the irrigation site should not be considered as competent site and need to be rejected from the list of potential sites

The following table indicating practical example from SNNPR experience that held selection and prioritization of potential sites in Yeki woroda

Out of the identified and listed potential sites (see table) from secondary sources further screening was made with wereda administration and technical staff to come up with most potential site for prioritization. Accordingly, during consultation meeting with stakeholders including technical staff of relevant offices, the flowing three project were selected for further analysis and prioritization.

Table 8-3: Selected Potential Sites for Small Scale Irrigation Project

Sr.No	Name of River	Kebele	Estimated River Discharge (l/s)	Estimated Command Area (ha)	Geographic Coordinate of Headwork Site		
					Longitude/ East (UTM)	Latitude/North (UTM)	Altitude (masl)
1	Bubi River	Alemo	150		794,724.00	800,165.00	1,305.00
2	Kashi/Barneta River	Komi	200		785,162.00	800,097.00	1,197.00
3	Achani River	Gobito	1700		763,445.00	800,303.00	1,310.00

Detail descriptions of three identified potential sites recommended for small scale irrigation development should be preared and presented in the Site identification and prioritization report. The assessment and response should cover the issues selected or proposed for site identification and prioritization discussed in section 6-1 to 6-8 and in table 8-3.

Based on the findings of the potential site multi-sectoral preliminary investigation and assessment the results are analyzed and compiled in Table 8-4 as follows:

Table 8-4: Example for Weighted Factor System Evaluation & Ranking sites

S.N	Evaluation Criteria	Score assigned for each criteria	Point given for small-scale irrigation potential site		
			Bubi	Kashi	Achani
I	**Water Resources**				
1	Seasonality of stream flow	15	15	15	15
2	Catchment morphology for better yield	20	16	20	20
3	Base flow discharge	30	22	30	30
4	sediment load in the flow	15	15	10	10
5	Water Quality	20	20	20	20
	Total	**100**	**88**	**95**	**95**
	Sector weighted value (0-1)	0.2	**17.6** (0.2*88=17.6)	**19** (0.2*95=19)	**19** (0.2*95=19)
II	**Engineering criteria**				
1	Suitability of headwork site for more low-cost structure (width and shape of the river)	20	18	14	14
2	Average Riverbed level with respect to maximum level within command area	10	9	5	5
3	Double side intake arrangement	20	12	12	12
4	Current accessibility to headwork site and Requirement of crossing on the main River	15	8	9	7
5	Suitability for surface irrigation	15	12	9	9

S.N	Evaluation Criteria	Score assigned for each criteria	Point given for small-scale irrigation potential site		
			Bubi	Kashi	Achani
6	Structure requirements of main canal	10	7	8	7
7	Simplicity of water abstraction technology	10	10	7	7
	Total	**100**	**76**	**64**	**61**
	Sector weighted value	0.2	**15.2**	**12.8**	**12.2**
III	**Geological Criteria**				
1	Foundation condition at headwork site	**20**	**17**	**16**	**16**
2	River banks stability	**20**	**16**	**18**	**18**
3	Availability of construction material around project site	**20**	**18**	**14**	**15**
4	Soil stability along main canal route	**20**	**14**	**13**	**13**
5	Fault zone around the headwork site	**20**	**15**	**16**	**16**
	Total	**100**	**80**	**77**	**78**
	Sector weighted value	**0.05**	4	3.85	3.9
IV	**Land & Soil Suitability criteria**				
1	Suitability of topographic feature of the command area	20	18	12	10
2	Vulnerability of the command area to soil erosion	10	8	8	8
3	Appropriateness of soil depth & fertility	20	20	20	20
4	Soil drainage condition	10	10	7	7
5	Extent of Rock outcrop condition	10	7	8	8
6	soil texture suitability for crop production	20	20	20	20
7	Command area size	10	7	8	5
	Sub **Total**	**100**	**90**	**83**	**78**
	Sector weighted value	0.15	**13.5**	**12.45**	**11.7**
V	**Irrigation Agronomy criteria**				
1	Agro-climate suitability for HVC	20	18	18	18
2	Crop yield performance (Low yield high score)	10	9	8	8
3	Adequacy of length of dry season growing period for irrigated agriculture	20	18	18	18
4	Existence of traditional and or modern irrigation schemes	20	16	0	0
5	Existence of potential irrigable crops in cropping pattern	10	10	5	5
6	Experience in improved farming practices	10	10	6	6
7	Unavailability of sever and frequent pest infestation	10	10	5	5
	Total	**100**	**91**	60	**60**
	Sector weighted value	0.1	**9.1**	**6**	**6**
VI	**Socioeconomics criteria**				
1	Settlement Pattern	10	10	5	5
2	Number of estimated beneficiaries (# of Users)	10	10	5	5
3	Labor Availability for construction & implementation	5	5	5	5
4	Existing livestock population	5	5	3	3
5	Accessibility & Availability of Social and Public	15	15	5	5

S.N	Evaluation Criteria	Score assigned for each criteria	Point given for small-scale irrigation potential site		
			Bubi	Kashi	Achani
	Infrastructures				
6	Extent of socio-economic Impacts & adversely affected communities	10	5	7	7
7	Possibility of social conflicts	10	5	10	10
8	Kebele development Priority	5	5	0	0
10	Market Location comparative advantages and the extents of its Viability	15	10	10	10
9	Attitudes and community willingness for participation and implementation & cost sharing	15	15	10	10
	Total	100	**85**	**60**	**60**
-	**Sector weighted value**	**0.15**	**12.75**	**9**	**9**
VII	**Watershed criteria**				
1	Watershed area coverage	**30**	20	30	30
2	Vulnerability to natural resource degradation	**25**	25	15	15
3	Community experience in watershed conservation	**25**	20	15	15
5	Existing water use u/s and d/s of the headwork Level of water use and demand of the catchment	**20**	15	18	18
-	Total	**100**	**80**	**78**	**78**
-	**Sector weighted value**	**0.05**	**4**	**3.9**	**3.9**
VIII	**Environmental & social Impact criteria**				
1	Potential Impacts on cultural heritage area, national park, reserved forest areas, historical places	20	20	20	20
2	Extent of potential impacts on water quality	20	20	20	20
3	Exposure of the project area to environmental hazards like frequent hazardous flooding	10	7	8	8
4	Possibility for water use conflicts between up and down stream users	10	10	10	10
5	Susceptibility of the command area to land degradation, and water pollution,	10	7	8	8
6	Capacity of the catchment to protect the irrigation scheme, to ensure sustainability of the water flow and project	20	18	18	18
7	Occurrence and visible land degradation features like gully intensity, rock outcrop, deforestation	10	8	5	5
	Total	**100**	90	89	89
	Sector weighted value	**0.1**	**9**	**8.9**	**8.9**
	Grand Total (all sectors weighted values)		85.15	75.9	74.6
	Ranking		**1**	**3**	**5**

9 BENEFICIARY AND STAKEHOLDERS ENDORSMENT

9.1 PRESENTATION, DISCUSSION AND ENDORSEMENT

The endorsement of site identification and prioritization study findings and recommendation are taken as an important part for the beneficiaries and stakeholders. After finalizing the selection and prioritization process, the study team will present the overall process and results at grassroots level where convenient for beneficiaries and stakeholders.

Objectives: Familiarize the site identification and prioritization process and presenting the findings and recommendations. Perceive the reflection of the farmers on the outputs of the site identification and prioritization for final recommendations

Participants: beneficiaries of the project; kebele administration, kebele development committee, development agents, cooperative expert, marketing agency, CBOs ,

Method of presentation: at grassroots level the site identification and prioritization process and results will be presented in two ways:

Presentation: the study team (core sector) should present the findings in power point/chart/oral to participants in local language or with the help of translator. It's suggested to have pictorial illustration to give a clear picture about the potential sites.

Content of the presentation:

- Major selection criteria considered
- Water and land resource aspects
- Alternative headwork sites comparative descriptions (refer selection factors for headwork site identification; environmental and social effects)
- main canal alignment and deliver pool (if any): (appropriateness to reach maximum commanding area; geological features and sustainability; social concern; environmental impacts)
- Preliminary crop selection and cropping pattern
- Socioeconomic aspects
- environmental aspects

Field verification: site visit need to be carried out to check the findings on the ground and for clarity. The site observation will be jointly undertaken starting from headwork site to water distribution structures and command area boundary.

Issues required for consensus: there could be some critical issues require to reach consensus, if it's the case, the study team should list them in and document for reference

Endorsement Minutes for confirmation

Minutes should be signed by all participants and attached in site identification and prioritization report

Recognition of prioritization results: If the endorsement process (section 10) supports the results of the recommendation or results of the prioritization analysis indicated in section 9, then the team will recommend the potential irrigation site according to their ranking. The first ranked site will have a priority for investment and the followings will be recommend to consider in other investment schedule

The endorsement of beneficiaries and stakeholder might impose to change the results of the prioritization analysis results, if so the study team has accept the conclusive recommendation given by beneficiary and stakeholders and revise accordingly.

9.2 APPROVAL AND INSTRUCTION TO PROCEED TO FS & DD

The results and recommendations from section 9 analysis, the combined weighted scores with the rank of three sites in their order with respect to site selection criteria has to be also discussed with the main implementing stakeholder and get approval.

The study can continue the feasibility and detail design for selected small-scale irrigation project. The approval and instruction to continue should be notified by official letter to the consultant and/or own-force team to undertake the assignment.

APPENDICES

APPENDIX I: Site Identification and Prioritization Work plan and Schedule

S.N	Work Activities	Schedule in weeks					
		0	1	2	3	4	5
1	**Organizing the study team**						
2	**Irrigation potential assessment and Preparation of working maps**						
3	**Introduction and woreda stakeholders consultation**						
4	**Identification of potential sites for screening**						
5	**Preliminary site observation and community consultation for screening**						
6	**Screening three sites for further evaluation**						
7	**Watershed assessment**						
7-1	**Detail Pre-field work activities**						
	Watershed delineation						
	Watershed parameters analysis						
	Preparation of checklists, questionnaires, data collection formats						
7-2	**Detail Field work activities**						
	Watershed delineation (optional)						
	Field observation and assessment						
	Community and technical staff consultation						
7-3	**Post –filed work activities**						
	Summarize and scoring selection criteria						
	Provide scoring results to team leader						
8	**Hydrology and climate study**						
8-1	**Pre-field work activities**						
	Preparation of hydrology base maps						
	Identify representative climate data source						
8-2	**Field work activities**						
	Water resource assessment						
	Field observation and assessment						
	Stream flow analysis						
	Preliminary Data collection						
8-3	**Post –field work activities**						
	Hydrology data compiling and interpretation						
	Scoring of sector selection criteria						
	Involve in weighted evaluation						
9	**Engineering sector**						
9-1	**Pre-field work activities**						
	Potential irrigation site identification						
	Preparation of base maps for potential sites						
9-2	**Field work activities**						
	Ground verification of the identified irrigation sites from secondary sources						
	Alternative headwork site identification and characterization						
	Fix the command area boundary						
	Set preliminary layout						
	Community and stakeholder consultation						
	Field observation and assessment						
9-3	**Post –field work activities**						
	Data compiling and interpretation						
	Scoring of sector selection criteria						
	Involve in weighted irrigation site evaluation						
	Prepare thematic map for potential sites						
10	**Geology sector**						

S.N	Work Activities	Schedule in weeks					
		0	1	2	3	4	5
10-1	**Pre-field work activities**						
	Review previous studies						
	Preparation of regional geological maps for potential sites						
10-2	**Field work activities**						
	Headwork sites geological observation						
	Identify potential construction materials site						
10-3	**Post –field work activities**						
	Data compiling and interpretation						
	Scoring of sector selection criteria						
	Involve in weighted irrigation site evaluation						
11	**Topography sector**						
11-2	**Field work activities**						
	Cross-sectional survey						
11-3	**Post –field work activities**						
	Data compiling and interpretation						
	Scoring of sector selection criteria						
	Involve in weighted irrigation site evaluation						
12	**Soils and land suitability study sector**						
12-1	**Pre-field work activities**						
	Review previous studies						
	Soil survey planning and base maps preparation						
	Preparation of field data description sheets for auger and profile pits.						
12-2	**Field work activities**						
	Updating the prepared soil base maps						
	Auger observation and profile description						
	pH and EC measuring						
12-3	**Post –field work activities**						
	Data compiling, auger and pit profile description						
	Land suitability mapping for indicative crops						
	Scoring of sector selection criteria						
	Involve in weighted irrigation site evaluation						
13	**Irrigation agronomy sector study**						
13-1	**Pre-field work activities**						
	Review previous studies						
	Preparation of checklists , questionnaires, data collection formats						
13-2	**Detail Field work activities**						
	Secondary agronomic data collection						
	Stakeholders and community consultation						
	Site observation						
13-3	**Post –field work activities**						
	Estimating water demand						
	Data compiling and site characterization						
	Scoring of agronomic selection criteria						
	Involve in weighted irrigation site evaluation						
14	**Socio-economy sector study**						
14-1	**Pre-field work activities**						
	Review previous studies						
	Preparation of checklists , questionnaires, data collection formats						
14-2	**Detail Field work activities**						
	Secondary socio-economic data collection						
	Stakeholder and community consultation						
	Site observation						
14-3	**Post –field work activities**						

S.N	Work Activities	Schedule in weeks					
		0	1	2	3	4	5
	Data compiling and site characterization						
	Scoring of socio-economy sector selection criteria						
	Involve in weighted irrigation site evaluation						
15	**Environmental and Social Impact assessment**						
15-1	**Pre-field work activities**						
	Review previous studies						
	Preparation of checklists and data collection formats						
15-2	**Detail Field work activities**						
	Environmentally sensitive site visit						
	Secondary ESIA data collection						
	Stakeholder and community consultation						
	Project area site observation						
15-3	**Post –field work activities**						
	Data compiling and site characterization						
	Project scoping						
	Scoring of ESIA selection criteria						
	Involve in weighted irrigation site evaluation						
16	**Prioritization of potential site**						
17	**Endorsement stakeholders meeting**						
18	**Recommendation of appropriate site**						
19	**Final recommendation for Feasibility study**						

APPENDIX II: Feasibility Study & Detail Design Work Schedule

S.N	Work Activities'	Schedule in weeks														
		6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	**Topo Survey**															
1.1	Detail Pre-field work activities															
	Survey team organization															
	Preparation of base maps															
1.2	**Detail Field work activities**															
	Benchmark Establishment															
	Assessment of existing infrastructures															
	Cross sections and detail survey works															
	Command area survey															
	On-site data reconciliation															
1.3	**Detailed post field work activities**															
	Data compilation and analysis															
	Contour generation & mapping															
	Report preparation															
2	**Hydrology**															
2.1	**Detail Pre-field work activities**															
	Preparation of base maps															
	Identification of Meteorological stations around projects & purchase of data															
2.2	**Detail Field work activities**															
	Measurement of base flow															
	Study of catchment area															
	Study of drainage network & flood condition															
	Study of sediment condition															
2.3	**Detailed post field work activities**															
	Data compilation and analysis															
	Fix lean flow/base flow for the river supposed to deliver irrigation water															
	Fix design discharge of different return period for the project															
	Fix drainage module for the command area															
	Report preparation															
3	**Geology & geotechnical works**															
3.1	**Detail Pre-field work activities**															
	Preparation of geologic base maps															
3.2	**Detail Field work activities**															
	Site investigation at headwork site															
	Site investigation at crossings & along MC route															
3.3	**Detailed post field work activities**															
	Data compilation and analysis															
	Laboratory test result interpretation															
	Report preparation															
4	**Soil & survey & land suitability**															
4.1	**Detail Pre-field work activities**															
	Necessary field equipment, material and other logistics will be arranged and fulfilled,															
	All available documents, maps and															

S.N	Work Activities'	Schedule in weeks														
		6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	other pertinent data sources of previous studies concerning the sites will be collected and thoroughly reviewed.															
	Boundary delineation of the study area, organization of database, preparation of field soil survey guidelines.															
	Prepare and duplication of field data description sheets for auger, profile pits, infiltration and hydraulic conductivity.															
	Systematic field soil survey planning and base map preparation															
	Work plan and preliminary soil mapping units will be prepared for the subsequent ground field survey work.															
4.2	**Detail Field work activities**															
	Arranging parallel transects and auger observations excavation along each transect.															
	Mapping based on identified distinct units															
	Presence of lime will be estimated qualitatively using dilute HCl															
	Collection of soil samples															
	Measure infiltration rate and hydraulic conductivity using double ring infiltrometer and inverse auger hole methods respectively; in triplicate at representative sites (one per mapping units) as soil condition permit															
4.3	**Detailed post field work activities**															
	Laboratory analysis															
	Laboratory and filed data encoding into computer database (Microsoft Access and MS Excel)															
	Data compilation and analysis															
	Identify and describe each mapping units															
	Produce soil maps at scale of 1:1,000, using Arc GIS 10.1 software															
	Produce suitability maps at scale of 1:1,000, using Arc GIS 10.1 software															
	Produce standard soil and land suitability report with all necessary end tables, appendices, figures and plates.															
5	**Headwork & Irrigation planning & design**															
5.1	**Detail Pre-field work activities**															
	Preparation of base maps															
	Preparation of study schedule and Mobilization of study team															
5.2	**Detail Field work activities**															
	Fix headwork site from the proposed															

S.N	Work Activities'	Schedule in weeks														
		6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	options															
	Identify intake structure arrangement & types															
	Assess main canal routes & identify crossing structure & types requirement															
	Assess scope of drainage & flood protection requirement															
	Assess backwater effect & protection requirement															
5.3	**Detailed post field work activities**															
	Data compilation and analysis															
	Headwork design															
	Headwork drawings & BOQ															
	Infrastructure layout system design															
	Canal cross section & profiles design															
	Canal structures design															
	Design drainage & flood protection system															
	Drawings of on-farm structures & BOQ															
	Report preparation															
6	**Socioeconomic and O&M works**															
	Detail Pre-field work activities															
	Review of Documents															
	preparation of checklists , questionnaires, data collection formats for socio economy and O&M studies															
	duplication and compilation of data collection formats															
	Detail Field work activities															
	selection and Training of enumerators															
	experience sharing with assigned regional socio economist staff															
	Conduct HH survey and field data and information including consultation															
	conduct community consultation, focus group discussion and key informant interview															
	collection of data and information from kebeleand woreda level offices															
	collection and organizing consultative minutes of meetings															
	Detailed post field work activities															
	Data compilation , entry and analysis															
	Report preparation															
7	**Irrigation Agronomy works**															
	Detail Pre-field work activities															
	Review of Documents															
	preparation of checklists , questionnaires, data collection formats															
	Detail Field work activities															
	experience sharing with assigned regional Agronomist staff															

S.N	Work Activities'	Schedule in weeks														
		6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	collection of data and information from kebeleand woreda level offices															
	conduct community consultation, focus group discussion and key informant interview															
	Conduct HH survey and field data and information including consultation															
	Detailed post field work activities															
	Data compilation , entry and analysis															
	Report preparation															
8	**Watershed development plan**															
	Detail Pre-field work activities															
	Review of Documents															
	Delineation and mapping															
	preparation of checklists, questionnaires, data collection formats															
	Detail Field work activities															
	collection of data and information from kebeleand woreda level offices															
	experience sharing with assigned watershed staff															
	field observation and assessment															
	Detailed post field work activities															
	Data compilation , entry and analysis															
	Report preparation															
9	**ESIA**															
	Detail Pre-field work activities															
	Reviewing of previous studies and relevant documents															
	Preparation of checklists and questionnaire															
	Make available relevant maps and interpretation															
	Detail Field work activities															
	Conduct field observation in the direct and indirect project impact areas															
	Assess environmentally sensitive areas and valued resources															
	Assess other existing or proposed development projects															
	Identify existing energy sources of the project															
	Assess Ecological Conditions: - Natural habitats, Biodiversity, wildlife, wet lands, if any.															
	Assess National parks, conservation areas, wildlife reserves, Control Hunting Areas and any protected area nearby the project if any.															
	Assess Land use land cover, land use patterns.															
	Assess Watershed condition of the area: - land degradation, soil erosion, deforestation etc.															
	Assessment of flora and fauna.															

S.N	Work Activities'	Schedule in weeks														
		6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	Assess Endemic species of flora and fauna.															
	Assess Aesthetic values and tourist attraction sites.															
	Assess Settlement pattern.															
	Conduct community consultation with representatives of different segments of society in selected kebeles.															
	Holding discussion with experts working in relevant organizations at Zonal, Woreda and Kebele levels on relevant issues.															
	Collect water samples for water quality compatibility identification.															
	Assess Environmental Health issues, malaria prevalence															
	Assess Gender Issues:-assess how the project intervention will affect men and women, the potential risks for spreading of HIV and sexually transmitted diseases due to the large influx of workers.															
	Detailed post field work activities															
	Summarize pertinent legal, policy and standards governing environmental issues.															
	Predict the positive potential impacts that will improve the lives of the people in the study area.															
	Predict any significant negative impacts associated with the pre-construction, construction and operation phase of the proposed project.															
	Identify possible cumulative impacts of other existing or proposed development projects in the study area, if any.															
	Identifying institutional responsibilities and needs for capacity building to implement recommendations of EIA.															
	Analysis of alternatives including the no-action alternative															
	Data compilation and analysis															
	Make visualize information on maps of suitable scale															
	Recommend feasible and cost-effective mitigation measures to prevent, reduce or compensate significant negative impacts to acceptable levels.															
	Develop detailed environmental management plan.															
	Develop comprehensive and detailed environmental monitoring plan.															
	Preparation of draft final environmental impact assessment															

S.N	Work Activities'	Schedule in weeks														
		6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	report with its full content.															
10	Financial and economic analysis															
	Detail Pre-field work activities															
	preparation of data collection formats															
	preparation of data analysis formats															
	Detail Field work activities															
	collection of data and information															
	Detailed post field work activities															
	data entry and analysis															
	Report preparation															
11	Detail engineering design & preparation of working drawings															
12	Specifications and tender document preparation															
13	Preparation of operation and Maintenance manual & M															

APPENDIX III: Delineation and assessment of watershed basic features

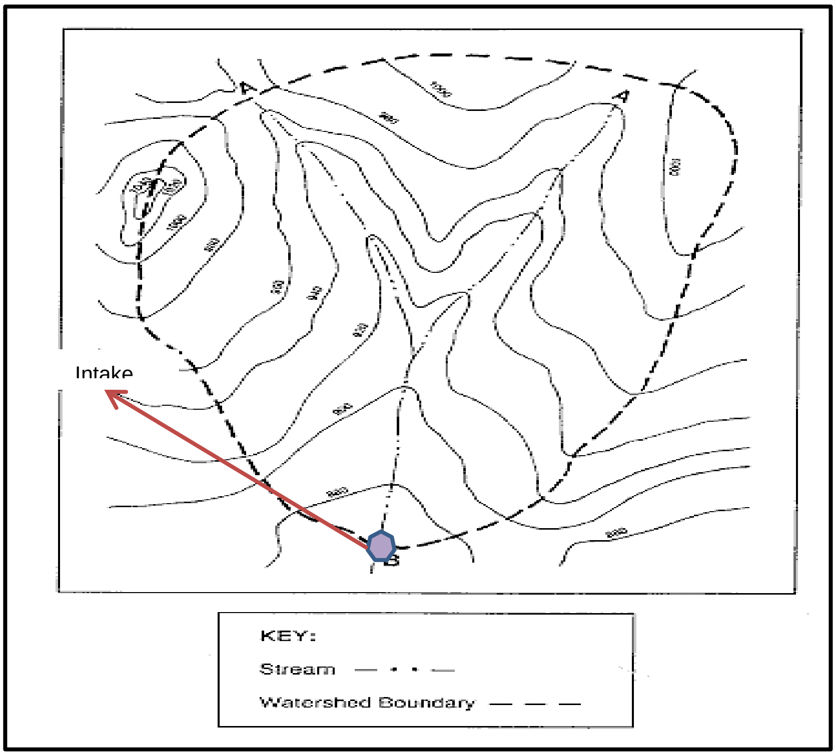
1. Watershed delineation using topographic maps

Basic steps for delineation:

- Choose the outlet or final downstream point of the river, stream, or wetland in which you are focusing the plan.
- Make sure you consider the total drainage area of the receiving water body and take into account
- From your outlet, identify high points along the watercourse which will create your boundary ridge.
- Connect the high points, beginning and ending with the outlet to form a closed polygon.

When connecting these high points, the contour lines should be crossed at right angles. Once you have delineated your watershed you need to check and refine its boundaries. You may be able to use an automated watershed delineation GIS tool that is based on digital elevation models/terrain models. While automated delineation tools may be a good starting point for determining watershed boundaries, the resolution may be too coarse to accurately delineate many sub watersheds. (See example in figure below)

After delineation or having the watershed map from secondary source, the expert should verify boundaries through field inspections to resolve any mistakes or discrepancies in the watershed boundaries and more accurately depict any questionable areas.



App Fig: 1: Typical watershed boundary

2. Watershed Delineation using DEM & ARCGIS/ARCSWAT software

After setup of a new ARC SWAT project, activate the Automatic Watershed Delineation button under the Watershed Delineator menu by clicking this button. The Watershed Delineation tool will appear. The tool's functions are divided into five sections, namely: DEM setup, Stream Definition, Outlet and Inlet Definition, Watershed Outlet(s) Selection and Definition. This tool is used to create watershed delineations using a combination of DEM, digitized network and other user inputs. The detailed procedures on how to use the Watershed Delineation tool are:

Step 1: Add DEM Grid: Select from Watershed View and Load DEM grid from disk. After loading DEM, the button will be activated. Using this button, the user can check the projection information of the DEM the DEM properties should correctly define the grid size and units. The user can change the Z unit to reflect the real situation

Step 2: Focusing on Watershed Area
The interface allows users to import or create a grid map that masks out a part of the DEM grid and/or a shape map that defines the stream network.

- Click beside Mask, then three options are available to specify the watershed area of interest :
- Select the Load mask grid from disk option and click OK.

Step 3: Burning in a stream network

Step 4: Stream Definition

- There are two ways to define the watershed and stream network:, the method based threshold area and another method based on pre-defined watershed
- In order to use the threshold method to delineate the watershed and stream network, the flow direction and accumulation needs to be calculated by clicking the button. Stream definition defines both the stream network and sub basin outlets.
- A minimum, maximum, and suggested sub watershed area (in hectares) is shown in the drainage area box .You have the option of changing the size of the sub basins within the specified range of values.
- After setting the threshold value of sub basin, then the user can delineate the stream network and outlets through clicking the button.
- The drainage network and stream juncture points, used to define sub basin outlets, are displayed on the DEM map

Next step is Outlet and Inlet Definition. Before proceeding, you have a number of options:

- change the threshold area and rerun the stream and outlet definition routine,
- add outlet points by importing a table that contains the locations,
- add outlet points manually, and
- Remove outlet points. Assuming the outlet and stream definition to be acceptable proceed to inlet definition for the study area.

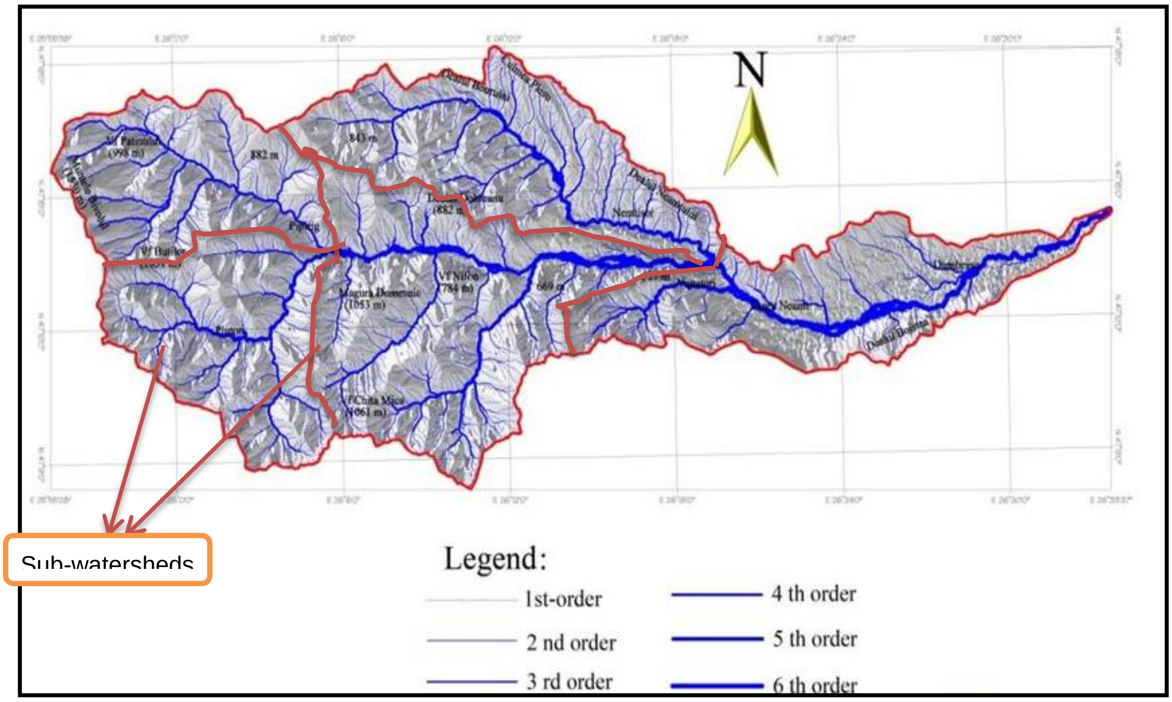
Inlets represent any point source loading into the study area or the inlets of drainage into the watershed from an upstream area.

Step 5: Main Watershed Outlet(s) Selection and Definition
In this step the users will select one or more outlet locations to define the boundary of the main watershed.

- Click on the select button to choose the watershed outlet. Draw a box covering the desired outlet locations will set the main Watershed Outlets. Select 1 outlet at the downstream edge of the masked area and click the Delineate Watershed button . Select YES in the following dialog to continue with the delineation of main watershed and sub basins. A prompt box will appear to announce completion of the watershed and sub basin delineation.
- The delineated watershed with sub basins will be added to the View. If the delineation is not satisfactory or if the user wants to select a different outlet for the watershed, click on the Cancel Selection button and repeat.
- Click on the Calculate sub basin parameters button to estimate the sub basin parameters. This function calculates basic watershed characteristics from the DEM and sub-watershed themes. It also assigns the necessary sub basin identification.
- The results of the calculations are stored as additional fields in the streams and sub basins theme database files. Click OK to completion of watershed delineation dialog box.
- Open the Reach or Watershed attribute tables to view the calculated characteristics

Step6: Exit the Watershed Delineation Dialog, Click EXIT in the watershed delineation main dialog

Step 7: View Topographic Report



App Fig: 2: Stream order and sub-watersheds of a given intake point

3. Assessment of basic features of watershed

Purpose: physiographic features of a watershed influence the hydrology regime which influences the catchment function or potential. Accordingly the description of the main hydrologic parameters will be used for site selection and prioritization in which it indicates the capacity of the catchment in generating adequate water supply.

Parameters to be assessed: watershed shape, watercourse slope, size of watershed, drainage density, and erodibility

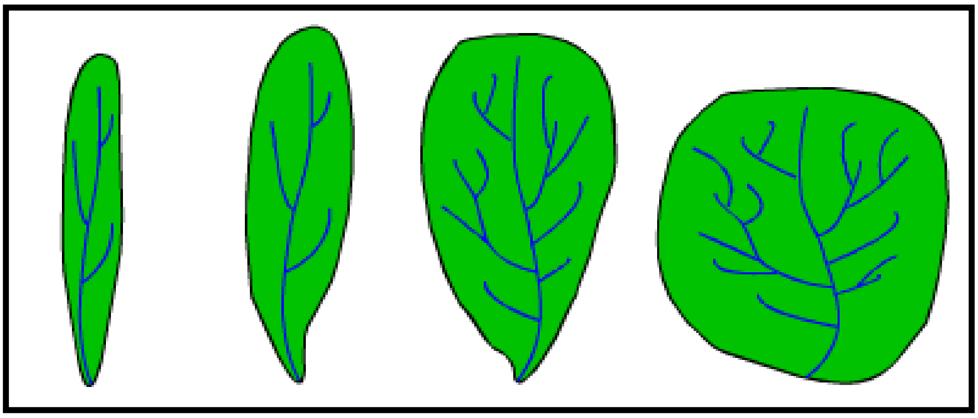
Size of watershed

Area of the watershed which can be estimated as ARC GIS software output or by grid estimation on topographic map of 1:50,000 scale (drainage area of the watershed can be estimated by counting grids on Topo map where 1 grid equals 100 ha). The volume of water available for runoff may be assumed as product of rainfall depth and drainage area. The watershed with wider drainage area could have larger volume of water taking the rainfall depth remain constant

Shape of the watershed

It is analyzed by form factor (Ff) may be defined as the ratio of basin area to square of the basin length. Smaller the value of “form factor” more elongated will be the watershed. The watershed with high form factors have high peak flows of shorter duration, whereas elongated watershed with low form factor ranges from 0.42 indicating then to be elongated in shape and flow for longer duration (Ranbabu Palaka, 2016)

For example, a long shape watershed generates, for the same rainfall, a lower outlet flow, as the concentration time is higher. A watershed having a fan-shape presents a lower concentration time, and it generates higher flow.



App Fig: 3: Different shapes of the watershed

Water course slope

Watershed slope reflects the rate of change in elevation with respect to distance along the principal flow path

$S = \frac{\Delta E}{L}$ $S = \frac{\Delta E}{L}$ ………………………………………………………………………………… [1]

S = watershed slope

∆ E = difference in elevation between end points of principal flow path

L = length of the principal flow path

Drainage density

Drainage density (Ratio of total length of all stream of all order within a watershed to the total area of watershed) the watershed with a high value of drainage density indicates a relatively high density of stream and thus rapid stream response.

Susceptibility to erosion of the catchment

The relative erodibility factor of the catchment gives a highlight on the potential of soil erosion appearance in the absence of conservation interventions. The erodibility indicator values will help the experts to characterize the watershed in terms of soil erosion exposure and to be used to make comparative analysis with other potential watersheds. The susceptibility to erosion of the catchment as a whole may be obtained from the weighted mean.

App Table 1: Erodibility factor based on land cover

Land cover	Description	Relative erodibility
Natural vegetation	Cover > 80%, forest, savanna, permanent pasture	0.001 – 0.05
Degraded forest	Savannah woodland, rough grazing, perennial crops	0.05 – 0.50
Cropland	Annual crops, scarp woodland	0.5 – 0.80
Bare soil	Cultivated land 0% cover, grazing land	0.80 – 1.00

Source: W.P Field; F.W. Collier, HR Wallingford ICID checklist for small-scale irrigation project, 1998

App Table 2: Summary of watershed study findings for three sites

S/N	Description	Site 1 watershed	Site 2 watershed	Site 3 watershed
1	Watershed Shape			
2	Watershed Size			
3	Drainage density			
4	Slope			
5	Erodibility			
6	Conservation measure coverage (%)			

APPENDIX IV: Description and assessment methods for land and soil suitability assessments

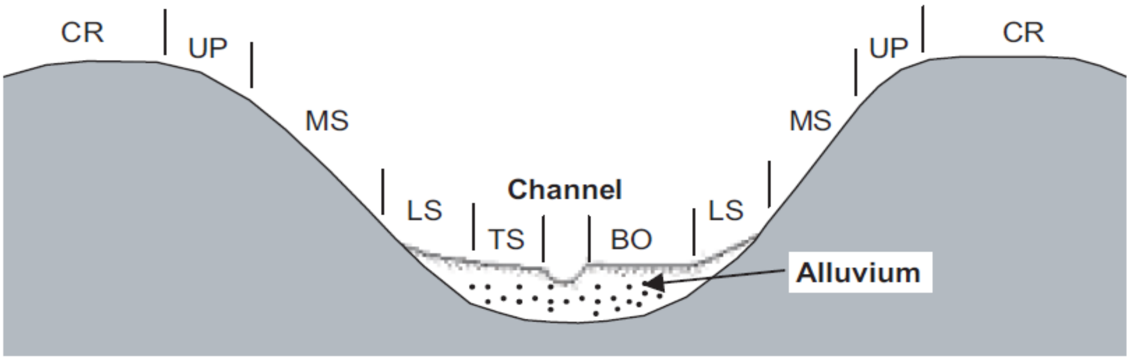
1. Description of land form and topography

Land topography is often a major factor in irrigation evaluation and selection of the most suitable areas for irrigation. It is therefore important to record following typographic features at each auger hole and profile description sites.

Major Land form: The land form is the shape of the land surface and should be classified as Level lands **(**like Plain, plateau, depression, and valley); and sloping and steep lands (like hills, mountains).

Slope Gradient (%): The slope gradient refers to the slope of the land immediately surrounding the auger profile site. It is measured using a clinometers or can be generated from digital elevation model (DEM) of high resolution.

Physiographic Position: position in the landscape is important as it affects the hydrological conditions of the site (external and internal drainage, surface runoff). It is particularly essential in the case of low lying areas (alluvial flood plain, swamp, lake shores and riparian areas) possible need for flood protection or drainage. Therefore, the relative position of the site within the land should be indicated during field soil survey. Figure App Fig 4 below indicates the relative position of slope in a land escape.



App Fig: 4: Slope positions in undulating and mountainous terrain

Position in undulating to mountainous terrain
CR = Crest (summit), UP = Upper slope (shoulder) ,MS = Middle slope (back slope)
LS = Lower slope (foot slope), TS = Toe slope, BO = Bottom (flat)
Source: FAO,2006

Depth of water table

The depth to the ground water might be determined by pit profiling and consulting with knowledgeable person around the command area. Moreover if there is shallow wells around the command area or at reasonable distance then that could indicate the depth of the ground water

Flood hazard

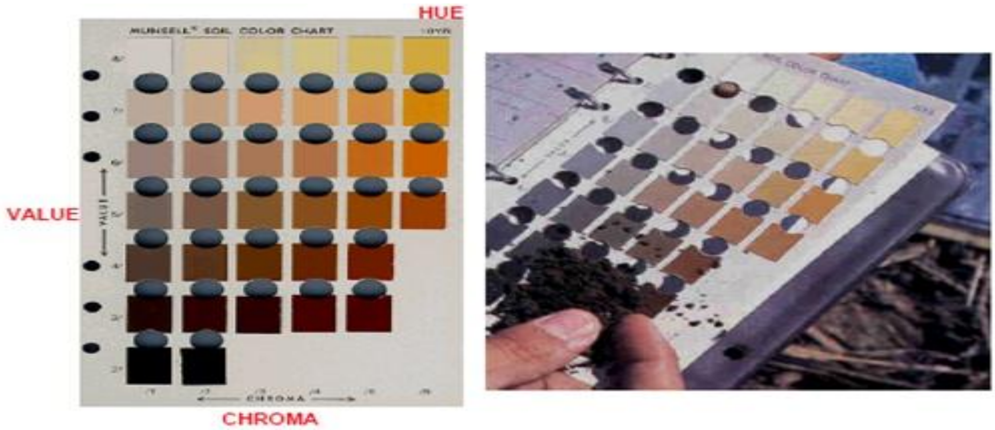
Floods are important events when describing a site. Visual analysis and local knowledge should be used for describing the frequency of floods. Flooding, depth of water and period of inundation (how many days the water stays on the soil surface)

Major soil physical properties

This observation survey is conducted to provide preliminary information of the major soil properties, such as colour, texture, depth of soil, drainage, stoniness, rockiness, evidence of salinity, cracking, land form slope, erosion status, land use and land cover which will help preliminary land evaluation for irrigated agriculture and then support the engineer to delineate the command area .

Colour soils or horizon are indicative of soil characteristics including degree of development, drainage condition, depth of ground water fluctuation, organic matter content and etc. For instance, if the land resource has uniform bright coloration reflects higher degree of soil development, good drainage condition, very deep groundwater table, and low organic matter content. On the contrary dark soil colours indicate lower level of soil development, impeded drainage conditions, and high organic matter content.

The colour is described in standard colour names and notations of the Munsell's soil colour charts by comparing a clod of soil sample taken out by means of survey knife from the layer with the colour chips of the chart



App Fig: 5: Munsell Soil Colour Chart and an example of how to use it

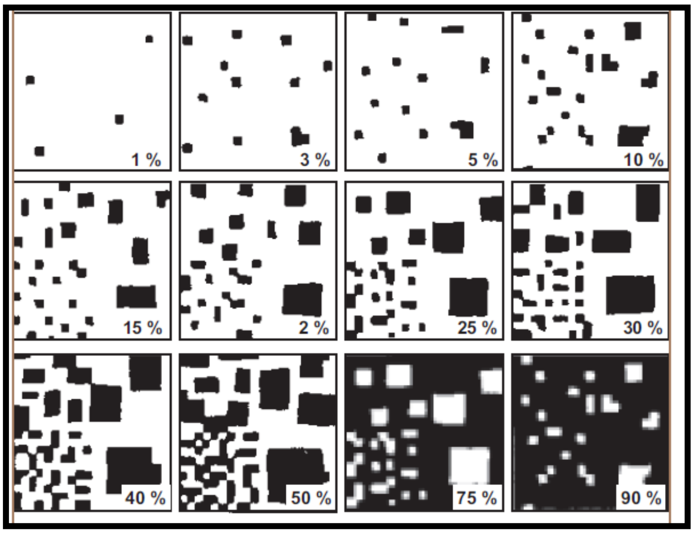
App Table 3: General interpretation of soil colours

Soil Color	Due To The Presence Of:	Comments
Dark or black	Organic matter	Mostly found at soil surfaces. Associated with well-aggregated soils with above-average nutrient levels
Clear or white	Calcium and magnesium carbonates, soluble salts or high proportion of sand (quartz crystals	May indicate considerable leaching and low organic matter.
Red and bright yellowish	Iron is oxidized and not hydrated with water	Under dry conditions or well-drained soils. The iron oxides have strong surface charge properties that promote good aggregation of soil particles with sufficient porous that allow air and water for root development
Yellowish brown/orange	Less oxidation of iron and hydration	Average air and moisture conditions
Mucky soil mass or clay with spots of red, yellow, and grey colours	Ferrous and ferric compounds	In soils that are waterlogged for at least one part of the year, or due to the activity of plant roots living in ponding
Grey/green/bluish-grey	Iron and manganese in reduced state	In waterlogged soils with lack of oxygen with colourless forms due to the loss of pigments.

Sedimentation: it is indicated by presence of laminated layer described in terms of frequency, type (deposited by water or wind) and degree or severity

Stoniness: refers the relative proportion of stones over 2mm in diameter in or on the soil surface. Stoniness should be visually estimated by the coverage and size of stones

Rocky outcrops should be described in terms of percentage surface cover, together with size, spacing and hardness of the individual outcrops. Chart for estimating percent of stoniness, rock outcrop nodules, mottles coverage is shown on figure App Fig 6.



App Fig: 6: Chart for visual estimating proportions stoniness, rock fragments, nodules, &mottles
Source: FAO, 2006

Presence of cracks: linear breakage of soil surface upon drying that point out the swelling and shrinking properties of the soils. These are measured and described in terms of width, depth, abundance

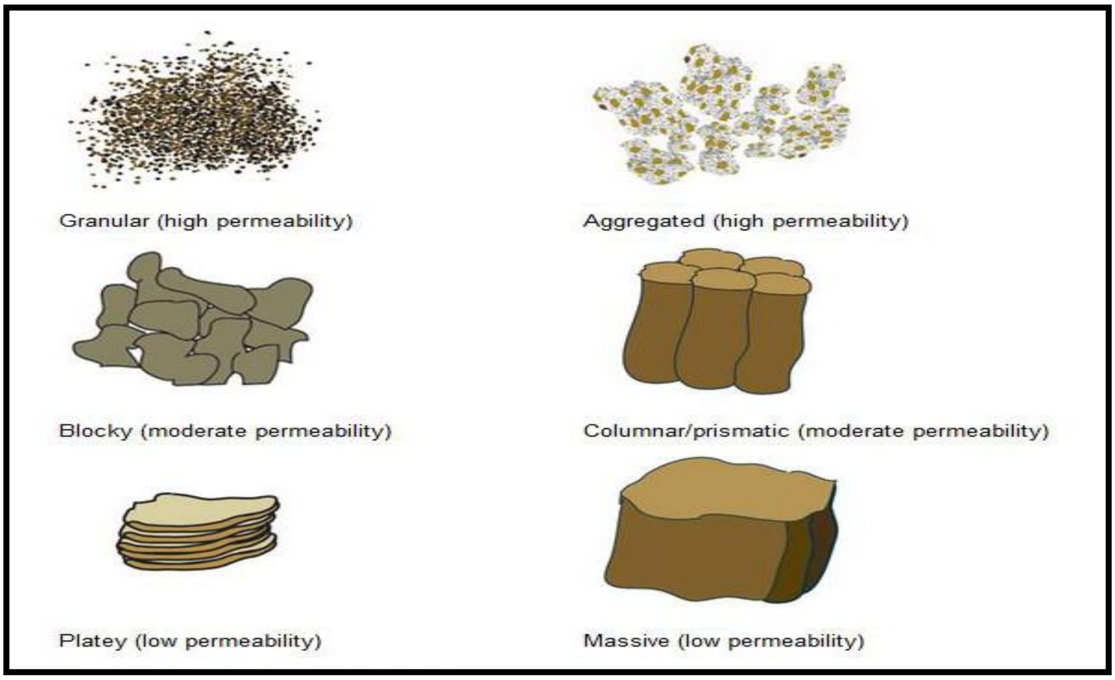
Effective depth: its measured directly from auger hole by means of steel tape and describe in terms of depth class

Texture: its determined by working with a fully wetted soil sample; it is rubbed between the fingers and thumb or by trying to form a ring.

App Table 4: Soil texture description in percentage of soil separates

S/N	Textural name	Range in relative percentage of soil separates		
		Sand	Silt	Clay
1	Sandy soil	85-100	0-15	0-10
2	Loamy sandy	70-90	0-30	0-15
3	Sandy loam	43-80	0-50	0-20
4	Loam	23-52	28-50	7-27
5	Silt loam	0-50	50-88	0-27
6	Silt	0-20	8-10	0-12
7	Sandy clay loam	45-80	0-28	20-35
8	Clay loam	20-45	15-53	27-40
9	Silty clay loam	0-20	40-73	27-40
10	Sandy clay	45-65	0-20	35-45
11	Silt clay	0-20	40-60	40-60
12	Silt	0-45	0-40	40-100

Structure: It can be observed in the field by gently breaking a large moist clod detached from a freshly cut wall of the soil pit. It describes in terms of grade, size and shape (see Fig App fig 7)

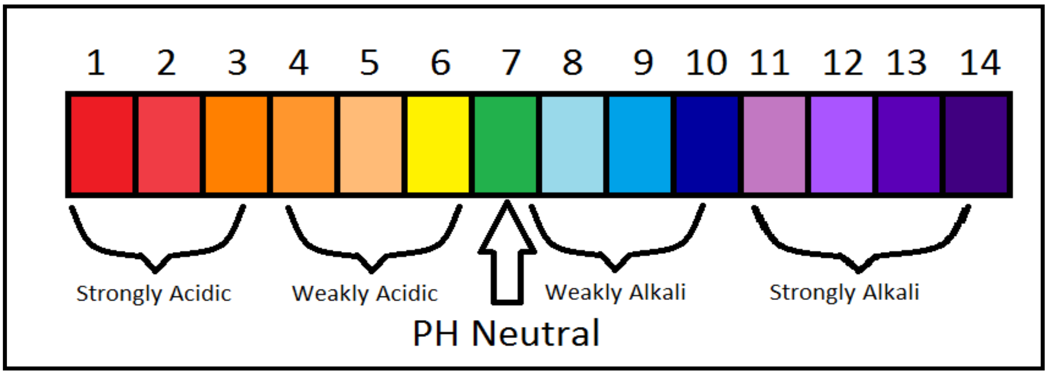


App Fig: 7: Basic type of soil structures

Organic matter content: the content of organic matter can be described from soil colour, structure and consistence. Usually soils with darker colour have higher organic matter, however in some cases, for instance the soil formed in volcanic ash which have black colours may have low organic matter while some soils formed in limestone might have light colours but still with high organic matter.

Salinity: the salinity may be observed in the field from appearance of salts at the soil surface in the form of whitish patches, generally with no or very few stunted plants growing on. The best alternative if there is such indication of salinity is to measure the electrical conductivity with portable EC meter in 1:2.5 or 1:5 soil water suspensions

Soil reaction (pH test): is important chemical soil property and a useful indicator of soil health and other soil properties. Portable pH meter should be used to determine the acidity and alkalinity of soils in each auger to characterize the soils. The pH scale presented in App Fig 8 could help to interpret and qualifying the soil reaction



App Fig: 8: The soil reaction pH scale

APPENDIX V: Procedures to estimate ETo, crop water requirement and irrigation requirements

1. Determine Reference Evapo-transpiration

I. Options to determine Reference ET_o values

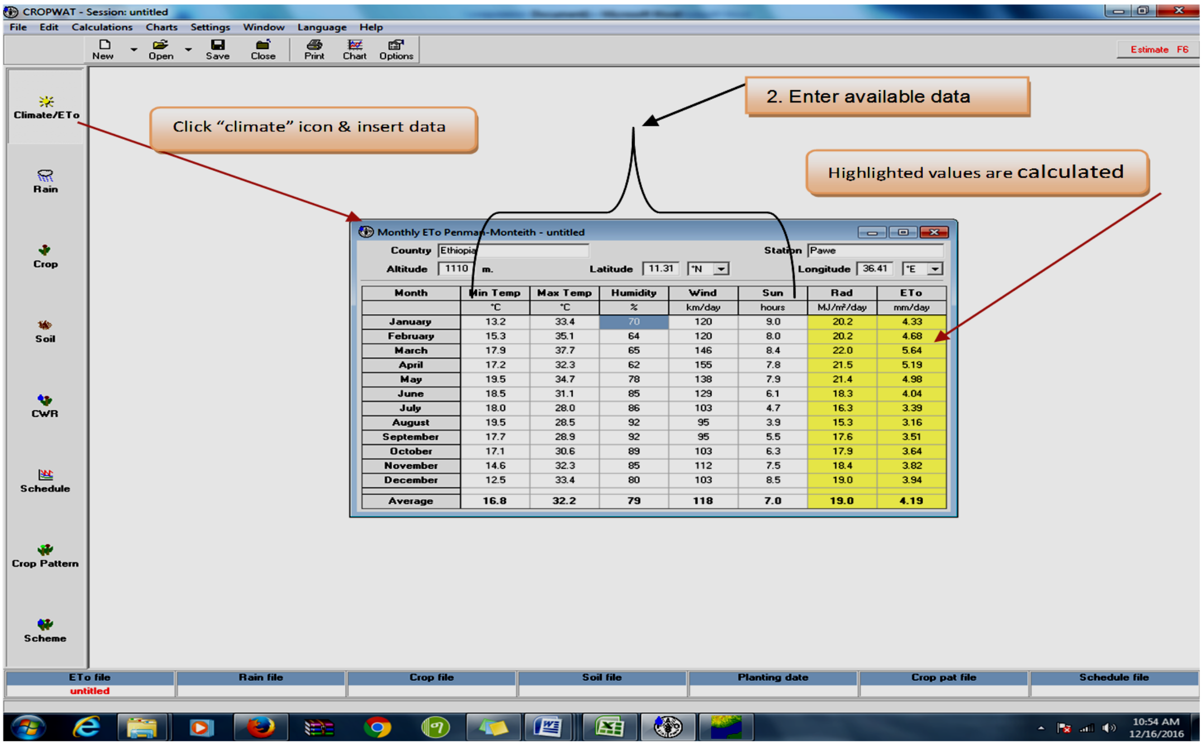
a) The agronomist can obtain the mean monthly ET_o values of the project sites from hydrologist of the study team *if not apply one of the following options*

b) The first option is get the calculated ET_o from national Meteorology station. The stations can provide monthly average Evapo-transpiration and to be used for represented area coverage. Then the data can be used directly to calculate the crop water requirements of each given crop (refer section 7.6.5) by multiplying adjusted crop coefficient

c) If monthly mean climate data are available then the agronomist can calculate the ETo by **CROPWAT 8.0 software**

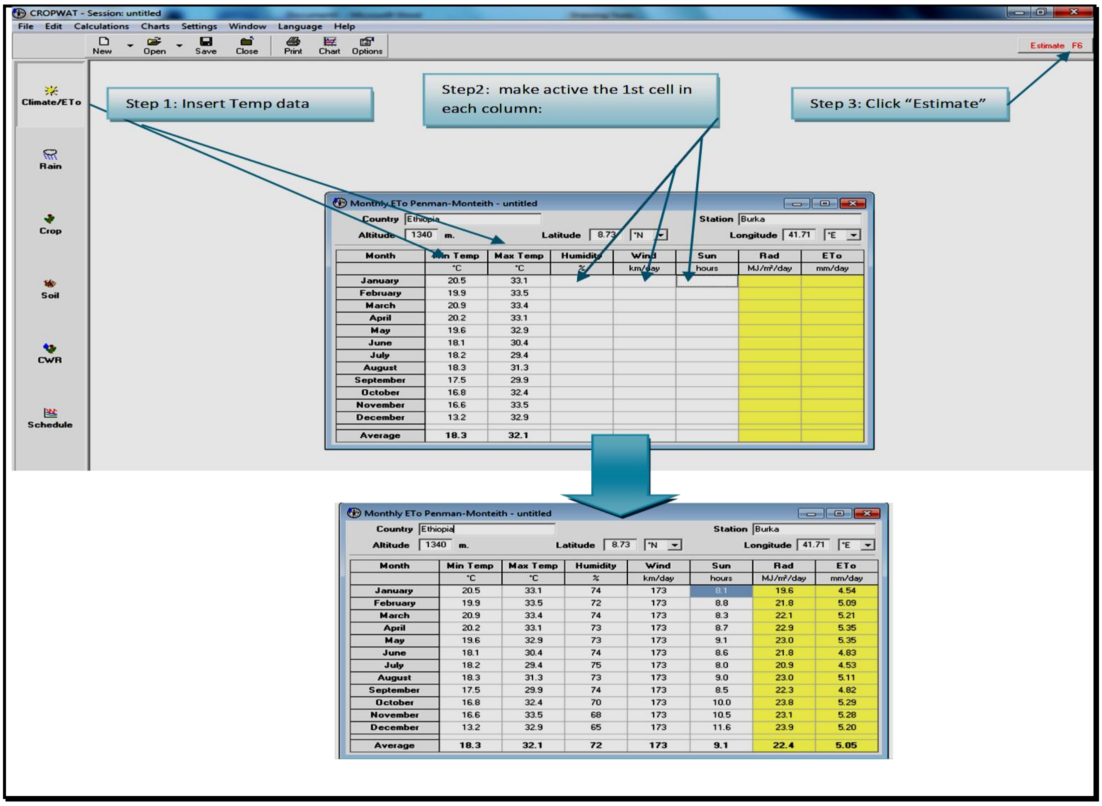
Once the agronomist ensured the availability of climate data then he/she shall arrange and insert the monthly average data in climate module of CROPWAT 8.0 software. The Evapotranspiration can be calculated in two ways based on the availability of climate data. The first option is when all the required climate data are available (Fig App Fig 9) while the second option is when the meteorology centers provide only temperature data (App Fig 10). Some examples are presented below.

Alternative 1: the Evapo-transpiration can be calculated by using all climate data including temperature, humidity, wind speed and sunshine hours as demonstrated in figure below:



App Fig: 9: CROPWAT 8.0 window and climate module for ETo estimation

Alternative 2: If the meteorological station has only temperature data the CROPWAT 8.0 software can estimate other data such as humidity, wind speed, sunshine hours and radiation considering the temperature, geographical location and altitude.

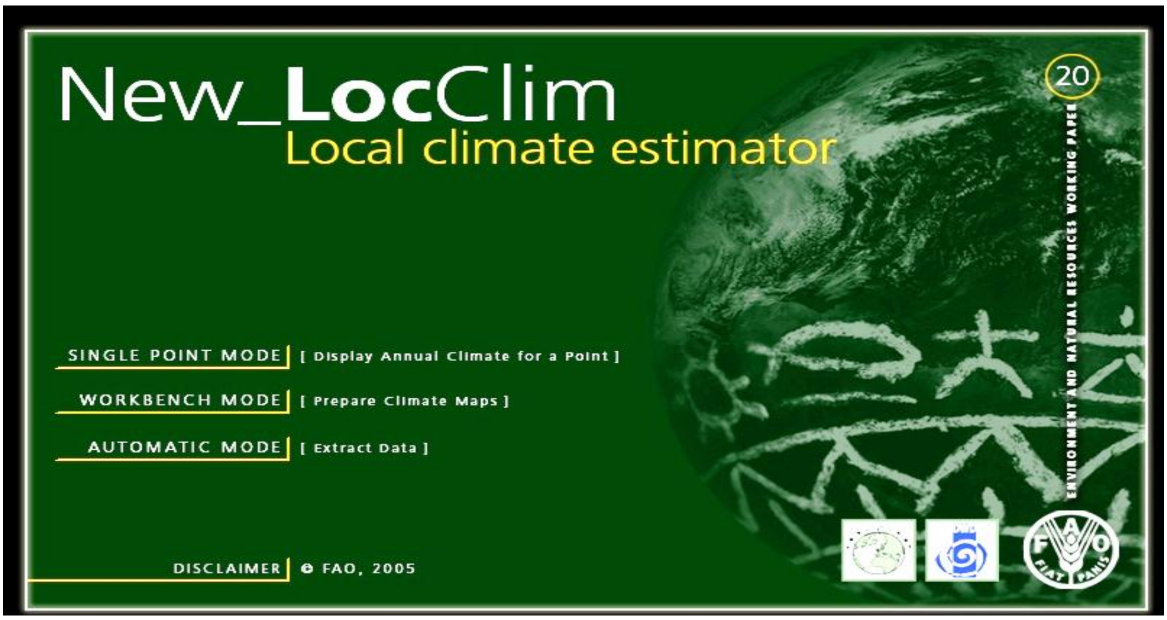


App Fig: 10: Evapotranspiration estimation from temperature data (Bereda lencha SSIP)

The CROPWAT 8 software also gives better estimated ETo values for areas with only min and max temperature data by extrapolating the missing climatic data from global database based on the location (Latitude and longitude) and altitude of the site which are specified in climate module.

d) New LocClim Local climate calculator

If the data source of option ''a'' and ''b'' are not available then the ET_o can be determined from software New Locclim v10.1 that gives ET_o of sites by location coordinate, cities and meteorology stations included the software. This software can be downloaded freely from internet



New Locclim Local estimator

Click Single point mode

How to select location (select 1:3)

a. select location map
b. select location by coordinates
c. ***Select location from list: click here and*** then a dialog box for site selection will be available

Selection of Location by Name

- Choose the continent then country town/village or Meteorological station

When you choose town (closer to the project site) instantly the location coordinate will be appeared and click **OK then**

From dialog box select Potential evapotranspiration (PET)

Finally the mean monthly PET will come in table format and take "best estimates" for your computation Transfer the monthly mean average data to excel file for further crop water requirement calculation

II. Crop water requirement calculation

Purpose of the calculation: the estimation only used for description and for rough estimate of crop water requirements to determine the irrigation water requirement. The results will be used for analysis of water source adequacy and to compare the alternative sites from water demand aspects. This estimation results will not be used for design purpose.

Methods: Excel spreadsheet based calculation is quite enough for comparison and site selection purpose. Follow the procedure for CWR computation:

Step 1: Refer proposed crops and cropping pattern for irrigation requirement analysis

Bring list of crops and cropping patterns recommended in section 6-6-5

Step 2: Determine the monthly Kc values to calculate monthly crop water requirement

Adjustment of crop coefficient value is important before the calculation of crop water requirements to apply empirical formula. It is because of the duration of each crop growth stage might extend to the next months which has different Kc value. Therefore the Kc value of a crop in a particular month has to be adjusted to reflect the crop condition at that month and growth stage which expressed in crop coefficient. For example, the initial growing stage of tomato has 20 days and the planting date is November 17 then 13 days of initial stage is found in November the remaining 7 days is in December. Therefor the Kc value of December should consider the Kc values of both the initial and crop development stages.

$$Kc\ adj = \left[\left(\frac{Crop\ growth\ stage\ days\ in\ Month1}{Number\ of\ days\ in\ month1}\right)\ X\ Kc1\right] + \left[\left(\frac{Crop\ growth\ stage\ days\ in\ Month2}{Number\ of\ days\ in\ month2}\right)\ X\ Kc2\right]$$

App Table 5: Example for tomato

Growth stage	Initial stage	Development	Middle stage	Late stage	Total
Kc	0.4	0.7	1.05	0.65	
LGP	20	35	45	20	120
Planting date	Nov 17				
Harvesting date	April 7				
Cropping month	Nov (30)	Dec (31)	Jan (31)	Feb (28)	March (31)
Number of days	13	7 ini +24 dev	11 dev + 20 Mid	20 Mid + 8 late	12 late
Adjusted Kc	0.4	0.63	0.93	0.94	0.65

$$Kc\ adj\ for\ dec\ = \left[\left(\frac{7\ days\ of\ Dec}{31}\right)\ X\ 0.4\right] + \left[\left(\frac{24\ days\ of\ Dec}{31}\right)\ X\ 0.7\right]$$

= 0.09 + 0.54

= 0.63

The Kc value for December is re-tuned from 0.7 to 0.63

The Kc values of November and March no need of adjustment because the entire period of the stage found in a single month

The tabulated Kc values can be referred from Appendix of SSIGL 8 Feasibility Study of Irrigation agronomy guideline

Step 3: Calculate the crop water need based on monthly Kc and ETo values

In order to estimate the crop water requirements of a crop, multiply the monthly ETo by adjusted Kc from Step 1 and step 2 respectively (refer examples in App Table 6 row 5, 7, 9, 11)

App Table 6: Example for Crop and Irrigation Water Requirement Computation

	Month	Unit	Jan	Feb	Mar	April	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
	Climate Data													
1	ETo (mm)	mm	111	113	136	147	125	100	82	82	101	109	102	96
2	Rainfall mm	mm	11.0	44.0	1.0	23.0	151.0	302.0	358.0	490.0	320.0	184.0	13.0	6.0
3	Effective rainfall (Pe)	mm	**0.0**	**16.4**	**0.0**	**3.8**	**66.6**	**157.2**	**190.8**	**270.0**	**168.0**	**86.4**	**0.0**	**0.0**
	Crop water Requirement													
	Tomato													
4	Kc values		0.93	0.94	0.65								0.4	0.63
5	ETc (mm) (1X4)	mm	**103.2**	**106.2**	**88.4**								**40.8**	**60.5**
	Maize													
6	Kc values		0.95	0.88	0.8								0.3	0.7
7	ETc (mm) (1X6)	mm	**105.3**	**99.5**	**108.8**								**30.6**	**67.2**
	Potato													
8	Kc values		1.02	0.95	0.8								0.4	0.66
9	ETc (mm) (1X8)	mm	**112.8**	**107.6**	**108.8**								**40.8**	**63.5**
	Haricot bean													
10	Kc values		0.90	1.01	0.70									0.25
11	ETc (mm) (1X10)	mm	**99.4**	**114.4**	**95.2**									**24.0**
	Net Irrigation Requirement (CWR-Pe), mm/month													
12	Tomato (5-3)	mm	103.2	89.8	88.4								40.8	60.5
13	Maize (7-3)	mm	**105.3**	**83.1**	**108.8**								**30.6**	**67.2**
14	Potato (9-3)	mm	112.8	91.2	108.8								40.8	63.5
15	Haricot bean (11-3)	mm	99.4	98.0	95.2								0.0	24.0
16	Total net irr mm/month/ha	mm	106.2	89.9	102.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.6	56.2
17	Project irrigation efficiency (Ep)		**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**
18	Gross Irrigation Requirement (16/17)	mm	**212.4**	**179.8**	**205.2**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**59.2**	**112.4**
19	Project irrigation supply lt/s/ha (18/259.2)		**0.82**	**0.69**	**0.79**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.23**	**0.43**
20	Actual irrigated area %		**100.0**	**100.0**	**100.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**80.0**	**100.0**

Step 4: Estimate the Irrigation Water Requirements
Net irrigation Requirement is a difference between the water supply and crop demand which mainly depend on the quantity of effective rainfall that can be used by given crop. Therefore in order to quantify the effective rainfall use the following formula for each month.

Peff = 0.6*P-10 for P month <= 70 mm; Peff = 0.8* P -24 for P month > 70 mm

NIR = Crop water requirement – (Peff +other supply source)

NIR = Crop water requirement – Peff

GIR = NIR / Project efficiency

Please see the illustrative table below (table6-18) for calculated NIR and GIR;

Step 5: calculate the project total net irrigation requirement in hectare basis (Table 6-18 row 16)

In this step the total net irrigation requirement of the project will be calculated by taking into account the cropland area coverage or cropping pattern of each crop. The cropping pattern should be expressed in % which earlier recommend by the agronomist in Table 7-17.
The general formula can be presented as follows

$$Total\ NIR\ per\ ha = (\mathrm{C1WR} * \mathrm{C1CP}) + (\mathrm{C2WR} * \mathrm{C2CP}) + (\mathrm{C3WR} * \mathrm{C3CP}) + (\mathrm{C4WR} * \mathrm{C4CP}) + (\mathrm{CnWR}) + \mathrm{CnCP})\ (\mathrm{CnWR}) + \mathrm{CnCP})$$

Total NIR = Total Net Irrigation Requirement of the project in mm/ha
C1WR = Crop water requirement for crop 1; C1CP = cropping pattern of crop 1 in %
CnWR = Crop water requirement for crop n; CnCP = Cropping pattern of crop 1 in %

Step 6: Estimate Gross Irrigation Requirement: after calculating the net irrigation requirement of the project then monthly gross water requirement should be estimated by dividing the NIR by project efficiency which recommended by irrigation agronomist and engineers in consultation considering the Conveyance, Distribution and Field Application efficiencies. See Row 18 in App Table 6 where row 16 divided by row 17

Step 7: Set the peak duty of the project
To estimate the duty in l/s/ha the GIR need to be divided by conversion value of **259.2** then the maximum value indicating the highest requirement of irrigation water will be identified from monthly values. The peak value will be used for comparison of the sites or projects in terms of their water requirement which is one of the site selection criteria

SSIGL 2

Prepared by

GIRDC