Guidelines on Soil and Water Conservation (SWC)

Indo-German Development Cooperation

Climate Change Adaptation Programme in the Himalaya, Component II: Tripura – Climate Resilience of Forest Ecosystems, Biodiversity & Adaptive Capacities of Forest Dependent Communities

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Acronyms

BMZ	Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung
BO	Beat Officer
BWCD	Brush Wood Check Dam
CREFLAT	Climate Resilient Forest Landscapes in Tripura
DFO	District Forest Officer
DPMA	District Project Management Authority
ECD	Earthen Check Dam
EDC	Eco Development Committee
ESMF	Environmental & Social Management Framework
FTL	Full Tank Level
GIS	Geographical Information System
GP	Gram Panchayat
IFPRA	Issue Focused Participatory Rural Appraisal
IGDC	Indo-German Development Cooperation
JFMC	Joint Forest Management Committee
JICA	Japan International Cooperation Agency
KfW	Kreditanstalt für Wiederaufbau
MGNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MGNREGS	Mahatma Gandhi National Rural Employment Guarantee Scheme
MLA	Member of Legislative Assembly
MWL	Maximum Water Level
NTFP	Non-Timber Forest Product
O&M	Operational & Maintenance
PD	Project Director
PES	Payment for Ecosystem Services
PMA	Project Management Authority
PMC	Project Management Consultant
PRA	Participatory Rural Appraisal
RL	Reduce Level
RO	Range Officer
RoFR	Recognition of Forest Right
SC	Schedule Cast
SCT	Staggered Contour Trench
SHG	Self-Help Group
ST	Schedule Tribe
SWC	Soil & Water Conservation
TA	Technical Assistant
TBL	Top Bund Level
TO	Technical Officer
TSR	Tripura Schedule of Rate
TW	Top Width
V:H	Vertical: Horizontal
VC	Village Committee
VCW	Village Community Worker
VDP	Village Development Plan

VDPIC	Village Development Planning and Implementation Committee
WAT	Water Absorption Trench

0 Executive Summary

The Tripura state characterised by varied physiography and climate is endowed with a variety of land use types and agricultural systems. Major causes for erosion are due to surface run-off; 25% of Tripura falls under the severe to very severe erosion class classification due to the removal of vegetation cover and shifting cultivation, as well as due to steep slopes of hilly areas.

However, these different causes behind soil erosion in particular are deforestation, overgrazing, faulty practices of farming, shifting cultivation, etc. Overall, the major cause of soil erosion in Tripura is due to Jhuming, especially in the hilly area. The maximum soil loss rate of 836 tons/ha/year occurs at agricultural fields and the minimum soil loss rate is predicted to be 11 tons/ha/year in a dense forest cover area in Tripura. The occurrence of soil erosion has a close relationship with the status of land use and the type of soil along with topographical characteristics such as slope length and steepness.

Accordingly, different steps are taken by the various line Departments of Govt. of Tripura and development projects to conserve soil and water. The project for “Climate Resilient Forest Landscapes in Tripura, CREFLAT” is one of them. The project has planned activities to conserve soil apart from plantations such as Contour trenches, brushwood check dam, earthen check dam, and rejuvenation and renovation of springs, mostly under its Output 2. These activities will be proposed and executed by the VDPICs & JFMCs/SHGs in assistance from CREFLAT/TFD. To equip the community, Village Community workers as well as CREFLAT Team members with the basic technical knowledge about mechanical measures, this guideline for soil and water conservation is prepared. This guideline contains the basic know-how about the commonly used engineering and vegetative measures, and also guides the process to prepare designs, drawings, and sample estimates of various structures which are suitable for most of the sites (though their actual designs depend upon so many factors like size and shape of the catchments, type of the soil, gradient, funds available etc.). Overall, Landscape-based VDP will form the basis for locating the soil and water conservation measures on participatory basis so that their maximum impact is achieved.

The CREFLAT Project Soil & Water Conservation Activities

Soil & water conservation is one of the main activities, which are useful for the augmentation of Soil & Water and for source sustainability with the ecological rehabilitation of the degraded catchment. The following mechanical and Vegetative measures/activities would be adopted in these components.

1) Mechanical & Vegetative measures (1600 Ha): The proposed physical and biological measures for this activity are Contour Trenches (Staggered/zigzag design), Water Absorption Trenches on contour to harvest catchment water, Brushwood check dam, and Grass sowing on small soil embankment made downside the contour trenches.

2) Rejuvenation of springs (10 ha Spring Catchment): In the Northeast region, the minimum catchment of the springshed is 10-30 ha. The project plans to rejuvenate 60 springs of each 10 ha catchment. The Measures proposed for springshed treatment are Contour trenches, brushwood check dams and rejuvenation of springs, storage tank and soak pits. The wastewater can also be used for recharging or life-saving irrigation for plants/crops/vegetables,

3) Earthen Check Dams (420 Nos.): Earthen Check dams made in the project area are useful to do pisciculture, some people are also doing the same as domestic animals and wildlife use drinking water from such infrastructure.

4) Repair, Renovation, and Restoration of seasonal water bodies (450 Ha): The activities proposed under this program.

5) Forest Based incentives scheme-pilot PES (150 ha) – The project may provide support in terms of kinds and materials and cash contributions arranged by the local community or by convergence from MGNREGA, or relevant public schemes of Agriculture & Horticulture Departments, Rural Development Department, MLA & MP funds, etc., that have relevance as

soil and water conservation output. However, since the concept of PES is planned only at the end of 2023, it may be added to this guideline later. Moreover, only activities that lead demonstrably to soil and water conservation (i.e., evidence-based) may qualify for PES as and when concept is ready and applied.

6) Soil & Water Conservation Training (CREFLAT): A capacity-building program needs to be designed and done with villagers of the project area, which would create awareness, and build local skills so that also post project management is possible. Wherever relevant project staff can benefit from such trainings.

1 Rationale and Pathway to Soil and Water Conservation

1.1 Introduction

The forest ecosystems provide critical and diverse services and values to human society. As primary habitat in Tripura with approximately 65% forest cover, these host a wide range of species as forests support biodiversity maintenance and conservation. Forest growth sequesters and stores carbon from the atmosphere, contributing to regulation of the global carbon cycle and climate change mitigation. Healthy forest ecosystems produce and conserve soil and stabilize stream flows and water runoff, thus preventing land degradation and desertification, and reducing the risks of natural disasters such as droughts, floods, and landslides. Forests play a critical role in building and maintaining soil fertility. Trees take up nutrients from the soil to enable their growth, and return nutrients back to the soil as they decay. Forests also act to promote soil stability, as the complex networks of tree roots present in a healthy forest act to hold soil in place, even on steep hillsides or during heavy rainfall when soil would otherwise erode away. Given that Tripura is still a “Jhum Area” soil conservation and its stability are under immense pressure leading also to land degradation and in turn affecting agriculture production. On the other hand, the watershed services provided by forests are particularly important in the context of growing freshwater scarcity in the times of Climate change as forests degrade. Keeping in view that in the project area, forest cover has reduced by 4 km² since 2019. Since the state is geared up to several infrastructure development investments, and Jhum practice even if reduced is still ongoing, forest cover may suffer further loss. Thus, due to scarcity of water, reduced per capita cultivable land and increased rate of population, it has become essential to make optimum use of available land resources. Soil and water are the prime resources, which provide the necessary base for increased crop production and vegetation on the earth. Presently these resources are affected by mismanagement to such an extent that it will never be able to produce food grain without proper corrective measures in time.

The project falls under the Indo-German Development Cooperation Programme” Climate Change Adaptation in the Himalayas” with a focus on sustainable community forestry and soil and water conservation. The overall objectives of the KfW-funded program are that investments in a sustainable community forestry model improve natural resources, minimize climate-related risks, increase rural productivity and income for the local population. The specific aim of this project is that forest landscapes in Tripura are managed in a sustainable and participative way for improving the climate resilience of local populations and ecosystems.

The project has the following five outputs:

1) Develop and Implement a Participatory village-based landscape planning system;
2) Implement Climate resilient forestland management;
3) Apply measures for mitigating adverse climate impacts on biodiversity;
4) Support processing and marketing of Natural Resources products;
5) Support an enabling environment for the Forest sector.

CREFLAT has a clear focus on Climate resilience building of forests using soil & water conservation under Output 2. Whereas SDG 6 covers Clean Water and Sanitation aiming to ensure the availability and sustainable management of water, Soils play an important role in several land-related SDGs by their contribution to ecosystem services that, in turn, contribute to biomass production (SDG2), water quality (SDG6), climate mitigation (SDG13) and biodiversity preservation (SDG15) SDG 13 and 15. Hence, rightfully, a landscape approach adopted by project includes the restoration of a mosaic of productive land use categories of different kinds as the basis for the project investments. The area of activities covered under component 2 will make a direct contribution to the project outcome of enhancing the climate resilience of different other investments/components. Vegetation cover loss and soil degradation as a result of many generations of Jhum cultivation at a shortened cycle, and also that the unsystematic forest utilization and lack of management are clear disturbing factors. This has resulted in wider aspects of landscape degradation such as soil loss through erosion, reduced water-holding

capacity, reduced Soil fertility, loss of biodiversity and prevalence of invasive species that affect not just forest land, but all other land use categories and soils associated with these.

The reduction in the volume and velocity of runoff confers to the following benefits:

- Reduction in soil erosion;
- Trapping of silt which reduces the rate of siltation in water harvesting structures in the lower reaches of the watershed;
- Increasing the soil moisture profile locally provides growing support to vegetation;
- Creating a hydraulic head locally enhances the infiltration of surface runoff into the groundwater system, and increases the duration of flow in the drainage line. Thus, the capacity of the water harvesting structures created downstream on the drainage line is utilized more fully as they get many more refills;
- Enhanced agricultural productivity can rise by 20 - 30%; and
- Reduced threats of local landslides

1.2 Purpose

The Purpose of this Guideline is to provide guidance & technical support to the various mechanical (Engineering/Physical) & Vegetative (Bio-Engineering) measures of soil and water conservation, maintain uniformity in the designs of various structures, and make the process & strategy of preparation as well as technical scrutiny of estimates easier and faster. Soil & Water Conservation activity improves soil moisture and its fertility, thus is expected to contribute project biomass, plant biodiversity, and income of the people as well as reduce the drudgery on women. CO_2 absorption enhancement due to improved flora and fauna, which ultimately can mitigate climate change.

1.3 The Target Group

This technical Guideline is primarily meant for different stakeholders like GP/VC/VDPIC/SHGs and JFMC members, project field staff of all levels, and the community involved in the execution of soil and water conservation work under CREFLAT.

1.4 The Project

The CREFLAT Project has been promoted by the Government of Tripura and funded by the IGDC Phase II. The primary approach in this Project is to implement its objectives through VDPICs and JFMCs under the overall monitoring of the Tripura Forest Department represented by CREFLAT Project. The project is originally expected to cover eleven development blocks in Dhalai (8) and North Tripura (3) districts respectively. Out of the envisaged 129 villages later based on landscape-based village selection criteria updated number of villages to be covered under IGDC-II, 107 in Dhalai and 22 Villages for North Tripura.

District	Dhalai (107 Vilages)	North Tripura (22 Villages)
Blocks	Ambassa	Damcherra
	Ganganagar	Dasada
	Salema	Jampui Hill
	Durga Chawmuni	
	Manu	
	Chawmanu	
	Dumburnagar	
	Raishyabari	

Dhalai and North Tripura districts are characterized by their undulating topography with a series of parallel hills and ridges running roughly northwest to southeast and reaching a maximum elevation of

914 m in the Jampui hills of north Tripura. The hills are mostly forested and the valley between these long ridges is the main cultivated area. These plains extend towards the north-western parts of both districts where they form the edge of the river flood plains that stretch across the border of Bangladesh.

Tripura has extremely erosive soil with intensive rainfall. Soil erosion is deemed as one of the most contributing factors to forest degradation and heavy sediment loads in streams and rivers. Therefore, intensive counter-measures of soil and water conservation are required in addition to vegetative measures and economic development activities.

The climate of the target area is hot, humid, and subtropical with high rainfall during the southwest monsoon season (From July to October) although rainfall occurs all year round (November and December are the driest months). Rainfall for the state average 2756 mm annually with the wettest month being July. Temperature ranges from 24-32 ℃ during the summer (July) and 13-25 ℃ in winter (January). Hailstones occasionally occur from April-May. Moreover, the vulnerability to climate change in all the 11 blocks of the project area varies largely between very vulnerable to moderately vulnerable (Department of Science and Technology, Tripura).

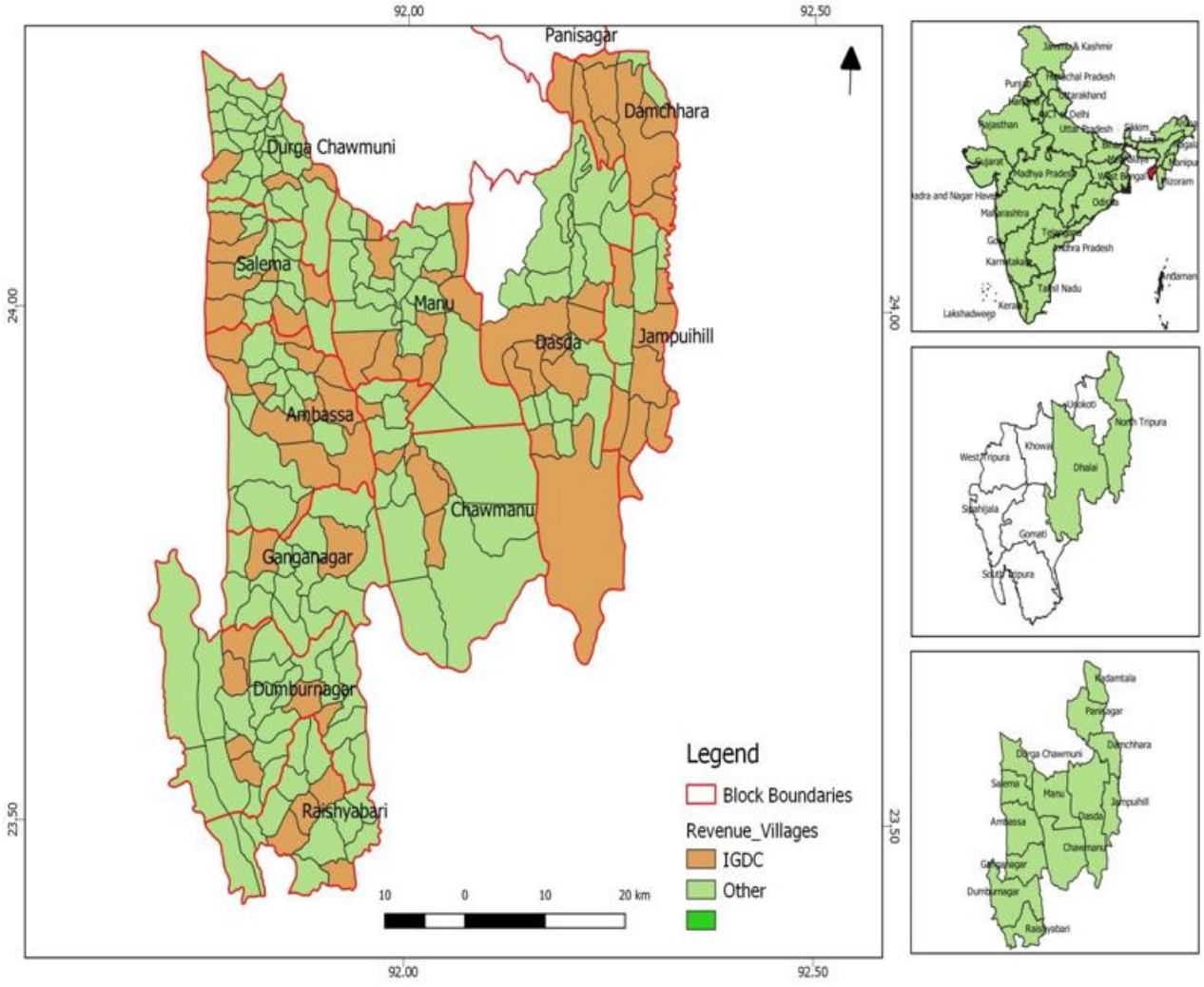


Figure 1. The project area.

1.5 Process for preparing this SWC Guideline

- Task assigned in TOR and its Review with CREFLAT
- Study secondary data- Website of Tripura, Guideline JICA, DPR of CREFLAT, (Please see in reference)

- Meeting with CEO/PD, APO, PO and TO and collected their view regarding SWC Guideline.
- Visited PMC JICA and study the JICA guideline. I also have my own experience in Tripura on SWC aspects.
- Field visit, discussion and understand existing and possible proposed SWC mechanical and vegetative measures of project area of Dhalai & North (Discussed with community and DPMA Team).
- Discussed and also collected the view of CEO & PD again on proposed SWC measures.
- Prepare Draft report and share with PMC for their review and feedback.
- Incorporated all feedback and submitted and revised report to PMC.

2 Participatory Micro Planning

2.1 Need for Soil and Water Conservation (SWC) for Forest Development

Soil and water conservation measures are essential for forest development particularly in degraded land where the availability of moisture in the soil is very low and the topsoil is eroded or prone to erosion. Tree growth responds more to water stress than any other perennial factors of the forest site. Thus, soil quality and water availability are the key to forest site productivity for many species. Soil-water stress plays an equally important role in the radial growth of trees. It affects the annual biomass growth, and thus forest productivity -apart from productivity of farm lands- and various wood properties, particularly, wood specific gravity. Forest floor, if denuded and subjected to heavy erosion, loses the top layers of the soil. The topmost layer, unique to forest soils, contains organic matter, partly or well decomposed, and the next horizon in the soil profile is mineral of soil mixed with organic matter. These layers supply nutrients to plants and contribute to forest growth. Thus, once these layers are removed due to erosion, the forest plants suffer from lack of micro/macro nutrients and become dependent on the supply of fertilizers for survival and growth. Heavy erosion of the forest soil also destroys its physical properties like soil texture, structure, porosity etc. The physical properties of the solid, liquid, and gaseous phases of soil have a substantial influence on the supply of water, nutrients and oxygen for metabolism, and the availability of physical space to anchor the underground plant structures. Thus, arrest of the soil erosion in forest floors is essential for the survival and growth of forest trees apart from positive influence to several forest ecosystem services at a landscape scale.

2.2 SWC measures in the IGDC CREFLAT using landscape

Because of land degradation, a major set of climate-related issues for forest and natural resource-dependent households in Tripura such as water resources is only exacerbated. Hence, Output 2 of the project consists of a range of physical and vegetative soil and water conservation techniques that will enhance infiltration, reduce surface runoff, reduce soil erosion, store water in situ (on watersheds), and improve the general capacity of the landscape to capture and store water resulting from excessive rainfall and make it release slowly to provide water resources that can be used for crops and consumption during periods of water scarcity (dry season). Applying soil and water conservation techniques will enhance the climate resilience of different land categories in the project area and will result in greater and denser vegetative cover that can provide critical environmental services for project target households (especially water). Careful site selection during village-based planning will ensure any critical upstream/downstream linkages and will reinforce the concept of ‘holistic’ development of identified critical areas. On the other hand, a landscape perspective using GIS data can diagnose where in an upstream and downstream context there are areas/zones that need treatment, which can then be discussed with local communities and for raising their awareness on the impacts of soil erosion and the resultant need for treatment.

Mechanical & Vegetative measures: Details of the techniques to be applied will be developed during the project and depending on the site-specific conditions of identified ‘areas. Emphasis will be on non-mechanized interventions as these provide a greater benefit in terms of paid employment and sensitivity to environmental concerns. Employment generated in this way will be equitably distributed with a focus on socially disadvantaged groups or households including women-headed households and SCs.

Proposed interventions that will be used especially on degraded forest land and Patta land or otherwise degraded land (but not be limited to):

Contour trenches (Staggered)	Gully plugging	Field bunds
Earthen ponds and percolation pits	Vegetative structures/BWCD	Land levelling
Retention walls	Diversion drains etc.	Katta crate Structures

These treatments will often be applied along with other interventions especially tree planting (various types) and earthen check dams to capture and store water.

The second set of land treatments under output 2 will include treatments designed to **rejuvenate springs through rainwater harvesting and water infiltration structures** using geo-hydrological techniques and GIS to locate correctly the treatments depending on the underlying topography and geology. This will be an important means for enhancing the environmental services (essentially for water) from local landscapes.

As **check dam construction** was a successful activity that was promoted during IGDC I, in the same line it will be continued in the IGDC CREFLAT project to identify suitable locations for small earthen check dams within the locally selected landscapes to enhance infiltration and water storage – thus providing/supplying for irrigation, human and livestock use, and for fish rearing. Structures will tend to be small (benefiting a few smaller farmers) and will be combined with land treatments to ensure that upstream soil erosion (and hence siltation of check dams) will be reduced. Wherever possible use of earth-moving machinery will be avoided to ensure less soil disturbance.

A further set of soil and water conservation interventions is for the **repair, renovation, and restoration of seasonal water bodies** e.g., clearing biomass/vegetation to prevent blockage; bank stabilization using gabion-based techniques; levelling; manual digging/silt removal, etc. These techniques aim to reduce flood damage during periods of excessive rainfall and associated erosion and scouring.

The project will support pilot **forest-based incentive schemes (Payment for Ecosystem Services, PES)** in a few selected locations. This will assist in working out methods by which upstream/downstream communities and water users can be linked through cash or kind incentives in a way that will be sustainable after the end of the project. More clarity is expected on PES once its concept is ready by the end of 2023. Hence, it will not be discussed in detail in this guideline.

Finally, **spring rejuvenation** has been identified as a prime activity. Springs are the primary water source for millions of people in the mid-hills of the Hindu Kush Himalayas (HKH), which includes Tripura and at places supply over 90% of water needs for domestic uses. Over the past decade or so, there has been increasing concern that springs are drying up or becoming seasonal, and their discharge is reducing over the years, even though quantitative evidence is still relatively sparse. For strengthening the basis for climate resilience building the sustainability of Himalayan springs and the larger Himalayan groundwater systems is of immense importance as otherwise the water security of the hill populations is unsure. In the past decade or so, spring revival efforts using the principles of hydrogeology has become the most widely accepted model of springshed management (SM) by several non-governmental organisations (NGOs) and governmental agencies in the Himalaya and models are available on improved springshed restoration. Since the project is adopting a Landscape Approach, the scope of spring rejuvenation as part of landscape restoration while planning at VDPIC level promises early impacts of the project.

2.3 Participatory processes as basis for Micro Planning

The Climate Resilience of Forest Ecosystems, Biodiversity and Adaptive Capacities of Forest Dependent Communities (CREFLAT) is a joint project of Government of Tripura and KfW under Indo-German Development Cooperation Programme. The main objective of the project is to develop sustainable community forestry models to improve natural resources, minimize climate-related risks, increase rural productivity, and income for the local population. Participatory landscape level village development planning is a pre-requisite for the project implementation. As such, active participation of

all the stakeholders, particularly the beneficiary community, from the beginning of the project i.e., planning stage, would ensure successful implementation subsequently. Since the project intends to strengthen the climate resiliency of forest ecosystems, and biodiversity, and enhance adaptive capacities of the forest-dependent communities, landscape approach in planning process has been envisaged. The landscape level planning would ensure identification of appropriate interventions at appropriate locations irrespective of village political/revenue boundaries. For instance, to ensure flow of clean and adequate water in a stream (an ecosystem service) in the face of climate change, it is required to protect the vegetation of the areas of stream origin and the catchment areas. It is also essential to keep these areas free from any human disturbance. This would need collaboration and participatory actions of all the villages along the flow of the stream or river irrespective of their geographical location in the watershed i.e., encompassing the villages at stream origin, upstream and downstream regions. Thus, the need of landscape level village development planning. Such necessities are equally applicable to ensure the flow of other ecosystem services as well as planning for the development of cluster-based resource production systems and their value addition. The whole value chain development for such resources would be more effective if the clusters are identified by taking a landscape approach.

Hence, project will use its Village development planning guidelines by triggering a PRA, and identify problems of soil erosion and water insecurity, so that detailed planning to address these issues rests on community participation. This can be part of issue-based PRAs (IFPRAs) that can be conducted on soil and water. In IFPRAs there is a need to do resource/ and land use planning by making existing maps and proposed maps with Community Participation, which is very much integrated in VDP process. For proposed sites and structures from maps there is a need to collect some of the details of existing data for individual structures like existing situation, benefits in terms of irrigation, fisheries, drinking water for domestic use and livestock drinking, etc. and their impact on people's lives of proposed sites. Table 1 gives a tentative set of information to be prepared at landscape/village level participatory planning.

Table 1. Tentative set of information to be prepared at landscape/village level participatory planning.

#	**Tentatively Proposed structures & Treatment by Resource Map and Land use map**	**Location, GPS (Local Name of Place, village and GP/VC**	**Existing Situation and Proposed Development options**	**Proposed Structures and Treatment/ Beneficiary/ Area and existing data** (production etc.)

2.4 VDP process as means to Soil & Water Conservation

All green investment related planning processes need to be conducted with the community on an inclusive basis. Local community needs to be empowered in the planning process to share their all problems and their suggestive solutions for the problems arising. If we have some better solution, then it needs to be discussed with people and build their understanding and consensus to incorporate in the proposed development option. Development options are identified with the community and they realize that this is their work and therefore are more adaptable and sustainable. The flow diagram below should be seen as part of PRA that will be used prepare VDP complemented with the application of environmental and social safeguards (see VDP Guidelines of CREFLAT). Planning for SWC activities would be part of the VDP preparation processes. It may be noted that (a) planning for SWCs in forest land in the form of construction of earthen check dams, spring rejuvenation, and SWC activities in the site-specific (particularly plots with more than 30 degree slopes) plantation sites such as staggered contour trenches/ bunding, half-moon terrace and/or gully-plugging, etc. would be prepared by the JFMCs; and (b) planning for common village spring rejuvenation and rehabilitation/renovation of common village water bodies would be done by VDPIC. However, coordination between VDPIC and JFMC has to be ensured.

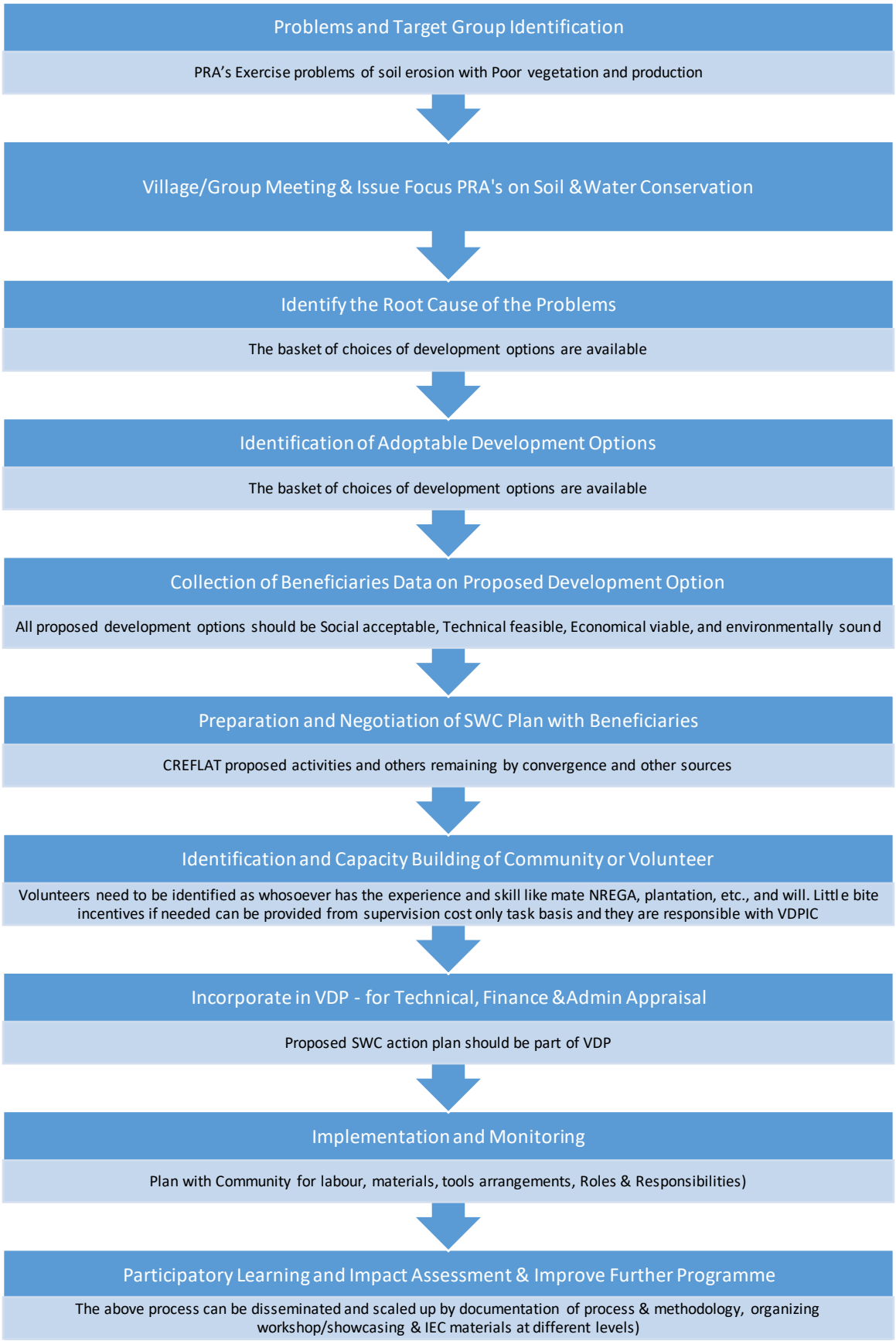
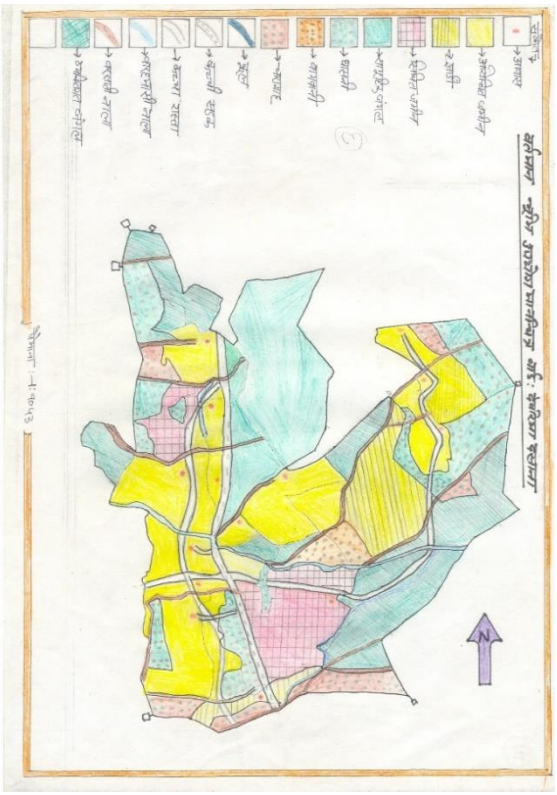
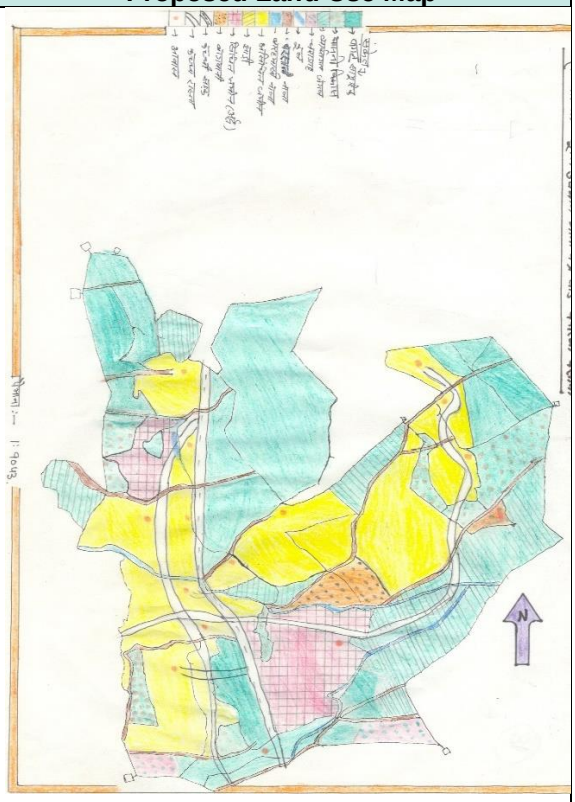


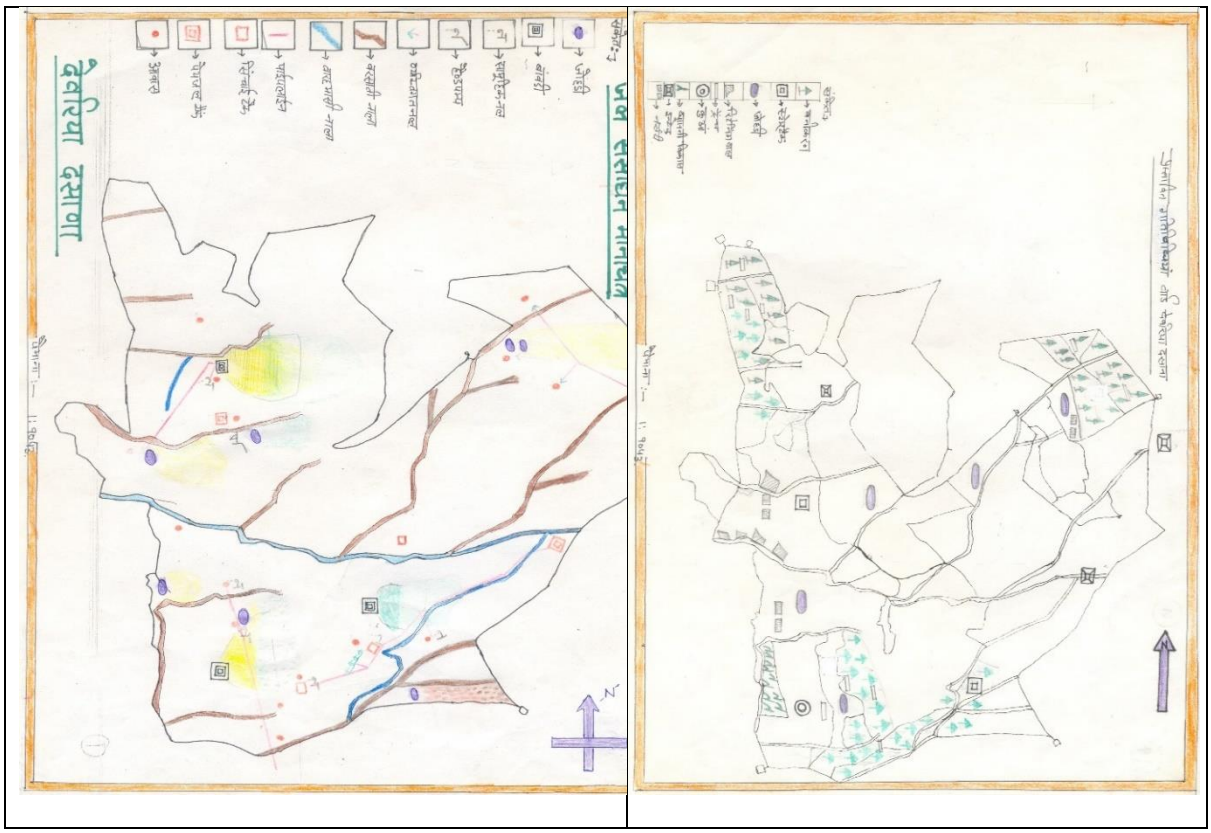
Figure 2. Steps of the VDP process.

2.5 Analysis of Demand and Supply

While elaborating on the local PRA process contributing to assessments such as current land use and resources being used, project will use the overall environmental situation of the landscape within which the said village is located amongst cluster of villages. These assessments will undergo joint analysis with local stakeholders along with village communities and forest department so that activities are identified as per the current planned activities and match these with people's as well as landscape's demand. Given below are the illustrations of existing land use and resource map with proposed land and resource use.

Table 2. Existing vs Proposed Resource Maps to be discussed during PRA.

Existing Land Use Map	Proposed Land Use Map
	
Existing Resource Map	**Proposed Resource Map**



2.6 Do's for Soil and water related conservation Micro-planning

- Based on existing and proposed land use we can decide the types of physical, vegetative and social measures that are possible to convert existing to proposed land use of a particular area.
- Based on the existing and proposed resources map we can decide on the need for structures or their renovation or new construction.
- After IFPRAs and map preparation there is a need for a transect walk to see the existing site and situation of structures.
- Root causes of the problems need to be identified and possible suitable and adaptable development options suggested which often can be inter-village.
- Net planning (Total planning of a particular unit in a designed format in VDP) of each field of RoFR with a technical survey needs to be done. A proper sketch of the field area map in format and details need to be filled in format. All existing details/data of every existing & proposed structure (Baseline of particular Unit)
- After securing the baseline on water table locally we need to monitor pre- and post-monsoon readings for 3 to 5 years. Project may use the current baseline survey data, which is under progress.
- There is a need to do a biomass survey, soil moisture and water table (If available) downstream and nearby areas where storage water is impacted and soil moisture is enhanced.
- Every structure should be technically feasible, economically viable, environmentally sound, and, socially acceptable. It should also fit ESMF format criteria.
- There is a need to collect all existing baseline data in a format for every structure during the baseline survey or during VDP process.
- During the process, we can also observe the people who have different skills and knowledge to be selected for capacity building, and make these responsible as a bridge between community and external support. These need to be selected by the community under project's facilitation.

3 Proposed Soil & Water Conservation Measures

3.1 Proposed Measures

Under Output 2: Climate resilient forest land management soil & water conservation is one of the main activities aiming at the augmentation of soil and water and source sustainability with the ecological rehabilitation of the degraded catchment. The following mechanical and Vegetative measures/activities would be adopted in these outputs.

1) Mechanical & Vegetative measures (1600 Ha) (S.No. 2.1.1)
2) Rejuvenation of Springs (60 ha Springs Catchment) (S.No. 2.1.2)
3) Earthen Check Dams (420 Nos.) (S.No. 2.1.3)
4) Repair, Renovation, and Restoration of seasonal water bodies (450 ha) (S.No. 2.1.4)
5) Forest-Based incentives scheme-pilot PES (150 ha) (S.No. 2.1.5)
6) Soil & Water Conservation Technical Training (24) (S.No. 2.6.1)

All SWC Activities will be planned and executed by VDPICs (in private, patta & community land) & JFMCs (in forest land in cooperation with VDPICs) which traditionally and primarily are interested in Earthen Check Dams, Spring Rejuvenation, and Repair/Renovation/ Restructuring of seasonal water bodies.

3.1.1 Mechanical & Vegetative measures (1600 ha) (S. No. 2.1.1)

Emphasis will be on non-mechanised interventions as these provide a greater benefit in terms of paid employment and sensitivity to environmental concerns. Employment generated in this way will be equitably distributed with a focus on socially disadvantaged groups or households including women-headed households and SCs. Proposed interventions that will be used especially on Patta or otherwise degraded land will include contour trenches with grass planted on soil embankment and brushwood check dams. These treatments will often be applied along with other interventions especially tree planting (various types) and earthen check dams to capture and store water.

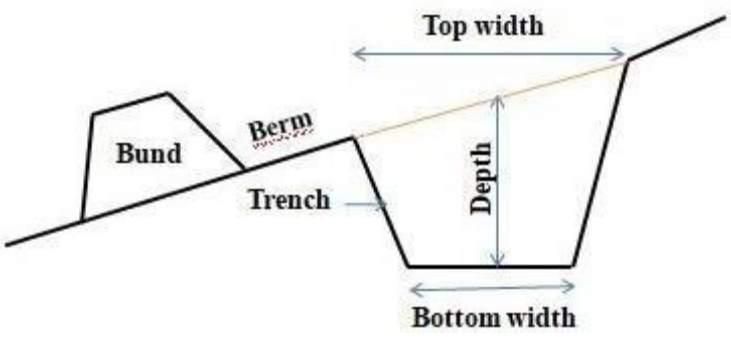
3.1.1.1 Staggered Contour Trench (SCT)

Contour trench is an excavated trench constructed along the contour across the slope of the land in the upper and middle reaches of the watershed. It is constructed both on hill slopes as well as on degraded and sloping wastelands for soil and water conservation and establishing vegetative cover. It breaks the slope lengths, reduces the velocity of flowing water and retards its scouring action. The rainwater retained in the trenches helps in situ conservation of moisture, which travels down and benefits the better types of land in the lower reaches of the watershed. These trenches are constructed in a trapezoidal shape and in a staggered manner. The trenches are excavated of shorter lengths in a row along the contour with interspaces between them,

Figure 3. Staggered Contour Trench.

Local Name: Khanty, Nali, Trench

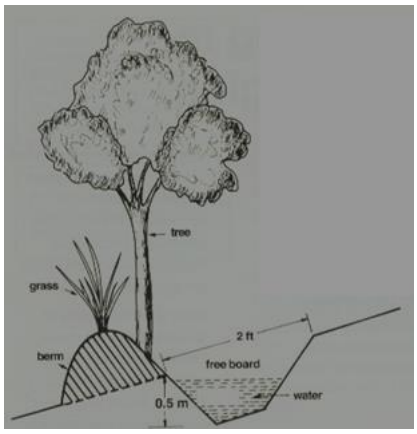
- Trenches dug on contour lines are called contour trenches. Contour trenches may be continuous or interrupted. The interrupted trenches may again be constructed in series, zigzag or a staggered manner. The contour line can be laid out in the field by A frame as given in the figure.



- The staggered contour trench technique is useful in slowing surface water run-off and soil erosion from sloping land, and re-vegetating degraded land. This is especially useful in areas with high rainfall, steep slopes, and thin soils, which should use slightly graded bunds/terraces/trenches to allow some drainage.

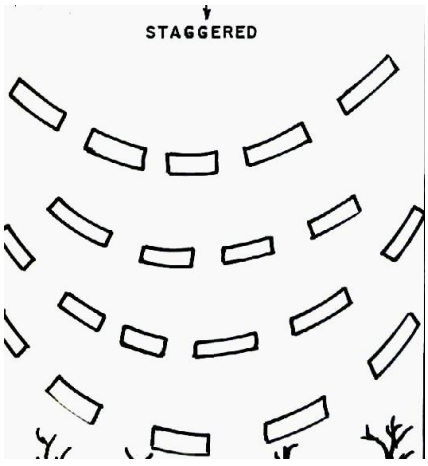
Purpose

- Slow down the velocity of runoff to less than the critical velocity of runoff and storing the whole or part of runoff in trenches.
- Decrease the runoff, increase the infiltration, and improve the local soil moisture profile.
- Check soil erosion and check siltation, which affects the capacities of water bodies by deposition.
- Groundwater recharge for the low-lying areas
- Trenches mostly need to be made for the regeneration of plants and pasture, afforestation, Silvi-pasture, and Pasture development.



Location: Ridge area of Watershed

- Staggered Contour trenches are the most appropriate where the slope of the ridge area lies between 10-50%.
- It is an ideal treatment for non-arable land.
- Catchment of Earthen Check Dam, if possible, on priorities.



Staggered Contour Trenches are dug on sites:

- Rainfall is high (more than 1200 mm annually)
- Slopes are higher (10-60%). They can, however, be dug up to a slope of about 60% only where the slope is stable.
- SCTs should not be dug where the slopes are higher as they could trigger landslides.
- The effort here is not to capture 100% surface runoff and allow some portion of the run to escape. Because of more rainfall, it is not possible to capture 100% run off and it might not be safe either.
- SCTs are preferred in the whole of North Eastern States except for some plain areas of Nagaland, Arunachal Pradesh and Assam. In both the above cases, small spillways are made for the safe disposal of surface run-off.

Design & dimension of contour trenches

Staggered /Zigzag Contour trenches only need to be made in areas wherever there is existing rootstock or plants or stony not possible to make continuous trenches and in high rainfall areas. The size of contour trenches in Lengths 1-5 m and x-section varies from 0.15- 0.25 m². Trenches are located directly with one another in alternate rows in a staggered fashion. Trenches need to be made after staking the plants at 3m x 3m and then the trenches layout needs to be done.

The distance between two successive rows of trenches: Spacing of Pits 3m x 3m. Therefore, trenches should be made on the upper side of each pit so that it can provide moisture to the root of the plant.

1100 Trenches Per ha (3m x 3m Spacing) but decision based on the site assessment.

Each Plant has been recharged by one CT of 1.5 m in Length.

Length of trench= 1.5 m

Width Top = 0.6 m

Bottom Width= 0.4 m

Av. Depth of Trench = 0.5 m

X-section area = 0.2 m^2

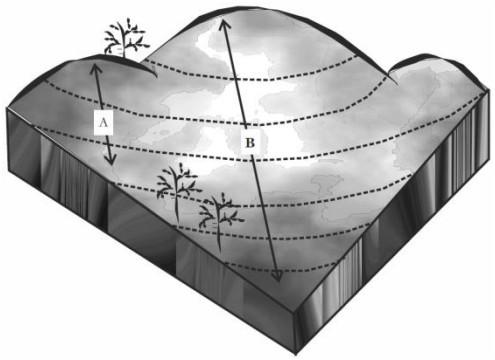
Volume per Trench (1.5 m) = 0.3 m^3/RM

Table 3. Design for Staggered Contour Trench.

Items	Formula	Calculation	Quantum
Quantum of Runoff and total water received by staggered trenches Q (m^3) - Catchment area=10 ha & Max. Daily Rainfall=200 mm & Runoff coefficient of area: 0.4 (for grazing land having slope between 10-30% C=Ratio of the retain capacity of trenches to daily runoff: 75%)	Q=10*Storage (%) * V * R(mm) * A (ha)	10 * 0.75*0.4*200*10	6000 m^3
X-Sectional Area & Volume of Contour Trenches V m^3 (area m^2) -The length of one trench is 1.5 m and the distance between two trenches in a row is 1.5 m. Assume that the trench gets 2 refills in a day. And make a plan for staggered contour trenching in silty sandy soil	Length (m) * Av. Width (m) * Depth (m) (Filled Twice in a day)	1.5*0.5*0.4	0.3 m^3 (0.2 m^2)
No. of Contour Trenches Required for 10 ha	Q/HD*VD	100,000/ (3*3)	11000 No.
Assume two fillings so water is available for filling per day	Max. water storage in a trench	6000/2	3000 m^3
Volume of Trenches Works in 10 ha including freeboard		11000*0.3	3300 m^3 (Sufficient to Harvest 3000 m^3 water) (330 m^3/ha)
Task Rate INR/ha based on SOR of Tripura State	Assume for Trench Excavation in soil @ 214.8 per m^3 has been taken from SOR PWD(volume-I) 2023 item 3.1(ii) (Rate analysis)	214.8*330	**INR 70884/- per ha**
Note: Contour Trenches need to be made above each pit so that there are around 1100 pits/ha therefore Staggered contour Trenches would be also 1100 of size Length=1.5 m, Top Width 0.6 m, Bottom Width = 0.4 m & Av. Depth = 0.4 m			

Note: Estimated costs are as per task rate and updated daily wage costs are incorporated in it

Implementation



- The layout of trenches needs to be done for the entire proposed area. Make sure that the water left out of one line of trenches is stopped by the line of trenches below
- Determine the length of the slope and mark the line of slope on the ground. Measure the length of each contour line and mention it in the format and drawing.
- Measure the slope in one section of the ridge area. Ensure that it is between 10 - 60%.
- Draw a straight line with wet lime between the highest and the lowest points along the slope.
- Decide the interval between successive lines of trenches.
- On the straight line, marks points at the decided interval.
- Starting from each mark, demarcate the contour line by A-frame, U-tube, Line level etc.
- During layout proper demarcation of contour and trenches need to be done by Ash or Chuna/Lime or any other suitable materials. Trench and berm layouts also need to be done before excavation.
- Dig trenches along these contour lines.
- Soil needs to be cut in proper slope and berms need to be made after 20 cm from the downside bank. Before starting the work, proper layout excavation needs to be clear to a farmer or whosoever is doing the construction.
- Construction of trenches should be started from the ridge and progressively extended towards the valley. No trenches are constructed in the downstream areas, unless the areas above are covered with trenches.
- Boulders and gravel from excavation should be stalked on the lower side of the trench to serve as a toe of the embankment.
- Trenching should preferably be carried out in winter and spring so that the site is ready for sowing and planting during the first monsoon season.
- Proper fencing is needed to protect from animal and human disturbances.

3.1.1.2 Water Absorption Trench (WAT)

WAT are constructed to harvest water wherever not possible to treat the upper catchment. Water harvesting is re-invigorated and provides benefits for low-lying areas. It is made at the top of the hill where after the flat-top and slope started it needs to be made on contour. In order to minimize man-animal conflicts and to put an end to encroachment on forest land, the Forest Department has dug water absorption trenches.

The experiment of the water absorption trenches is yielding results in multiple ways — recharge of groundwater and conservation of wildlife (Minimum Width not crossed by wildlife). The trenches have been

Figure 4. Water Absorption Trench.

planned along the forest and borders revenue and private land.

For WAT Construction all processes will be the same as contour trench construction. Top width 1.2 m, Bottom width 0.8 m and Av. depth 1 m, 1 m² x-section, and 1 m³/RM volume and need to be made on contour in a continuous manner.

3.1.1.3 Future Management and Quality Control

- Each year before rain, siltation deposited in the trench and needs to be excavated and excavated soil need to be put on the embankment or near the plant root.
- If there is some breakage that needs to be repaired properly.
- Do not excavate trenches where there is already dense vegetation.
- Do not excavate if the roots of a tree are encountered.
- Do not excavate trenches across large streams or drainage lines.
- It is also true that if trenches were not to follow a contour, such digging could increase the possibility of soil erosion because there would be a rise in the velocity of runoff following an increase in the slope of the land.
- Hook needs to be provided at the end of the trench on both sides or may open in proper diversion drain.

3.1.1.4 Operation and Maintenance of Contour Trench

The Contour trenches, Siltation in earthen work, works are the earthen. Therefore, periodical O&M works of the structures are required to keep those functions. After construction of the works, O&M of the structures shall be done by VDPIC/JFMC by local volunteers (Shramdaan). Material costs can come from Revolving funds or use of the revolving fund of VDPIC/JFMC/SHGs under the technical assistance of the Range Office.

3.1.1.5 Wooden Check Dam or Gully Plug

These structures are used in gullies to facilitate the establishment of vegetation or to provide protection at points that cannot be adequately protected in any other way. The erosive velocities of runoff are reduced by flattening out the steep uniform gradient of the gully by constructing a series of checks (commonly known as check dam) from top to bottom which transforms the longitudinal gradient into a series of steps with low risers and long flat treads.

The material to be used for check dams will depend upon whatever is available locally and no check damming should be attempted unless suitable stone, brick, timber, or brushwood is available near the spot.

Depending upon the material used these gully control structures are of the following types: Brush Wood Check Dams or Log Dams

3.1.1.5.1 Potential Environmental Impacts of wooden check dams

While the objective of this project is to improve climate change resilience and biodiversity, check dams will have positive impacts on the biophysical environment. One of the key measures to increase water conservation in forest areas is likely to be the provision of check dams or contour trenches. It must be ensured that the construction of check dams and contour trenches does not interfere with the water uses by local people downstream. Native endemic plants should not be removed as far as possible and should be preserved whenever possible. If adequate buffer strips of undisturbed vegetation along

streams should be implemented to slow its flow, allow suspended sediments to settle out, and ultimately reduce the siltation of streams.

3.1.1.5.2 Brush Wood Check-dam (BWCD)

Meaning: Brushwood check dam for gully plugging is the combination of the timbered trees as a fence and functions as gully plugging when assembled like a box and situated in the gully. Soil and/or Stones and/or fallen tree leaves is/are put into the box as to arrest the sediment from flowing downstream in the gully valley. The local bamboo trees can be used for lattice bars of the brushwood fences. How stiff the trees will be combined is the important point of whether the brushwood is durable and sustainable in the long run. The connecting wire or rope is advised to be bonded on the junction of the frame.

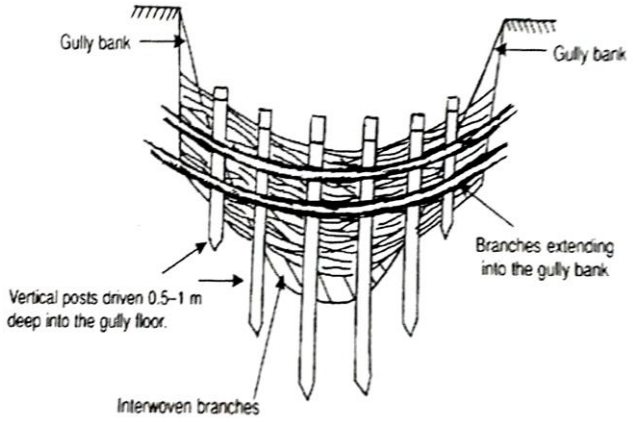
Brushwood check-dams shall be installed in the deteriorated valleys in the target area. Locations of the brushwood check-dams shall be determined in the sites by the Range Officer in consultation with the members of VDPIC/JFMC.

Objective: The main objective of brushwood check-dams is to hold fine materials /soil carried by flowing water in the gully.

Types: Brushwood check dams are classified as:

1) One row or single post brushwood dam (However, due to heavy rains such brushwood dams may have no relevance and thus costs are not calculated but suggested based on 2) below)
2) Double row post brushwood dams.

Brushwood check dams are constructed with the help of locally available wooden poles and brushwood. Wooden poles are driven into the ground in a single or double row across the nalla and brushwood is packed on the upstream face of the check dam.

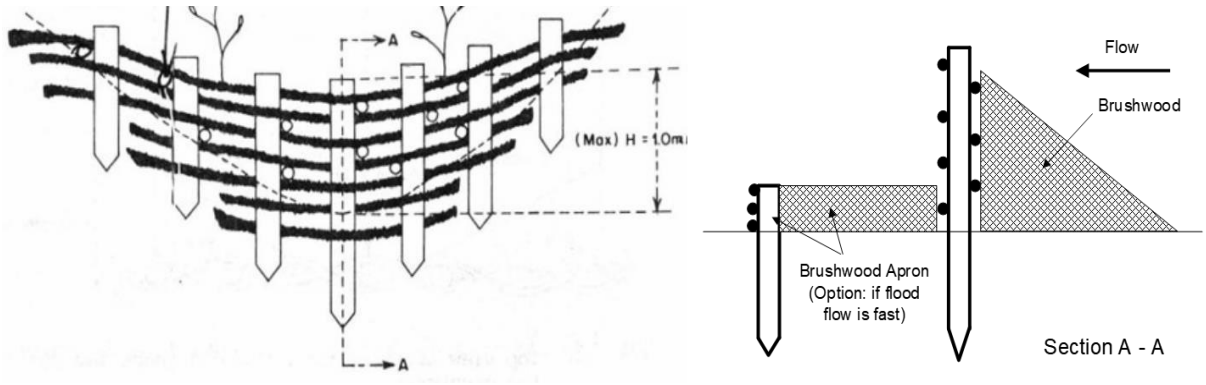


Suitability: These types of check dams are provided in Lunga (small and medium gullies) where wooden poles are locally available and the side slope of the gully is less than 100%. Depending upon the size of the gully and area of catchments, poles of about 8-10 cm diameter are driven into the ground in a single row or a double row across the nalla at a right angle to flow and accordingly these are called a single row or double row brushwood check dams. Single-row brushwood check dams are used in small gully heads not deeper than 1.00 m. In the case of medium gullies (up to about 2 m deep and 6.00 m wide), double-row brushwood dams are most suitable. The posts used should preferably be of species *Lannea coromandelica*, *Dalbergia Sisso* and *Ficus* species, which will strike roots.

3.1.1.5.3 Design Specifications

Single row brushwood check dam:

In case of a single row brushwood check dams wooden poles are driven 90 cm deep into the ground and the centre-to-centre spacing between two consecutive poles should be 60 cm. The height of the poles in the middle of the nalla bed should be 30 to 60 cm less than those of the poles on the banks This is to form a deep concave curve at the top to dispose of excess water. The brushwood is packed against the upstream side by the face of the poles. On the downstream side, brushwood matting is laid out which acts as an apron for the dam and protects the downstream from erosion. The wooden stakes may be treated with coal tar creosote oil to protect them from attack by white ants. For a brushwood check dam, an average height of about 0.5-1.0 m is usually considered ideal.



Construction procedure of Single Row Brushwood Check-dams:

These check dams can be used where the rate of runoff is less than 0.5 m^3/sec. The structure is temporary and its durability will depend on the quality of the posts used. If possible live posts of poplar and other trees should be used (8-10 cm diameter). Flexible branches are cut and woven around the posts. This dam is constructed across the channel or gully with brushwood materials, laid along the flow of water, keeping the butt ends towards the face of the gully. The brushwood is kept in position by tying it to the posts. Before the dam construction is begun, the sides of the gully or channel should be sloped to 1:1 and the gully bed should be excavated for 15 cm depth along the entire gully width over which brushwood has to be laid. In addition, a 15 cm excavation is also done into the bank to give the necessary notch capacity.

After excavation, the wooden posts of about 10 cm in diameter are driven in a line across the gully at an interval of 90 cm up to a depth of 75 cm in the gully bed. The top of bamboo/wooden posts should be kept at such a height to form a mark of the required size. The brushwood is tied from the front line and the other lines are tied using stimulated wire for keeping them in position. The lowest layer of the brushwood must be the longest. Detailed costs are not suggested, as single brush wood check dams are often not robust enough and not implemented either. Estimated costs could be 50% of the double-Row Brush Wood Check Dam.

Double-Row Brush Wood Check Dam:

Double row brushwood check-dams are suited where the rate of runoff is less than 1 m^3/sec. The construction of the dam starts with an excavation in the floor and into the sides of the gully to a depth of 0.5 m. Two rows of posts, 8-10 cm in diameter and 1-2 m in length are placed into the holes, across the floor of the gully to a depth of 0.5 m. The spacing between the posts is 0.5 m. Brushwood or branches are packed between the posts. The height of the posts in the centre should not exceed the height of the spillway otherwise the flow will be blocked and water may be forced to move to the gully sides. Temporary check-dams, which have a life span of three to eight years, collect and hold soil and moisture in the bottom of the gully to allow vegetation to establish. Runoff control structures may need to be commissioned in the gully (See Pictures on the right and below).

DOUBLE ROW BRUSHWOOD CHECK DAM
Figure II

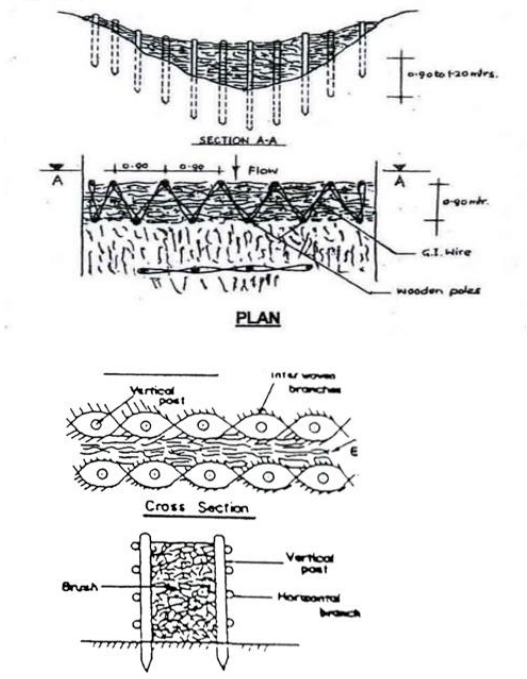


Table 4. Cost of Double Row Brushwood Check Dam (one unit). Size BWCD: Length = 14 m, Width = 1-1.5m, Height = 0.7-1 m

#	Items	Qty	Unit	Unit Rate (INR)	Amount (INR)
1	Cleaning, Grubbing, uprooting wild vegetation, grass, bushes, sapling tree of girth up to 30 cm removable stumps of such trees cut earlier and disposal of non-usable materials and staking of usable materials at the auction up to a lead 1000 mm/c 12m x 4.5 m = 54 m^2 = 0.0054 m^3	54	m^2	5.1	275.4
2	Supplying Bamboo/logs (first class) 85-100mm diameter and making shoes with and tapered up to 300 mm from the bottom of the bamboo as per drawing and specification. 2 x 14 x 4 = 112 M 2 x 10 x3.9 = 78M	190	m	35.4	6726
3	Handling & driving Bamboo (first Class) 85 to 100 mm Dia. Up to the length required by heavy humans as per drawing & specification (2x14x2 = 56 m)	56	m	28.65	1604.4
4	Providing, fitting and fixing Bamboo (first class) 85-100mm diameter for horizontal diagonal bracing strut etc., with nail/spikes and binding wire (at 2mm) 2 x 10 x 3.9 = 78 m	78	m	44.1	3439.8
5	Providing & Filling, fixing, brushes of (Tetul, Mandar, Shoora etc.) tight with 2mm GI wire 3.8 x 1.6 x 2.7= 16.416	16.416	m^3	274.5	5055.2

	Double Row Brush Wood Check Dam			**Total**	16010.58 = **16000**

Construction procedure of Double Row Brushwood Check-Dam:

Brushwood check-dams made up of posts and brushes are placed across the gully, like bamboo, piece of wood, herbs, shrubs, dry leaves, dry wood, etc.

3.1.1.5.4 Specifications for Brushwood Check-dams

- The choice of post for the brushwood check-dam must be made after careful examination of material available in the near vicinity. Otherwise, the problem of cutting all the sparse vegetation in the area would bring undesirable results.
- If the soil in the gully is deep enough, brushwood check dams can be used in all regions. The gradient of the gully channel may vary from 5-12%, but the length of the gully channel, beginning from the gully head, should not be more than 100 meters. The gully catchment area should be one ha or less.
- Brush wood check-dams particularly single-rowed ones can be strengthened with bamboo materials or sand-filled bags on the upstream part to serve as a shock absorber and to dissipate the runoff energy during pick flows.
- Any tree or shrub species can be used as posts. However, the wooden posts should be rot-resistant and termite proof. The brushwood must not be very dry and easily breakable.
- To avoid the brushwood being removed by flowing water, it is necessary to fix the brushwood with rope, wires, and nails.
- The ends of interlinked materials should enter at least 30 cm into the sides of the gully.
- The space behind the brushwood check-dams must be filled with soil to the spillway, if either sand bag or bamboo mat is not used.
- If sprouting species are selected as posts and interlink materials, brushwood check-dams should be constructed when the soil in the gully is saturated or during the early rainy season.
- Posts are set in trenches (0.3 by 0.2 m in size) across the gully to a depth of about 1/3 to 1/2 of the post length, and about 0.3 to 0.4 m apart. -The length of the posts is 1.0 to 1.5 m and their top-end diameter is 3 to 12 cm.
- Any tree or shrub species, such as Alnus, pine, bamboo, etc., can be used as posts but may need treatment with coal tar to counter challenge of white ants.
- If non-sprouting species are used as strips and interlink materials, brushwood check-dams can be constructed during any season.

3.1.1.5.5 Detailed process for Building BWCD

Site selection:

The site has to be selected as per the guideline given above, therefore concerned VDPIC/JFMC/SHGs members also need to be involved, but finally concerned RO/BO will finalize the plot/s for brushwood check dams.

Details on Planning for the work:

A specific plan has to be prepared (as per the selected site) for the successful completion of the work. Therefore, consultation and discussion are required among the CREFLAT personnel and VDPIC/JFMC members before starting the work. List of materials with the amount, workforce required, supervisor etc. need to be finalized through the plan.

Arrangement of workers:

We need young energetic, and selected senior experienced workers to understand the work as well as execute the work in a technically sound way and within the timeframe. Therefore, the proper selection of workers also is a part of process of work.

Arrangement of tools and materials:

Tools like measuring tape, rope, bamboo of different sizes, spade, other local digging tools, and pieces of bamboo/branches for staking. We cannot smoothly do the work without the tools and equipment.

Construction:

The work has to take place in the presence of an expert/RO/BO/BA and along with VDPIC/JFMC/SHG members as all are to learn the whole process and must see a demonstration. Required materials have to be in place (in advance) before the start of the work.

Supervision:

A person with complete knowledge should be there. In case, RO/BO/TO/TA/VCW has to be there during and throughout the execution of work, for avoiding any kind of wrong work.

Plantation:

Right after completion of BWCD work immediately another important task needs to be done i.e., plantation near the gully. Because only such BWCD cannot protect the gully erosion. Moreover, BWCD is a temporary work and plantation is the permanent solution to control erosion.

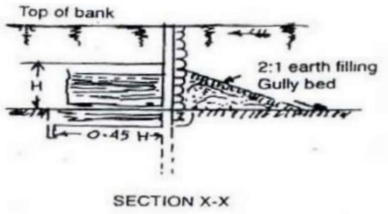
Annual maintenance:

The brushwood check dams are made of natural material, and the function of the brushwood check dam will deteriorate progressively. The maintenance works of the brushwood check-dams shall be once in every year/two years with site clearing and repair of brushwood check-dams by use of natural material around there and through community participation.

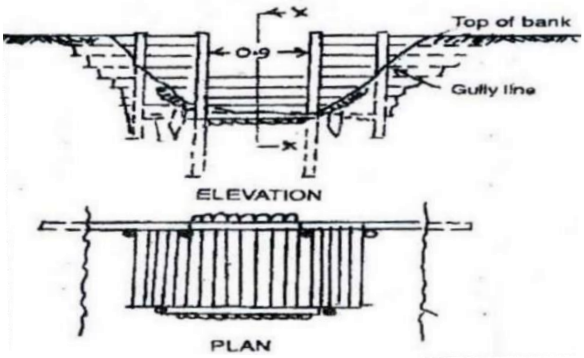
Output BWCD	Outcome BWCD	Impact BWCD
• A unit of work will be implemented. • A number of person-days will be created. • An erosion area will be treated.	• The rainwater does not immediately run off the hill. • The water flow will reduce towards the gully. • Surrounding crops do not suffer later on from water shortage.	• Soil erosion will be reduced. • Forest bio-diversity will be increased. • The particular area of groundwater/land becomes recharged. • Respective plants will get enough water for their survival. • Plants of the catchment area (of the gully area) will be benefited. • Successful model will be replicated in another part (erosion area) of the state.

3.1.1.5.6 Logwood Check Dams

The use of logwood check dams should be restricted only to the places where no other material such as stones, brick etc. is available and wooden logs are available in abundance. The use of wooden logs for the construction of check dams is explained diagrammatically in interconnected figure 5 (Section, Plan, Front View). White ants are greatest enemy of this type of structure and accordingly the required measures shall be taken beforehand.



Log Check dams made of logs and posts are placed across the gully. They can also be built of plants heavy boards, slabs, poles or old railroad ties. The main objectives of log check dams are to hold fine and coarse material carried by the flowing water in the gully, and to stabilize gully heads. They are used to stabilize incipient, small and branch gullies generally no longer than 100 m and with catchment areas less than 2 ha. The maximum height of the dam is 1.5 m from the ground level. Both its downstream and upstream face inclination of 25% backward. Its spillway form is rectangular. The Length of the spillway is 1-2 m and the depth is 0.5-0.6 m.



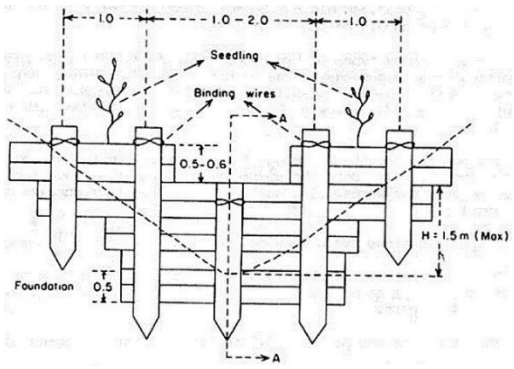


Figure 5. Section, Plan and Front view of a proper designed log check dam.

Table 5. Individual costs of few Mechanical (physical/engineering) & vegetative SWC measures.

Item	Quantity	Unit	Rate/Unit (INR)	Amounts (INR)	Remarks
Staggered Contour Trenches (SCT)	10	Ha	70884	7,08,840	Length= 1.5m. top width 0.6 m, Bottom width= 0.4 m and Depth 0.4 m, X-section 0.2 m^2 and trench Volume =0.3 m^3/RM
Water Absorption Trench	1000	m^3	214.8	214800	1 m^3/RM with size Top width 1.2 m Bottom width 0.8 m and depth = 1m; total X-section 1 m^2
Double row Brushwood	20	Nos.	16000	320,000	Size: 14m x 1.5m x 1m

Log Check Dam	10	Nos.	20000	200,000	Size: 10 x 1.5 x 1.0
Lemon/Khas/Aromatic Grass Plantation/saplings on SCT/WAT Berms	10	Ha	LS	41,173	For planting on the berms of trenches and WAT

Operation and Maintenance of Wooden Check Dam (Every two Years)

3.1.2 Earthen Check Dam (ECD)

As check dam construction was a successful activity promoted during IGDC I, in the same line it will be continued in the IGDC CREFLAT project to identify suitable locations for small earthen check dams within the locally selected landscapes. They provide a supply of water for irrigation, human and livestock use, and fishing. Structures will tend to be small (benefiting a few smaller farmers) and will be combined with land treatments to ensure that upstream soil erosion (and hence siltation of check dams) will be reduced. Wherever possible use of earth-moving machinery will be avoided to ensure maximum job creation.

Water is a critical input as soil nutrients for agriculture production. Timely availability of irrigation to the crop makes difference in good growth and overall agricultural productivity. At the same time, the failure of monsoon or non-availability of irrigation facilities affects badly the farm community and ultimately leads to food shortages and poverty traps.

Rainwater harvesting does not merely mean collecting and storing water in tanks or recharging underground aquifers as groundwater. It rather incorporates technologies of rainwater storage even in soil profiles, through an integrated watershed approach. This can help in encountering the problem of low productivity due to a decrease in soil moisture. It is time now that we realize the importance, need and potential of rainwater harvesting.

There is a provision for building 420 check dams at different locations in the project area with an average budget of INR 1,00,000 (One Lakh only) per check dam. There is need for side-based estimates and budgets. The proposed cost needs to be minimum like JICA minimum size structure (M1) which is equal to our structures (minimum cost of INR 1,12,298).

Positive Impacts of Check dams

- Check dams enhance the natural resource base by increasing soil humidity and capturing runoff rate. By enhancing vegetation growth thereby ultimately an increase in CO_2 absorption.
- Water conservation enhances the water table.
- The construction of check dams will create local employment by generating several working days and likelihood of increased ownership of such assets.
- By creating employment, check dams can contribute to additional income and which in turn can improve the local economic status.

Table 6. Check Dams Applied in the Project.

Model	Earthen Check Dam
Type & Size of Check Dam	Small earthen embankment types check dam with Spillway of size/Length not less than =16 m or more, Average Width = 9.75 m (Top = 3 m & Bottom =16.5 m) and Height= 3 m
Site condition	Upper part Terrain: Narrow valley (just downstream site of the gully) Slope < 10% and Catchment area should be a minimum of 3 ha and a maximum of 10 ha (Area of Catchment can be taken up to 20 ha but spillways place needs to be available and big spillway needs to be made in width, not in Depth)
Main purpose	Water harvesting, recharging, fisheries, and domestic use

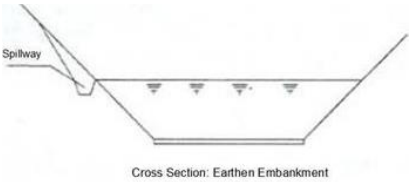
Proposed number of dams	Minimum 2 nos. earthen Check dam per VDPIC on an average (If more needed then take approval from DFO as per availability of Nos. sanctioned or funds)
Site selection	Range Officer in consultation with VDPIC/JFMC
Survey/design	Survey and Design by Range Officer/ Technical Officer cost estimate by VDPIC with the assistance of Range
Construction	Construction by VDPIC/JFMC under the supervision of Forest Ranger
Operation	Operation and monitoring by VDPIC/JFMC under the assistance of range
Maintenance	VDPIC/JFMC under the technical assistance of Forest Range Staff

Constructed Earthen check dams are relatively small-scale structures that can be constructed and maintained by local communities (VDPIC/JFMC/). Under Tripura conditions, they are the most cost-effective measures in the long run to harness rainwater and provide some key benefits early on as given below.

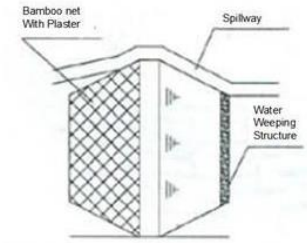
Benefits

Rainwater harvesting has multifarious benefits, apart from augmenting domestic water needs and providing protective/critical/lifesaving irrigation. Some of the additional benefits are:

- Ensures long-term water yield
- Increases water in the traditional water sources
- Recharges groundwater in valleys and lowlands
- Reduces flood damage and soil erosion
- Increases lean period flow



Cross Section: Earthen Embankment

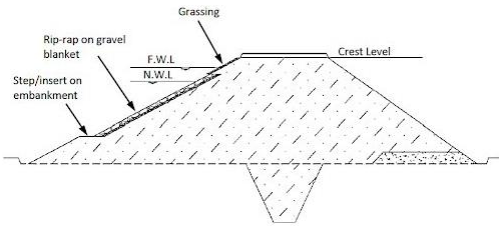


Layout: Earthen Embankment

Table 6 above highlights the usefulness of earthen embankments

Type of dams (See also images on the right):

3.1.2.1 Homogeneous Dam



- Built from a single material except material used for slope protection.
- Soil should be impervious in nature for an earthen barrier against seepage and have 20-30 % clay materials, with the balance made up of silt, sand and some gravel.
- Constructed relatively low to a moderate height of less than 6.0 m
- Side slope generally flat for protecting from sloughing at upstream at sudden draw down and at downstream soil high saturation level (Figure 6).

Height of dam (m)	Upstream	Downstream
3 to 3.5 m	2.5:1	2:1
3.6 to 6.0 m	3:1	2.5:1

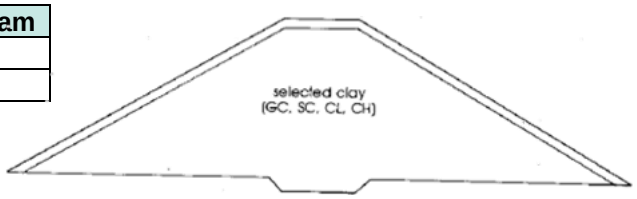


Figure 6. Materials recommended for a homogenous dam (in order of preference).

3.1.2.2 Diaphragm Dam

- At the place where the amount of clay is available in less quantity.
- The preferred material for the diaphragm is stable low plastic clay or sand clay i.e., material with 20-35% clay content.
- The thickness of the diaphragm is measured at right angles to the upstream face and depends on the height of the dam.
- 15 cm thickness added after each m of above 8 m.

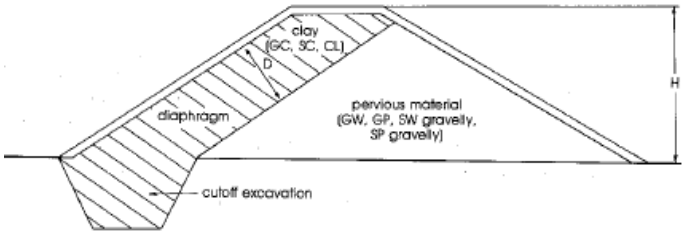


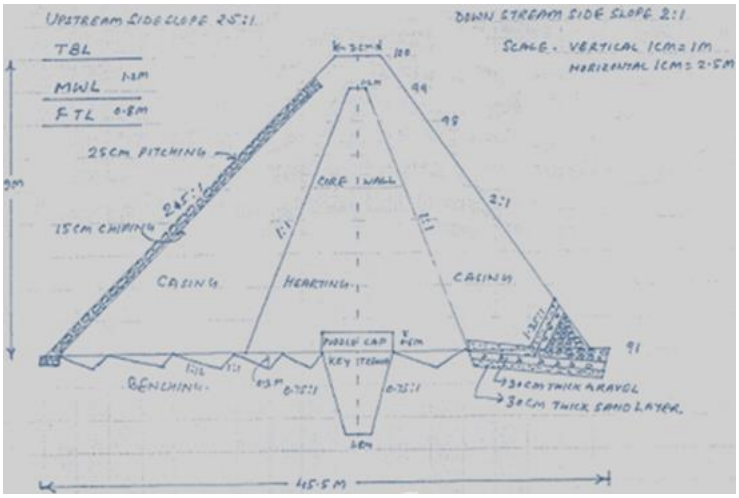
Figure 7. Materials recommended for a diaphragm dam (in order of preference).

- Such types of diaphragms can be used for repairs of existing/defunct earthen dams.

Height of dam (m)	Upstream
Up to 5	0.6
6.0	0.75
7.0	0.9
7.5	1.05
8.0	1.20

3.1.2.3 Zoned (Core wall) types

- Most stable and generally made by more than one type of soil with less quantity of material (see Image on the right).
- An impervious core is flanked in the centre of the dam.
- Pervious shell in the upstream side prevents the build-up of water pressures if a rapid drawdown of water level occurs in the storage.
- The downstream pervious shell forestalls the build-up of water pressure in the clay core by keeping the seepage line within the sown stream toe.



- The centre impervious core is composed of clay (Less than 35%).
- The horizontal drain of the rock toe also provides a suitable drainage system.

3.1.2.4 Examples of Earthen Check Design

3.1.2.4.1 Site Survey for Check Dam (Example)

1) Stand opposite of water flow/Slope in a gully (Lunga) or Nala (Chera).

2) Place two nails at both side of rivulet banks at around an equal height of the centreline of the cross-section of the dam. Tie a rope across the X-section of Gully & Rivulets (see Figure 8).
3) Start measurement from the left at 1-2 m horizontal distance at the depth of beds from the rope.
4) Measure all points and right in a table and draw figure also.
5) In case there is a need to measure more height side 1 m bamboo stick can be used as vertical from the last point and measure the horizontal distance from bamboo sticks to the bank of that level.

6) All dimensions need to be drawn and calculate the depth at a given distance from '0'.

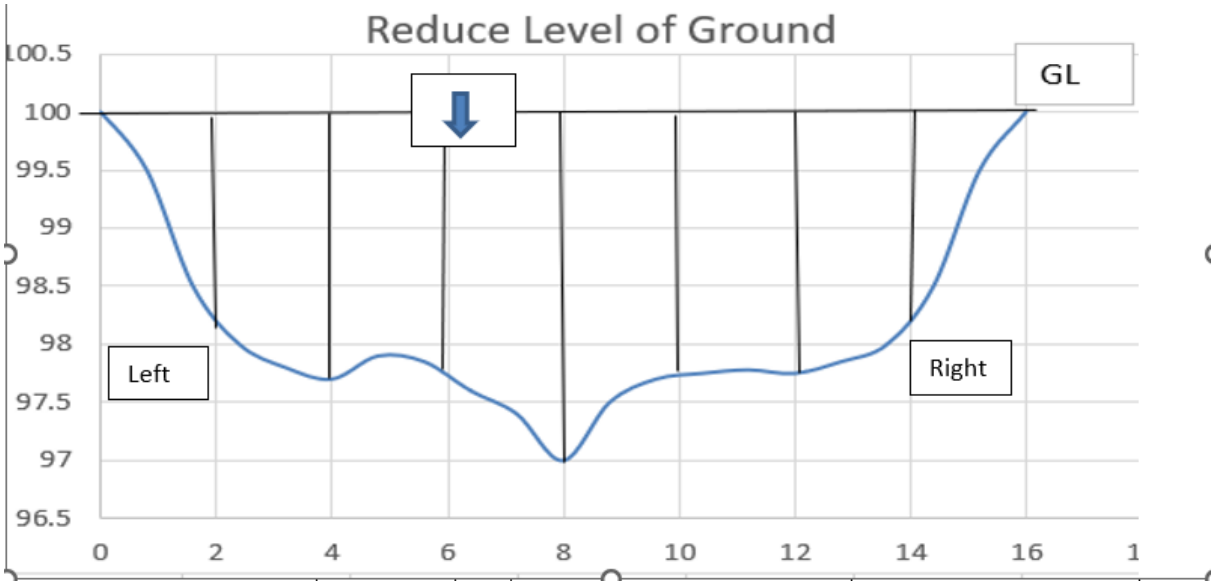
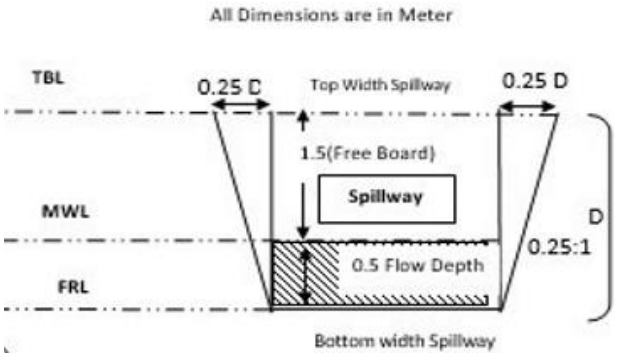


Figure 8. Cross-Section Survey of Earthen Check Dam.

VDPIC/JFMC: Burkhami			GPS Coordinate:	
DPMA: Dhalai			Range: Ambassa	
Measured Data and calculated			Calculated RL at different chainages by these data	
Distance (m)	Height (m)		Chainage	RL of Ground
0.00	0.00		0	100
0.80	0.50		0.80	99.5
0.80	1.50		1.60	98.5
0.80	2.00		2.40	98
0.80	2.20	1	3.20	97.8
0.80	2.30	2	4.00	97.7
0.80	2.10	3	4.80	97.9
0.80	2.15	4	5.60	97.85
0.80	2.40	5	6.40	97.6
0.80	2.60	6	7.20	97.4
0.80	3.00	7	8.00	97
0.80	2.50	8	8.80	97.5

0.80	2.30	9	9.60	97.7
0.80	2.25	10	10.40	97.75
0.80	2.22	11	11.20	97.78
0.80	2.25	12	12.00	97.75
0.80	2.15	13	12.80	97.85
0.80	2.00		13.60	98
0.80	1.50		14.40	98.5
0.80	0.50		15.20	99.5
0.80	0.00		16.00	100

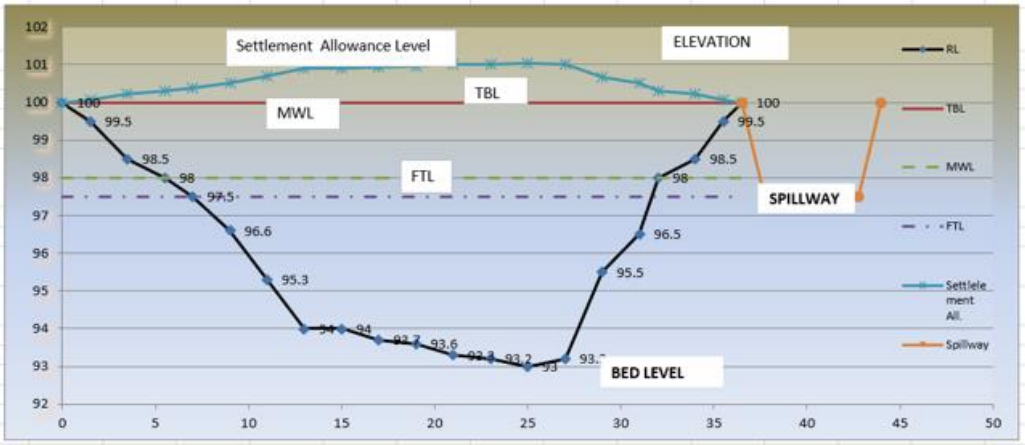
3.1.2.4.2 Spillway Size selection

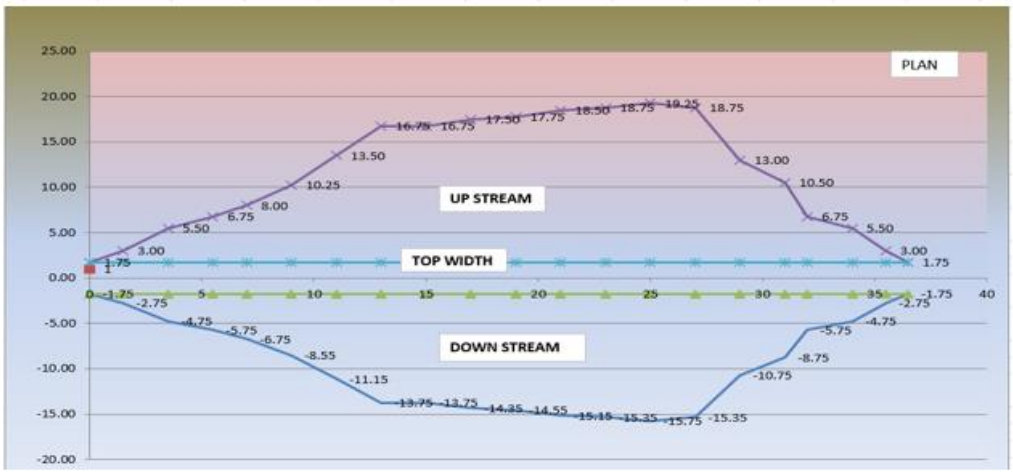


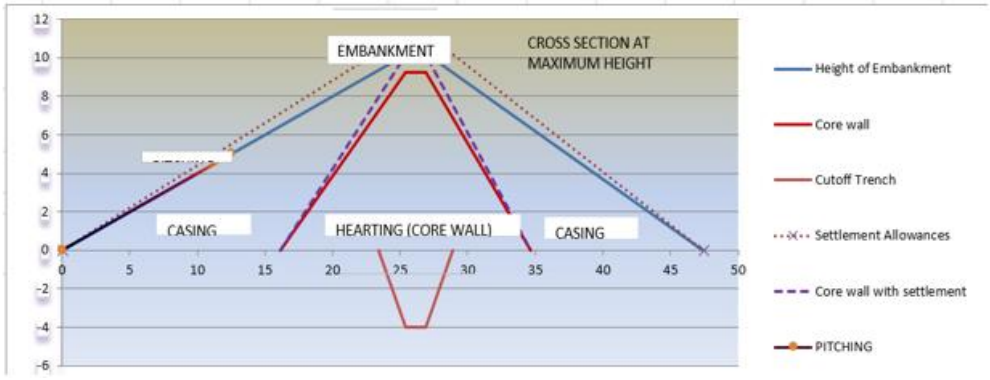
3.1.2.4.3 Spillway bottom width selection

Spillway Bottom Width (m)	**Depth of flow in spillways (m)**		
Catchment Area (ha)	**0.3**	**0.4**	**0.5**
2	2.7	1.75	1.25
2.5	3.13	2.03	1.5
3	3.6	2.33	1.67
3.5	4.03	2.61	1.87
4	4.45	2.89	2.07
4.5	4.86	3.16	2.26
5	5.26	3.42	2.44
5.5	5.66	3.68	2.62
6	6.04	3.92	2.8
6.5	6.42	4.17	2.98
7	6.78	4.4	3.15
7.5	7.14	4.64	3.32
8	7.5	4.86	3.48
8.5	7.84	5.094	3.65
9	8.2	5.31	3.8
10	8.86	5.75	4.11

3.1.2.4.4 CREFLAT Water Harvesting Tank







IC/JFMC: - **GPS Coordinate**

SALIENT FEATURES

#	Particulars	Unit	Designed dimensions	Considered
A 1	Catchment area (A)	ha	10	
2	Runoff coefficient (C)		14	
3	Dicken's formula Peak discharge (Q) = C*(A/100)$^{0.75}$	m^3/ sec	2.49	
B 4	**Silent features of the dam**			
5	Type of Water Harvesting Structure	Earthen Check Dam		
6	Beat			

7	Latitude /Longitude			
8	Top bund level (TBL)	m	100.00	100.00
9	Freeboard (F) (TBL-FRL) = 20% of the maximum height of the dam or 1.5 m whichever is more.	m	0.51	1.00
10	High Flood Level (HFL/MWL)/Pitching Level	m	99.00	99.00
11	Designed Discharge	m	2.490	2.490
12	Depth of flow over exit weir (hf) = 50% of the freeboard (F)	m	0.26	0.5
13	Width of exit weir (Wew) = Q/(1.71*hf3/2)	m	0.51	1
15	Full Reservoir Level (FRL)	m	98.50	99.00
16	Bed Level (BL)	m	96.6	96.6
17	Core wall	m	99.500	100.75
18	Length of Earthen Dam	m	16	16
19	Maximum Cross section Width of Bund	m	17.5	17.5
C	Settlement Allowance	%	**1O**	1O
1	Slope of Nala bed (N:1))	%	**100**	100
2	Maximum height of the dam (H)	m	3.40	3.40
3	Length of Embankment at full tank level (FTL)	m	10.4	139
D	Storage capacity of the dam = 0.22*1.5*W*D*L (K.D Nelson-Design & Construction of Small Dam- Pg 72-74)	m	11742.7	11742.72
E	**Design of dam body**			
2	Top width of the dam body (TW_{db}) = 1.5+H/5	m	2.18	2.20
3	Upstream side slope of the dam body (V:H), 1:	F	**2.5**	2.5
4	Downstream side slope of the dam body (V:H), 1	F	**2**	2
	Height of the pitching on the upstream side up to HFL			
F	**Design of Spillway**			
	Length	m	10	10
	Side Slope of the spillway (V: H),1:		0.25	0.25
	Av Width	m	1.25	1.25
	Av. Depth	m	1.00	1.00
	Total Spillway Excavation	m^3	26.25	26.25

Table 7. CREFLAT Earthen Check Dam – Estimating and Costing**.(SOR2023_PWD-V-II)**

S No./Item No	Particulars	Qty	Unit	Rate/ Unit (INR)	Amount (INR)
1. Item 2.1	Clearing jungle including the uprooting of rank vegetation, invasive plants, brushwood, trees and saplings of girth up to 30 cm measured at a height of 1m above ground level and removal of rubbish up to a distance of 50 m outside the periphery of the area cleared.	337.47	m^2	9.4	3172.218
Item no-2.7	Earth Work in surface excavation not exceeding 30cm in depth but exceeding 1.5m in width or 10 m^2 on the plan including disposal of excavated earth up to 50m and lift up to 1.5m, disposed of soil to levelled and neatly dressed. All kinds of soil.	150.03	m^2	69.00	10352.07

Item no-2.13	Earthwork in excavation by mechanical means (Hydraulic excavator)/ manual means in foundation trenches or drains (not exceeding 1.5 m in width or 10 m² on plan) including dressing of sides and ramming of bottoms, lift to 1.5 m, including getting out the excavated soil and disposal of surplus excavated soil as directed, within a lead of 50m. All kind of soil. Cut off/puddle Trench	14.87	m³	231.6	3443.892
Item no-2.8	Earthwork in rough excavation, banking excavated earth in layers not exceeding 20cm in depth, breaking clods watering, rolling each layer with 1/2 tone and dressing up in embankments for roads, flood banks, marginal banks and guide banks or filling up ground depressions, lead up to 50m and lift up to 1.5m. All kinds of soil. Cut off/puddle Trench filling	14.87	m³	556.00	8267.72
Item no. 2.13	Earthwork in excavation by mechanical means (Hydraulic excavator)/ manual means in foundation trenches or drains (not exceeding 1.5 m in width or 10 m² on plan) including dressing of sides and ramming of bottoms, lift up to 1.5 m, including getting out the excavated soil and disposal of surplus excavated soil as directed, within a lead of 50m. All kind of soil For Spillway	26.25	m³	231.6	6079.5
Item no-2.8	Earthwork in rough excavation, banking excavated earth in layers not exceeding 20cm in depth, breaking clods watering, rolling each layer with 1/2 tone and dressing up in embankments for roads, flood banks, marginal banks and guide banks or filling up ground depressions, lead up to 50m and lift up to 1.5m. All kinds of soil.	233.66	m³	556.00	129914.96
11. Item no-2.18	Extra for additional lift of 1.5m or part thereof. All kinds of soil.	37.68	m³	66.10	2490.648
Item 3.22	Turfing on the prepared surfaces including seed and sods	145.75	m²	51.10	7447.825
	(-) Deduct 15% of contractors' profit and overhead				25675.32
	Sub-Total				145493.51
	(+) Add 3% Contingencies				4364.81
	(+) Add 1% labour cess				1454.94
	Grand Total				**151313.25**
	Add SOR enhancement @ 4% SOR previous Financial Year (FY)				
	Add SOR enhancement @ 4% of 1st year	FY-2024-25		2nd Year	157365.77
	Add SOR enhancement @ 4% of 2nd year	FY- 2025-26		3rd Year	163660.40
	Add SOR enhancement @ 4% of 3rd year	FY- 2026-27		4th Year	170206.82
	Add SOR enhancement @ 4% of 4th Year	FY- 2027-28		5th year	177015.09

Table 8. Proposed Earthen Check Dam Cost per Unit/Year.

Particulars	Yr-1	Yr-2	Yr-3	Yr-4	Yr-5
Earthen Check Dam Cost Per Unit (INR)	151313.25	157365.77	163660.40	170206.82	177015.09

3.1.2.5 Process for Water Harvesting Planning -Earthen Check Dam

Below given is a step wise approach to planning process at village level that refers to social and technical feasibility, design and approval processes and finally implementation and M&E.

Table 9. Checklist of Construction of M1 (3-10 ha Catchment)-An Earthen Dam is a Homogeneous and zoned Type.

S. No.	Activities	Responsibilities	Timeline
A	**Pre-Implementation (Planning)**		
A1	**Site Selection**: It should be part of the approved Village Development Plan of GP/VC by VDPIC/JFMC/EDC	JFMC/EDC & (RO/DPMA/PMA)	2-3 days
A2	**Feasibility Study (Technically Feasible, Economically Viable, Environmentally & Socially Considered):** The length of the Check dam or the width of the valley should be short as possible. The catchment Area of the proposed structure needs to be calculated/measured by toposheet/GPS by peripheral boundary, google etc. The water storage area of Check dam should be as large as possible. The slope of the valley bed should be as minimum as possible but not steep (<10%) to store more water and soil materials in and around the dam site. Should be accessible and preferably in the 500 m of the vicinity of VDPIC/JFMC/EDC and appropriate for other proposed activities of the project i.e., Environment and Social Considerations & Gender sensitivity taken on board.	VDPIC/JFMC/EDC/RMA	1 day
A3	**Survey, Design & Estimates** Topographical Survey of the site: Cross section at extent covers the proposed embankment and longitudinal section at 10m Intervals, underground hard strata, Soil previous/Impervious storage area, and catchment erosion situation.	VDPIC/JFMC/ RO	5-7 days
A4	**Technical, Financial & Administrative approval:** DMA will approve the design and estimate and MoU should be signed between VDPIC/JFMC/EDC and RO. The technical and expenditure sanction will be as per norms and approved.	SDFO & DPMA	5-15 Days
B	**Implementation**		
B1	Procurement Person (labour), material and tools	VDPIC/JFMC/EDC/ RO	7 days
B2	Responsible for a resource person (from VDPIC) for ECD construction in villages	VDPIC/JFMC/Range Officer	1 day
B3	**Construction Steps**		

S. No.	Activities	Responsibilities	Timeline
a)	Site cleaning	Conducted by VDPIC//JFMC under the Assistance of RO (Design, cost estimate and timeline will be provided by DPMA, PMA, PMC	1-2 Days
b)	Stripping (Average 20 Cm depth) & refilling by soil same as used for embankment, watering & Compaction		2-5 days
c)	Layout & marking of by lime and pegs		1-2 days
d)	Excavation of Foundation Trench at centreline with bottom width min 1.5 m & Side slope 0.5:1		3-5 days
e)	Refilling of Excavated Foundation Trench, watering and compaction		3-5 days
f)	Embankment of Check Dam Construction, if possible, suitable soil need to be excavated from storage area of dam. Soil Laying in each layer 30 Cm height, watering and compacted up to 20 cm by manual by Durmut. Laying of soil in layers at embankment, watering in evening and compaction in morning is preferably need to be done if possible. For settlements, 10% of height at each point need to be considered in embankment. The junctions point of embankment dam with foundation, abutments, and masonry structures like overflow, non-overflow dams and outlets needs special attention with reference to one or all of the following criteria. (a) Good bond between embankment dam and foundations (b) Adequate creep length at the contact plane (c) Protection of embankment dam slope against scouring action.		40- 60 days
g)	**Spillways Excavation** and Construction, if needed, Free board need to be 20% of Height of dam above Max. Water Level i.e., 1-1.5 m. Sufficient spillway capacity should be provided to prevent overtopping.		5-7 days
h)	Upstream protection and **grass turfing** on top & downstream slope of embankment of Check Dam to protect from erosion.		3-5 days
B5	Signage Board & Branding	VDPIC/JFMC/RO	1 days
B6	Final Inspection and Completion report	VDPIC/JFMC/RO/SDO	1 days
B7	Regular monitoring & quality control checked by SDFOs	VDPIC//JFMC/EDC led by Range Office	Continue
C	**Post-Implementation**		
C1	Hand holding to VDPICs/JFMC/SHGs for Sustainable Management	VDPIC/JFMC/EDC/RO/SDO/PMA	7 days
C2	Operation: ECD shall be operated and monitored by VDPIC/JFMCs/SHGs	VDPIC/JFMC, technical Assistance by RO/TO	Continue
C3	Maintenance: By VDPIC/JFMC/EDC/SHGs under technical assistance of RO under supervision of DMA, PMA, PMC. Design of the maintenance works of all models by RO periodically prepare, minimum once in every two years. Revolving Fund of shall be used for O&M.	VDPIC/JFMC/EDC and Led by RO	Continue at every 2 years frequency
C4	Participatory Impact Study	RO/VDPIC /JFMC /PMA	Continue till 6 Years

3.1.3 Repair, Renovation & Restructuring of Seasonal water Bodies (450 Ha @ INR 20K/ha)

A further set of soil and water conservation interventions is for the repair, renovation, and restoration of seasonal water bodies e.g., clearing biomass/vegetation to prevent blockage; bank stabilization using gabion-based techniques; levelling; manual digging/silt removal, etc. The aim of these techniques is to reduce flood damage during periods of excessive rainfall and associated erosion and scouring. The basket of choice of the proposed measure is as follows. Select the suitable measure as per need the possible measures are as follows (Other suitable options that come out from the community can also be considered as an option for proposed measures).

3.1.3.1 Repair of Existing Check Dam

20 Earthen Check Dam already made under CREFLAT are part of improvement/consolidation. Catchment area need to be calculated of each check dam, as VDPs are prepared in the affiliated village.

3.1.3.2 Catchment Protection:

2 Nos. single brushwood per structure be made 8-10 m length. Brushwood check dam can be made in the water flow portion of Lunga. These are proposed Check dams @ 10000/each BWCD of size 8-10 m for 1 Ha catchment area of check dam. Activities in 3.1.3a & 3.1.3b both can also done combined if necessary and catchment area of structures are minimum or more than 2 ha.

3.1.3.3 Desilting & Repair of old breakage structures existing in the proposed area.

Desilting of earthen check dam and if possible, silt needs to be applied on the farmer's field as a Silt application. Transportation of soil need to be done by fully/partially by beneficiaries of silt application.

Filter strips can be promoted at the periphery of water storage area so that it checks the soil and reduces the silt deposition in the Check dam. Fencing also supports to allocate and protect

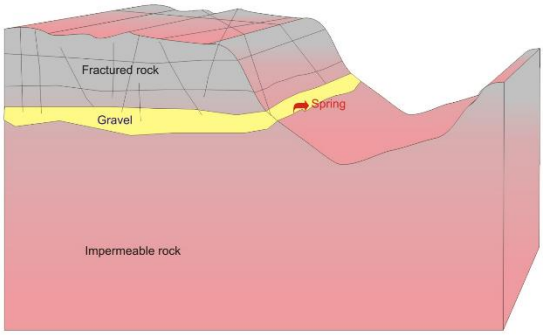
3.1.3.4 Rejuvenation of springs (50K/ha-60 ha)

The second set of land treatments under output 2 will include treatments designed to Rejuvenate springs through rainwater harvesting and water infiltration structures using geo-hydrological techniques and GIS to locate correctly the treatments depending on the underlying topography and geology. This will be an important means for enhancing the environmental services (essentially for water) from local landscapes. Rejuvenation of springs could offer a climate-resilient solution for livelihoods and ecosystems in hills, enhance water access, and contribute to achieve one or more of the Sustainable Development Goals (SDGs). An aquifer-based, springshed management approach holds much promise in the revival of springs. The approach, based on local context must combine cooperation between departments and community participation and ownership in spring revival (see schematic image below).

Spring rejuvenation calls for mapping of the springshed, identification of recharge areas, pinpointing sites for appropriate recharge structures, construction of recharge structures through convergence of activities under MGNREGS, PMKSY-WDC and related Schemes of State Governments. The estimated budget provided and its activities are proposed accordingly as basic springshed model.

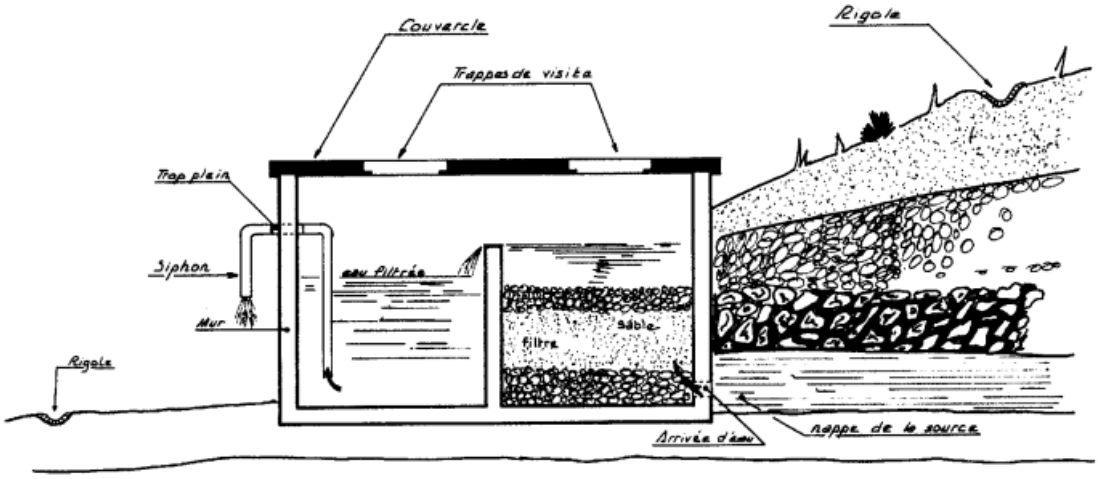
A spring is a point of exit at which groundwater from an aquifer flows out on top of earth crust and becomes surface water. Spring is a water resource formed when the side of a hill, a valley bottom, or other excavation intersects a flowing body of groundwater at or below the local water table, below which the subsurface material is saturated with water.

The intermittent seeps, flow only after much rain, to huge pools flowing hundreds of millions of gallons daily.



Springshed is an area within a ground or surface water basin that contribute to the spring flow. The boundary of spring flow is dynamic-they change based on the level of the aquifer (otherwise known as its potentiometric surface). In addition, springshed are the area within groundwater and surface water basins that contribute to the discharge of a spring. An aquifer is very much like an underground watershed. Unlike the plain area, in hilly areas, the springshed is the fractured rocky area under the hills, which contributes flow of water as the springs at the drainage outlet. The direction of the flow of water/springshed outlet depends on the types of rock and their geological formation.

An average of 10 ha catchment of each spring need to be considered, and therefore 60 springs (Project target) need to be selected: There should not be strict norms if the spring's size is small and can be covered under the given budget that need to be taken up. However, in North east region springs catchment size is often in the range of 10-30 ha. Mostly spring possibilities in north district due to high hill (6 springs of each Average 10 ha Catchment)



Springs are driven out onto the surface by various natural forces, such as gravity and hydrostatics. They vary in volumetric flow rate from nearly 0 to more than 14,000 litres per second (14 cum/s) for the biggest springs.




Table 10. Proposed Estimates and budgets for Rejuvenation of Springs- assume 10 ha Springshed.

Items	Consider the Average 10 ha springshed Catchment (INR)	Calculations
Platform	200283	Construction of Naula platform & Storage Tank (Civil works & Plumbing)
Recharge Trench	257760	3000 nos. trenches (SCT) of size 0.5 (2.0 m x 0.2 m^2) 1200 m^3 @ 214.8/ m^3 (Size Length 2.0 m,Top width 0.6m, Bottom width 0.4m & Depth 0.4 m)
Brushwood	54000	6 nos. Brushwood of size 8 m length @ 9000/each
Total	512043	During the Implementation, the budget can be shifted internally for structures of Rejuvenation of springs if the need arises

(Note: If springshed more/less than 10 ha, budget can be adjusted accordingly as allocated up to @100000/ha). However, if in the same catchment plantations are planned, costs may reduce accordingly. Overall, at larger scale of 10 ha catchment costs will reduce.

Note: All SWC measures mentioned above are costed as per standard rates and these can vary as per local context/sites of construction thus could be higher or lower and based on individual estimates!

3.1.4 Pilot of Forest-Based Incentive Scheme (PES)

Finally, the project will support the piloting of forest-based incentive schemes (Payment for Ecosystem Services (PES) in a few selected locations. This will assist in working out methods by which upstream/downstream communities and water users can be linked through in kind /material forest-based incentives in a way that will be sustainable after the end of the project.

Due to the availability and enhancement of moisture in the soil, people can promote planting NTFP of multiple tree species (MPTs) to form integral components of different agroforestry interventions in crop sustainability. Besides furnishing the multiple outputs like fuel, fodder, timber, tuber, fruits, and other miscellaneous products at their Patta lands and nearby lands help in the improvement of soil health and other ecological conditions trees, grasses, tubers, etc. It saves time for collection and other agricultural practices and especially reduces the drudgery of women due to reduction of harvesting site distance and saving time. Hence, they can take care of their children well or take up some short time economic development activities. Therefore, incentives can be provided for the same @ INR 60,000/ha. These activities can be done by convergence with NABARD, Departments such as Agriculture, Horticulture, Rural Development, and women and children welfare. Project to provide support in kind as material and labour work would be done by people themselves by MGNREGS or other support or self-contribution. Livestock can also be an integral part of the same because this is a component of the Cycle of Farming System Development. Nearby their forest-dwelling adding Jhum:

- NTFP Planted
- Plantation of multi-tree species for their annual needs of fuelwood, fodder, timber (house construction or repairs), fruits, etc.
- Wild fruits like Jamun and tamarind
- Roots and tuber crops for Pigs because people are rearing Pigs at home
- Fodder & Forage for their livestock
- Kitchen garden for vegetables and protection from malnutrition for women and children
- Group Vegetable cultivation and Marketing
- Livestock rearing and its management.

However, the overall concept of PES is yet to be developed and project will pursue two to three such cases in potential areas and as per potential related to conservation and value addition of natural resource management/forest ecosystem services at landscape scale.

Note: Some Plantations are proposed if the community is interested to adopt and choose any combination as per their needs: (Plantation density 400 plants/ha for Agroforestry and 200 Plants/Ha for silvi-pastoral or may consider the updated and agreed plantation models of CREFLAT).

Table 11. Three-Tier Plantation System or to be suggested from the list of Plantation Models agreed by KfW.

Canopy	Crops
Lower Canopy	Ginger (*Zingiber officinale*), turmeric (*Curcuma longa*), NTFPs having medicinal value, pineapple (*Ananas comosus*), arjun flower etc.
Middle Canopy	Papaya (*Carica papaya*), Mritinga, bamboo (*Bambusa tulda*), Bari bamboo (*Bambusa polymorpha*), Kanakkaich bamboo (*Bambusa affinis*), banana (Musa acuminate), black pepper (*Piper nigrum*), lemon (*Citrus limonium*), betel (*Piper betel*), guava (*Psidium guajava*), bael (*Aegle marmelos*), orange (*Citrus sinensis*), sajna (*Moringa oleifera*), *Acacia mangium* etc.
Top Canopy	Mango (*Mangifera indica*), jackfruit (*Artocarpus heterophyllus*), langchak (*Parkiya speciosa*), agar (*Aquilaria agallocha*), litchi (*Litchi chinensis*), bahera (*Terminalia belerica*), Boroi (*Ziziphus mauritiana*), tetul (*Tamarindus indica*), jam (*Eugenia jam-bolana*), Jarul (*Lagerstroemia spp*.) Kadam (*Anthocephalus cadamba*), Bombax ceiba, Toon (*Toona ciliate*), etc.

Table 12. Forest tree species preferred by the people in the project area.

Timber & high value species	Fruit species	Fuelwood species
Gmelina arborea	Artocarpus heterophyllus	Anthocephalus kadamba
Albizzia procera	Emblica officinalis	Samania saman
Toona ciliate	Averhhoea carambola	Leucaena leucocephala
Michelia montana	Tamarindus indica	Cassia fistula
Dalbergia latifolia	Syzygium cumini	Acacia auriculiformis
Michelia champaca	Mangifera indica	Acacia mangium
Artocarpus chaplasa	Dillenea indica	Peltophorum spp.
Albizzia lucida	Eleocarpus floribundus	Melia azedirach
Aquilaria melacensis	Moringa oleifera	Tectona grandis
Shorea robusta	Litchi chinensis	Azadirachta indica
Michelia champaca	Spondias pinnata	Ailanthus excelsior
Sterospermum personatum	Ficus glomerata	Albizzia lebbeck
Lagerstroemia speciosa	Garcinia pendunculata	Bamboo

3.2 Operation and Maintenance (O&M)

After the monsoon season, the overall inspection of structures should be carried out and the repair/rehabilitation work be planned by VDPIC/JFMC and Range Office. The planned repair/rehabilitation works should be carried out by VDPIC/JFMC before the monsoon season and the inspection to confirm the works shall be carried out by Range Office.

Particulars	Operation and Maintenance Responsibilities	Observer
Staggered Contour Trench/Water Absorption Trench (SCT/WAT)	The Contour trenches, Siltation in earthen work/works are earthen. Therefore, periodical O&M works of the structures are required to keep those functions. After construction of the works, O&M of the structures shall be done by VDPIC/JFMC/SHG by work volunteer (Shramdaan), and material costs can be from Revolving funds or use of the revolving fund of	GP/VC/Range Office

	VDPIC/JFMC under the technical assistance of the Range Office.	
Wooden Check Dam (Brush Wood &Log)	Maintenance every two years by the JFMC/VDPIC	GP/VC/Range Office
Earthen Check Dam (ECD)	By SHGs /JFMCs who is getting benefit by pisciculture/ domestic etc. with support from VDPIC. Group fund partially can also take to support the same if material required.	GP/VC Technical Support from Range Office
Repair, Renovation & Restructuring of Seasonal water Bodies	VDPIC ensure to repair Brushwood every two Years /De-siltation & Repair existing Tank every 5 years,	GP/VC with technical support Range Office
Rejuvenation Springs	VDPIC/Repair of platform (civil) work need to be done by group fund only for materials and labour work need to be done by beneficiaries themselves. The Contour trenches, Siltation in earthen work, works are the earthen. Therefore, periodical O&M works of the structures are required to keep those functions. After construction of the works, O&M of the structures shall be done by VDPIC/JFMC/SHG by work volunteer (Shramdaan) and material costs can be from Revolving funds of VDPIC/JFMC under the technical assistance of the Range Office	GP/VC/Range Office
Forest based Incentives Scheme	People should operate and self-maintain the same bi-annually or yearly. Beneficiaries need to be doing all repair & maintenance on self-basis.	VDPIC /GP/SHG/VC

3.3 Outputs of Soil & Water Conservation

- 1600 ha area treated by physical & Vegetative SWC Measures and due to soil erosion check, soil moisture and water table rise and vegetation growth enhanced and check siltation in the water storage area and reduce their capacity.
- 60 ha (6 Nos. Springs each with 10 ha springshed will be rejuvenated.
- 420 Earthen Check dam constructed
- 450 structures renovation - desilting, repairs, vegetative strips for check erosion and making the boundary of storage area.
- 150 Ha area material incentives have been provided

4 Proposed Soil & Water Conservation Measures

4.1 Strategy for Soil and Water Conservation

1) Capacity building of In-house staff both at PMA & DPMA (DPMA/Subdivision/Range) needs to be done on SWC based on pre-assessment of their awareness levels and skills.
2) Problems, people affected, probable solution, and development options identified by the General of PRA GP/VC/SHGs.
3) Meeting & Identification of the volunteer/community people (Positive attitude person) from each project village of GP/VC and who will be responsible for VDPIC/GP/VC/SHG.

4) Exposure Visit and Capacity building of the above-selected persons on SWC phase-wise problems, SWC mechanical and vegetative measures, springs management, and other proposed technical interventions and microplanning.
5) Issue focused PRA's need to be conducted on SWC of GP&VC/SHG during VDP preparation.
6) Net planning of proposed (proposed technical/mechanical/Vegetative/social measures of SWC for each village and measures should be socially acceptable, technically feasible, economically viable, and environmentally sound).
7) Compiling net planning of each village in Holistic VDP at GP/VC.
8) Technical, Financial, and administrative approval.
9) Meeting at Village /GP/VC level and sharing all approved activities, and convergence activities. All planning labour, tools and implements, materials, vendors, roles and responsibilities, etc. need to be discussed and decided with consensus. Inauguration of work can be done same days.
10) A convergence workshop with VDPIC needs to be conducted to prepare a roadmap of the convergence activities out of CREFLAT as per VDP identified during IFPRA or PRA's.
11) SWC training (2nd Phase) needs to be conducted with Technical (Mechanical/Vegetative/Social) & Monitoring aspects (Daily supervision, records keeping, etc.) both on-site, and off-site.
12) Implementation of approved SWC activities as per plan, daily supervision by Volunteer/VDPIC representatives with facilitation of Range Office.
13) Onsite suggestions by experts/other visitors on social, technical, monitoring, and financial issues.
14) A Farm data sheet (FDS) needs to be filled by village people/volunteered of the FDS. Range Officer (With help of a Forester/Beat Officer/ Forest Guard/TA) will prepare a Measurement Book (MB) and payment sheet after verification of FDS and submit for further approval to SDO/DPMA Chief. Payment can be made in account or cash as per CREFLAT norms and as agreed during the planning/implementation process.
15) Linkages and document preparation by VDPIC for convergence to other external departments both Govt. and Non-Govt.
16) Compilation of work with financial expenses and benefitted HHs/person/Female/Poor with Photographs need to be documented and further reported to CREFLAT CEO/PD i.e., process, concern phases, and how to overcome. All conflict that arise during work needs to be resolved as early as possible with a discussion with the DPMA Chief and needs to be properly documented.
17) After completion of the SWC measure, a work completion report needs to be prepared.
18) Assets prepared during implementation etc. need to be handed over to VDPIC (GP/VC). Livelihood development, Operation and maintenance related trainings (3rd Phase) needs to be given to the community.
19) Monitoring should be continued until confidence that people can self-manage. A withdrawal meeting needs to be conducted with the community once VDP implementation is completed and future management aspects are conveyed.

4.2 Institutional management

The participatory planning process, and proper time needs to be given to the community process documentation to be done in conformity with the above and other guidelines (e.g., M&E etc.) by the concerned expert.

4.2.1 Community mobilisation and empowerment

- Community needs to be made aware of CREFLAT Project and its objectives and proposed activities.
- They should form VDPIC at GP/VC level, JFMC for Forest area and VDP needs to be made.

- All decisions need to be taken in VDPIC and proper visual photos, video, and records need to be maintained for maintaining transparency.
- In every meeting agenda need to be fixed and discussion facilitated accordingly, and resolution of VDPIC etc. need to be signed by each person present in the meeting.

4.2.2 Action

1) For above all there is a need to do an exposure visit of people of villages to best practices done holistically manner for their vision building.
2) One new topic of economic development/Environment development/Health & Hygiene, Education needs to be shared with people during meeting and also their perception and viewpoint should be taken on the same.
3) Proper Identification of opinion leaders who have skills for a particular theme, can enhance their skills in a particular subject and they should be made empowered and provided all resources so that they can deliver their support regularly and in an efficient manner.
4) VDPIC needs to be formed and VDP can be prepared after completion of VDPIC.
5) During the preparation of VDP, there is a need to collect detailed thematic information also.
6) All decisions need to be done in VDPIC regular meetings with all community members consensus.
7) Economical activities can be done with SHGs also but should be allotted by VDPIC, not by JFMCs. It may allot through JFMC in a forest area.

VDPIC is a community-based organisations/Institution of CREFLAT and formed with participation of Gram Panchayat /Village council and para representatives (See VDP Guideline). For forest area work JFMC need to be responsible and overall project treats VDPIC as the overall responsible for all types of activities.

4.3 Training of CREFLAT Team & stakeholders

4.3.1 Topics: Training on "Soil and Water Conservation in Landscape & Climate Change Management Concept"

Trainings Planned under CREFLAT project is to build the capacity of CREFLAT DPMA level to Range Officer (ROs), Forester/Beat Guard/ TOs, TAs & VCWs. The aim here is to make aware and do skill building of the community about Soil and Water conservation through Watershed Approach, principles, survey methods, design of earthen check dam and management. This is primarily necessary for the effective implementation of work at the beat level and on-site improving efficiency by understanding the scientific principles. Three days training program will be organized with first day on Watershed/catchment, hydrological cycle, Demarcation of the catchment area, Slope measurement, SWC structure's Site Selection, Planning, layout, construction and monitoring both theory and practical exercise. The second day on site at the field level must be used to understand the concept of Landscape, Catchment, Land use, resource existing and proposed maps, and Technical survey, transect walk for ground truthing and technical survey of proposed structures with beneficiaries. Third day it is in-house analysis of data, identification of development activities and technical design of proposed structures. Their estimate and budgeting and how it integrate these Soil & Water Conservation measures i.e. check dams, SCT etc. site selection and survey, design and implementation.

The teams have the limited and improper technical knowledge on the need and means for soil and water conservation, which mainly affect the quality, quantity and time of completion of work. Improper Soil and Moisture conservation practices can also deteriorate the soil and land quality further, which affect overall production and quality of life of farmers.

Therefore, there is need to make aware and build knowledge base of our team on Climate Change and Landscape management by Soil & Water Conservation measures on the Watershed basis.

However, training design and packages have to be customised to project's capacity-building concept and programme so that soil and water conservation training figure at the stage of VDP preparation and its early implementation.

4.3.2 Purpose/Objective

To make aware, improve and build in-house capacity of SDFOs, ROs, Foresters/BO's/FGs/TOs/TA of all CREFLAT Team, including both male and female regarding Soil & Water Conservation with Landscape and Integrated conservation.

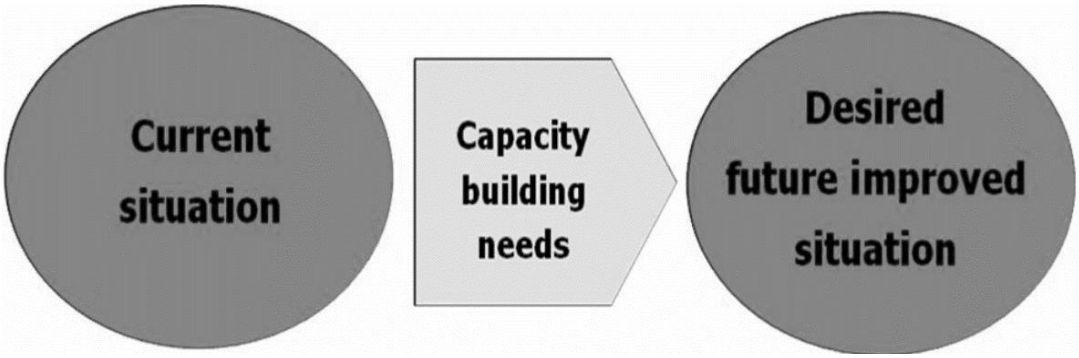


Figure 9. Approach to identifying capacity building needs.

4.3.3 Methodology

The theme shall be supported by various audio-visuals, moderation techniques, group discussions, brainstorming sessions, charts, movies etc. We will also display some chart, photographs of good modal implemented in the fields. The share of experience of individual participants may also be discussed during training program. Feedback from individuals will be collected and compiled. The concept, principles, conservation and management practices shall be through power points, whereas local issues, expectations, orientation of the training through brainstorming sessions, group discussions. The success stories and previous works exhibit through audio-visuals. Feedbacks will be taken through forms and mutual sharing.

It is reiterated that this methodology needs to be customised the overall capacity-building concept of CREFLAT as and when ready and matched with training activities and VDP planning processes and implementation timelines.

4.3.4 Training Module:

In the following table, details on the training module for Soil & Water Conservation are given:

Table 13. Contents of the training module for Soil & Water Conservation

Topic	Particular
Day 1	
Expectation & need assessment & Pre-test of participants on SWC.	Registration, Introduction, and experience sharing. Pre-test Format needs to be distributed and the same will be repeated after training in Post-test.
Soil & Water Conservation in terms of Landscape and climate change.	Importance of natural resources with reference to basic needs e.g., water, land, forest, livestock and human resources and problem-related natural resources and relation with landscape and climate change.
Basic arithmetic, science and convergence.	Simple calculation with specific area, volume, slope, velocity, and discharge, materials and labour calculation in physical work.

Survey, method and technique (practical).	Contour, vertical, interval, horizontal interval, slope, calculation, simple survey, instrument and used in surveying.
Map reading.	Map reading & scale, contour, delineating of catchment development, calculate Catchment area of ECD, water budgeting and imposing.
Soil & Water Conservation Measures in CREFLAT (Physical/ Engineering/ Mechanical Measures, Vegetative/ Bio-Engineering Measures & Agronomical Measures).	All measures of Soil & Water Conservation and how they relate to landscape and climate changes.
Planning and implementation of Earthen Check dam.	Understand the Process & SOP's of Planning and execution and monitoring of earthen check dam
Day 2 – Field Visit for Land use/type of resources, technical site identification and survey	
Recap of Day 1	Review of last day (session wise).
Beat, Catchment Visit.	Understand the concept of catchment and how it integrates with check dams and other SMC measures. Slope and Vertical Interval measurement. Site selection, Survey of Check dams.
Participatory Microplanning of SWC to incorporate in VDP.	PRA's and Issue Focus PRA's, Existing and Proposed Land Use & Resource Map and beneficiaries of each proposed work.
Microplanning for VDP Preparation.	Material list need to be prepared.
Map Preparation 1. Land use 2. Soil and Water Resource.	Existing and Proposed map.
Transect Walk & Ground Truthing.	All structures and sites need to be physically verified and beneficiaries list with their demographic data need to be collected by each structure and activities.
Day 3 – Field Visit, Micro Planning for VDP	
Recap of day 2.	Review of last day (session wise).
Calculation of land use data.	Area calculation etc.
In-house Design & Estimate of Check Dam.	Design and estimate calculation of Earthen Check Dam
Open discussion.	Review of all work and discussion clearing all concerns and phasing out details to be touched during planning and implementation.
Post- Evaluation, Concluding & valedictory session.	Feedback and vote of thanks.

Note: Training module can be modified during training after getting the expectations of participants. Training materials (Soft Copy) will be given to all participants after the completion of the session.

4.3.5 Proposed Training Schedule

The training needs to be done as early as possible. The Range-wise tentative Plan for SWC training are as follows:

During	Range (Blocks)	Venue	Participants	Remarks
3 days	Dhamcherra	Roha	10-15	Resource Person: PMC SWC Experts Two Days Each Training
3 days	Dasda & Jampui Hill	Kanchanpur	15-20	
3 days	Manu & Durga Chaumuhani	Manu	15-20	
3 days	Ambassa & Salema	Ambassa	15-20	
3 days	Ganga Nagar & Chawmanu	Ganganagar	15-20	
3 days	Raisabari & Dumbar Nagar	Gandacherra	15-20	

Note:

- Range-wise participants (Range Officer, concerned Forester/ Beat Officers, FGs, TAs & VCWs).
- One day of in-house training will be held. Second day field visit & demonstration in the selected area/plots for SWC and Third day proposed for land use and activities and data analysis, and estimate and Budget preparation of structures.
- DPMA chief will arrange necessary arrangements i.e., projector, pen, pad, folder, lodging and boarding for participants, Travel, site selection etc.

4.4 Community Capacity Building

To be aware of the project and to build skills in the communities/VDPIC/JFMC/SHGs of GP/VC of each cluster team on SWC conservation, development and Management to Implement SWC activities.

4.4.1 Meeting & Awareness Building

Project details objectives/purpose/activities and working areas need to be shared in community meetings.

4.4.2 Exposure Visit

Exposure visits of farmers /stakeholders/beneficiaries need to be planned and done in Tripura state to see the best practices already done by the community and it is sustaining. People will understand farmers to Farmers interactions very fast.

4.4.3 Training

The full training will be implemented in the field.

Topics	Method
Regarding CREFLAT and its activities	Sharing and brainstorming/Chart Paper
Community Role in CREFLAT and How to Own the structures?	Brain Storming
Site Identification and site survey	On site practically
Structure and How to construct?	How to construct, a stepwise discussion?
What are the Quality Criteria Do's & Don'ts?	Share Do's & Don'ts
Review of Training (Learning, methodology, arrangement, sites for practical training & Feedback)	Validity session and Vote of Thanks

4.5 Training Evaluation:

A detailed training schedule will be prepared based on current awareness standards, need identification and module. Accordingly pre-evaluation of all participants can be done based on key knowledge/skill aspects. After completing the training program, evaluation of the effectiveness of the training program based on the pre-decided aspects/criteria can be done. Technical Officer (Agartala) of CREFLAT, a subject expert, under the guidance of PMC experts will evaluate the effectiveness of the program during their visit.

Consultant & Training Officer CREFLAT after completing the training along with its photographs will submit after completion of training.

Table 14. Evaluation of pre- and post-assessment of SWC training.

#	Name	Designation	Posting	Pre-Training (%)	Post Training (%)	Remarks
1						
2						
3						
	Total					

4.6 Role, Responsibility and Timeline

Technical assistance for the preparation of detailed design cost estimates and time timelines be provided by RO/SDO/DPMA/PMA/PMC and resource agencies within the government.

#	Procedure	Responsibility	Timeline
1	**Planning (site selection)**	VDPIC/JFMC	1 day
2	**Design**		
2.1	Detailed Design	RO	7 -21 days
2.2	Cost estimate	VDPIC/JFMC	
2.3	Approval of design cost estimate and construction schedule	DPMA	7-14 days
2.4	Agreement of design cost estimate & construction schedule	VDPIC/JFMC	7 days
3.	**Construction**		
3.1	Clearing of stub/jungle	VDPIC/JFMC	3-14 days
3.2	The Layout of the plan on the site	VDPIC/JFMC	1-2 days
3.3	Arrangement of materials and equipment	VDPIC/JFMC	7-30 days
3.4	Arrangement of labour	VDPIC/JFMC	7-14 days
3.5	Construction	VDPIC/JFMC	20-60 days
3.6	Final inspection	RO	1 days

Note: SHGs to be involved wherever relevant or feasible.

4.7 Operation and effect Indicators related to Soil & Water Conservation

Benefit	Indicator	Target	Monitoring Method	Responsibility
Social Benefit	Ratio accessible of HHs on check dam	70% accessible HHs of SHGs who involved need to get benefit	HHs survey and small group meeting	RO/SDFO/DPMA/PMA
Technical Benefit	The soil moisture ratio	10% increase in the proportion of soil moisture	Quarterly measurement of Soil Moisture at 2 measurement points and 2 control points select one GP/VC in each Range.	Range Office/DPMA/PMA
	Springs	Water availability in quantity (10%) and duration enhanced one	Focus discussion and Quarterly measurement of discharge of springs	RO/SDFO/DPMA/PMA

		month minimum of springs		
	Storage Volume enhanced	10% need to be enhanced in water bodies by renovation/repair and desilting	Measurement of mathematical calculation or excavated volume of soil	RO/SDFO/DPMA/PMA
	Silt application	Area and minimum 10% production enhance	Farmer FGD /Interview	RO/SDFO/DPMA/PMA
Economic Benefit (In the longer run PES could be tested as benefit)	Economic benefit (Pisciculture)	Minimum INR 1000/- benefitted each beneficiary per season	Beneficiaries FGDs and analysis	RO/SDFO/DPMA/PMA
Environment Benefit	Carbon Sequestered	Needs details study	Technical experts	PMA

4.8 Parameters regarding socio-economic and environmental impacts

The impacts to be assessed with regard to environmental and social impacts are:

Type of Impact	Description
Environmental Impact	On the natural environment air, water and its uses, soils, waste, climate change, ecosystems, fauna and flora and trans-boundary/global scale impacts.
Social-economic Impact	Migration of population and involuntary resettlement, local economy (such as employment and livelihood), health hazards, utilization of land and local resources, social institutions (such as social capital and local decision-making institutions), existing social infrastructures and services, vulnerable social groups (such as poor and indigenous peoples), equality of benefits, losses and equality in the development process, gender, children rights, cultural heritage, local conflicts of interest, infectious diseases such as HIV/AIDS, and working conditions including occupational safety.

5 Reference and Sources

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