HIMACHAL PRADESH CROP DIVERSIFICATION PROMOTION PROJECT (Phase-II)

Operation and Maintenance Manual

for All Project Facilities

October 2024

Abbreviations

APMC	Agricultural Produce Marketing Committee
ARV	Air Release Valve
BPMU	Block Project Management Unit
BPT	Break Pressure Tank
CAT	Catchment Area Treatment
CCA	Cultivable Command Area
CGTMSE	Credit Guarantee Fund Trust for Micro and Small Enterprises
CM	Community Motivator
Cu. m.	Cubic meter
DAC&FW	Department of Agriculture, Cooperation and Farmers' Welfare
DoA	Department of Agriculture Himachal Pradesh State
DPD	Deputy Project Director
DPMU	District Project Management Unit
DPR	Detailed Project Report
DT	Distribution Tank
FC	Field Channel
FIG	Farmers' Interest Groups
FIS	Flow Irrigation Scheme
FOs	Farmers' Organization
FP	Flood Protection structure
GI	Galvanized Iron pipe
GoHP	Government of Himachal Pradesh
GoI	Government of India
HDPE	High Density Polyethylene pipe
HP	Himachal Pradesh
HP	Horsepower
HPCDP	Himachal Pradesh Crop Diversification Promotion Project
IPHD/JSV	Irrigation and Public Health Department/Jal Shakti Vibhag
JICA	Japan International Cooperation Agency
KVA	Krishak Vikas Association
LIS	Lift Irrigation Scheme
LPS	Liter Per Second
L-section	Longitudinal section
M	Meter
MDT	Main Delivery Tank
MGNREGA	Mahatma Gandhi National Rural Employment Guarantee
MIS	Micro Irrigation Scheme
MoA	Ministry of Agriculture Government of India
MoD	Minutes of Discussion
MS	Mild Steel
NABARD	National Bank for Agriculture and Rural Development
NGO	Non-Governmental Organization

NOC	No Objection Certificate
NRV	Non-Return Valve
O&M	Operation and Maintenance
ODA	Official Development Assistance
OHSR	Over Head Service Reservoir
OL/H	Outlet/Hydrant
PD	Project Director
PVC	Polyvinyl Chloride pipe
PW	Percolation Well
QA&QC	Quality Assurance and Quality Control
SFAC	Small Farmers' Agribusiness Consortium
SHG	Self-help Group
SPMU	State Project Management Unit
SV	Sluice/Scour Valve
SW	Sump Well
TIS	Tank Irrigation Scheme
TOR	Terms of Reference
TOT	Training of Trainers
TWIS	Tube Well Irrigation Scheme
WR	Water Requirement
WUA	Water Users' Association

Terminologies

Sub-project	The irrigation scheme or site found to be feasible for the implementation of project activities.
CCA	Cultivable Command Area (CCA) is the area that is proposed to be covered by the irrigation sub-project under the project.
Household	The group of people who live in one house and have one kitchen.
Landholding	The area of land owned by the household.
Landowner	The person who owns agriculture land as per the revenue record.
Land custodian	Landowner or the legal heir of landowner.
Land cultivator	The person who is cultivating the land.
KVA	Krishak Vikash Association (KVA) is an association of landowners of sub-project, irrespective of the village or Panchayat or Block: formed for the planning, evaluation, marketing, operation, and maintenance of project farms related interventions.
GH member	KVA General House member
MC Member	KVA Management Committee members
Kharif	This is the summer crop for which sowing is done in April to June and harvesting is done in September-Oct.
Rabi	The winter Crop in which sowing takes place in September- December and harvesting is done in April and May.
Zaid	Short crop season of 60-65 days between Kharif and Rabi crop seasons to grow early maturing crops.
CII	Cropping Intensity Index (CII) is the total cropped area/ CCA x100
CDI	Crop Diversification Index (CDI) = 1- $\Sigma(x2)2/ \Sigma(x)2$ % age of total harvested area under n crops /No. of n crops Where, n crops are those which individually occupy 5% or more of the total harvested area.

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1. INTRODUCTION

1.1 Background

Himachal Pradesh Crop Diversification Promotion (HPCDP) Project (Phase-II) is being implemented in the state of Himachal Pradesh with the financial support from Japan International Cooperation Agency (JICA). The Projects aims to promote agricultural productivity, sustainable crop diversification to high value crops and improvement of farmer's income by development of production infrastructures such as irrigation facilities and access farm roads, farmers support and institutional development as well as strengthening farmer's sales force with marketing development, thereby contributing to economic and social development in all districts of Himachal Pradesh.

AECOM was selected as the Project Management Consultant (PMC) for the project at the end of December 2022. Since the inception of the project in January 2023, the PMC team has been providing necessary technical and management support to State Project Management Unit (SPMU). The scope of work of PMC includes assisting SPMU in preparing and reviewing manuals and guidelines for the project activities. This Operation & Maintenance Manual (English) is one of the reporting deliverables of PMC specifically mentioned in the Minutes of Discussion (MOD) for the project between JICA and Department of Agriculture (DOA), Government of Himachal Pradesh (GoHP).

1.2 Operation and Maintenance and its Significance

Operation is defined as being functional, in effect or active while maintenance is the combination of all technical and administrative actions, including supervision actions, intended to retain an item in, or restore it to, a state in which it can perform the required function. In the context of irrigation, operation entails the implementation of smooth and timely actions for the supply of required amount of irrigation water to the farmers' field while maintenance is the act of keeping the canals, structures, and other facilities in smooth functioning conditions.

Operation is needed to deliver the predetermined flows to the demarcated points at prescribed times for specified durations by matching the supply with the demand as closely as possible. Maintenance is needed because of the effect of gradual natural processes like siltation, weed infestation, debris deposition etc. or because of the effect of human actions like tampering, digging, etc.

Operation is focused on adjusting the setting of structures while maintenance focusses on maintaining the capacity of the structures. However, despite their distinctions, these two terms are evidently closely linked with each other. Both are part of irrigation scheme management. Moreover, lack of timely maintenance results in changes in the hydraulic properties of a channel ultimately affecting the operations while observation of changes in hydraulic properties during operation indicates the need for specific maintenance. Hence, these two terms are commonly used as one i.e., Operation and Maintenance (O&M).

During the implementation of this HPCDP-II project many facilities and institutions will be developed. It is in the interest of the project that these facilities and institutions sustain and provide the intended benefits to the targeted stakeholder not just during the project but also beyond. The assets created by the project should produce the desired benefits both during project period and beyond. Many development projects function well during the project period but have been observed to crumble down as soon as the project is completed. This is one thing that this project would like to avoid. The project is geared towards ensuring that its outputs are sustained and that the targeted benefits are produced for their full life span which extends much beyond project period.

Explorations into the causes of lack of sustainability of facilities created by many development projects in the developing countries have traced to the lack of proper attention to the operation and maintenance of the concerned project facilities. This highlights the significance of proper operation and maintenance in achieving the full benefit from any project. To ensure proper operation and maintenance of project facilities, it is crucial that a system be established for operation and maintenance. For this, it is essential that a standard procedure for O&M of project facilities be developed and for it be documented so that the concerned people can refer to it and be fully acquainted with it as well as to update and refine it as required. This will ensure the safeguard the life span of the facilities. It is also emphasized that this O&M process be discussed with the concerned stakeholders including community members / Krishak Vikash Association (KVA) members right from the beginning as the KVAs will be mainly responsible for the O&M with technical support from DOA. As per the MOD, the DOA will support the KVA in mobilizing funds from subsidy schemes of State/Central Government and Panchayati Raj Institution (PRI).

1.3 Facilities Developed by HPCDPP-II

The various facilities developed through the project can be briefly summarized as follows:

i) Water source development
ii) Construction / rehabilitation of flow irrigation schemes
iii) Construction of lift irrigation schemes including solar pumping
iv) Construction of tube well irrigation schemes
v) Construction of tank irrigation scheme
vi) Establishment of micro-irrigation, irrigation accessories and equipment including solar fencing.
vii) Construction of buildings and access roads
viii) Catchment area treatment

In total, 296 irrigation sub-projects are planned to be constructed by the project and 10 sub-projects through convergence with the Jal Shakti Vibhag (JSV). Hence the securing and developing of 296 water sources can be considered as the first facility developed by the project. Minor repair may be expected from the beneficiaries, but the ownership of these works lies with the DOA and O&M responsibilities of these sub projects lies with the KVA. Hence, in the case of natural calamities and major damage, the DOA will shoulder the responsibility.

These sources are essential to keep the irrigation scheme functional and the performance of the irrigation scheme will be adversely affected if the sources are impacted by various reasons like natural calamities and climate change. The investment made in the whole sub-project can be futile if no water is available at the source. Hence, it is evident that proper preservation be carried out of these water sources developed by the project. In general, water sources selected by the project are adequate and suitable in terms of water availability and water quality and are unlikely to face any sustainability issues. The proposed surface water sources in this project are the tributaries of the major Rivers (like Beas and Sutlej), Khads and Nallahs. These rivers are perennial, and are generally snow and rainfed, and some have springs as origins. Only the major rivers are gauged for flow. Most of these streams carry high flow during monsoon and post monsoon months (July to October), after which flow slightly reduces but retain considerable (medium) flow in the months of November-February. After this, the flow further reduces in the months of March and April (low flow), followed by lean flow season of May and June. The snow-fed rivers carry considerable flow even during May and June but show lean flow during December-January. Therefore, depending on the nature of river/stream contribution from rain, snow, etc., lean season varies. In line with Himachal Pradesh Water Policy, 2013 which aims to ensure

equitable and adequate water to all key stakeholders, the province will strive towards protecting all water sources especially those developed by additional investments through different projects.

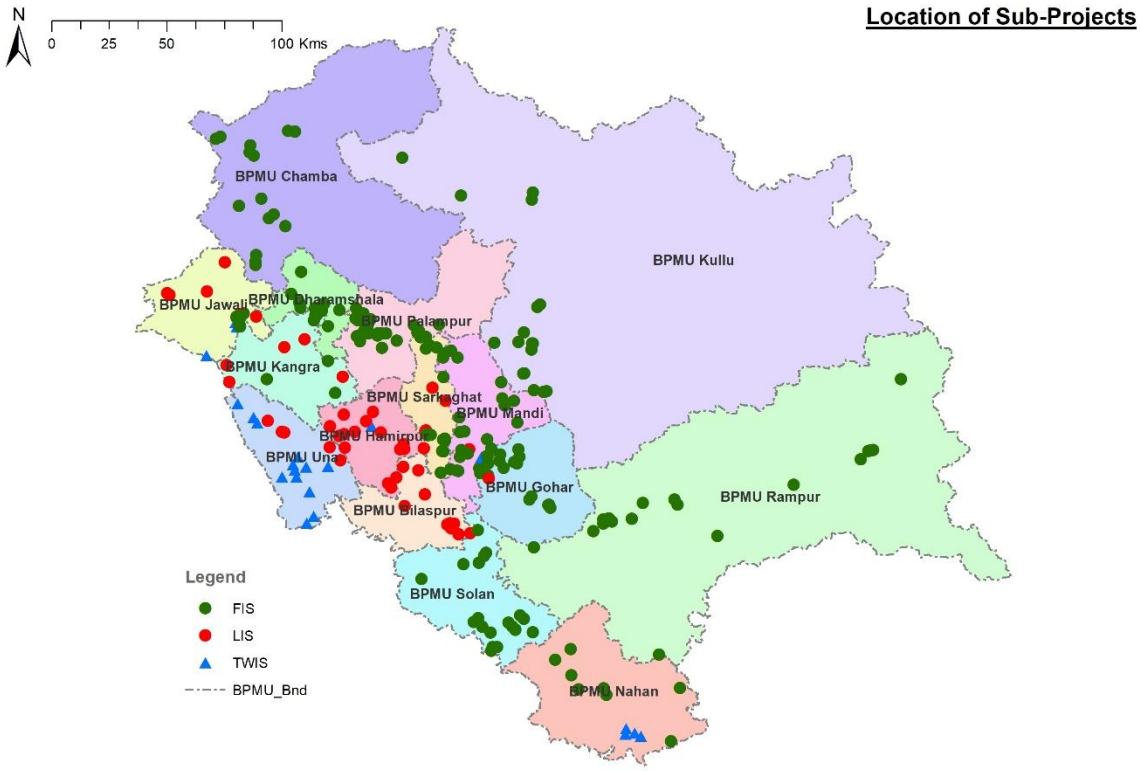


Figure 1: Location of Sources of the Identified Irrigation Sub-projects

Along with the water sources, the conveyance and distribution system will also be constructed for these 296 schemes. District-wise inventory of the infrastructure planned to be developed in the irrigation sub-projects (FIS, LIS and TWIS) as per MOD has been presented in **Annexure 2.**

Likewise, the project will also carry out catchment area treatment in essential areas for the protection of the catchment areas of the irrigation schemes.

1.4 Purpose of the O&M Manual

This O&M Manual has been prepared with the objective of documenting the operation and maintenance procedures for successful implementation of the project facilities on the ground. It will provide contents that may be useful for all concerned stakeholders including Project staff, DOA staff, members of Krishak Vikash Association (KVA), as well as ordinary farmers on how to sustainably operate and maintain the facilities created by this project. It can also be used for training purposes as it helps in understanding the components and workings of the various project facilities and assists in servicing and troubleshooting the issues in operating them. It also explains the various types of maintenance like routine, periodic and emergency maintenance for each of the different types of irrigation schemes and the other facilities developed by the project. The estimated life span of the facilities can be assured and even increased by strictly adhering to the procedures outlined in this manual and following the recommendations provided therein.

1.5 Content of this O&M Manual

This Manual includes nine chapters. It begins with an introductory chapter that outlines the background of the project and the provision of preparation of the manual. It also explains the significance of operations and maintenance and describes the various facilities developed by the project that need operation and maintenance. It then goes on to outline the different purpose of the manual and its content.

The second chapter discusses about the various institutions and actors and their roles and responsibilities in terms of operation and maintenance of the facilities developed by the project. It provides brief descriptions of all the physical and institutional assets created by the project.

Chapter 3 describes the conservation and maintenance actions required for the purpose of preservation of water sources of the different irrigation sub-projects under the project. Then, Chapter 4, 5 and 6 provide description of the operation and maintenance procedures of the three main categories of the irrigation sub-projects, namely: flow irrigation schemes (FIS), lift irrigation schemes (LIS) and tube well irrigation (TWIS), respectively. Similarly, Chapter 7 provides description of the maintenance of buildings and farm access roads that will be constructed under the project. Likewise, Chapter 8 outlines the procedure of operation and maintenance of the micro-irrigation and other accessories established by the project.

Finally, Chapter 9 of this manual is devoted towards the discussion on necessary management support required from the smooth implementation of the operation and maintenance functions. It dwells on the part on institutional strengthening of the relevant institutions as well as ensuring the necessary financing for the O&M functions. The **24 Annexures** attached with the main report provide templates and supporting information for O&M related functions.

2. INSTITUTIONS RESPONSIBLE FOR O&M

Various institutions have various responsibilities in the operation and maintenance of the different facilities developed by the project. These institutions can be primarily divided into two types: the first is the various types of organization of farmers formed by the project for specific purposes and second is the existing government agencies that are mandated to provide specific services to the public. This chapter of the manual discusses about these different institutions including their role in the operation and maintenance of the different project facilities.

2.1 Farmers' Organization formed by the Project

As part of the project activities various Farmers Organizations (FOs) are formed for different purposes. These FOs also have an important role in operating and maintaining the facilities developed by the project. Brief description of these FOs and their roles and responsibilities including their roles in the operation and maintenance of project facilities have been provided below.

2.1.1 Krishak Vikash Association (KVAs)

Krishak Vikash Association (KVA) is an association of landowners of a sub-project formed for the planning, evaluation, marketing, operation, and maintenance of project farms related interventions. They are registered under Cooperative Society Act 2006. All the people above the age of 18 whose farms are totally or partially within the command area of the sub-project are eligible to become a member of the KVA.

All KVA members are required to pay a one-time deposit membership fee and a monthly institutional development fee as decided by its General House (GH). GH of the KVA will comprise of all its members. All the members have the right to vote and 2/3 of the total members must be present. In case 50% attendance is not fulfilled, the secretary will call another meeting within 15 days in which 50% attendance is essential. In case this is also not fulfilled, then the President will call another meeting within 15 days and the strength on that day will be considered for conducting the meeting. The GH will meet once a year and will have the power to elect the members of the committee for the management of KVA activities, select the members of the Social Audit/Accountability Committee, accept or reject the annual accounts and audit report, and review and decide on issues related to functions and operations of KVA.

The KVA will also form a Management Committee (MC) to carry out its day-to-day affairs comprising of the following members:

- President
- Vice-president
- Secretary
- Joint Secretary
- Treasurer
- Other members

The total number of MC members must be within 5 to 11 of which 1/3rd shall be women and at least one member should be from scheduled caste or other backward class. Government, semi-government, or public corporation employee are not allowed in the MC. The period of the MC will be for 2 years after which re-election will be held. 1/3rd of the members shall retire by rotation each year.

O&M Roles and Responsibilities of the KVA

Operation and maintenance of the respective irrigation scheme is one of the key functions of the KVA. The MC should prepare a plan and program for adequate and equitable water distribution to all the concerned farmers in the command area of the scheme. Moreover, they should also establish a practice of preparing an annual budget and maintenance plan and develop mechanisms and procedures for carrying out the maintenance works. The MC should also monitor the works through its members or assigned staff and ensure prevention of wastage, misuse or unauthorized use and take action against cases of theft, misuse of water and damage to infrastructure. It should also decide on the water tariff on irrigation to be levied on the water users and be responsible for generating the necessary fund for its institutional development. The MC shall also ensure that the cash book is properly maintained and signed by the treasurer.

2.1.2 Farmer Interest Groups (FIGs)

Farmers' Interest Groups (FIGs) are self-managed, independent farmer organizations formed to jointly address production and market issues and provide pooling of resources to enhance the income of the concerned group of farmers. It is not a legal body, but all the members share common goal and interest. All interested farmers above 18 years residing in the village can be members of the FIG. One member from each household may be considered as a member of FIG and no one person can be a member in more than one FIG. The number of members in a FIG is between 15 to 20.

There will be a leader and representative for each FIG. FIG should choose their leader. It is always better that the leadership is rotational. It is also to be remembered that there should be sufficient time for the leadership to work before they changed. The executive body of the FIG has the mandate of smoothly conduct all the activities per the objective of the FIG. It will comprise of a group leader, deputy group leader, secretary, treasurer and record keeper. The members work together to achieve this goal by pooling their existing resources, gaining better access to other resources and to share in the resulting benefits.

Keeping the functions of FIG, area will be covered in a contiguous land patch of 20 farmers and these 20 farmers will form a potential FIG. Periodic meeting and constitutions at the village level is a must to keep the community informed about the interventions. At least one meeting a month and minimum 12 meetings per year must be conducted at FIG level.

Even though the FIGs is not legal bodies, they do get informal recognition from the agriculture and horticulture departments and their role in acting as collaterals through group pressure for loans linking with local governments for better access to public benefits is well recognized among the farming communities in India.

FIG must maintain a set of records related to membership register, proceeding register, financial transaction with signature of all members. Admission, removal, and resignation of members can formally be done at the FPO level. These can be recommendations from FIG, but the decision must be taken by FPO level.

The contribution and role of FIG member's vs benefit that he or she gets being members in FIG must be clearly communicated in a convincing way. It is better to clarify on member disqualification criteria also at the time of member mobilization itself. Any FIG member with a valid pan card can invest in FPO.

O&M Roles and Responsibilities of the FIGs

The project shall provide different relevant facilities to the FIGs formed under it depending on their area of interest. It shall be the responsibility of the concerned FIG to properly operate and maintain those facilities for the intended purpose and obtain the optimum benefit from it. For this purpose, the FIGs should prepare individual plans and programs of activities in their area of interest. They should maintain the common infrastructure like farm ponds, borewells, tractors and other equipment which cannot be afforded by individual farmers but can be owned by the group. They should also carry out proper planning to ensure optimal production with due consideration to household food security needs and the market demands. They can even play the role of linking with the local government at panchayat level to access agriculture and rural development funds. Additionally, for the benefits of the concerned group they can also contribute towards information sharing and capacity building in the topic of their interest.

2.1.3 Self-help Groups (SHGs)

SHGs are informal, unregistered entities formed by people who come together to find a way to improve their living conditions. They are generally self-governed and peer controlled. People of similar economic and social backgrounds generally associate with the help of any NGO or government agency and try to resolve their issues and improve their living conditions. Common Interest Groups can be formed at the subproject level. It will be based on the activities adopted by the target farmers, which may be: dairy farming, bee farming, sheep farming, goat farming, and fish farming. Networking among the common groups can lead to cluster formation and the federation of livelihood support activities.

Its members may be 10 to 25 between the ages of 18 to 50 and one member from one family. The Executives of the SHG are Pradhan, Up Pradhan, Secretary, Treasurer, and other members.

BPMU staff will organize and form at least one SHG in each sub-project. Already existing SHGs may also be considered. These SHGs will be selected based on needs, vulnerability, and present status of the activities (check the amount of savings, credit, and no of meetings conducted). Target farmers will be SC, ST, landless, BPL, single women etc.

BPMU staff will encourage, guide, and organize the target farmers in forming, storming, norming and performing stages of activities and taking up mushroom, dairy, fishery, bee farming, and service sectors under livelihood support activities. This will lead to increased income for target beneficiaries and their families, provide them with sustainable livelihoods, increase their self- confidence, enable them, and particularly single women, to become financially viable and independent.

Project staff will empower the SHGs to maintain environmental sustainability with the convergence of line departments (natural resources: water, forest, flora, pasture, and fodder) for the continuity of livelihood support activities.

BPMU level staff will help the SHGs open bank accounts. Bank linkages are the key strategy for delivering financial services to the poor in a sustainable manner. BPMU will monitor the assistance that will be provided to SHGs under the livelihood support activities. Impart training and exposure visits for the capacity building of the target farmers.

SHGs try to build the functional capacity of poor and marginal sections of society in domain and income generation activities, offer collateral free loans to sections of people that generally find it hard to get loans from the banks, and resolve conflicts through mutual discussion and collective leadership.

They are an important source of microfinance services for the poor and encourage the habit of saving among the poor.

The project will enhance the capacity of the self-help groups through basic and skill development trainings and exposure visits to successful sites of other projects from time to time. This will sustain the human capital. BPMU will ensure the proper functioning of the working of SHGs and CIGs organizations and institutions that are developed as part of the project.

BPMU will explore the linkages of dairy, sheep, goat, fish farming and beekeeping with the existing market channels like, FPOs, of concerned activities. Groups can achieve financial stability with these linkages. Besides this, groups will financial empowered themselves by collecting membership fee, interest on loan, convergence with the line department, NABARD for sustainability.

O&M Roles and Responsibilities of the SHGs

Based on selected field of work of the SHG like bee farming, dairy farming, sheep farming, goat farming, fish farming, the project shall provide relevant facilities and support to the SHGs. The concerned SHGs will have the responsibility of properly operating and maintaining those facilities to obtain the optimum benefit from them. For this purpose, the SHGs should prepare individual plans and programs of activities to maximize the incomes of the farmers through proper market links. For the benefits of the concerned group, they can also contribute towards information sharing and capacity building in the topic. Moreover, for the farmers who may need additional funds, they can even act as collateral through group pressure for loans

2.1.4 Farmers Produce Organizations (FPOs)

A Farmer Producer Organization (FPO) is an organization formed by groups of producers for either farm or nonfarm activities. The FPO will be created at BPMU and DPMU depending upon the producer's consideration of the demand potential to adopt a value chain approach to enhance farmer's producer's economic and social benefits. These FPOs will be registered under Cooperative Society Act 2006 or Indian Company Act.

FPO elaborates the business plan, including the design of the collection center, with the support of outsourced experts. One FPO will consist of around 300 farmers who will be members of KVAs. FPO will deal with the business activities related to agriculture under KVAs. KVA will have autonomous candidates at the beginning based on the motivation of farmers to participate in FPO. The BPMU level KVAs producer will be the shareholder of the FPO.

The aim of the FPO is to maintain a stable supply of agriculture produce in terms of quantity and quality, increase the value addition of agriculture produce (sorting, grading, packaging, and processing) collect and process market information for making a business plan, operate a business plan, manage an organization, finance, and accounting, and ensure better income for the producers through an organization of their own.

There are two types of FPOs: community-based resources-oriented FPOs and commodity- based market- oriented producer organization. A group of farmers with at least 10 members can form an FPO. It can have as little as 200 members up to 500, and the minimum operational areas of the FPO should depend upon the members of the FPO.

It is a registered body that works for the benefit of farmers. It deals with business activities related to the primary produce or products. A part of the business profit is shared amongst the producers. Farmers should be shareholders in the organization.

The following requirement must be met to become a member of FPOs:

- S/he must be a resident of the area of operation.
- S/he must be a member of a KVA.
- The members of any one FPO should be the farmers cultivating similar crops.
- S/he should not be a member of any other similar FPO.
- S/he should be of good character.
- S/he must fulfil all other conditions of membership led down in the act, the rules, and the bylaws.
- S/he may be an agriculturist, horticulturist, or be in the profession of sericulture, dairy farming, fish farming, poultry and beekeeping or any other agriculture and allied activity subservient to the object of the FPO in the area of operation.
- Her/his interest should not conflict with the interest of the FPO.
- No person should be eligible for admission as an ordinary member of the FPO if:
  - S/he has been adjudged by a competent court to be an insolvent or undercharged insolvent and does not genuinely need the services provided by the FPO.
  - S/he has been convicted of any offense under the act.
- S/he must pay the admission fee, must have purchased minimum one share, and paid the value thereof in full.

Accounts and records of the FPO should be maintained in the forms under specific acts, rules, and bye laws. They must be audited by an auditor at least once each year as per the previsions of the act. The remuneration of the auditors shall be paid by the FPO at the rate as fixed by the competent authority under the rules from time to time.

Structure and operation of FPO:

- General Body shall comprise of the members of FPO.
- Executive Body shall comprise of two farmer representatives per KVA and Farmer Interest Groups (FIGs).
- Board of Directors shall comprise of Chief Executive Officer (CEO) and professional staff-responsible for planning, implementation, and monitoring of the FPO.
- Local resource person: shall be people engaged in information collection through survey on input requirement estimate production.

The FPOs are formed at the initial stage through the intervention of the project in areas where awareness raising, and capacity enhancing is necessary for the farmers. A collection centre will be made after formulating FPOs along with their business plan. The project will support FPOs in terms of business management plans, infrastructure development, and financial access by creating corpus funds to fulfil the needs of FPOs by the time they acquire sufficient credibility to borrow from other financial institutions. FPOs shall be mobilized and empowered as a federation of village based KVAs. FPO is a core unit in the development of clusters of agricultural marketing and processing industries.

FPO will provide the following services:

- Organizational services: organizing farmers, capacity building, and catalysis collective action

- Production services: input supply, facilitation of production activities.
- Marketing services: transport and storage, processing, marketing, market information and analysis, certificate, and branding.
- Financial services: saving, loans, financial management.
- Technical services: research, education, and extension.
- Extension services: Business skills, production.
- Management of resources: water, land, forest.

O&M Roles and Responsibilities of the FPO

The FPOs also have an important role in making the optimum use of the agriculture produce related facilities developed by the project and operating and maintaining those facilities for that purpose. For this, each FPO should prepare a plan and program of activities related to the specific farm produce so that smooth market links can be established and maintained. In the process they should also establish necessary links with the concerned FIGs and SHGs.

2.2 Relevant Government Agencies

2.2.1 Local Governments

The concerned local governments also have a key responsibility in operating and maintaining such public properties. However, their responsibility extends to all sector of public infrastructures at the local level. Hence, their thrust towards irrigation infrastructure may be limited due to fund constraint. However, resources available at the local government level will always remain as helpful resort for small financial assistance when the KVAs run out of sufficient funds. The management committee of the KVA can approach their concerned local government for financial support. However, if the local government does not have the required funds, they can also approach and apply for available funds in the line agencies such as Rural Development Department dealing with watershed development projects under irrigation projects under JSV or DOA. MGRNEP funds can be used for desilting of repairing water diversion and water harvesting structures or desilting of channels.

2.2.2 Department of Agriculture (DOA)

It goes without saying that the Department of Agriculture, Government of Himachal Pradesh also has an important stake and responsibility in the operation and maintenance of the project facilities. In total, 296 sub-projects are planned to be constructed by the project and 10 sub-projects rehabilitated by the project during this project period. It is imperative that all the physical facilities developed the water sources of all these sub-projects be properly preserved. Both the ownership and O&M responsibilities of these works lies with the DOA. Minor repair may be expected from the beneficiaries but in the case of natural calamities and major damage, the DOA will have to shoulder the responsibility.

2.2.3 Jal Shakti Vibhag (JSV)

Similarly, as the state government agency responsible for the irrigation sub-sector, the Jal Shakti Vibhag (JSV), also has an important responsibility in ensuring that the operation and maintain of all the irrigation schemes in the province. Due to budget limitation, it is quite understandable that the department may not be able to fully take up this full responsibility of operating and maintain all the irrigation schemes completed by the project. Works within the capacity of the KVA shall be carried out by the KVA. However, if the works are beyond their capacity, the management committee of the KVAs can also approach the nearest JVS office. The merit of approaching the JSV office is that they have the professionals with the expertise in the irrigation related works. In this concern, it is even suggested that

some lift irrigation scheme which the KVAs find to be technically challenging for them to operate and maintained should be handed over to the JVS so that they can assign their field level staff to carry out its operation and maintenance.

2.2.4 Other Line Agencies and NGOs

If the KVAs in any irrigation scheme are not in a position technically or financially to operate or maintain their irrigation scheme, the option also exists for them to approach other line agencies and NGOs. Depending on the nature of the support required, the management committee of the KVA can seek support and apply for support from projects in other line agencies. For example, the Forestry Department (FD) sometimes has funds for watershed development. They may be ready to support some source conservation or catchment area protection works. Similarly, even though the NGOs generally do not have funds to support construction/rehabilitation works, they are usually ready to provide capacity development support at the community level. In this way, the KVAs can also utilize these supports to capacitate them for operating and maintaining their schemes.

3. PLANNING FOR OPERATION AND MAINTENANCE

Proper execution of operation and maintenance of project facilities demands proper homework in terms of planning. This chapter describes some of the preparatory work necessary for the operation of the irrigation schemes as well as for the other facilities. This is an effort towards making improvements in the current ad-hoc mechanisms in which the farmers are generally operating and maintaining the irrigation scheme in the state. Since this endeavor also includes some technical computation, it is urged that the technical staff of the DPMU and BPMU should guide the KVA in the beginning and later leave the task to be continued by the KVA.

3.1 Development of Operation Plan for Irrigation Schemes

The process of planned operation of the irrigation schemes begins with accurate coverage of its command area and proposed cropping pattern. Then, water requirement is assessed based on proposed cropping pattern. Similarly, water availability is assessed based on historic data and experiences. Considering the water availability and requirement, irrigation schedule and operation plan is prepared to distribute water as per the demand of the users (*Warabandi*). A simple diagram that illustrates the whole process has been shown in **Figure 2**. Details of how to carry out these different steps have been presented in the subsequent sections.

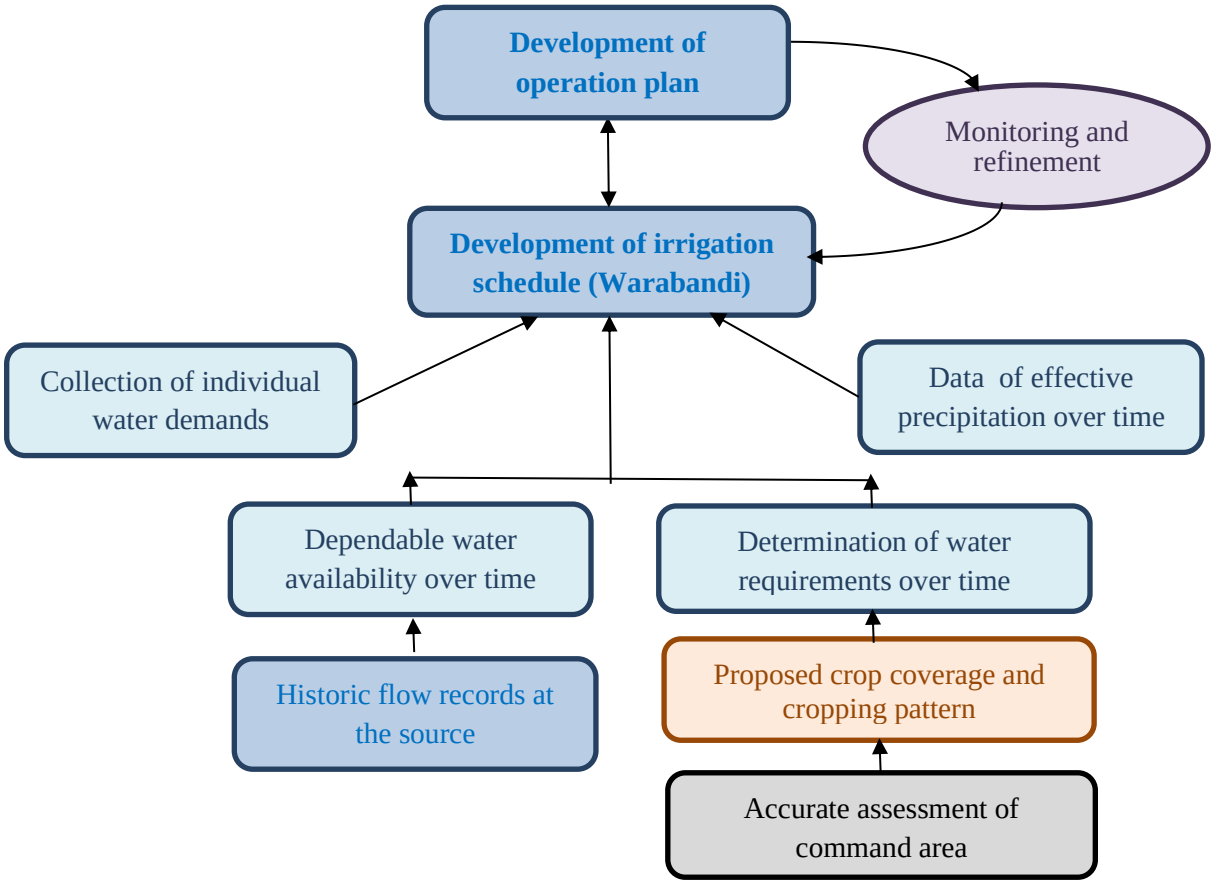


Figure 2: The Process of Developing the Operation Plan

3.1.1 Accurate assessment of command area

Accurate assessment of command area is the first step towards improving operation of the irrigation schemes, irrespective of the type of scheme. Precise records of irrigated area should be collected and regularly updated. Where possible, parcellary maps should be used as a base. It should be

noted that irrigated areas keep changing over time. Some parts may not be needing irrigation as the farmers may decide to leave them fallow while other areas may be left out due to defects in some stretches of the conveyance scheme. It is also possible that farmers extend the conveyance scheme in some parts to expand the command. All these should be considered while making the most accurate assessment of the command area.

3.1.2 Development of irrigation schedule (*warabandi*)

Distribution of water to the farmers' fields includes two distinct steps:

a) Preparation of the irrigation schedule, and
b) Planning and carrying out the operation of the delivery scheme.

Irrigation scheduling is the determination of the water distribution pattern of predetermined water requirement to the different areas for a specified period, such as a few days or a week. The irrigation scheduling is simply the compilation of the water demand of the concerned users. However, if there is a shortage of supply (in drought condition), irrigation scheduling needs to be adjusted to that situation i.e. lifesaving irrigation.

The process of preparing irrigation schedule has been outlined below:

1) Collect demand forms from all the farmers receiving water indicating the crops they are planning to cultivate and their hectarage.
2) Divide the total command area into different blocks from the water distribution point of view considering the channel capacities and grouping convenience
3) Select a suitable scheduling time interval
4) Identify the cropping pattern and compute the water requirements for each block
5) Develop a table grouping the blocks into different groups for water distribution.

It is suggested that before the sub-projects are handed over to the KVA, the concerned BPMU/DPMU should prepare a *Warabandi* roaster and train the KVA Management Committee members to prepare the irrigation schedules (*Warabandi*) for their respective schemes. Once they learn this process, they should conduct this exercise before every season. The process has been further elaborated below.

1. Collection of Demand Forms

The first step of the *warabandi* development process is the collection of demand forms from all the farmers receiving water. The demand forms provide the information from the farmers about the crops they are planning to cultivate and their coverage. The water users must fill the demand form and submit it to the Committee for further action and record. A sample of the demand form that the farmers/users must fill in has been attached in **Annexure 3**.

2. Division into Different Blocks

The second preparatory work for irrigation scheduling is the division of the total command area into different blocks. This division into different blocks in carried out from the water distribution point of view considering the channel capacities and grouping convenience. **Figure 3** below illustrates the possible grouping in the layout of typical command areas of irrigation schemes.

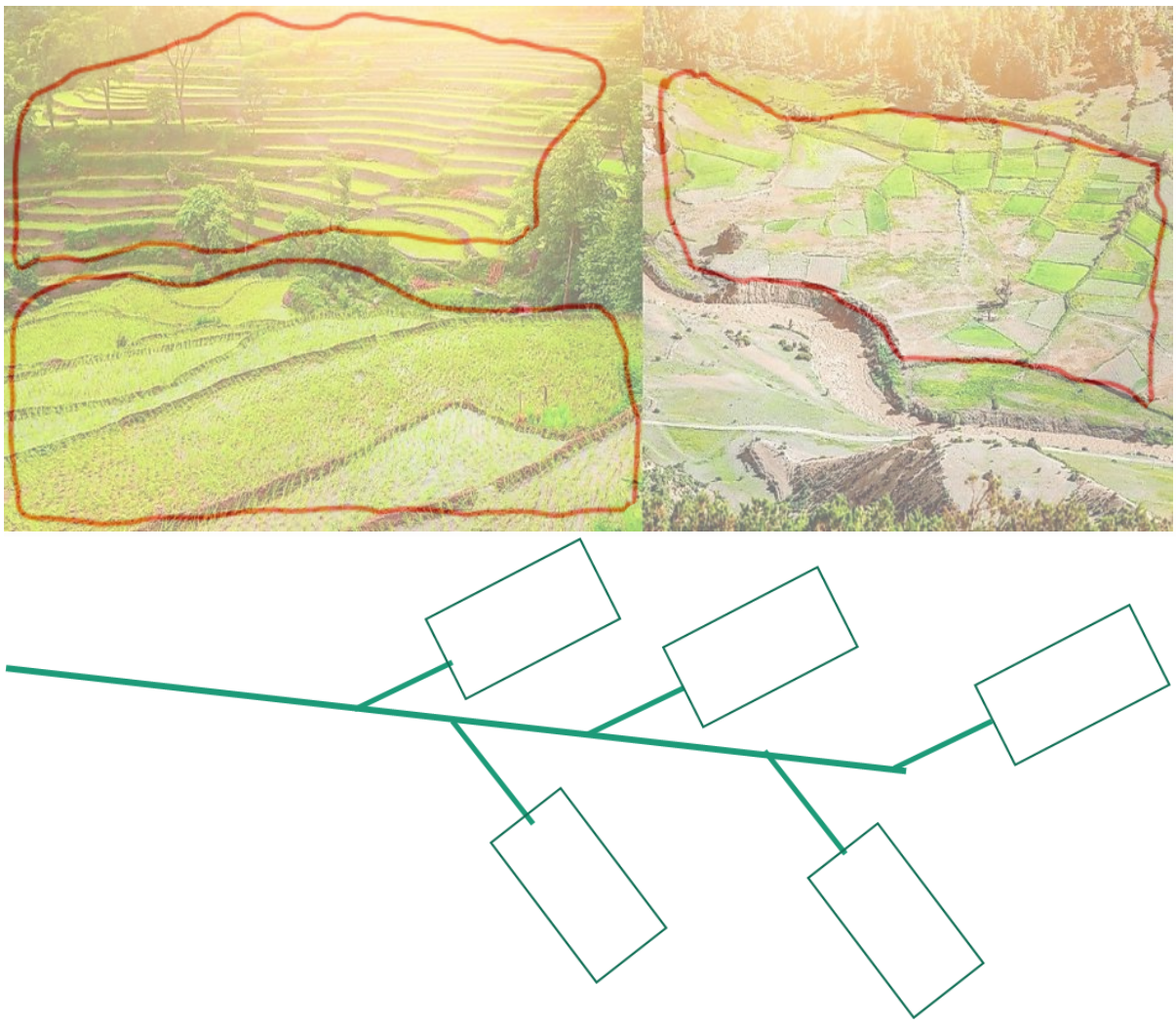


Figure 3: Dividing Command Area into Different Blocks based on Water Distribution

3. Selection of a suitable Scheduling Time Interval

The next step is to select a suitable time interval for irrigation schedule. The frequency of irrigation depends on crop type and their growth stage, climate, soil characteristics, and farmers' practices. The crops in the command area and their growth stage is the first factor to consider for deciding the frequency of irrigation. Different crops need water at different intervals e.g., rice needs frequent irrigations compared to wheat. Hence, the timing of irrigation needs to be decided accordingly. Moreover, there are different stages of crop when irrigation is critical for their growth and production. Critical periods for irrigation for the major crops in HP have been tabulated in **Annexure 4**.

Climate is the other factor that determines the rate and frequency of irrigation application. More frequent irrigation is required on hot days with long sunshine hours, low humidity, and high winds. Similarly, water holding capacity of soils is another key factor for irrigation scheduling. Clayey or heavier soils have more water holding capacity than lighter or sandy soils and medium or loamy soils. Irrigation interval is therefore longer in heavier soils. Finally, farmers' practices for soil conservation and water management also affect crop irrigation requirement. Soil mulching, weeding, and hoeing

reduce evaporation losses and conserve soil water. Similarly, method of water distribution and application techniques also influence the frequency of irrigation.

Considering all these factors, a suitable value of frequency of irrigation interval needs to be made. For the convenience of the HPCDIPP-II field level staff, a table of generalized value of frequency of irrigation for different commonly cultivated crops has been provided in **Table 1**.

Table 1: Generalized Values of Frequency of Irrigation for Different Crops

Crop	Avg. crop season	No. of irr.	1st irr.	2nd irr.	3rd irr.	4th irr.	5th irr.	Irrigation Interval	Avg. total irrigation
Frequently irrigated crops:									
M. Paddy	110 days	22	Day 1	Day 6	Day 11	Day 16	Day 21	5-day	110 cm
Cauliflower	85 days	16	Day 1	Day 6	Day 11	Day 16	Day 21	5-day	50 cm
Tomato	75 days	15	Day 1	Day 6	Day 11	Day 16	Day 21	5-day	60 cm
Cabbage	80 days	14	Day 1	Day 8	Day 15	Day 22	Day 29	7-day	45 cm
Sunflower	115 days	11	Day 1	Day 11	Day 21	Day 31	Day 41	10-day	110 cm
Potato	125 days	9	Day 1	Day 15	Day 29	Day 43	Day 57	14-day	60 cm
Radish	50 days	7	Day 1	Day 8	Day 15	Day 22	Day 29	7-day	35 cm
Peas	80 days	7	Day 1	Day 12	Day 23	Day 34	Day 45	11-day	45 cm
Crops irrigated at critical growth stages:									
Wheat	120 days	5	Day 22	Day 42	Day 72	Day 92	Day 112	different	55 cm
Soyabean	110 days	4	Day 18	Day 48	Day 88	Day 98		different	60 cm
Maize	105 days	4	Day 21	Day 44	Day 56	Day 91		different	65 cm
Groundnut	120 days	4	Day 1	Day 52	Day 86	Day 99		different	55 cm
Gram	145 days	3	Day 18	Day 48	Day 92			different	45 cm
Mustard	115 days	3	Day 32	Day 47	Day 65			different	40 cm

The above table only provides a general idea of the frequency of irrigation. The real-world situation is more complicated because a combination of crops is cultivated in the same block and the water delivery should match the requirements of each. Considering the prevailing combination of crops and local context, time interval of 3 to 10 days is generally used. **This is more of a practical judgement and can be refined based on experiences.**

4. Computation of water requirement for each block

Once the blocks are identified, the next step is to compute the cropped area of each crop type in the different blocks. Based on these crop coverages, the water requirement for each block be worked and prepare a water roaster (*Warabandi*)

5. Water Distribution Roaster (Warabandi)

The Water Distribution Roaster (Warabandi) is already given in the approved DPR of the related Sub-projects. It can be modified as per the need/season/cropping pattern. If there is any drought condition, the roaster can be prepared accordingly.

3.1.3 Preparation of operation plan

Apart from determining the irrigation schedule, additional considerations are required to operate an irrigation scheme. Operation includes the whole process of releasing, conveying, and dividing water in the irrigation scheme to ensure predetermined flows are delivered as per the stipulated irrigation schedule. While irrigation scheduling is more about deciding the water distribution pattern from a users' perspective, operation is more from the management perspective. Moreover, irrigation schedule is generally prepared for shorter periods i.e. for a week, but operation plan is prepared for longer period – generally a crop season or a year. The irrigation schedule can be easily adjusted with the changes in

prevailing conditions. These changes will also affect the operation plan. However, since the operation plan is more long-term, changes in it will also have to be predefined with the related conditions.

Operation should consider several additional factors, including:

- Size of project (ideal length, overall efficiency, etc.)
- Degree of regulation of the sources of water
- Type of conveyance and distribution facilities (open channels, buried pipes, etc)
- Method of water distribution
- Number of fields and cropping pattern
- Number and category of other users
- Quality of the water, mainly the silt content
- Impromptu climatic conditions (mainly, rain showers)

Operation Plan is prepared following the below steps:

1. *Application of appropriate water allocation criteria and procedures*

During situations of water shortage, some compromise and adjustments needs to be made in terms of supplying water as per the crop requirements. Farmers generally have a free choice of their crops and timing of cultivation activity. In some cases, there may be some control from the management on the cropping pattern e.g., restrictions on rice cultivation where applicable.

The other important aspect of formulating an irrigation operation plan is to develop an appropriate water allocation and distribution criteria, through proper consultation and preferably consensus of the water users. In these criteria, the rules for sharing water deficits should be well defined, for example:

- Increasing/decreasing the amount of irrigation water given
- Extending/reducing the interval between irrigation
- Allocating water to preferential crops.

2. *Matching supply and demand*

The whole idea behind preparing the operation plan for any irrigation scheme is to match its water demand with its supply. Since operation plans for irrigation schemes are generally prepared for a crop season or for a year, it is quite evident that it is very less likely that the prior assumed conditions will prevail for the whole planned period. Hence, it is prudent that the plan should also include specific procedures and instructions that apply when anomalies occur in the presumed conditions. These instructions should cover all the relevant operating features.

The exercise of preparing an Operation Plan is generally reiterative and complex, and the complexity varies from case to case. Difficulties arise for the estimation of water distribution ~~propagation~~ time, water use efficiencies, and effect of rain interruptions. Knowledge gained from prior operational experience should be used in refining the estimates. Additionally, to make the plan successful, it is also imperative that it is well discussed and disseminated among the KVAs members and farmers.

Since the irrigation schemes will be handed over to the concerned KVA after the completion of the project and the responsibility of operating the scheme will also go to the concerned KVA. The irrigation Management Committee of the KVA with the help of BPMU/ DPMU shall prepare a plan for the operation of irrigation scheme. A meeting shall be called inviting all KVA member to jointly accept the plan and follow accordingly.

For successful operation of irrigation schemes, the KVAs should consider the following:

- Operation of all water control structures (trash rack, flood control structures, desilting basin, regulation chambers, delivery tanks, outlets/hydrants, sluice valves, etc.)
- In case of LIS/TWIS, suction pipes, delivery pipes, foot valves, sluice valves, non-return valves, common header (where applicable), priming of pumps, fluctuations in the voltage, no over-running of motors, time to time greasing, proper check of nut & bolts, effectiveness of gaskets, timely cleaning of sump wells, to plug the water leakage if any,

3.2 Planning of Maintenance Works in Irrigation Schemes

3.2.1 Types of maintenance work in irrigation schemes

The maintenance works required in any irrigation scheme can broadly be divided into three types namely, routine, periodic and emergency maintenance works. Routine maintenance works are those works that must be repeated throughout the lifespan of an irrigation scheme to keep it functioning. On the other hand, periodic maintenance works are those works that must be carried out from time to time to safeguard the different components of irrigation scheme to ensure its proper operations. These periodic maintenance works can be carried out during the off-season when the farmers and operators (if employed) have spare time. Likewise, emergency maintenance works are works that require immediate action to prevent or reduce the damage to the irrigation scheme.

3.2.2 Preparation of maintenance plan

Rather than doing it on an ad-hoc basis, KVAs can benefit a lot by carrying out the irrigation maintenance works in a planned way. It is explained through a flow diagram in **Figure 4**.

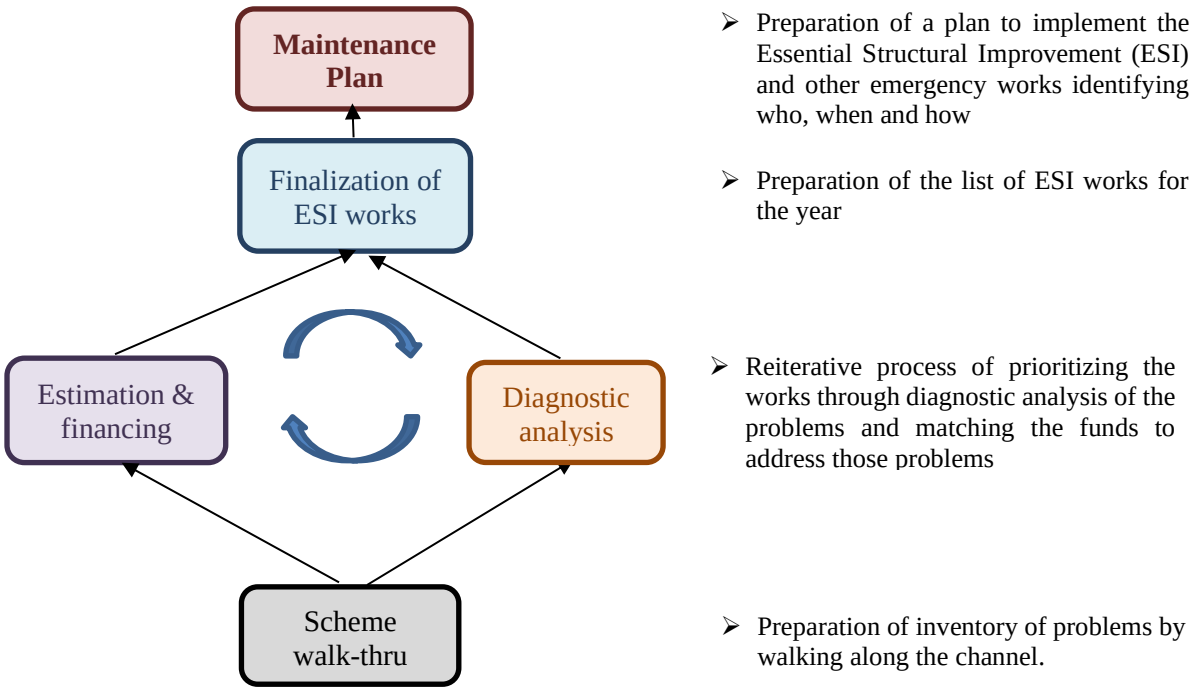


Figure 4: The Process of Developing a Maintenance Plan

Planning of maintenance works in irrigation begins by identifying the problems (bottlenecks) of the scheme. For this, the most suitable process is to walk along the channel (scheme walk-thru) and inspect all the parts of the scheme one by one. An inventory of necessary maintenance works is thus prepared. **Table 2** below shows the format for recording the inventory.

Table 2: Sample Inventory of Maintenance Work

S. No.	Description of maintenance need	Remarks
1	Greasing and repair of trash rack	Regular maintenance
2	Repair of damage of the intake structure	Damaged during floods
3	Protection of downstream scouring/ undermining	Gabion protection/ concrete plugging
4	Desilting basins	Regular desilting of sediment deposits
5	Field Channels	Regular cleaning of silt, foreign material, weeds, etc.
6	Maintenance of civil structures	Regular maintenance whenever necessary.
7	…	…

Once the inventory of all identified maintenance works is prepared, the next task is to select the works to be carried out during the current year. This goes through a reiterative process by the KVA of first roughly estimating the costs and prioritizing the works to come up with the list of what can be covered by the available resources considering the needs of the scheme. The financial status of the KVA for maintenance works can be known by keeping systematic record of income and expenditures.

Diagnostic Analysis (DA) can also be carried out to prioritize the works and make the works more cost-effective. It can be carried out during the walk-thru or separately later. DA is carried out by the KVA. Wherever possible, KVA should take the support from technical staff at the local government or line agencies. The team will examine the problematic spots of the irrigation scheme that are restricting its operation and explore their causes and magnitude, ranking the effect based on priority. The team try to identify the most appropriate and cost-effective solutions to the problems through joint discussions.

Essential Structural Improvement (ESI) works to be implemented for the year are identified to include all regular and deferred maintenance while after allocating about 10-20% of the total maintenance budget for emergency maintenance.

Once the ESI list is finalized, the annual maintenance plan is prepared. The maintenance plan should include details of maintenance works, timing, and resources for carrying out the works according to their importance for the scheme. Since annual maintenance works like channels desilting and major intake repair works are carried out through communal collective works based on their landholding size, cost of such works should be estimated based on the number of farmers participating in such jobs. Since skilled human resources may be required for some specialized jobs such as concrete or water gates repairs, they must be planned accordingly. Thus, the required resources both in terms of labor and cash is determined and planned collectively in advance. This will make it very convenient for the community to execute the required maintenance works.

3.3 Planning for O&M of Other Project Facilities

Apart from the irrigation schemes, the other facilities like access roads, building, etc. developed by the project also needs to be properly operated and maintained. This responsibility will go to the institution to which these are handed over. Before the handover process, the project will carry out the necessary capacity building activities so that they are capacitated to do it. They should also be supported to plan for the O&M of such facilities.

4. OPERATION AND MAINTENANCE OF FIS

4.1 Operation of FIS

To obtain full benefits from the FIS, it is imperative that the FIS should be properly maintained and operated. The following functions need to be carried out for proper operation:

- Water allocation: the task of allocating the available water to the different branches of the channel network.
- Water distribution and grievance redressal: the task of distributing the water to the different users (outlets). This task also includes the associated efforts of addressing the demands of the farmers and any grievances that may arise if any farmers do not receive the desired amount.

The following sections describe these operation functions.

4.1.1 Water allocation in FIS

The Management Committee of the KVA with the help of BPMU (DoA official after the completion of project) shall prepare a *warabandi* chart keeping in view as approved in DPR. Before every crop season the KVA will call a meeting of its member farmers, and they will jointly discuss and decide upon the type of crop which they will sow on their field in the coming season.

Allocation of water to the farmers be done based on actual water requirement. The farmers will regulate the use of water among the various outlets under its area of operation to promote economy in use of water allocated and monitor flow of water for irrigation.

After the estimate for water consumption is prepared, then a consensus is to be reached between the member farmers on distribution of water and the KVA shall at the beginning of every irrigation season and, especially, before each kharif and rabi season convene a meeting of the General House to discuss, deliberate and decide on the quantum of water available and the method of its distribution among the members and will fulfill the requirement as per availability of water. Priority shall be given to the farmers who opt for diversification to cash crops.

There may be instances where the water allotted to a particular farmer under the water distribution plan is not availed by the farmer. To avoid the loss of water unused, the KVA may introduce a scheme of registration of demand for additional water by any member who is desirous of utilizing water that remains unused. This register of demand may be maintained with the pump operator or at the KVA office, and in the event of allotted water not used by any specific farmer; it can be re-allotted to those farmers who have registered their demand for additional water on first come first serve basis.

4.1.2 Water distribution and grievance redressal in FIS

To develop the water distribution plan, the KVA may consider the guidelines stated hereinafter:

(i) The quantity of water that each cultivator shall get is proportional to his/her land holding irrespective of the crop grown.
(ii) However, while preparing the water distribution plan, it must be ensured that the tail end farmers first get the share of water. The length of the water course to be maintained by the farmers is proportional to their holdings. Also, the fill time and travel time shall be taken into consideration while calculating the water share timing. Each farmer shall get water as per predefined schedule.

To ensure effective water distribution, the KVA should follow these guidelines:

i. The main channel points shall operate at supply levels that would allow distributary channels to operate at their capacity or as per water requirement of the CCA to be irrigated.
ii. Only "authorized" outlets shall draw their allotted share of water from the main/distributary/field channel at the same time.
iii. Outlets when ungated shall deliver a flow of water proportional to the command area.

4.2 Maintenance for FIS

All three types of maintenance works (namely routine, periodic and emergency maintenance) need to be performed in an FIS. The procedure of different types of maintenance works of FIS are outlined here.

4.2.1 Routine maintenance of FISs

In FIS where water is used with the help of gravity, the following activities are daily routines and do not require special skills:

- Maintaining the diversion and intake structures*:* The head weir which is constructed for accumulating and controlling the flow of water into the irrigation scheme is generally made of Reinforcement Cement Concrete (RCC). However, some temporary arrangements are generally made using locally available materials like boulders, bamboo studs, thatch, etc. for channelizing water towards the intake, which is the entry point for water into the irrigation scheme. These temporary arrangements need routine maintenance. When water is not needed for irrigation, there is no need for such arrangement. However, during irrigation period, especially during dry spells such arrangements are very crucial. Hence, proper planning and assignment of work must be done prior to each irrigation season. Generally, the *kohli*/farmers will be responsible for making such arrangements.

- Removing vegetation and other trash*:* Growth of vegetation occurs along the channels and in the vicinity of irrigation structures. Similarly, other trash like tree leaves and plastics etc. also get into the irrigation scheme. These vegetations and trash tend to reduce the flow of water in the channels and disturb the hydraulic functioning of the irrigation structure. Hence, they need to be regularly cleaned so that the irrigation scheme can be smoothly operated, and water can be distributed to the farmers' field as desired. The responsibility of this work on a regular basis primarily lies with the *kohli* but all members of the KVA will be responsible for removing the vegetation and other materials from sides/embankments, water channels (*kuhals*) and drains before each crop season. It is suggested that this task be carried out by the first week of every month and that the KVA should set the day for it. Once it is completed, one MC member should inspect and record it in the Record Register.

- Removing silt from intake structure: Since all irrigation schemes are proposed on natural streams, it is very likely that some silt will get deposited upstream of the diversion structure (head weir). This silt shall be removed on quarterly/need basis. The same kind of mechanism, as mentioned above, will be developed for removing the silt from desilting basins, regulation chambers, outlets/hydrants, storage tanks and flushing of pipes.

A Maintenance Log will be maintained to document all these routine maintenance works. This log will maintain record of the type of routine maintenance work including the dates on which it was conducted and by whom. Comments received on the task shall also be recorded. This record shall be

checked and signed by the President of the KVA. The template of Maintenance Log for routine maintenance works in FIS has been attached in **Annexure 5** of this manual.

4.2.2 Periodic maintenance of FISs

The following types of activities fall under periodic maintenance in an FIS:

- Repairs of head weir**:** The head weir or check dam structure will need repair after some time. This task can be done during off season or when there is less water in the source. The Management Committee shall be responsible for this task. It is suggested that the MC should call a meeting prior to the need of such periodic maintenance and make a proper plan for carrying out such work. They can decide on whether to seek help from other members or get the works done through a contractor, depending on the nature and complexity of the work.

- Repairs of water regulation gates: Gates are generally used in irrigation structures for controlling and regulating water and diverting it to the different users as required. These gates need to be repaired from time to time. Greasing and oiling needs to be done to the moving parts on regular basis and some parts may also need to be replaced after wearing and tearing. This task is also generally performed by the Management Committee through a contractor or can also be carried out with the help of *Kohli*/farmers, depending on the nature and complexity of the work.

A maintenance log will be maintained to document all these periodic maintenance works. This log will maintain an up-to-date record of all works including the dates on which it was conducted, by whom it was conducted, and how much cost occurred. All comments received on the task shall also be recorded. This record shall be checked and signed by the President of the KVA. The record for periodic maintenance works for FIS may be maintained in the form set out in **Annexure 6.**

4.2.3 Emergency maintenance of FIS

Emergency maintenance works in FIS may include the following:

- Repair of head weir/intake structure: Due to flash flood or other reason if the structure is damaged partly or completely, then it should be repaired so that water distribution to CCA should not hampered.

- Emergency operation of water regulation structure: If due to heavy rain, water is overflowing to the farms and destroying the crops, then on emergency basis sluice gate of the head weir should be opened so that the excess flow can be safe diverted from the farms.

- Repair of damage due to natural disasters: If the irrigation scheme is damaged unexpectedly during any natural disaster, then all damages like floods, earthquakes, or storms, will have to be repaired on emergency basis. The Management Committee shall evaluate the whole damage and prepare a preliminary report and explain to all members of the KVA. After that, estimate of expenditure and other resources required to repair the damage shall be prepared. Emergency work expenses will be collected from each member of the KVA, as required, after considering subventions, if any, received from the State Government.

A separate maintenance log will be prepared for such emergency maintenance works. This log will maintain record the dates on which the emergency maintenance was conducted, the nature of the work and the people engaged in it. Comments received on the task shall also be recorded. This record shall be checked and signed by the President of the KVA. The template of the Emergency Maintenance Log in FIS and Operation record of FIS have been attached in **Annexure 7** and **Annexure 8** of this manual.

5. OPERATION AND MAINTENANCE OF LIS

Lift Irrigation Scheme (LIS) is an irrigation scheme in which water is lifted with the help of pump up to a certain height and then water is used with the gravity. The pumping is generally done by electric pumps but in some cases solar pumps have also been used.

5.1 Operation of LIS

Operation of LIS refers to timely and daily operation of all the components of the LIS such as pumping scheme (pumps/motors/accessories), rising mains/ gravity mains, distribution system, storage tanks/distribution chamber etc. An LIS is designed and installed as a permanent solution to irrigate areas in higher elevation that is not possible to be irrigated by gravity flow. The estimated life span of the LIS can be assured and even increased by closely following the planning and implementation procedure as suggested in this manual.

5.1.1 Preparatory works for operation of LIS

The procedure for preparation of operational plan is almost same as for FISs. The major difference is that since the LIS also needs more mechanical/electrical parts, rising mains, distribution pipelines etc., proper checking is necessary before the scheme goes into operation. Before turning on the pump, following checking should be done:

i. Check that system is workable before the start of season.
ii. Ensure that all regulating units are closed except outlets where water is needed on demand based.
iii. Inspect all mainline, lateral, and turnout valves. The first and last risers on each line, that is at a high point in the line, should be opened to release the air.
iv. Inspect that the foot valve in the suction pipe is fully operational.
v. Before turning on the pump, the valve should be opened at slow rate so that desired pressure is build up in the pump.
vi. After the rising main pipe is filled with water, slowly open the valve so that the rising main is filled with water.

5.1.2 Monitoring works during irrigation season

Proper surveillance needs to be maintained throughout the period of operation of LIS. The following parameters must be closely observed and checked:

i. Inspect the pipeline inlet daily or more often if necessary. Remove trash or debris.
ii. Check pressures regularly. A change means there is probably an operational or maintenance problem.
iii. Inspect flow meters at least monthly for proper operation.
iv. Check pump and valves for noisy operation. Noise is an indication that cavitation may be occurring. Cavitation can greatly reduce the life of the pump and valves.
v. Check that air-vacuum valves are seated and not discharging water.

5.2 Maintenance in LIS

Maintenance works for LIS is the act of keeping the structures, plants, machinery, equipment, other facilities, and ancillary requirements in an optimum working order. It includes replacements, correction of defects, prevention of breakdown, etc. In an LIS, maintenance of pumps, pipe network, gates, valves, metering devices, civil structures etc. are very important.

Generally, maintenance instructions are available from manufacturers, pump users' associations and other technical organizations. For most engine or electric motor driven pumps, checks and inspections are for noise, vibration, leakage, temperatures of bearings and windings, fuel/power consumption, capacity, and output (water discharge and dynamic head), ventilation screens etc. Special care should be taken to protect pumping units from moisture that can accumulate inside the machines and cause serious damage.

The procedures for routine, periodic and emergency maintenance of LIS are explained below:

5.2.1 Routine maintenance of LISs

The following are some of the routine maintenance works required in LIS to keep them functioning:

- Removing vegetation and other materials: All members of the KVA will be responsible for removing the vegetation and other materials from embankments, channels and drains. This activity is needed on routine monthly basis throughout the year. All members will be divided into groups and the Management Committee of the KVA shall assign this task to all groups turn by turn for the whole year. First group of farmers willdo the task during first month and then second group in the second month and so on. One week (first, second, third or fourth) of every month will be fixed for the assigned task and concerned group will decide the day within that month to do the task and inform the KVA. After completing the task one member of the Management Committee shall inspectthe irrigation schemes and record the task completed in Record Register.

- Lubrication oil or greasing the prime mover (electric motor): The Prime mover is needed to be lubricated or greased regularly. As per the maintenance book of electric motor, the KVA will make necessary arrangements for this task. The activity will be accomplished and inspected as per schedule. It is to be performed on quarterly/need based. It will be recorded as well.

- Pump station inspection and pump test: Evaluation includes a visual inspection of theStarter Panel, Electric Motor, Pump, and related pump scheme components. Running tests include Amp/Voltage readings and scheme pressure checks. This basic inspection can be utilized as the first line of defense in preventing major problems before they occur. This can be used to determine the overall performance of the pump. This task will be performed on monthly basis (even during the off-season) by the pump operator and inspected by one member of the Management Committee and recorded. Pump Test includes the Pump Station Inspection and measurement of the flow and/or pressure at different rates. This can be used to determine the overall performance of the pump. This task will be performed on monthly basis (even during the off-season) by the pump operator and inspected by one member of the Management Committee and recorded.

- Checking of electric wiring: The pump operator will check all the electrical wiring. The record of this task will be prepared on quarterly basis by the operator. The task will be monitored, inspected, recorded by one member of the Management Committee.

- Repairing of water hydrants: The hydrants are used for diverting water for use by different farmers in different direction, will also need repair after some time. Small repair shall be done under routine maintenance. This task will be performed by the operator with help of other farmers and/or contractor. Generally, this task will be carried out by hiring a local mason or local contractor. The task will be performed as per requirement.

To ensure that the pipes do not choke with silt, minimum prescribed velocities should be maintained for flushing the pipes. During the first irrigation, scour valves must be opened to scour out deposited foreign materials. Similarly, joint and valve leakages should be attended promptly to avoid wastages. Frequently used fittings should be kept spare for repair. Moreover, the right of approach to the field should be maintained and entry should be allowed at any time with prior notice. The record for routine maintenance works in LIS may be maintained in the form set out in **Annexure 9.**

5.2.2 Periodic maintenance of LISs

The following are some of the periodic maintenance works essential in LIS to ensure their proper operation:

- Removal of silt: The silt/debris deposited in the water bodies i.e, head weir, percolation well, intake chamber etc., sump well, chambers & MDT needs to be removed from time to time. This task can be taken up during off season. The Management Committee shall be solely responsible to do this task with the help of other members or through a contractor. The task will be performed as and when required.

- Repairs of water regulation structures/valves**:** The water regulation structures which are used for diverting water for use by different farmers in different direction, will also need repair after some time. This task will be performed by the Management Committee with the help of other farmersor by hiring a local mason or local contractor. The task will be performed on quarterly basis or as and when required.

- Service of pump and electric motor: The pump service should be undertaken regularly for its impellers, foundations, nut and bolt, pump shaft alignment, sluice valve and non-return valve should be regularly checked. Similarly electric motors service will be undertaken on annual basis or after every 1000 hours. The actual timings of service will be modified after purchasing a pump.The service will be performed by the authorized technician of the manufacturer as part of annual maintenance contract. The service will include checking and repairing of leakage, mechanical seal, bearing operating temperature, vibration level, alignment of the motor pump, motor winding insulation, motor windings, lubricating etc. The service shall be monitored, inspected, and recorded by the Management Committee.

To ensure that periodic maintenance works are carried out at appropriate times as required the following checking must done prior to each irrigation season:

i. Check pumps impellers for wear and tear. Repair if necessary.
ii. Re-pack bushes if necessary and lubricate pump timely.
iii. Suction pipe and its bend should be in proper angle and foot valve should be in working order and no pump should be run without priming.
iv. Pressure gauge should be in working order.
v. Check power panel board regularly to ensure that mouse nests and bird nests etc. are not built up.
vi. Trash rack should be regularly cleaned and repair it if necessary.
vii. Check civil structures and pipeline network for damage and repair it as needed.

Likewise, during winter season, the following precaution need to be taken for winterization:

i. Check the suction line leakage, efficient working of foot valves.
ii. Drain the pump. If the pump needs maintenance, do it.
iii. If sediment build up in the line is a problem, flush the pipeline.

iv. Close and lock the inlet structure gates and crack open all turnouts located at high points in the line and all low-lying turnouts.
v. In case of frost condition, open all drains and allow the pipe to drain. Flush out all low spots in the pipeline.
vi. Close all gates, valves and other openings where small animals or water could enter the pipeline.
vii. Leave drain valves etc., open during the winter in frost condition especially in the high-altitude area.

A periodic maintenance log may be maintained in the form set out in **Annexure 10** to document dates that maintenance was conducted, by whom, and any maintenance related comments about the task conducted. This record shall be checked and signed by the President of KVA.

5.2.3 Emergency maintenance of LISs

Emergency works in LIS may require immediate and joint action by relevant Departments of the State Government and farmers, to prevent or reduce the effects of unexpected adversaries. These works include:

- Repair of head weir: Due to flash floods or other reason if the head weir is damaged, timely action to be taken to repair it.

- Damages due to natural disasters (flood, earthquake or storm): If the irrigation scheme is damage unexpectedly during any natural disaster, then all damage will have to be repaired on emergency basis. The Management Committee shall evaluate the whole damage and prepare a preliminary report and explain to all members of KVA. After that, estimate of expenditure and other resources required to repair the damage shall be prepared. Emergency work expenses will be collected from each member of the KVA, as required, after considering subventions, if any, received from the State Government.

- Damage due to electricity short circuit: If the electricity wiring and transformer is damaged due to short circuit or moist, then the Management Committee shall inform the State Electricity Board Officials. The task will be performed by the technicians of the State Electricity Board. The task will be performed based on occurrence and/ or as and when required.

The record for emergency maintenance works for LIS may be maintained in the form set out in **Annexure 11.** The operation record of LIS is given in **Annexure 12**.

6. OPERATION AND MAINTENANCE OF TWIS/PERCOLATION WELL

Tube Well Irrigation Scheme (TWIS) is an irrigation scheme in which water is extracted from underground through tube well. The Tube wells are mostly electrically powered but, in some cases, also solar powered. There are 28 TWISs sub-projects. TWIS are of two types (1) Shallow Tube well and (2) Deep Tube well. The operation and maintenance of both types of tube wells is almost similar; and, hence, explained below collectively.

6.1 Operation of TWIS

In terms of operation, due to their generally smaller size, operation of TWISs is relatively easy. However, if not done properly, it can still be challenging in terms of management, efficiency, and even delivery of irrigation services. In this regard, poor maintenance, lack of accountability of the tube well operator of the community, domination by local elite, frequent power cuts, delays in repair and procurement of spare-parts, local dispute regarding the right of passage, etc., are amongst the several problems that TWIS suffer from. Small farmers generally benefit from TWISs through improvement in crop pattern, crop yields, and cropping intensity. However, experiences of some TWISs from the first phase has not been very encouraging in terms of water utilization.

6.1.1 Operation of the tubewells

Once the tubewells are handed over, their management responsibility also goes to the KVAs. The reliable quantitative estimates of water availability in the location through pumping test data can help in minimizing the risk of failure of TWISs. The hydrogeological characteristics of the aquifer are quantitatively defined by two parameters: permeability and storage. The most accurate, reliable, and commonly used method of determining aquifer characteristics is by controlled aquifer pumping test. It is designed to impose a hydraulic stress on the aquifer in such a way that measurements of the responses to the stress will fit in a theoretical model of aquifer responses.

6.1.2 Operation at the on-farm level

Following the principles of community management, the KVA are expected to play a key role in harnessing the available groundwater in their area through community decisions. This approach aims to enable the village community to make best use of the available resources. If farmers feel a genuine sense of ‘participation’ in community decisions, they may be much more inclined to comply with them. This has been demonstrated through efficiency and equity water distribution in many community tubewells in India. The basic ‘success’ factors of such arrangements are the small size of the groups and homogeneity in the group members in terms of economic status and landholding, quality of leadership, external support in both leadership, and management. These factors establish a sense of responsibility for the conserving and sustaining the tubewell. It is also important to note that the success of community management largely depends on the cooperation amongst the stakeholders. Their cooperation arises in two conditions: first, if there is a collective gain that is larger than the individual private gains, and second, if the problem of ‘free riders’ can be sought through coercion and sanctions (e.g., imposition of fines on those who violate the agreed rules of water use). Active role of KVA in the operation of the TWIS is also expected to equitable distribution of water as large farmers would not have virtual monopoly of access to this resource.

6.2 Maintenance for TWIS

The routine, periodic and emergency maintenance of TWIS has been described below.

6.2.1 Routine maintenance of TWIS

Routine maintenance of TWIS entails the following activities:

- Removing vegetation and silt: All KVA members are responsible for removing the vegetation and other materials from open channels/drains (*kuhal*). This activity is needed on routine basis throughout the year. All members will be divided into groups and the Management Committee of the KVA shall assign this task to all groups turn by turn for the whole year. First group of farmers will do the task during first month and then second group in the second month and so on. One week (first, second, third or fourth) of every month will be fixed for the assigned task and concerned group will decide the day within that month to do the task and inform the KVA. After completion of the task, one member of the Management Committee shall inspect the irrigation schemes and record the task completed in a Record Register.

- Inspection of submersible electric pump: This includes pump inspection and measurement of efficiency/ flow and/or pressure. This can be used to determine the overall performance of the pump. This task will be performed on monthly basis (evenduring the off-season) by the pump operator and inspected by one member of the Management Committee and recorded.

- Repair of electric wiring: The pump operator should check the electricity wiring scheme. The record of this task should be prepared on quarterly basis by the operator. The task should be monitored, inspected, and recorded by the Management Committee.

- Inspection of Water Hydrants: The hydrants are used for diverting water for use of water by different farmers in different direction, will be inspected by the operator on monthly basis. On an average there could be around 40 hydrants in an irrigation scheme. The inspection will be duly recorded as per standard procedure.

The record for routine maintenance works for TWIS may be maintained in the form set out in **Annexure 13.**

6.2.2 Periodic maintenance of TWIS

Periodic maintenance works of TWIS are generally carried out during off-season by the operator or farmers and for very large or difficult jobs, it may be necessary to hire a contractor. The following works may fall under this category:

- Repairs of water hydrants: The hydrants are used for diverting water for use of water by different farmers in different direction, will also need repair after some time. On an average there could be around 40 hydrants in an irrigation scheme. This task will be performed by the Management Committee with the help of other farmers and/or contractor, depending on the nature and complexity of the work. Generally, this task will be undertaken by hiring a local mason or local contractor. The task will be performed on quarterly basis.

- Service of Electric Driven Pump: The service of electric driven submersible pump shall be undertaken as per the instructions given by the pump manufacturer (number of months or number of hours). For the time being, it is assumed that the service will be carried out on annual basisor after every 1000 hours. The actual timings of service will be modified after purchasing a pump. The service will be done by the authorized technician of the manufacturer as part of

annual maintenance contract. The service will include checking and repairing of leakage, mechanical seal, bearing operating temperature, vibration level, alignment of the motor pump, integrity of motor winding insulation, motor windings, etc. The service will be monitored, inspected, recorded by the Management Committee.

A periodic maintenance log may be maintained in the form set out in **Annexure 14** to document dates that maintenance was conducted, by whom, and any maintenance related comments about the task conducted. This record shall be checked and signed by the President of KVA.

6.2.3 Emergency maintenance of TWIS

The following are the works that require immediate and joint action by relevant departments of the State Government and farmers, to prevent or reduce adverse effects on TWIS:

- Damage due to natural disasters like flood, earthquake, or storm: If the irrigation scheme is damaged unexpectedly during any natural disaster, then all damage will be repaired on emergency basis. The Management Committee shall evaluate the whole damage and prepare a preliminary report and explain to all members of the KVA. After that, estimate of expenditure and other resources required to repair the damage will be prepared. Emergency work expenses will be collected from each member of the KVA as required, after considering subvention, if any, received from the State Government. The task will be performed based on occurrence and/ or as and when required.

- Damage due to electricity short circuit: If the electricity wiring and transformer is damaged due to short circuit or moist, then the Management Committee shall inform the State Electricity Board officials. The task will be performed by the technicians of the State Electricity Board as and when required. The task will be performed based on occurrence and/ or as and when required.

An emergency maintenance log may be maintained in the form set out in **Annexure 15** to document dates that maintenance was conducted, by whom, and any maintenance related comments about the task conducted. This record shall be checked and signed by the President of the KVA**.** The operation record of TWIS is given in **Annexure 16**.

7. O&M OF BUILDINGS AND FARM ACCESS ROAD

7.1 Operation and Maintenance of Buildings

Operation and maintenance of buildings is undertaken to keep, restore or improve the facilities of a structure or building which include housekeeping, civil, E&M services, horticulture, and landscaping to keep the structure/building in good condition and in currently acceptable standards to sustain its utility and value.

The objective of maintenance is:

(i) To ensure safety of the occupants or the public at large.
(ii) To preserve building and services, in good operating and habitable condition.
(iii) To upgrade, renovate, rehabilitate, or retrofit the facilities to improved specifications and standards, where so required.

The expected economic life of the building under normal occupancy and maintenance conditions is taken as provided below:

(i) Monumental buildings 100 years.
(ii) RCC Framed construction 75 years.
(iii) Load bearing construction 55 years.
(iv) Semi-permanent structures 30 years.
(v) Purely temporary structures 5 years.

The life of the building mentioned above is only indicative and it depends on several factors like location, utilization, specifications, maintenance, and upkeep/caretaking. This highlights the importance of proper O&M of the buildings. This section describes the procedure for preventive measures, regular maintenance, periodic maintenance, and emergency maintenance.

7.1.1 Preventive measures

Preventive measures are essential to keep the building services in serviceable condition. Preventive maintenance is taken-up so that the services or the assets do not fail due to wear and tear and those components and services expected to fail are replaced well in time. Schemeatic inspections by all concerned officers are essential particularly of those services and components which are prone to higher wear and tear and nearing to outlive/outlived their life.

All Buildings/structures are required to be inspected twice a year by the JE and once in a year by concerned Engineer to check the visual defects, if any and suggest remedial measures like structural repair, replacement, retrofitting, up-gradation, horticulture works and submit estimates to the DOA or DD.

Cleanliness shall be maintained in and around the building and ensured that malba (garbage) is collected from the workplace and deposited at suitable identified spots, where residents/users do not throw garbage on it. Suitable provision will be made for disposal of malba on continuous basis and not allowed to accumulate / pile up. The arrangements of green and blue dust bins shall be made as per the standard norms. The arrangement for disposal of C&D (Construction & Demolition) waste shall be made separately.

Any leakage from the water supply line, sewers or unfiltered water supply line noticed in and around the building should be repaired immediately. It shall be ensured that sewer lines are not laid over water supply lines and are not in close vicinity due to which there is any chance of getting sewage

mixed into potable water. Thin members are exposed to severe weathering conditions, members affected by leakage/ seepage and members/components affected by water splashes should also be inspected.

Water should not be allowed to stagnate on the roofs, courtyards, roadside or any other place. It shall be ensured that before rains, all roofs, drains, and rainwater harvesting filter media are cleaned properly. In case unhygienic health hazardous conditions are noticed in the portion of areas/service maintained by local bodies, the same will be reported to them and pursued for action. Over-head tanks will be provided with lockable covers and Mosquito proof couplings. The occupants will be advised against storage of water in coolers not in use and apply Mosquito repellents in the Cooler's pads etc. to check spread of Malaria.

The following categories of items also have great significance in preventing maintenance; hence, special attention must be paid in respect of these items also:

(i) Cleanliness of roofs, inlet of rainwater pipes, *khurra*, *chajja*/sunshade top, outlet of rainwater pipes, plinth protection and drains at least twice a year and particularly before monsoon.
(ii) Cracks on *gola* and top of parapet.
(iii) Cleanliness and waterproofing of *mumty* roof.
(iv) Leakage from terrace tanks
(v) Damage of water proofing due to installation of various services on roof like Dish antenna, solar panels, etc or weed/vegetation.
(vi) Cracks on grit plaster, spalling of concrete, cladding stone coming out of substrate etc
(vii) Leakages/seepages.
(viii) Rusting of GI pipes and fittings showing seepage/leakage and crack in CPVC pipe.
(ix) Shafts for the leakage/seepage.
(x) Sagging false ceiling.
(xi) Termite affected areas and wooden members.
(xii) The cleaning of manholes and sewer lines and checking for rainwater getting mixed in sewer lines.
(xiii) Damaged cables & other abandoned service lines.
(xiv) Electrical schemes like main boards etc. should be checked annually.
(xv) Fire services particularly during hot weather and assessment of electric load due to additional services installed.
(xvi) Whether unprotected heaters in use likely to cause fire incident.

7.1.2 Regular maintenance of buildings

Day to day or routine repairs are the works which are to be attended on the day to day basis such as removing choking of drainage pipes, manholes, restoration of water supply, removing of leakage from water taps / angle valves / pipe joints / overhead tanks, replacement of faulty water taps / angle valves, PVC connections, waste pipe etc., replacement of broken sanitary fittings / fixtures, providing missing manhole covers / gully trap covers, replacement of broken wall / floor tiles, repairs of doors/windows, replacement of damaged door/window hardware, replacement of glass window panes, curtain rod, patch repair to plaster (less than 2.5 sqm), replacement of faulty switches, sockets, drivers/chocks of fittings (except tube light / lamps), repair of fans, replacement of wiring due to accident etc., watering of plants, lawn mowing, hedge cutting, sweeping of leaf falls etc. and other minor routine works required for keeping the building functional and habitable condition. These services are provided after receipt of complaints from the users as well as instructions from department's representative and contractor's representative. This does not include annual repair and special repair

works.

7.1.3 Periodic and preventive maintenance of buildings

The works of periodic nature like whitewashing, color washing, distempering, painting etc. are called periodic maintenance and are generally carried out once in a year through the scheme of contracts. The timing of various items under periodic maintenance is indicated in **Annexure 17**. In addition, works such as patch repair to plaster (more than 2.5 sqm), minor repairs to various items of work such as replacement of damaged soil / waste pipe stack, re-plastering in shafts, Gap filling of hedges/perennial beds, Replacement/Replanting of trees, shrubs, painting of tree guards, planting of annual beds and trimming/pruning of plants etc., which are not emergent works and are considered to be of routine type, can be collected and attended to for a group of houses at a time and particular period of financial year, depending upon the exigency. Such works can be done under regular maintenance also.

7.1.4 Emergency maintenance of buildings

As the building ages, there is deterioration to the various parts of the building and services and major repairs and replacement of elements become inevitable. It becomes necessary to prevent the structure from deterioration and undue wear and tear as well as to restore it back to its original condition to the extent possible.

There are two kinds of emergency repairs

a) Replacement of various building's elements after expiry of useful life
b) Major repairs undertaken due to wear and tear of the building

The following types of works in general are undertaken under special repairs: -

i. Provision of water proofing treatment to the roof. All the existing treatments known are supposed to last satisfactorily only for a period of about ten years.
ii. Repair of internal roads and pavements.
iii. Repairs/replacement of flooring, skirting, dado, and plaster.
iv. Replacement of doors, window frames, shutters, and fittings.
v. Replacement of water supply and sanitary installation like water tanks, WC cistern, wash basins, kitchen sinks, pipes etc. The life of GI pipes shall be considered as 25 years.
vi. Re-grassing of lawns/grass plots in 5 to 6 years without replacement of earth and in 8 to 10 years with replacement of earth.
vii. Renovation of lawn in 4 to 6 years as per site requirement.
viii. Replanting of hedges in 8-10 years.
ix. Completely uprooting and removing hedges / shrubbery.
x. Replanting of (a) Rose beds in 5-6 years. (b) Perennial beds in 5-6 years. (c) Canna beds in 1-2 years.
xi. Shifting of any garden feature from one site to another within building.
xii. Electrical Equipment's/ Installations after their useful life as given in **Annexure 18**.

7.2 Operation and Maintenance of Farm Access Roads

Road networks in the subproject area are classified as National highways, State Highways, Major district roads, other district roads, village roads and *katcha* path in case habitations. National Highways are generally of 14m of width bituminous road, State Highways are generally 8m Major District Road is generally 6 m in width bituminous road, other district roads are of 5m width bituminous road and village roads are generally 3.5m bituminous road or brick roads. Maximum dia pipes in the Project is

of size which can easily be laid in shoulders of the roads. In this project beneficiary will contribute up to10% for Farm Roads.

7.2.1 Maintenance, Repair and Rehabilitation of Cement Concrete Pavements

(Refer IRC: SP: 83-2018 - Guidelines for Maintenance, Repair and Rehabilitation of Cement Concrete Pavements)

Introduction:

Concrete Pavements also known as Rigid Pavements have a relatively long service life, provided these are properly designed, constructed and maintained. This is because concrete pavements are economical in life cycle cost and known to perform better with minimum maintenance. The concrete pavement can serve up to its design service life and even beyond if timely repairs are undertaken. Load transfer mechanism of the concrete pavement is through beam action and accordingly the concrete pavements are expected to perform relatively better than flexible pavements on weak sub grades, as these can bridge small soft or settled areas of sub-grades. The concrete pavement performance in high rainfall areas is found better than flexible pavement due to high resistance to water penetration. Similarly in hilly terrain, concrete pavement is able to resist impact load and abrasion due to braking and acceleration in a better way than flexible pavement.

General:

The repairs of CC Pavements are usually performed by skilled (sometimes specialist) labor. The main types of maintenance required in respect of cement concrete pavements are as follows:

(a) Routine Maintenance: Routine maintenance may be defined as those treatments that are applied to a pavement to keep the pavement functioning properly. As such routine maintenance is sometime called 'reactive maintenance'. This suggests that it is a work that is performed as a reaction to a specific distress. Routine maintenance is performed on pavement as they begin to show sign of deterioration but is generally considered to be a wasted effort on pavement that are severely distressed.

(b) Programmed Maintenance: It covers works undertaken to arrest deterioration and restore the asset to its original condition. Works are programmed in advance and defined to delay further deterioration. It normally includes work such as resealing the defective joint with sealant, cross-stitching, partial depth repairs, full depth and diamond grinding to remove faults in the rigid pavement.

(c) Rehabilitation and Strengthening: It refers to programmed works that are undertaken to structurally restore the condition of a road section to impart further design life to carry future expected traffic loads. The works upgrade the road to current design standards. It includes work like diamond grooving for restoring surface texture, slab stabilization, reconstruction or application of an overlay to rectify structural deficiencies in the pavement, retrofitting of dowel bars and tie bars wherever needed.

(d) Emergency Repairs: It covers responding to complaints or emergencies.

Distress Identification:

A site condition survey once a year, preferably in the beginning of monsoon season should be undertaken to assess the existing pavement condition and to identify the pavement distresses. Such site condition surveys should aim at two objectives: (i) to determine the root cause of pavement's distress. (ii) To track the rate of progression of the distress leading to pavement deterioration.

Distress Types: Distresses in concrete pavements are either structural or functional. Structural distresses primarily affect the pavement's ability to carry traffic load. Functional distresses mainly affect the riding quality and safety of the traffic.

Common Defects and Distresses in Concrete Pavements:

These could be due to poor quality of materials/workmanship/design defects and environmental causes. Manifestation of distress in cement concrete pavements may be classified in the form of:

Cracking:

(a) Plastic shrinkage cracks (b) Crow Foot or "Y" shaped cracks (c) Edge cracks (d) Corner cracks breaks (e) Transverse cracks (f) Longitudinal cracks (g) Diagonal cracks (h) Durability "D" cracking (i) Punchouts.

Surface Defects:

(a) Pop-outs/Small holes (b) Animal/Wheel impressions (c) Scaling (d) Raveling (e) Deep abrasion/scooping of surface (following accident) (f) Polished aggregates/glazing/smooth surface

Joint Defects:

(a) Spalling (b) Sealant failure and/or loss (c) Faulting at joints (d) Separation at joints.

Types of Repair Techniques:

Repair techniques can be broadly classified into two categories:

i. Preventive Techniques
ii. Corrective Techniques

Preventive techniques are pro-active techniques/activities. These are aimed to slow down or prevent the occurrence of the distress to ensure a longer service life of the pavement. Joint and crack resealing are the most applied preventive repair techniques. Full depth repairs are examples of corrective repair activities. There are several corrective activities/ repair techniques which perform both the function of corrective as well as preventive repair activities. Diamond grinding, grooving, slab stabilization, cross-stitching, retrofitting of dowel bars/edge drains and retexturing are some of the activities of the repair techniques which act both as corrective and preventive repair activities.

Repair Methodology:

Tables 3, 4, and 4 list a range of techniques and applications for repairing and restoring the integrity of the concrete pavement slab.

Table 3: Concrete Pavement Repair Techniques (Preventive Activities)

S. No.	Repair Technique	Application
1	Crack and Joint resealing with flexible sealant	Used to minimize infiltration of water and incompressible material into joint system.
2	Crack sealing with epoxy resin	Used to seal shallow fine to medium width cracks and prevent concrete breaking out at spalls
3	Crack cross stitching	Used to repair low and medium severity longitudinal cracks.
4	Partial depth repairs	Used to repair joint and crack deterioration and surface distress. Used to repair popouts and potholes.

Table 4: Concrete Pavement Repair Techniques (Corrective Activities)

(Ref: ACPA Concrete Pavement Restoration Guide)

S. No.	Repair Technique	Application
1	Full depth repairs	Used to repair full depth cracks and joint deterioration. Used to repair punchouts (CRCP)
2	Slab stabilization	A specialized technique used to alleviate pumping
3	Dowel bar retrofit	A specialized technique used to restore load transfer at joints and cracks
4	Slab lifting or jacking	A specialized technique used to raise sunken slabs by lifting or pressure grouting beneath the panel.

S. No.	Repair Technique	Application
5	Diamond grinding	A specialized technique used to extend serviceability, improve ride and skid resistance
6	Diamond Grooving	A specialized technique used to reduce wet weather accidents and prevent hydroplaning

Table 5: Annual calendar of Road Maintenance Activities for Rigid and Flexible Pavements

S. N.	Item of Work	Intervention Standard	Response Time	Frequency	Remarks
1	**Cleaning/Desilting of roadside drain/ gutter**			Thrice February, May and June i) August and ii) September and iii) and when required blockade more than one-fourth	Refer Govt of HP Rural Road maintenance policy 2015
	Water diverted out of drain onto roadway	Causing a hazard to traffic	Immediate		
	Obstruction or Siltation impeding flow	Blocked by more than one-fourth of the size of the drain	14 days and prior to monsoon		
2	**Pothole Filling**				
	Collection of patch repair material for Bituminous roads			i) January and February ii) July to September	
	Collection of patch repair material for WBM repair			i) January and February ii) July to August	
	Pothole filling in Bituminous and rigid pavement with maximum dimension more than 200mm, cracks, edge breaks, ruts and depressions	All potholes = 75mm depth, Cracks > 5mm in width, Ruts > 50 mm in depth, Depressions > 50 mm in depth	21 days	Immediate on their occurrence	
	Pothole filling in WBM with maximum dimension >200mm	Depth > 75mm	21 days		
	Pothole filling in Gravel/ Katcha surface	Depth > 50mm width > 300mm	45 days		
3	**Filling edges of bituminous surfaces and replenishing/ lowering earthen/ hard shoulders**	Difference (-) 50mm/ (+) 0mm		Before and after monsoons and as and when requirements as specified are exceeded as per Col.3	
4	**Dressing of berms**			Before and after monsoons and once in between i.e. February/ March, June, August and September	
5	**Restoration of rain cuts and side slopes**			September and as and when required	

7.2.2 Maintenance, Repair and Rehabilitation of Cement Concrete Pavements

(Based on IRC: SP: 63-2018 -Guidelines for the use of Interlocking Concrete Block Pavement)

General:

Like any other road work, block pavement also required to be maintained to get long service. The maintenance requirement of block pavement is minimal. The block pavement requires initial maintenance soon after its laying, say after a week or two for checking sand in the joints. Subsequently, the maintenance is in the form of replacing any damaged block/blocks or raising the settled section, if

any. Repair especially after laying a cable duct is much simpler in the case of block pavements. The cut area can be reinstated without any blemish.

Initial Maintenance:

After about a week of laying the blocks there is a need to inspect the surface to check for any loss of sand at joints. Wherever sand level has dropped down it should be reinstated. This type of inspection should continue for two to three months till the sand level is stabilized and topping up is no more required. With time, the joints receive fine dust and detritus thus making them waterproof. During rains these joints may allow weeds to grow but these normally should get eliminated with the traffic. In case, it does not get eliminated, these may have to be controlled by spraying herbicide or by manual removal. Annual inspection, however, will be required.

Storage of Blocks:

For reinstating damaged blocks, it is necessary to stockpile a small percentage of blocks from the lots used in the construction. The size and color of the blocks may be difficult to obtain at a later date matching with the original blocks. For important projects, it is normal to stockpile blocks from 1 per cent to 3 per cent of initial supply for subsequent use.

Coating and Cleaning:

As part of preventive maintenance, blocks can be sealed using compounds, like, silicone, acrylics and silica fluorides for enhancing the color, reducing absorptive nature of the blocks and for improving surface toughness. These coatings have life of 1 to 3 years and hence they have to be repeated as per the requirement. The most durable of these chemicals is solvent borne acrylics which are abrasion resistant and also minimize chemical effects of spillage even at 60°C.

Cleaning of block pavement can be done by mechanical brooms, compressors or even by manual means. For removing certain stains, chemicals, like, oxalic, acetic and phosphoric acids etc. are used. Sometimes it may be expedient to replace the blocks where stains have penetrated to a greater depth.

8. O&M OF MICRO IRRIGATION AND OTHER FACILITIES

8.1 Operation and Maintenance of Drip Irrigation Scheme

An irrigation system requires minimal maintenance if it is planned and designed as recommended. It is advisable that all components must be checked as per the guidelines for installation of specific products. A maintenance plan and regular monitoring of the system ensures that minor problems do not turn into major ones.

The quality of water differs with its source. Higher rainfall in summer means that water sources are muddy due to increased content of silt and sand. Algae are more prevalent during warmer months, which increases the biomass that must be filtered. The quality of water, usually, becomes poor because of lower water level as pumps tend to suck more dirt and there is little time for the silt and sand to settle out of the water. When the water quality is poor, filters must be flushed at regular intervals. It is essential to keep a record of lateral flushing, filter flushing and water quality.

In 'preventive maintenance', a procedure or group of procedures is adopted to prevent obstructions from plugging, clogging or blocking of drippers. In 'corrective maintenance', obstructions that cause dysfunction to the system are removed.

It is also required to check the working of filters, air release valves and the fertigation unit. Once it is ensured that all the components are functioning properly and the required pressure exists in the scheme, the scheme is ready for use.

8.1.1 Operation of drip scheme components

When the drip irrigation scheme is in use, it is of course desired that the scheme be operated properly in a trouble-free and durable manner. The following guidelines may be considered for this purpose:

1) Keep all the design, evaluation and testing information from the designer, installer, and dealer handy.
2) Compute the time of operation of different subunits based on the climatological data of previous day(s) or from the average historical data; prepare the time schedules for different valves and operate the valves accordingly to release the desired quantity of water, compute the volume of water to be applied for each setting/subunit and ensure that the desire quantity of water is applied.
3) Check the pressure at the pressure gages regularly.
4) For the scheme involving the operation of valves hydraulically, ensure proper setting of the hydraulic metering valve.
5) Operating the head valve to begin irrigation.
6) Checking the scheme all components for proper operation, beginning with pressure readings at the control header.
7) Checking the emitters, randomly for its discharge.
8) Measure the emission uniformity of the scheme at least at the start of the irrigation season.
9) Check the chemical and fertilizer injection equipment to ensure the application of desired quantity and concentration.

8.1.2 Maintenance of drip scheme components

Periodic preventive maintenance of all the components of the drip irrigation scheme is required for successful operation of drip irrigation scheme.

Maintenance of Pumps

Usually, maintenance instructions are available from manufacturers, pump users' associations and other technical organizations. For most engine or electric motor driven pumps, checks and inspections are for noise, vibration, leakage, temperatures of bearings and windings, fuel/power consumption, capacity and output (water discharge and dynamic head), ventilation screens etc. Special care should be taken to protect engines from moisture that can accumulate inside the machines and cause serious damage.

Pre-season Maintenance

1) Check pumps impellers for wear. Repair if necessary.
2) Re-pack bushings if necessary and lubricate pump.
3) Install the suction pipe on a pump. Make sure it is well supported and has no air leaks. A vacuum gauge installed in the suction line is a good way to monitor suction problems.
4) Make sure a pressure gauge is installed at the outlet and is operable. A good fluid filled pressure gauge is a good monitoring tool.
5) Check power panel, wiring and pump enclosure to make sure mouse nests, bird nests, and other such problems are resolved.
6) Inlet screens should be cleaned, and trash removed from the structure. Repair screens as necessary.
7) Check headgates and valves for proper operation. Grease gate stems.
8) Check structures and pipeline for damage and repair as needed.

Operation Check list for Pumps

Before turning on the pump, following shall be done:

1) Check that all pre-season maintenance is complete.
2) Before starting, read and record flow meter totals.
3) Inspect all drains to be sure that drain valves are closed.
4) Inspect all mainline, lateral, and turnout valves. Open the operational turnout. The first and last risers on each line, as well as any riser that is at a high point in the line, should be cracked open to allow air to be released from the system.
5) Open all manual air release valves.
6) Inspect all air valves to see that the airway is open (stem pushed down) and the float ball and seat are in place and undamaged.
7) Visually inspect all pressure relief valves to be sure that they are free to operate and have not been adjusted to a higher or lower pressure setting.
8) Before turning on the pump, the valve at the pump should be closed to the point that it is not more than 1/4 open.
9) After the pipeline is filled, slowly open the valve to full open. If the flow must be throttled during operation, consideration should be given to making changes in the system. Throttled valve wastes energy.

Maintenance of Valves

All kinds of valves should be anchored properly so as to minimize the turning movement imparted to the pipe by operation.

Maintenance of distribution network

A drip irrigation system requires more attention and maintenance as compared to other irrigation systems. A drip irrigation system is vulnerable to over-pressurization and clogging, both of which can drastically reduce the system's durability and performance.

For drip irrigation, turn on the system 20–30 minutes before inspection to allow enough time for emitter wetting patterns to show up. Check for leaks or clogged emitters from the valve to the end of the irrigation line. Check the placement of emitters near plants.

Emitters

The emitter functioning, wetting pattern and leakage of pipes, valves, and fittings should be checked regularly. The placement of emitters should be ascertained. If the placement is disturbed, place them in proper position. If emitters do not give the rated pressure, they need to be cleaned manually either by flushing or provide manual or automatic chemical (acid or chlorine) treatments. Emitters not giving the rated discharge even after flushing or the chemical treatments should be replaced. Leakage through filter gaskets in the lids, flushing valves & fittings etc. are monitored regularly.

Sub-main and Lateral / System Flushing

System flushing is the process of opening flush valves on the main line, sub-mains or laterals while under pressure. It is possible that the silt or other dirt materials escape through the filters and settles in sub mains and laterals. Also, some algae and bacteria lead to the formation of slimes/pastes in the sub mains and laterals. The sub mains should be flushed by opening the flush valves to remove these formations. The lateral should be flushed by removing the end caps allowing water to pass through.

Flushing increases the water velocity inside the pipeline or dripper line, which scours and removes contaminants off the walls or from individual emitters. The pressure of the regulating valve is increased to achieve enhanced velocities, nevertheless, care must be taken not to exceed the burst pressure of the emitter line and take-off adapters. Recommended flushing velocities are as follows.

1) Main line: 1 meter per second
2) Sub-mains: 1 meter per second
3) Laterals: 0.5 meter per second

Choking of Pipes by excess silt minimum velocities as prescribed shall be maintained for flushing of the pipes. During the first irrigation, scour valves should be let open to scour out any foreign material deposited.

System flushing needs to be carried out at regular intervals. The frequency of flushing depends mainly on the water quality and weather. Table indicates the starting point for flushing. However, individual site conditions influence the increase or decrease of flushing intervals. Table 6 below presents the quality of flushing intervals for different water sources.

Table 6: Quality of Flushing for Different Water Sources at Different Intervals

Quality	Water source	Flushing interval
Good	• Bore water with no presence of iron or magnesium	6 months
Average	• Rivers, dams or lagoons that are slow flowing • Wastewater discharged from industries after treatment	4 months
Poor	• Rivers, creeks or canals found in hot climates with increased biological growth and no chemical treatment • Faulty placement of the pumping point in the direction of wind with little or no sedimentation • Untreated effluent water after sedimentation	Monthly
Very poor	• Bore water having high iron or magnesium content	Fortnightly

Maintenance Schedule

A. Daily maintenance:

Following activities should be carried out daily:

1) Start the pump and allow the pressure to become stable. Open the drain valves of the screen filters and hydro cyclone filters to remove the debris. Backwash the sand filter.

Back washing is the process in which the flow direction is reversed so that the water flows upwards through the sand bed. The sand gets lifted and expands allowing it to release the dirt arrested in it, the dirt then driven out of the filter through the back wash valve. Back washing of the sand filter should be strictly done in the following sequence.

1) Open the Backwash valve.
2) Close the outlet valve
3) Open the bypass valve.
4) Close the inlet valve.

Back wash operation is complete when clear water starts flowing out through the backwash valve to resume the filtration process again.

Manual cleaning processes is open the cap of the sand filter before starting the system and remove all dust, algae and other dirty particles manually.

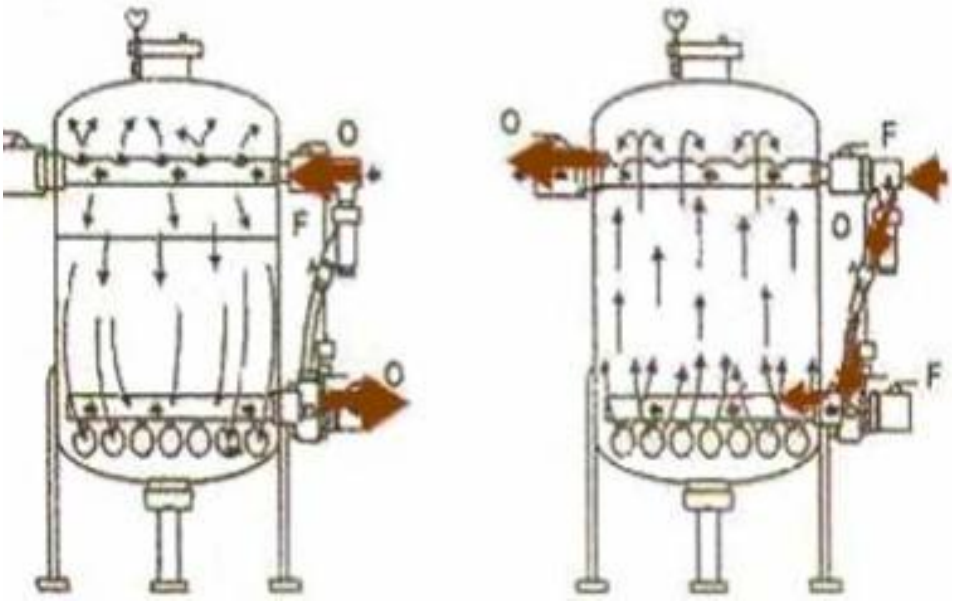
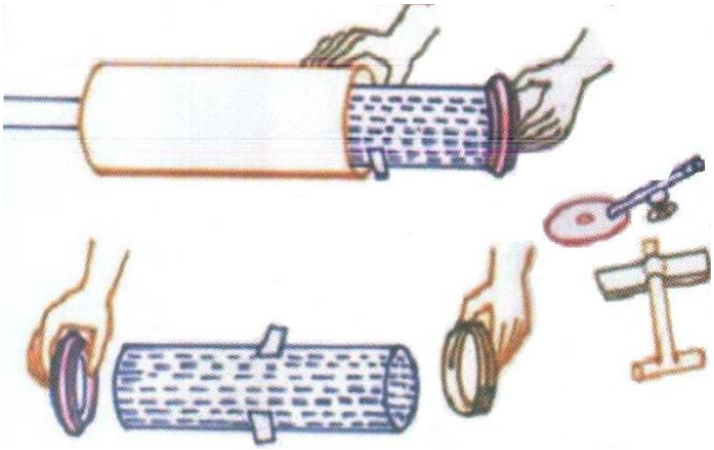


Figure 5: Back-wash Cleaning of Sand Filter in a Drip System

2) After cleaning the filters, operate the by-pass valve of the header assembly to obtain the desire pressure in the system. It should be about 1-1.5 kg/cm2 at the inlet of filter and 1.1 kg/cm2 at the inlet of the sub-mains.
3) Take a round of the entire field and check if there is any leakage at joints or damage to any component of the system. Rectify the defects if any by replacing the spares. Remove the folds or kinks on the lateral if found, make them straight.
4) Check the drippers for uniformity of discharge. Open and clean the drippers which are not emitting water. Do not pull the emitter when cleaning; it will enlarge the hole on the lateral causing leakage.
5) After irrigation over, check whether the wetting patterns of the drippers are uniform or not.
6) Check the position of the drippers, if drippers are misplaced, place them at proper location.
7) Remove the end stops and flush the laterals, flush the sub-main at the end of the irrigation cycle.

B. Fortnightly Maintenance:



After completing the steps 1 – 7 of the daily maintenance, perform the following operations every 15 days. Filter is the heart of a drip irrigation scheme, and its failure will lead to clogging of the emitters and in turn the poor performance of the scheme. Pressure difference across the filter is used as the indicator for deciding the timing of cleaning of the filter.

a) Hydro Cyclone Filter

Hydro cyclone filter should be installed before sand and screen filter in case there is heavy load of sand in irrigation water. Water enters the hydro-cyclone via a tangential inlet, which creates a spiral flow along the walls of the filter. The centrifugal force separates the waste and sand particles and pushes them towards the walls of the sand separator. Particles gravitate downwards into the sedimentation tank, while clean water moves upwards and exits through the top outlet. A hydro-cyclone filter requires least maintenance as regards to cleaning. For cleaning, flush the chamber by opening the flush valve or cap or open the main valve. The filter becomes ineffective once the dirt collection chamber is full.

b) Sand Filter

The sand filter should be backwashed every day for five minutes to remove the silt other dirt or any other organic matter accumulated during the previous day's irrigation. Once a week, while back washing, the backwash water should be allowed to pass through the lid instead of the backwash valves. The sand in the filter bed is stirred up to the filter candles without damaging them. Whatever dirt is accumulated deep inside the sand bed will get free and goes out with the water through the lid. The need of back washing can be detected by monitoring the pressure drop across the filter. When the pressure drops increased to a pre-determined level, the filter should be backflushed.

The pressure difference between the inlet and outlet of the filter is an indicator that suggests whether filters need cleaning. The difference is more than 0.5 kg/cm2, it means that the filter needs cleaning.

- Open the lid of the sand filter.
- Allow the water to come out through the lid opening. Adjust the flow using bypass valve such that sand does not come out of the opening.
- Stir the sand thoroughly by moving the hand through entire sand media from top to bottom. Be careful and do not disturb the position of black filter candles provided at the bottom, else sand may enter the screen filter.
- Break the lumps of the sand by squeezing in hand.
- Ensure that half the filter is filled with sand up to the level marked on the filter. Add new sand if it is below the mark.
- Allow water flow till clean water starts flowing out of the opening.
- Put the lid back in position tightly.

c) Screen Filter

The fine particles and dirt which escape through the sand filter are arrested on the filtering element of the screen filter. This affects the filtering process. Therefore, it is essential to clean the filtering element every 15 days. Flushing at scheduled intervals is necessary for the maintenance of

screen filters. It is recommended to flush the screen filter when the pressure drops more than 0.5 kg/cm2 (5 m at water head). The pressure difference can be observed by checking the inlet and outlet pressure by using a single three-way control valve at regular intervals. The process of cleaning the screen filter is simple. Flushing of a screen filter is done in the following manner.

1) Open the drain valve, thereby, allowing the water force to flush out dirt through the valve.
2) Open the screen filter lid. Remove the screen and clean it under running water by rubbing it with a cloth or soft nylon brush.
3) Protect the metal parts of the filter from scratches, acid, chlorine or fertiliser spillage, and apply oil paint immediately on the scratch to avoid corrosion.

d) Disc filter

A disc filter serves as a primary or secondary filter for water, which contains high amount of organic or inorganic matter. It consists of a stack of discs, each with a series of microscopic grooves. The dimension of the grooves determines the effective mesh size of the filter, which generally, ranges from 40 to 600 mesh. Disc filter requires less maintenance. Flushing of the disc filter is done either by opening the drain valve or by back flushing. The steps followed for cleaning the disc filter are as follows.

Step 1: Remove the filter element and loosen the disc set by extending the spine element.

Step 2: Now, remove the screen and clean it with pressurized clean water.

Step 3: Replace the worn-out discs with clean ones

Step 4: If the disc filter is to be cleaned with an acid or a chlorine solution, use the recommended concentration.

Step 5: Assemble the filter after cleaning.

C. Monthly Maintenance:

If the salts, algae and other impurities present in the water enter into the drip irrigation system, then the laterals and drippers get clogged and may stop emitting water. Therefore, it is necessary to apply acid and chlorine treatments once in a month or as recommended in the water quality analysis report. The procedure and calculation of doses for acid and chlorine treatment are explained in detail in Acid treatment.

- Perform the treatment to remove precipitated salts from drippers and pipeline network.
- Perform chlorine treatment to remove bacterial slime, algae or other biological contamination.
- Inspect all the components above ground for physical abuse, damage by field machinery rata, squirrels etc.
- Do not perform both acid and chlorine treatment simultaneously.

D. Half yearly maintenance:

- Change the sand of the media filter with new one as sand particles get rounded off due to continuous abrasion during operation.
- Check out the system wear and tear, replace the spares whenever required.
- Make necessary maintenance of the pump as per instructions given by the pump manufacturer.

8.1.3 Maintenance of fertigation equipment

It is always advisable to allow clean water through venturi or other injectors for 10 to 15 minutes before and after fertilizer application for uniform application of fertilizers. It will also prevent clogging of suction port of venturi from clogging. It is important to note that equipment is resistant to acid. The lid of the fertilizer tank should be fully tightened while in operation. To check leaks between the body and bell housing in fertigation pump, clean the seal seating and put back the seal or change and keep the position of bell housing at upright.

Chemical Treatments

Clogging or plugging of emitters/orifices is due to precipitation and accumulation of certain dissolved salts like carbonates, bi-carbonates, iron, calcium, and manganese salts. The clogging is also due to the presence of microorganisms and the related iron and sulfur slimes due to algae and bacteria. The clogging or plugging is usually removed by chemical treatment. Chemical treatments commonly used in drip irrigation schemes include application of chloride and/or acid with water. The frequency of chemical treatment is decided on the degree of clogging and quality of water. Chlorine treatment is required to remove organic, and any physical materials and acid treatment is required to remove the salt and any chemical precipitates from the scheme. Generally, acid treatment is performed once in ten days and chlorine treatment once in fifteen days.

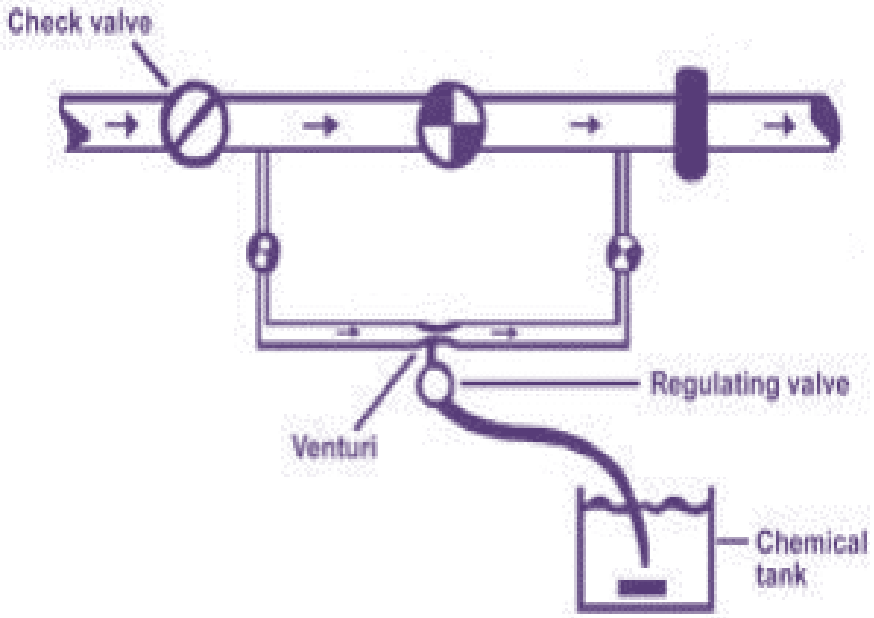


Figure 6: Chemical or Acid Treatment Procedure for Cleaning Drip System

i) Acid Treatment

Acid is injected into the drip irrigation scheme at the rate suggested in the water analysis report. The acid treatment is performed till a pH of 4 is observed at the end of pipe. After achieving a pH of 4 the scheme is shut off for 24 hours. The scheme is then flushed by opening the flush valve and lateral end caps.

For acid treatment any one of the following acids can be used.

a. Hydrochloric Acid
b. Sulphuric Acid
c. Nitric Acid
d. Phosphoric Acid.

Material and accessories required.

1) A plastic bucket or jar
2) An empty water bottle of 1 liter volume
3) A dropper (available in any medical shop)
4) pH paper that indicates color change according to pH shifts
5) Hydrochloric acid (it is normally readily available in the market).

Procedure:

Step 1: Estimation of volume of acid required for treatment

1. From the water source used for drip system, take 1 liter of water in a plastic bucket or jar.
2. Add acid drop by drop in this 1-liter water using a dropper. Stir the water well and measure its pH value.
3. Continue the above process till the pH value of water is equal to 4.
4. Note the quantity of acid in ml required to obtain pH value of 4.
5. The time required for water to reach the furthest dripper can be physically measured in the field by noting the time of starting the pump and the time when water reaches the last dripper of the section. A fair estimate of this can also be obtained by dividing the total length of mainline + sub-main + lateral by the velocity of flow 1.5m/s. If a section of a field has 900 m pipe length, the time taken to reach the last dripper is 900/105 seconds. I.e. 600 seconds or 10 min.
6. Note the flow rate of the section to be treated from the design. If the system flow rate is not known, then use the value of nominal flow rate in m^3/hr written on the filter of the system. Say the system flow rate 25m^3.
7. Calculate the quantity of acid required for the treatment of the selected section as given below.
   Acid required for 1 liter water for attaining pH value of 4 = 2ml.
   Motive flow in the section just to fill the section (total flow in 10 min) = (25000/60) x 10 = 4166.67 liter.
   Volume of acid required for acidulating 4166.67-liter water = 4166.67 x 2ml = 8.33 liter. Thus approximately 9 liter of acid will be required to treat the section.

Step 2: Injection procedure:

1. To avoid injection of commercial acid directly to the Venturi, mix the estimated quantity of acid (9 liter in this case) in an equal amount of water in a plastic bucket.
2. It is recommended to use a Venturi tube assembly for the acid injection. Connect the Venturi to the manifold of filter. Start the pump.
3. First, begin closing the Throttle valve keeping the suction tube of the Venturi assembly outside the bucket contains acid. Water comes out of the small filter attached to the suction tube of the Venturi assembly.
4. Continue closing the throttle valve till the outward flow of water from the suction tube stops and air bubbles start moving into the tube in the reverse direction.
5. Place the tube inside the bucket with acid solution keeping the filter end below the surface of the acid solution.
6. Check the pH of water at the nearest dripper of the section. If pH is observed to be more than 4, then increase the suction rate by slightly closing the valve.
7. In this way throttling the valve allow the acid mixed water having pH value of 4 to reach up to the last dripper. Close the sub-main valve or switch off the pump. Keep the system closed for 24 hrs. It takes a minimum of 6 hrs. for the salts in the system to dissolve in the acid mixed water.
8. After 24 hrs. open the sub-main flush valve and the ends of all laterals. Start the pump and flush out the entire system so that all acid and dissolve salts are driven out of the system.

ii) Chlorine Treatment

Chlorine treatment in the form of bleaching powder is performed to inhibit the growth of microorganisms like algae and bacteria. The bleaching powder is dissolved in water and this solution is injected into the scheme for about 30 minutes. Then the scheme is shut off for 24 hours. The lateral end caps and flush valves are opened to flush out the water with impurities. The recommended chlorine dosages are 0.5 to 1.0 mg/liter continuously or 20 mg/liter for 20 minutes at the end of each irrigation

cycle for algae while for slimes, 1.0 mg/liter free residual chlorine is maintained at the end of each lateral. For iron precipitation, 0.64 times the Fe++ content are used to maintain 1.0 mg/liter free residual chlorine at the end of each lateral. Efficiency of chlorine injection is related to pH of the water to be treated. More chlorine is required at a high pH. The rate of injection of liquid chlorine or acid depends on the scheme flow rate and can be determined by using the following expressions.

$$q_C = K\frac{uxQ_s}{C}$$

Where:

q_c = Rate of injection of the chemical into the scheme,

K = Conversion constant, 6 x 10^{-3}

U = Desired concentration of chemical in irrigation water, mg/liter.

Qs = Supply flow rate, L/min

C = Concentration of chemical in the solution to be injected, percent

8.1.4 Troubleshooting in drip irrigation system

The biggest problem of any drip irrigation system is clogging of emitters. Drip Irrigation System Kits use very simple emitters that are less prone to clogging due to a wider flow path. Therefore, it requires less maintenance than other drippers. However, periodic and preventive maintenance is essential for smooth system function. The following general checks can be carried out periodically depending on the local condition and water quality:

1. Clogging of emitters and wetting pattern
2. Placement of emitters / micro-tubes
3. Leakages in pipes, valves, filter, fittings, etc.
4. Flushing & cleaning of filter by opening and cleaning the screen
5. Flushing of sub-main & laterals by releasing the end caps

Apart from physical impurities that can be separated by using a screen filter, there are dissolved chemical (mainly salts) impurities and biological impurities like algae, bacteria, etc. present in some water sources. If the dissolved salts are more concentrated, they can accumulate and clog the emitters. Hydrochloric acid can be applied to the emitters to flush the salts. If bacteria or algae clogs the system, chlorine treatment in the form of bleaching powder (2mg/liter) can be added to clean the emitters and inhibit slime growth. Some common problems faced by micro irrigation systems, causes and troubleshooting required are given in the following tables.

Table 7: Troubleshooting Potential Problems of Micro Irrigation Systems

Problem	Cause	Troubleshooting
Micro-tube/ emitter not delivering water.	Clogging due to impurities in water or air bubble in micro-tube/emitter	1. Take out micro-tube from lateral pipe and shake it or blow it so that the dirt or trapped air comes out. If it is a different type of emitter, open it and clean it with a needle so that dirt is removed. Then fix the emitter and check it is working. 2. Check the filter screen and gasket for any possible leakage and if required, replace them.
Leakage in lateral, sub-main or main pipe	Cut in pipe due to mechanical damage, rodents, etc.	Cut the pipe at the place of damage and connect it by using joiner / connector. For large diameter pipes, if joiners are not available then a service saddle can be used.
Leakage in fittings of lateral pipe.	Pipe expansion or frequent use	Cut the pipe end for the expanded portion and insert the fitting in it again. If the fitting is too

Problem	Cause	Troubleshooting
		loose for the pipe diameter it can be adjusted by heating it.
Reduced flow of water from emitter.	1. Caked filter 2. Pipe leakage 3. Open end cap	1. Clean the filter screen. 2. Repair pipe leakage as mentioned above. 3. Tighten the end.
Leakage of water at the joint between sub main and lateral	Damaged joints	Correct damages
Water not flowing upto lateral end	Holes in laterals. Cuts in laterals. Bents in laterals.	Close the holes and cuts. Remove the bends.
Out coming of white mixture on removing the end plug	More salinity in water. Uncleaned lateral	Remove the end stop. Clean the laterals fortnightly
Under flow or overflow from laterals	Clogging of drippers. Unclosed end plug	Clean the sand and screen filters. Close the end cap
Oily gum material comes out on opening the lateral end	More algae or ferrous material in water	Clean the laterals with water or give chemical treatment
More pressure drop in filters	Accumulation of dirt in filters	Clean filters every week. Back wash the filters for every 5 minutes daily.
Pressure gauge not working	Rainwater entry inside. Corrosion in gauge pointer damage	Provide plastic cover and fix pointer properly.
Drop in pressure	Leakage in main opened outlet. Low water level in well.	Arrest the leakage and close outlet. Lower the pump with reference to well water level
More pressure at the entry of sand filter	No bypass in the pipeline/bypass not opened. Displacement of filter element. Less quantity of sand in filters	Provide bypass before filter and regulate pressure. Place filter element properly. Fill required quantity of sand
Accumulation of sand and debris in screen filter	Displacement of filter element. Less quantity of sand in filters	Place filter element properly. Fill required quantity of sand
Venturi not working during chemical treatment and fertigation	Excess pressure on filters. Improper fitting of venturi assembly.	Bypass extra water to reduce pressure Repair the venturi assembly.
Leakage of water from air release valve.	Damaged air release valve ring.	Replace the damaged ring.

8.2 Operation and Maintenance of Sprinkler Irrigation Scheme

Proper operation of any irrigation system involves ensuring that the irrigation duration matches both the application rate and the soil's intake rate, maximizing water storage in the root zone. To fully benefit from a sprinkler system, it must be operated according to its design specifications. Adjusting sprinkler spacing or movement distance compensates for variations due to wind or exceptionally hot days, ensuring uniform water application.

However, successful design of a sprinkler irrigation system alone does not guarantee success. It is crucial to align the prime mover and pump correctly. Both the drive shaft and pump shaft should ideally be at the same height to avoid excessive angles on the universal shaft.

When laying main and lateral pipes, starting from the pump ensures proper connection of all quick coupling pipes. During coupling, cleanliness of both the couplings and rubber seal rings is essential.

Initiating the sprinkler system involves starting the motor or engine with valves closed. The pump must achieve the pressure specified on the type plate; otherwise, there may be an issue with the suction line. Once the pump reaches the regulated pressure, slowly open the delivery valve. Similarly, after stopping the power unit, close the delivery valve and adjust pipes and sprinkler lines as necessary, especially for portable systems. The following steps outline how to operate a sprinkler system

effectively.

1) Start the pump and open the valve to fill the pipes with water.
2) Release all end caps and flush valves to clean the system of dirt and clogging. Before operating the system, remove the end caps from the ends of the laterals and sub-mains to allow dirt to be flushed out and air to escape. Open the control valve to allow water to flow freely through the pipes for a period. Then, close the end caps and verify that water is coming out from each sprinkler
3) Check the pressure and discharge of water and ensure that all sprinklers are operational.
4) Operate the system according to the recommended irrigation schedule.

8.2.1 Operation and monitoring of sprinkler irrigation system

The installation of spray heads for sprinklers typically falls into two main types: risers and pop-ups. These options come in various spray patterns, such as full-circle, half-circle, quarter-circle, and fully adjustable. Each nozzle is designed to achieve matched precipitation rates, ensuring that a quarter-circle pattern delivers one-fourth the water of a full-circle pattern. This uniformity is crucial within each zone to prevent uneven distribution, which can lead to dry or overly saturated areas if different sprinkler head types are mixed on the same lateral.

The effectiveness of sprinkler operation hinges on the uniformity of water application, influenced by the spray distribution characteristics of the nozzles and the spacing between sprinklers. Overlapping coverage between sprinklers, although it may seem redundant, is necessary to ensure consistent watering.

The spray distribution characteristics vary based on nozzle size and operating pressure. Lower pressures produce larger drops that fall farther from the sprinkler in a ring pattern, while higher pressures create finer droplets that fall closer to the sprinkler. Most sprinklers include a built-in radius adjustment to control the throw of water.

Operating a sprinkler at pressures above the design range results in excessive misting (small droplet size) and water is easily blown away or evaporated or may accumulate close to the sprinkler. The actual spacing, however, shall be guided by the size of pipes available in market. Generally, pipes of 6 m (full size) and 3 m (half size) are available.

8.2.2 Maintenance of sprinkler irrigation system

At the beginning of each growing season, check the irrigation line from the valve to the spray heads for leaks. Take a round of the entire field and check if there is leakage at joints or damage to any component of the system. Rectify the defects, if any, by replacing the spare parts. Remove folds or kinks on laterals or pipes and make them straight.

Clean the irrigation system periodically to remove dirt and debris that have built up over time. There are few basic steps that one must take at least once in a year to ensure that water always gets through the system. Using a filter can prevent build-up of minerals and organic particles in pipes, risers and nozzles, and make it easy for cleaning. It is also important to follow these instructions to flush each zone in the system at least once a year.

1) Turn off water supply to one zone and remove nozzles and sprinkler heads.
2) Run water through the zone for few minutes until the filter is clean and a clear stream of water flows from each sprinkler.
3) Take apart the nozzles (depending on the type, one can do this by hand or with a screwdriver or special key).

4) Clean the nozzles to remove dirt or deposits.
5) Rinse the filter screen or basket.
6) Reassemble the filter and replace the damaged or worn-out parts.
7) Turn on the zone again to check that everything is leak-proof and operational.

Table 8: Maintenance Schedule for Sprinkler Irrigation System

Frequency	Item	Action
Daily	Pressures	Check that pump and block pressures are within the prescribed limits.
	Emitter operation	Check for clogged, broken or misplaced emitters. Repair, replace, unclog, or reposition the emitters.
	Leaks	Check for water wastage and leaks in pipes and other equipment and repair them immediately.
	Primary filter	Flush primary filters as prescribed.
	Fertigation application	Check that fertigation applications are within specifications.
Weekly	Lateral lines	Flush the lateral lines as prescribed.
	Exposed joints	Check and repair them if needed, e.g., quick coupling rubbers.
	Secondary filters	Flush the secondary filters as prescribed.
	System pressure and flow	Check that the system pressure and flow are as per the irrigation design plan.
	Pump operation	Check that pump operation is within the prescribed parameters.
	Block pressures for automated valves	Check that the block pressures are within the prescribed limits where automated valves are used.
	Pump oil levels	Check pump oil levels as prescribed.
	Fertigation plant	Inspect the fertigation plant.
	Pipes	Check for leaks and repair them.
Monthly	Valves, water meter and gauges	Visually check the valves, water meter and gauges, and look for damage and vandalism.
	Filters	Open and inspect the filters as prescribed.
	Pump pipe work	Check for leaks at the pump station that causes water losses and airlocks.
	Pump motor	The pump motor must be greased as prescribed.
Annually	Valves	Check the service valves and replace them, if required.
	Filters	Clean the filters and replace them annually or in two years.
	Pump	Change oil in the pump.
	Water sampling	Take water sample at the end of lateral lines and send it for analysis.
	Emitter delivery tests	Test specific emitters for discharge and pressure.
	Sprinkler parts	Replace nozzles annually and the other parts when needed.
2–10 years	Pump	Replace the bearings and other worn-out parts of the pump every five years.
	Hydraulic valves	Replace the diaphragms in hydraulic valves every three years.
	Poly pipe and emitters	Replace the poly pipe and emitters every 7–10 years.

Maintenance schedule for pumps

The following maintenance schedules, generally, apply to most pumps under average operating conditions.

Table 9: Maintenance Schedule for Pumps in Sprinkle Irrigation System

Frequency	Action
Monthly	Check the bearing temperature, as the bearing may run hot due to lack of lubrication or its excess.
Quarterly	Drain lubricants in ring oil bearings and wash out the oil wells and bearing with kerosene.
Half-yearly	Check the alignment of pump and driver, and add shims, if required. If misalignment occurs frequently, the entire piping system may have to be checked and necessary corrective actions may have to be taken. Replace gland packing.
Yearly	Thoroughly inspect the unit once in a year. Remove bearings, clean and examine them for flaws. Remove the packing and examine wear and tear in the shaft sleeve or shaft. Disconnect coupling valves and check alignment. Inspect foot valve and check valves.

Table 10: General Pump Glitches and their Causes in Sprinkle Irrigation System

Glitches	Causes
No water delivered/ Not enough water delivered	• Pump not primed • Speed too low • Discharge head too high/higher than anticipated • Suction lift too high • Impeller or suction pipe completely/partially plugged • Wrong direction of rotation • Air pocket in suction line • Air leakage in suction line or stuffing box • Insufficient net positive suction head available • Foot valve too small • Insufficient submergence of suction inlet • Bearings worn out
Not enough pressure developed	• Speed too low • Excessive amount of air or gas in liquid • Wrong direction of rotation • Viscosity of liquid higher than anticipated • Bearings worn out • Impeller diameter too small
Pump works for a while and then loses prime	• Air leak in suction line or clogging • Excess amount of air or gas in liquid • Air pocket in suction line • Water seal tube clogged • Suction lift too high • Insufficient submergence of suction inlet
Pump requires excessive power	• Speed too high • Head lower than anticipated, pumps too much water • Specific gravity or viscosity too high • Wrong direction of rotation • Misalignment • Stuffing box too tight • Rotating element rubbing or binding • Bent shaft • Bearings worn out
Stuffing box leaks excessively	• Packing is worn out and not adequately lubricated. • Packing not as per recommendations • Shaft sleeve scored. • Bent shaft

Glitches	Causes
Pump noisy or vibrates	• Suction lift too high • Insufficient Net Positive Suction Head (NPSH) available • Impeller or suction pipe partially plugged • Misalignment • Foundation not rigid • Lack of lubrication • Bearings worn out • Rotating element out of balance • Bent shaft

8.2.3 Troubleshooting in sprinkler schemes

The following are the general guidelines to identify and remove the common troubles in the sprinkler schemes:

1. Pump does not prime or deliver water

1) Check that the suction lift is within the limits. If not, get the pump closer to the water.
2) Check the suction pipeline and all connections for air leaks. All connections and flanges should be airtight.
3) Check that the strainer on the foot valve is not blocked.
4) Check that the flap in the foot valve is free to open fully.
5) Check the pump glands for air leaks. If air leaks are suspected, tighten the gland (s) gently. If necessary, repack the glands using a thick grease to seal the gland satisfactorily.
6) Check that the gate valve on the delivery pipe is fully closed during priming and opens fully when the pump is running.
7) Check that the direction of rotation of the pump is correct.

2. Sprinklers do not turn

1) Check pressure.
2) Check that the nozzle is not blocked. Preferably unscrew the nozzle or use a small soft piece of wood to clear the blockage. Do not use a piece of wire or metal as this may damage the nozzle.
3) Check the condition of washers at the bottom of the bearing and replace them if worn or damaged.
4) Check that the swing arm moves freely and that the spoon which moves into the water stream is not bent by comparing it with a sprinkler which is operating correctly.
5) Adjust the swing arm spring tension~ Usually it should not be necessary to pull up the spring by more than about 6 mm.
6) Sprinkler bearing should be free and smooth. Sprinkler can usually be pushed down towards the riser pipes so that the water pressure flushes out the bearing. If the bearing is still stiff dismantle and then clean it. Oil, grease or any lubricant should not be used.

3. Leakage from coupler or fittings

The sealing rings in the couplers and fittings are usually designed to drain the water from the pipes when the pressure is turned off. This ensures that the pipes are automatically emptied and ready to be moved. With full pressure in the scheme, the couplers and fittings will be effectively leak-free. If, however, there is a leakage, check the following:

1) There is no accumulation of dirt or sand in the groove in the coupler in which the sealing ring fits. Clean out any dirt or sand and refit the sealing ring.
2) The end of the pipe going inside the coupler is smooth, clean, and not distorted.
3) In the case of fittings such as bends, tees and reducers ensure that the fitting has been properly

connected into the coupler.

8.2.4 Maintenance of pipes and fittings of sprinkle systems

In general, the pipes and fittings of sprinkler systems virtually do not require any maintenance. However, attention must be given to the following procedures:

1) Occasionally clean any dirt or sand out of the groove in the coupler in which the rubber sealing ring fits. Accumulation of dirt or sand will affect the performance of the rubber sealing ring.
2) Keep all nuts and bolts tight.
3) Do not lay pipes on new damp concrete or on piles of fertilizer. Do not lay fertilizer sacks on the pipe.
4) Avoid trampling over the pipes.
5) The pipes are automatically emptied and ready to be moved. When the pump is first started and before the pressure has built up in the system, the seals may give a little leakage. With full pressure in the system, the couplers and fittings will be effectively leak free.

Remove the end stop or end cap and flush the laterals or pipes for 1–2 minutes. Starting from the sub-main inlet, flush the first 4–5 laterals or pipes and proceed to the end. This will help in gaining higher velocity in the laterals and pipes for cleaning. Flush the sub-mains at the end of the irrigation process to remove debris.

8.2.5 Maintenance of underground micro/mini-sprinkler irrigation system

The underground component of the system requires no maintenance. However, at times, because of careless errors during cultural practices, pipes must be replaced for the system to operate at designated pressure. The above ground components of the sprinkler system, if carefully operated and maintained, are expected to last for about 15 years. This would require careful movement of aluminum/ plastic pipe, after each riser and sprinklers have been disconnected from the pipe to facilitate ease of movement to the next position. Portable aluminum / PVC pipes connected through coupling with rubber rings to ensure watertight connections. These rings have a life of 2 years and need to be replaced accordingly.

The hoses used for sprinkler systems are rated at 7 meters pressure and are reinforced. Their life expectancy is 8 years. However, at times perforations or cuts occur during cultivation. Line joiners can be used to repair the hoses.

With respect to sprinklers, it is necessary that all nozzles are replaced at least every two years (four seasons), to maintain the correct flow and distribution of water from the sprinkler. This is particularly important when surface water with a high load of suspended solids is used for irrigation. The tension of the sprinkler spring and rear of some of the plastic seals also requires attention. It is therefore necessary that every 4-5 years the sprinklers are taken to the supplier for an overall check-up.

Backwashing

Backwashing is a process, in which the direction of the flow is reversed so that the water flows upwards through the sand bed. If backwashing is not done regularly, then impurities accumulate in the sand bed, thereby reducing the efficiency of the filter. Besides, the system does not get water at the desired pressure.

The backwash operation is complete when clear water starts flowing out through the backwash valve. To resume the filtration process, perform the following:

- Open the inlet valve.

- Close the bypass valve.
- Open the outlet valve.
- Close the backwash valve.

Cleaning of filters

Clean the filters every 5–6 hours or at recommended timings based on the water quality analysis report. After cleaning the filters, operate the bypass valve of the header assembly to obtain the desired pressure in the system. It must be about 1.5–2 kg/cm² at the inlet of the filter and 1 kg/cm² at the inlet of the sub-mains.

Sprinkler heads

The sprinkler heads should be given the following attention:

1) When moving the sprinkler lines, make sure that the sprinklers are not damaged or pushed into the soil.
2) Do not apply oil, grease, or any lubricant to the sprinklers. They are water lubricated and using oil, grease or any other lubricant may stop them from working.
3) Sprinklers usually have a sealed bearing and at the bottom of the bearing there are washers. Usually, it is the washers that wear and not the more expensive metal parts.
4) Check the washers for wear once a season or every six months which is especially important where water is sandy. Replace the washers if worn.
5) After several season's operation the swing arm spring may need tightening. This is done by pulling out the spring end at the top and re-bending it. This will increase the spring tension.
6) In general, check all equipment at the end of the season and make any necessary repairs and adjustments and order the spare parts immediately so that the equipment is in perfect condition to start in the next season.
7) Check that each spray head covers the desired area of a field. The heads may have been knocked out of alignment by foot traffic, agriculture tools or machinery. To adjust this, move the nozzle of the sprinkler heads to redirect the spray and turn the spray reduction adjustment screw on the top of the nozzle. Replace the spray heads, if necessary.
8) Sometimes, spray heads produce mist or fogging action rather than larger drops necessary for watering. This indicates that the water pressure is too strong. Adjust it at the main shut-off valve. Turn the valve clockwise, manually, until large drops of water are seen at the sprinkler heads. Some automatic valves have a special knob for adjustment called ‘flow control’, which adjusts the flow to minimize misting and fogging.

8.2.6 Storage of sprinkler equipment

The following points are to be observed while storing the sprinkler equipment during off season:

1) Remove the sprinklers and store in a cool, dry place.
2) Remove the rubber sealing rings from the couplers and fittings and store them in a cool, dark place.
3) The pipes can be stored outdoors in which case they should be placed in racks with one end higher than the other. Do not store pipes along with fertilizer.
4) Disconnect the suction and delivery pipework from the pump and pour in a small quantity of medium grade oil. Rotate the pump for a few minutes. Blank the suction and delivery branches. This will prevent the pump from rusting. Grease the shaft.
5) Protect the electric motor from the ingress of dust, dampness, and rodents.

8.3 Operation and Maintenance of Solar Pumping System

For the optimal operation of a Solar Pumping system and PV plant, maintenance must be carried out on a regular basis. All the components should be kept clean. It should be ensured that all the components are fastened well at their due place. During the mandatory O&M period of 5 years, the Solar pumping system must be maintained by the vendor for the activity assigned to electrician/technician. The user shall be suitably guided by the vendor for all tasks lying in scope of the user and the user shall also be providedwith appropriate documents for such guidance.

8.3.1 Operational guidelines for various components of solar pumping system

Operation guidelines for the various components viz. solar panels, inverter, wiring, motor/pumps, mounting structure etc. are discussed one by one below:

Solar Panel

Although the cleaning frequency for the panels will vary from site to site depending on soiling, it is recommended that:

a) The panels are cleaned at least once every fifteen days.
b) Any bird droppings or spots should be cleaned immediately.
c) Use water and a soft sponge or cloth for cleaning.
d) Do not use detergent or any abrasive material for panel cleaning.
e) Iso-propyl alcohol may be used to remove oil or grease stains.
f) Do not spray water on the panel if the panel glass is cracked or the back side is perforated.
g) Wipe water from module as soon as possible.
h) Use proper safety belts while cleaning modules at inclined roofs etc.
i) The modules should not be cleaned when they are excessively hot. Early morning is particularly good time for module cleaning.
j) Check if there are any shade problems due to vegetation or new building. If there are, arrange the removal of vegetation or move the panels to a shade-free place.
k) Ensure that the module terminal connections are not exposed while cleaning; this poses a risk of electric shock.
l) Never use panels for any unintended use, e. g. drying clothes, chips etc.
m) Ensure that monkeys or other animals do not damage the panels.

Cables and Connection Boxes

a) Check the connections for corrosion and tightness.
b) Check the connection box to make sure that the wires are tight, and the water seals are not damaged.
c) There should be no vermin inside the box.
d) Check the cable insulating sheath for cracks, breaks or burns. If the insulation is damaged, replace the wire
e) If the wire is outside the building, use wire with weather-resistant insulation.
f) Make sure that the wire is clamped properly and that it should not rub against any sharp edges or corners.
g) If some wire needs to be changed, make sure it is of proper rating and type.
h) Check the cleanliness, blocking cables and connection of all visible equipment (pumps, motor, inverter, panels etc….)

Inverter/Controller

a) The inverter/Controller should be installed in a clean, dry, and ventilated area which is separated from, and not directly above, the battery bank (if applicable).

b) Remove any excess dust in heat sinks and ventilations. This should only be done with a dry cloth or brush.
c) Check that vermin have not infested the inverter/controller. Typical signs of this include
d) Spider webs on ventilation grills or wasps' nests in heat sinks.
e) Check functionality, e.g. automatic disconnection upon loss of grid power supply, at least once a month.
f) Verify the state of DC/AC surge arrestors, cable connections, and circuit breakers.

Pumps/Motor

a) Ensure proper installation and alignment of the pump and motor and also check that all valves and controls are set correctly.
b) Regularly monitor the system for unusual noises, vibrations, and temperature changes.
c) Check the pump's flow rate and pressure to ensure they are within specified ranges and observe the motor's electrical parameters.
d) Regularly inspect the pump and motor for signs of wear, corrosion, and leaks and check the alignment of the pump and motor shafts.
e) Inspect seals, gaskets, and other components for signs of damage and ensure proper lubrication of bearings and other moving parts according to the manufacturer's recommendations.
f) Clean filters, strainers, and cooling fins to ensure efficient operation, remove any debris or obstructions from the pump and motor area.
g) Preventive Maintenance- Schedule regular maintenance tasks, such as changing oil, replacing seals, and recalibrating sensors and maintain a log of maintenance activities, including dates, observations, and actions taken.

Shutting Down the System

a) Disconnect system from all power sources in accordance with instructions for all other components used in the system.
b) Completely cover system modules with an opaque material to prevent electricity from being generated while disconnecting conductors.
c) To the extent possible, system shutdown will not be done during daytime or peak generation.

Table 11: Inspection and Maintenance Schedule for Solar Pumping System

Component	Activity	Description	Interval
PV Module	Cleaning	Clean any bird droppings/ dark spots on module	Immediately
	Cleaning	Clean PV modules with Plain water. Do not use brushes, any types of solvents, abrasives, or harsh detergents.	Fortnightly or as per the site conditions
PV Array	Inspection	Check the PV modules and rack for anydamage. Note downlocation and serial number of damaged modules.	Annual
	Inspection	Determine if any new objects, such as vegetationgrowth, are causingshading of the array and move them if possible.	Annual
	Vermin Removal	Remove bird nests or Vermin from array andrack area.	Need basis
JunctionBoxes	Inspection	Inspect electrical boxesfor corrosion or intrusion of water or insects. Seal boxes if required. Check position of switches and breakers. Check operation of all protection devices.	Annual
Wiring	Inspection	Inspect cabling for signs of cracks, defects, loose connections, overheating,arcing, short or open circuits, and ground faults.	Annual

Component	Activity	Description	Interval
Inverter	Inspection	Observe:	Quarterly
		Instantaneous operationalindicators on the faceplate of the inverter to ensure thatthe amount of power being generated is typical of the conditions. Inspect Inverter housing or shelter for physical maintenance, if required.	
Inverter	Service	Clean or replace anyair filters.	As needed
Instrument	Validation	Spot-check monitoring instruments pyranometer etc.) with standard instruments to ensure that they are operational andwithin specifications.	Annual
Transformer	Inspection	Inspect transformer oil level, temperature gauges, breather, silica gel, meter, connections etc.	Annual
Tracker (if present)	Inspection	Inspect gears, gear boxes,bearings as required.	Annual
	Service	Lubricate tracker mounting bearings, gearbox as required.	Bi-annual
Plant	Monitoring	Daily Operation and Performance Monitoring	Daily
Pumps / Motor	Inspection	Alignment of the pump and motor. Monitor the system for unusual noises, vibrations, and temperature. Signs of wear, corrosion, and leaks. Inspect seals, gaskets, and other components.	Quarterly
Spare Parts	Management	Manage inventory of spare parts.	As needed
Logbook	Documentation	Document all O&M activities in a workbookavailable to all service personnel	Continuous

8.3.2 Maintenance Guidelines of Solar Pumping System

The guidelines for the maintenance of the solar pumping system have been broadly outlined below:

a) Periodic cleaning of solar modules, preferably once every fortnight or as per site conditions. As this task must be done by the beneficiary, the contractor shall train the beneficiary on the importance and proper technique for cleaning.

b) Maintenance of Solar Power Plant shall be compliant with grid requirements to achieve committed energy generation.

c) Periodic checks of the Modules, Inverter, PCUs shall be carried out as a part of routine preventive and breakdown maintenance.

d) Immediate replacement of defective Modules, Invertors/PCUs and other equipment as and when required.

e) Supply of all spares, consumables and fixtures as required. Such stock shall bemaintained for all associated equipment and materials as per manufacturer/ supplier's recommendations.

f) All the equipment testing instrument required for Testing, Commissioning and O&M for the healthy operation of the Plant shall be maintained by the Bidder. The testing equipment must be calibrated once every 2 years from NABL accredited labs and the certificate of calibration must be kept for reference as required.

g) If negligence/ mal operation on part of the Bidder's operator results in failure of equipment, such equipment should be repaired/ replaced by the Bidder free of cost.

h) Contractor shall submit the testing, installation and commissioning report to the Owner.

8.4 Operation and Maintenance of Solar Fencing

Solar fencing is used in locations where there is potential threat from wild animals to agriculture farms and settlements. However, they too need proper operation and maintenance. Care must be exercised in carrying out O&M of solar fencing. The following are some of the "dos" and "don'ts":

8.4.1 The dos and don'ts for solar fencing

The Dos:

a) The company erecting solar fence must source all the products/components from MNRE approved and certified companies. Certificates regarding animal & human safety need to be insisted upon. Solar fencing is a solution and not a product, hence it is to be designed as per the requirements laid out by the customer, solar fencing as a unit is not certified, however, all the individual components are.
b) Take help of an authorized/ experienced agency to install the unit.
c) Keep the fence neat and clean.
d) Maintain the wire tension regularly.
e) Water the fence earth scheme periodically.
f) Maintain battery health properly.
g) Remove Energizer connections during heavy storms like lightning.
h) Test the fence voltage at 2 or 3 points on the fence regularly.
i) Always use proper fence tools during fence construction and maintenance.

The Don'ts:

a) Do not connect AC mains power to the Energizer and to the fence lines, unless scheme is designed for.
b) Do not add acid to your battery where dry maintenance free battery is installed.
c) Do not power the Energizer directly from the charger or from the solar panel.
d) Do not electrify barbed wires as this can trap the animals and lead to death.
e) Do not over-extend the fence beyond the limits of the energizer.

8.4.2 Maintaining solar fence scheme

While minimal maintenance is required, regular checks of solar scheme (every 6 to 8 weeks) will ensure reliable performance.

Some pointers to maximize the life and performance of solar fencing scheme are as under:

a) Solar panels need to be cleaned with a soft, damp cloth to remove any residue or dust film. Any snow accumulated on the panels needs to be cleaned to maintain the scheme in operation.
b) Check the mounting bracket is secure and the tilt angle is correct. If necessary, the angle can be changed to accommodate the change in seasons.
c) Check all leads and connections are secure and undamaged by animals or vegetation.
d) Check electrolyte level in batteries.
e) Check all exposed terminals and wires for evidence of corrosion from environmental conditions such as salt or chemicals.
f) Clear any debris or vegetation that may be causing a shot on the fence. Vegetation touching the fence will complete the loop causing the output voltage of the energizer to drop. It is very important, therefore, to minimize the growth on the fence line to ensure that the animal receives the maximum shock available. Trees near the fence may allow monkeys to cross the fence.

8.5 Operation and Maintenance of Agri-machinery and Implement

The agriculture machinery and implements provided by the projects also needs to be taken care of and properly operated and maintained for them to provide the intended benefits. Operation and maintenance of tractors, ploughs, and sprayers have been considered in this manual and their O&M procedures have been described below.

8.5.1 O&M of tractors for farm operations

The tractor is a prime mover which can be used for carrying out farm operations such as ploughing, harrowing, seeding, inter-cultivation, harvesting, transportation, land leveling and operating stationary machines (irrigation pumps, threshers, chaff cutters, cane crusher etc.). All the machines require periodical servicing, maintenance, and repairs for efficient and economical performance to stay in good operating conditions throughout working life. Although, most of the tractor manufacturers provide User's Manual and have appointed their dealers to provide operational know-how, after sales and services of their products, these are inadequate. Consequently, many machines are not properly maintained and are subjected to abnormal breakdowns, wear and tear and thereby reducing the effective life of the machines.

Due to improper maintenance and servicing of the tractors, it has been found that many tractors have been rendered unserviceable within a short period of 5000 hours or even less. Seizures of engine due to lack of oil in the sump and overheating of engine due to inadequate water in the radiator are common troubles. Damage of front wheel bearings and other moving parts due to improper lubrication and adjustments has also been seen often.

Daily check points for starting and safety in tractor are:

1) Check fuel in fuel tank (is there enough fuel to complete the task).
2) Check coolant level in the radiator or inspect cooling fins on air cooled models of tractor.
3) Check tyre inflation pressure (refers to owner's manual for proper inflation of front and rear tires for each job).
4) Check the condition of the tyre. Look for cuts, cracks and buckling.
5) Check the battery, cables and terminals and electrolyte level.
6) Check the transmission and hydraulic oil levels.
7) Check air filter elements, or the oil level in an oil bath type air cleaner.
8) Check the guards and shields to ensure that they are correctly installed and in good condition.
9) Check operator's station. Be sure that it is clear of spilled fuel, oil, grease, crop residue,or loose objects.
10) Check the lighting scheme and ensure "Slow Moving Vehicle Emblem "is placed.

Steps for starting a tractor:

1) Make necessary checks before riding on the tractor.
2) Ride the tractor from the left side of the tractor
3) Sit down on the seat
4) Make necessary checks after sitting on the seat
5) Move the hand accelerator to half of its total travel
6) Put the key into the main switch and turn it clockwise to warm the engine with heater (if required).
7) Turn the key further clockwise to crank the engine.
8) If the engine does not start within 10-20 seconds, repeat cranking of the engine after about 30 seconds.
9) Keep the engine running till it is warmed-up (for 2-3 minutes).
10) Disengage the clutch by pressing the clutch pedal.
11) Select suitable gear depending on speed and load requirement.
12) Release parking brake.

13) Increase engine speed by moving throttle lever clockwise and slowly release the clutch pedal, until the tractor moves off.
14) Take off the foot from the clutch pedal.
15) Change gear (up or down) to reduce the engine speed by moving the hand throttle anticlockwise.
16) Press the clutch pedal and let the tractor come to the stop position (or crawling speed) to select the desired gear and repeat step 13.

Steps for stopping a tractor

1) Reduce the engine speed (by hand throttle lever) to idling position.
2) Press the clutch pedal to disengage the clutch and put the gear shift lever in neutral position.
3) Release the clutch.
4) Stop the tractor (by applying brakes)
5) Pull the fuel shut-off knob/ stop switch till engine stops.
6) Withdraw key by turning it anticlockwise.
7) Engage parking brake.
8) Get up from the seat
9) Get down from the tractor from left side only.

General precaution guidelines for tractor operation safety precautions:

1) Run and maintain the tractor according to the operator's Manual of Tractor provided by the tractor manufacturer.
2) Check the working of all controls just after riding the tractor.
3) Release the parking brakes before starting.
4) Be alert and alert to drive it safely.
5) Bring gear-shift lever to neutral position whenever the tractor is stopped, even for a short while.
6) Always park the tractor with gear shift lever in the neutral position with parking brake applied.
7) Operate the tractor smoothly; avoid jerky starts, turns, and stops.
8) Drive slowly in difficult conditions.
9) Look at the rear while reversing the tractor.
10) Attend immediately to oil and fuel leakages.
11) Listen to the noise or sound in the engine and investigate in case of abnormalities.
12) Always keep a watch ahead of the tractor.
13) When stopped and the tractor went out of gear, set brakes firmly.
14) Refuel the tractor only when the engine is cool, doesn't spill fuel and never smoke while refueling.
15) Hitch implements only to drawbar or specified hitch points of the tractor.
16) Remove air intake assembly before raising the bonnet.
17) Beware of oily steps & slippery platforms.
18) Never drive after taking alcohol drink or drugs.
19) Never run the tractor engine in a closed shed or garage.
20) Don't permit unauthorized' persons to ride the tractor unnecessarily.
21) Never operate the hand accelerator of tractor from the ground.
22) Do not allow the tractor wheels to run over sharp objects.
23) Do not keep foot (ride) on the clutch and brake pedals while the tractor is running.
24) Do not sit or stand on the implement when the tractor is in motion.
25) Do not attempt the dual selector lever when the tractor is in motion.
26) Avoid spilling fuel over the engine.

27) Avoid overloading of the tractor during operations.
28) Do not get off or on the tractor when it is in motion.
29) Do not remove the radiator cap while the engine is hot.
30) Never leave the key in the starting switch

Guidelines for safety on the farm with the tractors:

1) Set the wheels as wide as required for the job. Use wider wheel track on slopes for stability.
2) Add weights on rear or front as needed, for proper traction.
3) Keep P.T.O. and belt pulley shields in proper place.
4) Do not hook load at a point above the drawbar.
5) Reverse the tractor in low gear.
6) Drive tractor in low gears while overcoming obstacles like small bunds and ditches.
7) Draft control should not be used for raising or lowering the implements at the end of trip/ row.
8) Do not ride the drawbar of tractor during operation.

Guidelines for Road Safety

1) Obey the traffic rules while driving on the road.
2) Drive slowly while making turns.
3) Use lower gear during up and down-hill driving.
4) Be careful during road crossings.
5) Stop the tractor on the left side of the road.
6) Keep brake pedals interlocked when driving on the road.
7) Give way to automobile vehicles.
8) While driving at night on a trolley, do make extensive provision for lights at the rear as well as on the sides.
9) Never drive down- hill in neutral gear.
10) Never depress clutch pedal while driving down-hill.
11) Do not tend to turn sharply using independent brakes when travelling at high speeds.
12) Do not overload trolley.
13) Do not drive without rear-view mirrors

The manufacturers of tractors and other machinery usually provide Manuals to the purchaser for familiarization with the periodical service schedules. The dealers request the buyers to follow service schedule as given in the Manual so that the machine can be used for long time without any bear and tear. Generally, it is recommended to bring the Tractor to the agency after 125, 250, 500 hours use of the machines. In the job chart, they have mentioned the action to be taken by the agency/ service provider. Regular and satisfactory operations together with economic and long-lasting use of the machines depend on the compliance with manufacturer's instructions.

8.5.2 O&M of ploughs for tillage

Mold board ploughs are the other agriculture machinery promoted by the project. This plough is one of the oldest of all the agricultural implements and is generally considered to be the most important tillage implement. Ploughing accounts for more traction energy than any other field operation. Although yield studies have indicated that under certain conditions with some crops there is no apparent advantage in plowing, the mold board plough is still by far the most used implement for primary tillage in seedbed preparation.

M.B. Plough is equipped with a heavy-duty box frame specially designed for deep ploughing / land preparation of rough soil. It is designed to work in all types of soils for basic functions such as soil

breaking, soil raising, soli pulverization and soil turning. It can handle the toughest ploughing job with outstanding penetration performance.

Satisfactory operations:

Regular and satisfactory operations together with economic and long-lasting use of the implement depend on the compliance with manufacturer's instructions.

Tractor preparations for field operations:

Instructions for tractor preparations

1) The horsepower of tractor selected should match the implement size.
2) Provide adequate front-end ballast for tractor stability.
3) All plough adjustment should be carried out.
4) Select load and depth control setting according to tractor operators manual.

M.B. Plough Adjustments:

To get better results from M.B. Plough, the following adjustments are necessary:

1) Leveling the plough: The level of the plough is controlled by the tractor top link. If the rear end of the plough beam is higher than the front end of the beam, lengthen the top link. If the rear end of the plough beam is lower than the front end, then shorten the top link. Lateral leveling is controlled by adjusting the length of the tractor right lower link. These adjustments must be made with the plough prior to operation.
2) Horizontal suction or land suction: Horizontal suction is the amount the point of share is bend offline with the land side. The object of the suction is to make the plough take the proper amount of furrow width. Horizontal suction is measured by placing a straight edge on the side of the plough extending from the heel of the landside to the point of share, then measuring horizontally the greatest distance from the straight edge to the plough bottom. The amount is usually about 3/16 inch.
3) Vertical suction or down suction: This is the bend downward of the point of share to make the plough penetrate the soil to the proper depth when the plough is pulled forward. The amount of suction shall vary from 1/8 to 3/16 inch depending on the style of plough and the soil it will make to work in. This suction can be measured by placing a straight edge on the bottom of the plough extending from the heel of the bottom of land side to the point of share, then measuring vertically and the greatest clearance from the straight edge to the plough bottom.
4) Draft of the M B plough: The type of soil is the greatest external factor to consider the draft of any plough. In very hard ground, it is often necessary to add weight to the wheels to force the plough into the soil. Draft is also affected by the depth and width of cut per bottom for complete plough. Speed is also another factor which increases the draft, doubling the speed increases the draft by about 20 -25%. Soil moisture is also an important factor for draft.
5) Adjustment for deeper ploughing: The depth of the plough can be obtained by the position and draft control levers of the tractor hydraulic scheme. However more depth can be obtained by:
    a. Adding extra weight to the plough.
    b. Vertical suction
    c. If the ground is covered with trash, set the plough in an almost vertical position, and add weight to the plough. In such soils notched plough gives better results.
6) Warning for driver:
    a) Before ploughing check all nuts and bolts of the MB. Plough.
    b) Don't plough on stony soil.
    c) Tractor should be in high first gear.

7) Danger:

Before ploughing with M B Plough take care that nobody stands near it.

Usage instructions:

1) Before mounting the M.B. plough make sure that all nuts and bolts are properly secured.
2) Attaching the plough to the tractor
   a) Place the plough duly leveled on the flat piece of land.
   b) Reverse the tractor to the plough (Do not drag the plough up the tractor)
   c) Attach the left arm of the tractor to the plough first.
   d) Attach the central arm to the plough. To attach, turn the screws on both sides to an equal length. If the arm is too short or too long, turn the screw to adjust both at the same time until aligned with the hole on the central arm
   e) To attach the lower right arm, turn the screw until the mounting pin is at the same level as the hole on the tractor arm. If the gap between hole and mounting pin is too close or too distant, turn the control arm in or pull it away to an appropriate distance. You may have to adjust both height and distance at the same time. When the hole at tractor arm and mounting pin are even, insert the pin in the hole and lock it with the lynch pin.
   f) After attaching the plough lift it and adjust the control arm parallel to the ground. When you look from both rear and sideways, the point should all be touching the ground uniformly.
3) NB: The plough will work best when the right wheel of the tractor is inside the previously ploughed furrow. So that the plough is in one of the furrows. Readjust the plough alignments again if necessary.
4) Instructions for driver
   a) When M.B. plough is ready for use don't stand between M.B. plough & the tractor.
   b) Properly fit the three-point linkage as mentioned above and lock with lynch pin.
   c) Never turn the tractor to the right or left when the plough is engaged in the soil.
   d) Never reverse the tractor when the plough is engaged in the soil.

If you work the M.B. Plough on stony land, then maintenance also increases. The following rules must be followed to get the best results from maintenance of M.B. Plough:

1) If M.B. plough is new, then after the first two hours of working tightened all nut bolts.
2) Check the plough adjustments if the steering is hard.
3) Constantly check for loose nuts and bolts.
4) After every fifty hours tighten all nuts and bolts.
5) Sharpen the bar point and shares if the shares are dull. Blunt shares increase the draft considerably.

8.5.3 O&M of thresher for harvest

A thresher is a machine to separate grains from the harvested crop and provide clean grain without much loss and damage. Bureau of Indian Standards has specified that the total grain loss should not be more than 5 per cent, in which broken grain should be less than 2 percent.

Component of a thresher and working principle:

A crop thresher mainly consists of the following components:

a) Feeding device (chute/tray/trough/hopper/conveyor),
b) Threshing cylinder (hammers/spikes/rasp-bars/wire-loops/syndicator),
c) Concave (woven-wire mesh/punched sheet/welded square bars),
d) Blower,

e) Sieve-shaker/straw-walker.

In present times use of multi crop thresher is very common because with a single machine a number of crops can be threshed with minor settings and adjustments. In Himachal Pradesh, mainly cereal crop wheat, paddy and maize are grown beside some pulses and other crops. For paddy threshing separate axial flow thresher is required.

The factors which affect the quality and efficiency of threshing by any thresher are broadly classified in following three groups:

a) Crop factors: Type of crop, Variety of crop, Moisture in crop material.
b) Machine factors: Feeding chute angle, Cylinder type, Cylinder diameter, Spike shape, size, and number, concave size, shape and clearance
c) Operational factors: Cylinder speed, Feed rate, method of feeding, Machine adjustments.

Therefore, to get the optimum performance from the machine and good quality of threshed material, combinations of these factors should be adjusted during operation for a particular crop.

A. Adjustments in threshers:

Various adjustments are required before starting threshing operation. The machine is to be installed on clean level ground and is to be set according to crop and crop conditions. The adjustments necessary to get the best performance from the machine are (i) concave clearance, (ii) sieve clearance, (iii) sieve slope, (iv) stroke length and (v) blower suction opening. Besides these, cylinder concave grate, top sieve hole size and cylinder speeds for threshing different crops are important for a multi crop thresher. The following are some general guidelines for adjustments of a thresher. At all times, consult the user's manual that is provided by the manufacturer. Also, review the safety/ health precautions for threshing machines. Thresher has a number of high-speed rotating parts therefore safety is very important for operators while working.

1) Position the thresher on a level area close to the crop stack to minimize handling and shattering losses.
2) Spread cloth, canvas, or mat underneath the thresher to collect spilled grain from the grain discharge chute or due to shattering during handling.
3) Install the cylinder, cover, and feed tray if dismantled during field transport.
4) Position the thresher so that the straw is thrown with the direction of the wind. This will eliminate the blowing of straw, chaff, and dust back toward the operator and the threshed grain.
5) Check each belt's alignment and tension. Adjust the idler pulley on the blower/cylinder belt to correct tension. Improper alignment and tension are the major causes of premature belt failure.
6) Check pulley surfaces. Rough grooves must be smoothened with a fine file if nicked. Cracked pulleys should be replaced immediately.
7) Open the cover and check all pegs on the threshing cylinder for tightness. Loose pegs will damage the machine and can be dangerous to the operators.
8) Examine the peg teeth for wear. Maximum wear occurs at the feed end of the cylinder and is more prominent at the leading side in the direction of rotation. Worn pegs must be rotated 180 degrees or interchanged with those located near the straw paddles. Badly worn pegs must be replaced with new ones by opening nuts and bolts. Advisable to set all pegs at same level.
9) Rotate the threshing cylinder manually at least five revolutions to ensure that there are no obstructions or interferences.

10) Lubricate all bearings with good quality grease, the belt idler and oscillating screen eccentric bearings.
11) Check engine oil and fuel levels if it is engine is operated. Otherwise, if electric motor operated check the connections as recommended by manufacturer's recommendations.
12) Start the thresher and allow to run for 2 to 3 minutes to observe if any bad sound is not coming from rotating components.
13) Feed the thresher with the crop to be threshed for performance checking to see that clean grain is coming, no broken grains. Increase cylinder speed if excessive amounts of unthreshed and unseparated grain are observed with the straw.
14) Optimum threshing and cleaning is obtained with cylinder speeds of 600 to 750 rpm for wheat and for other crops set as per manufacturer's booklet.

B. Operating the thresher:

1) Load the feed tray with the harvested crop. Three to four persons are required to operate the machine. One or two men to load the crops in feeding hopper depending on size of thresher. Two persons require to bring crop bundles. Another person bags the threshed grain and ensures that the cleaning screen is kept free of clinging straw especially when threshing wet material. Use a stick to remove clinging straw from the oscillating screen to protect hands from possible injury.
2) Harvested crops must be placed on the feed tray with the panicle away from the operator, so panicle towards cylinder is first fed into the thresher.
3) Feed the crop at a uniform rate and maintain maximum feeding rate without overloading the power source. Adjust the feed rate to match the condition of the material being threshed. For wet crops or crops with decomposed straw, reduce the feed rate to avoid overloading the cleaning screen.
4) For higher threshing efficiency, the crops should be dried well otherwise unthreshed grain increases. Adjust blower openings (shutters) to give the air flow needed for winnowing. Open slowly to provide more air for a cleaner output if cleaning of grains at outlet is not good. The blower opening must be adjusted to suit the threshing conditions.
5) The cutter knives between the pegs prevent straw from wrapping around the cylinder and aid in threshing hard–threshing varieties.
6) Reduce feeding rate when threshing wet or partially decomposed materials to avoid overloading.
7) Open the cylinder cover periodically to remove straw and chaff accumulation at the lower concave if threshing cylinder is clogged after stoppage of all rotating parts.

C. Safety precautions in threshing operation: -

1) Leave all guards and shields in place when operating the machine
2) Before cleaning, servicing, or repairing the machine, disconnect the power to the unit.
3) Use only properly grounded outlet (electric only).
4) Keep hands out of threshing belt entry area.
5) Do not wear loose clothing when operating this machine. Clothing can be grabbed by chain drives or rotating shafts and severe injury can result.
6) Keep hands and feet away from chain drives and v-belts when machine is running.
7) Don't use any alcohol drinks/narcotics items by the operators.
8) Thresher fitted with safe feeding chute should only be used. The movement of hands while feeding should not go beyond the covered area on feeding chute.

D. Guidelines for maintenance of a crop thresher:

1) Lubricate cylinder and fan bearings with good-quality general purpose grease every 25 hours of operation. Periodically apply a small amount of oil to all hinge points.
2) Inspect the machine regularly for loose, worn, or damaged peg teeth, concave bars, cylinder, and other parts, and tighten, repair, or replace them immediately if required. Missing bolts or nuts must also be replaced.
3) Reduce belt tensions by loosening the idler pulley and engine mounting bolts when the machine is not in used for an extended period to minimize deterioration.
4) Service the engine air cleaner, fuel filter, fuel line, regularly according to engine manufacturer's instructions. Electric motor should be removed when thresher is not in use.

E. Guidelines for storage of a threshing machine

1) Clean the machine thoroughly.
2) Remove belts and store in a dry place.
3) Store the machine in a clean, dry location and cover to reduce damage from dust accumulation.
4) Paint parts that need repainting.
5) Clean and apply oil to exposed metal surfaces to prevent rusting.
6) Follow the manufacturer's recommendations on engine/motor storage.

8.5.4 O&M of Spraying equipment

Spraying equipment or sprayer is a machine which is used to atomize the liquid chemical and spray at the plant uniformly. In agriculture, a sprayer is an equipment that is used to apply herbicides, pesticides, and fertilizers to agricultural crops. Sprayers range in size from man-portable units (typically backpack and spray guns) to trailed sprayers that are connected to a tractor, to self-propelled units.

Adjustments in sprayers:

1) Boom sprayers: Spraying is the final defense in an integrated pest management plan, timed according to pest and plant development. For optimal results, make minor adjustments before each application, to account for changes in the crop (size, shape and canopy density), weather conditions (relative humidity, wind speed and wind direction), the nature of the pest and the product chemistry. Often, to meet a strict spraying schedule, operators do not take the time to properly adjust their sprayers to match application conditions, resulting in over- or under-spraying. Over-spraying leads to unnecessary environmental contamination and financial loss due to run-off and drift; under-spraying requires more frequent applications to compensate for reduced protection and results in greater net waste compared to a schedule of applications that are correctly calibrated.
    a) Sprayer output (nozzle discharge rate): Adjust sprayer output and distribution at least twice a year, to ensure the sprayer will uniformly cover the target with the optimal volume. The first adjustment should take place during calibration at the beginning of the season; the second when the target crop has grown, and the canopy filled to such an extent that it requires different sprayer settings to achieve coverage. For example, apple trees at the 1-in. fruit stage of development require different sprayer settings than when they are at bud break - the tree is larger, fuller and requires more spray to cover the increase in surface area (i.e., leaves and fruit). At this stage, re-nozzle the sprayer to enable higher output and re-distribute the spray to match the shape and density of the target. Adjust deflector positions to ensure the spray just reaches the top of the highest tree in the block and does not spray below the canopy (Figure 1). Altering driving speed and/or pressure to account for wind or

canopy density is common practice for making minor changes to spray quality and sprayer output, but changing nozzle tips is more accurate and is therefore the preferred method when possible.

b) Spray droplet size: Spray droplet size is highly important for efficient and effective utilization of pesticides with minimum contamination of environment. Select optimum droplet size (mmd) for selection of type of nozzle to be used. Usually spray droplet size vary from coarse sprays (more than 400µm) to Aerosols (<50µm) and accordingly, a good sprayer should be able to produce droplets of uniform size. Air assisted sprayer should be used to get uniform droplet size and droplet density.

2) Uniformity of spray application: The uniformity of spray application on plants depends on:
   a) Spray boom/ lance height
   b) Spray angle and
   c) Degree of overlap (depends on spray boom height = spray angle and nozzle spacing)

Adjustments in T.D. Aero blast sprayer:

Aero blast sprayer is a precision spraying equipment. It projects fine droplets of chemicals into the target by spraying liquid chemical from hydraulic nozzles into an entraining blast of air generated by fans or turbine directed by volute, deflectors, or ducts.

1) Sprayer output volume: Optimal sprayer output volume is crop specific. For apple orchards, it is generally 400-1,500 L/ha. Except for dormant oil drenches, the goal is to cover all target surfaces with a minimum droplet density of 80-90 fine-to-medium-sized droplets/cm². This can be difficult to achieve given that the outside of the canopy receives more coverage than the inside. Ideally, the canopy should not drip. Valuable feedback can be obtained through the use of water-sensitive paper placed throughout the target canopy.
2) Air speed and volume: It is equally important to change the speed and volume of carrier air over the season. In apple trees, the air should barely rustle the outer leaves in the next row. This means setting the air volume high and the air speed low (except to compensate for wind). Adjust air by using a lower PTO speed, gearing up and throttling down, adjusting blade pitch and/or installing a hydraulic motor to control fan speed).

Calibration of sprayers:

1) Calibration: To apply a specified rate of chemical to the target surface (e.g. plant, soil, pest); one needs to measure the total spray output of the machine, the travel speed and the swath width. Then calculate the application rate.
2) Total sprayer output (L/min): The aim here is to measure the total liquid sprayed from the spray machine in one minute. First, disengage the gearbox and set the engine revs (1500 is a good starting point) with the power take-off (PTO) engaged at a normal operating speed. Set the pressure at the correct level for spraying. The correct pressure is specified by the manufacturer and determined by the type of nozzles used. All nozzles used for spraying should be left on.
   a) Fill the spray tank with clean water.
   b) Place a measuring jug under one nozzle. To avoid personal wetting, attach a piece of plastic hose to the nozzle and place the other end into the jug.
   c) Run the sprayer for one minute at the correct pressure with all nozzles operating.
   d) Measure the quantity of water collected in the jug. Compare this to the output specified by the manufacturer using the correct pressure. Nozzle output should not vary by more than 10%. If it does, the nozzle could be worn or damaged and should be replaced. All nozzles on the boom should have a similar output.

e) Repeat steps 2–4 for all the nozzles.
f) Add all the jug measurements to find the total sprayer output in liters per minute.

3) Travel speed (km/h): The normal speed for spraying with small boom sprayers in horticulture situations is 4–10 km/h. The slower one travels the higher is the application rate. A change in ground speed of 10% results in a 10% change in application rate. Adjust the travel speed to suit the ground conditions.
   a) Measure out a distance of 100 meters on the ground to be sprayed and mark the start and finish positions with pegs.
   b) Select the right gear and engine revolutions for spraying.
   c) Measure the time in seconds it takes to travel 100 meters with the sprayer attached and half full.
   d) Calculate sprayer travel speed by inserting the time in seconds into the following formula:

$$\text{Travel speed (km/h)} = \frac{100\ (\text{m}) \times 3.6}{\text{Time (seconds)}}$$

4) To calculate spray application rate (L/ha): First, measure swath width (in meters). For general broadcast spraying, the swath width is equal to the number of nozzles multiplied by the nozzle spacing. For band spraying the swath width is equal to the total of all the band widths.
5) Calculate the application rate: Calculated using the following formula:

$$\text{Application rate (L/ha)} = \frac{600 \times \text{total sprayer output (L/min)}}{\text{Swath width (m)} \times \text{travel speed (km/h)}}$$

For example: If total sprayer output is 5 L/min, & operating speed is 10 km/h, and the swath width is 5m,then application rate is:

$$\frac{600 \times 5}{5 \times 10} = \frac{3000}{50} = 60\text{L/ha}$$

5 Benefits of calibration: By calibrating the spraying machine one can find out the spray application rate. This information is necessary whenever the uses of chemicals are specified in amounts per hectare. It also helps to work out how many spray tanks are needed for a particular spraying job. The spray application rate varies for different crops, different row spacing and the age, height and density of crops. This means, it requires to calibrate for each crop or block. Calibration ensures good coverage of the target surface and sprays the correct amount without wastage. It saves time and money, results in a more effective and efficient praying job, and protects the environment.

Safety precautions in operation of sprayers before spraying:

1) Identify the pest and ascertain the damage done
2) Use pesticide only if crop damage has exceeded the Economical Injury Level.
3) Use only the recommended least toxic pesticide.
4) Read instructions manual of the pesticide and equipment.
5) Check the spraying equipment and accessories which are to be used.
6) Ascertain that all components are clean, especially filling and suction strainer, sprayer tank, cut off device and nozzles.
7) Replace worn out parts such as 'O' ring, seal, and gasket, worn out nozzle tips, hose clamps and valves.
8) Test the sprayer and ascertain whether it pumps the required liquid output at rated pressure.

Check the nozzle spray pattern and discharge rate.

9) Calibrate the sprayer. Set spraying speed and nozzle swath by adjusting spray height and nozzle spacing.
10) Make sure that appropriate protective clothing is available and is used.
11) Train all concerned with the application and understand the recommendations.
12) Ensure that soap, towel and plenty of water is available

Safety precautions during spraying:

1) Take only sufficient pesticide for the day's application from the store to the site.
2) Do not transfer pesticides from original container and packing into the containers.
3) Recheck the use instructions of pesticide and equipment.
4) Make sure pesticides are mixed in the correct quantities
5) Wear appropriate clothing.
6) Avoid contamination of the skin especially eyes and mouth.
7) Liquid formulation should be poured carefully to avoid splashing.
8) Do not spray in high wind, high temperature and rain.
9) Avoid drift by selecting proper direction of spraying by holding nozzle and boom at a proper height.
10) Start spraying near the downwind edge of the field and proceed upwind so that operator moves into unsprayed area.
11) Never eat, drink, or smoke when mixing or applying pesticides. Never blow out clogged nozzles or hoses with a mouth.
12) Follow correct spray technique. Spray plant crops thoroughly by operating sprayer at correct speed and correct pressure.
13) Never allow children or other unauthorized persons to be nearby during mixing.
14) Never leave pesticides unattended in the field.
15) Never spray if the wind is blowing towards grazing livestock or pastures regularly used.

Safety precautions after spraying:

1) Remaining pesticides left in the tank after spraying should be emptied and disposed of in pits dug on wasteland.
2) Never empty the tank into irrigation channels or ponds.
3) Never leave unused pesticides in sprayers. Always clean equipment properly. After use, oil it and then keep away in storeroom.
4) Do not use empty pesticide containers for any purpose.
5) Crush and bury the containers preferably in a land filled dump.
6) Clean buckets, sticks, measuring jars, etc. are used in preparing the spray solution.
7) Remove and wash protective clothing and footwear. Wash yourself well and put on clean clothing.
8) Keep an accurate record of pesticide usage.
9) Prevent persons from entering treated areas until it is safe to do so.
10) Mark the sprayed plots with a flag.

Maintaining the sprayer:

Sprayers are precision spray equipment that must be kept in good operating condition to ensure proper spray quality. Never assume that following the manufacturer's service instructions for winterizing a sprayer means it is ready for immediate hook-up and use in the coming season. Observe the following start-up steps before using the sprayer. This will prevent unnecessary and costly

breakdowns and improper application and may increase the lifespan of the spray equipment.

1) Cleaning the sprayer: Before cleaning a sprayer, read the equipment manufacturer's directions and consult the pesticide label for any special instructions. Ideally, clean sprayers at the end of each day (even if the same pesticide will be sprayed the next day) and before switching products. Many growers do not do this, but residues increase the chance of operator contamination, can damage sprayer components and may be incompatible with other products. There are two situation-specific methods for cleaning a sprayer. The first is when similar products will be used on two consecutive occasions. The second is when the product will be changed or when storing the sprayer for a prolonged period (e.g., winterizing). Common to both are the steps for triple-rinsing the sprayer.
2) Triple rinsing: Sprayers can retain several liters of spray solution following an application, even when the tank appears empty. Rinsing the spray tank multiple times with lower volumes has proven more effective at reducing pesticide residue concentration than a single, high-volume rinse. Low-volume rinsing may not be suitable for certain products; check the pesticide label for cleaning instructions.
    a) Add clean water to the tank to 10% capacity (ideally 10 parts water to 1 part spray solution remaining in the lines) and circulate it through the entire sprayer for 10 minutes. Open and close any control valves during this process.
    b) Carry clean water in a separate tank on the sprayer or on a support vehicle and rinse the exterior of the sprayer to remove pesticide deposits. Wearing appropriate personal protective equipment, scrub any persistent exterior deposits. When possible, perform this rinse in the field that was sprayed. The dilute rinse can now be flushed through the lines and sprayed out through the nozzles onto the crop provided the operator does not exceed the label rate.
    c) Move the sprayer to a permanent loading/mixing pad and rinse the interior of the sprayer twice more (for a total of three) to ensure that the nozzle discharge is clear. Never allow rinse to enter a waterway, drainage scheme or well. For more information, see the Ontario Pesticide Education Program's Grower Pesticide Safety Course manual.

Low-volume tank rinse schemes that reduce operator exposure to pesticide residue are available on newer sprayers. They generally consist of a 200-L supply tank mounted above the pump to supply clean water to rinse nozzles inside the tank. The number and orientation of the rinse nozzles should provide enough water to contact all surfaces inside the tank; use rinse nozzles regularly to prevent seizing. Once again, run the scheme three times and open and close any control valves during this process.

9. MANAGEMENT SUPPORTS FOR O&M FUNCTIONS

This chapter deals with the management supports that needs to be carried out to efficiently carry out the core operation and maintenance functions for making utilization of the project facilities. These management supports can broadly be divided include two categories namely, institutional strengthening of related institutions and financial management.

Apart from following the recommended procedure for operation and maintenance, few basic things are also key to ensure sustainability of project facilities. First, since the FOs have a key role in operating and maintaining the facilities, it needs to be ensured that the FOs themselves are functional and active. Hence, measures for sustaining the FOs have been provided below. Secondly, the financially sustaining mechanism for the necessary operation and maintenance works is also equally. Some suggestions on how that can be established in the context of the facilities developed by the project has also been outlined here.

9.1 Institutional Strengthening of Related Institutions

9.1.1 Awareness raising and capacity building

General awareness and necessary knowledge and skills with the concerned people sets the enabling environment and conditions for the effective operation and maintenance. In this concern awareness raising on various topics including the need for and importance of O&M, roles, and responsibilities of the various institutions in the O&M, judicial use of water, etc. are helpful. Moreover, building the capacity of the concerned institutions by imparting knowledge and skills on the proper procedures for operation and maintenance and addressing associated social and environmental issues is considered to contribute towards improving the operation and maintenance.

Awareness raising on the significance of O&M

First and foremost, the concerned institutions should be made aware of the need for and importance of O&M. They should be informed how much they can benefit from proper O&M.

Awareness raising on the roles, and responsibilities of the various institutions in the O&M

Confusion may also occur if the role and responsibilities is not clear. Hence, clarification of the roles and responsibilities of the different actors and institutions in the different O&M functions should be made from the very beginning.

During the project period, the role and responsibility of establishing the project facilities goes to the project. However, upon completion of the construction works of the irrigation schemes (FIS, LIS and TWIS), they are handed over to the concerned KVA and their ownership is transferred to the KVA. The respective KVA will then be responsible for the O&M of these minor irrigation schemes. Along with construction of different types of irrigation schemes, the project will also support the farmers with micro irrigation and solar schemes. The ownership of these irrigation accessories and equipment will also be transferred to the KVA once their work is completed. Their O&M responsible will also lie with the respective KVA.

The other infrastructure developed by the project are buildings and farm access roads. The project will do the construction and handover the buildings to the concerned government organization for operation and maintenance. In the case of farm access roads, the project will only do the construction, both the ownership and O&M responsibility lies with the concerned KVAs.

If any additional works are felt necessary during the operation and maintenance phase of the irrigation sub-project, then the irrigation Management Committee of the KVA shall call a meeting inviting all KVA member farmers to jointly discuss and decide upon the activities to be carried out and how to accomplish it. They shall prepare a plan of necessary works to be carried out along with a rough estimate of the cost involved. Works within the financial and human resources capacity of the KVA shall be carried out by the KVA. However, if the works are beyond their capacity, the KVA shall approach the relevant institutions for financial support. They can first approach the concerned local government. In case the local government is not able to provide the required support, the KVA shall identify relevant projects in the line agencies like DOA, JSV, DF who can support them for the works.

The main functions of the KVAs are the water allocation, water distribution and grievance redressal. It also includes tariff fixation collection and maintenance of record of the collection as per the KVA Regulations/Byelaws and awareness building: among farmers for judicious use of water.

Awareness raising on judicial use of water and water saving

The KVA shall also play an important role in awareness building for judicial use of water. Awareness building activities shall be taken up by the KVA through:

i) Facilitating in the organization of training camps with technical assistance from the Department of Agriculture, GoHP, and/or project authorities concerned.
ii) Facilitating in the arrangement of exposure visits of a team of members to other well-performing KVAs (success stories) in or outside the State.
iii) Facilitating group interaction with agriculture university and relevant technical state institutes.
iv) Distribution of sample brochures and setting up of instructive hoardings on the selection of water efficient crops, efficient water management practices, etc.

Capacity building on proper O&M procedures

The KVA should also be capacitated about the proper O&M procedures, and how they should go about them.

9.1.2 Institutional strengthening of the FOs

Since the FOs have a key role in operating and maintaining the facilities, it needs to be ensured that the FOs themselves are functional and active. Hence, measures for sustaining the FOs have been provided below.

Institutional Strengthening of KVAs

For the sustainability of the KVAs, a hierarchy structure with its federation at the state level has been suggested. The organization at the different level shall be as follows:

- Krishak Vikas Association (KVA) at Sub Project level
- Krishak Vikas Sangathan at BPMU level
- Krishak Vikas Munch at DPMU level
- Krishak Vikas Federation at State level

Moreover, for the sustainability it is suggested that every sub-project should be developed into a micro-finance institution. The KVAs of each sub-project should be registered as a Farm Produce Organization (FPO), a cooperative society under Act 1968. The sources of fund for micro-finance should be the KVA membership and its renewal, water user fees for providing irrigation, women SHGs, etc. In this project beneficiary will contribute up to 50% for farm inputs and up to10% for Farm Roads. Revolving fund, compulsory monthly savings, and annual membership will be generated which is

expected to be instrumental in developing a sense of ownership, confidence, and passion within these different groups.

Institutional Strengthening of FPOs:

For the success of the FPO, it is essential that they should be ready to take risks and calculate risks both financial and for the business. Hence, it is first essential that they the farmers be made aware and familiar with the kind of facilities which are being provide by the government.

Empower individual farmers, KVAs, FIGs and SHGs to achieve economic independence, improve their quality of life and contribute to sustain development. Through the holistic approach that combines skill development, enterprise support and market access, we seek to create lasting positive change and unlock the potential of every participant.

Understand the competition which is around you: how good you are in products, how cost effective the products and how good you are understand the competition

For the sustainability of any individual or any organization, regular financial flow or capital is required. Financial capital can be sustained by the issue of shares to members, membership fees, loans such credits, and profit earned over the course of business. For this, there are many organizations that support financially and technically for the promotion and handholding of FPOs, i.e., NABARD, SFAC (Small Farmers Agri Business Consortium), Corporations and NGOs, and domestic and international agencies. For social capital management FPO should function effectively and address the problems of the member of FPO regularly.

The stability of the FPO depends upon the ability to organize its member and resources not only in gaining economic growth and achieve market share, but also in maintain member's satisfaction, commitment and retaining them. Failing to put more concentration on the social part of action or decision can lead to the process of collapse of the circle of sustainability.

For the sustainability of the FPOs it is recommended to use participatory approach; focus on the enhancement of knowledge of the target farmers, transparency, trust building, dedicated members, adequate working capital, should be confirm for the proper functioning of the FPO and all the activities carried in the FPO should be share among the FPO members, concentration on social, financial and environment issues.

Social factor: build the skill of the farmers on the level of self - sustainability by providing continuous capacity building trainings, enhance knowledge in all aspects).

Environment factors: aware and sensitize the farmers on environment issues which is a big challenge in the near feature use of chemicals fertilizer, chemicals pesticides and, weedicides which shall help the farmers to reach the sustainability of FPO.

Financial factor: build the capacity of the farmers to become socially and economically self-sufficient and self-reliant.

All the FPOs, with the help of the project, can form a state level federation under the name "AGRIFED." The project should support and empower the federation in all aspects of self-sustainability. At this level, the federation will never look for any outside support.

Institutional Strengthening of FIGs:

Sustainability of the farmer interest group depends on the dedication of the leader. S/he has to organize and facilitate the entire group unbiased. The group members have to exchange and share new knowledge, skills, and improved technology with each other in group meetings. They have to build social cohesion, develop operational plan, regularly meeting, manage revolving fund, good planning, manage water wisely, and high motivation for sustainability.

Institutional Strengthening of SHGs:

For the sustainability of the SHGs it is suggested that the selection of the beneficiaries should be need based. Provide continuous trainings on the activities adopted by the farmers under livelihood support activities. To build the capacity of the SHGs members on various issues related to how to manage and handle financial matter, leadership skills, marketing, and entrepreneurship. By rewarding the good and active SHGs you can create a positive space for sustainability.

SHGs members should maintain register regularly, member should take SHGs meeting seriously, direct linkages with the producer and customer. So that these SHGs never look further for any other agencies for their sustainability.

9.1.3 Addressing environmental and social issues

Usually, the difference or the dispute among the members of the KVA mainly pertain to sharing and use of water and, in the process, lead to protest against payment of water tariff. The procedures that the KVA shall follow to resolve the differences are stated below:

i) Any member who has a complaint against another member will notify the President.

ii) The President shall, soon after receiving the complaint, call the disputing parties, consider their submissions, and endeavour to settle the matter amicably.

iii) If amicable settlement cannot be reached, the President shall within 3 days of receipt of the complaint call a meeting of the Management Committee to resolve the conflict after hearing the disputing members. The decision shall be taken by a simple majority of votes.

iv) In case any of the disputing parties are not satisfied with the decision of the Management Committee and notifies the same to the President, a meeting of theGeneral House shall be convened to discuss and resolve the matter. The decision in the General House shall also be taken by a simple majority of votes.

v) In case any of the disputing parties is not satisfied with the decision of the General House, then aggrieved parties may approach the Block Level Coordination Committee and a meeting will be held at BPMU in the presence of the Management Committee. The Committee shall consist of the following members:

- Block Project Manager: Chairman
- Block Development Committee Member (s) of respective sub-project (s)
- Naib-Tehsildar
- Chairman KVA (s) of respective sub-project
- Forest Range Officer
- Junior Engineer, JVS of respective section
- Junior Engineer, Electricity of respective section
- Agriculture Development Officer (Block)
- Agriculture Development Officer (HPCDP): Member Secretary

vi) In case any of the disputing parties is not satisfied with the decision of the Block Level Coordination Committee, then the concerned parties may approach the District Level Coordination Committee under the chairmanship of District Collector or his/her nominated representative. The Committee shall consist of the following members:

- District Collector or his/her nominated representative: Chairman
- Superintending Engineer, Irrigation & Public Health Department
- Superintending Engineer, Electricity
- Conservator Forest Department
- Deputy Director, Agriculture Department
- District Revenue Officer
- Project Officer, District Rural Development Agency
- Scientist In-charge, Krishak Vighyan Kendra
- Deputy Project Director, Soil and Water Conservation, HPCDP
- Non-official member (with experience and exposure in agriculture sector): to be nominated by Chairman
- DPM of respective district: Member Secretary

Further, to minimize the likelihood of disputes, Management Committee meeting will be held at least once in a month during the irrigation season to examine and resolve any contentious issue that may come to its knowledge, and two General Seasonal Meetings of the KVA shall be convened one month before every kharif and rabi season for preparing crop plan, and agreed water distribution schedule, with the objective to attain general consensus among members.

9.2 Financial Management Improvements

9.2.1 Water tariff fixation

The Water rates are levied for the supply of water to ensure equitable water distribution, the efficiency of the irrigation system, and its management. The National Water Policy Statement of 2002 also advocates for ***"the water charges for various uses and should be fixed in such a way that they cover at least the Maintenance and Operation charges of providing the service initially and a part of the Capital Costs subsequently".***

As per Bureau of Indian Standard (IS 14519: 1998): **"GUIDELINES FOR FIXING RATES FOR IRRIGATION WATER",** the water rates should be adequate to cover the annual maintenance and operation charges and a part of the fixed costs. The water rates depend on type of irrigation schemes i.e. Lift, Tube well or Flow irrigation scheme. The Cost of water can be worked out on Economic Considerations, by computing the following:

(i) Repayment of Project Cost.
(ii) Rate of interest on the investment.
(iii) Electricity charges in case of Lift & Tube Well irrigation.
(iv) Its effective life span.
(v) Actual Operational and maintenance charges on irrigation system.

In the State, there are mainly two cropping seasons namely, Kharif and Rabi but as per advancements made in agriculture methods, improved seeds, and the use of fertilizers, the farmers of this hilly-area-dominated State have started growing Zaid crops in the period between Rabi and Kharif on lands, where assured irrigation facilities are available. The farmers will also grow off-season vegetables after getting assured irrigation from HPCDP. The principal crops grown in the State during Kharif season include Maize, Paddy, Sugarcane, Oilseed, Orchards, Vegetables and Fodder etc. and in

Rabi season are Wheat, Oilseeds, Grams, Pulses, Barley, Bajra, Masoor, Vegetables and Fodder etc. Crops like Toria, Potatoes and Peas are cultivated during Zaid season.

In view of the above, season-wise economic rates of providing water to farmers for annual repayment of loan & interest and O&M of the sub projects charges are given in the tables below:

Table. 9.2.1.1. Season-wise water rates fixed for providing water to farmers under HPCDP, Phase-II (Annual Repayment of Loan & Interest):

S. No.	Season	Flow Irrigation			Lift Irrigation			TW Irrigation		
		(Rs/ Ha- cm)	(Rs/ m^3)	(Rs./ Hour)	(Rs/ Ha- cm)	(Rs/ m^3)	(Rs./ Hour)	(Rs/ Ha- cm)	(Rs/ m^3)	(Rs./ Hour)
1.	**Kharif**	247.00	2.47	91.00	884.00	8.84	325.00	897.00	8.97	329.00
2.	**Rabi**	247.00	2.47	91.00	884.00	8.84	325.00	897.00	8.97	329.00

Table. 9.2.1.2. Season-wise water rates fixed for providing water to farmers under HPCDP, Phase-II (O&M charges will be borne by KVA/Farmers):

S. No.	Season	Flow Irrigation			Lift Irrigation			TW Irrigation		
		(Rs/ Ha- cm)	(Rs/ m^3)	(Rs./ Hour)	(Rs/ Ha- cm)	(Rs/ m^3)	(Rs./ Hour)	(Rs/ Ha- cm)	(Rs/ m^3)	(Rs./ Hour)
1.	**Kharif**	129.00	1.29	47.00	367.00	3.67	135.00	372.00	3.72	137.00
2.	**Rabi**	129.00	1.29	47.00	367.00	3.67	135.00	372.00	3.72	137.00

Table. 9.2.1.3. Project Assistance for providing water to farmers under HPCDP, Phase-II:

S. No.	Season	Flow Irrigation			Lift Irrigation			TW Irrigation		
		(Rs/ Ha- cm)	(Rs/ m^3)	(Rs./ Hour)	(Rs/ Ha- cm)	(Rs/ m^3)	(Rs./ Hour)	(Rs/ Ha- cm)	(Rs/ m^3)	(Rs./ Hour)
1.	**Kharif**	118.00	1.18	44.00	517.00	5.17	190.00	525.00	5.25	192.00
2.	**Rabi**	118.00	1.18	44.00	517.00	5.17	190.00	525.00	5.25	192.00

9.2.2 Financial management

In accordance with the provisions of the Regulations/ Byelaws of the KVA, following Accounts Registers shall be maintained:

(i) Cash Book (**Annexure 19**)
(ii) Bill Register (**Annexure 20**)
(iii) Receipt Book; (**Annexure 21**))
(iv) Asset Register; (**Annexure 22**))
(v) Register of Demand and Collection of Water Tariff; (**Annexure 23**)
(vi) Register of Landholders; (**Annexure 24**).

All operating funds of the KVA shall be deposited in a savings account in the post office or cooperative bank or nationalized bank. For Institutional Development Fund, separate bank account shall be opened in the post office or cooperative bank or nationalized bank. All The bank account shall be operated through joint signatories of the President, Secretary (in absence of the President) and the

Treasurer of the KVA.

At the end of each financial year, the Management Committee shall submit to the General House an audited Financial Statement in accordance with the provisions of the Regulations/Byelaws of the KVA for its approval.

9.2.3 Sustaining mechanisms

Learning from the experiences from the first phase of the project, it has been concluded that there need to be some incentivization scheme for the farmers' organization (FOs) to be active and sustainable. In this concern, it is suggested that the FOs should be developed into micro-finance institutions. Moreover, necessary capacity building programs should be conducted to raise awareness and enhance their capacity. Further, it is also suggested that sustainable value chains be developed by organizing proper linkages among producers, traders, processors, and service providers to improve productivity and add value of their activities and supporting these groups to sustain business with help of self-generating revenue scheme can make these concepts sustainable. It is observed that a dual intervention of both supporting the farmers' psychological needs for autonomy, competence or relatedness and at the same time mitigating the asymmetry of information in the market helps the target farmers to manage their farming business on their own initiative and improve their livelihood without external help.

Financial sustainability of irrigation schemes can also be assured through funds from line agencies such as Rural Development Department dealing with watershed development projects and O&M budget for irrigation projects under JSV or DOA. MGNREGA funds can be used for desilting of repairing water diversion and water harvesting structures or desilting of channels.

The Management of Corpus Fund

Corpus fund is one of the options for availing necessary funds for O&M of irrigation sub-projects. In this regard, the following provisions of the MOD are worth noting:

- "In order to maintain the assets created under the Project and develop business of FPO, the Corpus Fund, at the rate of INR 1,000 Lakh, shall be provided. This fund would be managed by PMU in the form of fixed deposit, based on the business plan interest accrual shall be used by the FPO. On the other hand, the existing FPO, HAVI can also avail loan for processing and value addition activities on the similar terms and conditions and the details of operation and maintenance of corpus funds shall be framed in consultation with PMC expert" Point No. 114 of Annex II of MoD.
- "FPOs need to secure operational cost to purchase the produce from its member farmers. However, it is a challenge for FPOs to access financial services due to lack of collateral. The Project will take steps to provide FPOs with financial access by creating corpus fund to fulfill the needs of FPOs by the time they acquire adequate credibility to borrow from other financial institutions, in order to maintain the assets created under the Project and develop business of FPO, the Corpus Fund shall be provided" point No. 3.1.4 of Attachment 2 of MoD.

National Agriculture Infra Financing Facility

Another useful option is this regard is the National Agriculture Infra Financing Facility. In view of the crucial role of infrastructure for developing agriculture production dynamics to the next level and optimally utilizing the opportunity for value addition and fair deal for the farmers, , the Hon'ble Finance Minister announced on 15.05.2020, 1 lakh crore Agri Infrastructure Fund for farm-gate infrastructure for farmers. Financing facility of Rs. 1,00,000 crore will be provided for funding Agriculture Infrastructure Projects at farm-gate & aggregation points (Primary Agricultural Cooperative Societies,

Farmers Producer Organizations, Agriculture entrepreneurs, Start-ups, etc.). Impetus for development of farm gate and aggregation point, affordable and financially viable Post Harvest Management infrastructure.

Accordingly, DAC&FW has formulated the Central Sector Scheme to mobilize a medium - long term debt financing facility for investment in viable projects relating to postharvest management Infrastructure and community farming assets through incentives and financial support.

Subsequently, in the budget announcement made on 01.02.2021, it was decided to extend the benefit of the scheme to APMCs. Accordingly, modifications in the scheme were carried out with the approval of Cabinet to make it more inclusive.

Credit guarantee coverage will be available for eligible borrowers from this financing facility under Credit Guarantee Fund Trust for Micro and Small Enterprises (CGTMSE) scheme for loans up to ₹ 2 crore. The fee for this coverage will be paid by the Government. In case of FPOs the credit guarantee may be availed from the facility created under FPO promotion scheme of DAC&FW.

All loans under this financing facility will have interest subvention of 3% per annum up to a limit of ₹ 2 crore. This subvention will be available for a maximum period of 7 years. In case of loans beyond ₹ 2 crore, then interest subvention will be limited up to ₹ 2 crore. The extent and percentage of funding to private entrepreneurs out of the total financing facility may be fixed by the National Monitoring Committee.

The Scheme will be operational from 2020-21 to 2032-33. Loan disbursement under the scheme will complete in six years. Our sub-projects can also benefit from such national schemes.

Annexures

Annexure 1: Units and Measures

Units	Measures
Cum	cubic meter [1 cum = 35.32 cubic feet (cft)]
Ha	Hectare [1 ha = 2.471 acres (ac)]
Kanal	1 Kanal = 505 square meter
Marla	20 Marla = 1 Kanal
q	1 Quintal = 100 kg
MT	1 Metric Ton = 1000 kg
m	meter, [1 m = 3.28 feet (ft)]
M cft	Million cubic Feet, [1 M. cft = 28.32 T cum]
M cum	million cubic meters
no.	Number/s
sq km	Square kilometer [1sqkm = 0.39 sq. miles]
sq m	Square meter [1 sqm = 10.8 square feet (sft)]
T cum	thousand cubic meters
Temperature	Centigrade = 5/9 X (F-32)

Annexure 2: District wise Data of Minor Irrigation Infrastructure to be Developed

(Refer section 1.3)

As per the MOD (Table 1.1.2 and Table 1.1.3), the complete list of infrastructure to be developed has been provided in the Table below:

S. N.	Activity	Unit	Bilaspur	Chamba	Hamirpur	Kangra	Kinnaur	Kullu	Lahaul & Spiti	Mandi	Shimla	Sirmour	Solan	Una	Total
1	Diversion Weir	No	-	17	-	43	-	22	21	41	20	5	8	-	177
2	Protection Work/Spur	No	33	-	46	157	-	-	-	2	-	5	4	-	247
3	Water Harvesting Structure	No	12	-	5	18	-	2	-	6	-	-	2	7	52
4	Tube Well	N.	-	-	1	-	-	-	-	-	-	-	-	10	11
5	Main Channel	m	-	11,165	-	96,985	-	23,380	28,300	80,950	63,820	2,200	20,300	-	327,100
6	Distribution Scheme (HDPE pipeline)	m	9,500	19,290	81,845	91,200	11,000	39,300	61,500	212,490	13,690	22,975	11,050	70,000	683,840
7	Percolation Well	No	-	-	10	2	-	-	-	7	-	3	5	1	28
8	Pump House	No	12	-	22	14	-	2	-	15	-	3	7	19	94
9	Intake Chamber	No	10	16	-	37	2	61	39	41	24	9	49	-	288
10	Pumping Machinery	No	12	-	22	19	-	2	-	14	-	3	7	19	98
11	Storage Tank (No.)	m	39	28	14	37	-	20	20	81	29	16	17	4	305
12	Raising Main	m	6,415	-	10,580	11,200	-	1,500	-	9,100	-	4,900	7,000	8,275	58,970
13	Main Delivery Tank	No	12	-	22	16	-	2	-	17	-	3	7	19	98
14	Pucca Field Channel	m	-	5,700	-	59,850	600	31,850	14,800	-	46,100	2,900	5,700	-	167,500
15	Outlet Chamber	No	490	160	1,062	1,399	10	279	281	3,111	448	28	200	686	8,154
16	Sluice Valve Chamber	No	-	-	191	229	-	-	-	-	-	-	2	-	422
17	Nallah/ Road Crossing	No	16	-	20	42	-	-	-	4	-	6	4	11	103
18	Retaining Wall	No	32	206	34	241	-	157	83	192	2,889	29	744	33	4,640

Annexure 3: Irrigation Water Demand Collection Form

(Refer section 3.1.4)

Name of the Irrigation Scheme: …….

Location of the Irrigation Scheme: …….

Requester:

Name of the farmer requesting for water: …….

Address of the farmer requesting for water: ……

Water supplying route:

- Channel/branch channel: ……
- Outlet: ……

Request:

Desired flow of water: …….

Desired duration of water delivery (minutes): …….

Desired timing of water delivery (date and time): ……

Rationale for the Request:

1. Crop production: Cropping pattern: …….
2. Fisheries: Number: …….
3. Livestock: Type and number: ……
4. Domestic use: Specify: ……..

Request submitted by: ……

Date of submission of request: …….

Annexure 4: Critical Periods of Irrigation for Major Crops

(Refer section 3.1.4)

S. No.	Crops	Cropping period (days)	Average Water Required (mm/season)	Critical Periods for Irrigation
Cereal crops:				
1	Paddy	100 - 120	900 - 1500	1. Crop elongation period 2. Jointing period 3. Flowering stage 4. Dough stage
2	Wheat	110 - 130	450 - 650	1. Crown Root initiation 2. Tillering stage 3. Jointing stage 4. Flowering stage 5. Dough stage
3	Maize	90 - 120	500 - 800	1. Knee-high stage 2. Tassel formation stage 3. Grain formation stage 4. Grain maturity stage
4	Barley	110 - 130	450 - 650	1. Flowering stage 2. Grain Formation stage
Vegetable crops:				
1	Tomato	60 - 90	400 - 800	1. Crop elongation 2. Flowering stage
2	Potato	100 - 150	500 - 700	1. Growing stage 2. Tuber shoot formation 3. Tuberization stage
3	Radish	40 - 60	300 - 400	1. Growing stage 2. Root development stage 3. Tap root development stage
4	Cauliflower	55 - 120	350 - 600	• Frequent irrigation from planting to harvest
5	Cabbage	70 - 90	350 - 500	• During head formation and enlargement
Legumes:				
1	Moong	90 - 100	400 - 500	1. Germination stage 2. Flowering stage 3. Pod formation stage
2	Gram	140 - 145	400 - 550	1. Branching stage 2. Flowering stage 3. Pod formation stage
3	Pea	65 - 100	350 - 500	1. Growing stage 2. Flowering stage
4	Soyabean	100 - 120	450 - 700	1. Growing stage 2. Pod formation stage
Oil seed crops:				
1	Mustard	90 - 125	350 – 450	1. Growing stage 2. Before-flowering stage 3. Pod/grain stage
2	Groundnut	110 - 130	550 – 600	1. Growing stage 2. Jointing period 3. Flowering stage 4. Nut-formation stage
3	Sunflower	90 - 120	900 – 1300	1. Growing stage 2. Before-flowering stage
Industrial crops				
1	Sugarcane	300 - 360	1800 – 2400	1. Growing stage 2. Tillering stage

S. No.	Crops	Cropping period (days)	Average Water Required (mm/season)	Critical Periods for Irrigation
				3. Stem development stage 4. Node development stage
2	Cotton	150 - 180	700 – 1300	1. Growing stage 2. Flowering stage 3. No water logging
3	Jute	110 - 140	500 – 700	1. Plant development 2. Stem growth stage 3. Flowering stage

Annexure 5: Maintenance Log of Routine Maintenance in FIS

(Refer section 4.2.1)

Name of FIS: ……...

Date of start of work maintenance: (date/month/year) ……/……/…202……

Type of routine maintenance work: (please tick √)

- ☐ Strengthening the head weir or intake structure
- ☐ Removing vegetation and other trash from the irrigation network
- ☐ Removing Silt from Water Retention structures
- ☐ Other routine maintenance works, mention: ……...

Performed by:

- ☐ Kohli
- ☐ Concerned beneficiary/ farmers
- ☐ Farmers' group
- ☐ Contractor

List of people engaged in the routine maintenance:

S. N.	Name	Sign	Remarks
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
		Inspected by	
		Recorded by	
		Record signed by	

Annexure 6: Maintenance Log of Periodic Maintenance of FIS

(Refer section 4.2.2)

Name of FIS: ……...

Date of start of work maintenance: (date/month/year) ……/……/…202……

Type of periodic maintenance work: (please tick √)

- ☐ Periodic repair of intake structures
- ☐ Repair of outlets/hydrants/water control gates etc.
- ☐ Maintenance of farm access roads
- ☐ Other periodic maintenance works, mention: …….

Performed by: (please tick √)

- ☐ Kohli
- ☐ Concerned beneficiary/farmers
- ☐ Management Committee of KVA
- ☐ Contractor

List of people engaged in the routine maintenance:

S. N.	Name	Sign:	Remarks
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
			Inspected by
			Recorded by
			Record signed by

Annexure 7: Maintenance Log of Emergency Maintenance of FIS

(Refer section 4.2.3)

Name of FIS: ……...

Date of start of work maintenance: (date/month/year) ……/……/…202……

Type of emergency maintenance work: (please tick √)

- Emergency repair of head weir/intake structure
- Opening of flood regulation structure
- Repair of damage due to natural disaster like floods, earthquakes, or storms
- Other emergency maintenance works, mention: ……

Performed by: (please tick √)

- Kohli
- Concerned beneficiary/ farmers
- Management Committee of KVA
- Contractor

List of people engaged in the routine maintenance:

S. N.	Name	Sign:	Remarks
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
			Inspected by
			Recorded by
			Record signed by

Annexure 8: Operation record of FIS

(Refer section 4.2.3)

Name of Sub-project:

Sr. No.	Name of Farmer	Pump Operation				Water Charges/ Hour (Rs)	Total Water Charges (Rs.)	Area (Ha)	Name of crops irrigated	Signature of Pump Operator	Remarks
		Date	Start Time	Closing Time	Total Time (Hours)						
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
Total											

Annexure 9: Maintenance Log of Routine Maintenance in LIS

(Refer section 5.2.1)

Name of LIS: ……...

Date of start of work maintenance: (date/month/year) ……/……/…202……

Type of routine maintenance work: (please tick √)

- ☐ Inspection of pump station
- ☐ Lubrication (oiling and greasing) of electric driven pumps
- ☐ Removing silt from water bodies, sump wells, MDT etc.
- ☐ Removing vegetation and other trash from the irrigation network
- ☐ Other routine maintenance works, mention: ……...

Performed by:

- ☐ Pump operator
- ☐ Concerned beneficiary/ farmers
- ☐ Farmers' group
- ☐ Contractor

List of people engaged in the routine maintenance:

S. N.	Name	Sign:	Remarks
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
			Inspected by
			Recorded by
			Record signed by

Annexure 10: Maintenance Log of Periodic Maintenance of LIS

(Refer section 5.2.2)

Name of LIS: ……...

Date of start of work maintenance: (date/month/year) ……/……/…202……

Type of periodic maintenance works: (please tick √)

- Periodic clearance of intake structures
- Servicing of electric driven pumps/ prime movers
- Repair of civil structures and allied accessories
- Maintenance of farm access roads
- Other periodic maintenance works, mention: …….

Performed by: (please tick √)

- Concerned beneficiary/ farmers
- Management Committee of KVA
- Contractor
- Authorized dealer

List of people engaged in the routine maintenance:

S. N.	Name	Sign:	Remarks
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
			Inspected by
			Recorded by
			Record signed by

Annexure 11: Maintenance Log of Emergency Maintenance of LIS

(Refer section 5.2.3)

Name of LIS: ……...

Date of start of work maintenance: (date/month/year) ……/……/…202……

Type of emergency maintenance works: (please tick √)

- □ Emergency repair of intake structures
- □ Opening of flood regulation structure during excess water
- □ Repair of damage due to natural disaster like floods, earthquakes, or storms
- □ Damage due to electric short circuit/ moist in transformer
- □ Other emergency maintenance works, mention: ……

Performed by: (please tick √)

- □ Electricity Board Technician
- □ Pump operator
- □ Concerned beneficiary/ farmers
- □ Management Committee of KVA
- □ Contractor

List of people engaged in the routine maintenance:

S. N.	Name	Sign:	Remarks
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
			Inspected by
			Recorded by
			Record signed by

Annexure 12: Operation record of LIS

(Refer section 5.2.3)

Name of Sub-project:

Sr. No.	Name of Farmer	Pump Operation				Water Charges/ Hour (Rs)	Total Water Charges (Rs.)	Area (Ha)	Name of crops irrigated	Signature of Pump Operator	Remarks
		Date	Start Time	Closing Time	Total Time (Hours)						
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
Total											

Annexure 13: Maintenance Log of Routine Maintenance in TWIS

(Refer section 6.2.1)

Name of TWIS: ……...

Date of start of work maintenance: (date/month/year) ……/……/…202……

Type of routine maintenance work: (please tick √)

- ☐ Inspection of electric driven pump, prime movers and wiring
- ☐ Lubrication (oiling and greasing) of electric driven pump
- ☐ Repair of civil structure and accessories
- ☐ Removing vegetation and other trash from the irrigation scheme
- ☐ Other routine maintenance works, mention: ……...

Performed by:

- ☐ Pump operator
- ☐ Concerned beneficiary/ farmers
- ☐ Farmers' group
- ☐ Contractor

List of people engaged in the routine maintenance:

S. N.	Name	Sign:	Remarks
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
			Inspected by
			Recorded by
			Record signed by

Annexure 14: Maintenance Log of Periodic Maintenance of TWIS

(Refer section 6.2.2)

Name of TWIS: ……...

Date of start of work maintenance: (date/month/year) ……/……/…202……

Type of periodic maintenance work: (please tick √)

- Periodic repair of tube well
- Servicing of electric driven pumps
- Repair of civil structure and accessories
- Maintenance of farm access roads
- Other periodic maintenance works, mention: …….

Performed by: (please tick √)

- Concerned beneficiary/ farmers
- Management Committee of KVA
- Contractor
- Authorized dealer

List of people engaged in the routine maintenance:

S. No.	Name	Signature	Remarks
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
			Inspected by
			Recorded by
			Record signed by

Annexure 15: Maintenance Log of Emergency Maintenance of TWIS

(Refer section 6.2.3)

Name of TWIS: ……...

Date of start of work maintenance: (date/month/year) ……/……/…202……

Type of emergency maintenance work: (please tick √)

- ☐ Drying up of tubewell
- ☐ Damage due to electric short circuit
- ☐ Repair of damage due to natural disaster like floods, earthquakes, or storms
- ☐ Other emergency maintenance works, mention: ……

Performed by: (please tick √)

- ☐ Electricity Board Technician
- ☐ Pump operator
- ☐ Concerned beneficiaries/ farmers
- ☐ Management Committee of KVA
- ☐ Contractor

List of people engaged in the routine maintenance:

S. No.	Name	Signature	Remarks
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
			Inspected by
			Recorded by
			Record signed by

Annexure 16: Operation record of TWIS

(Refer section 6.2.3)

Name of Sub-project:

Sr. No.	Name of Farmer	Pump Operation				Water Charges/ Hour (Rs)	Total Water Charges (Rs.)	Area (Ha)	Name of crops irrigated	Signature of Pump Operator	Remarks
		Date	Start Time	Closing Time	Total Time (Hours)						
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
Total											

Annexure 17: Maintenance Norms, Frequency of Application of Finishing Items

S. No.	Item	Periodicity	
		Residential	Office
1	Painting with plastic/Acrylic Emulsion paint, Acrylic Synthetic enamel paint, Oil bound distemper etc.	3 years	3 years
2	Painting external surface with exterior emulsion or equivalent paint.	5 years	5 years
3	Painting external surface with water proofing cement paint.	3 years	3 years
4	Cleaning and disinfecting of water storage/distribution tanks, water mains.	6 months	6 months
5	Cleaning of Manholes/Gully chambers and flushing of building sewers.	1 year	1 year
6	Cleaning of storm water drains.	1 year	1 year
7	Painting steel water tanks inside with bitumastic paint.	3 years	3 years
8	Polishing wooden doors/ windows with spirit polish/ synthetic acrylic polish.	3 years	3 years
9	Cleaning Electrical installation, fans etc.	1 year	1 year
10	Premix, semi dense/dense carpeting of roads.	5 years	5 years
11	Collection of water samples for physical, chemical and bacteriological analysis of water.	6 months	6 months

Annexure 18: Useful Life of Various Electrical Equipment/Installations Etc.

Sl. No.	Description of Equipment/ Installation	Life years
A	**Wiring of Electrical Installations**	
1	Conduit wiring non-coastal area	20
2	Conduit wiring coastal area	15
3	MS Pole	20
4	GI Pole	25
5	***Outdoor luminaries***	7
6	***Indoor luminaries***	5
B	**Fans**	
1	Ceiling Fan AC	15
2	Exhaust Fan AC	6
C	**External Electrical Lines**	
1	Permanent overhead line on steel / RCC poles	20
2	Underground Cable Lines	20
D	**Lifts**	
1	Electric Lifts ***residential complex***	15
2	Electric Lifts ***Office building***	20
3	Hospital Lifts	15
4	Escalators	15
E	**Refrigerators, Coolers & Air Conditioners**	
1	Refrigerators	6
2	Cold storage plant with air-cooled condensing unit	8
3	Desert Coolers (1500-2000 cfm) (Evaporative type)	4
4	Water Coolers	5
5	Window type / Split type Air-conditioning units with air cooled	

Annexure 19: Sample Cash Book

(Refer section 9.2.2)

Receipt				Payments			
Date	**Receipt No.**	**Particulars**	**Amount (Rs.)**	**Date**	**Voucher No.**	**Particulars**	**Amount (Rs.)**

(Authorized Signature)

Annexure 20: Sample Bill Register

Refer section 9.2.2)

Month of _____

Sl. No.	Bill		Name and Address of Vendor/Supplier	Description of Supplies/ Works	Amount (Rs.)
	No.	Date			

(Authorized Signature)

Annexure 21: Sample Bill Register

(Refer section 9.2.2)

Receipt No._____ **Date: _____**

Received
from_____of_____

_____(address) a sum of Rs._____

(Rupees_____)
only towards_____
_____

(Signature of Treasurer)

Annexure 22: Sample Asset Registry

(Refer section 9.2.2)

Sl. No.	Description of Asset	Date of acquired	Unit	Location	Amount (Rs.)

(Dated) **(Signature of Management Committee)**

Annexure 23: Sample Bill Register

(Refer section 9.2.2)

Sl. No.	Member		Tariff Charged		Tariff Collected		Amount Uncollected (Rs.)	Remarks
	Name	Address	Demand No.	Amount (Rs.)	Receipt no.	Amount (Rs.)		

(Dated) **(Signature of Management Committee)**

Annexure 24: Sample Register of Landholders

(Refer section 9.2.2)

Sl. No.	Name & address of Landholder	Land Identification Details	Area	Location	Remarks

(Dated) **(Signature of KVA)**