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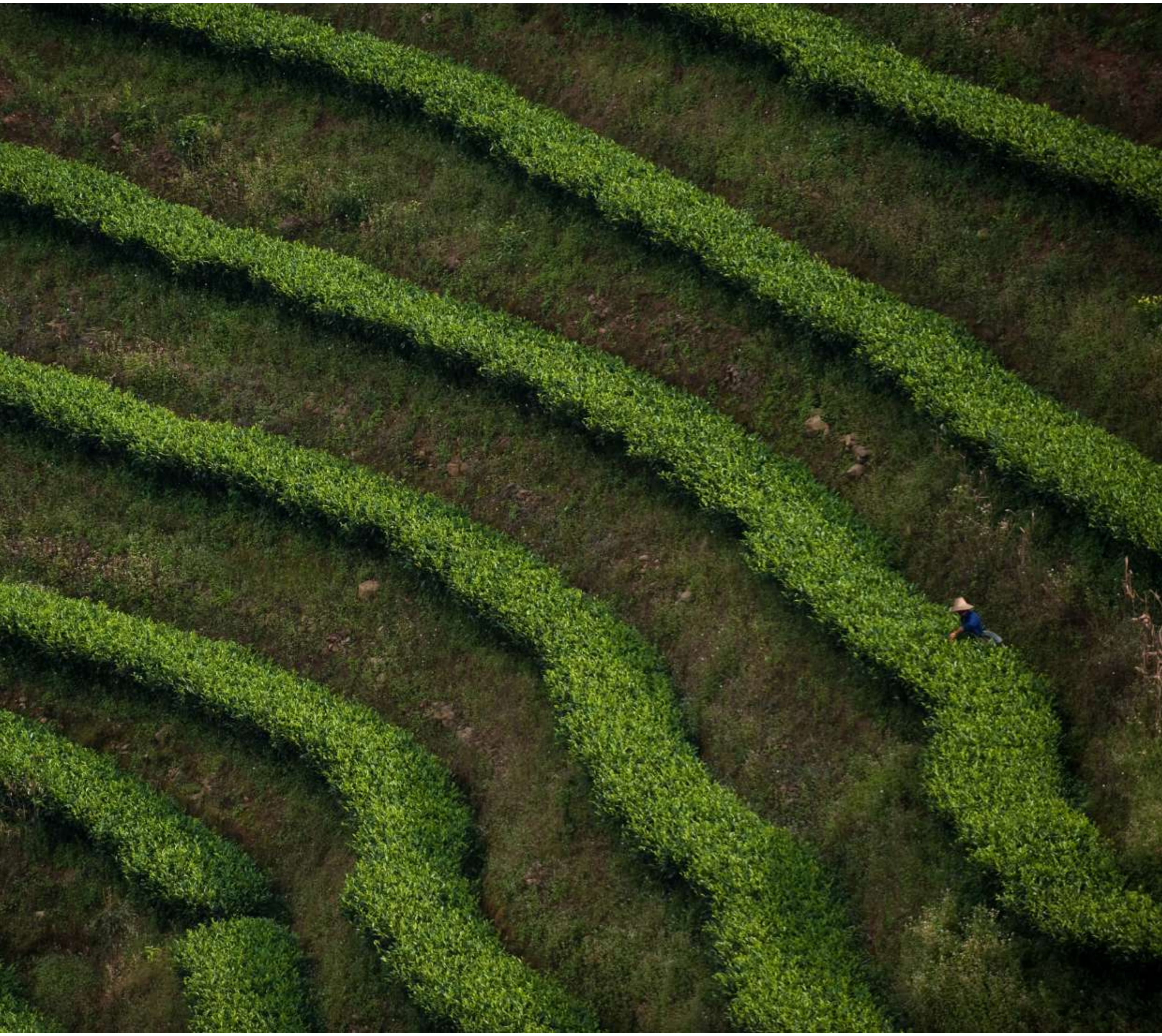

Detailed Feasibility Study Framework for Renewable Energy Irrigation Systems

April 2024

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Government of Nepal,
Alternative Energy Promotion Centre (AEPC)

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Foreword

Alternative Promotion Centre (AEPC) is the focal agency of Government of Nepal (GoN) on renewable energy and energy efficiency. The GoN of Nepal is committed to promoting the use of renewable energy technologies, raising the living standards of the rural people, protecting the environment; and developing commercially viable renewable energy industries in the country. To ensure the consistency and reliability in the assessment process of renewable energy irrigation systems in Nepal across national, provincial and local levels. AEPC with support from the International Centre for Integrated Mountain Development (ICIMOD) has formulated this Detailed Feasibility Framework (DFS) for renewable energy irrigation systems in Nepal.

This DFS framework transcends its technical nature and serves as an inspiring symbol of progress for communities contending with the intertwined issues of energy access and agricultural sustainability. By providing a structured approach to assessing the feasibility of renewable energy-based irrigation systems, this framework empowers stakeholders at all levels to make informed decisions that contribute to the socio-economic advancement of our nation.

I believe that this DFS framework will support the generation of well-informed decisions, robust project implementation and sustainable outcomes, ultimately contributing to the AEPC's mission of fostering resilient and renewable energy-powered community-based irrigation systems. On behalf of AEPC, I would also like to express my gratitude to ICIMOD, whose support and collaboration have been invaluable throughout this journey.

I also extend my heartfelt appreciation to the dedicated team at AEPC, ICIMOD, IWMI, AEPC/DKTI and AEPC/RERL, who have worked tirelessly to conceptualize and refine this DFS framework. Their expertise, passion, and dedication have been instrumental in turning this vision into reality.

As we continue our journey, I am confident that this DFS framework will serve as the foundation for significant progress in renewable energy efforts, addressing critical challenges and facilitating the transition to clean energy solutions.

Nawa Raj Dhakal
Executive Director

The National Agency Working for Renewable Energy and Energy Efficiency

Pema Gyamtsho Ph.D.
Director General

Preface

It is with great pleasure and a sense of shared accomplishment that we present the detailed feasibility study (DFS) framework for renewable energy-based irrigation systems in Nepal, developed in collaboration between the International Centre for Integrated Mountain Development (ICIMOD) and the Alternative Energy Promotion Centre (AEPC).

Under the ICIMOD's Green Energy Management for Mountain Economies (GEM Nepal) project, supported by the Embassy of the Kingdom of Norway in Nepal, ICIMOD and AEPC have embarked on a journey to strengthen the management of the renewable energy sector in Nepal in support of green, resilient, and inclusive mountain economies by enhancing knowledge and building the capacity with national and local government and mountain communities. Our collaborative endeavors are focused on utilizing renewable energy solutions to tackle the urgent issues that mountain communities are confronted with, specifically regarding irrigation.

This DFS framework serves as evidence of our dedication to innovation and sustainable development. It is intended to serve as a guide for conducting in-depth feasibility studies on renewable energy irrigation systems in Nepal, with the overarching goal of ensuring consistency and reliability in the assessment process. Through this DFS framework, we aim to equip stakeholders with the necessary information to make informed decisions, enabling robust design and implementation, and thereby producing sustainable outcomes. This ultimately contributes to fostering resilient and renewable energy-powered irrigation systems.

We are grateful to AEPC for their support and direction during this collaborative endeavor. Their experience and passion have helped shape this DFS framework into a useful and successful tool for the promotion of renewable energy irrigation systems in Nepal.

In addition, we would like to extend our gratitude to IWMI, AEPC/DKTI, and RERL/UNDP who contributed to the formulation of this DFS framework. By combining our efforts and having a shared vision, we can establish a pathway towards a more sustainable and resilient future for Nepal.

As we move forward, we remain committed to fostering partnerships, promoting innovation, and driving positive change in the energy landscape of the agriculture sector. Together, we can harness the power of renewable energy to transform livelihoods, mitigate climate risks, and build a more resilient future for generations to come.

Pema Gyamtsho
Director General
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Table of Contents

Foreword i

Preface ii

List of Tables vi

List of Figures vi

Acronyms vii

Terms and Definitions viii

Introduction 1

Expected outcomes and goals 2

Problem statement 2

Objectives 2

Users and skillsets needed to execute the framework 3

Methodology 4

Step I: Inception 7

Step II: Site survey 9

Step III: Analysis and design 12

Step IV: Finalising the detailed feasibility study 15

Checklist 16

Annexe – Step I: Inception stage 17

- Annexe 1. Initial consultations with the project owner and primary stakeholder(s) 18
- Annexe 2. Study of background materials 18
- Annexe 3. Detailed feasibility study work plan 18
- Annexe 4. Preparation for the site survey 19

Annexe – Step II: Survey checklist 21

- Annexe 5. Community, local government, and stakeholder engagement 22
- Annexe 6. Household and institutional survey 24

Annexe 7. Technical survey 25
7.1 Statutory requirements 25
7.2 Agriculture and irrigation 26
7.2.1 Existing practices in agriculture and irrigation 26
7.2.2 Water sources and availability 28
7.2.3 Reviving springs 30
7.2.4 Mapping the command area 30
7.2.5 Agriculture and water-use plan 31
7.2.6 Inputs for cost-benefit analysis 32
7.3 Civil survey 36
7.3.1 Delivery head 36
7.3.2 Water intake survey 36
7.3.3 Reservoirs survey 37
7.3.4 Water transmission survey 38
7.3.5 Water distribution network survey 39
7.4 Energy and electromechanical survey 40
7.4.1 Available electricity infrastructure survey 40
7.4.2 Location of electromechanical components survey 41
Annexe 8. Environmental and Social Safeguard survey 42
Annexe – Step III: Analysis and design checklist 45
Annexe 9. Determining water requirements and the best available technology 46
9.1 Water requirement and total dynamic head 46
9.2 Selection of energy infrastructure 47
9.3 Assessment of the best available technology 47

Annexe 10. Electromechanical design 49
10.1 Pump selection and sizing 49
Annexe 11. Civil design 50
11.1 Water intake design 50
11.2 Reservoirs design 51
11.3 Water transmission design 52
11.4 Water distribution network design 53
11.5 Irrigation methods 53
Annexe 12. ESMP, risks, and mitigation 54
Annexe 13. Operational and management plan 47
13.1 Modalities of operations and management 54
Annexe 14. Cost-benefit analysis 59
Annexe 15. Costs and bill of quantity 64
Annexe – Step IV: Finalising the detailed feasibility study checklist 67
Annexe 16. Briefing the project owner and key stakeholder(s) 68
Annexe 17. Briefing the community 68
Annexe 18. Revision of the detailed feasibility study report 68
Annexe 19. Finalisation of the detailed feasibility study report 68

List of Tables

Table 1.	Macro-level enablers	5
Table 2.	Meso-level enablers	5
Table 3.	Micro-level enablers	6
Table 4.	Description of activities in the inception stage	7
Table 5.	Description of activities in the site survey stage	9
Table 6.	Description of activities in the analysis and design stage	12
Table 7.	Description of activities in the stage of finalisation of DFS	8
Table 8.	Risk rating	15
Table 9.	Description of operational modality	57
Table 10.	Cost-and-benefit parameters	60
Table 11.	DFS documentation	69

List of Figures

Figure 1.	The three-tier approach	4
Figure 2.	Four aspects of the identification of water source	28
Figure 3.	Examples of available energy infrastructure in the site	41
Figure 4.	Examples of micro-irrigation and deficit irrigation	53

Acronyms

AEPC	Alternative Energy Promotion Centre
ARAP	Abbreviated Resettlement Action Plan
BAT	Best Available Technology
CBA	Cost–Benefit Analysis
DFS	Detailed Feasibility Study
DTW	Deep Tube Well
EIA	Environmental Impact Assessment
ESMP	Environmental and Social Management Plan
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
GESI	Gender Equality and Social Inclusion
IEE	Initial Environmental Examination
IPP	Indigenous Peoples Plan
M&E	Monitoring and Evaluation
NAP	National Adaptation Plan
NbS	Nature-based Solutions
NPR	Nepalese Rupee
O&M	Operations and Management
RAP	Resettlement Action Plan
VCDP	Vulnerable Community Development Plan

Terms and Definitions

Availability of energy supply	An attribute of energy supply that implies the ability to draw energy when needed for the use of energy services. Availability is measured as the time and duration of supply. The availability of electricity can be measured as the time during the day (and night) when electricity is available, or the total number of hours when electricity is available each day. Fuel availability can be measured as the number of days per year during which the fuel is available, or whether a secondary fuel is used to address the lack of availability of a preferred fuel. The availability of electricity supply is often more important during the evening hours, especially for lighting needs. Therefore, the evening supply may sometimes be treated as a separate indicator of the availability of electricity supply [1].
Best available technology for energy supply	Refers to the selection of the most effective and advanced form of energy supply under economically and technically viable conditions to power the pump as per site conditions.
Capacity of energy supply	The capacity of energy supply relates to the quantity of energy made available to the user. It can be measured as a combination of the total energy available over a period of time and the maximum power (the rate of energy delivery) that can be used. For example, for electricity, the capacity of energy supply is the maximum power available (in watts) or the total energy available [1].
Command area	In this document, “command area” means the land area to be irrigated by the pumping system.
Community	In this document, “community” refers to the detailed feasibility study aspects concerning only the direct beneficiary farmers.
Community engagement	This means keeping all the community members informed of the project activities and ensuring that all the members participate in all levels of the project cycle.
Climate proofing	It is a process that integrates climate change mitigation and adaptation measures into the development of infrastructure projects [2].
Deficit irrigation	Deficit irrigation, defined as the application of water below the full crop-water requirements (evapotranspiration), is an important tool to achieve the goal of reducing irrigation water use [3].
Demographics	Demographics are statistics that describe populations and their characteristics [4].
Detailed feasibility study	In this document, “detailed feasibility study” specifically refers to renewable energy irrigation systems.
Focus group discussion (FGD)	An FGD involves gathering people from similar backgrounds or experiences to discuss a specific topic of interest. It is a form of qualitative research where questions are asked about the participants’ perceptions, attitudes, beliefs, opinions, and ideas. In FGDs, the participants are free to talk with other group members; unlike other research methods, it encourages discussions with other participants. It generally involves interviews involving small groups consisting of 8 to 12 people. It is led by a moderator (interviewer) who conducts a loosely structured discussion on various topics of interest [5].

Land plot	This means individual division of agricultural land inside the command area which may or may not be owned by different farmers.
Mechanisation	Mechanisation involves the production, distribution, and utilisation of a variety of tools, machinery, and equipment for developing agricultural land, planting, harvesting, and primary processing [6].
Primary stakeholders	Primary stakeholders are those who are directly involved in the project.
Project owner	Refers to the primary owner and chief funder of the project.
Project area	In this document, "project area" refers to the broader physical and institutional region near the community and command area which influences the project.
Site	Refers to the location of the project.
Socio-economic analysis	Socio-economic analysis is the study of the environmental, economic, social, and institutional patterns, and their linkages, which make up the context for development [7].
Stakeholder engagement	This involves keeping all the stakeholders informed of the project activities and ensuring that they actively participate in all levels of the project cycle [8].
Statutory requirements	These are any mandatory compliance requirements of the community, local government, provincial government, and federal government.
Quality of energy supply	An attribute of energy supply that implies the correct level and stability of voltage (and frequency) in the case of electricity, and the absence of adulteration (including excessive moisture) in the case of fuels so that the desired combustion characteristics can be achieved [1].
Reliability of energy supply	An attribute of energy supply that entails the absence of unpredictable outages of energy supply. It is measured by the frequency and length of the unpredictable outages [1].
Total dynamic head	This is the total vertical height from which the pump has to push water, and takes into account all losses. The vertical height is the 90°-height difference from the water level to the maximum water delivery point [9].
User group	A user group is a focal group of the community that is consulted during the detailed feasibility study. The user group may or may not be officially registered with the local government.
Water user group	A water user group is formed within the community and is the one that is officially recognised by the local government as the entity responsible for the operation and management of the irrigation system.

Introduction

Agriculture holds a significant position in Nepal's economy. This is particularly exemplified by the fact that it contributed 24.67 per cent to the country's GDP in 2022. However, agricultural activities have been experiencing a decline in recent times. [1] This is reflected by the consistent rise in food imports over the last two decades. While Nepal's trade deficit in terms of food products stood at NPR 11 billion in 2007/08, it escalated to NPR 173 billion in 2018/19 – a 16-fold increase in a decade [10]. Since multiple factors have contributed to this deficit, there is an urgent need for effective and targeted interventions. One such intervention involves providing farmers with enhanced access to irrigation.

As regards to the national targets and policies related to irrigation, Nepal's National Water Plan, 2005, outlines ambitious goals, aiming to achieve year-round irrigation of 67 per cent of the total irrigated area and to cover 97 per cent of the potential irrigable area using irrigation systems by 2027. Besides, the National Adaptation Plan (NAP) 2021–2050 prioritises promoting water-pumping technology in water-scarce areas utilising renewable energy sources [11]. Moreover, to enhance effective irrigation efforts, the 2006 Rural Energy Policy emphasises the deployment of rural energy for diverse productive uses, including irrigation [12]; the policy also promotes the integration of energy technologies for irrigation, such as mini- and micro-hydro systems and solar photovoltaics. Against the backdrop of these national targets and the guidance provided by the Rural Energy Policy of 2006, the Alternative Energy Promotion Centre (AEPC) is dedicated to supporting renewable energy-based irrigation systems.

However, to effectively develop renewable energy irrigation systems, a guiding framework for conducting detailed feasibility studies does not exist. Thus, this document has been developed to establish such a framework which will aid multidisciplinary practitioners in undertaking detailed feasibility studies of renewable energy irrigation systems.

1 Dropping from 25.8 per cent in FY 2020/2021 to 24.67 per cent in FY 2021/22 [24].

Expected outcomes and goals

The foundation of successful irrigation projects lies in a comprehensive and robust Detailed Feasibility Study (DFS) that covers multiple dimensions, including technical, social, environmental, and economic aspects of projects. The DFS aims to generate information for making informed decisions, enabling robust design and implementation, and thereby producing sustainable outcomes. This ultimately contributes to the AEPC's mission of fostering resilient and renewable energy-powered irrigation systems.

Problem statement

The current renewable energy-powered irrigation systems lack a comprehensive framework to overcome the following challenges:

- Implementing a comprehensive and climate-adaptive strategy that integrates technical, social, policy, environmental, and economic considerations.
- Effective engagement with relevant stakeholders, particularly through inclusive community consultations with a focus on empowering the marginalised segments.
- Enhancing project assessments by using a three-tier approach (macro, meso, and micro) to understand the site better in its context.
- Proactive risk mitigation during the feasibility stage to efficiently address underlying factors.
- The successful addressing of these challenges is imperative for the DFS's execution, leading to enhanced site characterisation and optimal project operations.

Objectives

This framework is intended to serve as a guide for conducting in-depth feasibility studies on renewable energy irrigation systems in Nepal, with the overarching goal of ensuring consistency and reliability in the assessment process.

Users and skillsets needed to execute the framework

The framework applies to multidisciplinary practitioners undertaking such feasibility studies. The users shall refer to the four steps (described in the **Methodology** section); those are: (i) inception (initial planning stage); (ii) site survey; (iii) analysis and design; and (iv) finalising a DFS which will guide the activities of renewable energy irrigation systems. The Annexes in the document elaborate on the specific activities that need to be covered at each of the four steps. Each activity is linked to an Annexe and a checklist is provided for the user to follow through the DFS stages (see **Checklist** section).

Furthermore, carrying out detailed and all-round feasibility studies under this framework demands a team equipped with skilled resources and with diverse skill sets.

The following describes the skill sets required to conduct a comprehensive DFS.

a. Assessment and designing of irrigation systems. For example, but not limited to, existing practices and irrigation plans, water requirement calculations, climate conditions, water distribution plans, and irrigation methods.

b. Assessment of agricultural practices and opportunities on the site.

c. Preparation of crop plans.

d. Assessment and designing of electromechanical systems. For example, but not limited to, pump sizing and selection, best available technology for energy supply, electrical infrastructure, and placement of electrical and electronic components.

e. Assessment and designing of civil systems. For example, but not limited to, water collection infrastructure, water distribution infrastructure, transmission pipes, distribution pipes, and infrastructure for component placement.

f. Conducting an economic analysis of the project. For example, a cost–benefit analysis (CBA) and a study of market access.

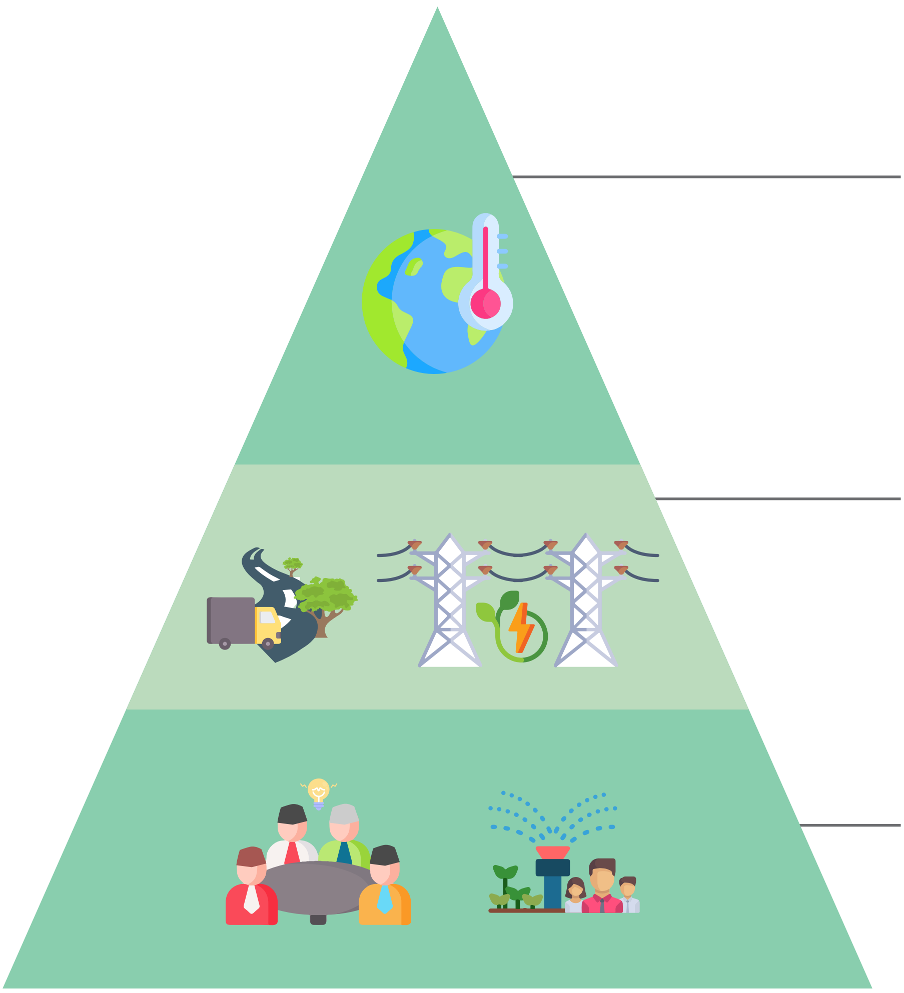
g. Conducting an environmental and social analysis of the project.

h. Assessment of Gender Equality and Social Inclusion (GESI) aspects.

Methodology

The efficacy and enduring viability of renewable energy-powered irrigation projects are contingent upon the assessment of both internal and external enabling environments. Often conceptualised in isolation, these projects tend to disregard the broader framework that profoundly affects their operational efficiency. To optimise project outcomes, adopting a comprehensive methodology is imperative, involving an in-depth exploration of the reciprocal relationship between project objectives and the enabling environment.

Within this methodological framework, the identification and evaluation of key enablers emerge as pivotal considerations, exerting substantial influence on project design adjustments and trajectory. This chapter aims to conduct a methodologically rigorous examination using the analytical structure of evolutionary economics and the three-tier approach – macro, meso, and micro [13] – to comprehensively understand the contextual factors that impact the feasibility and execution of such initiatives (Figure 1).



Macro

Macro-level enablers encompass overarching elements that span regional and systemic dimensions.

Meso

Meso-level enablers relate to the community and regional factors that influence project implementation.

Micro

Micro-level enablers pertain to the individual components and elements within the irrigation project itself where the decisions are controlled by the project owner.

Figure 1. The three-tier approach

These three enablers are explained as follows.

Macro-level enablers

For a renewable energy irrigation system, these encompass external factors beyond immediate project control (Table 1). Although the macro-level enablers are outside of project control, their understanding is crucial for decisions made during the DFS.

Table 1. Macro-level enablers

Category	Factors and specific examples
National Policies and Regulations	Rural Energy Policy, 2006 AD; Renewable Energy Subsidy Policy, 2078 B.S. (2022 AD); Irrigation Rules, 2056 B.S. (2000 AD); Water Resources Rules, 2050 B.S. (1993 AD); Water Resources Act, 2049 B.S. (1992 AD); Environmental and Social Safeguard Policy of AEPC, 2018 AD; Alternative Energy Promotion Centre Gender Equality and Social Inclusion (GESI) Policy, 2018 AD; Environmental Protection Rule, 2020 AD; National Adaptation Plan (NAP), 2021–2050 AD; and trade policies (related to prices and access to products).
Climate Resilience Context	Understanding climate patterns and designing irrigation systems that are adaptable to changing weather conditions and water availability is important for long-term viability. For example, adapting to changing climate and reducing weather-related risks.

Meso-level enablers

Meso-level enablers for renewable energy irrigation projects involve industry-specific external factors directly influencing the sector and project market. These are external conditioning factors beyond project control (Table 2).

Table 2. Meso-level enablers

Category	Factors and specific examples
Market Access and Absorption	Establishing local market links for surplus crops, ensuring consumption in identified markets.
Financial Access and Incentives	Availability of grants, subsidies, or favourable financing to encourage irrigation adoption.
Regulatory Policies	Region-specific policies by provincial and local governments for the project.
Partnerships with Local Institutions	Access to agricultural extension services, research institutions, public services, and nonprofits.
Infrastructure	Availability and stability of energy, roads, and communication infrastructure.
Supply Chain	Accessibility of essential components in the agricultural value chain.

Micro-level enablers

Micro-level enablers are specific activities under the project owner's control. They involve the project's internal parts and how they work together, as described, but not limited to, the categories in Table 3.

Table 3. Micro-level enablers

Category	Factors and specific examples
Technical Designs	Selection of optimal renewable energy solutions, water-efficient systems, civil structures, and climate-proofing for long-term functionality.
Irrigation Management	Institutional framework promoting transparency, accountability, and community engagement for smooth operation and sustainability.
Local Skills and Expertise	Skilled technicians for system installation, maintenance, and troubleshooting, ensuring smooth operation and quick issue resolution.
Community Engagement	Involving local communities in planning and execution to foster a sense of ownership and acceptance, and thus, increased the likelihood of project success.

These three tiers form a framework to assess how the enabling environment impacts renewable energy irrigation projects, thereby enhancing the prospect of success. Each enabler contributes to project resilience, sustainability, and the capacity to address agricultural challenges. Moreover, recognising these linkages allows the stakeholders to strategically tailor interventions and leverage synergies for tangible and lasting benefits. To put the three tiers of enablers into practice, the DFS for renewable energy irrigation systems will follow the following four steps.

Step I
Inception (initial planning phase)

Step II
Site survey

Step III
Analysis and design

Step IV
Finalising the detailed feasibility study

The following sections describe the activities conducted at each of the four steps.

Step I: Inception

Objective: The objective of the inception stage is to understand the expectations of the project and prepare for the activities of the DFS.

Table 4. Description of activities in the inception stage

	Activity	Description	Methodology and tools
1	Consultations with the project owner and primary stakeholder(s)[2]	Conducting meetings with the project owner and primary stakeholder(s) to understand the project goals, the project owner's expectations, and site details. (For details, refer to Annexe 1.)	Scheduling of meetings with the project owner and primary stakeholder(s).
2	Study of background materials	Gathering the essential background information relevant to the DFS. This provides valuable insights into the project's history and context and establishes a crucial foundation for informed decision-making during the DFS process. By comprehensively reviewing the project's background and linkages across the three-tier level (macro, meso, and micro), including previous assessments, market research, and initial planning stages, the stakeholders can gain a deeper understanding of the project's objectives, challenges, and potential opportunities. This knowledge not only informs the scope and methodology of the DFS but also ensures that it is aligned with the project's overarching goals and objectives. (For details, refer to Annexe 2.)	Gathering and studying of relevant documents and resources relevant to the DFS.
3	Preparation of an inception report	The DFS team shall prepare an inception report that serves as a reference for further activities. This report shall be prepared in consultation with the project owner to ensure that there are no omissions in the DFS process and that both parties are aligned with the planned activities. (For details, refer to Annexe 3.)	The inception report shall be approved by the project owner before proceeding to Activity 4.

2 Primary stakeholders are stakeholders who are directly involved in the project.

4	Preparation for the site survey	The DFS team shall prepare for the site survey by: (i) establishing contact with the community and stakeholders; (ii) inviting the community members to participate in discussions during the site survey; and (iii) preparing the relevant documents, questionnaires, and resources needed to conduct the survey. (For details, refer to Annexe 4.)	• Community group discussion questionnaire. • Household and institutional survey questionnaires. • Technical, environmental, and social safeguard survey questionnaire. • Survey tools and resources.

Output: The output of the inception stage is the inception report approved by the project owner, which encompasses group discussion questions, household and institutional survey questionnaires, and technical survey questions.

Step II: Site survey

Objective: The objective of the site survey is to engage with the community, meet the relevant stakeholders, assess the project enablers, and gather data for site characterisation (such as socio-economic, technical, environmental, and social safeguarding aspects).

Table 5. Description of activities in the site survey stage

	Activity	Description	Methodology and tools
1	Identifying and conducting a meeting of the user group	The first step in the site survey is to identify the user group that will remain the focal point for community engagement. If there is an existing user group, it shall be engaged in the discussion. If there are no existing user groups, a group shall be formed that shall be inclusive, strongly aligned with the principles of GESI, and one which will have representation from the local government. A discussion with the user group shall be conducted to: (i) brief the community about the objectives of the DFS; (ii) gather information about the site; and (iii) gather inputs and concerns about the project. Through user group discussions, the DFS team can get valuable information about the site to develop an understanding of meso- and micro-level enablers. The meso-level information will help gauge the opportunities of the project and also the constraints that the community is facing from external factors, whereas the micro-level information relates to site characteristics. The user group discussions will also provide a platform for the community to voice its expectations and concerns; these shall be documented and some of them may be addressed during the DFS stage. (For details, refer to Annexe 5.)	■ FGD with the user group. ■ Refer to the AEPC's GESI Policy, 2018.

2	Conducting a socio-economic survey	After identifying the user group and conducting a discussion, the DFS team will focus on the micro-level enablers of the site. Here, a household and institutional survey will be conducted. This survey will gather information about the demographic, administrative, and socio-economic status of the site; this will support the cost–benefit analysis, help ensure that the user group is inclusive, and help gauge the ambition and willingness of the community to maximise irrigation for improved income and livelihood. (Refer to Annexe 6 for more details.)	Household and institutional survey.
3	Conducting a technical survey	After the household and institutional survey, a technical survey shall be conducted. This survey relates to the agriculture, irrigation, civil, and electromechanical aspects of the DFS. The information gathered from this survey will feed into the design of the community-based irrigation system. The technical survey will cover: ■ Statutory requirements (refer to Annexe 7.1 for details) ■ Agriculture and irrigation (refer to Annexe 7.2 for details) ■ Civil infrastructure (refer to Annexe 7.3 for details) ■ Energy and electromechanical components (refer to Annexe 7.4 for details)	A technical survey where some information may be gathered from user group discussions in Activity 1.
4	Conducting an environmental and social safeguarding survey	The next part of the survey shall cover the environmental and social safeguarding aspects. This includes environmental impacts, social impacts, climate-induced technical and social risks, and management risks. This survey shall be conducted in line with the Environmental and Social Safeguard Policy (2018) of AEPC. (Refer to Annexe 8 for more details.)	■ An environmental and social safeguarding survey where some information may be gathered from user group discussions in Activity 1. ■ Guided by the Environmental and Social Safeguard Policy, 2018, of AEPC.

5	Meeting with relevant stakeholders and project enablers	Upon the survey of technical, environmental, and social safeguarding aspects, the scope of the survey expands beyond micro-level factors to encompass meso-level considerations. This stage involves engaging with local and regional stakeholders who are directly or indirectly associated with the project. These stakeholders may include governmental bodies, financial institutions, non-profit organisations, and private-sector entities such as actors in the agricultural supply chain, depending on the project's requirements. The stakeholder engagement plan shall follow AEPC's Stakeholders Engagement Framework, 2023. Additionally, the information regarding other meso-level factors, such as market access and infrastructure, will be documented. The insights gathered from the stakeholders and project enablers will be utilised to conduct a cost–benefit analysis, assess the viability of the irrigation system's business model, and evaluate the potential external support mechanisms for the project. This approach reflects a multi-stakeholder perspective integral to the DFS process.	■ Meetings with relevant stakeholders and observation of project enablers. ■ Some information may be gathered from user group discussions in Activity 1. ■ Guided by AEPC's Stakeholders Engagement Framework, 2023.

Output: The output of the site survey stage is to capture the necessary information that will feed into the analysis and design stage of the DFS.

Step III: Analysis and design

Objective: Based on the information gathered from the site survey, the objective is to perform comprehensive technical, socio-economic, environmental, and social safeguarding analyses; and prepare a draft DFS report.

Table 6. Description of activities in the analysis and design stage

Activity		Description	Methodology and tools
1	Determination of water requirements and energy source	After gathering information on the three-tier project enablers through the site survey, the DFS will advance to the analysis and design phase. The initial step involves determining the water requirement for irrigation and selecting the energy source to power the irrigation system. The crop-water requirement can be established by considering both meso- and micro-level project characteristics. At the meso level, understanding the market demand is crucial for crop selection, while at the micro level, information on soil type, climate conditions, human–wildlife conflicts, and crop parameters collected during the site survey is taken into account. This data is then computed using established guidelines and software. Ensuring a reliable and trusted method for calculating crop-water requirements is crucial as it forms the foundation for subsequent technical designs so that they adequately meet irrigation needs. Following the determination of crop-water requirements, the micro- and meso-level information gathered from the site survey on existing and potential energy sources is utilised to evaluate the most suitable energy source to power the pump. Here, the factors considered include the reliability, affordability, and compatibility of the nearest grid connection at the micro level, and permits and approvals for grid extensions at the meso level. (Refer to Annexe 9 for more details.)	■ FAO's No. 56 "Crop Evapotranspiration – Guidelines for computing crop water requirements". ■ CropWat software.

2	Electromechanical design	The electromechanical design phase entails selecting the pump along with all the necessary electrical, electronic, and mechanical components. This process is guided by site-specific information at both micro and meso levels. For instance, the choice of pump is determined by micro-level site requirements, meso-level supply capability, and the pump's availability in the market. Further details are available in Annexe 10. Moreover, the electromechanical design can be conducted concurrently with the civil design (Activity 3) because information on the electromechanical design influences the decision on the civil design, and vice versa. This parallel approach ensures comprehensive integration and alignment between the two phases, thereby optimising the overall efficiency of the project's implementation.	Design and selection of the electromechanical components.
3	Civil design	The civil design phase encompasses various components such as water intake structures, reservoirs for collection and distribution, the water distribution network, and irrigation methods. This phase of the design process is shaped by site-specific information at both micro and meso levels. For instance, the choice of construction materials can be optimised by utilising locally available resources, a decision driven by micro-level characteristics. Similarly, considerations such as the supply chain and means of transportation are determined by factors at the meso level. By leveraging both micro- and meso-level insights, civil design can be tailored to maximise efficiency and effectiveness while minimising costs and environmental impacts. (Refer to Annexe 11 for more details.)	Design and selection of the civil components.

4	Environmental and Social Management Plan, project risks, and mitigation measures	The Environmental and Social Management Plan (ESMP), along with project risks and mitigation measures, is to be prepared based on micro-, meso-, and macro-level information relevant to the subject. This allows the project owner to plan for safeguarding measures before the implementation of the project which contributes to its long-term sustainability. The costs associated with ESMP and project-risk mitigation measures can be built into the cost–benefit analysis (Activity 5), thereby ensuring that costs beyond the technical aspects are covered in the CBA. (Refer to Annexe 12 for more details.)	■ Guided by the Environmental and Social Safeguard Policy, 2018, of AEPC. ■ Risk-evaluation matrix.
5	Cost–benefit analysis	Upon completion of the technical design phase, as well as the preparation of ESMP and the evaluation of risks and mitigations, a CBA is conducted. This is valuable in terms of the financial and economic considerations related to developing an irrigation system in a specific location [14]. The CBA allows for optimisation of the project costs and assesses the viability of the project operation model; this will influence the financial decisions that are made later for project implementation. (For details on operation and management models, refer to Annexe 14.) (For details on CBA, refer to Annexe 14.)	Cost–benefit analysis
6	Drafting of a comprehensive DFS report	Upon completion of the CBA and all the above-mentioned phases, the activities under them shall be narrated, along with findings and recommendations, in a comprehensive draft DFS report. The report shall also have a section on the costs involved in the implementation of the renewable energy irrigation system. (Refer to Annexe 15 for more details.)	■ Refer to AEPC's GESI Policy, 2018. ■ Narration of observations, analyses, designs, findings, and recommendations. ■ List of all materials and activities for project implementation.

Output: The output of the analysis and design stage is a comprehensive DFS report that includes detailed information on irrigation needs, the chosen technology for the pumping system, a thorough cost analysis with a cost–benefit evaluation, and a risk assessment report outlining potential environmental and social risks, along with corresponding mitigation measures. This documentation is instrumental in shaping the project's design and ensuring its viability while adhering to responsible environmental and social practices.

Step IV: Finalising the detailed feasibility study

Objective: The objective is to brief the project owner, stakeholders, and the community on the DFS, and thus gather comments and endorsements related to its findings, which leads to the finalisation of the DFS report.

Table 7. Description of activities in the stage of finalisation of DFS

Activity		Description	Methodology and tools
1	Briefing the project owner and primary stakeholders	Under the multi-stakeholder approach to the DFS, its findings should be conveyed to the project owner and primary stakeholders. Their comments and inputs should then be gathered to improve the analytical and design aspects of the DFS. (Refer to Annexe 16 for more details.)	Meetings with the project owner and the primary stakeholders.
2	Briefing the community	The community user group must be briefed on the DFS findings. Under the guiding principle of community engagement, the user group's inputs and concerns hold immense value and are directly linked to the success of the project. (Refer to Annexe 17 for more details.)	Community user group briefing at the project location.
3	Revision of the DFS report	Based on the inputs gathered from the project owner, primary stakeholders, and the community, the DFS report shall be revised to address all their comments and concerns. During the revision process, further consultations with the relevant parties may be required. (Refer to Annexe 18 for more details.)	Revision process of the DFS report, which may also require further consultations.
4	Finalisation of the DFS report	Upon revision of the DFS report, it shall be finalised, along with supporting documents, to the extent applicable as described in Annexe 19. The final DFS report and supporting documents shall be submitted to the project owner for approval.	■ Finalisation and packaging of the DFS report. ■ Submission and approval of the DFS report and supporting documents.

Output: The output of this stage is a comprehensive DFS report, along with supporting documents, that covers all aspects of the framework, which is then submitted to and approved by the project owner.

Checklist

Step I: Inception stage	Refer to
☐ Initial consultations with the project owner and primary stakeholder(s)	Annexe 1
☐ Study of background materials	Annexe 2
☐ Detailed feasibility study work plan	Annexe 3
☐ Preparation for the site survey	Annexe 4
Step II: Site survey	
☐ Community, local government, and stakeholder engagement	Annexe 5
☐ Household and institutional survey	Annexe 6
☐ Technical survey	Annexe 7
☐ Environmental and social safeguard survey	Annexe 8
☐ Determining water requirements and the best available technology	Annexe 9
Step III: Analysis and design	
☐ Electromechanical design	Annexe 10
☐ Civil design	Annexe 11
☐ ESMP, risks, and mitigation	Annexe 12
☐ Operational and management plan	Annexe 13
☐ Cost-benefit analysis	Annexe 14
☐ Costs and bill of quantity	Annexe 15
Step IV: Finalising the detailed feasibility study	
☐ Briefing the project owner and key stakeholder(s)	Annexe 16
☐ Briefing the community	Annexe 17
☐ Revision of the detailed feasibility study report	Annexe 18
☐ Finalisation of the detailed feasibility study report	Annexe 19

Annexe – Step I

Inception stage

Annexe 1.

Initial consultations with the project owner and primary stakeholder(s)

1. Upon initiation of the DFS work, the first step is to meet with the project owner for the following information:
   a. Learning about the project background and activities conducted before the DFS.
   b. Understanding the project objectives, scope, and expectations of the project owner on the DFS.
   c. Identifying the key stakeholders of the project and their roles.
   d. Learning about the site characteristics from the project owner's prior site visits (if applicable).

2. Consultations with the primary stakeholder(s) who are already engaged in the project will be necessary. This will help in:
   a. Knowing about their role in the project.
   b. Learning about the activities conducted before the DFS.
   c. Learning about the site characteristics.

Annexe 2.

Study of background materials

1. Upon initial consultations, the relevant background materials of the project shall be requested from the project owner and the primary stakeholder(s) for the study. These materials are parameters at the three-tier levels, project concept notes, preliminary site information, demand applications, etc. respective to the nature of the project. The background materials will give a deeper understanding of the project and prior activities.

Annexe 3.

Detailed feasibility study work plan

1. Upon study of the background materials, an inception report with a detailed work plan shall be prepared in consultation with the project owner. The inception report should include:
   a. Project objectives and scope of work.
   b. Timeline and chronological sequence of activities.
   c. Roles and responsibilities of the team members, including details of support from the project owner's team.
   d. Detailed methodology of the DFS along with listing of the equipment to be used.

e. Identification of the local stakeholder(s) and project enablers to the extent possible. For example, the nearest Agriculture Knowledge Centre, research institutions, and agricultural markets, to name a few. Guiding questions need to be prepared for each stakeholder and project enabler.
f. Questionnaires for the site survey. These include:
   i. FGD questionnaire.
   ii. Household and institutional survey questionnaires.
   iii. Technical, environmental, and social safeguard questionnaire.

Annexe 4.

Preparation for the site survey

1. Upon preparation of the inception report, contact shall be established with the community and relevant stakeholders. The initial contact shall aim to establish the following:

   a. Introduce the DFS team and their objectives.
   b. Identify and invite the community members who will participate in the FGD during the site survey. The invitations should satisfy norms related to gender equality and disadvantaged and socially inclusive representation (see Annexe 5).
   c. Communicate the activities that will be conducted during the site survey. For example, the community members must be aware that the household and institutional survey will be conducted on a certain date so that they can plan their presence accordingly.
   d. Plan a detailed itinerary for the site survey.

2. Before the site survey, the local stakeholder(s) and project enablers shall be contacted to the extent possible to communicate the objectives of the DFS and to plan a meeting during the site survey.

3. The DFS team shall equip itself with all the necessary documents, tools, and resources that are needed during the site survey.

Annexe – Step II

Survey checklist

Annexe 5.

Community, local government, and stakeholder engagement

1. The rationale and the narrative of the DFS must be anchored in effective community and stakeholder engagement. At the stage of the feasibility study, community groups may not have been formed. In this case, prior communication shall be initiated with the community personnel to identify a representative group that is inclusive and has representation from the ward office or rural municipality.

2. To ensure active community engagement from an early stage, the site survey during the DFS should conduct FGDs with a preset questionnaire. The FGDs shall be arranged on the following major aspects:

    a. Community members and the local government should be informed beforehand and invited for the FGDs with instructions on maintaining gender equality and having disadvantaged and socially inclusive representation.

    Example: *The community will be interested to participate and learn about new projects in their area. In areas with hierarchical ethnic differences, there is a risk that only the elite will actively participate in the project activities, leaving the disadvantaged ethnic groups behind. During the site survey, the DFS team must understand the demographics of the project area and ensure that all the ethnic groups of the project area are represented equally in the FGDs.*

    b. If there are any existing user group(s) in the project area, they should be invited to the FGDs. During the site survey, administrative information on the user group(s) shall be collected, including on:

        i. Existing projects or systems that are managed by the community via formations such as water user group, mother's group, women's group, or any other relevant group.
        ii. Formation of the user group members in terms of gender, equality, disability, and social inclusiveness.
        iii. Governance structure and roles and responsibilities of the user group.
        iv. Financial performance and transparency in operations of the user group.
        v. The service efficiency of the user group functions.
        vi. Conflicts relating to the user group.

Example: *A user group has been successfully managing a solar mini-grid system within the project area. It has been collecting timely electricity tariff from the households and properly operating the grid. The survey during the DFS should study the operation and management modality of the existing solar mini-grid user group. The data related to the members of the user group, its cohesiveness (in terms of regular meetings, conflict handling, reporting procedure), and its efficiency (timely tariff collection and user support) should be observed and recorded.*

3. These data will then inform the DFS regarding the operational modality of the renewable energy irrigation system.

4. Discussions and conclusions of the FGDs shall be documented and endorsed by the participants.

5. During the DFS, multiple stakeholders need to be consulted and engaged. These stakeholders may be from the government, nonprofit, or the private sector depending on the nature of the project. Thus, the stakeholder engagement plan shall follow AEPC's Stakeholders Engagement Framework, 2023 [15].

6. During the discussions with the community, inquiries should be made regarding existing and historical projects related to agriculture and irrigation within or near the project area. The purpose of this is to:
   a. Learn about the past initiatives in the project area (in terms of institutional support, activities, timeline, and costs).
   b. Note the successes, failures, and learnings from the historical projects.

This information is to be gathered from the household and institutional survey, as well as from FGDs, and may inform the design and analysis during the DFS.

Example: *During the site visit, it is learnt from the community that near the project site, a community-based pumped irrigation system had been implemented three years ago. The operational model of the project included collection of water tariff from the farmers on a per-litre basis. However, the user group did not diligently collect the tariff which led it to not being able to pay the monthly salary of the pump operator, and after four months of work, the operator resigned from the role. After the operator's resignation, the pumping system was not adequately maintained, and soon, after a year's operation, the pumping system stopped working due to a technical glitch. Now the user group is struggling to gather funds to repair the pumping system.*

7. Learning about such cases through the survey will alert and inform the design team to take preventive measures while recommending potential operation and management models at the DFS stage itself.

8. During the discussions with the community, inquiries should be made and responses recorded regarding the responsibilities held by the community on past projects. In some cases, the responsibilities or obligations of the community towards past projects can serve as a motivation to ensure the success of the irrigation system.

Example: *The existing user group may have an outstanding loan from the micro-hydropower plant constructed three years ago. The obligation to repay the loan may be a motivating factor to maximise income via agriculture production, and hence may serve as a strong impetus to support the irrigation system. The user group may also be willing to restructure the group by expanding its role as a water user group.*

Annexe 6.

Household and institutional survey

1. The household and institutional survey will gather information about the demographic, administrative, and socio-economic status of the community. This will support the CBA, enable a representative formation of the user group at a later stage, and help gauge the ambition and willingness of the community to maximise irrigation for income purposes. A questionnaire needs to be developed before this survey.

2. During the site survey, demographic information about the community shall be collected; this will cover: gender relations; disaggregation of labour by sex; land ownership; and castes and ethnicities.

3. During the survey, information about the socio-economic condition of the community shall be collected under these four aspects:

    a. Employment
        i. The employment status of members of each household.
        ii. Status of in- and out-migration.
        iii. Year-round availability of household resources for agricultural activities.

    b. Income
        i. Income sources of households with a focus on agricultural income.
        ii. Adequacy of income related to expenditure and saving.

    c. Family and social support

i. Roles of household members (men, women, and children) in agricultural activities.
ii. Social benefits that households have been receiving from the government, nonprofits, or other institutions for agricultural activities.

d. Education
   i. Literacy status of the members of each household.

Annexe 7.
Technical survey

The technical survey gathers data on the following: water requirement for irrigation; appropriate energy sources to power the pump; electromechanical design; and civil design.

7.1 Statutory requirements

1. Land-use permit: At the DFS stage, the land for the installation and construction of the system equipment and components shall be identified. Land-use permits shall be obtained for:

   a. Civil infrastructure (for example, intake systems, filtration systems, collection reservoir, distribution reservoir, transmission pipes, and distribution pipes).

   b. Electromechanical equipment and components (for example, right-of-way for extension of power distribution line, solar photovoltaic array, and control equipment placement).

   Private land: Private land may be acquired through voluntary means or by negotiation (through lease agreements, purchase, or other arrangements). A letter from the local government is necessary, providing details and confirming the private land acquisition.

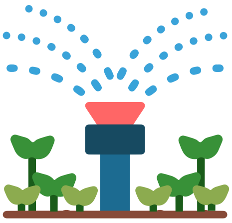
   Public land: The use of public land requires a permit from the local government assembly. A letter from the local government is necessary, providing details and confirming the public land acquisition.

   Any conflict relating to the use of land shall be resolved as per local regulations and social safeguarding practices.

2. Water-use permit: At the DFS stage, the source(s) of water for the irrigation system shall be identified and permission for water use shall be obtained from the community and the local government assembly. The details of the water source(s) and permission for their use shall be stated in a letter issued by the local government.

3. Environmental assessment: The DFS should comply with the environmental assessment based on site characteristics. (See Annexe 8 for more details.)

4. Any other statutory requirements specific to the project shall be fulfilled.



7.2 Agriculture and irrigation

7.2.1 Existing practices in agriculture and irrigation

1. During the site survey, data regarding the existing practices in agriculture and irrigation shall be gathered which will inform the analysis of the DFS with baseline information and contextualised design decisions.

   a. **Agriculture:** The market opportunity and current agricultural practice of the community should be recorded. The information that should be included are:
      i. Practised types of crops and share of crops in the crop cycle.
      ii. Assessment of market opportunities and competitiveness for any specific crop production.
      iii. The practice of staple low-value crops and high-value crops, including crops with high nutritional value.
      iv. The practice of any modern agricultural methods.

Example: Conservation agriculture involving mulching, minimum tillage, and incorporation of crop residues.

v. Agriculture inputs that are used during the entire growth period of each crop.

Example: Agriculture inputs include plant cost, manure, fertilisers, and other inputs used during the total growth period.

vi. The proportion of self-consumption and sale of crops by households.
vii. Assessment of land utilisation for agriculture.

Example: Is the agricultural land being utilised to its maximum? If not, what are the limitations and how can land utilisation be increased?

viii. Cohesion in the crop production practice among the farmers.

Example: Are the farmers in the community cooperating with each other and planning crops in a coordinated manner? Or, are agricultural practices fragmented and individualistic?

ix Existence of any farmers' groups, cooperatives, or mothers' groups working together for the betterment of agricultural production.
x. Roles of each gender in agricultural activities.
xi. Status of participation of socially disadvantaged groups in agricultural activities.
xii. Condition of land pooling and land fragmentation in the area.
xiii. Agriculture limitations faced by the community
xiv. Human and wildlife conflicts in the area.

This assessment will give insights into how the community is practising agriculture and will help design a pragmatic irrigation system.

b. **Irrigation:** During the site survey, the current means deployed by the community for irrigation should be recorded. The guiding information that should be included are:
   i. Water sources that are currently used for irrigation.
   ii. Technologies currently utilised for irrigation.

Example: A community may be using sprinkler or drip irrigation methods.

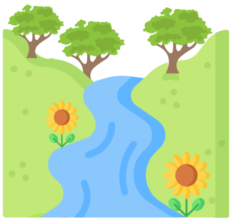
iii. Resource-sharing of irrigation mechanism, its pattern, and sufficiency among the farmers.

Example: There may be a water distribution reservoir and the distribution pipes cover the project area partially. Thus, the farmers are in the habit of sharing this distribution infrastructure. They may schedule irrigation in their fields on a weekly or fortnightly basis based on the availability of water.

iv. Any mechanism/experience of fee collection for relevant services.
v. Roles of each gender in agriculture and irrigation.
vi. Status of equality among caste and ethnic groups in agriculture and irrigation resources.
vii. The existing method of water rationing among farmers, if any.

Example: Are farmers irrigating cropland based on an understanding of crop-water requirements or are they simply depending on their own experiences?

viii. Irrigation limitations faced by the community.



7.2.2 Water sources and availability

1. Upon understanding the existing practices in agriculture and irrigation, the site survey should assess the potential source(s) of water.

    ix. Water sources:
    x. River
    xi. Stream and spring
    xii. Canal
    xiii. Open well
    xiv. Borewell/Deep tube well
    xv. Lake
    xvi. Pond

2. The four aspects that must be considered during the identification of water source(s) are shown in Figure 2.

    a. *Year-round availability of water*: Whether adequate water is available for irrigation year-round; this also means understanding the seasonal variations from the source.

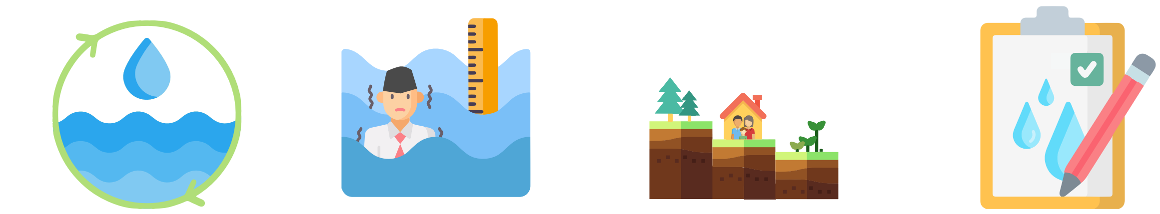


Figure 2. Four aspects of the identification of water source

b. *Protection from extreme events*: The potential risks to the water source during extreme events should be understood; this will influence the design of the water intake infrastructure. Information on extreme events can be gathered via:
    i. Recording the community's experience of extreme events during the site survey.
    ii. Historical extreme event data can be obtained from the Department of Hydrology and Meteorology or online databases like the one of ICIMOD on flood inundation mapping; this will inform the selection and placement of the components of the pumped irrigation system.

c. *Equitable water use*: The use of water sources for irrigation purposes should not disturb the existing use of water in the project area and downstream, and should avert conflicts regarding water use in the community.

d. *Water-use permit*: The local government (rural municipality/municipality) shall permit the use of water for irrigation purposes via an official letter.

Example: *In the case of a river, assess the immediate downstream use of the water. If the river water is being used downstream for drinking water purposes near the project area, the impact of the project on the drinking water system will have to be assessed.*

In the case of stream and canal, assess the immediate downstream use of the water and assess the adequacy of the flow after pumped irrigation. The downstream use of water should not be disturbed by pumped irrigation.

In the case of an open well (either existing or to be constructed), assess the security of the well when it comes to extreme events such as floods (see 7.3.2 for details). For an existing open well, assess the recharge rate if there is an existing pumping mechanism.

In the case of a borewell/deep tube well (either existing or to be constructed), assess the water level.

3. For water sources where groundwater is to be utilised, the basics of groundwater sources should be understood for the betterment of the site survey. A geologic formation from which significant amounts of groundwater can be pumped is known as an aquifer. There are two types of aquifers: unconfined and confined. An unconfined aquifer has no water barrier, i.e. it is permeable (for example, the uppermost aquifers) and may be recharged by rainwater or irrigation water. The water level in a borehole drilled into an unconfined aquifer will be at the same depth as the water table in the aquifer [16].

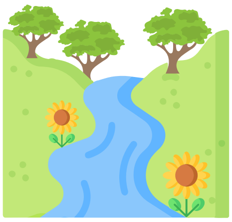
   A confined aquifer is a sandwich between water barriers (for example, bedrock). The water in a confined aquifer is pressurised, meaning that the water level in a borehole drilled into a confined aquifer will rise significantly above the top of the aquifer [16].

   Surface water is water on the land surface in the form of rivers, streams, lakes, and wetlands. Surface water comprises the gravity movement of water in channels; this varies in size – from those containing the smallest, ill-defined trickles to the largest rivers [17].

   An irrigation system may utilise either a groundwater source or a surface water source depending on the site characteristics. Having a basic understanding of these water sources will help suggest strategies for managing missing data about a water source and thus make informed recommendations on source protection during site surveys. All suggestions and discussions shall involve the community ensuring that there are no social restrictions on water use and management.

4. After further analysis, the DFS shall also identify an alternative water source in case the preferred water source cannot be utilised.

7.2.3 Reviving springs



1. Effective and sustainable management of water resources plays a crucial role in ensuring the success of agricultural activities and promoting the overall welfare of communities. The incorporation of nature-based solutions (NbS) for water replenishment, such as in the form of restoration of springs, is of great importance, in tandem with lift irrigation, within the context of the irrigation systems in Nepal. NbS are essential for the preservation of water balance and the replenishment of groundwater. These solutions comprise a range of practices, including afforestation, wetland restoration, soil conservation, and the revival of springs [18]. The incorporation of NbS in lift irrigation is a collaborative strategy that can amplify the accessibility of water resources for agricultural activities. In this context, the act of reviving springs not only serves to enhance the availability of water resources but also facilitates the rejuvenation of indigenous ecosystems within the surrounding area. In the Nepalese milieu, where the issue of water shortage is a serious concern, it becomes imperative to conduct a complete feasibility study that encompasses NbS. The study should also specifically focus on the resurrection of springs and the use of lift irrigation techniques. Such an integrated strategy can not only tackle the issue of water scarcity but can also encourage the adoption of sustainable water management practices, thereby guaranteeing the enduring efficacy of irrigation systems.

7.2.4 Mapping the command area

1. The command area means the land area to be irrigated by the pumping system.
2. The entire command area should be demarcated using plot-register prints if available. The plot-register prints will allow for the identification of the landholdings, ensuring that no one is left behind. This provides a basis for the design of the water distribution mechanism.
3. Survey the area to gather relevant data, including about boundary lines, topography, soil types, existing land use, and the locations of water sources and water reservoir.
4. Obtain a copy of the land area map from the Survey Department of the Government of Nepal. Use the map to divide the command area into smaller zones based on factors such as crop type, soil type, topography, and water requirements. These zones help in better management of water distribution and ensure that each area receives an appropriate amount of water.
5. Within each zone, map the individual fields and plot their locations, areas, and the type of crops or plants grown in each field.
6. The mapping of the command area and the collection of data shall be conducted in consultation with the community members and they shall be briefed during the FGD.

7.2.5 Agriculture and water-use plan

1. After understanding the current agriculture and irrigation practices, the future agriculture and water-use plan following the installation of the irrigation system should be prepared in consultation with the community. The issue of access to and right to water is frequently contentious and is a source of conflict amongst the communities [19]. Therefore, the agriculture and water-use plan should be prepared during the FGD.

2. The outputs of the discussion on the agriculture plan should include:

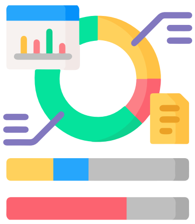
    i. An annual crop calendar for the command area.
    ii. Agricultural inputs required for each crop type.
    iii. Estimated quantity of season-wise production for each crop type.

3. The outputs of the discussion on the irrigation plan should include a mechanism of equitable and timely water distribution without negatively impacting crop growth in any of the plots.

Example: Within a cluster of the same crop plantation, irrigation needs may coincide – all farmers may require water on the same day. In such cases, the distribution of water should be staggered.

Example: A water-use plan is to be developed for a solar-powered, community-based pumped irrigation project. The community agrees on hourly scheduling for water distribution. However, because of the characteristics of solar radiation, the farmers receive considerably less water in the morning and evening even though each farmer has been allocated equal time. The DFS must consider and mitigate such potential issues when designing a water-use plan.

The water-use plan also needs to highlight water-accounting methods to ensure that sufficient water resources are available year-round. An irrigation schedule needs to be developed so that water resources are equitably distributed. Provisions of adopting micro-irrigation technologies such as drip and sprinklers need to be identified for efficient use of water resources (see Annexe 11.5 for details).



7.2.6 Inputs for cost-benefit analysis

1. CBA holds significance when assessing small- and medium-scale irrigation systems designed for subsistence agriculture. Subsistence farmers often operate with limited resources, and the implementation of an irrigation system can have profound implications for their livelihoods. In the absence of comprehensive CBA analysis, decision-makers/implementers struggle to showcase the rationale of irrigation interventions.

2. During the site survey, on-farm inputs for the CBA shall be collected. The CBA should take into account the on-farm inputs and the interventions that support on-farm production.

On-farm inputs are as follows:
   a. Seeds
   b. Water
   c. Fertilisers, pesticides, and other chemicals
   d. Land
   e. Management

The data shall be gathered for each crop type.

Interventions to support on-farm production are as follows:
   a. Transportation
   b. Storage
   c. Processing and packaging
   d. Market information
   e. Policies and institutions
   f. Access to finance

The data regarding the interventions that support on-farm production shall be collected during the DFS survey.

3. Empirical data on the following questions need to be obtained for calculating the net value of the agricultural output (obtained from *Agriculture Sector Cost-Benefit Analysis Guidance* report [20]):

   a. Typically, how many seasons do farmers cultivate crops in?
   b. Which crops do farmers grow and what shares of their plots are devoted to the cultivation of each of these crops?
   c. What are the output prices?
   d. What yields do farmers achieve on average and what share of value is lost to spoilage?
   e. Which inputs do farmers use, in what quantities, and at what costs?
   f. What is the total area under cultivation total, how many beneficiary farmers are there, and what are the average beneficiary farmer plot sizes?

Further, to comprehend the extent to which farmers may change their farming behaviours after the project, an understanding should be developed of the current farming practices.

4. To calculate the net value of the agricultural output, data on the following key inputs are crucial:
   a. *Planting seasons*: Information about how many seasons farmers typically cultivate crops in a year serves as a basis for analysing whether the pumping system will enable the community to increase the number of planting seasons in a year. While it must also be recognised that the entire community may not increase their planting seasons in a year, some farmers may do so.

Example of information on planting season aiding the CBA: Before the advent of the project, the farmers who are now benefitting from the project would presumably have experienced smaller income increases by cultivating crops in multiple seasons. Thus, it would be useful to understand the extent to which the farmers were already familiar with and making profits from off-season cultivation before the establishment of the project [20].

   b. *Crop choice*: Crops that the farmers choose to grow will have a significant effect on their incomes. However, this must be evaluated against their tolerance of risk.

Example of risk aversion: Farmers may choose to continue cultivating low-value, weather-robust staple crops even though they understand that high-value crops will increase their income. This decision may stem from the choice to avoid the risk of a failed crop and subsequent hunger compared to maximising expected income.

   The data collected should also consist of a list of crops that the farmers grow and the share of the plot for each crop.

   c. *Prices*: Prices determine the value of the agricultural output, and thus, it is a key input for the CBA. In the financial analysis, if the agricultural output reaches the market via middlemen who cover the transportation costs, the farm gate price data should be taken to calculate farmer incomes. Similarly, if the project owner himself/herself is responsible for managing the supply chain to the market, the market price should be calculated by factoring in transportation, farm gate price, and profit.

   For better accuracy, the price data should be collected for multiple years so that an average can be taken. This data should be compared with data from agricultural research institutes or data from nearby regions through secondary sources. If the data collected is inconsistent and varies greatly, it is advised to take the minimum value for conservative calculations.

It must be noted that price rates could vary depending on the quantity that is sold (in settings where buyers offer bulk premiums) [20].
After the implementation of the project, the prices may increase or decrease. With the rising local and national demand, food prices may increase. However, food prices may also decrease if the supply exceeds the local demand and there is lack of access to distant markets. This can be analysed by gauging the appetite of the local market in terms of current sales and demand – and whether the increased yield or lucrative crops grown from the improved irrigation system can be absorbed in the local market and whether they have the ability to access distant markets. If there is a lack of data on the local market, projections should be made based on the trend of past prices.

d. *Yields*: Crop yields determine the quantity of the agricultural output, and thus, it is a key input for the CBA.

   To factor in inter-annual variation in yields, the yield data should be collected for multiple years so that an average can be taken. This data – on crop types and their yield – can be obtained from the farms and from agricultural research institutes or other credible institutions.

   Factors such as the decrease in crop yields caused by increasingly common occurrences of flood and drought can be taken into account for an accurate projection. However, if there is a lack of data about how yield changes over time, projections should be made based on the trend of yields in recent years.

e. *Inputs*: The CBA must account for the monetarised opportunity costs of all the inputs that are used in the production of an agricultural output. These include:

   i. Cost of capital
   ii. Materials such as fertilisers, pesticides, insecticides, water, seeds, and other items associated with harvest such as nets or bags.

   The costs should include both social costs and costs incurred in a unit of input. In the financial analysis, the prices that farmers incur should be used. The data for these inputs shall be obtained from a representative sample of beneficiary farmers. In the absence of data from a representative sample, data from agricultural research institutes or other credible institutions should be used.

   While calculating the quantity and value of any labour, both hired and family labour should be accounted for because each will be involved in a variety of agricultural tasks. All labour should be valued according to its most likely or feasible alternative use, which could be the local wage for unskilled labour or zero (if labour would otherwise be unemployed). This means that the extent of seasonal migration and the wages that might be earned by unskilled migrant members of farm households should be understood (particularly during seasons when cultivation is rare). This data can be obtained from the household and institutional survey. However, if this survey does not reveal the information, local experts should be consulted to provide an overview of the local labour context.

5. The CBA should be able to assess the farmers' living standards. Some guiding questions related to economic analysis during the site survey shall be (obtained from the *Agriculture Sector Cost-Benefit Analysis Guidance* report [20]):

    a. Are farmers earning a comfortable living, or are they just near subsistence?
    b. Are farmers willing to take risks concerning crop choices or input usage, or do they seem unwilling to invest in these ways?
    c. How widespread is the experience in cultivating more lucrative crops, and to what extent do farmers seem focused on the cultivation of relatively hardy staple crops?
    d. Do farmers seem to behave as if they are trying to maximise their (net) incomes, or is their primary objective perhaps more related to household food security and minimising the likelihood of experiencing crop failure?

7.3 Civil survey

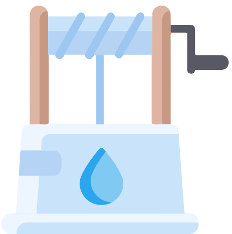
7.3.1 Delivery head

1. During the site survey, the vertical height from the water source to the maximum water delivery point shall be measured. This parameter is important for the adequate sizing of the pump; thus, the accuracy of the measurement method shall be carefully evaluated.

Example: *Engineer A recorded two GPS points during the site visit, one for the location of the stream and the other for the location of the distribution reservoir. A vertical height of 50 m is calculated after plotting the two GPS points in Google Earth.*

For verification, Engineer B used Total Station (which is more accurate than obtaining the vertical height from Google Earth) to determine the vertical height between the stream and the distribution reservoir. Engineer B calculated the vertical height to be 37 m.

If the desired water flow is 20 m3/h, Engineer A identified a 6 HP pump and Engineer B identified a 4.5 HP pump. This demonstrates that the accuracy of the vertical height measurement has significant implications in terms of the selection of the pump size and the corresponding system costs. Therefore, the accuracy and limitations of the measurement instruments must be known and appropriate instruments should be selected.



7.3.2 Water intake survey

1. A water intake mechanism connects the water source to the collection reservoir. A careful survey of water intake infrastructure is important to appropriately size the structures to meet the water requirement year-round and to ensure safe pump operation.

2. The location and the type of water intake infrastructure shall be assessed based on the following factors:

   a. *Security from natural risks*: The intake structure should be designed considering the factor of safety and appropriate measures for security from natural risks. With access to historical extreme event data, climate-proofing measures can be adopted for the longevity of the infrastructure.

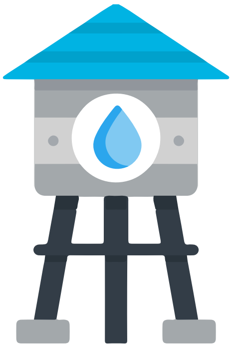
Example: *If the intake system has to be located at a river bend, it must be in a stable area, and it should be at the outer bend to limit sediment deposition and to ensure flow availability during the dry season. Rock outcrops or large boulders that offer natural protection to the intake structure should be taken advantage of.*

b. *Adequacy of year-round water flow*: The water intake system shall ensure that the required quantity of water can be withdrawn from the water source year-round to meet the irrigation needs.

c. *Ease of construction and maintenance*: The type of water intake assessed should take into account the locally available materials and ease of transporting materials to the site for construction.

   Similarly, the type of water intake should be assessed considering ease of maintenance.

Example: In gravel trap and settling basin, a flushing arrangement should be provided to flush out gravel and sediment [21].



7.3.3 Reservoirs survey

1. A reservoir is an open or closed storage area (usually formed by masonry) where water is collected and kept in quantity so that it may be drawn off for use. A reservoir may or may not be needed depending on the site conditions.

2. Depending on the need, irrigation systems generally have two reservoirs: (i) a collection reservoir; and (ii) a distribution reservoir.

   a. *Collection reservoir*: The collection reservoir is connected to the water intake system and is constructed near the water source. During the site survey, the location of the collection reservoir shall be assessed based on the following factors:

      i. *Security from natural risks*: Assess the natural risks in the location of the collection reservoir. This can be assessed based on historical events at or near the location, as learnt from the community, or from available historical events data. The experience and expertise of the survey team shall contribute to the identification of the natural risks.
      ii. *Adequate land area*: The land area for the collection reservoir should be adequate with margins for expansion. The margin for expansion is recommended because, at the time of the site survey, the capacity and dimensions of the collection reservoir will not have been determined.
      iii. *Secure placement of pump*: During the site survey, the optimal mechanism for secure placement of the pump shall be identified.

Example: In the case of a submersible pump, the collection reservoir shall allow enough space inside it for the installation of the submersible pump.

In the case of a surface pump, the collection reservoir shall allow provisions for the suction pipe of the surface pump.

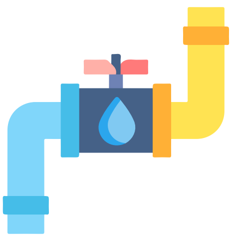
iv. *Ease of construction and maintenance:* During the site survey, the locally available construction materials shall be listed.

b. *Distribution reservoir*: The distribution reservoir is constructed near the command area and connected to the water distribution network.

The location and design of the distribution reservoir shall be assessed based on the following factors:

i. *Security from natural risks:* Similar to the assessment of the water intake structure, the location of the distribution reservoir shall be selected based on an assessment of the natural risks involved. This can be assessed based on any historical events at or near the location, as learnt from the community, or from available historical events data. The experience and expertise of the survey team shall contribute to the identification of the natural risks.
ii. *Adequate land area:* The land area for the distribution reservoir should be adequate with margins for expansion. The margin for expansion is recommended because, at the time of the site survey, the capacity and dimensions of the distribution reservoir will not have been determined.
iii. *Ease of construction and maintenance:* During the site survey, the locally available construction materials shall be listed.

7.3.4 Water transmission survey



1. Water transmission is the medium through which the pumped water from the intake system is transported to the distribution reservoir.

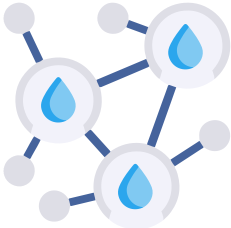
2. During the site survey, the water transmission mechanism shall be assessed based on the following aspects:

a. *Pathway*: The shortest pathway of the transmission pipe should be mapped in consultation with the community.

b. *Permit*: The pathway of the transmission pipe should have the community's approval without the likelihood of disputes. The permission for the plots where the transmission pipe will be laid has to be confirmed through a letter issued by the local government.

c. *Environmental and natural risks*: All environmental and natural risks along the transmission pipe pathway shall be recorded and their mitigation measures, including climate-proofing mechanisms, shall be identified.

d. *Infrastructure components*: Pertaining to the site conditions, the components of the water transmission system will vary. Therefore, during the survey, all the components that will ensure reliable water transmission should be assessed and recorded rather than relying on a standard bill of quantity.



7.3.5 Water distribution network survey

1. The water distribution network is the medium through which water is distributed from the distribution reservoir to the irrigation plots.

2. During the site survey, the distribution network shall be assessed based on the following aspects:

   a. *Pathway*: All pathways of the distribution network should be mapped in consultation with the community.

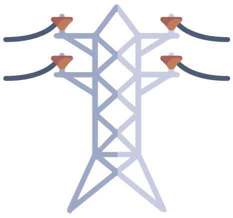
Example: *The laying of pipe through private land can be a sensitive issue for the landowners and conflicts may arise during installation. Thus, while mapping each pathway of the distribution network during the survey, the owners of the land should be consulted and alternative routes should be recorded if there is potential for conflicts.*

   b. *Permit*: The pathway of the distribution network should have the community's approval without the likelihood of disputes. The permission for the plots where the distribution pipes and their components will be laid has to be confirmed through a letter issued by the local government.

   c. *Environmental and natural risks*: All environmental and natural risks along the transmission pipe pathway shall be recorded and their mitigation measures, including climate-proofing mechanisms, shall be identified.

   d. *Infrastructure components*: Pertaining to the site conditions, the components of the water distribution system will vary. Therefore, during the survey, all the components that will ensure reliable water distribution should be assessed and recorded rather than relying on a standard bill of quantity.

7.4 Energy and electromechanical survey



7.4.1 Available electricity infrastructure survey

1. Electricity should be available to power the pump and its supporting electrical and electronic systems. The source of energy may be selected based on the site conditions. However, along with the availability of electricity, the characteristics of the electricity source must also be assessed; those are:

    a. Quality of electricity supply: Quality looks at the usability of the energy. (For a definition, refer to Terms and Definitions.)

Example: *Measuring the voltage and checking if it is fit to power the electrical and electronic equipment.*

    b. Capacity of electricity supply: Capacity looks at the capacity of the energy source to accommodate the addition of an irrigation system. (For a definition, refer to Terms and Definitions.)

    c. Availability of electricity supply: Availability looks at the ability to use electricity when needed by the user. (For a definition, refer to Terms and Definitions.)

    d. Reliability of electricity supply: Reliability looks at the consistent performance of the electricity over a period of time. (For a definition, refer to Terms and Definitions.)

Example: *There may be grid electricity available in the project area but it suffers from frequent outages every day – thus, making it unreliable.*

    e. Compatibility: Compatibility looks at the provisions of integrating the pumping system into the existing infrastructure.

Example: *A single-phase power distribution line is not compatible to power a three-phase pump.*

    f. Affordability: Affordability looks at the capacity of the project owner – ascertained through the CBA – and determines whether the owner can afford to utilise the selected electricity source and its infrastructure.

2. To power the pumping system, all sources of electricity within the site must be recorded in the DFS. This may include but is not limited to, existing mini-/micro-hydropower plants, solar photovoltaic systems such as solar mini-grids, wind energy systems such as wind-solar hybrid mini-grids, or the national grid. These examples are shown in Figure 3.

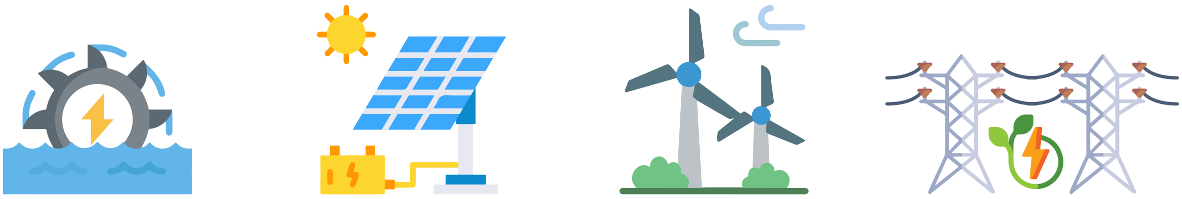


Figure 3. Examples of available energy infrastructure in the site

7.4.2 Location of electromechanical components survey

1. During the site survey, the appropriate locations of the electromechanical components shall be identified. The electromechanical components include a pump, controller, protection equipment, and cable router, to name a few. The location of the components is subject to the location of the water source and the selected source of energy supply. For example, the pump may be located in the water intake adjacent to the water source while the electrical control panel that powers the pump may be located near the solar photovoltaic array in the case of a solar photovoltaic system.

2. Any permits or agreements relating to the location of the components shall be documented.

Example: *A control room may have to be constructed for the placement of a controller box and protection equipment. This requires land permission for its construction. The user group or the community may agree to allocate land for a control room based on monetary compensation or other conditions. After negotiations, the user group may agree to compensate the landowner if the project comes to fruition. Therefore, the DFS must include the minutes of the meetings with the user group, the person concerned, or the relevant entity(ies), along with a letter from the local government.*

3. The location of the components shall be appropriately documented with the aid of drawings, GPS coordinates, and photos.

Annexe 8.

Environmental and Social Safeguard survey

1. Renewable energy irrigation systems must undergo an environmental and social safeguard assessment based on the Environmental and Social Safeguard Policy, 2018, of AEPC. During the site survey, an environmental and social assessment exercise shall be conducted in line with the seven principles outlined in the policy:

    i. Assessment and management of environmental and social risks, as well as impacts.
    ii. Biodiversity conservation and sustainable management of living natural resources.
    iii. Human rights.
    iv. Labour and working conditions.
    v. Community health safety and security.
    vi. Land acquisition and involuntary resettlement.
    vii. Resource efficiency and pollution prevention.

As per the Environmental and Social Safeguard Policy, 2018, of AEPC, projects are divided into three categories.

Category A: Projects with the potential to cause significant adverse social and/or environmental impacts which are diverse, irreversible, or unprecedented.

Category B: Projects with the potential to cause limited adverse social and/or environmental impacts which are generally site-specific, largely reversible, and readily addressed through mitigation measures.

Category C: Projects that include activities with minimal or no risks of adverse social and environmental consequences.

Projects in Category A are discontinued from the initial conceptual phase itself or require an Environmental Impact Assessment (EIA) study.

Projects in Category B require an Initial Environmental Examination (IEE) study.

Projects in Category C require an Environmental and Social Management Plan (ESMP).

Resettlement Action Plan (RAP) and Abbreviated Resettlement Action Plan (ARAP): During the social screening, if the proposed project refers to involuntary resettlement and dislocation, RAP (Category A) and ARAP (Category B) documents shall be prepared.

Vulnerable Community Development Plan (VCDP) or Indigenous Peoples Plan (IPP): If it’s involuntary land acquisition and involuntary resettlement, VCDP and IPP shall be prepared along with RAP or ARAP.

2. During the site survey, information relating to any environmental or social protection zone shall be gathered. These include whether the project area falls under:

    a. Buffer zone
    b. Conservation area
    c. Community forest
    d. National park
    e. Hunting reserve
    f. Wildlife reserve

As per the Environmental Protection Rule, 2020, projects in the buffer zone, conservation area, and community forest will require a Brief Environmental Study.

Projects in the national park, hunting reserve, and wildlife reserve will require an EIA.

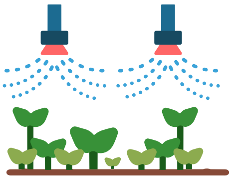
3. During the analysis, it is probable that some aspects of the project will be rejected due to conflict with environmental and social norms. Hence, during the site survey, the DFS shall identify alternatives to the proposed aspects of the project, especially in terms of:

    a. Land use (includes alternative placement of civil and electromechanical components)
    b. Water use (includes an alternative water source)

4. The DFS should justify the proposed land-use and water-use aspects of the project.

Annexe – Step III

Analysis and design checklist



Annexe 9.

Determining water requirements and the best available technology

9.1 Water requirement and total dynamic head

1. Determining the daily water requirement is the first stage of analysis and design because the technical design and subsequent economic analyses hinge on the water requirement for irrigation. Similarly, for the design and selection of a pump for the irrigation system regardless of the source of energy, the crop-water requirement per day for the command area has to be determined.

Example: *If a pump is to be powered by a micro-hydropower plant, the fulfilment of daily water requirements shall consider factors such as the operating period of the plant and the capacity of the distribution reservoir.*

Similarly, if a pump is to be powered by solar photovoltaics, the fulfilment of daily water requirements shall consider the site-specific solar resource availability (by simulating over seasons) and the capacity of the distribution reservoir.

2. The crop-water requirement shall be calculated by taking into account soil, climate, and crop parameters such as:

    a. Minimum and maximum temperature
    b. Relative humidity
    c. Wind speed
    d. Sunshine hours/solar irradiance
    e. Average rainfall
    f. Soil characteristics
    g. Crop types and plantation plan
    h. Crop calendar

Recognised guidelines and tools shall be used for calculating the crop-water requirement.

Example: *The Food and Agriculture Organization (FAO)'s guidelines for computing crop-water requirements – as cited in its Irrigation and Drainage Paper – describe a detailed procedure for such calculations.*

Similarly, the CropWat computer program developed by FAO is to be used to estimate crop water and irrigation requirements based on soil, climate, and crop data. In addition, the program allows for the development of irrigation schedules for different management conditions and the calculation of scheme water supply for varying crop patterns. CropWat can also be used to evaluate farmers' irrigation practices and to estimate crop performance under both *rain-fed and irrigated conditions. CropWat is based on FAO's No. 56 "Crop Evapotranspiration – Guidelines for computing crop water requirements" and No. 33 titled "Yield response to water" [22].*

3. When a pump is lifting or pumping water, the vertical height from the elevation of the suction side of the pump to the elevation of the discharge side of the pump. The total dynamic head is the static head plus pipe friction losses.

9.2 Selection of energy infrastructure

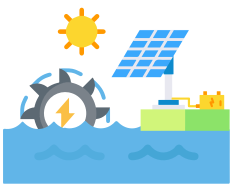
1. All attributes described in Annexe 7.4.1 shall be deemed satisfactory for considering the source of electricity for the pumping system.

Example: A site is located 100 m from the power distribution line of an existing mini-hydropower plant. The extension of the distribution line to power the pump is a possibility. During the DFS, the capacity, availability, reliability, and quality of the electricity of the plant shall be assessed. Given that this is the most likely economical solution, other sources of electricity shall only be considered if the assessment of the four attributes concludes that the source of electricity is not satisfactory.

2. Upon evaluation of the capacity, availability, reliability, quality, compatibility, and affordability of the sources of electricity, permission to utilise the electricity source shall be pursued. Electricity sources can be considered for the pumping system only if all national and local permissions related to their utilisation can be fulfilled.

Example: A site is located 100 m from the power distribution line from an existing solar mini-grid plant. The extension of the distribution line to power the pump is a possibility. During the DFS, permissions from the solar mini-grid user group must be obtained. If the user group declines to grant permission, then alternative sources of electricity will have to be explored. Similarly, if the group puts forward conditions before the mini-grid can extend power to the pumping system, those conditions must be documented and discussed with the project owner before a decision is made – thus concluding whether permission will be granted or not.

9.3 Assessment of the best available technology



1. Upon assessment of the available energy infrastructure on the site, the selection of electricity sources to power the pump shall be based on the assessment of the best available technology (BAT). For BAT assessment, three aspects shall be considered:

   a. Technical viability
   b. Economic viability
   c. Social viability

Example: A site is located 1,000 m from the power distribution line of an existing mini-hydropower plant. There are no other sources of electricity. Upon evaluation, the site has good solar energy potential. The DFS shall include a comparative assessment of the technical viability of extending the power distribution line from the mini-hydro plant or utilising solar photovoltaics to power the pump.

From a technical standpoint, the assessment of the micro-hydropower plant shall consider factors such as available power capacity, power losses from extension, and ease of operation, to name a few. Similarly, for the solar photovoltaic, the assessment shall consider factors such as daily, monthly, and yearly solar resource assessment, land availability for the solar arrays, ownership, and operation management, to name a few.

From an economic standpoint, the assessment of the micro-hydropower plant shall consider factors such as: cost of power-line extension; permits for the right-of-way of the lines; additional benefits from power-line extension in the form of an increase in household connections; and the user group's willingness to own the responsibility of the pumping system.

Upon evaluation of the various technical and economic aspects, the limiting factors may be that the costs involved in the extension of the hydropower plant and in associated local regulatory requirements may prove to be greater compared to having an independent solar photovoltaic source. Hence, solar photovoltaics may be chosen as the BAT for energy supply.

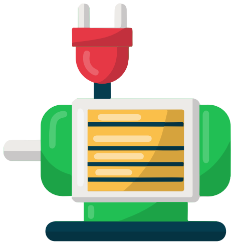
2. The evaluation of BAT may include a combination of energy sources to power a pump.

Example: *A site has access to national grid electricity but suffers from frequent outages. Upon evaluation, the site also has good solar energy potential. The BAT assessment shall conduct a study about utilising both the national grid and the solar photovoltaics for powering the pump using a pump controller that accepts both these energy sources. This will allow the beneficiary to utilise solar photovoltaics during the daytime and the national grid (when available) during the evenings to power the pump.*

3. The evaluation of BAT shall consider the farmers' irrigation patterns.

Example: *In a village, farmers require irrigation at night, but the distribution reservoir capacity does not suffice for this purpose. Thus, the evaluation of BAT shall involve selecting technologies that enable the pump to be powered at night.*

4. The DFS shall include justification for the selected source(s) of energy supply, based on the findings of the technical and economic viability assessments.



Annexe 10.

Electromechanical design

10.1 Pump selection and sizing

1. The appropriate type of pump and its size shall be determined based on technical parameters, user behaviour, availability in the market, and the service mechanism of the pump.

   a. Technical parameters: Technical parameters shall include all the relevant parameters of the site to fulfil the desired water output to the irrigation command area for the entire design life of the project. For example, daily water requirement for irrigation, total dynamic head, and water quality, to name a few, are some of the parameters that are used to determine the type and size of a pump.

   b. User behaviour: User behaviour can influence usability and adoption of pump types which ultimately reflects in ownership and proper operation of the pumps after installation.

Example: Farmers in a site are well versed in the operation of a surface centrifugal pump that is powered by the national grid. However, due to recent poor power quality and frequent outages, the existing pump has been damaged and the community is looking for an alternative reliable source of power to run a pump for irrigation. In this case, the DFS shall factor in the user's familiarity with surface pumps when making a choice between surface and submersible pumps. If the surface pumps fulfil all the technical parameters, the farmers' familiarity with the surface pumps can lead to benefits such as better confidence in the new system, better operation, and a better ability to self-diagnose minor technical issues. On the contrary, unfamiliarity with submersible pumps may result in lower confidence in the pumping technology wherein the farmer will have to learn the operation methods of the pump and s/he may also not be able to self-diagnose minor technical issues.

   c. Availability in the market and service: While selecting pumps for reference in the DFS, ascertain the availability of the pump in the Nepalese market. The selection of such pumps during the DFS ensures that the technical parameters, service requirements, and costs suit Nepal's context. For instance, if the suppliers have been providing the pump in Nepal for the last five years, it gives higher confidence that the repair, maintenance, and replacement service for the pump will be available in Nepal for the duration of the project life.

2. For the design and selection of a pump for the irrigation system, the total dynamic head must be calculated.

3. Upon selection of the pump, all the electromechanical components to power the pump shall be determined in line with the best available technology. The components include a pump, controller, protection equipment, and power line.

Annexe 11.

Civil design

11.1 Water intake design

1. Based on the site survey, the design of the water intake infrastructure shall include the following:

    a. Water collection mechanism: The collection mechanism should ensure the security of the collection reservoir while allowing adequate water to flow into the reservoir year-round.

Example: For a river water source, an upstream canal that is parallel to the river may need to be constructed with a slope angle lower than that of the river. The canal is then connected to a collection reservoir located in a stable and safe area away from the river.

    b. In the case of a deep tube well, the investigation should indicate good potential for deep aquifers, not shallow ones.

    c. Water control mechanism: A water control mechanism allows water flow within acceptable limits year-round. An appropriate water control mechanism is especially relevant in the case of river and stream water sources.

Example: The intake from the river should be through a rectangular orifice if site conditions permit as this type of intake, when appropriately sized, allows not only the design flow into the waterways but also limits excess flow during floods. The intake orifice should be fully submerged during the dry season to ensure the full design flow. A spreadsheet program will help the designer check the orifice size for various design flow conditions [21].

Similarly, a water control mechanism such as a control/sluice gate should be provided at the intake so that the system can be easily closed for repair and maintenance as and when required [21].

d. Water filtration: For river water pumping, a settling basin is essential because every river carries some sediment, and all sediment is detrimental to pumps.

Example: Water filtration mechanisms such as gravel trap and settling basin (located in the intake) need to be incorporated only if the river carries significant gravel during the monsoon season [21].

Similarly, a coarse trash rack should be placed at the intake mouth to prevent floating logs and boulders from entering the headrace canal. The bars in the trash rack should be spaced such that any gravel that enters the system can be transported by the headrace to the downstream flushing structure, such as a gravel trap.

11.2 Reservoirs design

1. *Collection reservoir*: The design of a collection reservoir shall consider the following factors:

   a. *Security from natural risks*: Based on the site survey, the collection reservoir should be designed considering the factor of safety and appropriate measures for security from natural risks. Factors related to climate-proofing of the reservoir should be considered based on the available historical data on extreme events.

   b. *Adequate capacity for irrigation practice*: The capacity aspect of the collection reservoir shall consider: (i) the balance between the recharge rate and the water-pumping flow rate; and (ii) the quantity of water needed to remain as a buffer to fulfil the water needs for irrigation.

   c. *Secure placement of pump*: The design of the collection reservoir shall take into account the secure placement of the pump.

Example: In the case of a submersible pump, the collection reservoir shall allow enough space inside it for the installation of the submersible pump.

In the case of a surface pump, the collection reservoir shall allow provisions for the suction pipe of the surface pump.

   d. *Ease of construction and maintenance*: Similar to the assessment of the water intake structure, the design chosen should take into account the locally available materials and the ease of transporting materials to the site for construction.

   Similarly, the design should be done considering ease of maintenance.

2. *Distribution reservoir*: The distribution reservoir is constructed near the command area and is connected to the water distribution network.

   The design of a distribution reservoir shall be assessed based on the following factors:

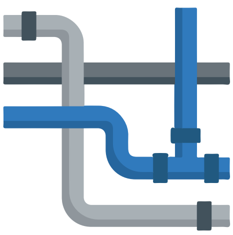
   a. *Security from natural risks*: Based on the site survey, the distribution reservoir should be designed considering the factor of safety and appropriate measures for security from natural risks. Factors related to climate-proofing of the reservoir should be considered based on the available historical data on extreme events.

   b. *Adequate capacity for irrigation practice*: The capacity aspect of the distribution reservoir shall consider: (i) the balance between the incoming flow rate and the distribution flow rate; and (ii) the quantity of water needed to remain as a buffer to fulfil the water needs for irrigation.

   c. *Control mechanism for water distribution*: The design and components chosen for the distribution reservoir shall include mechanisms for controlling water flow, such as the inclusion of a control valve chamber.

   d. *Ease of construction and maintenance*: Similar to the assessment of the water intake structure, the design chosen should take into account the locally available materials and the ease of transporting materials to the site for construction.

      Similarly, the design should be done considering ease of maintenance.

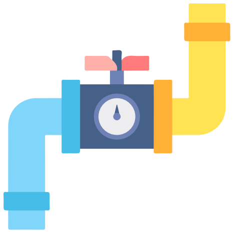


11.3 Water transmission design

1. The design of water transmission must take into account these three aspects:

   a. Ensuring proper assessment of frictional loss and total dynamic head. This will require spreadsheet or software-based calculations to determine the optimum sizing of the water transmission components (for example, anchor blocks, pipe access points, control valves, size of pipes, material of pipes, choice of fittings, etc.).

   b. Ensuring the desired water flow into the reservoir or distribution point.



11.4 Water distribution network design

1. The design of water distribution must take into account these three aspects:

    a. Ensuring adequate water supply to each plot within the command area. This will require spreadsheet or software-based calculations to determine the optimum sizing of the distribution network components (for example, positioning of intermediate water distribution chambers, control valves, size of pipes in different sections, material of pipes, choice of fittings, etc.).

    b. Mechanisms for measurement of water supply for water-use tariff and accounting methods (for example, water flow meters).

    c. Ensuring socially equitable water access to farmers.

11.5 Irrigation methods

1. The effectiveness of an irrigation method relies on how well the water is distributed to the agricultural fields. Against the backdrop of the impacts of climate change, the diminishing of national resources related to water will be a big challenge in the future. Conservation of water resources is also critical for the longevity of the project. Thus, it becomes essential to thoroughly analyse each irrigation method (Figure 4) and compare various techniques to identify the most appropriate one for the given project or plots. There are numerous irrigation methods, each with its advantages and limitations.

Example: In regions facing water scarcity, micro-irrigation technologies or deficit irrigation may be viable options.

Figure 4. Examples of micro-irrigation and deficit irrigation

2. In Nepal's context, although surface irrigation is popular, the DFS shall include a review of the possibility of promoting micro-irrigation or deficit irrigation methods based on the context of the site. This involves performing a comparative examination of different irrigation methods, assessing their merits, drawbacks, and appropriateness for diverse crop types, soil compositions, and weather conditions. The exercise shall consider aspects such as:

    a. Water efficiency
    b. Consistency of water distribution
    c. Labour demands
    d. Initial capital costs
    e. Operating costs
    f. Assessing the ability of each method to sustainably support agriculture and adapt to changing conditions
    g. Community willingness to adopt the chosen irrigation method
    h. Ability to establish a support mechanism for the community

Example: *In a community that is using surface irrigation methods, the DFS may identify that sprinkler irrigation will contribute to more efficient water use. The community may also be willing to adopt sprinkler irrigation methods. However, a community that is transitioning from surface to sprinkler irrigation will require frequent advisory support via access to agriculture and irrigation experts. If no such support mechanism is accounted for during the DFS, then the community, due to a lack of guidance in the use of the sprinkler irrigation method, may fall back to surface irrigation. This increases the risk of inadequate water supply because of reverting to a lower water-use efficiency method, i.e. surface irrigation, and results in project failure.*

Annexe 12.

ESMP, risks, and mitigation

1. The DFS shall include an Environmental and Social Management Plan (ESMP) matrix based on the environmental and social assessments, which describes:

    a. Environmental impacts: Describes the environmental impacts relating to:

        i. Physical environment: Construction phase and operational phase
        ii. Biological environment: Construction phase and operational phase
        iii. Socio-economic and cultural environment: Construction phase and operational phase

b. Mitigation measures: Describes the mitigation measures against environmental impacts.

c. Responsible authority: Describes the responsible authority for actions on mitigation measures.

d. Monitoring parameter: Describes the parameter used to track the progress and achievement of the mitigation measures.

e. Timing of action: Describes the phase of the project when the mitigation measures shall be implemented.

2. The environmental and social safeguarding measures may incur costs. Such costs shall be included in the bill of quantity of the DFS (see Annexe 15).

3. Similarly, other project-related risks and mitigations shall also be described. These are different from the ESMP matrix which focuses on the physical, biological, socio-economic, and cultural environments. The risks and mitigations here should focus on:

a. Climate-induced technical and social risks

i. Extreme event risks

Example: *Historical extreme event records show that extreme river flood occurs every five years and, following the trend, there is a likelihood that the next flood will occur after two years. The mitigation measures thus shall describe the measures taken for climate-proofing of the water intake infrastructure.*

b. Management risks:

i. Operational risks

Example: *Due to the high rate of out-migration in the project area, there is a high probability that the operator may migrate, resulting in an operational risk to the system. The mitigation measures thus shall describe measures such as capacitating multiple members of the community about system operation.*

ii. Financial risks

Example: *The community may have contributed equity to the project via a loan from a financial institution. There is a risk that the community may not pay the loan instalments on time. The mitigation measures thus shall describe measures such as greater supervision of the local government regarding the tracking of the community's revenue, expenses, and loan payments.*

iii. Governance risks

Example: *If the community members are not a cohesive unit due to ethnic and caste differences, there is a risk of conflicts and a lack of financial transparency in water use. The mitigation measures thus shall describe measures such as greater supervision of the local government with provisions for audits.*

4. The risks and mitigations shall be tabulated in the DFS and shall include:

    a. Description of risk

    b. Likelihood of occurrence

    c. Severity in terms of project construction and operation

    d. Mitigation measures

The likelihood and the severity of the risk, both rated between 1 and 3, provide a risk rating that identifies risks as high, low, or medium. These risk rates are shown in Table 8. This helps the authorities concerned to prioritise mitigation measures following the assessment of the risks identified in the DFS.

Table 8. Risk Rating

Severity	Severe	3	3 Medium	6 High	9 High
	Moderate	2	2 Low	4 Medium	6 High
	Insignificant	1	1 Low	2 Low	3 Medium
			1	2	3
			Unlikely	Possible	Very likely
			Likelihood		

Annexe 13.

Operational and management plan

Modalities of operations and management

1. Conflicts in a community can be a result of unclear roles and coordination systems which harm the sustainable and equitable management of resources. Hence, it is crucial to determine during the DFS what kind of operational modality best suits the project in the local context to construct a just and reliable mechanism for maintaining the project's functionality and taking care of its operations and management (O&M) mechanism after the irrigation system has been put into service.

2. For renewable energy irrigation projects, the commonly used modalities to operate and manage the projects are:

    a. Community operated

    b. Fee-for-service or the water entrepreneurship model

    c. Local government operated

Each of the above modalities is explained in Table 9.

An appropriate modality for the O&M of the project needs to be identified by the DFS based on aspects such as the characteristics of the user group, the availability of local water entrepreneurs or the private sector, and ownership by the local government. Potential candidates who can work as an operator or a manager of the project need to be identified and any capacity-building activities needed for the user group need to be assessed and recommended.

Table 9. Description of operation modality

Operational modality	Description	Key characteristics
Community operated Ownership – user group O&M – user group	The user group assigns an operator who is responsible for operating the electromechanical equipment, as also for water scheduling and distribution. The community collects a nominal amount for the maintenance of the project and for financial compensation of the operator.	The community has a history of managing and operating similar projects. The user group structure is established and has a robust governance structure. The user group has individuals with good leadership and social dynamics. Availability of local individuals who can take up the responsibilities of an operator.

Fee-for-service or water entrepreneurship Ownership – user group or entrepreneur O&M – entrepreneur	The water entrepreneur provides irrigation water as a service to the water user group. The user group pays for the water as per the tariff. The water entrepreneur is responsible for the O&M of the system.	The user group doesn't have good community dynamics but needs irrigation water. Has a good market for its produce. Individual farmers in the water user group are willing to pay for the irrigation service. No one in the community has the qualification to be an operator or does not want to become one.
Local government operated Ownership – local government O&M – local government-assigned operator	The local government assigns an operator and provides financial compensation. The user group pays a nominal tariff to the local government for the irrigation water. The water fee serves as a revenue stream for the local government.	The local government is interested in providing irrigation services. The user group is willing to work with the local government and pay for the service.

Example: *A site has a community that already has a registered user group which has a good governance structure in place. However, upon evaluation, it is found that it doesn't have any prior experience in managing community-based pumped irrigation projects, and there is no likely candidate who can perform the role of the operator.*

In consultation with the local stakeholders, the DFS must assess which modality of O&M best suits this project. Ascertaining the willingness of the local government to be involved in such projects is also a requirement. If there are any individuals (water entrepreneurs) or organisations (microfinance institutions or from the private sector) that are interested in running a fee-for-service model, the DFS must include their details.

4. The O&M of renewable energy irrigation systems shall emphasise gender parity. Women should be involved in the process from the beginning and throughout the O&M stage, which provides opportunities to meet practical gender needs.

Annexe 14.

Cost-benefit analysis

1. CBA is a valuable tool for assessing the investment required to develop an irrigation system in a specific location and for understanding how the costs can be covered through the production of different types of crops [14]. CBA helps to quantify the costs involved in terms of irrigation infrastructure development, equipment procurement, repair and maintenance, and labour. It also takes into account indirect costs like environmental costs, including potential impacts on water availability, soil health, and biodiversity, as well as social costs.

2. On the benefit side, CBA studies how different types of crop enterprises can generate income to cover the costs of the irrigation system; it also evaluates the potential increase in crop yields and farm income resulting from improved access to water or switching to more profitable crops in the irrigated fields. Such analysis provides insights into the profitability of different crops; it also helps in estimating the shadow price of irrigation water for different crop enterprises and their ability to cover the investment costs partially or fully, which will enable targeted decision-making regarding irrigation infrastructure. The analysis is subject to types of crops that can be grown in a particular agroecology, as well as to farming typologies, opportunities in the value chain, and market constraints.

3. In subsistence agriculture, farmers primarily grow crops for self-consumption and only the surplus is marketed. The introduction of a small-scale irrigation system may not be profitable if the CBA is narrowly defined and calculated. It should also consider the societal and environmental benefits at the macro level such as improved food and nutritional security, reduced food import, reduced emission, reduced vulnerability to climate-related risks, and enhanced community cohesion through shared water resources, collective management, capacity building, and knowledge transfer among small-scale farmers.

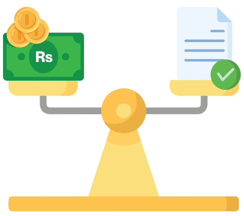
   Table 10 describes the cost-and-benefit parameters that should be considered in the CBA.

Table 10. Cost-and-benefit parameters

Costs				Benefits			
Capital costs (direct)	Operation and maintenance costs (direct)	Environmental costs (indirect)	Social costs (indirect)	Farm-level/household-level benefits (direct)	Cost saving (direct)	Environmental benefits (indirect)	Social benefits (indirect)
Initial investment required for constructing the irrigation system, such as the cost of pumps, pipes, canals, and infrastructure.	Consider the ongoing expenses for operating and maintaining the irrigation system, including energy costs, labour costs, repair and maintenance costs, and any administrative costs.	Account for any potential negative environmental impacts caused by the irrigation system, such as groundwater depletion, water logging, water pollution (both surface and groundwater due to the use of agrochemicals), soil erosion, loss of biodiversity, etc. For instance, reduction in the yield of marginal and rain-fed crops like upland-paddy and buckwheat, and a loss of agro-biodiversity.	Include costs such as displacement of communities, loss of cultivable land, loss of livelihoods, and adverse health effects. Social conflicts over rights to spring sources; and land acquisition to develop irrigation infrastructure.	Increase in cropped area, cropping intensity, crop yields, and crop diversification, resulting from improved access to water through the irrigation system; increase in income (due to increased yield and market prices); as well as improvement in household food security. Additional benefits from fish production, as well as from the use of water for domestic and livestock purposes.	Cost savings (as well as saving on energy, labour, time, and inputs) due to the adoption of an irrigation system that is different from the manual method.	Positive environmental impacts resulting from the irrigation system, such as by way of improved water management, reduced soil erosion, and enhanced biodiversity. Increased groundwater recharge.	Improvement in overall food security, reduction in food import, value addition, increased employment opportunities, and enhanced GESI status.

4. *Valuation approach*: The valuation approach is an important component of the CBA. It involves assigning monetary values or qualitative merits to the costs and benefits associated with the implementation and operation of the irrigation system. Given the limited resources and livelihood implications for subsistence farmers, a thorough valuation approach becomes essential for the decision-makers and implementers to justify and prioritise irrigation interventions. There are different approaches to evaluating the cost and benefit generated by interventions of irrigation systems.

   CBA is conducted on either one or a combination of techniques based on the availability of information and the precision of the analysis that is required. Based on the results of the analysis, decision-makers can obtain a comprehensive understanding of the costs and benefits of irrigation systems. This information enables more informed and targeted decision-making, considering the economic, environmental, and social impacts of irrigation interventions on farming communities. Ultimately, a well-conducted CBA facilitates the rational planning and implementation of irrigation interventions to enhance livelihoods and improve sustainable agricultural practices. The following are the common methods of evaluating the impact of irrigation systems; these have been adapted from the paper, *Comprehensive Assessment of Socio-Economic Impacts of Agricultural Water Uses: Concepts, Approaches and Analytical Tools* (by I. Hussain and M. Bhattarai) [23].

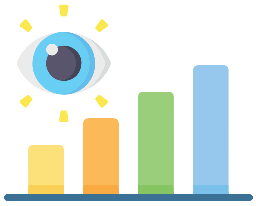


   a. *Market-based approach:* In the context of small- and medium-scale irrigation systems, the market-based approach involves using actual market prices and associated transaction costs to determine the economic value of the costs and benefits. For example, the market value of different crops grown using the irrigation system can be estimated based on the prevailing market prices. If the irrigation system enables farmers to cultivate high-value cash crops, such as vegetables or fruits, the increased revenue from selling these crops in the market becomes a direct benefit that can be quantified using market-based prices.

Example: If implementing the irrigation system allows farmers to switch from growing low-value traditional crops such as rice or wheat to high-value vegetables, the market-based valuation approach would consider the difference in revenue generated by selling traditional crops versus the revenue from selling vegetables at their market prices.

   b. *Replacement cost approach:* The replacement cost approach estimates the value of costs and benefits by considering the expenses that would be incurred to replace or replicate the irrigation system. Such an approach helps in understanding the opportunity cost of investing in the irrigation system compared to alternative methods of water supply.

Example: If farmers were previously using manual watering methods such as carrying water using buckets, and then they adopt the irrigation system, the replacement cost approach would estimate the savings in terms of the labour and time required for manual irrigation.



c. *Revealed preference approach*: The revealed preference approach infers the value of costs and benefits from the observable choices and behaviours of farmers after the implementation of the irrigation system. It examines how farmers respond to the changes brought about by the system, thereby providing insights into their preferences and priorities.

Example: If the introduction of the irrigation system leads to an increase in the cropped area or cropping intensity, it indicates that farmers value the benefits of improved access to water and are willing to allocate more land to cultivate crops.

d. *Stated preference approach*: The stated preference approach involves directly gathering information from the farmers through surveys or interviews, asking them about their preferences and willingness to pay for specific benefits or whether they want to accept compensation for specific costs associated with the irrigation system.

Example: Farmers could be asked about how much they are willing to pay for access to the irrigation system or if they are willing to accept reduced crop diversity in exchange for increased yields and water availability.

5. *Irrigation costs*: Irrigation cost matters in assessing the financial viability of adopting irrigation systems. The government, investors, and farmers need to carefully weigh the costs against the potential benefits to make informed decisions about investing in irrigation infrastructure. Affordability is another critical factor influenced by irrigation costs. Many small-scale farmers operate with limited financial resources, making it essential for them to have a clear understanding of the costs associated with adopting the irrigation system. Knowing about the expenses involved enables the farmers to plan and budget effectively, thereby ensuring that they can afford and sustain the irrigation system without facing financial strain or debt burdens.

   In addition to individual farm-level considerations, irrigation cost also plays a role in resource allocation by governments and development agencies. Authorities often prioritise projects based on CBA where understanding the irrigation costs becomes crucial in identifying interventions that can make the most significant impact on agricultural productivity and rural development. By directing resources towards economically viable irrigation projects, governments can optimise their investments and improve overall agricultural outcomes.

The determination of irrigation costs involves several elements. The initial capital investment is a critical component, encompassing the purchase and installation of irrigation equipment such as pumps, energy source components such as solar panels (if applicable), and extension of power distribution lines, pipes, and reservoirs, to name a few. The type and scale of the irrigation system can significantly impact these capital costs. Furthermore, the recurring expenses related to the operation and maintenance of the system must be considered. These ongoing costs may include energy consumption (for electric pumps) and labour for system management and regular maintenance to ensure the efficiency and longevity of the irrigation infrastructure (Table 10).

Aside from the tangible costs, irrigation interventions may also have intangible costs, such as by way of environmental and social impacts. These costs account for any adverse effects the irrigation system may have on the environment, such as in the form of water depletion or pollution, and social impacts like displacement of communities or conflicts over water rights. Properly accounting for both direct and indirect costs provides a comprehensive understanding of the overall implications of the irrigation intervention.

For farmers, contributing to irrigation costs can take different forms. User fees or tariffs may be imposed on farmers to support the maintenance and operation of the irrigation system. By paying these fees, the farmers actively contribute to covering the ongoing expenses, thereby ensuring the sustainability of the irrigation infrastructure. Additionally, in some cases, the farmers may provide labour services for routine maintenance, cleaning canals, or managing the irrigation system. This labour contribution reduces the overall cash expenditure and fosters a sense of ownership and community involvement in the irrigation project.

On the government side, there is often a role for subsidies and support to facilitate irrigation development. Governments may provide financial assistance to farmers to promote the adoption of modern and efficient irrigation practices. The extent of government subsidy may vary based on factors such as a region's economic development, social welfare considerations, and environmental concerns. Subsidies can play a significant role in making irrigation technologies accessible to the farmers, thereby enhancing agricultural growth, reducing imports, and improving the food and nutritional security of not only a locality but also the region as a whole at the macro level.

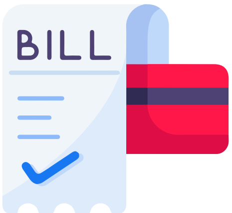
6. The CBA should also estimate what the highest net income a farmer could earn is (given the output prices, yields, and so on for the crops that any farmer cultivates) [20]. This should be compared to actual farmer behaviour which will show a divergence between the actual behaviour and the path to the highest net income. This will help in judging whether the scenario in the financial model can be expected

after the actualisation of the project. It will further inform any project design improvements that are necessary, as also the evaluation of underlying assumptions, and may trigger a rethink on the scale of the project's ambitions to make them realistic.

7. During the CBA, it must be noted that less than cent per cent of the irrigation command area will be cultivated in a given season. This may be because the farmers may be satisfied with their farm income, have limited farm labour, lack managerial capacity, or are limited by the irrigation decisions of fellow farmers. The percentage of irrigation in a command area for a given season will vary from site to site. Thus, data should be obtained based on an understanding of current irrigation practices and through consultations with the local community and experts.

Annexe 15.

Costs and bill of quantity



1. The bill of quantity is that part of the DFS that defines the quality and quantity of work which is required to be carried out to complete a project. The project owner will utilise the bill of quantity for budget allocation and to define the specifications. During the preparation of the bill of quantity, costs should be determined based on:

    a. District rate: The item costs shall be based on the rate in the district where the site is located.

    b. Market rate: Any item not listed in the district rate shall be costed based on the market rate.

2. A sample list of items for a bill of quantity for a renewable energy irrigation system powered by a mini-hydro plant is given below. It must be understood that the sample is an example and thus, not prescriptive. However, it serves to communicate the expectation from the bill of quantity, which must be prepared as per the site requirements.

    Some items in the bill of quantity may be exempt from tax. The costs of these items need to be listed separately.

***Example:** If solar photovoltaic is used, the solar panels may be exempt from tax. Therefore, the cost of the solar panels should be listed separately in the column of items on which VAT (value-added tax) is not levied.*

Electromechanical component costs

a. Pump
b. Control unit
c. Distribution poles
d. Distribution cable (extension of a mini-hydropower plant)
e. Pump cable
f. Earthing
g. Flow meter for pump water output (transmission)
h. Flow meters for water distribution
i. Installation accessories (nuts, bolts, tapes, etc.)

Civil construction costs

a. Pump control room housing
b. Pump intake security (for example, gabion walls)
c. Water filtration
d. Water collection (intake)
e. Water reservoir
f. Water pipes for transmission
g. Water pipes for distribution
h. Intermediate water distribution chambers
i. Pipe-fitting accessories (flanges, nuts, bolts, bends, etc.)
j. Support pillar and anchor blocks for transmission and distribution pipes

Environmental and social safeguarding costs

List items related to environmental and social safeguarding for example erosion control measures, resettlement and rehabilitation.

After-sales service costs

a. Scheduled and unscheduled service
b. Spare parts

Insurance costs

a. Project insurance costs

Project construction costs

a. Transportation
b. Labour
c. Installation

Annexe – Step IV

Finalising the detailed feasibility study checklist

Annexe 16.

Briefing the project owner and key stakeholder(s)

1. Upon preparation of the draft DFS report, the project owner and key stakeholder(s) shall be briefed on the analysis and design. The key stakeholders shall mean any stakeholder who is crucial for the review and who can provide inputs to the analysis and design of the aspects of the DFS relevant to them.

Annexe 17.

Briefing the community

1. The community user group must be briefed on the DFS findings. Their inputs and concerns hold immense value and are directly linked to the success of the project.
2. The briefing of the community user group must be conducted on-site to the extent possible rather than relaying information via phone or email.

Annexe 18.

Revision of the detailed feasibility study report

1. Based on the inputs gathered from the project owner, primary stakeholders, and the community, the DFS report shall be revised to address all comments and concerns.
2. During revision, further consultations with the party(ies) concerned may be required.

Annexe 19.

Finalisation of the detailed feasibility study report

1. Upon revision of the draft DFS report, the final submission shall be made to the project owner. This submission shall contain:

   a. A detailed feasibility report

   b. Permits

   c. Minutes of meetings

   d. Technical support documents

To the extent applicable, the list of documents that make up a comprehensive report is described in Table 11.

Table 11. DFS documentation

Document	Prepared or issued by	Description of content
Detailed feasibility report	The team conducting the DFS	The report shall include the following: • Site characterisation, including climate risks • Technical design • Cost and bill of quantity • Cost-benefit analysis • An Environmental and Social Management Plan • An Operational and Management Plan • Risks and mitigation measures
Permits	Local government (rural municipality or municipality)	• Preferably one letter attached as an annexe in the DFS report which includes the following details: • Identification of the user group with names and designated positions • Land-use permissions for civil infrastructure (pump house, intake reservoir, distribution reservoir, transmission pipe, and distribution pipes, etc.); electromechanical infrastructure (power distribution line from the micro-hydropower plant, solar photovoltaic array); water-use permission; and water-use tariff and accounting method
Minutes of meetings	Community members who participated in the FGDs	• Based on the discussion agenda and conclusions, the minutes of the meetings may include the following: • List of the elected members of the user group • Agreement on land use for civil infrastructure (pump house, intake reservoir, distribution reservoir, transmission pipe, and distribution pipes, etc.); electromechanical infrastructure (power distribution line from the micro-hydropower plant, solar photovoltaic array); agreement on water use; and agreement on water-use tariff and accounting method
Technical support documents	The team conducting the DFS	Engineering drawings
	Manufacturer's documentation referenced by the lead DFS team	Equipment data sheets

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