PUBLIC WORKS PROGRAM UNDER PSSN III

Climate Smart Public Work Technical Manual
for use by Trainers and Site Supervisors

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Acknowledgement

The Climate-Smart Public Works (CSPW) Technical Manual is the result of a collaborative effort involving numerous stakeholders, including communities, village/*mtaa*/*shehia* representatives, and experts from project area authorities (PAAs). The development and review of this manual were supported with technical assistance from World Agroforestry (ICRAF), the World Food Programme (WFP), and the World Bank (WB). The Tanzania Social Action Fund (TASAF) Management Unit also provided valuable contributions throughout the compilation of this technical manual. The revision of this technical manual was necessary to incorporate new design elements for Productive Social Safety Net (PSSN) III, which were not included in the previous manual used during the implementation of PSSN I and II.

We would like to express our sincere appreciation to the TASAF Executive Director, Mr. Shedrack S. Mziray, and the Director of Community Support, Mr. John Elisha, for their valuable support during the revision of this technical manual. We also extend our gratitude to ICRAF (Represented by Anthony A. Kimaro and Boniphace Nkombe), WFP, and WB for their technical assistance in reviewing and developing this manual by incorporating new components aligned with the design of PSSN III. Special thanks are extended to the technical team that participated in reviewing the work norms during a workshop held in Dar es Salaam, Tanzania.

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Foreword

This technical manual for the design of Climate-Smart Public Works (CSPW) under PSSN III is a revised version of the 2019 TASAF Public Works Technical Manual. This edition has incorporated additional technologies from other countries implementing similar public works (PW) activities under their respective social protection programmes. Standards and provisional work norms showing work activities per day are also included in this revised technical manual. These work norms are instrumental in the preparation of an annual budget, considering the project type and the person-days (PDs) required for its implementation. PAA experts and ward-level extension officers are encouraged to customize these work norms to suit the Tanzanian context.

The technical manual has been prepared to provide practical guidance for PAA experts and ward-level extension officers to design and implement potential CSPW sub-projects that can create societal assets, ensure continuous project development, and help communities adapt to and/or mitigate the negative impacts of climate change.

The preparation of this technical manual was carefully undertaken, particularly in the selection of common techniques and technologies that are suitable and appropriate for land and water management activities. This technical manual is relevant to, but not limited to, intervention areas such as soil and water conservation, flood control, rainwater harvesting, small-scale irrigation, soil fertility management, climate-smart community access roads, waste disposal, small-scale clean energy technologies, forestry, and agroforestry.

This manual is supported with simple diagrams that simplify the design process in accordance with the required norms and standards. PAA sector experts are urged to read and use this manual when designing and implementing CSPW sub-projects.

Mr. Shedrack S. Mziray
Executive Director

Abbreviations

Acronym	**Full Form**
BOQ	Bill of quantity
BT	Bench terrace
BW	Bottom width
CCDR	Centre for Climate Change and Disaster Reduction
cm	Centimetre
CMC	Community management committee
CSPW	Climate-Smart Public Works
D/S	Downstream
EV	Eyebrow valley
FBD	Forest and Beekeeping Division
H	Height
ha	Hectare
HB	Herring bone
HT	Hillside terrace
HTT	Hillside terrace with trench
km	Kilometre
L	Length
LPG	Liquefied petroleum gas
LSP	Local service provider
m	Metre
MTRs	Micro-trenches
PAA	Project area authority
PSSN	Productive Social Safety Net
pd	Person-day
PW	Public Works
VC	Village council
VI	Vertical interval
W	Width
WFP	World Food Programme

PART I: BACKGROUND

A. Introduction

The Tanzania Country Climate and Development Report (World Bank 2024) and a study on climate change in East Africa, particularly in Somalia and Tanzania (Jalango et al. 2021), show that Tanzania's rural livelihoods and natural-resource systems are increasingly affected by rising temperatures, erratic rainfall, recurrent droughts, floods, erosion, and salinity intrusion. Over 60% of the rural poor live in high-risk zones where land degradation and poverty reinforce each other, resulting in fragile production systems and heightened vulnerability to climate shocks (World Bank 2024; Tanzania Country Climate and Development Report). Within this context, the Public Works Program (PWP) implemented under the Productive Social Safety Net (PSSN) has provided temporary employment and community assets such as roads, ponds, and woodlots; however, most of these assets remain exposed to climate hazards and environmental degradation due to limited integration of climate risk information, ecosystem data, and adaptive design principles (World Bank 2023). Consequently, the performance and durability of conventional PW interventions have been constrained, limiting their potential to contribute to long-term resilience and ecosystem restoration.

Climate-Smart Public Works (CSPW) is the next step in Tanzania's PWP evolution: it embeds climate-risk information and ecosystem-based practice into asset creation so that investments deliver triple dividends – better livelihoods and productivity, restored ecosystems, and reduced vulnerability to droughts, floods, erosion, and salinity. It operationalizes the national direction to mainstream climate change across sectors and local government planning and aligns with Tanzania's National Climate Change Response Strategy (NCCRS) (2021–2026) and the 2021 Nationally Determined Contributions (NDCs), which call for adaptive, low-emission development and risk-informed public investment. Evidence from the Centre for Climate Change and Disaster Reduction (CCDR) (2024) and WFP's Climate Response Analysis (2021) underscores the need for PW choices to be tailored by hazard and agro-ecological conditions, avoiding maladaptation and strengthening resilience at community level. These insights guide the development of a practical framework linking each sub-project to local hazards and agro-ecological zones, ensuring that CSPW investments remain climate-responsive, restorative, and sustainable.

This technical manual provides essential guidance for project area authority (PAA) experts, ward extension officers, and community project supervisors on the technical specifications and sector norms required to implement CSPW activities under PSSN III. It outlines the planning and implementation of technical standards in relation to local conditions such as topography, soil type, landscape, vegetation cover, and rainfall patterns. The manual is designed as a practical information kit that summarizes key technological parametres and directs users to consult additional sources where necessary.

The manual is organized into categories that reflect the range of field technologies commonly applied through CSPW, including soil and water conservation, flood control, rainwater harvesting, small-scale irrigation, soil fertility management, forestry and agroforestry, urban forestation, disposal of inorganic wastes, simple soil-texture testing techniques, climate-smart community access roads, and small-scale clean energy technologies. While the content presents standard parametres and diagrams for field use, it remains flexible so as to accommodate diverse local agro-ecological conditions.

In adapting the manual to CSPW, the approach builds on Tanzania's public works experience while intentionally integrating climate risk, ecosystem restoration, and low-emission development objectives. CSPW aligns public works with climate-smart agriculture (CSA) and sustainable land management (SLM) so that each sub-project contributes to three mutually reinforcing outcomes: productivity and livelihoods, resilience and adaptation, and mitigation and environmental sustainability. This evolution from conventional PW to CSPW enables community assets to deliver longer-term, climate-resilient benefits.

The subsequent subsections set out the manual's objectives, the criteria for technology selection, participatory identification and prioritization of projects, the technical skills required for quality delivery, and health and safety measures for all worksites. Section 3 will dedicate technology selection to the CSPW framework, ensuring activities are screened and designed using climate-informed criteria consistent with national priorities.

Objectives of the technical manual

The main objective of this technical manual is to guide sector experts in following minimum technical standards for the planning and implementation of CSPW sub-projects, considering local conditions such as topography, soil type, landscape, vegetation cover, rainfall patterns, and other relevant design parametres .

The manual is designed to equip experts and field supervisors with essential practical information on design specifications, construction requirements, and sector norms necessary for effective implementation of CSPW activities. It ensures that all interventions contribute to both the creation of productive community assets and the strengthening of resilience to climate variability and environmental degradation. In line with the CSPW approach, the manual also aims to enhance the integration of social protection, ecosystem restoration, and climate adaptation objectives.

By applying the technical standards outlined here, PAA experts and ward-level extension officers will be able to design and supervise sub-projects that are technically sound, environmentally sustainable, and socially inclusive. The manual therefore serves as both a reference and a training tool for practitioners implementing CSPW sub-projects across Tanzania, ensuring consistency, quality, and long-term benefits in line with national and programmatic priorities under PSSN III.

Selection of CSPW technologies

The selection of CSPW technologies is central to ensuring that sub-projects contribute not only to employment creation but also to sustainable resource management, ecosystem restoration, and climate resilience. The technologies included in this manual are labour-based interventions that promote adaptation and resilience to climate change while maintaining the simplicity necessary for community-level implementation. They have been designed for areas at risk of natural resource degradation, declining productivity, and increased climate variability. The technical diagrams and guidelines in this manual have been simplified for easy application by PAA experts, ward extension officers, and community coordinators.

In selecting appropriate CSPW technologies, priority should be given to interventions that address the most pressing local challenges related to soil degradation, water scarcity, vegetation loss, and climate shocks. Selection should therefore be guided by climate-risk screening and participatory planning processes to ensure that technologies are demand-driven, technically sound, environmentally sustainable, and economically viable. Each sub-project should be aligned with the CSPW framework, which integrates three interrelated pillars: productivity and livelihood enhancement; resilience and adaptation; and mitigation and environmental sustainability.

Operationalization of the CSPW pillars

The Climate-Smart Public Works (CSPW) framework translates its three conceptual pillars into field-level actions that deliver concurrent social, ecological, and climate benefits. Each pillar complements the others, forming a single adaptive system that connects social protection with ecosystem restoration and climate objectives (Figure 1.1.1).

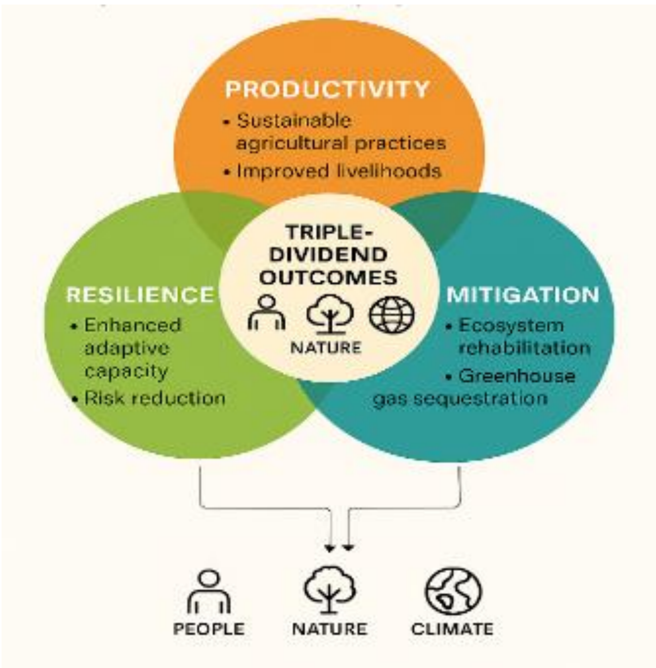


Figure 1.1.1 *Integrated Climate-Smart Public Works (CSPW) framework showing interlinkages among productivity, resilience, and mitigation pillars and their combined triple-dividend outcomes (people–nature–climate).*

a) Productivity and livelihood enhancement

This pillar focuses on creating productive community assets and livelihood opportunities that improve household income while restoring degraded land and water systems. CSPW applies climate-smart agriculture (CSA) and sustainable land management (SLM) technologies – such as contour bunds, terraces, water-harvesting structures, woodlots, and agroforestry systems – to enhance land productivity, diversify income sources, and stabilize yields in variable climates. The works involved during asset creation processes are based on the following qualities: decent in nature, labour intensive, and accessible, i.e., not more than one-hour walking distance away. Beyond wages and skills delivered through short-term employment, participants benefit from improved soil fertility, increased access to water, and more reliable yields, forming the economic foundation upon which resilience and mitigation outcomes are built.

b) Ecosystem resilience and adaptation

The second pillar strengthens the ability of households and ecosystems to absorb and recover from climatic shocks. CSPW integrates climate-risk and vulnerability information into project screening to ensure that investments target the most exposed and resource-constrained communities. Activities such as watershed restoration, rangeland reseeding, flood-control structures, and vegetative buffer zones reduce hazard exposure while maintaining productive potential. At programme level, this pillar aligns with the principles of adaptive social protection (ASP), linking predictable safety-net transfers with early-warning systems, contingency financing, and local resources governance.

c) Mitigation and environmental sustainability

The third pillar ensures that CSPW contributes to long-term environmental and climate-mitigation goals. Many CSPW activities such as afforestation, agroforestry, rangeland management, and soil-organic-matter enhancement sequester carbon while reducing deforestation and land degradation. Beyond carbon benefits, this pillar enhances ecosystem services that support livelihoods, including groundwater recharge, erosion control, biodiversity restoration, and micro-climate regulation. Integrating environmental indicators – such as vegetation cover, soil carbon change, and erosion reduction into monitoring frameworks helps track these co-benefits and supports accountability for national climate commitments.

d) Integration of the three pillars

The three CSPW pillars are mutually reinforcing. Productivity interventions provide the livelihood base that supports adaptation; adaptive actions secure those gains against shocks; and mitigation measures sustain the natural systems on which both depend. Together, they deliver triple-dividend outcomes – benefits for people (livelihoods and well-being), nature (ecosystem health), and the climate (reduced emissions and enhanced carbon storage).

To operationalize these pillars in practice, CSPW implementation follows five interlinked design steps that guide project planning from site identification to results monitoring (Figure 1.1.2). These steps include climate-risk screening; participatory community prioritization; technical design and standardization; implementation and supervision; and monitoring, evaluation, and learning. Together, they form the operational backbone of the CSPW framework, ensuring that every selected technology and sub-project progresses systematically from climate-risk identification to measurable livelihood and ecosystem outcomes.

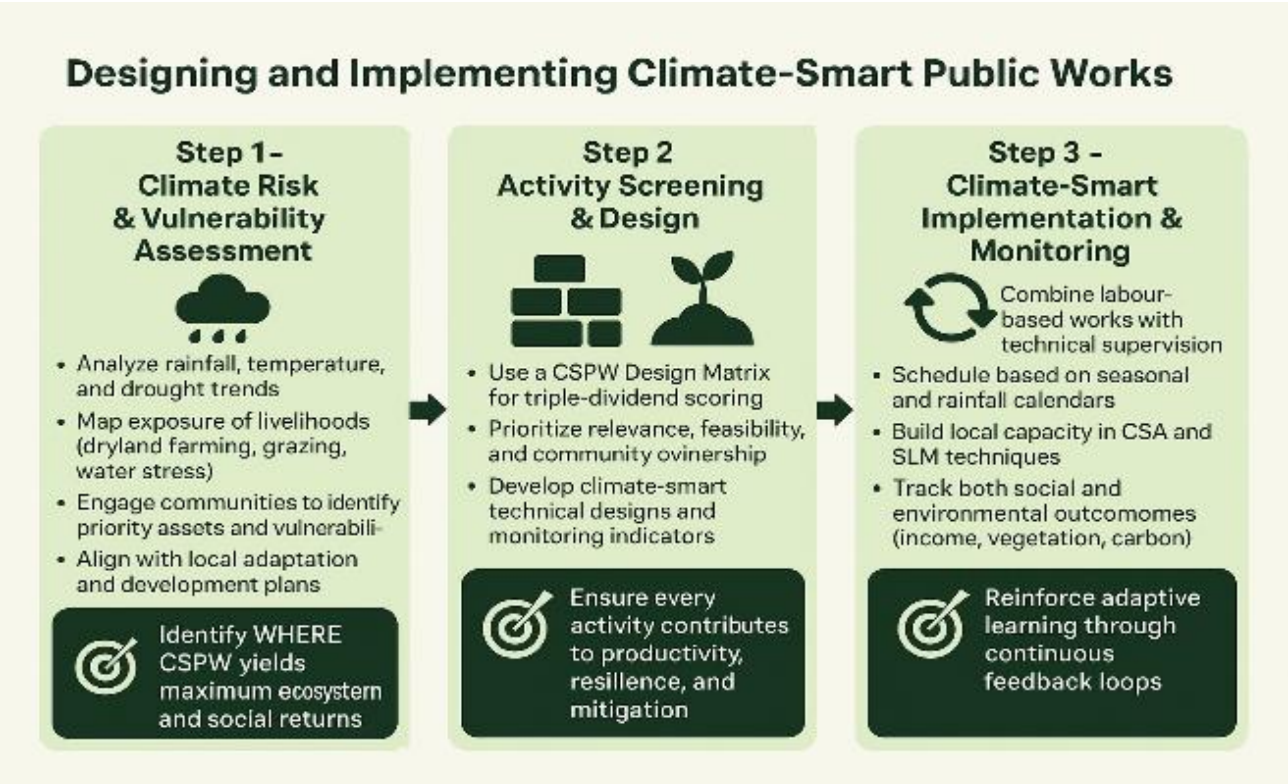


Figure 1.1.2 *Sequential CSPW design steps from climate-risk screening to monitoring and learning, showing how implementation moves systematically from risk identification to sustainable livelihood and ecosystem outcomes.*

Each stage of the CSPW design and implementation process is intentionally structured to reinforce the three operational pillars – productivity and livelihood enhancement, resilience and adaptation, and mitigation and environmental sustainability. The matrix in Figure 1.1.3 illustrates how every design step contributes simultaneously to these pillars, ensuring that CSPW delivers triple-dividend outcomes across all phases of implementation.

This integrated design logic confirms that CSPW is not a separate or parallel programme, but a climate-informed evolution of Tanzania’s existing public works. Through this approach, the programme strengthens national commitments on climate adaptation and mitigation while aligning public works investments with the broader objectives of sustainable landscape restoration.

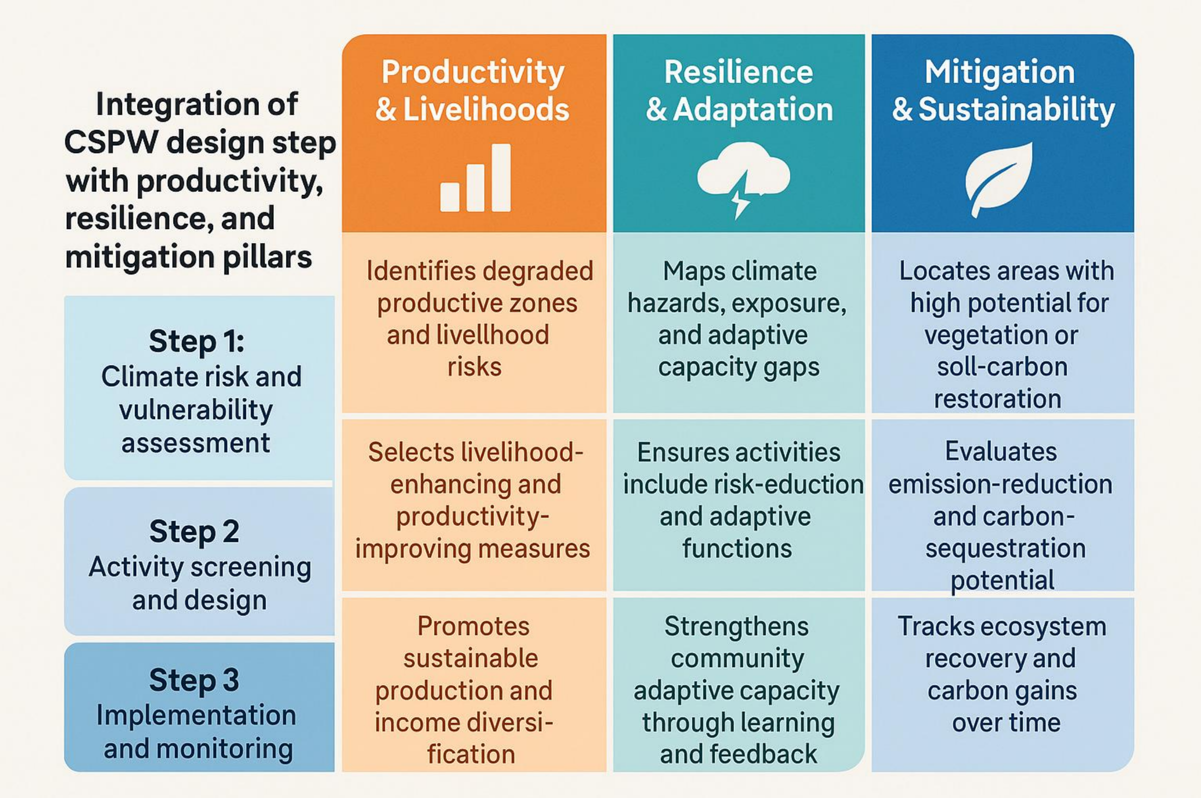


Figure 1.1.3. *Integration of CSPW design steps with productivity, resilience, and mitigation pillars, demonstrating how each stage of the implementation process contributes simultaneously to the three operational outcomes across the programme cycle.*

Identification and prioritization of sub-projects

Identification and prioritization of CSPW sub-projects is a crucial step in ensuring that interventions are community demand-driven, technically sound, and environmentally sustainable. This process builds on the existing TASAF's PW model, which emphasizes community participation, technical guidance from PAA experts, and the use of local knowledge to identify priority areas for development and restoration.

Communities are responsible for identifying and prioritizing sub-projects that respond to their immediate needs and development priorities. These may include activities such as soil and water conservation, road rehabilitation, afforestation, and rainwater harvesting. Under CSPW, this process is further strengthened by integrating climate-risk and vulnerability screening to ensure that proposed sub-projects address both current and projected climate challenges.

The sub-project's identification process begins at the community level, where PAA facilitators facilitate the communities at village, mtaa, or shehia levels to identify and prioritize the potential sub-projects through the community meetings. Participatory tools such as resource mapping, problem ranking, and seasonal calendars are used to identify degraded areas and determine the types of interventions required. In CSPW, additional emphasis is placed on identifying zones affected by erosion, water scarcity, or recurrent drought to align with climate adaptation and mitigation priorities.

Once communities have proposed a list of potential sub-projects, it is submitted to ward level for review and approval by ward development committees (WDCs) before submission to PAA level. Upon the submission to PAA level, PAA sector experts review and verify the technical feasibility of each activity and prepare sub-project application packages. The review ensures that sub-projects conform to CSPW technical standards, are environmentally appropriate, and can be implemented using manual labour. During this stage, experts may also introduce complementary measures, such as soil fertility improvement, rangeland rehabilitation, or tree-planting activities that enhance ecosystem resilience.

The prioritization process follows criteria agreed upon by the community and guided by TASAF procedures, which are described in the CSPW Handbook. Priority is given to projects that:

- address the most severe forms of land degradation and climate vulnerability
- create productive and durable community assets
- benefit many community members, including women and youth
- are technically feasible and labour intensive
- align with national and local development and environmental goals.

The selected sub-projects are then incorporated into the community action plans (CAPs) and forwarded to the PAA technical teams for final review and approval. Under CSPW, an additional layer of screening is introduced to assess the climate and environmental co-benefits of each project, ensuring that selected activities contribute to the three CSPW pillars – productivity, resilience, and mitigation.

By maintaining Tanzania's well-established participatory PW structure while incorporating climate-risk analysis and environmental safeguards, CSPW ensures that public works investments remain community-driven yet aligned with national climate priorities. The process also builds local ownership, strengthens adaptive capacity, and supports the creation of productive, climate-resilient assets that sustain both livelihoods and ecosystems.

Technical skill requirements

Implementation of CSPW projects requires a combination of technical expertise, community experience, and practical field skills to ensure quality and sustainability of results. The existing structure used for public works under TASAF remains the foundation for project execution, with additional emphasis placed on climate-smart planning, design, and supervision.

At the PAA level, sector experts including agricultural, environmental, forestry, community development, and engineering experts provide technical oversight during project design, implementation, and operation. They ensure that CSPW sub-projects meet the required technical standards, adhere to environmental safeguards, and are aligned with the programme's three operational pillars: productivity, resilience, and mitigation. Their responsibilities also extend to ensuring that planned CSPW activities incorporate adaptive measures such as soil and water conservation, vegetative stabilization, and the use of climate-resilient materials where applicable.

a) Village extension officers play a key role in overall supervision of the planned CSPW activities in the communities (villages/mitaa/shehia) located at their respective village level to ensure that implementation of CSPW sub-projects considers the required procedures and guidelines. Also, they provide technical support to village councils (VCs) and community management committees (CMCs) during the planning, implementation, and operational stages of the CSPW sub-projects.

b) At community level, local service providers (LSPs) and CMCs are generally responsible for day-to-day monitoring of CSPW planning, implementation, and post-implementation at community level.

At the community level, the CMC is responsible for supervising the day-to-day implementation of CSPW activities. The CMC will also be responsible for the planning, implementation, monitoring, and evaluation of CSPW activities. This committee operates under the auspices of a village council/shehia advisory council/mtaa committee.

LSPs are persons with the technical ability and skills needed for a particular sub-project; they act as intermediaries between the CMC and the PAA technical team. They act as day-to-day local technical site supervisors and ensure that the sub-project is implemented according to sector norms and standards by interpreting the work plans, drawings, and bills of quantities (BOQs) provided.

To strengthen technical capacity, continuous on-the-job training and supervision are encouraged throughout the project cycle. This includes refresher sessions on design interpretation, simple surveying techniques, and maintenance planning. In areas exposed to high climate risk, additional coaching on early-warning response, erosion control, and water-harvesting techniques is provided to enhance the long-term effectiveness of CSPW assets.

Safety at the workplace

The health and safety risks to which community workers may be exposed from each type of sub-project will be assessed, as well as the ability to prevent or eliminate such risks. Where risk cannot be prevented or eliminated, measures to protect community workers from exposure will be implemented.

Labour risks that may arise from the nature of activities to be undertaken include incidents of child labour, accidents and injuries, and other occupational health and safety hazards. In such circumstances, the project will address these risks by providing awareness to site supervisors and beneficiaries on occupational health and safety, providing safety gear, and ensuring the availability of sanitary and waste disposal facilities at each sub-project site.

The risk of child labour will be mitigated through certification of workers' age. This will be done using legally recognized documents such as the national identification card, voter registration card, or birth certificate. In circumstances where these documents are not available, an affidavit of birth will be used. In addition, awareness-raising sessions will be regularly conducted in the community to sensitize members on the prohibition and negative impacts of child and forced labour.

To minimize the risk of accidents at workplaces, each site will be planned to include a description of all important areas, including an emergency assembly point. Signboards will be installed in appropriate locations to provide information on safety precautions and recommended actions to avoid accidents.

Under CSPW, special attention should also be given to climate- and weather-related risks such as extreme heat, heavy rainfall, or strong winds that may affect worker safety. Work schedules should consider these conditions to ensure safe and continuous implementation of activities.

B. Simple land surveying techniques

Surveying is the technique, profession, and science of determining the terrestrial or three-dimensional positions of points, and the distances and angles between them. It includes setting out contour lines, determining differences in elevation, and measuring horizontal distances between various points. The use of line levels, mason's or water levels, and A-frames are the types of equipment described in this section. These simple instruments can be used by technical staff or local service providers after a short period of training. The methods presented here can be applied in the implementation of sub-projects such as the layout of charco dams, irrigation canals, and soil and water conservation structures.

In the context of CSPW, accurate land surveying ensures that all sub-projects are properly designed and aligned to site conditions such as slope, elevation, and terrain features. This improves the quality, stability, and effectiveness of assets created under the programme while supporting climate-resilient planning and implementation.

Line level (water level)

Description

Line levels are small-sized spirit levels designed for levelling land surfaces over long distances by attaching them at the centre of a horizontal string supported by two vertical wooden poles at each end. They are simple devices that can be used over relatively long distances (up to about 20 m). To avoid the cost of purchasing a line level, a mason's level together with a cord or rope can be used to form a simple line level. See Figure 1.2.1.

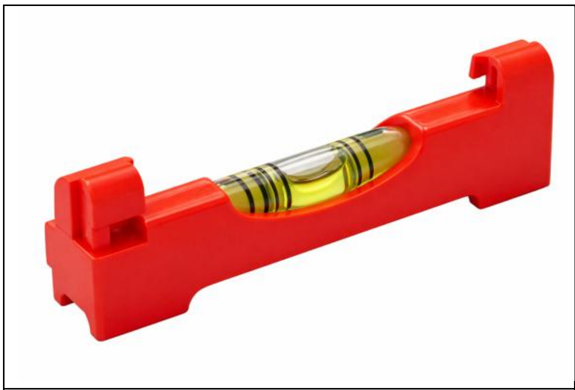
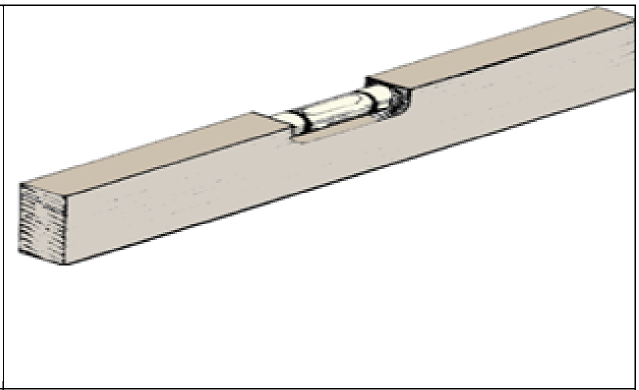
	
Line level (a)	Mason's/sprit level(b)

Figure 1.2.1. *Line level (a) and mason's or spirit level (b) used for establishing a horizontal reference line in simple land surveying.*

How to make a simple line level using a mason's level

Procedures

- Obtain a cheap mason's level with a wooden case and screw a strong screw-eye into each end-face, on the centreline and close to the top of the case.
- Use two cords or strings, each 5 m to 10 m long, and tie them to the screw-eyes.

- Depending on the slope and vegetation at the site to be surveyed, wrap the ends of the cords or strings so that the total distance between poles is at least 10 m to 20 m.
- The level should lie at the centre of the cord or string. The mason's level can now be used as a line level (see Figure 1.2.2).

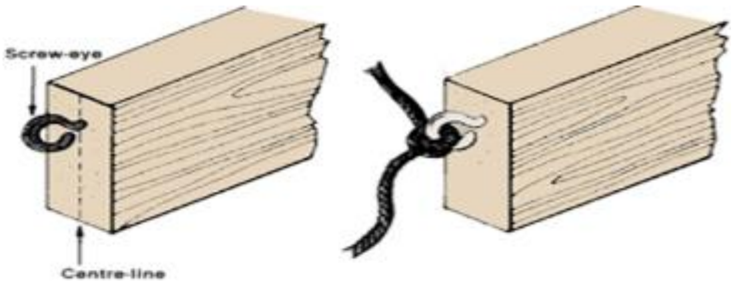


Figure 1.2.2. Assembling a simple line level using a mason's level and cords.

Marking contour lines with a line level

A contour is an imaginary line joining points of equal elevation. By marking contours in an area, it becomes possible to plan water-harvesting and erosion-control measures such as contour bunds, contour trenches, and irrigation canals (see Figure 1.2.3).

Figure 1.2.3. Field demonstration of contour marking using a line level, showing a three-person team operating along a gentle slope to identify points of equal elevation.

Requirements
Line level; thin plastic rope (11 m long); two wooden poles (2 m each, marked at 10 cm intervals); measuring tape; and short poles for ground marking.

Preparation
Fix the rope to each wooden pole so that exactly 10 m of rope is between the poles. Mark the middle of the rope (5 m) with a knot. Hang the small line level at the centre of the rope. At least three people are needed to survey a level line and mark it on the ground (Figure 1.2.4).

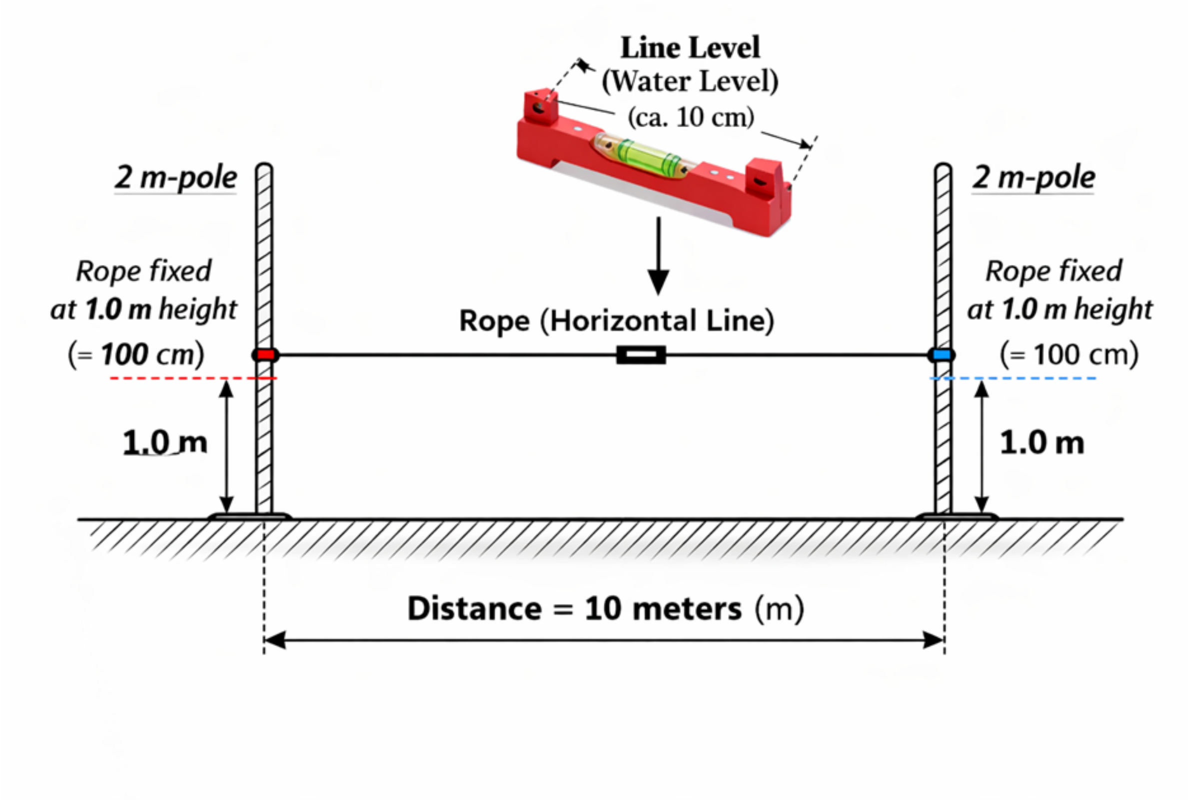


Figure 1.2.4. *Equipment setup for contour marking with a line level*

Procedures

- The rear person places a levelling staff on starting point A of the line to be surveyed. Attach one end of the cord at the 1 m graduation of the staff. The total cord length after tightening should allow 10 m between poles.
- The front person takes another levelling staff or pole with a marking pin and the other end of the cord, walks along the line, and stops when the cord is well stretched.
- Place the second staff vertically on the ground along the line being levelled. Adjust the cord until the line level is approximately horizontal. Mark this point with a pin.
- The centre person signals the front or rear person to move the cord up or down until the bubble in the line level is centred.
- The rear and front persons read the heights of their respective cords on the staffs. Record rear and front readings in separate columns.
- The front person removes the staff and replaces it with a marking pin. The team then progresses forward along the line, repeating the same procedure.
- Begin the next measurement from point B and continue to the last point (D). (Figure 1.2.5).

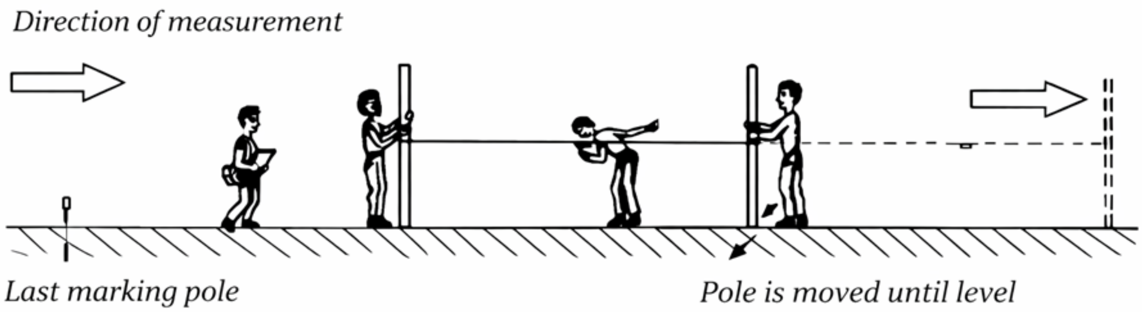


Figure 1.2.5. *Field marking of contour points along a level line.*

Example of field measurements and slope calculation using a line level

The height differences found during measurement can be summarized as shown in Table 1.2.1. Table 1.2.2 shows how to calculate the height difference and slope percentage.

Table 1.2.1. Field readings for contour measurement using a line level

Stations	Rear (R) (cm)	Front (F) (cm)
1 (A–B)	100	96
2 (B–C)	100	89
3 (C–D)	100	92

To calculate height differences for the entire line:

The height differences found during measurement can be summarised as shown below.

- Subtract the front reading from the rear reading for each station, then add up the differences to find the total height difference.

Table 1.2.2. Calculation of height differences and slope percentage between points A and D

Stations	Rear (R) (cm)	Front (F) (cm)	Difference (cm)
1 (A–B)	100	96	4
2 (B–C)	100	89	11
3 (C–D)	100	92	8
1 to 2	Total		23

The vertical interval between A and D is 4 + 11 + 8 = 23 cm (0.23 m). The horizontal distance A–D is 10 m × 3 = 30 m.

Slope (%) = (change in vertical distance × 100) / change in horizontal distance Therefore, average slope between A and D = (0.23 × 100) / 30 = 0.8%.

The Pipe Level

A pipe level is made of a transparent pipe, at least 5 m long, fastened to two wooden staffs marked at 10 cm intervals. It operates on the principle that stationary (non-flowing) water always attains the same level. When the water level in both ends of the pipe is the same, the two points are at equal elevation. Readings from the scale should always be viewed from the bottom upward, not from top to bottom. The pipe level is simple, low-cost, and suitable for community-based CSPW works requiring accurate contour or gradient establishment. See Figure 1.2.6..

Figure 1.2.6. *Illustration of a pipe level set-up showing two wooden scales connected by a transparent water-filled tube, demonstrating how equal water levels at both ends indicate points of equal elevation.*

Requirements

- Two wooden rulers or scales, each about 1 m long (can be locally made if not available).
- A thin, transparent plastic pipe of at least 5 m length.
- Fine thread or transparent adhesive tape for fastening.

Preparation

1. Tie one end of the pipe to one of the wooden scales so that about 15 cm of pipe extends beyond the end.
2. Fasten the pipe along both scales at 2–3 points using transparent tape or thread, ensuring the pipe stays close to the scales (see Figure 1.2.7).

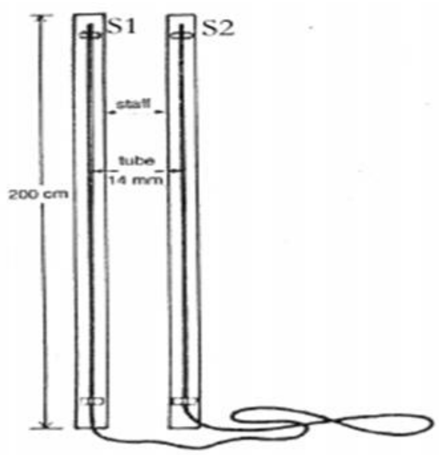


Figure 1.2.7. *Assembly of a simple pipe level using transparent tubing and two wooden scales*

3. Collect clean water in a broad vessel (e.g., a bucket) placed slightly higher than ground level. Dip one end of the pipe into the water and gently suck at the other end until water starts to rise inside (Figure 1.2.8).

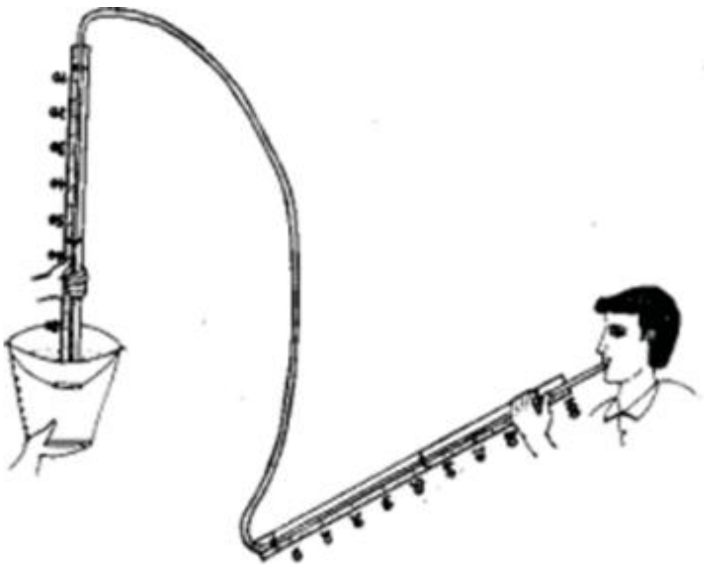


Figure 1.2.8. *Filling the transparent pipe with water to prepare the pipe level.*

4. Remove the pipe from your mouth and ensure no air bubbles remain inside. If bubbles appear, let them flow out before use.
5. Press both ends of the pipe with your thumbs and place them together on the ground. When both ends are filled with water, lower one end slightly to release any excess until the water column measures about 50–60 cm in each arm.
6. Place one scale on a slightly higher surface and the other on a lower surface. Even though the readings on each scale may differ, the water level in both pipe ends will always be identical. The pipe level is now ready for use (Figure 2.9).

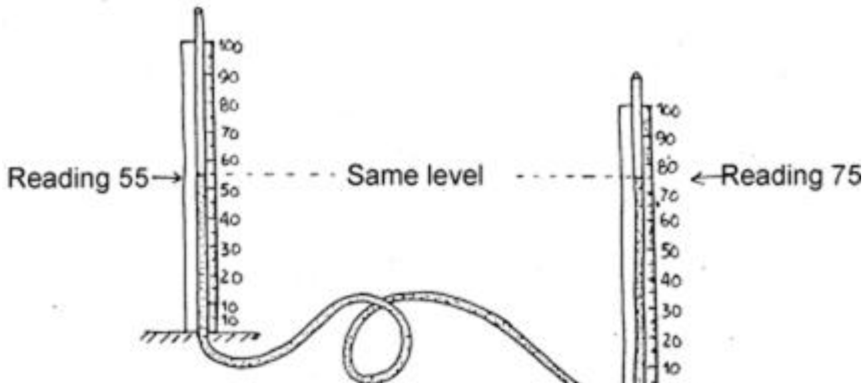


Figure 1.2.9. *Testing the pipe level on uneven ground to confirm that water levels remain equal at both ends, indicating accurate levelling.*

Marking Contour Lines Using a pipe level

Accurate contour marking helps in the design of soil and water conservation works, irrigation layouts, and small dam embankments. In CSPW applications, these contours ensure that community works are properly aligned with terrain and hydrological conditions to enhance water retention and reduce erosion.

Procedures

- Place one scale (S_1) at a chosen starting point in the area. Position the other scale (S_2) at another point to be checked.
- Compare the water levels in both scales. If the readings are equal, the two points are at the same elevation.
- If readings differ:
    - When S_2's water level appears higher than S_1, the ground at S_2 is lower - move S_2 uphill.
    - When S_2's water level is lower, S_2 is higher - move S_2 downhill.
- Continue adjusting until both readings match, then fix a peg where S_1 was located.
- Keeping S_2 in place, move S_1 to a new point and repeat. Fix another peg where the readings coincide.
- Repeat, alternately moving S_1 and S_2 until the whole area is covered.
- Join all pegged points with a line - this represents a contour line.

Contours identified this way form the basis for locating contour trenches, bunds, or irrigation canals (Figure 1.2.10).

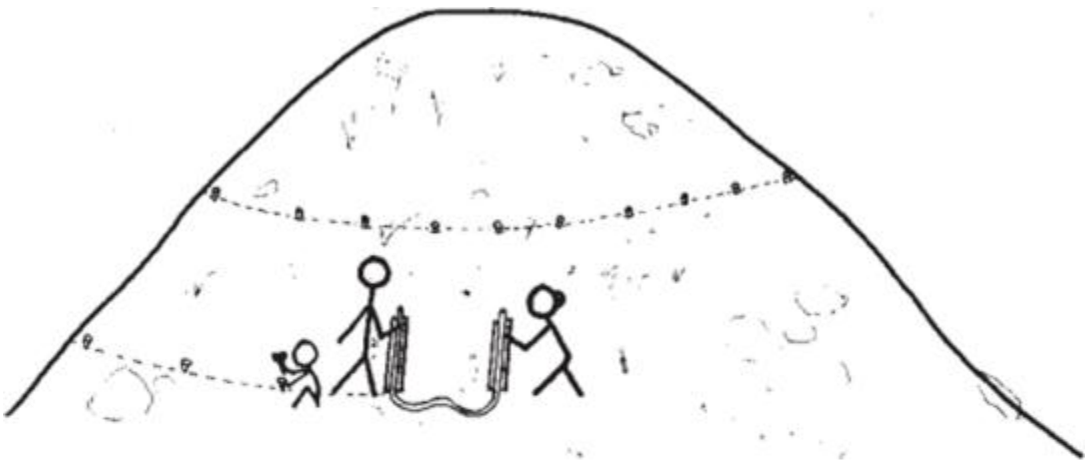


Figure 1.2.10. *Field use of a pipe level for contour marking, showing alternating placement of scales S_1 and S_2 along a slope.*

Calculation of Slopes

To determine land slope using the pipe level (**Figure 1.2.9**):

- Keep S_1 at point A and S_2 at point B. Record the water-level readings on both scales.
- The difference between the two readings is the vertical interval between A and B. Measure or pace the horizontal distance between the same points.
- Keeping S_2 at B, shift S_1 to C and repeat the process until the last point E is reached.
- Add all vertical intervals to obtain the total vertical interval (V).
- Add all horizontal intervals to obtain the total horizontal interval (H).

- Compute slope (%) = (V × 100) / H.

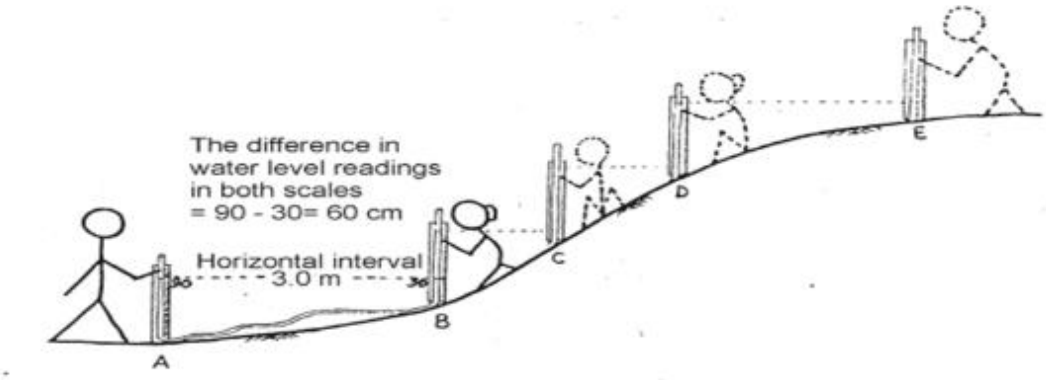


Figure 1.2.11. *Using a pipe level to survey a streambed and determine the proposed dam height and spillway location.*

Application of levelling techniques for surveying before dam construction

Both the pipe level and line level can be applied along a streambed or valley to determine the maximum dam height, embankment alignment, and spillway location before construction. By measuring relative elevation changes, technicians can estimate fill volumes and identify suitable spillway points for charco dams or similar small-scale CSPW water-harvesting structures (Figure 1.2.12)

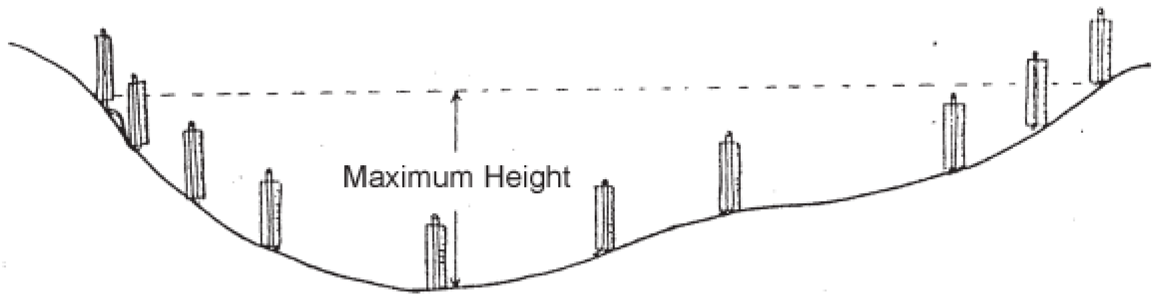


Figure 1.2.12 Surveying a streambed using a pipe level to determine dam height and spillway alignment.

Slope Calculation (Table 1.2.3)

Table 1.2.3. Example of slope calculation using readings from a pipe level.

Point pair	Vertical difference (m)	Horizontal distance (m)
A–B	0.60	3.0
B–C	0.44	1.8
C–D	0.38	2.2
D–E	0.43	3.2

Total vertical interval = 0.60 + 0.44 + 0.38 + 0.43 = 1.85 m
Total horizontal interval = 3.0 + 1.8 + 2.2 + 3.2 = 10.2 m

Average slope (%) = (1.85 × 100) / 10.2 = 18 %

Relationship between vertical interval, horizontal interval, and slope

The slope of land is the ratio between the vertical interval (rise) and horizontal interval (run). It can be expressed as a percentage or in degrees.

- The *horizontal interval* is the straight-line distance across the ground.
- The *vertical interval* is the direct rise or fall between the same points.

Example
If you walk 3 m horizontally while gaining 1 m in height:
Slope (%) = (1 × 100) / 3 = 33.3 %

The A-frame

An A-frame is a simple wooden instrument used mainly to identify contour lines. The simplest form of an A-frame consists of two similarly sized wooden or steel poles, each about 2 m long, joined at the top to form an angle of about 45 degrees or more. A third horizontal pole connects the two legs, completing the letter "A." The joints are tied with rope or welded, and a plumb bob or small weight is hung from the top joint between the two legs (*Figure 1.2.13*).

It is a simple, inexpensive tool that can be made from locally available materials and is easy to use, making it ideal for community-based CSPW fieldwork.

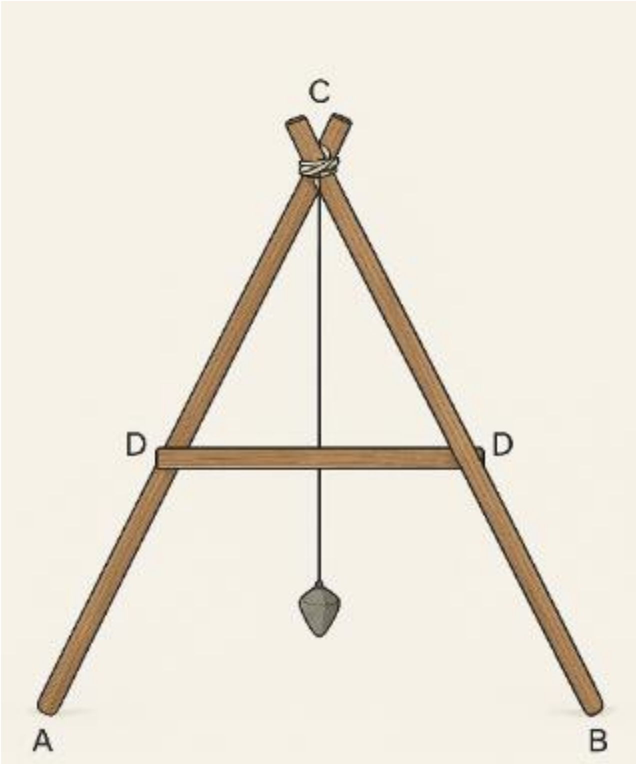


Figure 1.2.13. *Basic structure of an A-frame showing legs A and B, crossbar D, and plumb line with stone.*

Requirements and procedures for making an A-frame

- Two wood poles, each about 2 m long
- Fine thread
- Thick, strong rope
- Small, flat stone or plumb bob
- Small saw or knife
- Measuring tape

To construct the A-frame

Preparation

- Take two wood poles of equal height and sharpen one end of each. These ends will be inserted into the ground. Leave about 15–20 cm at the top and join the poles to form the letter “A.”
- Mark the joint where the two poles meet (point C). Make shallow notches and tie the poles securely with rope. These poles form foot A and foot B.
- Fix a third horizontal pole (D) across the two legs to complete the A-frame. Mark the points where pole D meets poles A and B, make notches, and fasten tightly with rope.

- Tie a thin thread at point C and hang a small flat stone or plumb bob so that it hangs freely below the crossbar D, just above the ground.

Calibration

- Place the A-frame on level ground with both feet touching the surface (points X and Y). Observe where the thread crosses the crossbar and mark this position as K (Figure 1.2.14).
- Reverse the frame (swap X and Y) and mark the new position L.
- Measure the midpoint between K and L and mark it O. When the plumb line crosses O, the A-frame stands level on the ground.

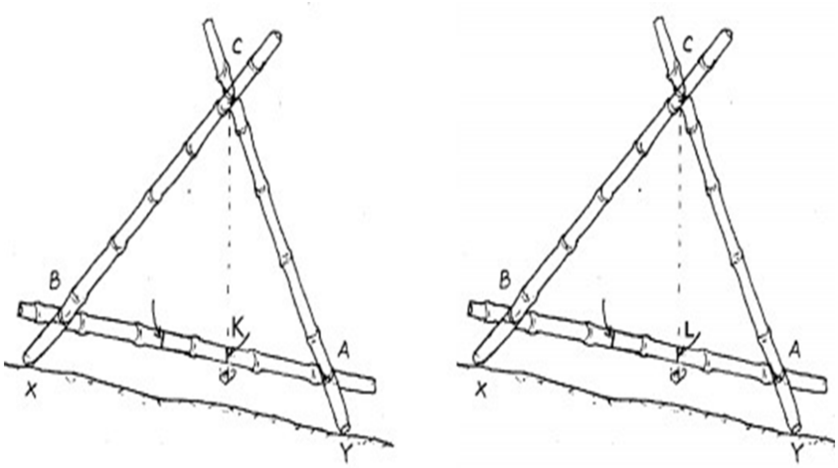


Figure 1.2.14: *Calibration of an A-frame showing the plumb line intersecting midpoint O to indicate level ground.*

Marking contour lines using an A-frame

When marking contours (Figure 1.2.15)

- Place foot A at the starting point P.
- Move foot B until the plumb line passes exactly through midpoint O. If it does, points A and B are at the same elevation.
- If the line falls to one side of O, shift foot B forward or backward until it aligns.
- Fix a peg at P and move foot A to a new point Q, keeping foot B in place.
- Repeat the process to find additional contour points (Q, R, S…).
- Connect all pegged points to form a continuous contour line.

This method enables accurate planning of structures such as contour bunds, trenches, and water-harvesting channels along natural contour lines.

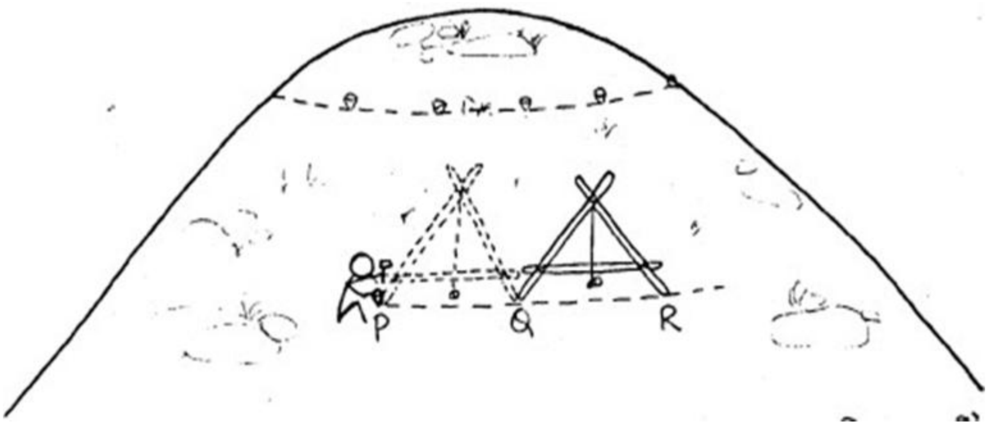


Figure 1.2.15. *Using an A-frame in the field to identify contour points for layout of soil and water conservation structures*.

Measuring land slope using an A-frame

The slope of land is determined using the formula:
Slope (%) = (Height / Horizontal Distance) × 100

Procedure: Place the A-frame on level ground with feet A and B touching points X and Y. Confirm that the plumb line crosses midpoint O; this indicates a level position. (Figure 1.2.16)

- Measure the distance between X and Y (e.g. 2 m = 200 cm).
- Raise foot B by 10 cm using a brick or block. The plumb line will move away from O and cross the crossbar at a new point — the 5% slope mark (since 10 ÷ 200 × 100 = 5 %).
- To mark other slopes: 10% → raise 20 cm; 15% → 30 cm; 20% → 40 cm, and so on.
- Repeat for both sides of O to indicate upslope and downslope positions.
- When measuring slope, take at least five readings and calculate their average for accuracy.

Example
If slope readings are 7, 9, 15, 12, and 7,
Average slope = (7 + 9 + 15 + 12 + 7) ÷ 5 = 10%

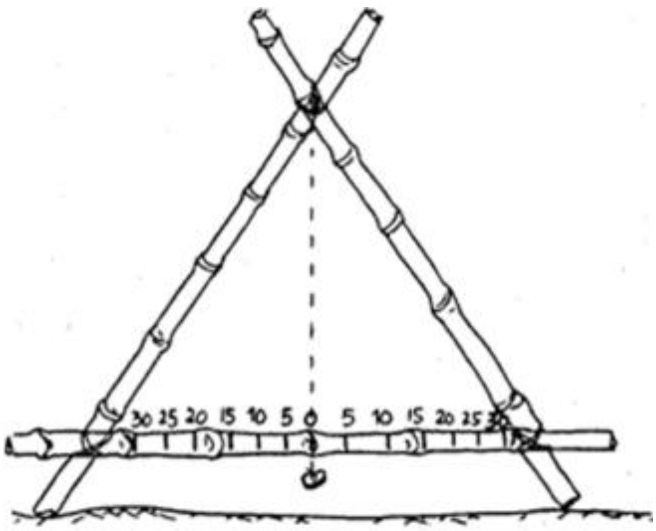


Figure 1.2.16. *Marking slope percentages on an A-frame by raising one foot to known heights.*

Special Precautions

- Ensure the A-frame is securely fastened; loose joints cause errors.
- If bamboo is unavailable, use wooden poles of similar length joined with bolts and nuts.
- The plumb line must hang freely from point C at the centre of the frame.
- Use a flat stone as the weight to prevent twisting.
- The feet of the A-frame should not be sharp or pointed, to avoid sinking into soft soil.
- Keep the A-frame upright during measurement to allow free movement of the plumb line.
- The thread should be of moderate length not so long that it touches the ground and not so short that it misses the crossbar D (*Figure 1.2.17*).

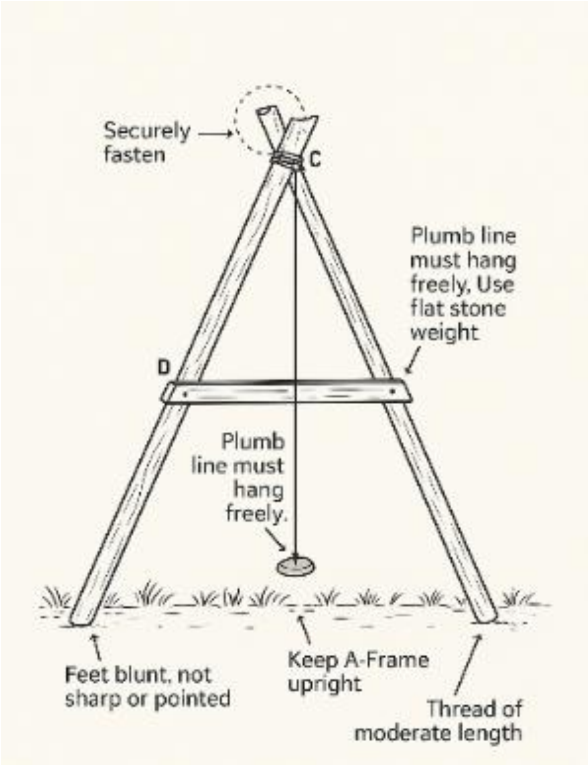


Figure 1.2.17. *Proper field positioning of an A-frame and precautions for accurate readings.*

C. Simple soil texture testing techniques

Soil types can be classified based on several factors such as colour, productivity, and texture (Figure 1.3.1). This section describes simple field methods used to determine soil texture, which is an important factor influencing water retention, drainage, and suitability for different CSPW structures such as bunds, terraces, and ponds.

Figure 1.3.1. *Common soil texture types: sand, silt, and clay*

Preparation of soil samples for texture determination

Procedure

- Collect the soil sample from a depth and location corresponding to where construction materials will be excavated or where infrastructure will be built.
- Separate the fine earth fraction (soil composed of sand, silt, and clay) from large particles such as gravel, pebbles, and stones.
- Use only the fine earth portion for performing soil texture tests.

Figure 1.3.2. *Collecting and preparing a representative soil sample for field texture testing (a) and bottle test method showing sedimentation layers of sand, silt, and clay after settling (b)*

Simple methods for determining soil texture

Two quick field methods can be used to estimate soil texture based on the proportions of sand, silt, and clay:

1. The bottle Test Method – visual estimation of layers after settling in water.
2. The manipulative (hand feel) test method – tactile estimation by moulding moist soil.

Bottle soil test method

In this method, a soil sample is mixed with clean water in a transparent bottle. After shaking and settling, distinct layers form, representing different soil fractions: sand (bottom), silt (middle), and clay (top). (Figure 1.3.2)

Procedure

- Fill a transparent bottle one-third full of fine soil.
- Add clean water until the bottle is about three-quarters full.
- Optionally, add a small amount of salt or liquid soap to help particles separate.
- Shake the bottle vigorously for about 3–5 minutes until the soil is well mixed.
- Place the bottle on a stable surface and let the contents settle undisturbed for 24 hours.
- Observe the layers formed:
  - Sand settles first (bottom layer).
  - Silt forms the middle layer.
  - Clay remains suspended the longest, forming the top layer.

    - Measure the thickness of each layer using a ruler and calculate the percentage composition.

Manipulative (Hand Feel) test method

This method estimates soil texture by feeling and shaping a moist soil sample in the hand (Figure 1.3.3).

Procedure

- Moisten a handful of soil with clean water until it becomes pliable but not sticky.
- Knead the soil and try forming shapes such as a ball, ribbon, or ring.
- Observe how the soil behaves:
    - Sand: feels gritty, cannot form a ball.
    - Sandy loam: forms a weak ball that breaks easily.
    - Loam: forms a smooth, flexible ball or ribbon.
    - Clay: feels sticky, can form a strong ribbon or ring without breaking.
- Compare the feel and behaviour to a standard soil texture chart to determine the approximate type.

Figure 1.3.3. *Field manipulation of moist soil to estimate texture by hand feel*

Interpretation and use

Soil texture determines how well soil holds water, nutrients, and supports CSPW structures.

- Sandy soils drain quickly but are prone to erosion.
- Clay soils retain water but may crack when dry.
- Loam soils offer the best balance and are ideal for most CSPW interventions.

Field texture testing helps technicians and communities to choose suitable sites and designs for structures such as infiltration trenches, bunds, and charco dams.

PART II: CSPW SUB-PROJECTS

1.0 Natural resources management interventions for land rehabilitation

1.1 Physical soil water conservation interventions

Physical soil and water conservation (SWC) refer to a set of structural measures designed to manage surface runoff, reduce soil erosion, and enhance infiltration for sustainable land productivity. These interventions are applied through the construction of earth, stone, or composite structures such as bunds, terraces, and check dams that physically modify land surfaces to control water flow and stabilize soils.

They play a foundational role in restoring degraded landscapes and supporting agricultural productivity, particularly in erosion-prone and semi-arid areas. Within the CSPW framework, physical SWC constitutes a central component of Natural resource management (NRM) interventions aimed at achieving climate-resilient and productive landscapes. These interventions contribute directly to the three CSPW pillars of productivity and livelihood enhancement, ecosystem adaptation, and mitigation and environmental sustainability.

At the livelihood level, improved soil and water retention enhances soil fertility, increases crop and fodder yields, and strengthens household income through more stable and productive agricultural systems. At the resilience level, SWC reduces the impacts of droughts and floods by lowering runoff velocity, promoting infiltration, and stabilizing community assets such as roads, canals, and small reservoirs. At the environmental level, these measures promote vegetation recovery, increase soil organic matter, and contribute to carbon sequestration, thereby enhancing ecosystem services and long-term land sustainability.

Physical SWC measures are generally applied when vegetative or biological interventions alone cannot sufficiently control erosion or runoff. They are labour intensive but deliver long-term benefits through improved soil stability, water availability, and land productivity. The design, selection, and implementation of each measure are guided by technical standards adapted to site-specific conditions, including slope, soil type, rainfall pattern, and land-use characteristics. Integration with biological and agronomic measures ensures that physical works function as part of a coherent landscape rehabilitation plan.

In this manual, the main physical SWC technologies implemented under PSSN III CSPW are presented and discussed. Each technology is largely explained using a standardized format to ensure clarity, comparability, and field applicability. The format includes *general description, technical standards, measurements and tools requirements, layout, implementation procedures and work norm guidelines, management guidelines, and limitations.* However, not all technologies will necessarily include every element, as the depth of detail depends on the nature and complexity of each intervention.

The following are the principal physical SWC technologies promoted under PSSN III CSPW for land rehabilitation and resilience building:

- Contour bunds
- Level *fanya juu* bunds
- Riser bunds
- Level *fanya chini* bunds
- Stone bunds
- Bench terraces
- Hillside terraces
- Stone check dams
- Seawater control bunds
- Micro-basins
- Eyebrow basins
- Herring bones
- Micro-trenches
- Water-collection trenches
- Improved pits (IP)

Each technology contributes to the broader CSPW objectives of restoring degraded land, improving water management, and enhancing the adaptive capacity of vulnerable communities to climate change.

Name of the Technology	CONTOUR BUNDS

General Description

Contour bunds are earthen ridges constructed along the contour by excavating soil from a trench on the upslope side. They reduce runoff velocity, control erosion, and enhance infiltration, improving soil moisture retention and supporting gradual formation of natural terraces. Under CSPW, contour bunds restore degraded agricultural landscapes and support climate adaptation (Figure 2.1.1).

Figure 2.1.1. Cross-section of a contour bund showing the ridge and upslope trench orientation.

Geographical Extent of Use

Suitable in semi-arid to sub-humid areas with gentle to moderate slopes. Commonly applied on cultivated lands affected by sheet and rill erosion, including regions such as Dodoma, Singida, Shinyanga, and Manyara.

Technical Standards

- Height: minimum 60 cm after compaction
- Base width: 1.0–1.2 m (stable soils); 1.2–1.5 m (unstable soils)
- Top width: 30 cm (stable soils); up to 50 cm (unstable soils)
- Bund length: 30–60 m; up to 80 m on gentle slopes
- Ties: 3–6 m intervals where required

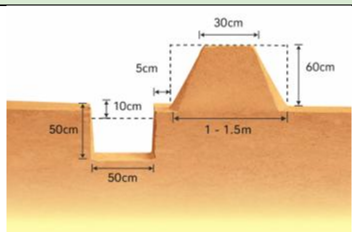


Figure 2.1.2. Contour bunds technical standards design

Vertical Interval (VI) Guidelines

- Slope 3–8%: 1.0–1.5 m
- Slope 8–15%: 1.0–2.0 m
- Slope 15–20%: 1.5–2.5 m

Measurements and Tools Requirements

A-frame or line water level, range poles (1.0–1.5 m marked at 5 cm), string (2.5–10 m), shovels, pickaxes, wooden compactors, and personal protective equipment (Figure 2.1.3)

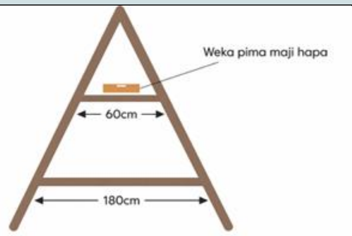


Figure 2.1.3. A-frame with a water level in designing contour bunds across slope

Layout, Implementation Procedures and Work Norm

- Survey land and establish the first bund on the upper slope.
- Mark contours using an A-frame, excavate the upslope trench, heap soil to form the bund, shape and compact thoroughly, and verify alignment along the contour.
- Work norm: approximately 150 person-days per kilometre (Figure 2.1.4).

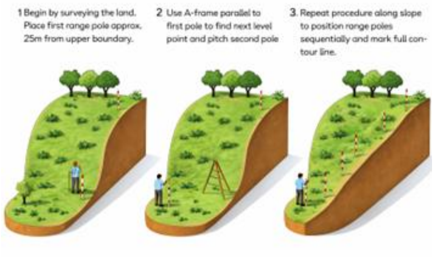


Figure 2.1.4. Procedures to create ditches and bunds using an A Frame

Management Guidelines
- Bunds gradually evolve into bench terraces. - Stabilize embankments with grasses and legumes using cut-and-carry. - Restrict livestock grazing for at least one year and repair damage after heavy rains.
Limitations
- Risk of temporary waterlogging in heavy clay soils if drainage is inadequate. - Requires regular maintenance, and stability is reduced without vegetative reinforcement.

Name of the Technology	LEVEL FANYA JUU BUNDS (FJ)

General Description

Level *fanya juu* bunds (Swahili for “throw uphill”) are embankments constructed along the contour by excavating soil from the lower side and throwing it upslope, forming a bund with a trench at its base. The structure intercepts and slows surface runoff, reduces soil erosion, and enhances water infiltration, improving soil moisture and fertility. Progressive sediment accumulation behind the bund leads to gradual terrace formation and improved productivity of sloping farmland. Under CSPW, Level *fanya juu* bunds support climate-resilient and productive agricultural landscapes (Figure 2.1.5).

Figure 2.1.5. Cross-section of a Level fanya juu bund showing the embankment and trench orientation.

Geographical Extent of Use

Suitable for gently sloping cultivated lands (3–15% slope) in semi-arid to sub-humid areas with medium to deep, well-drained soils. Applied where soil erosion, declining fertility, and moisture stress limit crop productivity.

Technical Standards

- Height (after compaction): 0.6–1.0 m
- Base width: 1.0–1.2 m (stable soils); up to 1.5 m (unstable soils)
- Top width: 0.3–0.5 m
- Trench (collection ditch): 0.6 m wide × 0.5 m deep
- Bund length: 60–80 m, depending on slope and runoff
- Ties (cross-bunds): every 3–6 m
- Bunds constructed level; slight grade (0.2–0.4%) may be applied for safe drainage where required

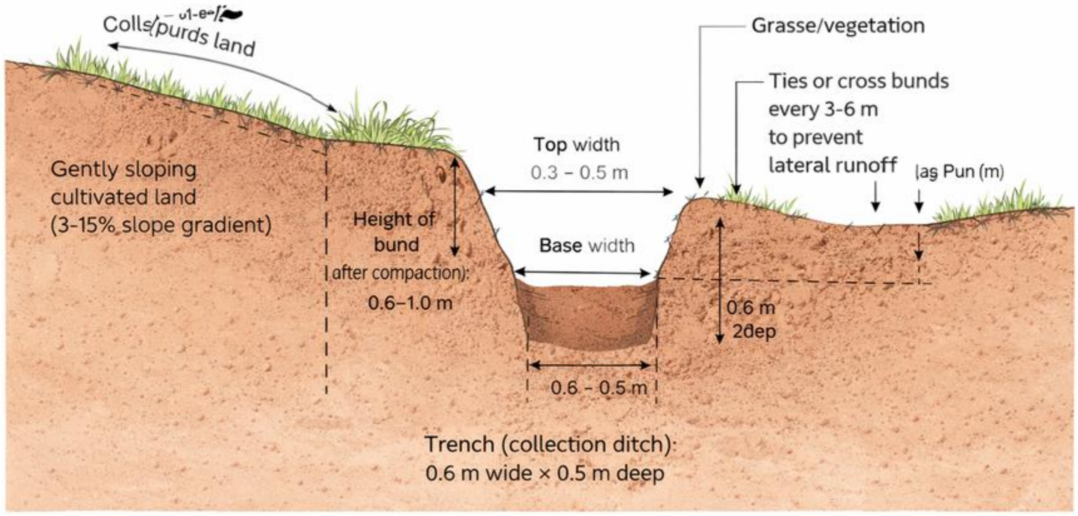


Figure 2.1.6. Level fanya Juu bund technical standards and cross-section design.

Vertical Interval (VI) Guidelines

- Slope 3–8%: VI = 1.0–1.5 m
- Slope 8–15%: VI = 1.5–2.0 m
- Slopes >15%: Apply only with reinforcement and reduced spacing

Measurements and Tools Requirements

<table>
<tr><td>- A-frame, line level or water-tube level; two range poles marked in centimetres; 10–15 m string; hoes, shovels, pickaxes, wooden compactors; measuring tape, pegs, and personal protective equipment (Figure 2.1.7).</td><td>
Figure 2.1.7. A-frame used for contour alignment in Level Fanya Juu Bund layout.</td></tr>
<tr><td colspan="2">Layout, Implementation Procedures and Work Norm</td></tr>
<tr><td>- Survey land and mark true contour lines using an A-frame or line level.
- Excavate the trench on the lower side and throw soil upslope to form the bund.
- Shape and compact the embankment thoroughly and verify level alignment.
- Install crossties at 3–6 m intervals where required.
- Work norm: approximately 60–80 m of bund per team per day, depending on soil and slope</td><td>

Figure 2.1.8. Procedures for constructing level fanya juu bunds using an A-frame.</td></tr>
<tr><td colspan="2">Management Guidelines</td></tr>
<tr><td colspan="2">- Inspect bunds regularly, especially after heavy rainfall, and repair breaches promptly.
- Desilt trenches periodically to maintain infiltration capacity.
- Stabilize bunds with grasses and legumes using cut-and-carry methods.
- Restrict livestock grazing during the first year after construction.
- Integrate contour farming and organic soil fertility management to enhance benefits.</td></tr>
<tr><td colspan="2">Limitations</td></tr>
<tr><td colspan="2">- Requires regular maintenance, particularly during the first two years.
- May cause temporary waterlogging in shallow or poorly drained soils if not well managed.
- Labour-intensive during initial construction and requires careful supervision.
- Vulnerable to erosion and weakening if not vegetatively stabilized.
- Not suitable on very steep or highly erodible slopes without reinforcement.</td></tr>
</table>

Name of the Technology	RISER BUNDS (RBs)

General Description

Riser bunds are compacted earthen embankments constructed along the contour on moderate to steep slopes (3–15%) to retain soil and runoff within cultivated terraces. The bund functions as a retaining wall (riser) that controls runoff, reduces downslope soil movement, and promotes gradual terrace formation. A collection ditch on the lower side traps sediment and runoff, increasing soil depth and moisture retention over time. Riser bunds are typically established as an upgrade to level *fanya juu* bunds after soil accumulation upslope. The riser face should be stabilized with grass, legumes, or shrubs to improve structural stability and reduce erosion. Under CSPW, riser bunds support slope stabilization, land restoration, improved infiltration, and sustained agricultural productivity (Figure 2.1.9).

Figure 2.1.9. *Cross-section of a riser bund showing the embankment and lower-side collection ditch.*

Geographical Extent of Use

Applied on moderate to steep cultivated slopes (3–15%), particularly in terraced or erosion-prone landscapes where soil loss, runoff concentration, and shallow soils limit crop production.

Technical Standards

- Bund height (after compaction): ≥ 0.6 m
- Base width: 1.0–1.2 m in stable soils (1H:2V); 1.2–1.5 m in unstable soils (1H:1V)
- Top width: 0.3 m in stable soils; up to 0.5 m in unstable soils
- Collection ditch (lower side): 0.6 m wide × 0.5 m deep
- Bund length: typically, ≤ 60 m; maximum 80 m
- Ties (cross-bunds): spaced every 3–6 m
- Alignment: level on the contour; graded at 0.2–0.4% where controlled drainage is required

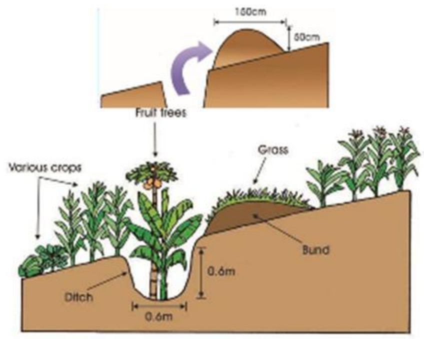


Figure 2.1.10. Cross-section of a riser bund showing the embankment and collection ditch on the lower side.

Vertical Interval (VI) Guidelines

- Slope 3–8%: VI = 1.0–1.5 m
- Slope 8–15%: VI = 1.0–2.0 m

Measurements and Tools Requirements

- Line level or water-tube level (Figure 2.1.11)
- Two range poles (1–1.5 m) marked at 5 cm intervals
- String (2.5–10 m depending on slope)
- Hoes, shovels, pickaxes, wooden compactors
- Measuring tape, pegs, gumboots, PPE
- One first-aid kit per team

Figure 2.1.11. *Line level used for contour alignment in riser bund layout.*

Layout, Implementation Procedures and Work Norm

- Mark contour alignment using line level or water-tube level; apply graded layouts (0.2–0.4%) where runoff is high.
- Clear vegetation and loosen soil along the bund line.
- Excavate the lower-side collection ditch and throw soil upslope in compacted layers.
- Shape and compact the bund to design dimensions.

- Stabilize the riser face with grasses or stones where erosion risk is high.
- Work norm: Approximately 200 person-days per km of bund. A three-person team can construct 2–3 ha per day, depending on slope and soil type (Figure 2.1.12).

Figure 2.1.12. Construction steps for riser bunds along the contour.

Management Guidelines

- Upgrade bunds gradually into level terraces using deposited soil.
- Maintain vegetation through cut-and-carry methods.
- Inspect and repair bunds after heavy rainfall, especially in the first year.
- Stagger bunds where needed to allow livestock movement.

Limitations

- Risk of temporary waterlogging without adequate drainage and fertility management.
- Narrow spacing may reduce cultivable area.
- Less effective in moisture conservation than full soil bunds and requires regular maintenance to prevent overtopping or failure.

Name of the Technology	LEVEL FANYA CHINI BUNDS (FCBs)

General Description

Level *fanya chini* bunds are earthen contour embankments formed by excavating a trench on the upper side of the contour and throwing the soil downhill to create a ridge (Figure 2.1.13). The trench temporarily stores runoff and promotes infiltration, while the downhill embankment slows runoff and reduces soil erosion. Over time, sediment deposition improves soil depth, moisture retention, and slope rehabilitation. The technology is suitable for gentle to moderate slopes (2–10%) with well-drained soils and moderate rainfall. Stabilizing the ridge with grasses, legumes, or fodder species enhances structural stability and soil fertility. Under CSPW, Level *fanya chini* bunds support water harvesting, soil conservation, and productive use of conserved moisture.

Figure 2.1.13. Cross-section of a Level Fanya Chini Bund showing the upper-side trench and downhill embankment

Geographical Extent of Use

Applied on cultivated lowland to gently sloping areas (2–10%), particularly where runoff control, moisture conservation, and rehabilitation of degraded slopes are required.

Technical Standards

- Bund height (after compaction): 0.6–1.0 m
- Base width: 1.0–1.2 m in stable soils; up to 1.5 m in unstable soils
- Top width: 0.3–0.5 m
- Trench (upper side): 0.6 m wide × 0.5 m deep
- Bund length: typically, 60–80 m
- Ties (cross-bunds): spaced every 3–6 m
- Alignment: level on the contour

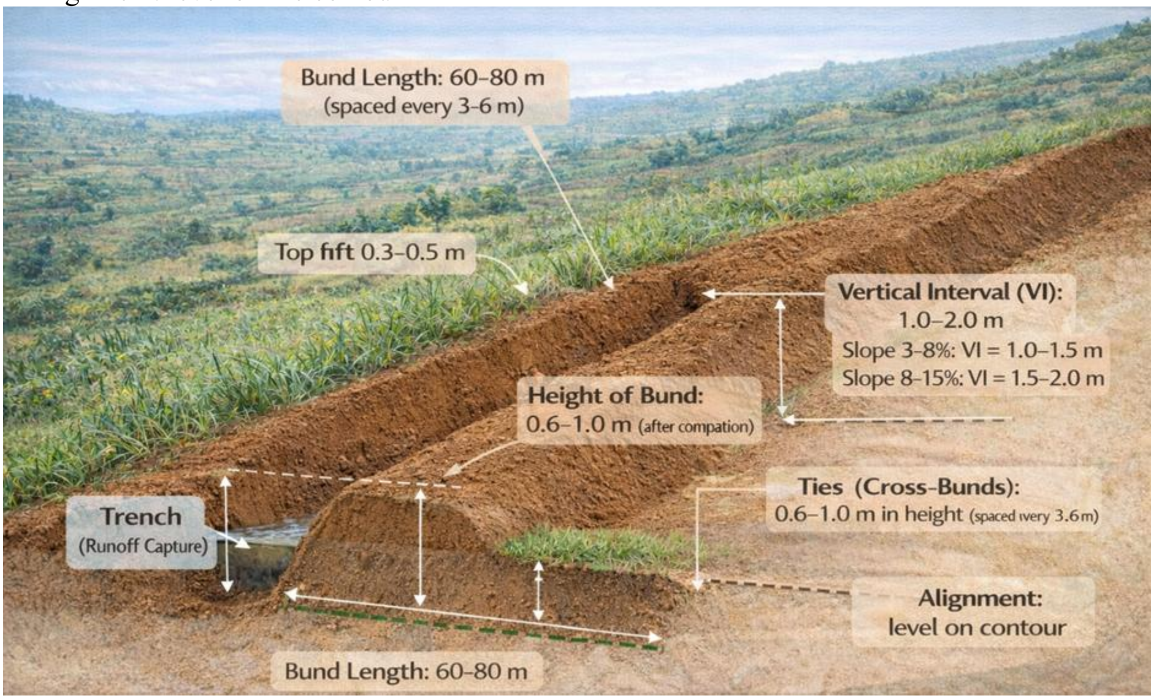


Figure 2.1.14. Technical design of a Level fanya chini bund.

Vertical Interval (VI) Guidelines

- Slope 3–8%: VI = 1.0–1.5 m
- Slope 8–15%: VI = 1.5–2.0 m

Measurements and Tools Requirements

- A-frame, line level, or water-tube level
- Two range poles (1–1.5 m) marked at 5 cm intervals
- String (10–15 m), pegs
- Hoes, shovels, pickaxes, wooden compactors
- Measuring tape, gumboots, PPE
- One first-aid kit per team

Layout, Implementation Procedures and Work Norm

- Mark contour alignment using an A-frame or line level.
- Excavate the trench on the upper side of the contour and throw soil downhill to form the bund.
- Compact the embankment in layers to achieve design height and width.
- Shape and smooth the top of the bund; maintain a gentle upper-side slope to direct runoff into the trench.
- Stabilize the ridge immediately with grasses, legumes, or fodder species.
- Work norm: Approximately 60–80 m of bund per team per day, depending on soil hardness and slope.

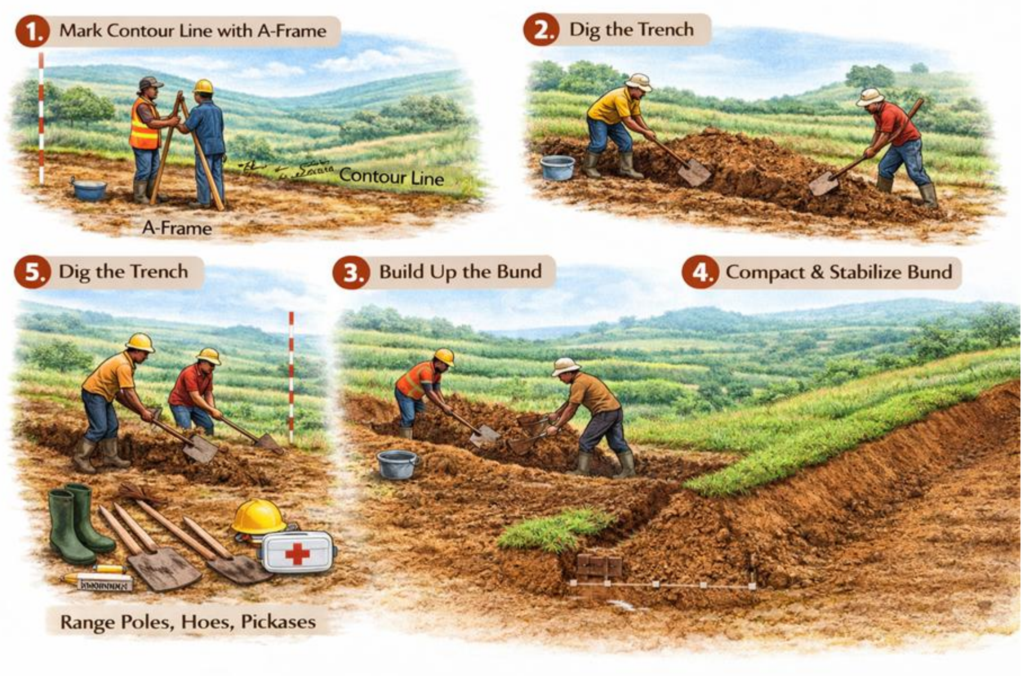


Figure 2.1.15. Step-by-step construction of a level Fanya Chini bund

Management Guidelines

- Inspect bunds after rainfall and repair eroded sections promptly.
- Remove accumulated silt from trenches to maintain storage capacity.
- Maintain vegetative cover on the ridge for stabilization and fodder production.
- Re-shape bunds annually during the dry season to preserve dimensions and drainage function.

Limitations

- Risk of localized waterlogging on poorly drained soils.
- Requires regular desilting of trenches to remain effective.
- Labour-intensive during initial establishment.
- Less suitable for steep slopes (>15%) without additional reinforcement.

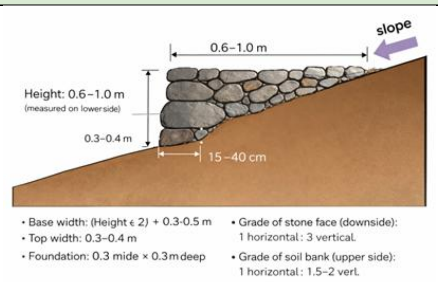
Name of the Technology	STONE BUNDS (SBs)
General Description	
Stone bunds are contour-aligned barriers constructed from stones to reduce runoff velocity, control erosion, and enhance infiltration (Figure 2.1.16). They trap sediments, gradually improve soil depth and moisture retention, and increase productivity in dryland farming systems. The technology is particularly suitable in semi-arid and arid areas and is best constructed during the dry season. Under CSPW, stone bunds provide durable, low-maintenance landscape stabilization and drought resilience.  *Figure 2.1.16. Stone bund constructed along contour lines to control runoff and enhance infiltration.*	
Geographical Extent of Use	
Suitable in semi-arid and arid zones, and in medium rainfall areas with deep, well-drained soils. Applied on cultivated slopes affected by sheet and rill erosion.	
Technical Standards	
- Height: 0.6–1.0 m (measured on lower side) - Base width: (Height ÷ 2) + 0.3–0.5 m - Top width: 0.3–0.4 m - Foundation: 0.3 m wide × 0.3 m deep - Downslope stone face: 1H:3V - Upslope stone face: 1H:4V - Upper soil seal: 1H:1.5–2V - Maximum bund length: 60–80 m - Maintain staggered spacing where livestock crossings are required	 *Figure 2.1.17. Cross-sectional design of a stone bund showing foundation trench, stone arrangement and slope alignment.*
Vertical Interval (VI) Guidelines	

Table 2.1.1. Stone bund technical specifications

Ground slope %	Height of bund (m)	Vertical interval (m)	Distance apart (m)
5	0.50	1.00	20
10	0.50	1.50	15
15	0.75	2.20	12
20	0.75	2.40	10
25	1.00	2.50	8
30	1.00	2.60	8
35	1.00	2.80	6
40	1.00	2.80	5
60	1.15	2.80	4

Measurements and Tools Requirements

- Water line level or line level
- Two graduated range poles and 10 m string
- Crowbars, sledgehammers, pickaxes, shovels
- Gloves, gumboots, PPE
- One first-aid kit per team

Layout, Implementation Procedures and Work Norm

- Align bund along contour using water line or line level; apply 0.2–0.4% grade where controlled drainage is required (Figure 2.1.18)
- Excavate shallow foundation trench (10–15 cm deep, 15–30 cm wide).
- Place large stones at the base; fill gaps with smaller stones.
- Seal upper side with compacted soil to prevent underflow.
- Construct stone ties at ~5 m intervals where needed; reinforce depressions.
- Work norm: ~2 m^2 per person-day; a three-person team can construct 2–3 ha/day depending on stone availability.

Figure 2.1.18. Step-by-step construction of a stone bund

Management Guidelines
- Establish grasses or fodder species along or slightly below the bund. - Replace displaced stones after heavy rainfall. - Maintain soil seal and remove excess sediment. - Promote community-based maintenance under CSPW.
Limitations
- Risk of temporary waterlogging in poorly drained soils. - Close spacing may reduce cultivable areas. - Labour-intensive where stones are scarce.

Name of the Technology	BENCH TERRACES (BTs)

General Description

Bench terraces are contour-based soil and water conservation structures formed by reshaping sloping land into a series of level or near-level steps along the contour (Figure 2.1.19). They reduce slope length and runoff velocity, minimize erosion, and improve moisture retention. Risers between terraces are compacted and stabilized with grasses or legumes to trap sediment, enhance soil fertility, and provide fodder. Bench terraces support intensive and permanent cultivation on hilly terrain, including irrigation and contour farming, and under CSPW contribute to land restoration and climate resilience. Construction is best undertaken during the dry season.

Figure 2.1.19. Bench terraces established along the contour with stabilized risers and crops cultivated on terrace beds.

Geographical Extent of Use

Suitable for moderate to steep slopes (15–55%) with deep soils and severe erosion risk. Most appropriate in densely populated areas with small landholdings or high labor availability under CSPW, and in locations where irrigation supports high-value crop production.

Technical Standards

- Vertical Interval (VI): For slopes ≤ 24%, VI = (Slope % ÷ 4) + 0.3 m; for slopes > 24%, VI = (Slope % ÷ 8) + 0.3 m.
- Terrace width: 2.5–5 m under manual construction; 3.5–8 m where machine-built.
- Horizontal gradient: 0.5–1% depending on climate and soil type (about 1% in humid or clay soils; <0.5% in semi-arid areas). Reverse-sloped terraces may reach up to 5%, and outward-sloped terraces may reach up to 3%.
- Riser height: Not more than 2 m; risers must be compacted and stabilized with grass or stones.

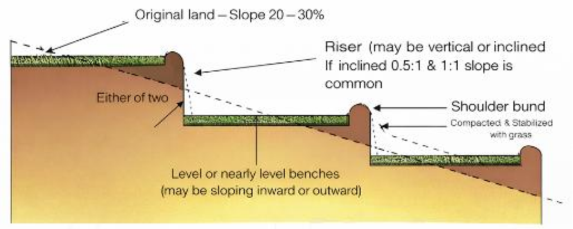


Figure 2.1.20. Cross-section of a bench terrace.

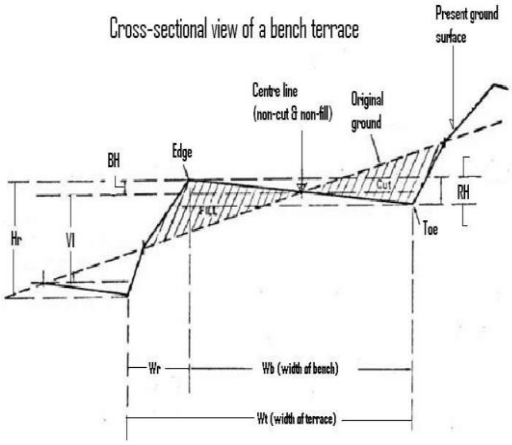


Figure 2.1.21 Engineering design of a bench terrace showing key dimensions

Measurements and Tools Requirements

- Water line level or line level
- Two graduated range poles and 2.5–10 m string
- Hoes, shovels, pickaxes, crowbars, wooden compactors
- Pangas for clearing vegetation
- Sledgehammer, gloves, gumboots, PPE
- One first-aid kit per team

Layout, Implementation Procedures and Work Norm

- Establish contour alignment using line or water level.
- Clear vegetation and loosen soil along alignment.

- Excavate soil from upper slope and deposit downslope to form bench.
- Shape and level terrace platform to required gradient.
- Compact riser and bench thoroughly.
- Stabilize risers immediately with grasses or legumes.
- Work norm: Approximately 50–100 m per three-person team per day; 1–2 ha/day depending on slope and soil hardness.

Figure 2.1.22. Step-by-step construction of a bench terrace.

Management Guidelines

- Maintain vegetative cover on risers; apply cut-and-carry instead of direct grazing.
- Inspect after heavy rains and repair cracks or localized erosion.
- Improve soil fertility during first two years using compost or organic matter.
- Promote community-based maintenance under CSPW.

Limitations

- Risk of waterlogging if drainage is inadequate.
- High initial labour demand.
- Temporary low fertility during early establishment phase.
- Structural instability if risers are not properly compacted or vegetated.

Name of the Technology	HILLSIDE TERRACES (HT)

General Description

Hillside terraces are contour-aligned soil and water conservation structures constructed on steep and degraded slopes to intercept runoff, reduce erosion, and trap sediments (Figure 2.1.23). They are particularly suitable for shallow soils and hilly landscapes where runoff and soil loss are severe. The terraces are commonly stone-faced for structural stability and designed with a gentle back slope to enhance moisture retention and controlled drainage. Under the CSPW framework, hillside terraces rehabilitate degraded slopes, reduce downstream siltation and flooding, and enable productive land use on marginal terrain. Construction is best carried out during the dry season or shortly after rainfall when soil is firm enough for shaping and stone placement.

Figure 2.1.23. Hillside terraces showing contour alignment, stone riser stabilization, and terrace platform.

Geographical Extent of Use

Suitable for steep slopes (20–50%) with shallow or degraded soils where erosion risk is high. Appropriate in hilly and mountainous landscapes requiring slope stabilization, sediment control, and rehabilitation of marginal agricultural land under CSPW.

Technical Standards

- Slope range: 20–50%.
- Vertical interval (VI): 2–3 m between successive terraces.
- Riser height (stone wall): 0.5–0.75 m.
- Terrace width: 1.5–2.0 m.
- Foundation: 0.3 m wide × 0.3 m deep.
- Grade of stone riser: 1H:3V with well-placed and tightly packed stones.
- Back slope gradient: 5–10% in low-rainfall areas for safe drainage.

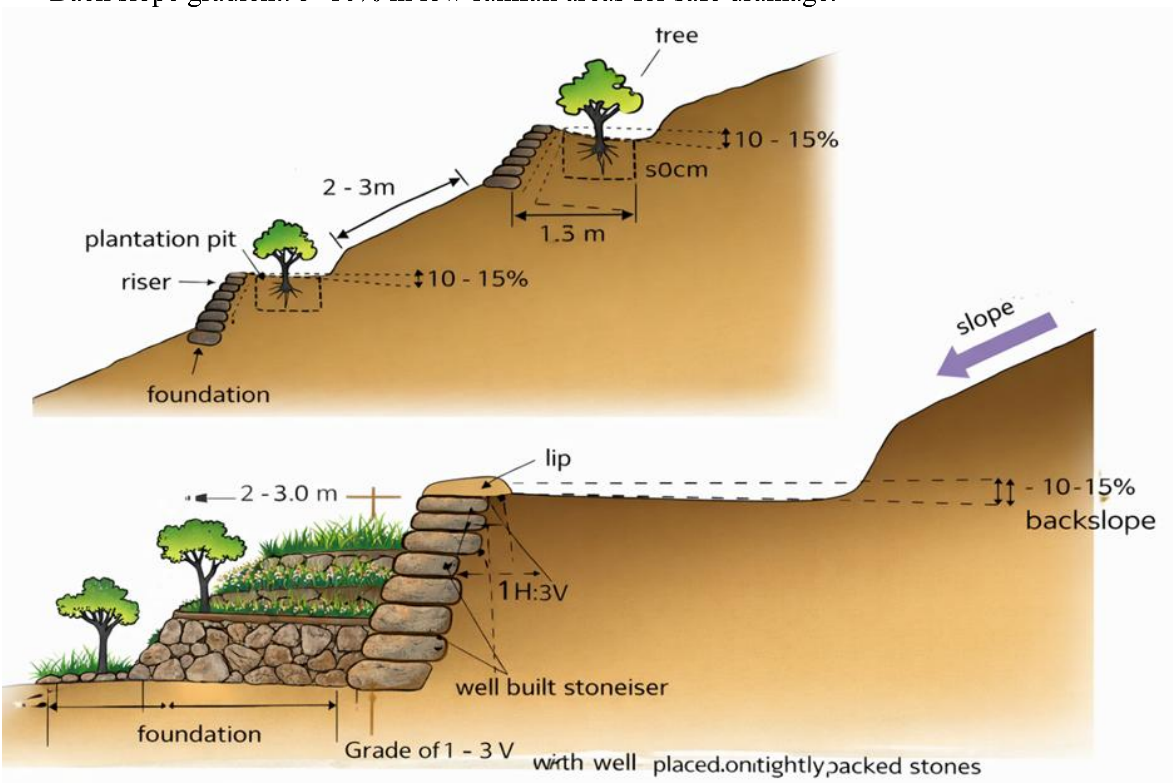


Figure 2.1.24. Layout and cross-section of a hillside terrace showing foundation trench, stone riser, back slope, and terrace spacing.

Measurements and Tools Requirements

- A-frame or water line level
- Two graduated range poles and 2.5–10 m string
- Hoes, shovels, pickaxes, crowbars
- Sledgehammers and pangas/curved knives
- Wooden compactors
- Gumboots, PPE
- One first-aid kit per team

Layout, Implementation Procedures and Work Norm

- Identify and mark contour alignment using A-frame or line level (Figure 2.1.25).
- Clear vegetation and loose soil along alignment.
- Excavate and apply cut-and-fill to form level or slightly inward-sloping terrace platform.
- Excavate foundation trench (0.3 m × 0.3 m).
- Construct stone riser using large base stones and smaller stones above; compact firmly.
- Construct optional stone ties at ~5 m intervals to reduce side flow.
- Level terrace surface to required back slope using A-frame.
- Work norm: Approximately 1–1.5 m² per person-day; a three-person team can construct about 1 hectare per day depending on slope and stone availability.

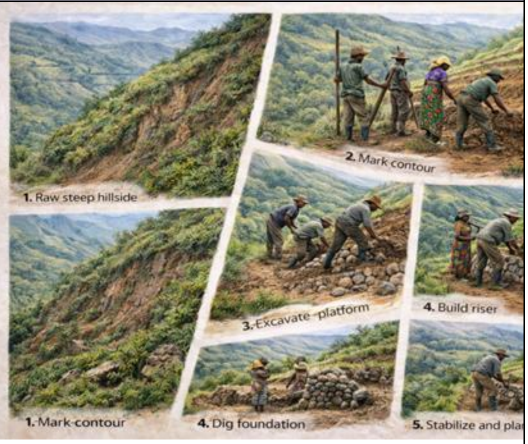


Figure 2.1.25. Stepwise construction of hillside terraces on a steep slope showing contour alignment, narrow cut-and-fill formation, stone riser construction, and vegetative stabilization.

Management Guidelines

- Plant drought-tolerant grasses, shrubs, or legumes on risers and terrace edges for stabilization.
- Avoid grazing on newly constructed terraces for at least one year.
- Use cut-and-carry system for fodder.
- Inspect after rainfall and repair eroded sections promptly.
- Promote community-based maintenance under CSPW for long-term sustainability.

Limitations

- May be overtopped if not integrated with trenches or adequate drainage.
- Requires periodic maintenance, especially during first two years.
- Labor-intensive during establishment on steep slopes.

Name of the Technology	STONE CHECK DAMS (SCDs)

General Description

Stone check dams are compact stone structures constructed across small gullies or seasonal water channels to reduce runoff velocity, trap sediments, and prevent further deepening and widening of gullies (Figure 2.1.26). By slowing concentrated flow, they enhance infiltration, promote sediment deposition, and gradually rehabilitate degraded channels. They are suitable for feeder gullies, terrace outlets, and upstream ponds for silt trapping. Construction is recommended during the dry season when flow is minimal and foundations are stable. Under CSPW, stone check dams stabilize degraded watersheds, enhance downstream soil moisture, and create durable climate-resilient community assets.

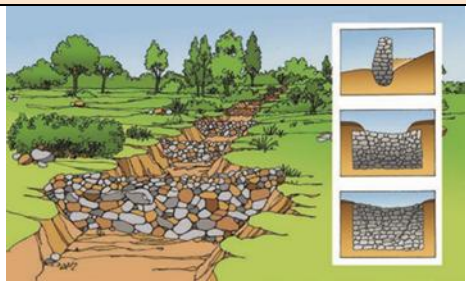


Figure 2.1.26. Cross-section of a stone check dam showing foundation key, spillway, and apron for controlled runoff and sediment trapping.

Geographical Extent of Use

Suitable in areas where stones are readily available. Applied in small to medium gullies within cultivated slopes, grazing lands, and hilly or semi-arid landscapes affected by gully erosion. Not suitable for large deep channels without engineered reinforcement.

Technical Standards

- Height: 1.0–1.5 m (excluding foundation)
- Base width: 1.5–3.5 m
- Foundation (bottom key): 0.5 m deep
- Side keys: 0.7–1.0 m into each gully bank
- Stone face ratio (V:H): 1:3 to 1:4 for structural stability
- Spillway (central trapezoidal): 0.25–0.30 m depth, 0.75–1.2 m width, 0.25 m freeboard
- Apron: Minimum 0.5 m thick, extending 1.5–3 m downstream
- Drop structure: Required on slopes >15%, constructed with ladder-placed stones for energy dissipation
- Spacing between dams: S = (Height × 1.2) ÷ gully bed slope (decimal fraction)

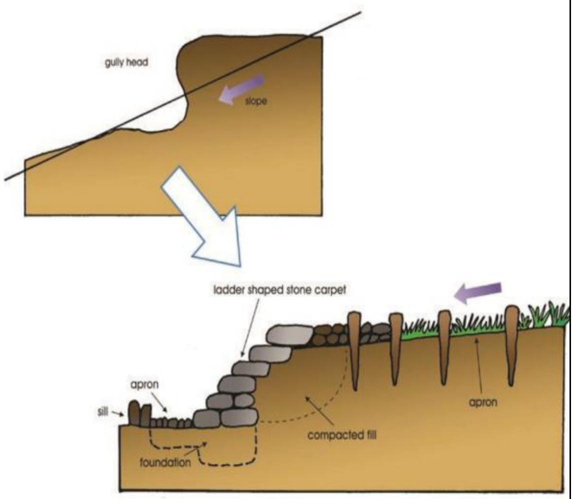


Figure 2.1.27. Detailed cross-section of a stone check dam showing foundation trench, side keys, central spillway, downstream apron, and ladder stone drop structure

Measurements and Tools Requirements

- Water line level or line level
- Two range poles (1–1.5 m) marked at 5 cm intervals with 2.5–10 m string
- Crowbars, sledgehammers, pickaxes, shovels, hoes
- Gloves, gumboots, PPE
- One first-aid kit per team

Layout, Implementation Procedures and Work Norm

- Assess gully width, depth, slope, and flow characteristics before layout (Figure 2.1.28)
- Mark alignment perpendicular to flow using a line level.
- Excavate 0.5 m deep foundation trench and cut side keys 0.7–1.0 m into gully banks.
- Place large stones at the base and build upward with slight upstream inclination.
- Construct a central trapezoidal spillway to safely pass excess runoff.
- Install downstream apron (minimum 0.5 m thick and 1.5–3 m long) to prevent scouring.
- On steep slopes, install ladder-type drop structure before apron.

- Backfill voids with smaller stones and compacted soil for stability.
- **Work norm**:
- Approximately 2–3 m² per person-day; a 3-person team can construct 1–2 check dams per day depending on gully size and stone availability.

Figure 2.1.28. Step-by-step construction of a stone check dam showing excavation, stone placement, spillway shaping, and apron installation.

Management Guidelines

- Inspect after each rainy season and repair displaced stones promptly.
- Reinforce scoured aprons and weak sections immediately.
- Gradually raise dam height as sediment accumulates.
- Promote re-vegetation of deposited sediments and stabilization of gully sides.
- Encourage collective community maintenance under CSPW.

Limitations

- Effective mainly for small to medium gullies.
- Requires adequate local stone supply.
- Labour-intensive during construction.
- Requires periodic maintenance for long-term safety and performance.

Name of the Technology	SEAWATER CONTROL BUNDS (SCBs)

General Description

Seawater control bunds are compacted clay embankments constructed along coastal areas to protect adjacent low-lying land from periodic inundation and erosion caused by tidal movements or storm surges (Figure 2.1.29). The bunds act as physical barriers that retain or exclude seawater, enabling reclamation of saline-prone land for productive uses such as rice cultivation, vegetable production, fodder development, and mangrove restoration. Construction is best undertaken during the dry season or when tidal levels are lowest to ensure proper compaction and structural stability. Under CSPW, seawater control bunds enhance coastal climate resilience, protect agricultural land, and support adaptive livelihood diversification in vulnerable communities.

Figure 2.1.29. Seawater control bund constructed along coastal farmland to prevent tidal intrusion.

Geographical Extent of Use

Suitable in coastal and estuarine zones prone to tidal flooding, saline intrusion, and storm surges. Applied in low-lying coastal farmland and degraded saline areas targeted for agricultural recovery or ecosystem restoration.

Technical Standards

- Height: 1.0–2.0 m, depending on highest tidal or floodwater level
- Top width: 1.0–1.2 m
- Side slopes: 1:2 on seawater-facing side and 1:1 on landward side
- Base width: Top width + (height × 2) on upstream side + (height × 1) on downstream side
- Foundation: Minimum 1.0 m wide × 1.0 m deep for stability and watertightness
- Maximum bund length: 50 m; longer sections require expansion joints or sluices
- Protective reinforcement: Stone pitching or grass stabilization on seawater-facing slope recommended

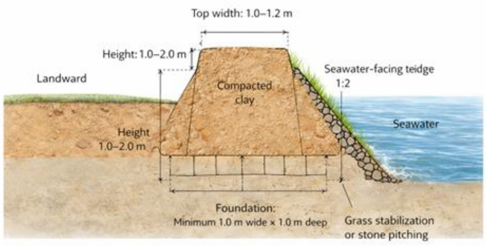


Figure 2.1.30. Cross-sectional design of a seawater control bund showing foundation depth, side slopes, and protective reinforcement.

Measurements and Tools Requirements

- Water line level or A-frame
- Two range poles graduated in centimetres and 10m string line
- Crowbars, shovels, pickaxes, sledgehammers, hoes
- Wooden compactors, wheelbarrows, gumboots
- One first-aid kit per team

Layout, Implementation Procedures and Work Norm

- Conduct preliminary survey to determine highest tidal mark and saline intrusion boundary.
- Mark bund alignment along tidal boundary using water level or A-frame.
- Excavate foundation trench to minimum 1.0 m depth and compact thoroughly.
- Construct bund using clayey or loamy soil; compact in layers to ensure watertight structure.
- Reinforce seawater-facing slope with stones, grass cover, or geotextile where available.
- Shape and level the crest to required top width, ensuring smooth curves and joint transitions.
- Install sluices or culverts where necessary for controlled drainage and maintenance access.
- Work norm: Approximately 200 person-days per kilometre of bund depending on soil type and moisture conditions.
- A three-person team can construct 1–2 bund sections (approximately 0.5–1 ha protected area) per day depending on tidal exposure and soil conditions.

Figure 2.1.31. Step-by-step construction of a seawater control bund showing excavation, layered compaction, slope shaping, and reinforcement.

Management Guidelines

- Inspect regularly after high tides, storms, and heavy rainfall to detect erosion, cracks, or seepage.
- Repair weak sections immediately and maintain slope reinforcement.
- Establish stabilizing vegetation such as Paspalum vaginatum, vetiver grass, or mangroves.
- Ensure proper functioning of drainage sluices or culverts to prevent waterlogging.
- Promote community-led maintenance under CSPW to ensure long-term coastal protection and integration with ecosystem restoration initiatives.

Limitations

- Poor drainage may cause temporary waterlogging on landward side.
- Requires high-quality clay and thorough compaction to withstand seawater pressure.
- Bunds without slope reinforcement may erode under wave action.
- Long continuous bunds require expansion joints or spillways to prevent structural failure during extreme tides.

Name of the Technology	MICRO BASINS (MBs)

General Description

Micro basins (MBs) are small circular, stone-faced moisture harvesting structures constructed for tree planting in areas with medium to low rainfall, shallow or stony soils, and sloping terrain (Figure 2.1.32.). They capture runoff, enhance infiltration, and retain moisture around planting pits, improving tree survival under semi-arid conditions. They are constructed during the dry season or after short rains when soils are workable. MBs are often integrated with other moisture conservation measures such as trenches, eyebrow basins, and hillside terraces to improve slope stabilization and moisture efficiency. Under CSPW, MBs support tree establishment, agroforestry integration, and landscape restoration in semi-arid systems.

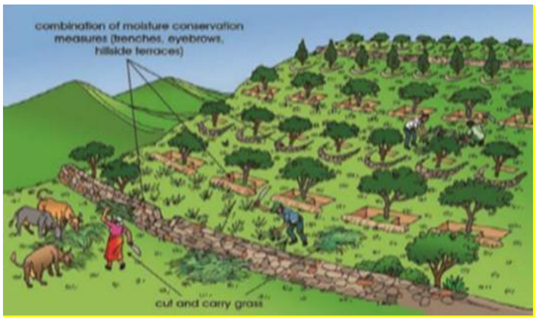


Figure 2.1.32. Micro-basin constructed for tree establishment on sloping semi-arid farmland.

Geographical Extent of Use

Suitable in semi-arid and moderately dry zones with shallow, stony, or degraded soils. Commonly practised along farm boundaries for tree planting. Rarely applied in communal degraded lands, although expansion into such areas can promote restoration and community protection.

Technical Standards

- Basin diameter: 1.0–1.5 m
- Stone riser foundation: 0.2 m
- Stone riser height: 0.2–0.4 m above ground level (depending on slope)
- Plantation pit: 40 cm diameter × 50 cm depth
- Soil sealing: Compacted soil from cut area
- Layout: Staggered arrangement between rows
- Basins of 1 m diameter require close spacing; slight overlap between rows may occur.

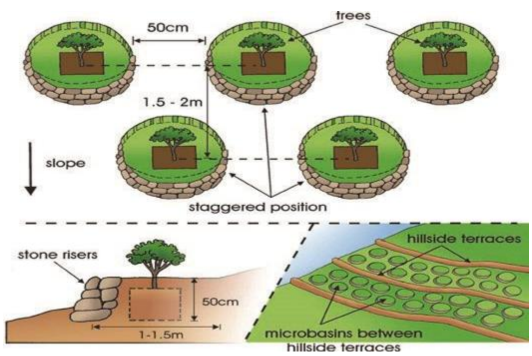


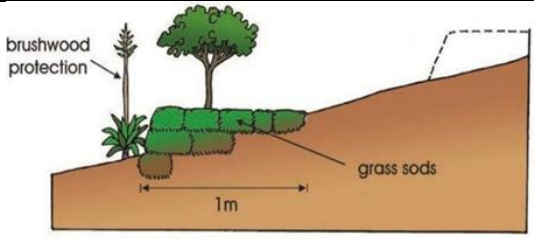
Figure 2.1.33. Cross-sectional design of a micro-basin showing stone riser, foundation, pit dimensions and cut-and-fill sealing.

Measurements and Tools Requirements

- A-frame or water line level
- 5 m rope and two ranging poles
- Crowbars, sledgehammers, pickaxes, shovels
- PPE (gloves, gumboots, helmets)
- First-aid kit

Layout, Implementation Procedures and Work Norm

- Align micro-basins along the contour in staggered positions to enhance runoff capture.
- Arrange basins between rows and closely spaced within rows, particularly for 1 m diameter basins.

- Mark contour lines and basin positions using levelling tools (A-frame or water line level). - Excavate circular foundations and construct a 0.2 m stone riser with a firm base. - Use soil from the cut area to fill, shape, and compact the basin to create an effective seal. - Dig a central tree planting pit measuring 40 cm diameter × 50 cm depth. - On steeper slopes, integrate micro-basins with hillside terraces or brushwood barriers to reduce runoff velocity and improve stability. - Work norm: 5 micro-basins (1–1.5 m diameter) per person-day under average soil and stone availability conditions. -	 *Figure 2.1.34. Brushwood and grass-sod barrier established along the contour to reduce runoff and stabilize the slope*
Management Guidelines	
- Controlled grazing and temporary area closure required. - Plant fodder legumes or shrubs (e.g., pigeon pea) in smaller pits where trees are not planted. - Apply manure and mulch to improve soil fertility and moisture retention. - Integrate with strong check dams in depressions and small gullies. - Regular inspection and repair of damaged risers.	
Limitations	
- Easily overtopped under high runoff; requires integration with hillside techniques. - Requires maintenance if poorly constructed or not stabilized. - Limited use in communal lands without collective management.	

Name of the Technology	EYEBROW BASINS (EBs)s

General Description

Eyebrow basins (EBs) are large circular, stone-faced moisture-harvesting structures constructed for tree or multipurpose species planting in low-rainfall areas (Figure 2.1.35). They control runoff velocity, enhance infiltration, and increase localized water retention, thereby improving soil moisture and supporting groundwater recharge. EBs are particularly effective in degraded and moisture-deficit landscapes and are constructed during the dry season or after short rains when soils are workable. Compared with micro-basins, they are larger and designed to capture greater runoff volumes for improved tree survival and productivity.

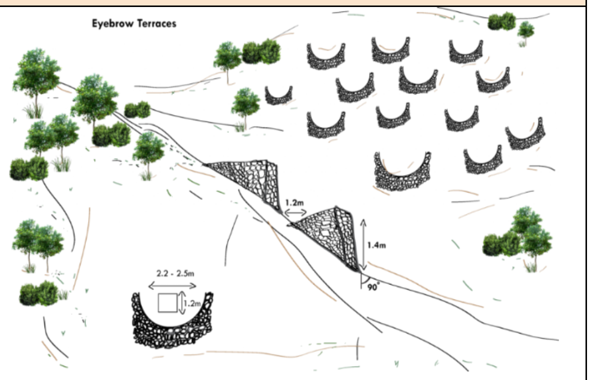


Figure 2.1.35. Sizes of eyebrows with gradient.

Geographical Extent of Use

Suitable in low-rainfall semi-arid zones, degraded slopes, and areas requiring enhanced moisture harvesting for tree establishment. Particularly effective in water-limited environments and suitable for integration with fodder shrubs and cash crops.

Technical Standards

- Basin diameter: 2.2–2.5 m
- Stone riser foundation depth: 0.2 m
- Stone riser height: 0.4–0.6 m (may be stabilized with brushwood or live fence)
- Stone riser sealed with excavated soil
- Water collection area: 1 m width × 1 m length × 20–25 cm depth (lower side)
- Tree planting pit: 50 cm depth × 40 cm diameter
- Water collection ditch may be placed sideways or in front of plantation pits depending on soil type

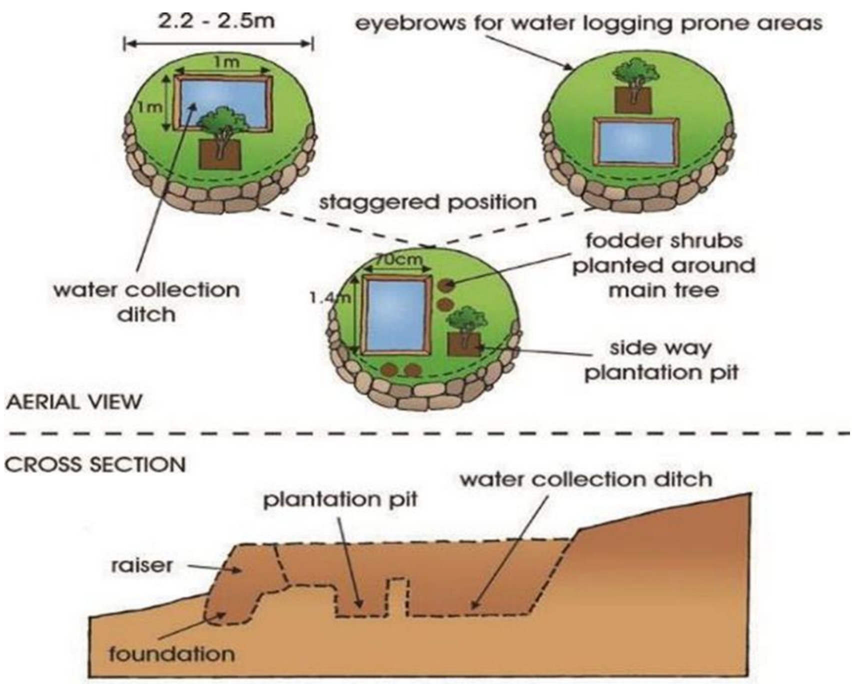
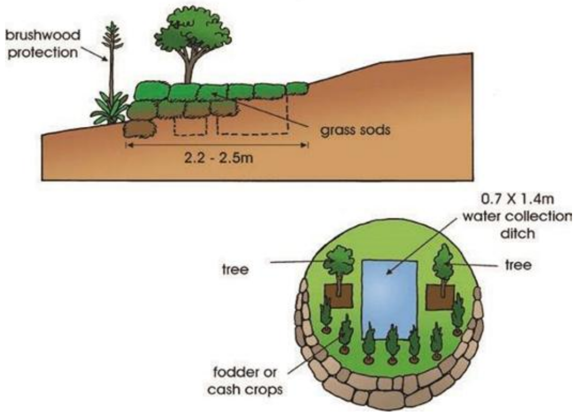


Figure 2.1.36. Eyebrow basin layout showing aerial and cross-section views, illustrating the water-collection ditch, plantation pits, staggered arrangement, and integration of fodder shrubs and main trees for moisture conservation in in areas prone to waterlogging.

Measurements and Tools Requirements	
- A-frame or water line level - 5 m rope and two range poles - Crowbars, sledgehammers, shovels, pickaxes - PPE: overalls, gumboots, helmets, gloves, masks - First-aid kit available on site	
Layout, Implementation Procedures and Work Norm	
- Conduct precise contour layout using A-frame or levelling tools. - Collect stones from the working site. - Excavate foundation and construct stone riser (0.2 m foundation). - Excavate water collection area behind planting pit (1 m × 1 m × 20–25 cm). - Construct planting pit(s) between riser and water collection ditch. - Backfill, shape, and seal the structure with excavated soil. - Integrate fodder shrubs or crops around basin where appropriate. - Work norm: 1 person-day per 3 eyebrow basins.	 *Figure 2.1.37. Eyebrow basin reinforced with grass sods and brushwood showing circular layout and stabilization measures.*
Management Guidelines	
- Controlled grazing is a precondition for effective functioning, even light trampling compromises performance. - Fodder or cash crops established on eyebrow basins should be cut and carried rather than uprooted. - Regular inspection and maintenance of stone risers and collection ditch required. - Stabilize with grass sods, brushwood, or live fencing where necessary.	
Limitations	
- Must be well constructed and stabilized to function effectively. - Susceptible to damage from uncontrolled grazing and trampling. - Requires maintenance, especially after heavy rainfall events.	

Name of the Technology	HERRING BONES (HB)

General Description

Herring Bones (HBs) are small 'A'-shaped trapezoidal soil and water conservation structures constructed along the contour to harvest runoff and support tree (Figure 2.1.38.) establishment in dry to medium rainfall areas (500–900 mm). They are suitable on slopes greater than 5% with medium soil depth (<50 cm). The extended arms intercept runoff and direct water toward a planting pit located behind a water collection ditch. This enhances infiltration, improves soil moisture retention, and supports establishment of trees and associated crops. Construction is undertaken during the dry season or after short rains when soils are firm for shaping and compaction. Under CSPW, herring bones contribute to moisture harvesting, slope rehabilitation, and productive tree-based systems in semi-arid landscapes.

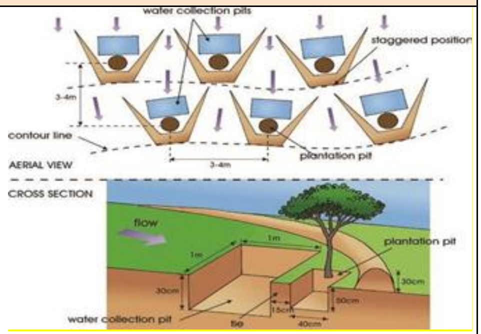


Figure 2.1.38. Layout and cross-section of a Herring Bone showing extended arms, water collection ditch, planting pit, and embankment height.

Geographical Extent of Use

Suitable in dry to medium rainfall zones (500–900 mm) on slopes >5% and shallow to medium soils (<50 cm depth). Applied in degraded hillsides and cultivated slopes where runoff control and tree establishment are constrained by moisture stress.

Technical Standards

- Spacing along contour: 3 m apart (maximum 4 m in very dry areas).
- Distance between tips of extended arms: 2.5–3 m (average).
- Water collection ditch (lower side): 1 m × 1 m × 0.3 m depth.
- Planting pit: 40 cm diameter × 50 cm depth.
- Maximum embankment height downslope: 0.4–0.5 m.
- Embankment tapers approximately 20 cm at arm ends.
- Structures aligned precisely along the contour using A-frame or water level.

Measurements and Tools Requirements

- A-frame
- Water level
- Measuring tape and pegs
- Shovels
- Pickaxes
- Personal protective equipment (overalls, gumboots, gloves, helmets)
- One first-aid kit per team

Workers should wear appropriate safety gear during excavation and compaction. Basic occupational safety measures must be observed to prevent injuries from tools, soil collapse, or slips on sloping ground.

Layout, Implementation Procedures and Work Norm

- Mark contour alignment using an A-frame or water level.
- Excavate the water collection ditch and dig the planting pit behind the ditch. Construct the 'A'-shaped embankment with extended arms directing runoff toward the planting pit. Compact embankments thoroughly to maintain stability and prevent overtopping.
- Planting arrangements should optimize moisture use and productivity:

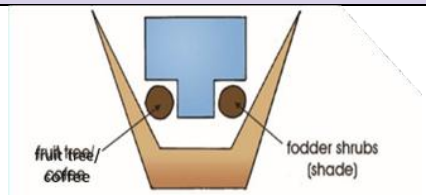


Figure 2.1.39. Example planting arrangement showing a central fruit tree supported by fodder shrubs within a Herring Bone structure.

- Fodder shrubs mixed with cash crops, with a slow-growing tree planted behind the water collection pit.
- Alternate HBs along the contour: one planted with cash crops and fodder species, the next planted with trees only.
- Double pits placed sideways to the water collection trench: one pit planted with fodder trees (e.g., Sesbania) and the second with fruit trees, coffee, or other high-value species.
- Work norm: 1 person-day constructs approximately 4 Herring Bones.

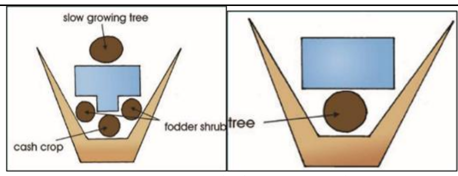


Figure 2.1.40. Integrated planting combinations showing alternating tree-only and mixed crop-fodder Herring Bones along the contour.

Management Guidelines

- Controlled grazing is mandatory, even light trampling compromises structure performance.
- Ensure proper spacing and compaction to prevent overtopping and downslope breakages.
- Apply cut-and-carry system; crops and fodder should not be uprooted.
- Inspect and repair embankments after heavy rainfall.
- Maintain ditch capacity to ensure continued runoff capture.

Limitations

- Suitable only on gentle slopes.
- Requires precise construction and stabilization.
- Vulnerable to overtopping if poorly spaced or compacted.
- Performance declines under uncontrolled grazing.

Name of the Technology	MICRO-TRENCHES (MTRs)

General Description

Micro-trenches (MTRs) are rectangular and deep water-harvesting pits constructed along the contour to intercept runoff and enhance soil moisture for tree and shrub establishments (Figure 2.1.41). They are suitable on slopes of 3–30% maximum gradient and soils of at least 50 cm depth. MTRs are constructed during the dry season or after the short rains when soils are firm for excavation. The trenches capture runoff, reduce surface flow velocity, and improve infiltration, thereby supporting establishment of trees, fodder shrubs, and other high-density planting systems. Under CSPW, Micro-trenches contribute to moisture conservation, slope stabilization, and improved biomass production in semi-arid and medium rainfall areas.

Figure 2.1.41. On-farm micro-trenches retaining runoff and supporting young tree establishment in a grass-covered field.

Geographical Extent of Use

Suitable in semi-arid and medium rainfall areas (600–900 mm). Applied in pastoral areas for grazing reserves and in cultivated lands where moisture conservation is required. Micro-trenches are more effective than micro-basins in capturing and conserving larger volumes of runoff. They are preferable to larger trenches in areas receiving above 600–700 mm rainfall and for species planted at higher density per hectare, particularly fodder shrubs.

Technical Standards

- Average trench size: 1.5 m length × 0.4 m width × 0.5 m depth (downslope side).
- In very permeable soil, provide a small central tie (15 cm width) to regulate water flow.
- Trees are not planted in the middle of the trench but in front of it.
- Spacing along slope: 1.5–2 m.
- Lateral spacing between trenches: 30–50 cm.
- Plantation pit size: 50 cm depth × 40 cm width (larger pits possible depending on species).

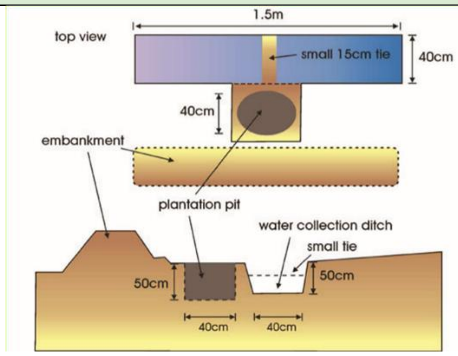


Figure 2.1.42. Layout and cross-section of a water-collection micro-trench (MTR), showing plantation pit, embankment, water harvesting ditch, and stabilizing tie.

Measurements and Tools Requirements

- A-frame or water level
- Crowbar
- Pickaxe
- Shovel
- Measuring tape and pegs
- Personal protective equipment (overalls, gumboots, gloves, helmets)
- One first-aid kit per team
- Workers should observe occupational safety measures during excavation and compaction, especially on sloping terrain and when using crowbars or pickaxes.

Layout, Implementation Procedures and Work Norm
- Carry out precise contour layout using an A-frame or other levelling equipment. - Excavate the trench to the specified dimensions, ensuring correct depth and width on the downslope side. - Construct a downstream embankment with compacted soil. Where required, incorporate a 15 cm stabilizing tie in the middle to regulate runoff flow (Fig. 2.1.43) - Dig plantation pits in front of the trench (not inside the trench). - Compact embankments thoroughly to prevent overtopping and erosion. - **Work norm**: Approximately three micro-trenches per person-day, including precise layout, excavation of trench and planting pits, embankment construction, and compaction.

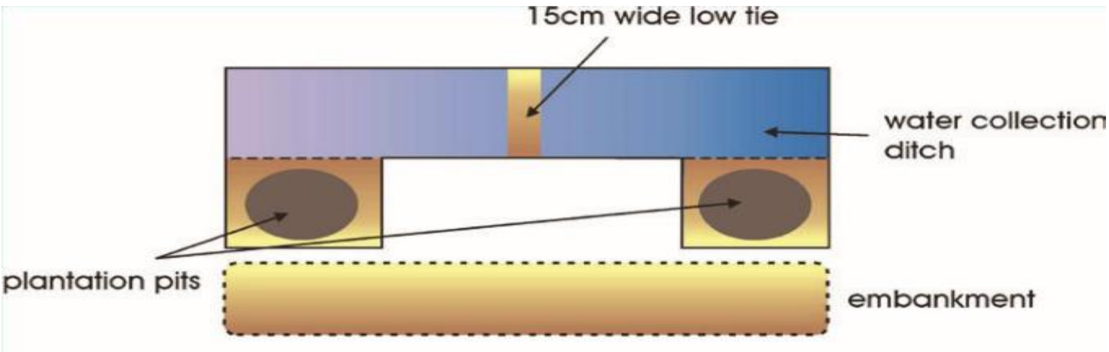


Figure 2.1.43. Top-view layout of a micro-trench showing paired plantation pits, central trench, 15cm tie, and downstream embankment.

Management Guidelines
- Controlled grazing is mandatory; trampling compromises trench structure and water retention function. - Ensure proper spacing and compaction to prevent overtopping and downslope breakages. - Apply cut-and-carry method for vegetation growing around MTRs. - Maintain trenches and repair eroded sections after heavy rainfall. - Ensure ties remain functional to regulate water flow in permeable soils.

Limitations
- Performance declines under uncontrolled grazing. - Poor spacing or inadequate compaction may lead to overtopping and structural failure. - Requires periodic maintenance, particularly in high rainfall events. - Not suitable in soils shallower than 50 cm.

Name of the Technology	WATER-COLLECTION TRENCHES (WCT)

General Description

Water collection trenches (WCTs) are large contour-aligned moisture-harvesting trenches constructed to collect and store rainfall for establishment of trees, shrubs, grasses and cash crops in degraded and moisture-stressed areas (Figure 2.1.44). They are suitable in areas receiving 350–900 mm of rainfall. WCTs function by intercepting runoff, concentrating water within a trench-pit system, and improving infiltration for planted species. Depending on land use objectives, WCTs may be designed for single trees, multiple trees, fodder shrubs, coffee or fruit trees, or integrated agroforestry systems. Construction is carried out during the dry season or up to one month before the onset of rains to ensure timely planting and structural stability. Under CSPW, WCTs contribute to land restoration, grazing improvement, forest enrichment and climate-resilient agroforestry.

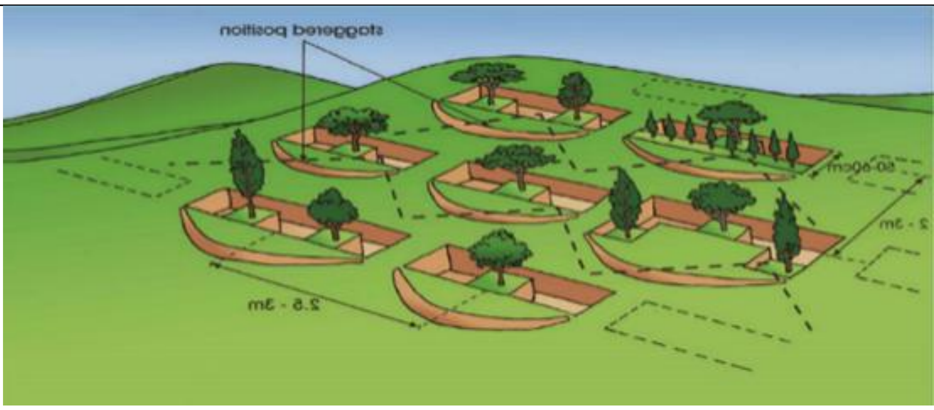


Figure 2.1.44. Layout of water collection trenches (WCTs) on sloping land showing staggered contour alignment, trench dimensions (2.5–3 m), plantation pits, and integration of trees and fodder species for enhanced moisture retention and slope stabilization.

Geographical Extent of Use

Suitable in highland and mid-altitude areas receiving 350–900 mm of rainfall, including degraded lands, grazing reserves, forest enrichment zones and abandoned lands targeted for restoration. Applied on hillsides with slopes ranging from 5–50% where soil depth is at least 50 cm and soils are not excessively rocky. Also suitable in homestead areas for establishment of high-value trees and diversified agroforestry systems.

Technical Standards

Core structural parametres

- Standard trench length: 2.5–3 m
- Trench width: 50 cm
- Initial trench depth: 20–25 cm
- Final collection depth (around tie): up to 50 cm
- Plantation pit (standard): 50 × 50 cm width × 40 cm depth
- Bottom of pit positioned 10–15 cm deeper than trench bottom
- Tie positioned approximately 10 cm from pit border on both sides
- Lateral spacing between trenches: 25–50 cm
- Distance between trench lines: 2–3 m
- Catchment area to trench area ratio: 3–5:1 depending on rainfall and species water requirement
- Typical density: 800–1200 trenches per hectare

Larger trench option (for coffee or fruit systems)

- Trench depth: 60 cm
- Trench length: 3–5 m
- Trench width: 60–80 cm
- Plantation pit: 60 × 60 × 60 cm
- Double tie is approximately 80 cm wide.

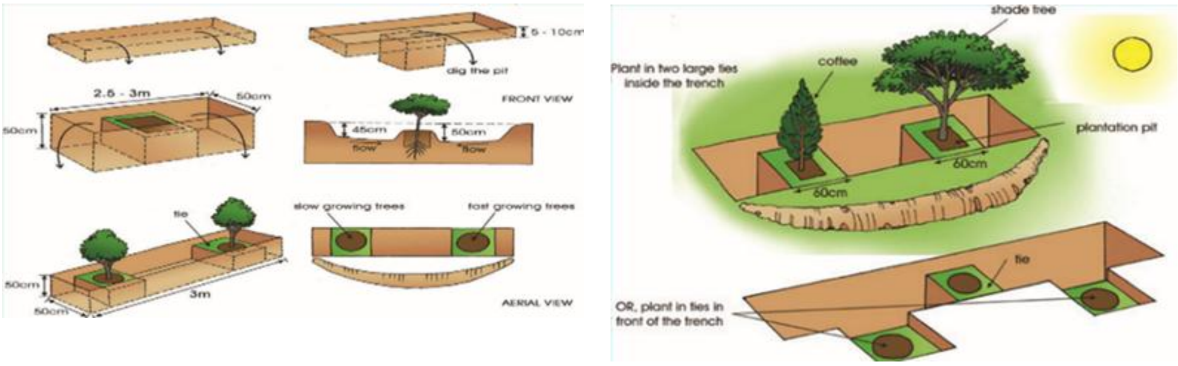


Figure 2.1.45. Cross-section and layout of water collection trenches (WCT) showing trench dimensions, tie placement, embankment structure, and planting pit configuration.

Measurements and Tools Requirements

- A-frame or water level
- Crowbar
- Pick axe
- Shovel
- Measuring tape and pegs
- Gloves, gumboots, PPE
- One first-aid kit per team

Layout, Implementation Procedures and Work Norm

- Start layout from the upper slope and proceed downslope.
- Mark contour alignment using an A-frame equal to trench length (2.5–3 m).
- Construct trenches in staggered (triangular) arrangement.
- Excavate trench and deepen collection zone around tie.
- Construct and compact embankment properly.
- Dig plantation pit(s) according to selected design.

Design variations during implementation

- Single-tree system: One tree planted in central pit.
- Two–three-tree system: Combine one fast-growing tree with one or two slow-growing trees planted in ties or in front of trench.
- Fodder/cash crop system: Small pits (15 × 15 cm) dug along trench step for shrubs or crops (pigeon pea, Sesbania or Leucaena).
- Coffee/fruit system: Larger trench and double tie, including shade tree pit.
- **Work norm**: Two people construct approximately three standard trenches per day.

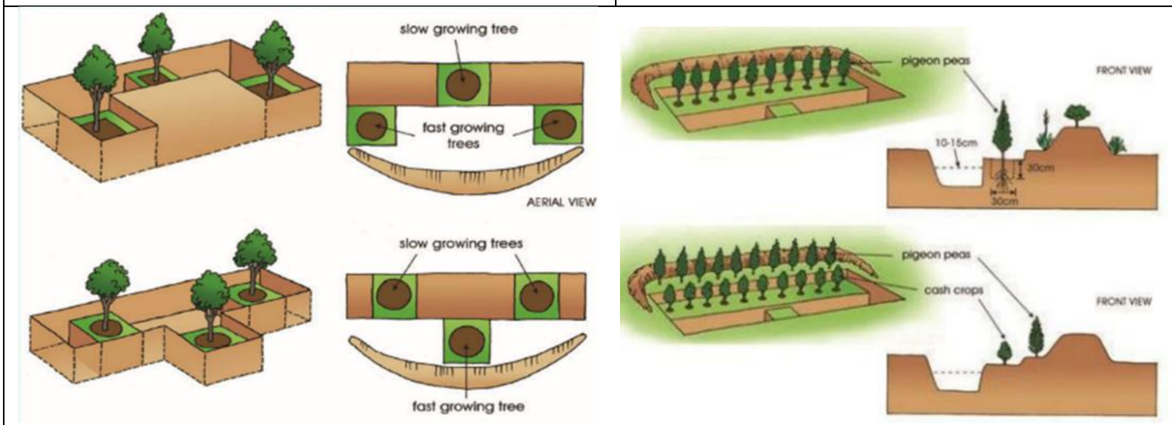


Figure 2.1.46. Layout variations and integrated planting configurations in water collection trenches (WCT), showing single- and multi-tree systems, fodder and cash crop integration, and trench alignment in staggered arrangement

Management Guidelines
- Cut and use surrounding grass as mulch for pits and trench zone. - Apply compost in planting pits and water collection areas. - Maintain ties and embankments to prevent overtopping. - Monitor growth where multiple trees are planted; prune or thin as required. - Maintain heavy mulching for at least two years in multipurpose systems. - Stabilize embankments with legumes or grass where necessary.
Limitations
- Requires minimum 50 cm topsoil depth. - Not suitable in very rocky soil. - High initial labour demand. - Requires continuous mulching and maintenance during early establishment phase.

Name of the Technology	IMPROVED PITS (IP)

General Description

Improved pits (IPs) are individual moisture-harvesting planting pits constructed along the contour to capture and retain runoff for tree and shrub establishments in degraded and moisture-stressed areas (Figure 2.1.47). Unlike trenches, Improved pits are discrete units and do not form continuous linear excavations. Each pit functions as a localized water-collection basin, enhancing infiltration and concentrating moisture directly around the root zone. The pits are arranged in staggered formation along the contour to optimize runoff capture and slope stabilization. Construction is carried out during the dry season or shortly before the onset of rains to ensure timely planting. Under CSPW, improved pits support land rehabilitation, tree establishment, and biomass production in semi-arid and medium rainfall areas.

Figure 2.1.47 Layout of improved pits (IP) on sloping land showing staggered arrangement and integration of trees and fodder species.

Geographical Extent of Use

Suitable in semi-arid and medium rainfall areas (350–900 mm), particularly on degraded slopes and abandoned lands targeted for restoration. Applied on hillsides with slopes typically ranging from 5–50% where soil depth is at least 50 cm and soils are not excessively rocky. Also suitable in grazing reserves, forest enrichment zones, and homesteads for establishment of high-value trees.

Technical Standards

- Standard pit dimensions: 60 cm × 60 cm × 60 cm (length × width × depth).
- Pit depth may be adjusted based on soil depth and rainfall conditions.
- Topsoil should be separated during excavation and returned around the root zone.
- Pits aligned along contour in staggered (triangular) pattern.
- Spacing between pits typically 2–3 m depending on species and slope gradient.
- Embankment formed on downslope side using excavated soil to improve runoff capture.

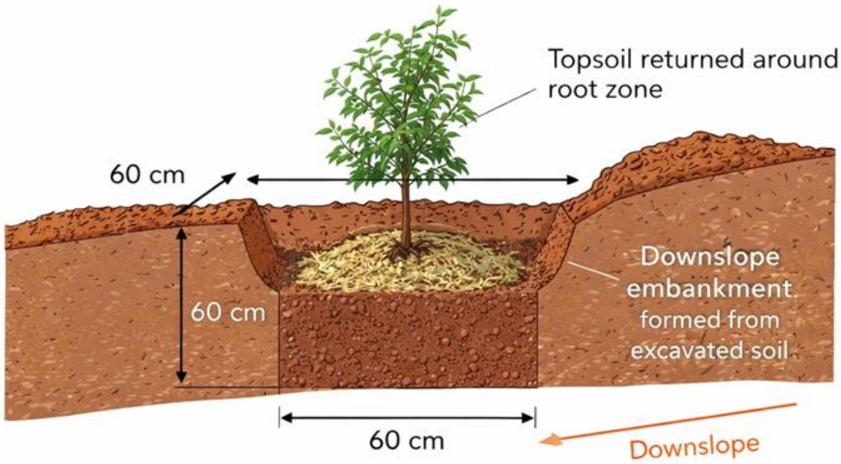


Figure 2.1.48. Cross-section of an Improved Pit showing pit dimensions, downslope embankment, and planting position.

Measurements and Tools Requirements

- A-frame or water level
- Measuring tape and pegs
- Pick axe
- Crowbar (where soils are compacted)
- Gloves, gumboots, PPE
- One first-aid kit per team

- Shovel

Layout, Implementation Procedures and Work Norm

- Mark contour alignment using an A-frame or water level.
- Peg pit positions in staggered arrangement.
- Excavate pits to specified dimensions, separating topsoil and subsoil.
- Construct a small embankment on the downslope side using excavated soil.
- Return topsoil to pit and incorporate compost where available.
- Plant selected tree or shrub species and mulch immediately after planting.
- **Work norm**: One person constructs approximately 2–3 improved pits per day depending on soil condition and depth.

Figure 2.1.49. Step-by-step construction of improved pits

Management Guidelines

- Apply mulch to conserve moisture and reduce evaporation.
- Apply compost or manure during planting where available.
- Protect pits from grazing and trampling.
- Repair embankments after heavy rainfall if damaged.
- Monitor tree growth and replace failed seedlings where necessary.

Limitations

- Requires minimum soil depth of approximately 50 cm.
- Labor-intensive in hard or rocky soils.
- Limited water capture compared to larger trench systems.
- Requires protection from grazing during establishment phase.

1.2 Biological Soil and Water Conservation

Biological soil and water conservation (SWC) interventions focus on the use of vegetation and sustainable agronomic practices to protect, restore, and enhance soil and water resources. These practices rely on living materials such as grasses, shrubs, and trees to stabilize the soil, reduce runoff velocity, and promote infiltration. When properly established, biological measures improve soil structure and fertility, increase water-holding capacity, and enhance vegetation cover, thereby supporting long-term land productivity and ecological balance.

Within the CSPW framework, biological SWC plays a vital role in achieving triple-dividend outcomes that link livelihoods, resilience, and environmental sustainability. Productivity and livelihood enhancement are achieved by improving soil fertility and moisture availability, increasing crop and fodder yields, and supporting livestock feed systems; resilience and adaptation are accomplished by reducing erosion, restoring degraded landscapes, and stabilizing physical conservation structures such as bunds and check dams; and mitigation and environmental sustainability are realized by increasing vegetation cover, enhancing biomass and soil-carbon sequestration, and strengthening the ecosystem’s capacity to withstand climate shocks.

Biological SWC measures are low cost, labour intensive, and highly suitable for implementation through community-based public works. They are often used to complement physical soil and water conservation structures, providing long-term stability and ecological benefits. Typical approaches include planting cover grasses and legumes, establishing grass strips or hedgerows along contours, and reinforcing gullies and bunds with vegetation.

Under PSSN III Climate-Smart Public Works (CSPW), these measures contribute to natural resources management (NRM) and land rehabilitation objectives by restoring soil productivity, improving water-use efficiency, and promoting climate adaptation at community level. Each technology is implemented following standard technical guidance that considers site conditions such as slope, soil type, rainfall, and existing vegetation to ensure effectiveness and sustainability. The following biological SWC technologies are promoted under CSPW for land rehabilitation and resilience building.

- Live check dams
- Planting of cover grasses (vetiver grass)
- Stabilization of physical structures
- Gully erosion control through vegetative measures

Name of the Technology	LIVE CHECK DAMS (LCD)

General Description

Live check dams are biological barriers established in gullies or small drainage channels to control erosion and slow down runoff. They are formed by planting or inserting cuttings of live woody or herbaceous species across the gully bed, creating a vegetative structure that traps sediments, enhances infiltration, and stabilizes the gully floor over time (Figure 2.1.50). They provide a cost-effective alternative to stone or masonry check dams and can naturally regenerate, delivering ecological and livelihood benefits. Within the CSPW framework, live check dams enhance productivity through improved soil moisture and fodder regrowth, build resilience by reducing flood impacts and gully expansion, and promote mitigation and sustainability by increasing vegetation cover and carbon sequestration. The technology is most effective on gullies and dry riverbeds with low to medium slopes where runoff velocity is moderate.

Figure 2.1.50. Construction of a live check dam using interwoven woody stems (woody plant box).

Geographical Extent of Use

Suitable in degraded micro-watersheds, seasonal gullies, and drainage lines in semi-arid to sub-humid zones with low to medium slopes. Applied where runoff is moderate and planting materials can establish at the onset of the rainy season.

Technical Standards

- Cutting diameter: 2–4 cm
- Cutting length: Approximately 70 cm
- Insertion depth: 20 cm
- Spacing between cuttings: Approximately 50 cm
- Planting period: Beginning of rainy season
- Suitable slope: Low–medium gradient gullies with moderate runoff

Tools Requirements

- Machetes or pruning saws
- Shovels and hoes
- Gloves and gumboots (PPE)
- One first-aid kit per team

Layout, Implementation Procedures and Work Norm

- Align vegetative barrier perpendicular to runoff flow across the gully bed (Figure 2.1.51).
- Insert fresh cuttings 20 cm deep at approximately 50 cm spacing.
- Fill gaps with additional stems to form a dense live barrier.
- Apply reinforced bundling using Elephant grass and vetiver grass where necessary.
- Establish deep-rooted water-tolerant species such as *Acacia melanoxylon* or *Acacia mellifera* along the gully bed where appropriate.
- Protect the site from grazing and trampling during establishment.
- **Work norm**: 15–20 m of live check dam per person-day under medium gully conditions (1–2 m width) including cutting preparation, insertion, and soil firming.

Figure 2.1.51: Completed live check dam showing woven woody stems forming a vegetative barrier to slow runoff and trap sediments.

Management Guidelines
- Maintain continuous vegetation cover by replanting where survival is low. - Coppice, prune, or pollard woody species to encourage regrowth and provide poles, fuelwood, or fodder. - Protect the structure from grazing during early establishment. - Combine with upstream soil and water conservation measures to reduce sediment load.
Limitations
- Ineffective on steep slopes or where runoff is very high without complementary physical measures. - Requires adequate moisture and protection from livestock to ensure establishment. - Initial maintenance and replanting are necessary until vegetation becomes well-rooted.

Name of the Technology	PLANTING OF COVER GRASS (VETIVER GRASS)

General Description

Vetiver grass (*Chrysopogon zizanioides*) is deep-rooted perennial grass used widely for soil and water conservation, slope stabilization, and land rehabilitation. The plant produces dense vertical shoots and strong fibrous roots reaching up to 7 metres deep within 2–3 years, effectively binding soil and preventing erosion and landslides on sloping or flood-prone areas. It can grow up to 2 metres high and is highly tolerant to acidic, saline, or contaminated soils, drought, and floods. Because of its non-invasive root system, it does not compete with crop roots and can be safely planted along field boundaries and contours. Within the CSPW framework, vetiver grass is a low-cost biological technology that enhances productivity, resilience, and ecosystem restoration by reducing erosion, improving soil structure, increasing water infiltration, and providing livestock fodder.

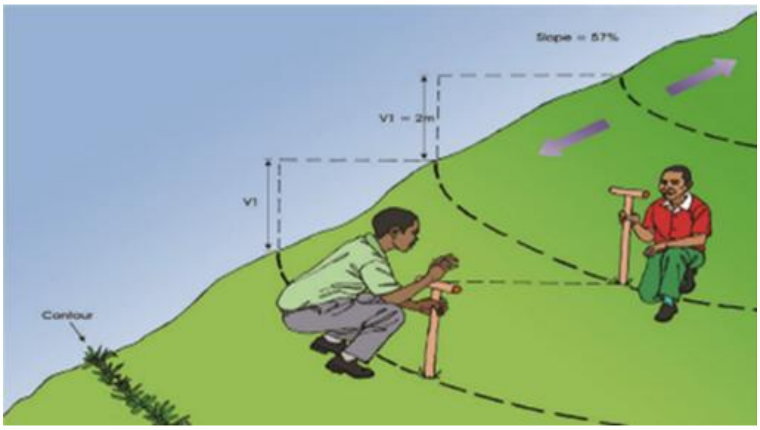


Figure 2.1.52: Using an A-frame to mark contour lines before planting vetiver grass (a) and a vetiver grass seedling with intact roots ready for planting (b).

Geographical Extent of Use

Suitable in areas on sloping cultivated land, degraded hillsides, bunds, terraces, drainage channels, and flood-prone areas. Applicable in semi-arid to humid zones due to its tolerance to drought, flooding, and poor soil conditions.

Technical Standards

- Channel width: 20 cm
- Channel depth: 30 cm
- Root trimming length: About 10 cm
- Spacing between plant centres: 15–20 cm
- Spacing within row: 10–15 cm
- Crown placement: 2 cm below soil surface
- Vertical spacing between contour rows: about 2 m (depending on slope gradient)
- Planting time: Onset of rainy season

Tools Requirements

- A-frame or line level
- T-shaped rod (for marking subsequent contours)
- Hand hoe or digger
- Shovels
- Gloves, gumboots, PPE
- One first-aid kit per team

Layout, Implementation Procedures and Work Norm

- Mark contour lines using an A-frame or line level.
- Dig a channel 20 cm wide and 30 cm deep along each contour line.
- Uproot seedlings from existing clumps, keeping roots intact, and trim roots to about 10 cm.
- Plant seedlings at the onset of the rainy season with the crown 2 cm the below soil surface and roots directed vertically downward (Figure 2.1.53).
- Maintain 10–15 cm spacing within a row.
- Establish additional contour rows about 2 metres apart vertically, depending on slope gradient.

Figure 2.1.53: Mature vetiver hedgerow stabilizing soil and conserving moisture along the contour.

- Weed regularly and prune leaves to 30–50 cm height to encourage tillering and dense hedgerow formation. - Full establishment is achieved after 2–3 growing seasons. - **Work norm**: 40–60 m of vetiver hedgerow per person-day under normal soil conditions, including contour marking, channel digging, and planting.	
Management Guidelines	
- Protect newly planted strips from grazing until well established. - Replant missing clumps to maintain continuous hedgerows. - Combine vetiver strips with physical structures such as bunds, terraces, or check dams to enhance performance in erosion-prone areas. - Harvest excess grass for fodder, mulching, or thatching as needed.	
Limitations	
- Requires initial labor for planting and regular maintenance during establishment. - Ineffective on very steep slopes unless combined with physical structures. - Grazing pressure may hinder establishment if not protected.	

Name of the Technology	STABILIZATION OF PHYSICAL STRUCTURES (SPS)

General Description

Stabilization of physical structures refers to the use of vegetation such as grasses, legumes, shrubs, trees, or crops to reinforce soil and water conservation structures including bunds, terraces, trenches, and check dams (Figure 2.1.54). Vegetation reduces erosion, protects structures from rainfall splash and runoff, strengthens embankments and risers, and enhances soil fertility and moisture retention. Within the CSPW framework, stabilization improves the durability of constructed works while increasing vegetation cover, supporting fodder and food production, enhancing biodiversity, and contributing to carbon sequestration. Implementation is usually undertaken at the onset of the rainy season or using residual soil moisture to ensure good establishment.

Figure 2.1.54. Example of stabilized physical structures where vegetative growth reinforces stone check dams and bunds, improving erosion control and landscape restoration

Geographical Extent of Use

Applicable in semi-arid, sub-humid, and highland areas where physical soil and water conservation structures have been constructed. Suitable along bunds, terraces, trenches, check dams, and embankments on cultivated slopes, rangelands, and degraded watersheds.

Technical Standards

Spacing and planting arrangement:

- *Trees and shrubs*: Plant 30–60 cm apart in a single row or staggered double row along the berm and/or lower edge of structures.
- *Grasses and legumes:* Sow 1–2 cm deep in rows; combine 2 rows grass with 1 row legume where possible.
- *Crops*: Plant along bund edges, embankment tops, or trench bottoms depending on moisture conditions.
- Mixed systems may combine fruit trees, fodder trees, grasses, legumes, and crops in compatible arrangements to enhance structural stability and productivity.

Species selection:

- Select species suited to local soil type, rainfall, slope, and community preference.
- Prioritize nitrogen-fixing and multipurpose species such as *Leucaena* spp, *Sesbania sesban*, Pigeonpea, *Acacia saligna*, and *Albizia lebbeck*.
- Fruit and multipurpose trees such as neem, Cordia, ziziphus, mango, guava, and citrus may be integrated where appropriate.
- For introduced forage species, germination rate of 50–80% is acceptable and expert consultation is recommended.

Establishment timing:

- Plant at the onset of the rainy season to ensure adequate moisture.
- In dry areas, use seedlings for trees and shrubs to enhance survival.
- Apply controlled grazing or temporary closure to allow establishment.

Measurements and Tools Requirements

- Line level or A-frame (where alignment is required)
- Pegs and string for marking planting lines
- Hoes, shovels, pangas
- Seedlings or certified seeds

- Watering cans where necessary - Gloves, gumboots, PPE - One first-aid kit per team
Layout, Implementation Procedures and Work Norm
- Identify stabilization zones along upper and lower edges, riser faces, or crests of structures. - Mark planting alignment along the structure. - Dig planting holes for trees and shrubs and compact soil after planting. - Sow grasses and legumes in rows and weed after 1–2 months to reduce competition. - Harvest crops and grasses by cutting stems rather than uprooting to protect structural integrity. - Prune or pollard trees after 1–2 years to reduce shading and competition with crops. - **Work norm**: Approximately 25–35 person-days per hectare of stabilized structures, or 80–120 seedlings planted per person-day depending on soil hardness and planting density.
Management Guidelines
- Protect planted areas from free grazing and trampling during establishment. - Inspect structures after heavy rainfall and replace failed seedlings promptly. - Maintain vegetative cover through cut-and-carry practices rather than uprooting. - Apply pruning and crop rotation to reduce competition and sustain soil fertility. - Promote community-based maintenance under CSPW to ensure long-term sustainability.
Limitations
- Requires protection from grazing during establishment. - Poor species selection or spacing may cause shading and competition. - Uprooting crops during harvest can damage structures. - Continuous cropping without rotation may reduce soil fertility.

Name of the Technology	GULLY EROSION CONTROL (GEC) THROUGH VEGETATIVE MEASURES
General Description	
Gully erosion control through vegetative measures aims to rehabilitate and stabilize small to medium-sized gullies using vegetation supported by soil and water conservation practices (Figure 2.1.55). The intervention reduces runoff velocity, reshapes unstable gully sides and bottoms, encourages re-vegetation, and restores land productivity. Vegetative cover anchors soil, enhances infiltration, and minimizes sediment loss. Under the Climate-CSPW framework, gully rehabilitation integrates biological measures with supportive physical structures such as check dams or stone bunds, transforming degraded gullies into stable and productive landscapes that enhance ecosystem resilience, carbon sequestration, and sustainable livelihoods.	 *Figure 2.1.55. Example of an active gully before rehabilitation, showing severe soil erosion and land degradation resulting from uncontrolled runoff*
Geographical Extent of Use	
Suitable for small and medium-sized gullies in cultivated and mixed-use landscapes, including previously abandoned areas. Applicable across all agro-climatic zones where runoff can be safely diverted to stable waterways. In dryland areas, supplementary soil and water conservation measures or small-scale irrigation may be required.	
Technical Standards	
Reshaping and stabilization: - Reshape gully heads, sides, and bottoms to stable slopes before planting. - Fill unstable sections and compact soil where necessary. - Construct small check dams or bunds where runoff concentration is high. - Smooth and level gully floors to promote even water distribution and infiltration	 *Figure 2.1.56: Rehabilitated gully stabilized with vegetation and biological measures, reducing runoff and restoring land productivity*
Measurements and Tools Requirements	
- Water line level - Two graduated range poles - 10 m string - Shovels, pickaxes - Crowbars, sledgehammers - Planting materials (grass slips, shrub seedlings, tree cuttings) - PPE and first-aid kit	
Layout, Implementation Procedures and Work Norm	
- Assess gully size, slope, and runoff pathways. - Divert excess runoff to stable waterways where necessary.	

- Collect stones and prepare foundations for small check dams or bunds. - Reshape and stabilize gully head cuts and side banks. - Level the gully bottom to distribute water evenly. - Establish vegetation immediately after reshaping anchor soil. - Protect rehabilitated areas from grazing during establishment. - Replace failed plants and repair physical structures after heavy rainfall. - **Work norm**: Approximately 500 person-days per hectare of gully area rehabilitated.
Management Guidelines
- Enforce controlled grazing or temporary closure for at least one year. - Apply cut-and-carry systems for fodder harvesting to prevent trampling. - Conduct routine inspections after heavy rains to prevent reactivation. - Maintain dense vegetative cover to ensure long-term stabilization.
Limitations
- Difficult to implement in areas receiving less than 600 mm rainfall without supplemental water. - Requires technical guidance for reshaping and species selection. - Demands sufficient planting materials and skilled labour for effective establishment.

1.3 Flood control measures

A flood is an overflow of water that submerges land that is usually dry. A flood can occur:

a) Anywhere after heavy rains with an overflow but without a spillway, especially after runoff on a hillside or slope
b) Besides a river or after heavy rains or during floods
c) Besides a lake or sea where heavy winds push water towards the coast, especially with overtopping or a spring tide.

Mostly, floods cause adverse effects to human beings, animals, plants, farms and land in general. This guide provides technical details for the following flood control technologies:

- Waterways
- Cut-off drains
- Graded soil bund
- Graded risers
- River training

Name of the Technology	WATERWAY (WW)

General Description

A waterway is a natural or artificial surface water drainage channel constructed along a slope or in a valley to collect and discharge excess runoff safely without creating erosion (Figure 2.1.57). Natural waterways are formed as part of the natural topography such as depressions or small valleys and are stabilized with vegetation to drain water without erosion. They usually maintain continuous or seasonal flow and are characterized by irregular cross-sections and meandering courses. Artificial waterways are constructed surface drainage structures designed to receive and safely dispose of excess runoff to natural watercourses, percolation areas, or water-harvesting structures. Stone-paved waterways are constructed in areas with stones to protect from scouring, whereas vegetative waterways are constructed in areas without stones using grass cover. The use of grass vegetation in waterways is commonly practised locally. Construction is recommended during the dry season.

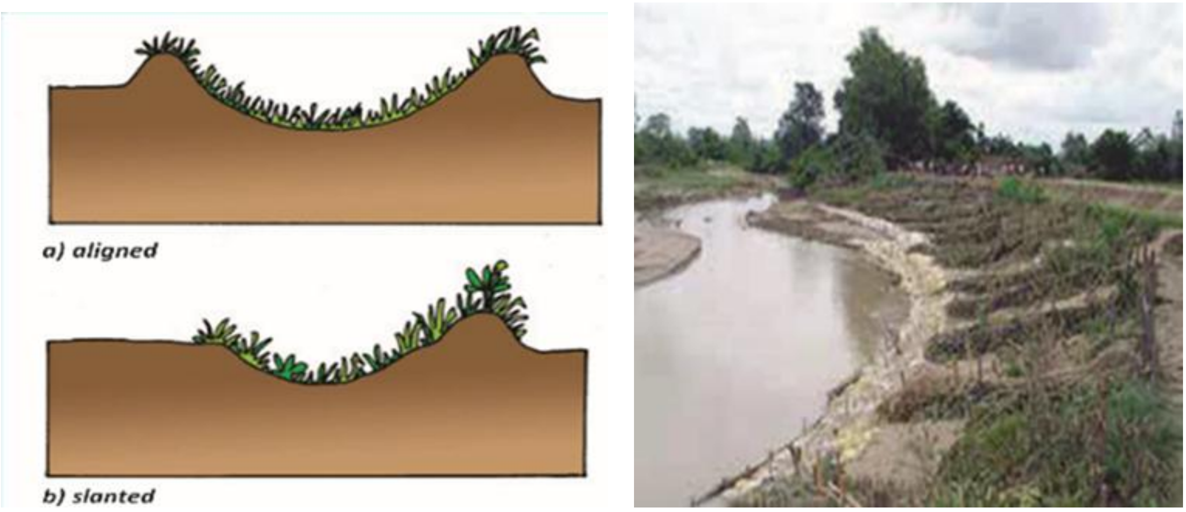


Figure 2.1.57: Variations of waterway cross-section and field application, showing (a) aligned waterway profile, (b) slanted waterway profile, and (c) stabilized field example.

Geographical Extent of Use

Waterways are applicable in all agro-climatic conditions, particularly in moist areas and areas prone to floods. Applied in sloping and relatively flat lands with low or medium infiltration capacity, or in areas experiencing high-intensity rainfall that exceeds normal infiltration capacity.

Technical Standards

Vegetative waterway	Stone-paved waterway
- Slope: Recommended slope < 10%. - Shape: Parabolic cross-section resembling a natural waterway. - Size: Small waterways draining 1–5 ha. Must have sufficient width and depth to accommodate expected runoff volume. - Freeboard: Increase design depth by 25% to accommodate exceptional runoff conditions. - Checks-drop-aprons (CDAs): Place stone or brushwood CDAs every 20 m (slope < 5%), 10 m (slope 5–10%), and 5 m (slope 10–25%).	- Slope: Recommended slope < 20–25%. - Shape: Parabolic cross-section. - Size: Small waterways draining 1–5 ha. - Freeboard: Increase waterway depth by 10% to create a safety margin. - Stone checks-drop-aprons: Construct at 1 m vertical interval; apron length equal to drop height; CDA height 0.3–0.5 m.

Table 2.1.2: Relationship between drainage area and recommended width of waterways

Runoff area (ha)	Width of the waterway (m)		
	Slope (0–5%)	Slope (6–12%)	Slope (13–25%)
1	1.5	1.5	1.5
2	1.5	2	2.5
5	2	3	4.5
10	3	6	9
1.5	1.5	8	12
20	4.5	12	18

Measurements and Tools Requirements

- Water line level
- Two graduated range poles
- 10 m string
- Shovels, hoes, pickaxes
- Crowbars, sledgehammers
- Hammer and ties
- First aid kit
- Gumboots

Layout, Implementation Procedures and Work Norm

- Follow the natural waterway alignment to determine length and width using pegs.
- Determine drainage area.
- Determine width from Table 2.1.2 based on drainage area and slope.
- Determine excavation depth according to design.
- Excavate soil from the centre and throw it to each side to form banks. In sloping land, one lower embankment may suffice. Compact piled soil to stabilize embankments.
- For stone-paved waterways, place flat heavy stones at the bottom and fill spaces between large stones with smaller ones.
- Construct checks-drop-aprons as specified.
- Stabilize banks using local grass or sods during the first year (Figure 2.1.58).

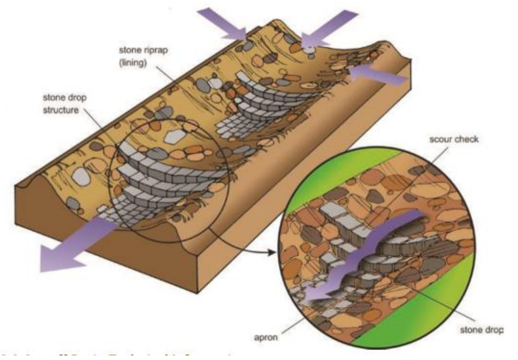


Figure 2.1.58: Stone drop structures installed along a sloping waterway, demonstrating energy dissipation and erosion control

Work norms:

- Vegetative waterway: 1 person-day per 1 m³ (including layout, excavation, erosion control, and outlet improvement).
- Stone paved waterway: 1 person-day per 0.75 m³ of earth/stone movement including drop structures.
- Groups of 5–20 households can work together to increase efficiency.

Management Guidelines

- 5–20 households should work together during and after construction for proper maintenance.
- Inspect waterways after heavy storms and repair damage promptly.
- Stabilize banks and plant channel beds to maintain structural stability.

- Link waterways with in-field water harvesting structures such as charcoal dams and ponds for proper drainage management. Excess runoff may be collected or allowed to percolate into groundwater.
Limitations
- Risk of gully formation if waterways are not properly constructed to discharge water safely. - Land scarcity may force deep and narrow construction, increase erosive force and accelerate gully formation.

Name of the Technology	CUT-OFF DRAIN (COD)

General Description

A cut-off drain is a graded channel constructed along the upper boundary of cultivated land, infrastructure, or irrigation schemes to intercept and safely divert surface runoff to a natural waterway or reservoir. It reduces excess runoff entering fields, protects downstream areas from erosion and flooding, and stabilizes cultivated land (Figure 2.1.59). Cut-off drains are designed to accommodate peak runoff from the heaviest expected storm (typically 10-year return period). Grass stabilization of embankments improves structural stability and contributes to carbon soil sequestration. Construction is recommended during the dry season.

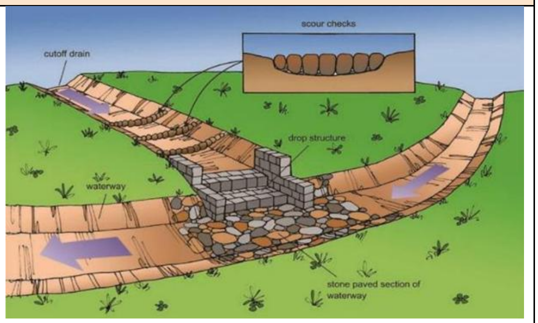


Figure 2.1.59: Stabilized drainage system incorporating a cut-off drain, scour checks, drop structures, and stone-paved sections for safe runoff conveyance

Geographical Extent of Use

Suitable in medium to high rainfall areas where natural waterways exist. Applicable in dry areas to protect irrigation schemes and cultivated land by diverting runoff into reservoirs. Appropriate for catchments less than 50 ha. Very steep slopes (>50%) should be avoided.

Technical Standards

Cut-off drains are designed to safely convey estimated peak runoff.

Step 1: Estimate peak discharge

- Qpt = Qp × Ca
- (Qp from Table 2.1.3; Ca = catchment area in ha)

Table 2.1.3: Run-off coefficient values for different land uses and slope categories.

Land use/cover	Run-off coefficient		
	Slope (0.5%)	Slope (5-10%)	Slope (10-30%)
Cultivated land			
Open sandy loam	0.20-0.30	0.4	0.02
Clay and silt loam	0.5	0.6	0.72
Tight clay	0.6	0.7	0.62
Pastures			
Dense cover	0.1	0.10	0.22
Medium cover	0.3	0.36	0.42
Scattered cover	0.4	0.55	0.8
Forest/woodland			
Dense cover	0.1	0.25	0.3
Medium cover	0.3	0.36	0.6
Scattered cover	0.4	0.5	0.8

Step 2: Determine required cross-sectional area

- A = Qpt / V
- (V from Table 2.1.4)

Table 2.1.4: Maximum allowable flow velocity (m/s) for different channel slopes and depths.

Channel slope	**Maximum allowable velocity (m/sec)**					
Slope (%)	0.0	0.9	1.2	1.5	1.8	2.1
1					0.4	0.5
0.5				0.5	0.7	0.9
0.20	0.3	0.4	0.8	0.0		

Step 3: Select channel shape

- Trapezoidal or parabolic cross-section recommended.

Step 4: Select gradient:

- 1–10 ha = 0.8–1%
- 10–30 ha = 0.5%
- 30–50 ha = 0.25%

Step 5: Determine depth and discharge per unit width from (Table 2.1.5.)

Step 6: Compute top width

- Top width = catchment runoff ÷ discharge per unit width.

Measurements and Tools Requirements

- Layout tools: Water level, rope, tape measure, pegs
- Excavation tools: Shovel, hoe, axe, machete
- Earth handling tools: Wheelbarrow, mortar pans
- PPE and first-aid kit

Layout, Implementation Procedures and Work Norm

- Set graded contour and place pegs at 10 m intervals.
- Peg "O" marks channel centre; N and P define width; M–N–O–P indicate top width (Figure 2.1.60).
- Excavate NSRP first, then shape channel by digging MNR and PQS.
- Compact embankments and stabilize with grass.

Task rates:

- Setting out: 150 m/person-day
- Bush clearing: 150 m²/person-day
- Excavation: 1.5 m³/person-day
- Shaping/compaction: 20 m²/person-day
- Scour checks: 5 units/person-day

Design Illustration (application example)

- For a 6-ha clay catchment with 20% slope and medium grass cover:
- Peak runoff: Q = KIA/36 = 2.05 m³/sec
- Maximum velocity: 1.8 m/sec
- Selected gradient: 1%
- Required depth: 0.4 m

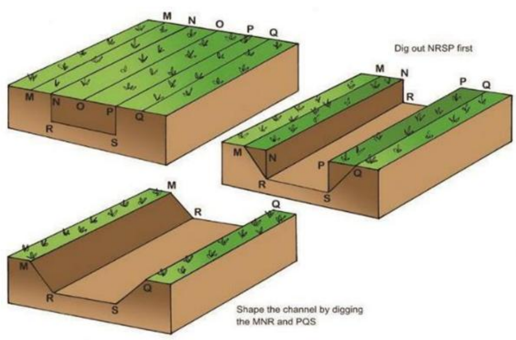


Figure 2.1.60: Sequential excavation steps for shaping a grassed channel cross-section

Table 2.1.5: Discharge per metre width (m³/sec) for different channel depths.

Depth of channel			
	0.01	0.5	0.25
0.3	0.6	0.4	2.25
0.4	0.9	0.65	0.45
0.5	1.3	0.85	0.65

From Table 2.1.5: Discharge per meter width for different channel depths. - Top width: $2.05 \div 0.9 = 2.3$ m - This illustrates practical application of Tables 2.1.3–2.1.5 for sizing a cut-off drain.	
Management Guidelines	
- Inspect drains after heavy storms and repair overtopping sections. - Maintain grass stabilization on embankments. - Ensure safe discharge into stable waterways or reservoirs.	
Limitations	
- Excessive runoff may overtop embankments and cause downstream damage. - Undersized or poorly graded channels increase erosion risk.	

Name of the Technology	GRADED SOIL BUND (GSB)

General Description

A graded soil bund is an embankment constructed along the contour with a gentle gradient (maximum 1%) to safely divert excess runoff to natural or artificial waterways (Figure 2.1.61). It is similar to a level soil bund but is applied in areas receiving more than 600 mm rainfall where runoff must be drained gradually without causing erosion. The objective is to reduce surface runoff accumulation, prevent waterlogging, and protect cultivated land. Grass and leguminous shrubs such as elephant grass, Napier grass, pigeon pea, and *Acacia saligna* are planted to stabilize bunds, enhance soil structure, and provide food and fodder.

Figure 2.1.61: Graded soil bund constructed along the contour with a 1% gradient to divert excess runoff safely to a waterway. Vegetative stabilization protects the embankment and reduces erosion in high rainfall areas.

Geographical Extent of Use

Suitable in high rainfall and humid agro-ecological zones, especially in poorly drained soils. Applicable in highland and midland traditional agro-ecological systems.

Technical Standards

- Layout along contours with 1% gradient using a water line level.
- Maximum bund length: 50–80 m (the steeper the slope, the shorter the bund).

Vertical intervals (VI):

- Slope 3–8% → VI = 1–1.5 m
- Slope 8–15% → VI = 1–2 m
- Slope 15–30% → VI = 1.5–2.5 m (exceptional cases, reinforced only)
- Caution: Soil bunds above 15% slope (maximum 20%) should only be constructed where space is limited and must include a drainage channel. For slopes above 15%, stone-faced or stone bunds are preferred.
- Proper linking and stone pitching required where bund meets waterway.

Measurements and Tools Requirements

- Layout tools: Water line level, two graduated range poles, 10 m string
- Excavation tools: Shovels, pickaxes
- Compaction tools: Wooden compactors
- PPE and first-aid kit

Layout, Implementation Procedures and Work Norm

- Precise layout along contour with 1% gradient using line level.
- Remove grasses from bund foundation area for proper bonding.
- Excavate channel and form embankment, construct ties where necessary.
- Level and compact bund crest using A-frame.
- Stabilize embankment with grass and legumes immediately after construction.

Work norm:

- Approximately 150 person-days per kilometre of graded soil bund constructed.

Management Guidelines

- Stabilize bunds with grasses and legumes, apply cut-and-carry method (do not uproot).
- Inspect after heavy rainfall and repair scouring sections.
- When upgrading to level terraces, use soil from the lower riser to preserve fertile deposited soil.

Limitations

- Excessive gradient may cause scouring.
- Insufficient gradient may cause flow blockage and overtopping.
- Limited stability without re-vegetation requires regular maintenance.

Name of the Technology	GRADED RISER BUND (GRB)

General Description

Graded riser bunds are embankments constructed along cultivated slopes of 3–15% with a maximum 1% gradient to discharge excess runoff safely into adjoining natural or artificial waterways (Figure 2.1.62). They are applied mainly in high rainfall areas where controlled drainage is required to reduce runoff concentration and soil erosion. With regular maintenance, graded riser bunds can gradually develop into benched terraces, improving long-term land stability and productivity. Construction is undertaken during the dry season and should not interfere with land preparation.

Figure 2.1.62. Graded riser bund constructed along a sloping cultivated field with a defined riser face and downstream drainage ditch. The 1% gradient allows safe runoff discharge while reducing soil erosion.

Geographical Extent of Use

Suitable in high rainfall and humid agro-ecological zones, especially where soils are poorly drained. Applicable in highland and midland farming systems and in sloping homestead areas combined with cash crops.

Technical Standards

- **Height**: Minimum 60 cm after compaction.
- **Base width**:
- 1–1.2 m in stable soils (1H:2V) and 1.2–1.5 m in unstable soils (1H:1V)

Top width:

- 30 cm (stable soils)
- 50 cm (unstable soils)
- Drainage ditch: 60 cm width × 50 cm depth.
- Ties: Placed every 3–6 m along the channel.
- Bund length: Up to 60 m (maximum 80 m on gentle slopes 3–5%).
- Channel cross-section increases toward the outlet due to water concentration (e.g., 25 cm × 50 cm to 50 cm × 100 cm).

Vertical interval (VI):

- Slope 3–8% → VI = 1–1.5 m
- Slope 8–15% → VI = 1–2 m

Measurements and Tools Requirements

- Layout tools: Water line level, graduated range poles, string, pegs
- Excavation tools: Shovels, pickaxe
- Compaction tools: Wooden compactors
- PPE and first-aid kit

Layout, Implementation Procedures and Work Norm

- Precise layout along contour with 1% gradient using line level.
- Remove vegetation along bund alignment for proper bonding.
- Excavate downstream ditch and construct ties.
- Build embankment, reshape and compact thoroughly.
- Level bund crest using A-frame.
- **Work norm**: Approximately 200 person-days per kilometre of graded riser bund constructed.

Management Guidelines

- Upgrade progressively into level terraces using soil accumulated in the ditch below the bund (riser principle).
- Apply cut-and-carry method for grasses and legumes; do not uproot.
- Repair breakages immediately after rainfall, particularly during the first year.

Limitations

- Not suitable where cattle crossings are frequent.
- Narrow spacing may reduce cultivable land area.

Name of the Technology	RIVER TRAINING (RT)
General Description	
River training refers to engineering works constructed along rivers to guide, confine, and stabilize flow within a defined channel alignment and cross-section (Figure 2.1.63). The aim is to ensure safe disposal of floodwaters and sediment loads while preventing riverbank erosion and channel shifting. These measures are required particularly in alluvial plains where rivers frequently change course and damage adjacent land, settlements, and infrastructure. River training stabilizes the channel, protects riverbanks, prevents outflanking of structures such as bridges and weirs, and maintains adequate flow depth for navigation and sediment transport.	 *Figure 2.1.63. River retaining by using gabions stones*
Geographical Extent of Use	
Applicable in flood-prone river basins, alluvial plains, and areas where rivers threaten farmland, settlements, irrigation schemes, or infrastructure.	
Technical Standards	
- River training works are designed to stabilize the river along a defined alignment and cross-section capable of safely conveying flood discharge and sediment loads. - Depending on the objective, works may focus on: (i) high water (flood discharge) control, (ii) low water or depth control, (iii) sediment regulation. - Common structural and bio-engineering measures include: (i) gabion retaining structures, (ii) loose stone pitching (Figure 2.1.64), (iii) vegetative bank stabilization (Figure 2.1.65), (iv) concrete retaining walls (Figure 2.1.66). - Selection of measures depends on flow velocity, sediment load, bank material, and level of infrastructure protection required.  *Figure 2.1.64 River retaining using loose stone pitching*  *Figure 2.1.65. River retaining using vegetation*	
Measurements and Tools Requirements	
- Excavation and stone placement tools - Gabion baskets or concrete materials (where applicable) - Compaction tools - PPE and safety equipment	

<table>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">Layout, Implementation Procedures and Work Norm</td></tr>
<tr><td>- Assess river alignment and identify erosion-prone sections.
- Establish stable channel alignment and cross-section.
- Install selected protection measures (gabions, stone pitching, vegetation, or retaining walls).
- Ensure proper anchoring and toe protection to prevent undermining.
- Work norm: Approximately 1500–2000 person-days per kilometre for structural river training works (gabions, stone pitching, retaining walls); vegetative stabilization alone may require 300–500 person-days per kilometre depending on planting density and site conditions</td><td>
Figure 2.1.66. River retaining using concrete wall.</td></tr>
<tr><td colspan="2">Management Guidelines</td></tr>
<tr><td colspan="2">- Inspect riverbanks after flood events for scouring or structural damage.
- Repair displaced stones, damaged gabions, or eroded vegetative sections.
- Maintain vegetation cover for long-term stabilization.</td></tr>
<tr><td colspan="2">Limitations</td></tr>
<tr><td colspan="2">- High construction and maintenance costs for structural measures.
- Requires hydrological and engineering assessment.
- Poor alignment or design may shift erosion downstream.</td></tr>
</table>

1.4 Agroforestry and forestry

Agroforestry

Agroforestry is an ecologically based land use system that integrates trees with crops and/or livestock in the agricultural landscape to diversify and sustains production for increased social, economic, and environmental benefits to land users. Trees, crops and/or livestock/fodder are major components of an agroforestry system. Based on these components, agroforestry systems are broadly categorized into:

- **Agrisilvicultural systems**, composed of a combination of trees and shrubs with arable crops in spatial (same place and time) or temporal (same place at different time) arrangements. Examples include *Faidherbia albida* agroforests in Mbarali Mbeya, baobab parkland agroforestry and fertilizer tree-cereal intercropping in semi-arid areas, and cocoa agroforestry (mixture of cocoa, shade tree and crops) in Morogoro and Tanga regions
- **Silvopastoral Systems** in which trees/shrubs are combined with livestock or fodder. Examples include *Ngitili* and *Alalili* silvopastoral systems in semiarid areas in the lake zone (Shinyanga, Simiyu, Mwanza) and northern Tanzania (Manyara and Arusha regions), and zero grazing in sub-humid and humid areas like Arusha, Kilimanjaro and Southern Highlands. Both *Ngitili* and *Alalili* are traditional rangeland management practices which make use of local institutions and participatory approaches to foster sustainable management and conservation of natural resources to sustain livestock productivity while providing wood and non-wood resources to improve rural livelihoods.
- **Agrosilvopastoral systems** with a combination of all three components (trees/shrubs and crops and livestock/pasture) in spatial arrangements. Examples of agroforestry technologies in this category are coffee home garden agroforestry in Bukoba and Kilimanjaro regions comprised of combinations of shade trees and crops (banana and coffee) in homesteads with or without integration of livestock or fodder. This technology is also known as a shaded perennial-crops system when established away from home and with no livestock integration (Figure 2.1.67).

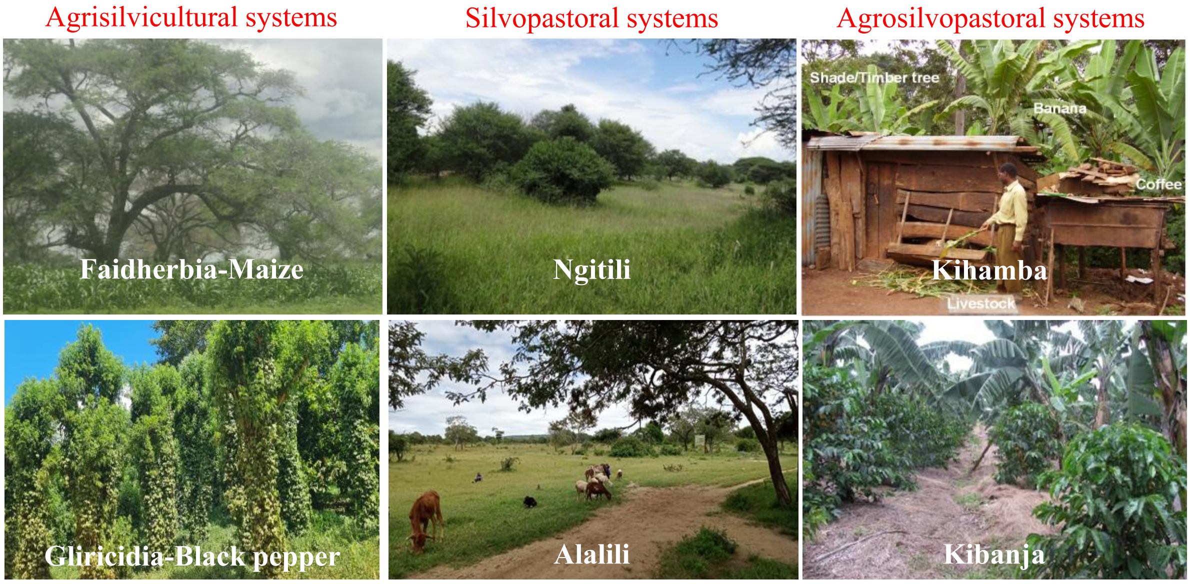


Figure 2.1.67. Examples of agroforestry systems and technologies in Tanzania.

Agroforestry and CSPW Programmes

As implied in the definition, agroforestry provides environmental, economic, and social or livelihood benefits by integrating trees with crops and/or livestock. Environmental benefits include improved soil health, restoration of degraded land, enhanced climate resilience of cropping systems (agro-ecosystem resilience), increased biodiversity, and carbon sequestration.

Economically, it increases and sustains yields by providing diverse income streams from multiple products from trees, crops, and livestock; reducing the risk of total crop failure and market volatility as farmers produce and sell multiple products from their farm; and bringing about job creation. Socially, it can empower local communities by increasing food security and preserving traditional knowledge. Thus, integrating agroforestry into the PSSN III program will contribute to productivity/livelihood, adaptation, and mitigation outcomes of the CSPW sub-projects.

Experience from Ethiopia and Malawi demonstrates that the benefits of integrating agroforestry technologies in CSPW programs helps to restored degraded landscape, improve soil health and climate resilience, and sequester carbon.

In Tanzania, agroforestry technologies that meet the PW criteria for integration into the CSPW program include boundary or roadside tree planting, and tree planting or regeneration (including fruit trees) for landscape restoration and aesthetic value on institutional lands like schools and hospitals. Although agroforestry is largely implemented on individual farms, local communities can also be trained to use various agroforestry technologies in combination with other CSPW sub-projects (e.g., soil and water conservation, rainwater harvesting, and small-scale irrigation) to increase the impact of CSPW on crop and livestock productivity, climate resilience, and carbon sequestration.

Forestry

The United Republic of Tanzania defines forest as an area of land of at least 0.5 ha with a minimum tree crown cover of 10% or with existing tree species, planted or natural, having the potential of attaining more than 10% crown cover, and with trees that have the potential to or have reached a minimum height of 3 m at maturity in situ. The forest cover in the country is estimated at 48.1 million hectares.

Forests are vital to rural livelihoods, providing firewood, timber, fruits, medicinal plants, and other non-timber products, while supporting biodiversity, soil fertility, and water regulation. The contribution of the forest sector to Tanzania economy is 3.3% of GDP, but it could be increased up to 20% if ecosystem services like water regulation and carbon storage are factored in.

Modern forestry management practices also recognize that the benefits extend beyond timber and other wood products to include climate change mitigation, carbon storage, clean water, flood prevention, and recreational opportunities. Forest and landscape restoration is an active process that brings people together to identify, negotiate, and implement practices that restore an agreed optimal balance of the ecological, social, and economic benefits of forests and trees within a broader pattern of land uses.

Climate-Smart Public Work activities to be done by beneficiaries will enhance the capacity of agroforestry systems and forest ecosystems to produce both wood and non-timber forest products as well as provision of other ecosystem services like water supply, carbon sequestration, and biodiversity conservation. These activities may include catchment forest conservation, enrichment planting and natural regeneration of trees in degraded forests and woodlands, establishment of woodlots for wood supply (timber, poles, fuelwood, etc.), and environmental conservation, beekeeping and participatory management of forests for livelihood and environmental benefits such as beekeeping and supply of non-timber forest products (mushroom, fruits, medicinal trees, grass for fodder, and house roofing). The success of tree planting and enrichment planting is, among other things, dependent upon supply of quality planting materials (seed and/or tree seedlings) of sufficient quantity.

Technical details of the following agroforestry and forestry practices most relevant to CSPW in Tanzania are described in this manual

- Seed collection
- Tree nursery
- Woodlot
- Boundary tree planting and live fences
- Urban forestry, including roadside tree planting
- Beekeeping

Name of the Technology	SEED COLLECTION (SC)

General Description

Seed collection (SC) is the activity of collecting tree, shrub, and grass seeds for specific use. Seed collection can be done from small tree plantations, homestead areas, and forests (Figure 2.1.68). The objective is to ensure availability of sufficient seeds for multipurpose uses such as stabilization, homestead planting, grazing land improvement, fencing, gully control, and protection of valuable tree species. Communities can also earn income through the sale of seeds. Diversified tree seed collection supports biodiversity conservation and provides households with products and services including firewood, shade, fruits, timber, bark, medicines, fodder, fertilizer, dyes, gums, and fibre.

Figure 2.1.68: Cleaned and dried seeds collected from mature pods, ready for processing and storage.

Geographical Extent of Use

Applicable in small plantations, homesteads, forests, reserves and other accessible areas where seed-producing trees, shrubs and grasses are available.

Technical Standards

The following specifications ensure collection of high-quality seeds and safe procedures (Figures 2.1.69 and 2.1.70):

Genetic diversity

- Collect seeds from many genetically unrelated and well-dispersed parent trees.
- Collect from multiple, well-distributed locations within a defined seed zone.
- Avoid collecting from few or closely related trees to maintain adaptability and disease resistance.
- **Seed collection methods (FAO recommended):**

Depending on tree species and access conditions, the following methods may be applied:

- **Natural seed fall** – Clear ground beneath mother tree before seed fall; collect daily using rake or sheets; sieve to remove debris.
- **Shaking trees** – Spread clean sheet/net; shake trunk or branches manually or using poles; collect and separate seeds from pods/fruits.
- **Pruning seed-bearing branches** – Select branches with mature pods; position ground sheets; cut branches carefully; collect and remove seeds.
- **Climbing trees** – Only trained personnel should climb trees. Use ladders or platforms; climb only branches strong enough to support body weight; cut seed-bearing branches carefully. Do not climb alone.
- **Felled trees** – Collect mature seeds only; never fell trees solely for seed collection.

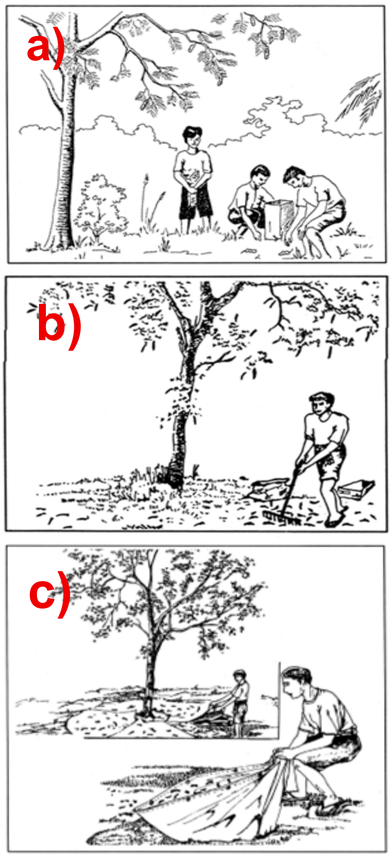


Figure 2.1.69. Natural seed fall collection methods (a–c). Source: FAO.

Measurements and Tools Requirements

- Ladders, sticks and pole pruners with saw or hooked knife.
- Plastic bags or sacks to prevent contamination from soil and moisture.
- Different sizes of bags, baskets, and containers for storage.
- Large canvas, cloth, or plastic sheets for seed collection.
- Rake for cleaning ground before seed fall.
- Sieve for cleaning seeds after threshing.
- Aerated and dry storage facility.

- Proper safety gear (ropes, gloves, helmets, boots) for climbing and field operations.

Implementation Procedures and Work Norm

- Identify and prioritize community seed needs through technical consultation and local knowledge.
- Conduct inventory of seed-producing trees and grasses.
- Select healthy and vigorous mother trees; collect ripe seeds at proper time (not fresh, fallen, or old).
- Clean, dry, and remove impurities; bag and store in aerated and dry facilities.
- Organize community groups and provide training on unfamiliar species.
- Develop a realistic seed collection plan including labour estimates and storage arrangements.

Work norm:

- 1 person-day / 50 g of clean tree seed.
- Grevillea robusta = 1 person-day / 15 g.

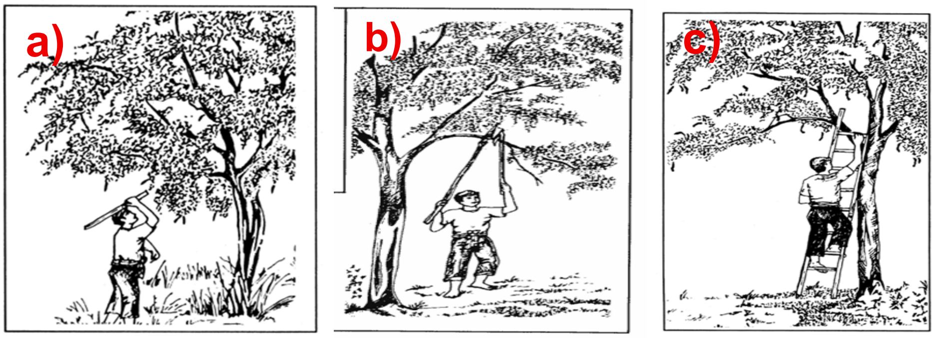


Figure 2.1.70. Shaking, pruning and climbing methods for seed collection (a–c). Source: FAO.

Management Guidelines

- Ensure seeds are collected at correct maturity stage.
- Maintain proper cleaning, drying, and storage conditions.
- Integrate traditional knowledge with technical guidance.
- Monitor seed viability before nursery use.

Limitations

- Limited availability of mature, quality seed trees in degraded areas.
- Access challenges due to tree height, terrain, or forest restrictions.
- Risk of contamination from moisture or soil without proper containers.
- Inadequate knowledge in identifying ripe seeds and proper handling.
- Poor storage conditions leading to seed deterioration.
- There are safety risks when climbing is done without using proper gear or equipment.

Safety measures at work

- Only trained personnel should attempt tree climbing
- Use proper safety gears for climbing trees and other seed collection in the field.
- Do not climb a tree when alone. Rather, use other means of seed collection described here.

Name of the Technology	TREE NURSERY

General Description

Tree, shrubs, and grass nurseries are established to produce seedlings for multiple uses including soil and water conservation, land restoration, shade, windbreaks, fodder, timber, fuelwood, medicine and other household needs (Figure 2.1.71). Nurseries are prepared and established before the rainy season to ensure reliable water supply for seedling production. Under CSPW, tree nurseries support landscape restoration, biodiversity conservation, livelihood improvement, and climate resilience.

Figure 2.1.71. Community tree nursery showing well-arranged seedlings in polythene tubes (left), and farmers inspecting and tending young seedlings as part of routine nursery management activities (right)

Geographical Extent of Use

Tree nurseries can be established in all ecological zones where the following conditions are met:
- Availability of clean and adequate water near the nursery site.
- Location close to the community for ease of access and supervision.
- Slightly elevated site to prevent water stagnation.
- Protection using living fence species (e.g., *Pithecellobium dulce*, *Grevillea*, *Dovyalis cafra*) to minimize damage by humans and livestock.

Technical Standards

Nursery size and capacity
- A standard nursery area of approximately 0.25 ha can hold up to 100,000 seedlings.

Technical steps
- Collect topsoil, manure, and sand for soil mixtures.
- Recommended soil ratio: 3 wheelbarrows of topsoil : 2 manure : 1 sand.
- Sieve and mix soil thoroughly.
- Cut and fill polythene tubes.
- Prepare and water seedbeds.
- Sow seeds and transplant seedlings.
- Conduct root pruning.
- Arrange seedlings based on size and quality.
- Maintain clean, well-drained and supportive nursery environment.
- Install adequate drainage to reduce erosion and waterlogging.

Measurements and Tools Requirements

Required tools:
- Digging hoes, shovels, and sieves.
- Root-pruning knives, ropes.
- Polythene tubes.
- Watering cans, buckets.
- Rakes and wheelbarrows.

Safety and site facilities:
- Protective gear: Overalls, gumboots, gloves, helmets, and masks.
- First-aid kit and basic medicines available on site.
- Construct a latrine for workers.
- Exercise care during lifting, bending, carrying materials, and tool use to avoid injuries.

Layout, Implementation Procedures and Work Norm

- Select suitable elevated sites near water source and community.
- Fence nursery using living fence species.
- Prepare soil mixture and fill polythene tubes.
- Establish seedbeds and sow seeds.

- Transplant seedlings into tubes. - Maintain watering, weeding, pruning and pest control routines. - Install drainage channels to prevent water stagnation. **Work norms** - Collection of soil mixture (3 topsoil : 2 manure : 1 sand): 1.5 m^3/pd. - Sieving and mixing soil: 1.2 m^3/pd. - Cutting and filling polythene tubes: 350 tubes/pd. - Preparation and mulching of 1 × 6 m seedbed: 1 seedbed/pd. - Watering and weeding: 1 person per 20 seedbeds/day or 1 person per 2,000 pots/day (depending on water distance). - Uprooting and transplanting seedlings: 800 seedlings/pd. - Root pruning, weeding and pest/disease control: 800 seedlings/pd.
Management Guidelines
- Ensure regular watering depending on rainfall and seedling stage. - Maintain nursery hygiene to prevent pest and disease outbreaks. - Conduct routine root pruning to promote strong root systems. - Arrange seedlings by size and quality for uniform growth. - Protect nursery using living fences and community supervision.
Limitations
- Soil erosion may occur at soil collection sites. - Areas used for soil extraction should be rested for 5–10 years to allow natural regeneration. - Poor drainage may cause waterlogging and seedling loss. - Labour-intensive during peak production stages.

Name of the Technology	WOODLOT

General Description

A woodlot is a parcel of woodland or forest capable of small-scale production of forest products such as wood fuel, sawlogs, and pulpwood, as well as recreational uses (Figure 2.1.72). Planted woodlots are common in Tanzania, especially in the Southern Highlands, and Kilimanjaro and Arusha regions, where they are managed for timber, poles, and woodfuel. Woodlots were widely promoted in the Lake Zone under the *Hifadhi Ardhi Shinyanga* (HASHI) programme for land restoration and woodfuel production to reduce pressure on native forests. Planted woodlots commonly use fast-growing exotic species to meet growing biomass demand. Tanzania Forest Services (TFS) estimates that by 2030, small- and medium-scale woodlots will supply about 50% of projected wood demand of 20 million m^3/year).

Figure 2.1.72: Woodlot of Albizia spp at TARI-Tumbi (Photo Credit A. Kimaro/ICRAF)

Geographical Extent of Use

Woodlots can be established in all agro-ecological zones of Tanzania when species are matched to local site conditions. Forest plantation and woodlot guidelines are provided by Forest and Beekeeping Division – FBD (2017) and in the FBD Technical Order No. 1 of 2021.

Technical Standards

Site and species selection:

- Select non-waterlogged sites; degraded or abandoned farmland preferred.
- Match species with site conditions and intended objective (timber, poles, fuelwood, conservation) using national guidelines and expert consultation.

Spacing:

- 2.5 m × 2.5 m for fuelwood and poles.
- 3.0 m × 3.0 m for timber production.
- Enrichment planting and assisted natural regeneration recommended for native woodlots.
- Pitting and Planting

Pit size:

- 20–30 cm × 20–30 cm (humid/sub-humid areas).
- 40 cm × 40 cm (dry areas).
- Dig and plant after first rains to improve survival.
- Replace dead seedlings (beating-up) when mortality reaches 10–20%.

(Refer to FBD Technical Order No. 1 of 2021 for detailed prescriptions

Measurements and Tools Requirements

Tools:

- Ropes/strings for row alignment.
- Hoes, shovels, machetes.
- Pruning saws and thinning tools.

Safety:

- Workers must wear overalls, gumboots, helmets, gloves and masks.
- First-aid kit and basic medicines available on site.
- Construct a latrine for workers.
- Observe safety during pitting, pruning, thinning and firebreak construction.

Layout, Implementation Procedures and Work Norm

- Select site and mark planting rows using ropes.
- Dig pits according to recommended size and spacing.
- Plant seedlings at onset of rains.
- Conduct replacement planting where necessary.

Work Norms
- Pitting: 10 holes/pd - Tree planting: 20 trees/pd - Weeding: 10 trees/pd - Firebreak making: 5 m/pd - Pruning: 10 trees/pd - Thinning/Cutting: 5 trees/pd
Management Guidelines
- Weed at least twice annually during first three years. - Taungya (intercropping) allowed before canopy closure with caution. - Prune 40–50% of crown using sharp curved saw; avoid wet season pruning. - Conduct thinning (especially in pine) twice during rotation to enhance diameter growth and sawlog production. - Establish and maintain annual 5 m firebreak around the woodlot. - Monitor survival rate and replace dead seedlings promptly.
Limitations
- Land used for woodlots may reduce agricultural land availability. - Poor management due to labour and cost constraints reduces final product quality.

Name of the Technology	BOUNDARY TREE PLANTING AND LIVE FENCES
General Description	
Boundary planting, also known as live fence planting, is a technique used to mark farm boundaries or protect crops from interference by people and animals by planting trees or shrubs along farm boundaries to form a shield-like barrier (Figure 2.1.73). In addition to protection, boundary planting can provide wood products such as timber and poles, ornamental value, and environmental benefits such as windbreak and shade. Under CSPW, boundary tree planting supports land restoration, farm protection and wood production.	 *Figure 2.1.73: Acacia polyacantha planted on farm boundary to protect crops against livestock (Photo credits A. Kimaro/ICRAF)*
Geographical Extent of Use	
Boundary tree planting can be practised in all agro-ecological zones of Tanzania when appropriate tree species adapted to local site conditions are used. Technical guidelines from the Forest and Beekeeping Division provide recommended indigenous and exotic species for different zones.	

Technical Standards

Tree species selection:
- Match species with site conditions and intended purpose (protection, timber, poles, ornamental).
- Prefer thorny species for strong barriers.
- For homestead live fences, use sprouting trees/shrubs or flowering species (e.g., bougainvillea) for protection and ornamental value.

Buffer zone:
- Plant trees at least 3 m inside the boundary to minimize conflicts with neighbours (shade or branch encroachment).
- Alternatively, establish two rows of trees on each side of the boundary so each farmer manages their own trees.

Spacing:
- 2 m spacing for narrow canopy species.
- 3 m spacing for wide canopy species.
- Other silvicultural practices follow those recommended for woodlots.

Measurements and Tools Requirements

Tools:
- Digging hoe, rattle tool, rake.
- Panga/machete, knife, shovel.
- Pruning and thinning tools where necessary

Safety:
- Workers must wear overalls, gumboots, helmets, gloves, and masks.
- First-aid kit and basic medicines available on site.
- Construct a latrine for workers.
- Observe safety during pitting, pruning, and thinning operations.

Layout, Implementation Procedures and Work Norm
- Mark boundary lines clearly before planting.
- Dig pits according to spacing standards.
- Plant seedlings during rainy season.
- Replace dead seedlings where necessary.
- Conduct regular pruning and thinning as required.

Work norms - Pitting: 10 holes/pd - Tree planting: 20 trees/pd - Weeding: 10 trees/pd - Pruning: 10 trees/pd - Thinning/Cutting: 5 trees/pd
Management Guidelines
- Conduct regular weeding especially during first three years. - Prune to maintain barrier strength and desired tree shape. - Thin where necessary to maintain spacing and tree quality. - Monitor boundary alignment to prevent disputes.
Limitations
- Boundary trees may reduce available agricultural land along edges. - Poor management (weeding, pruning, thinning) due to labour and cost constraints may reduce effectiveness and product quality.

Name of the Technology	URBAN FORESTRY
General Description	
Urban forestry is defined by the Food and Agriculture Organization (FAO) as an integrated approach to planting, care, and management of trees in cities to provide environmental and social benefits (Figure 2.1.74). It includes woodlands, groups of trees, and individual trees in areas such as streets, parks, residential zones, and other public spaces. Urban tree planting improves air quality by absorbing pollutants, reduces urban heat through shading and cooling, manages stormwater, enhances biodiversity, conserves energy, increases property values, and contributes to improved physical and mental well-being of urban residents.	 *Figure 2.1.74. Trees planted adjacent to office premises in Arusha, Tanzania (Photo Credits A. Kimaro/ICRAF)*
Geographical Extent of Use	
Urban forestry can be practised in all urban and peri-urban areas depending on purpose, local climate and land use preference. Ornamental and fruit trees are commonly planted in residential and institutional areas, while parks and conservation areas may accommodate diverse species. Suitable sites include open or degraded fields, reserved lands such as mountains and slopes, government and community facilities (schools, universities, health centres and offices), road reserves and land demarcation areas.	
Technical Standards	
Site and species selection: - Select species based on local climate, purpose (shade, fruit, ornamental, conservation) and land use. - Avoid conflict with infrastructure (buildings, roads, utilities). **Planting and establishment:** - Prepare planting holes according to species requirements. - Apply manure and mulch to improve soil fertility and conserve moisture. - Install fencing where livestock interference is possible. - Include stable check bunds in valleys or small gullies where necessary.	
Measurements and Tools Requirements	
Tools: - Pickaxe, shovel/spade, rake. - Rope, pegs, tape measure. - Sieve, knife/razorblade, machete/panga. - Jerrycans, trolley, hammer. - Pruning scissors and wire for root pruning. - Seedlings or seeds. - Record book. **Safety:** - Workers must use overalls, gloves, gumboots, helmets and protective masks. - First-aid kit and medicines available on site. - Provide latrine facilities for sites far from estates.	
Layout, Implementation Procedures and Work Norm	
- Identify appropriate urban planting sites. - Select species according to purpose and site suitability. - Prepare planting holes and apply manure and mulch. - Plant seedlings and provide regular watering. - Install protective fencing where necessary. - Conduct routine pruning, maintenance, and monitoring.	

Work norm - 10 persons per day per hectare (10 persons/day/ha).
Management Guidelines
- Control livestock grazing through fencing and closures. - Apply manure and mulch to conserve soil moisture. - Prevent bush fires and other destructive activities. - Prevent deforestation for charcoal, firewood, or farming. - Monitor reserved urban tree areas to prevent misuse (garbage disposal, burning, grazing).
Limitations
- Urban reserved areas may be misused for grazing, garbage disposal, or fire. - Limited space designated for tree planting in urban settings. - Lack of alternative energy sources increases pressure on urban trees for fuelwood.

2.0 Water related sub-projects

2.1 Rainwater harvesting

Rainwater harvesting (RWH) is simply collecting, storing, and purifying the naturally soft and pure rainfall that falls upon the roof and or land surfaces. Rainwater harvesting is practised to supplement water supply from the above-mentioned sources. Water shortage is an acute problem in arid and semi-arid areas where there is high spatial and temporal variability in rainfall patterns.

With the existing climate change exaggerating the challenge of water shortage, it is imperative that RWH should be considered as a potential source of water, especially in the rural areas where availability of water from other sources is still a challenge. Harvested rainwater has several uses including domestic uses by community, offering support for home gardens for vegetables, and fruit and shade trees; and providing small-scale irrigation for crops and vegetable farming, fish farming, and livestock uses. These benefits help community to diversify livelihood strategies, increase crop production and income to adapt to climate change impacts, and contribute to environmental sustainability (tree planting) even in arid and semi-arid areas with harsh growing conditions.

The technical manual covers the design and implementation of the following water harvesting technologies:

1. Roof rainwater harvesting
2. Underground water harvesting, including springs, hand-dug wells and construction of ground water tanks.
3. Surface rainwater harvesting: Runoff from areas like roads, foot paths, small grazing land areas, rocky places, etc., is harvested and distributed to farms or preserved in storage systems such as tanks, dams, and pools for future usage. Technologies included in this manual are small ponds, earth dams, and small-scale earth dams
4. Rainwater harvesting in farms

Name of the Technology	ROOF RAINWATER HARVESTING (RRWH)

General Description

Roof rainwater harvesting is a system with roof catchments that divert rainwater to an appropriate storage system such as tanks or water reservoirs (Figure 2.2.1). This mostly occurs on iron sheet roofs or tiled roofs for domestic purposes, livestock, and farming.

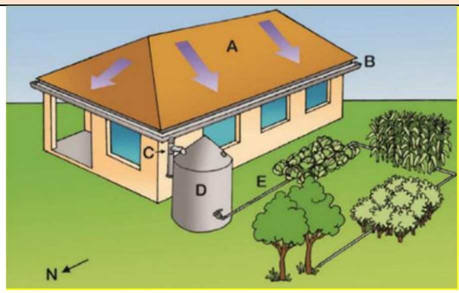


Figure 2.2.1. Schematic illustration of a typical roof rainwater harvesting system showing roof catchment (A), gutters (B), downpipe (C), storage tank (D), and distribution to crops (E).

Geographical Extent of Use

Roof rainwater harvesting is applicable in all agro-ecological zones, but it is more feasible in arid and semi-arid zones where the access for surface water and groundwater is very limited and expensive.

Technical Standards

- Measure the area of your roof in m².
- Calculate the average annual rainfall in litres per square metre (L/m²) or millimetres (mm).
- Estimate the volume of water that can be collected/harvested from the roof surface (area of roof, m² × annual rainfall (mm).
- Establish the size of water tank, which is equal to the annual volume of water from a roof.
- Measure the tank construction site (the shape of the tank can be circular, rectangular or square etc.).
- Dig up the tank's foundation and use an expert to continue with the other steps of tank construction. (Figure 2.2.2)

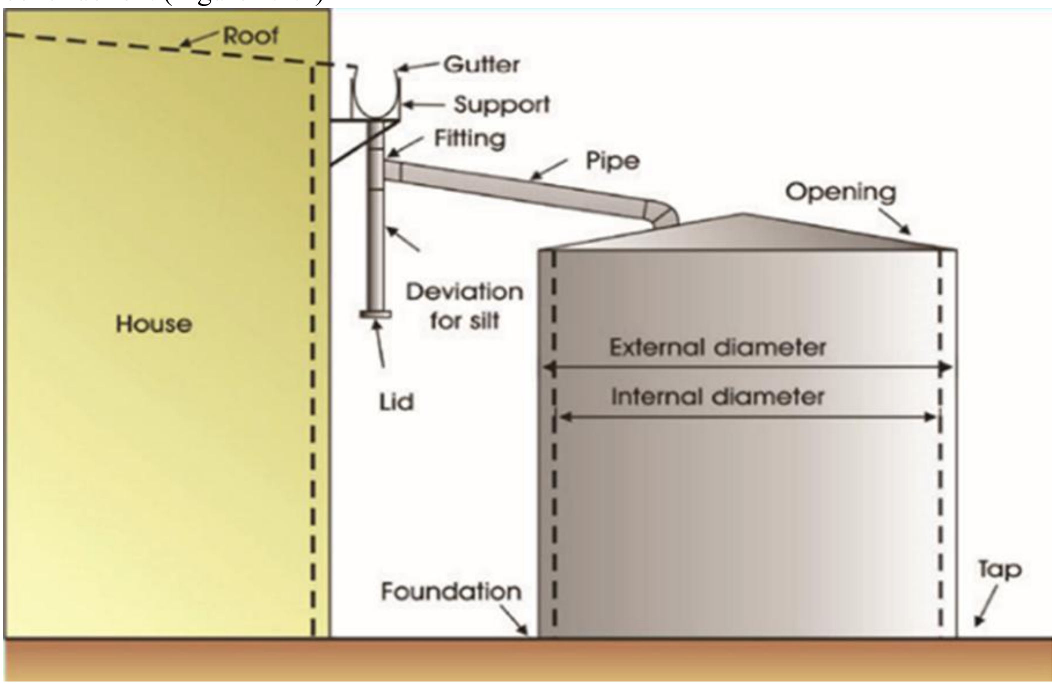


Figure 2.2.2: Components of a household rainwater harvesting system showing gutter, downpipe, silt diversion, inlet pipe, storage tank, lid, and tap outlet.

Measurements and Tools Requirements

- Roof area measurement tools (measuring tape).
- Rainfall data (annual rainfall in mm or L/m²).
- Basic excavation tools for tank foundation.

- Stone collection and transport tools. - Concrete application tools.
Layout, Implementation Procedures and Work Norm
- The system involves roof catchment preparation, gutter and downpipe installation, and construction of a storage tank. **Work norms:** - Digging the foundation ditch: 2 m^3 - Stones collection: 0.8 m^3 - Breaking of the big stones: 0.4 m^3 - Transportation of stones for a distance not exceeding 150 m: 0.8 m^3 - Transportation of stones for a distance exceeding 150 m: 0.5 m^3 - Arrangement of stones to build a stone wall: 1.5 m^3 - Applying concrete: 0.4 m^3
Management Guidelines
- The system should be frequently cleaned before storing water in the tank. - Ensure gutters, downpipes, and inlet systems are free from blockage. - Maintain the tank lid properly to prevent contamination.
Limitations
- Avoid collecting rainwater at the start of the rain shower as the water is usually dirty with dust, bird faeces, etc.

Name of the Technology	SPRINGS

General Description

Spring is a place on the Earth's surface where groundwater emerges naturally. The water source of most springs is rainfall that seeps into the ground uphill, which then comes out from the spring outlet. Spring water moves downhill through soil or cracks in rock until it is forced out of the ground by natural pressure. Protected springs improve water quantity and quality for domestic consumption and other productive purposes (Figure 2.2.3).

Figure 2.2.3. A constructed spring protection structure featuring a reinforced collection chamber, delivery outlets, and surrounding drainage area used for safe water abstraction by the community.

Geographical Extent of Use

Springs are applicable in areas where groundwater naturally emerges at the surface. They are suitable in upland and hilly areas where rainfall infiltrates uphill and re-emerges downslope. Protection is particularly important in rural communities relying on natural spring water for domestic and productive uses.

Technical Standards

- Identify a spring with potential water flow. Measure the water flow from the spring during the dry period using a bucket and a clock.
- Hold discussions with the community on the location and layout. The spring protection site should be on a relatively high spot to prevent surface water from entering the spring chamber.
- Runoff from the areas surrounding the spring should be diverted away from the spring protection point.
- A small impermeable opening with concrete cover should be provided.
- Thin concrete aprons around the spring tops should be constructed to prevent spilled water and other wastes from seeping into the spring chamber.

Measurements and Tools Requirements

- Bucket and clock for measuring water discharge during dry period.
- Basic excavation tools for preparation of the spring chamber area.
- Concrete mixing and application tools.
- Materials for impermeable cover and apron construction.

Layout, Implementation Procedures and Work Norm

- Conduct site identification and dry-season discharge measurement.
- Engage the community in determining reliable spring source and layout.
- Excavate around the spring eye carefully to avoid disturbing natural flow.
- Construct a reinforced collection chamber.
- Provide a small impermeable opening with a concrete cover.
- Construct thin concrete aprons around the spring top.
- Divert surrounding runoff away from the protected spring.

Management Guidelines

- Ensure runoff diversion channels are maintained to prevent contamination.
- Keep the spring chamber clean and sealed.
- Conduct regular inspection and maintenance of concrete aprons and covers.
- Involve the community in routine monitoring and protection of the spring source.

Limitations

- Springs are susceptible to contamination from surface runoff, requiring protection and regular maintenance at a point where the water leaves the ground.
- The quantity of available water may change seasonally, especially when local community members are not consulted to determine a reliable spring water source.

Name of the Technology	**HAND-DUG WELLS (HDWs)**

General Description

A hand-dug well (HDW) is an underground hole dug reaching the water storage table for human consumption, animals or for farming purposes (Figure 2.2.4). This is a traditional way of obtaining water from the ground. Normally, a hand dug well is completed by putting up stability structures such as pipes, stones or concrete slabs preventing the well from collapsing. This also prevents the well from getting dirt and any pump from scooping sand. The well should be located at least 30 m from a stream, pit latrine or open water hole. The well should be dug during the dry season and when the water table is low.

Figure 2.2.4. Examples of community-managed water points, including a protected shallow well with a concrete cover and inspection chamber (a), and a hand pump installed on a lined well for safe groundwater abstraction (b).

Geographical Extent of Use

Productive and suitable wells can be obtained in areas with permeable geological formation (aquifers less than 30 metres) and good potential for groundwater recharge, on alluvial deposits following the main waterway and along the main watercourses.

Technical Standards

- Assess the topography and land use pattern.
- The well site should be on a relatively high spot to prevent surface water from entering the well.
- On hard rock formation, the diameter of the well could be 1.5–3.0 m.
- In unstable soils, the diameter could be wider 5–7 m at the top and 1.5 m from the point where hard/stable formation is encountered.
- Once the water-bearing layer is reached, it should be penetrated as far as possible. If the wall is unstable, it should be supported.
- A small opening with a concrete cover should be provided to enable easy fetching of water.
- Concrete aprons around the well tops should be constructed to prevent spilled water and other waste from seeping into the well (Figures 2.2.5 and 2.2.6).

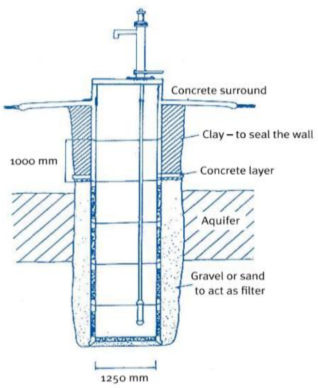


Figure 2.2.5. Section view of a shallow well installed with hand pump

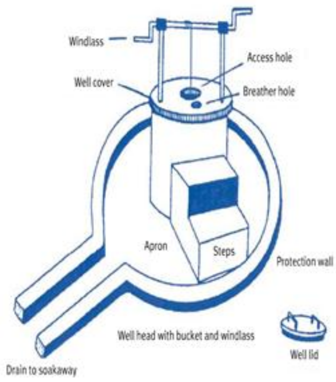


Figure 2.2.6. Plan view of a shallow well installed with hand pump

Measurements and Tools Requirements

- Shovels
- Pickaxes
- Crowbars
- Buckets for dewatering
- Gum boots
- Masks and gloves

Layout, Implementation Procedures and Work Norm
- Select a suitable site at least 30 m away from contamination sources. - Dig during the dry season when the water table is low. - Excavate manually until the water-bearing layer is reached. - Support unstable walls using stones, pipes or concrete slabs. - Construct concrete covers and aprons. - Provide proper drainage around the well. **Work norm** - Excavation: 1.5 m^3 per person day on ordinary soil for the first one meter. Thereafter, task rate is reduced according to the depth, but up to 0.5 m^3/pd work that involves digging and disposing excavated material. - Stone excavation: 0.4 m^3/person-day - Stone collection: 0.8 m^3/person-day - Breaking of big stones: 0.4 m^3/day - Transportation of stones for a distance not exceeding 150 m: 0.8 m^3/day - Gravelling: 0.4 m^3/day - Transportation of gravel for a distance not exceeding 150 m: 0.5 m^3/day - Transportation of gravel for a distance exceeding 150 m: 0.8 m^3/day
Management Guidelines
- Open wells should be inspected every day to ensure that no debris enters the well, while closed wells should be inspected periodically for the same reason. - Cut-off drains should be well maintained to prevent runoff, spilled water and animal waste from seeping or entering directly into the wells. - To prevent contamination of the water, the rope and bucket used to collect the water should be suspended from the wellhead so that it cannot touch the ground. - To avoid contamination of the closed well and ease fetching of water, the pulley or roller attached to a rope and bucket can be used. - Facilitate the community to form a well management committee. - The management committee and the users collaborate with the local government to come up with simple laws for the protection of the well. - The management committee and the users collaborate with the local government to agree and to start collection of O&M fees for the well. - Provide a programme of activities to sensitize the community on strategies for hygiene and conservation of the wells.
Limitations
- Shallow wells are dug manually by using hands; their use is restricted to suitable types of ground such as clay, sand, gravels and mixed soils where only small boulders are encountered. - Depth of hand-dug wells range from shallow wells of about 5 m deep to deep wells of over 20 m deep.

Name of the Technology	SMALL PONDS (SPs)

General Description

Small ponds are used in the collection and preservation of water flowing from small water catchment areas inside and outside a residential area (Figure 2.2.7). They can collect water from feeder roads, graded bunds, spillways, and other runoff sources, and are ideally constructed during the dry season. Small ponds may be cemented or non-cemented. Cemented ponds are used for harvesting water for small-scale irrigation to ensure availability of excess water during the rain period and a few months after the rain season, while non-cemented ponds are used for harvesting water for extra usage during insufficient rainfall periods to increase availability of water on the ground.

Figure 2.2.7. Completed earth-lined surface water harvesting pond.

Geographical Extent of Use

Small ponds are suitable in areas with seasonal rainfall where runoff from small catchment areas can be harvested and stored. They are applicable where supplementary irrigation, livestock watering, or water buffering during dry spells is required.

Technical Standards

Round-shaped ponds

- Usually 4 - 6 metres radius and 3–4 metres deep.
- The cone of the pond is truncated at its bottom, allowing for 2 - 3 metres diameter flat bottom.
- The bottom and sides should be tightly stone paved/faced using mortar (cement/sand 1:4), reinforced with mesh and plastered (cement/sand ratio 1:2 - 3).
- Moisten the cemented wall/bottom for 2 - 3 weeks after construction to avoid cracks (Figure 2.2.8).

Square or rectangular micro-pond

- Depth 2.5 - 3.5 m; side slope 1:1.
- Usually cheaper, not cemented and used mostly to supplement water during rainy season and dry spells.
- To reduce seepage, stone paving + clay blanket (10–15 cm layer) and/or plastic sheets can be used.
- Side walls may be faced or stone stepped to increase stability and reduce lateral seepage.

Seepage and evaporation control

- Through the floor**:** A layer of clay soil is used to reduce water evaporation. This technique is used in areas with medium textured soils by applying a clay blanket (20 - 30 cm) lined and compacted at the bottom to decrease vertical seepage.
- To apply a clay blanket, moisturize and compact every 3 cm depth of the soil.
- **Through the pond walls:** Walls can be stone faced and plastered using local cement mortar (cement: soil ratio 1:6 - 8).
- Side walls may also be built stone stepped; masonry work should be carefully done and spaces between stones filled with mortar.

Figure 2.2.8. Partially constructed circular micro-pond with stone-lined walls and adjacent inlet/silt trap structure.

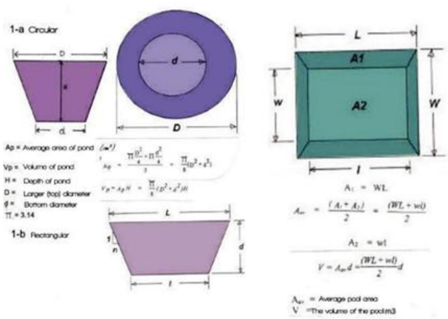


Figure 2.2.9. Geometric methods for estimating the volume of circular and rectangular water-harvesting ponds showing dimensions and calculation formulas.

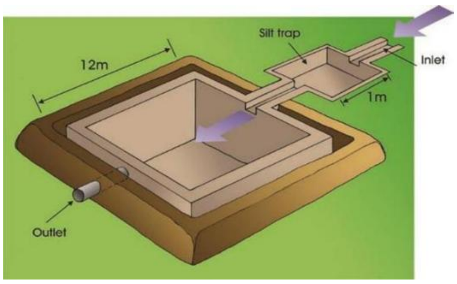


Figure 2.2.10. Surface water-harvesting pond showing inlet channel, silt trap, spillway and outlet arrangement in plan view.

Calculations for pond volumes:

- 1-a: Circular pond
- 1-b: Rectangular pond
- Geometric methods are used for estimating the average area and total storage capacity based on pond shape and dimensions (Figure 2.2.9 and Figure 2.2.10).

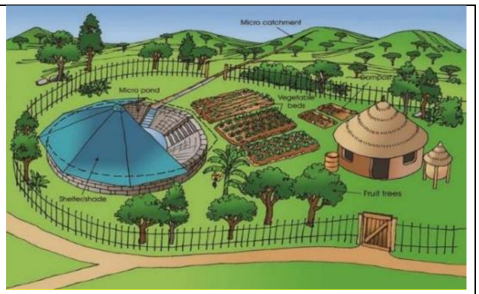


Figure 2.2.11. Integrated homestead water-harvesting system illustrating a micro-pond, micro-catchment channels, vegetable beds, compost area, and surrounding fruit trees within a fenced compound.

Measurements and Tools Requirements

- Survey pegs, 10–15 m rope, measuring tape, crowbars, pickaxes, shovels, wooden compactors, gum boots, masks and gloves.
- Technical preparedness:
- Discuss and agree with communities on location, size, production area and catchment areas of the ponds.
- Activities include bush clearing, setting out and excavating the pond.
- Excavation of cut-off drains.

Layout, Implementation Procedures and Work Norm

- Site selection and agreement with the community.
- Setting out using pegs and rope.
- Bush clearing and excavating the pond.
- Construction of cut-off drains.
- Installation of inlet channel and silt trap.
- Construction of spillway and outlet arrangement.
- Lining (stone paving, clay blanket or cementing depending on design).

Work norm

- Excavations: 2 m^3 per person-day (decreasing according to depth).
- Stone collection: 0.8 m^3 per person-day.
- Breaking of big stones: 0.4 m^3 per person-day.
- Transportation of stones not exceeding 150 m: 0.8 m^3 per person-day.
- Transportation of stones exceeding 150 m: 0.5 m^3 per person-day..

Management Guidelines

- Removal of silt from reservoir/silt trap as required (fine silt can be used for seed beds).
- Construct small silt traps before water enters the pond.
- Check whether shading is effective (e.g. mats, palm leaves roofs).
- Build shade to reduce evaporation.
- Check fence for safety and create awareness to children of hazards.
- Maintain cut-off drains and inlet channels.

Limitations

- Seepage losses may occur if lining is not properly compacted or reinforced.
- High evaporation in hot areas may reduce stored water.
- Poor maintenance of silt traps and inlet structures may reduce storage capacity.

Name of the Technology	EARTH DAMS (EDs)

General Description

An earth dam or sand dam is a stone or concrete wall built on the upstream face of a seasonal river with the aim of preventing and collecting earth on the upper side of the wall, enabling water conservation during the rainy period (Figures 2.2.12). Building of the wall is mainly done during the dry period after water has dried up. By collecting water within the trapped earth, natural water channels increase, causing water levels in the catchment area to rise. As a result, the amount of water available for community usage increases. If the river has good, trapped earth, the amount of water that can be preserved is about 35% of all the trapped earth. Some dams have been able to collect up to 6,000 m³ of water for community usage.

Figure 2.2.12. Constructed earth dam showing impounded water and spillway section.

Geographical Extent of Use

Earth dam construction technology is preferred in arid or semi-arid areas that experience extreme rainfall shortage. Suitable sites should have a rocky riverbed where the rock is thick, impermeable and not cracked, covering the entire river region and located near or at the riverbed level. The river valley should be narrow to avoid constructing an excessively high wall, yet deep enough to allow trapping of large volumes of earth. River edges should be high to increase storage volume. The construction site should not be located on sharp river bends or easily erosive areas. The upper side of the wall should be large enough to trap significant earth volume, and the site should not be cracked to reduce water loss. River valleys with a drop of 1–2% are more suitable as they allow greater volume for water preservation.

Technical Standards

- Excavate a large channel forming the wall foundation down to the rock or hard soil level.
- Construct the dam wall initially 1 m high, with a length not exceeding 90 m and a width of 1m.
- After bund construction using stones or concrete, cover all work using sacks or earth and irrigate for not less than 10 days to ensure proper curing.
- Provide an outlet or spillway to ensure safety of the wall during heavy rains.

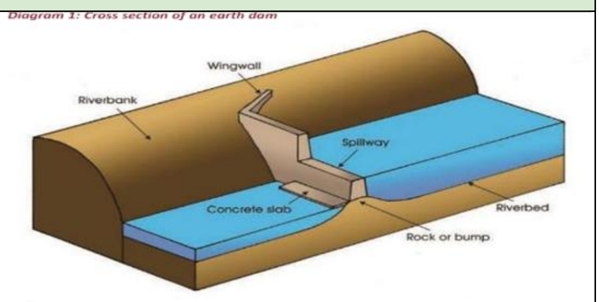
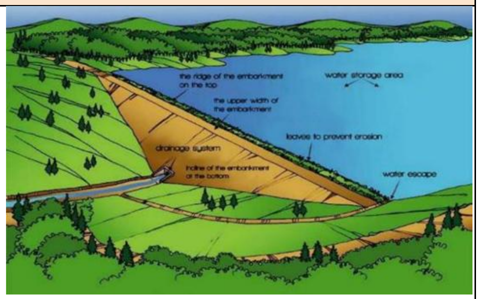


Figure 2.2.13. Cross-section of an earth dam showing spillway, wingwall and reinforced concrete slab.

Benefits

- Earth dams are a simpler and cheaper way of protecting and preserving water in dry regions and provide assurance of quality water to communities living far from villages.
- They provide clean and reliable water for long periods at short distances from residential areas, enabling quicker access and creating more time for economic activities.
- They reduce desert conditions by increasing underground water levels, resulting in continuous productivity.
- They reduce the effects of climate change through increased water availability for farming activities.
- They reduce conflicts by increasing water availability for human and livestock consumption in dry areas.
- They increase the community’s drought resistance and improve food availability.
- They enable digging of shallow wells on the upper sides of the dam that produce water for human consumption.

Layout, Implementation Procedures and Work Norm
- Conduct site investigation to identify a suitable seasonal river with stable rocks and good ground conditions. Rivers with round stones and thick earth (crystalline rocks and coarse sand) produce the best results. - Excavate the foundation trench to reach stable rock or hard soil. - Construct the wall across the river channel to the specified dimensions. - Provide spillway and outlet structures for safe overflow during heavy rainfall. - Ensure curing stone or concrete work for not less than 10 days. **Work norm** - Productivity rates for site clearance, excavation, soil transportation, embankment compaction in 15 cm layers, stone pitching, spillway construction, revegetation and associated works shall follow the approved labour-based task rates. - Refer to Appendix D (S/N 10: Charco dams / Earth fill dam / Micro-ponds) for detailed task rates.
Management Guidelines
- Inspect the dam wall and spillway regularly, especially after heavy rains. - Ensure outlet structures remain clear to prevent overtopping and damage. - Protect the upstream and downstream sides from erosion. - Encourage community participation in maintenance and protection of the structure.
Limitations
- After bund construction using stones or concrete, ensure all the work is covered using sacks or earth and irrigated for not less than 10 days. - Ensure an outlet is constructed for the safety of the wall during heavy rains.

Name of the Technology	SMALL-SCALE EARTH DAMS (SSEDs)
General Description	
Small-scale earth fill dams and charco dams are constructed for rainwater harvesting for purposes such as environmental conservation, livestock watering, domestic use, irrigation, and fish production (Figures 2.2.14). They are constructed under labour-based technology and incorporate spillways to protect the structure from overtopping during excess runoff flows. A small-scale earth fill dam is formed by constructing a compacted earth embankment across a seasonal stream in a natural depression or wide V-shaped valley to create a reservoir. Excavated soil is deposited on the lower side to form the embankment. Suitable filling material may be obtained from the reservoir area or from an approved borrow pit. Small earth dams generally have embankment heights in the range of 2–5 m. Under Public Works programmes, typical embankment heights are 2–3 m with storage capacities up to about 10,000 m³.	 *Figure 2.2.14. Cross-section of an earth embankment showing water storage area, drainage system, embankment structure, and erosion-control measures*
Geographical Extent of Use	
Small-scale earth dams are suitable in natural depressions where rainwater flows or accumulates during the rainy season. Preferred soils include deep clay, silt, or black cotton soils. Coarse sandy soils should be avoided due to high permeability. Site selection should consider catchment area size and runoff potential, soil and rock type, adequate waterway, and availability of construction materials.	
Technical Standards	

Design parameters

- Crest width should not be less than 3 m.
- Embankment height should not exceed 3.0 m.
- Freeboard approximately 0.5 m (or as guided by the design tables; Table 2.2.1).
- Upstream slope ratio: 1:3.
- Downstream slope ratio: 1:2.
- Crest width may also be calculated using b = 0.4D + 1.

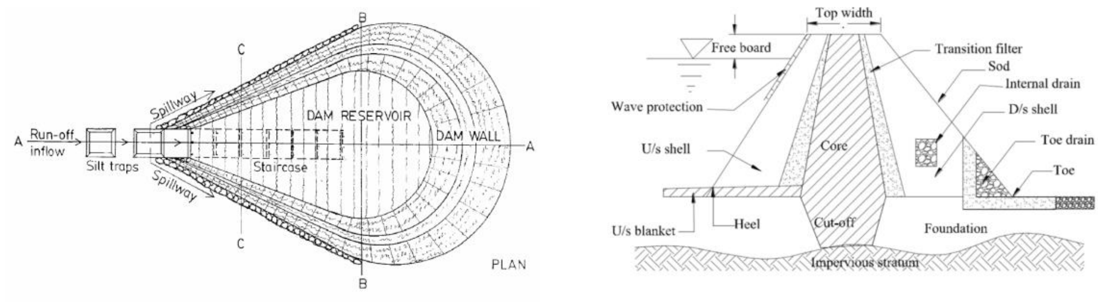


Figure 2.2.15. Plan view and cross section of an earthen dam

Table 2.2.1. Recommended dimensions for dam embankment crest width based on dam height

Height of dam (H) (metres)	Crest width (B) (metres)*
up to 2.0	2.5
2.1 to 3.0	2.8
3.1 to 4.0	3.0
4.1 to 5.0	3.3

Storage capacity estimation

- Storage capacity depends on runoff from the catchment area and reservoir geometry.
- For small-scale dams (2–3 m height), storage capacity is generally up to about 10,000 m³.
- Capacity may be estimated using: Q = (L × T × D) / 6,
  where Q is storage capacity (m³), L is the length of the dam wall at top water level (m), T is throwback/fetch (m), and D is maximum water depth (m).

Measurements and Tools Requirements

- Water level hosepipe, theodolite, range poles, measuring tapes or marking string
- Sledgehammer, crowbars, shovels, hoes, pickaxes, wheelbarrows
- Soil compacting tools
- PPE: Masks, gum boots and gloves

Layout, Implementation Procedures and Work Norm

Construction steps

- Determine crest and bottom widths based on height and slope ratios (Table 2.2.2).
- Clear vegetation and prepare foundation area.
- Divert stream where necessary.
- Set out dam alignment using pegs and water level method.
- Excavate core trench to minimum 600 mm into impervious soil/rock; width 8–10% of bottom width.
- Fill core trench with selected clay in layers ≤15 cm and compact thoroughly (Table 2.2.3).
- Construct embankment in 100–150 mm layers with proper moisture and compaction.
- Install drainage pipe with proper compaction; provide anti-seepage collar where possible.
- Stabilize embankment using grass cover and stone pitching (up to 0.6 m above water level).
- Construct spillway on hard soil away from dam edge; minimum width and depth according to catchment size (10 m/1 m for ≤5 km²; 15 m/1.5 m for >5 km²).

Work norm

- Productivity rates for site clearance, excavation, soil transportation, embankment compaction in 15 cm layers, stone pitching, spillway construction, revegetation and associated works shall follow the approved labour-based task rates.
- Refer to Appendix D (S/N 10: Charco dams / Earth fill dam / Micro-ponds) for detailed task rates.

Table 2.2.2. Preliminary dimensions of the dam

Height of the dam (m)	Maximum freeboard (m)	Top width (m)	Upstream slope (H.V)	Downstream slope (H.V)
Up to 3	1.2 - 1.5	1.85 – 2.0	2:1	1.5:1
3.0m and above	1.5 - 1.8	0.4D + 1	2.5:1	1.75:1

Table 2.2.3. Dimensions of upstream and downstream slopes by soil type

Type of construction materials	Upstream slope (H:V)	Downstream slope (H:V)
Homogeneous well graded soil	2.5:1	2:1
Homogeneous course silt soil	3:1	2.5:1

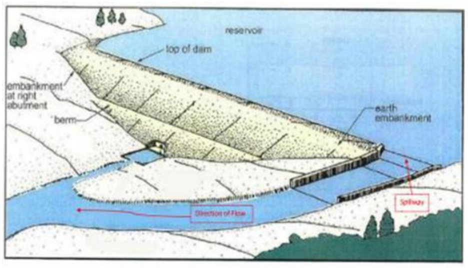


Figure 2.2.16: Schematic view of an earth dam showing the reservoir, embankment, berm, and spillway arrangement

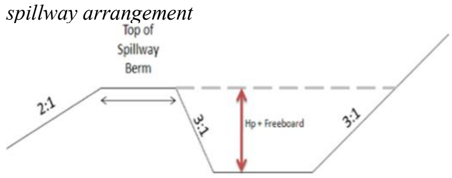


Figure 2.2.17: Cross-section of a spillway channel showing side slopes, berm, and design depth (Hp + freeboard)

Management Guidelines

- Form a dam management committee.
- Develop protection by laws in collaboration with local government.
- Establish a maintenance fund.

- Regularly inspect embankment, spillway and outlet structures. - Maintain erosion control and hygiene around the dam.
Limitations
- Embankment height exceeding 3.0 m may cause instability. - Poor compaction may result in seepage and structural failure. - Improper spillway design may lead to overtopping. - Unsuitable soils (e.g., sandy soils) increase seepage risk.

Name of the Technology	RAINWATER HARVESTING IN FARMS (RWHF)

General Description

Rainwater harvesting in farms involves collecting and preserving rainwater to be used by plants, to conserve soil moisture, and increase groundwater levels (Figures 2.2.18). The methods used include oval-shaped bunds, trapezoidal bunds, triangular bunds, recharge pits, rice beds, etc. If applied well, these methods help in conservation of moisture, water, and soil, and increase yields. The best period for implementation of neighbouring water and crop harvesting structures is during the dry period before the start of the rainy season. Technology can be applied in arid areas, areas with medium rainfall, and in high-rainfall areas for soil and water conservation.

Figure 2.2.18. Semi-circular bunds showing field installation and staggered downslope layout.

Geographical Extent of Use

Suitable in arid areas, semi-arid areas, medium rainfall areas and high rainfall areas for soil and water conservation. Suitability depends on soil type, rainfall status, crop type to be planted, land slope, and cost.

Technical Standards

- Establish the most suitable method for a certain region considering soil type, rainfall status (arid or semi-arid), crop type, land slope and cost.
- In flat areas, rice beds or semi-circular shaped bunds can be prepared by having a big internal surface area.
- On medium slope areas, rice beds and semi-circular shaped bunds require a small internal surface area because on steep slope areas water flow has a higher velocity, hence a possibility of bund breakage.
- During design of semi-circular bunds and rice beds consider spacing between the bunds, spacing of rice beds and spacing between plants.
- Design must adhere to agricultural advice for the concerned crop type

Table 2.2.4. Technical dimensions for oval-shaped bunds (diameter, circumference and internal surface area; spacing based on crop type and agronomic advice).

No.	Diameter (m)	Circumference (m)	Internal bund surface area (m2)
1	0.5	0.8	0.1
2	1	1.6	0.4
3	2	3	1.6
4	3	4.7	3.5
5	4	6.3	6.3
6	5	8	9.8
7	10	15.7	

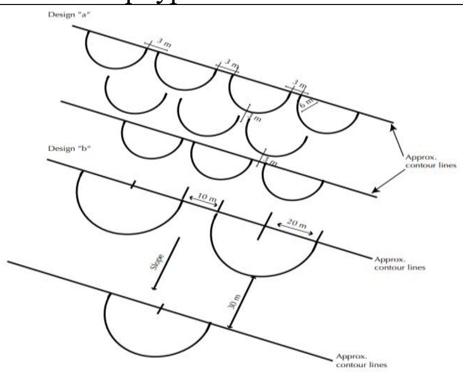


Figure 2.2.19. Layout pattern for oval-shaped bunds (horizontal and vertical spacing).

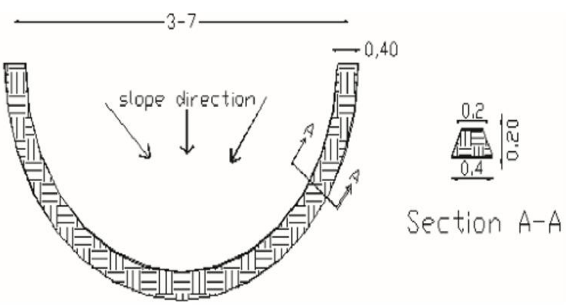


Figure 2.2.20. Cross-section of oval-shaped bund (0.4 m base width, 0.2 m top width, 0.20 m height).

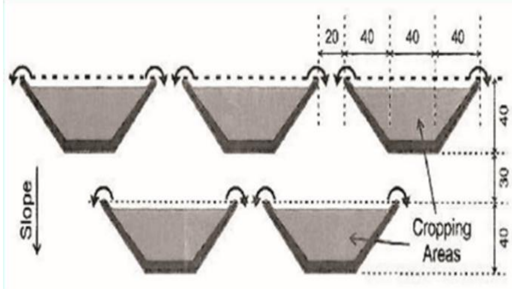


Figure 2.2.21. Trapezoidal-shaped planting basins along slope.

Measurements and Tools Requirements

- Digging hoes, shovels, pickaxes, crowbars.
- Pegs, rope/string, oval-shape drawers (wooden compass).
- Pipes, cement.
- Safety equipment such as gumboots, masks, and gloves

Layout, Implementation Procedures and Work Norm

- Before preparation of the bunds levelling should be done.
- During layout and construction of the bunds it is important to consider staggering the bunds to ensure water collection in all areas.
- In flat areas, rice beds or semi-circular shaped bunds can have a big internal surface area; on medium slopes smaller internal surface areas are recommended to reduce risk of breakage due to higher runoff velocity.

Work norm

- Cleanliness of the area: 200 m²/pd
- Excavation of stumps: No/pd
- Soil loosening: 200 m²/pd
- Levelling: 200 m²/pd
- Preparation of oval-shaped bunds and rice beds: No/pd
- Cow dung or compost manure preparation: 1.5 m³/pd

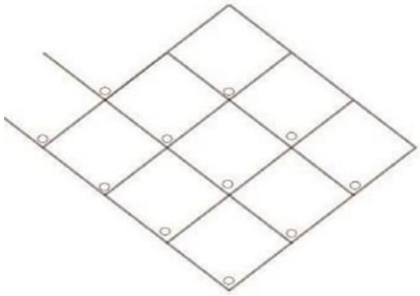


Figure 2.2.22. Square grid planting pits layout.

Figure 2.2.23. V-shaped stone bund for tree establishment.

Management Guidelines

- Frequent rehabilitation, especially on the bunds at the start of the rains because during this period the bund is not well compacted.
- Ensure all crop maintenance activities such as weeding are done on time.
- Regarding neighbouring areas and grazing lands, simple laws to be set to control livestock from causing damages.
- Drainage canals should be cleaned and frequently maintained to prevent stagnation of water in the farms.

Limitations

- The depth of the waterlogged area for the bunds or holes should be in line with the depth of the water to be harvested according to the water need requirement of a certain crop.
- Rice can flourish in waterlogged areas unlike crops such as sorghum and millet.
- For arid areas, soil moisture retention may be low unless cow dung manure, compost, or debris are applied during planting.
- On sandy soil areas or non-fertile areas, bunds may require mixing good soil from a different region with that of the affected area.

3.0 Small-scale irrigation (SSI) development

3.1 Small-scale irrigation farming

Irrigation is a farming scheme where water is supplied to crops in the farm whenever there is insufficient rainfall or in dry areas. This kind of farming boosts crop productivity, and hence increases income. There are several types of irrigation, among them sprinkler irrigation, drip irrigation, furrow or rice beds/flooding. Furrow, drip irrigation (locally drip irrigation), and rice beds/flooding irrigation types can be implemented under the PWP. In Tanzania, a small-scale irrigation system means an irrigation system with a command area of up to 500 hectares. The irrigation infrastructures should be prepared during the dry season to avoid interference with land preparation.

This manual describes technical specifications of the following types of small-scale irrigation:

- Furrow irrigation
- Flood irrigation
- Drip irrigation

Name of the Technology	FURROW IRRIGATION

Description

Furrows are small channels constructed between two rows of crops or alternately after every two rows of crops (Figure 2.3.1 and Figure 2.3.2). The crop is usually grown on the ridges between the furrows. During irrigation, water is applied to the channels (furrows), and it then moves laterally by capillaries to the un-watered areas below the ridge and downward to wet the root zone soil. It is suitable for all crops that cannot stand waterlogging. Benefits of furrow irrigation include reduced evaporation losses and improved aeration of the root zone; it contributes to climate change adaptation and mitigation as it saves irrigation water if managed well, increases and diversifies farm production options, supports tree planting, and reduces salt accumulation in the soil.

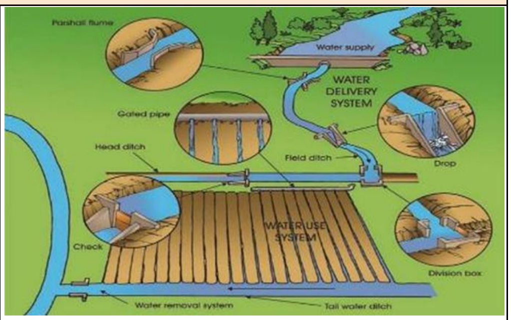


Figure 2.3.1. Components of a small-scale surface irrigation system, showing water supply, water delivery structures (head ditch, field ditch, gated pipes, drops, division box, and checks), and the water-use and removal system (irrigated field and tail-water ditch).

Suitability

- Furrow irrigation is suitable for all row crops, especially those which are planted in rows (Figure 2.3.2). It is particularly suited for closely spaced crops such as vegetables (onions, cabbage and pepper, maize, ground nuts, sugarcane, cotton, and potatoes).
- It is usually applicable on gently sloping land up to 3% in arid climates and 0.3% in humid areas because of the risk of erosion during intensive rainfall.
- The furrow method is well suited both to small and large farms.

Figure 2.3.2. Lined and maintained field canal conveying irrigation water to adjacent farm plots in a smallholder irrigation scheme.

Technical Standards

- Tools: Wheelbarrow, shovel, axe, digging hoe, panga, water level, pick axe, rope, tape measure, profile board, pegs, surveying machine.
- Layout: Length of furrow to be used is determined by a few factors such as slope, soil type, stream size, irrigation depth, duration of the water application. In general, furrow length ranges from 60m to 300m.
- Furrow spacing: Furrow spacing in sandy soils is in arrange of 60 to 80cm, whereas in clay soils 75 to 150cm and in loam soils 60 to 90cm.
- Gated intake structure can be constructed using stones and cement. A typical cross-section of an unlined earthen canal for small-scale irrigation is shown in Figures 2.3.3–2.3.5.
- The required size of the canal can be decided using the Manning's formula:

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

whereby
Q = Discharge in m3/hr or l/sec.,
A = Cross-section area in m2,
R = Hydraulic radius,
S = Channel bed slope,
n = Coefficient of roughness.

Work Norm

- Removing vegetable soil: 100 m^2/pd
- Collection of stones: 0.8 m^3/pd
- Stone masonry: 0.4 m^3/pd

- Concrete work: 0.4 m^3/pd
- Excavation: 1.5 m^3/pd
- Formation of canal embankment: 1.5 m^3/pd
- Regular canals and drains cleaning.
- Lining of canals. Building canals at the cement level: 2.0 m^2/pd
- Shaping and compaction of embankment: 20 m^2/pd

Environmental protection and conservation

- Proper sitting and design of irrigation system.
- Training on proper operation and maintenance of the irrigation scheme.
- Control of agrochemical use, limiting pumping hours.
- Selection of suitable crops for the irrigation scheme.
- Regular cleaning of irrigation canals.
- Education on proper health and sanitation practices

Limitations

- Increase of soil erosion.
- Soil water logging because of improper drainage.
- Clogging of canals caused by weeds.
- Depletion of aquifers due to overexploitation.
- Disturbance of flow regimes.
- Inefficient water flows because of sedimentation.
- Disturbance of natural habitats.
- Proliferation of aquatic weeds.
- Risk of water borne diseases from artificial water flows like malaria.
- Toxicity of pesticides.
- Involuntary resettlement, loss of property.
- Conflicts over water use.
- Social problems associated with land use and pollutant discharges.

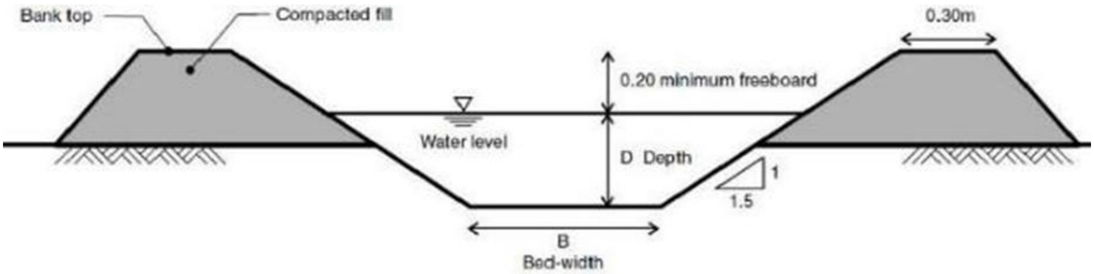


Figure 2.3.3. Typical cross-section of an unlined irrigation canal showing bed-width (B), flow depth (D), minimum freeboard, and standard side-slope and embankment dimensions. NOTE: The freeboard is the height from the design water level to the top of the bank

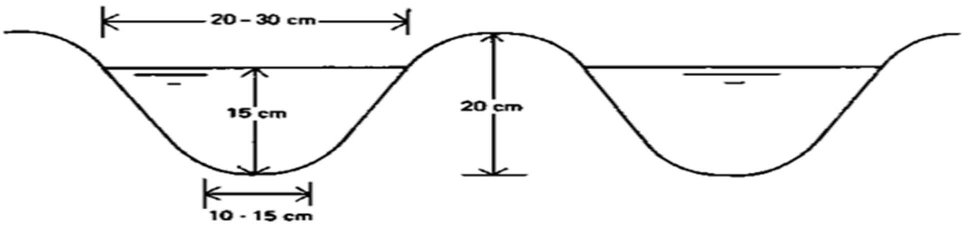


Figure 2.3.4. Cross-section of a small field drain showing typical dimensions for depth, width, and spacing between adjacent drains.

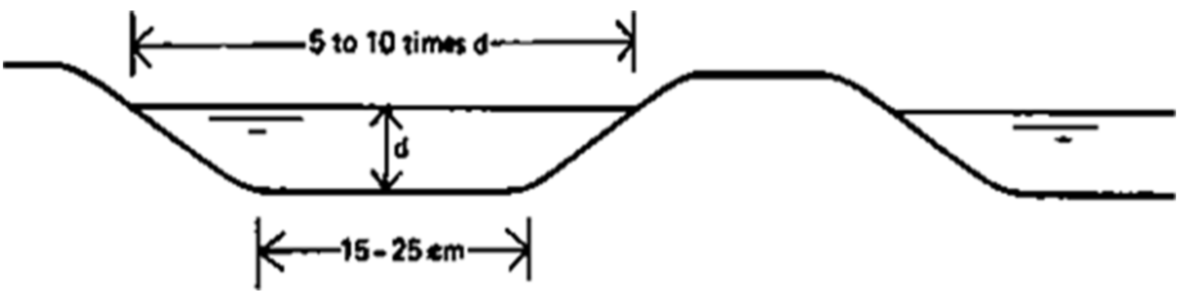


Figure 2.3.5. Recommended dimensions for shallow field drains, showing depth (d), drain width, and spacing of 5-10 times the drain depth

Name of the Technology	FLOOD IRRIGATION

Description

Flood irrigation is a system of irrigation where cultivated land is irrigated by floodwater diverted or harvested from ephemeral watercourses during and immediately after a rainfall event (Figure 3.2.6). Flood irrigation is more suitable on land that has rice beds, and is levelled. The land that is levelled enables water to spread to a levelled depth. Land levelling can be carried out when the cultivated land is dry or when it is still moist.

Figure 2.3.6. Farmers using wooden levelling tools to puddle and smoothen the rice field before transplanting, ensuring even water distribution(a) and field workers marking and shaping levelled paddies into uniform grids to guide orderly transplanting and optimal crop spacing (b)

Suitability

- Areas suitable for flood irrigation should have deep alluvial soils with moderate infiltration rates to hold moisture for long periods.
- Presence of soil moisture conservation structures like rice beds/bunds is critical for success of flood irrigation system as floods often come ahead of the sowing season.
- Presence of social organization is necessary for the success of a flood irrigation system. It helps to ensure there is local knowledge and experience in building indigenous systems to capture short floods or release excess and destructive floodwater, to conduct timely and regular maintenance to manage sediments, and to oversee the fair distribution of the floodwater if diverted into reservoirs for future use.
- Flood irrigation is traditionally used for rice cultivation using rice beds (Figure 2.3.7). Rice beds are also suitable for cereal crops (sorghum), especially in arid and semi-arid areas. However, rice bed irrigation is not suitable for crops that cannot withstand stagnated water for a period of more than 24 hours. Among these crops are potatoes, cassava, and carrots. Large-scale and commercial rice farming is recommended in areas that have irrigation schemes by using rice beds.

Figure 2.3.7. Farmers weeding rice fields manually under a controlled irrigation system

Technical Standards

- **Tools**: Farm/cultivated land-levelling tools are digging hoe, rake, levelling planks.

Establishment: Factors to be considered in establishment of flood irrigation

- **Land slope**: Flat land is more suitable for the formation of rice beds (Table 2.3.1). In addition, flat land makes land levelling easy. Also, it is possible to form rice beds on steep slopes by building them using the bench terrace system.
- **Suitable soil type**: Suitable soil type depends on the type of crop to be grown. Rice is a suitable crop to grow on clay soils that can retain water for a long period of time. Clay and loose soils are preferred for farming using rice beds. It is not advisable to form rice beds on sandy soils as they drain faster.
- **Rice beds arrangement**: Rice beds arrangement does not only refer to the shape and size of the rice bed but also to the shape and size of the bunds. The farm is surrounded by a small earth wall, and the land is filled with water. Filling of the farm is repeated until crops (such as rice) mature. Other crops such as rice are grown many times on land that is covered by water for several months.
- **Shape and size of the rice bed**: The shape and size of the rice beds depend on the land slope, soil type, quantity of water, required depth of water, and farming techniques.
- **Width of the rice bed**: The width of the rice bed depends on the land slope. If it is on a steep slope, then the rice bed should be thin; if not, a huge task of soil shifting will be required to attain a levelled rice bed.
- **Dimension of rice beds**: Width and size/shape are determined by depth of fertile soil, rice beds formation system, and farming techniques as described here. Hand-formed rice beds usually become thin, unlike those built using machines which become wide for efficiency during the formation period.
- **Size of rice bed**: The size of rice beds does not only depend on the land slope but also on the soil type and availability of water on the rice beds (Table 2.3.1).

Table 2.3.1: Recommended width of rice beds (m) at different land slopes

Slope %	Ratio
0.2	35 – 55
0.3	30 - 45
0.4	25 – 40
0.5	20 - 35
0.6	20 – 30
0.8	15 – 30
1.0	15 - 25
1.2	10 – 20
1.5	10 – 20
2.0	5 - 15
3.0	5 - 10
4.0	3 - 8

Table 2.3.2. Surface area of rice bed (m^2) for different soil types and availability of water (1/sec).

Amount of water (litre/second)	Surface area of rice bed (m^2)			
	Sand soil	Coarse silt soil	Loose clay soil	Clay soil
5	35	100	200	350
10	65	200	400	650
15	100	300	600	1000
30	200	600	1200	2000
60	400	1200	2400	4000
90	600	1800	3600	6000

Example of approximate size of rice beds

Question:

Approximate the dimensions of the rice bed, if it is on loose clay soil and the land slope is 1%. If rice beds are formed using machines, then the bench terraces should be wide enough. The amount of water is 25l/sec.

Answer:

From Table 2.3.1, the width of the rice bed on a land slope of 1% is 25m (from 15-25m).

From Table 2.3.2, the surface area of rice bed on loose clay soil with amount of water as 25l/sec is 1000m^2. If the total surface area of rice bed is 1000m^2 and its width is 25m, then its height is 1000/25 = 40m.

Shape and dimensions of rice bed bunds

Rice beds are small bunds formed using soil; they are used to control water for irrigation of rice beds (Figure 2.3.8). The height of the bund depends on the depth of irrigation. The width of the bund should be stable and impermeable.

Long-lasting bunds have a width of 130–160 cm on the lower side and a depth of 60–90 cm during the formation period. After compaction, the depth becomes 40–50 cm (Figure 2.3.9). Temporary bunds for rice beds usually have a width of 60–120 cm on the lower side and a depth of 1.5–30 cm beyond land level.

Work norms

- Excavation of diversion floodwater structures ditches: 1.5-2 m^3/pd
- Excavation for maintenance of diversion structures: 1-2m^3/pd

Figure 2.3.8. Furrow irrigation layout showing water flowing between raised crop rows

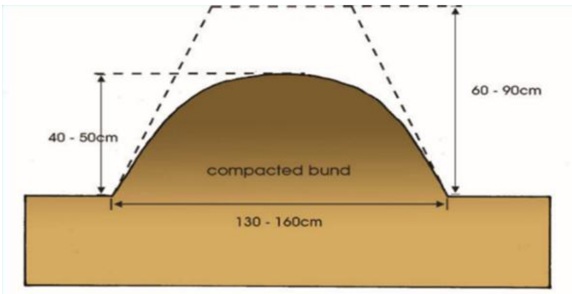


Figure 2.3.9. Cross-section of a compacted bund showing recommended height, width, and side-slope dimensions.

Limitations
- Maintenance of embankments of flood irrigation structures like water diversion structures can be labour intensive; it is usually done by the community. - The unpredictable nature of rainfall events makes flood irrigation systems risky and difficult to manage, especially regarding the timing, quantities, and consequences of floodwaters. The main flood flow may sometimes change course away from water diversion structures, damaging downstream cultivated areas and settlements. - Sedimentation is a major problem in spate irrigation as the floodwater has high sediment loads. - This requires frequent checking and maintenance after rainfall events.

Name of the Technology	DRIP IRRIGATION

Description

Drip irrigation is a system which delivers water directly to the plant roots through plastic tubes with the intention of providing the right amount of water to crops at the right time with minimal water loss (Figure 2.3.10). Water is discharged into the root zone by emitters at a rate proportional to the crop water requirement and soil structure. However, this system can be localized to plastic bottles perforated to allow water discharge directly to plants' root zone. The system can be carried out on many crops such as vegetables, fruits, and cereals. The following are benefits of using the drip irrigation system:

- Helps with water conservation as water is consumed effectively.
- Saves resources as little water is consumed.
- Helps reduce weeds as water drips on one crop at a time.
- Gives the crops a certain required amount of water.
- Reduces damping-off sicknesses and rotting of the base.
- Enables availability of water during all seasons.
- Reduces expenditure on unskilled labour
- Soil erosion is very minimal.
- Helps the usage of water manures.

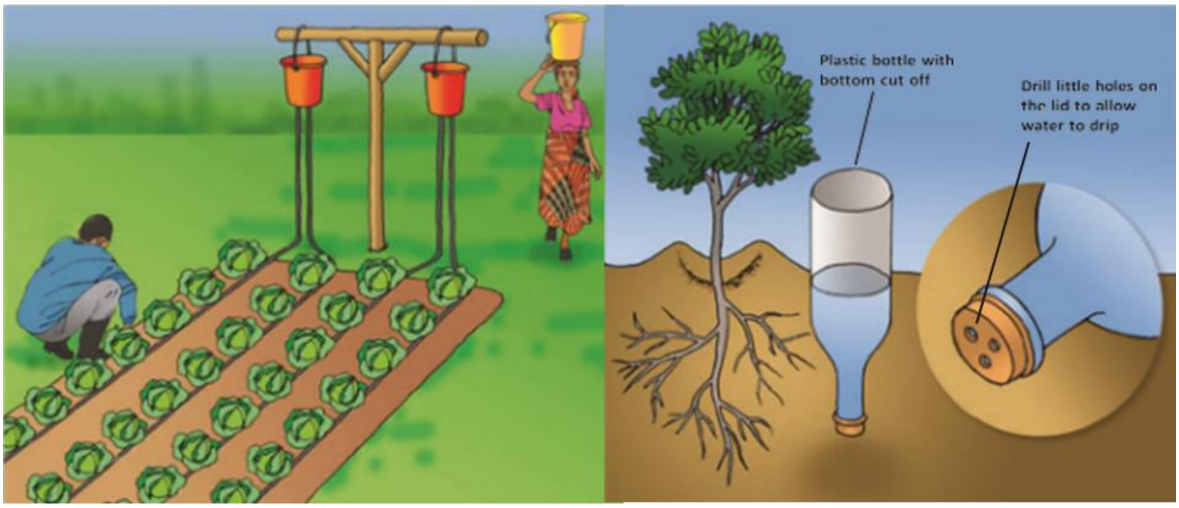


Figure 2.3.10. Low-cost drip irrigation options using hanging containers and modified plastic bottles for controlled water delivery to crops and trees

Suitability

Small-scale drip irrigation systems are suitable in arid and semi-arid areas where crop production is limited due to water shortage.

Technical Standards

Tools: Tools required include ropes/strings to ensure that the rows are straight, hoes, shovels, wheelbarrows and machetes, pipes, filters, valves and emitters

- **Water source**: Can be tanks; ensure tanks are perforated to drain water to pipes that are directly placed on the crops (Figure 2.3.11).
- **Pipes**: These should be perforated depending on crop spacing and crop rows such that if there are 10 crop rows then there should be 10 pipes. These are part of this irrigation system.
- **Valves**: The function of this equipment is to allow water in and out; it is similar to a cock as other refer to it.
- **Filter**: This is very important as it helps in filtering water, thereby preventing the entry of dirt such as soil and grass that can clog the outlets. Filters should be fixed before the irrigation pipes are closed.
- **Emitters**: These are holes that pass water to the crops. They normally pass water for a period of 1 hour for 4 litres of water (approx. 1 gallon).

Figure 2.3.11. Simple gravity-fed bottle irrigation system using large water containers to deliver slow, controlled moisture directly to the root zone of young plants

Technical requirements

- The small-scale drip system operates under 1 to 2m water pressure.
- One small-scale drip system can irrigate from 25 m^2 to 1000 m^2 and over. The system is suitable only for row planted crops (Figure 2.3.12).
- Land digging and levelling: the use of drip irrigation does not necessarily require land levelling.

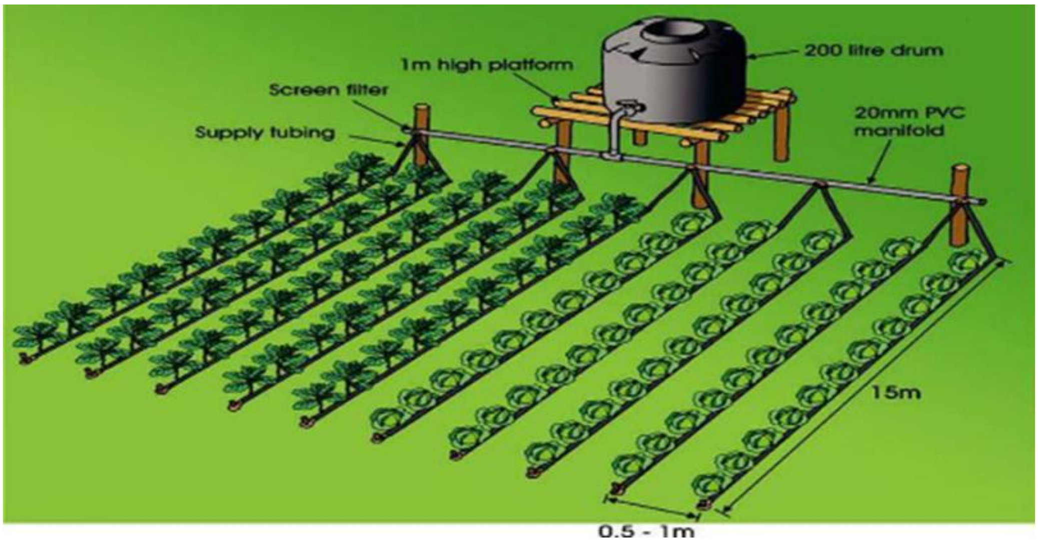


Figure 2.3.12. Low-cost drip irrigation system using a raised 200-litre drum, PVC manifold, and supply tubing to distribute water efficiently across vegetable rows.

Work Norm

- Bush clearing: 100 m^2/pd
- Excavation of ditches: 1.5/pd
- Laying of pipes: 100 m/pd
- Covering ditches: 1.5 m^3/pd
- Compaction: 10 m^2/pd
- Cutting trees: 5 No/pd
- Excavation, filling, and compaction: 20 No/pd
- Fetching water: 100 litres/pd

Environmental Protection and Conservation (Implementation Guidelines)
- Training in irrigation agronomy, water management, and drip irrigation operation and maintenance is essential. - Ensure the water is properly filtered and the pipes are flushed once a month. - Urea can be supplied to the crops through the drip system. But it is not recommended to apply Diammonium Phosphate (DAP) using the system as it clogs the emitters
Limitations
- Clogging of drippers due to waste /soil particles. - Clogging of emitters due to application of chemical fertilizers. - Chewing of drippers by rodents. - Conflict over land use. - This system is costly in installing the pipes. - This system requires expertise especially in the minor fixations. - Many people do not enquire about the soil type, types of crops to grow, and existing crops. Hence, the pipes pass the same amount of water daily. - Operation of this irrigation system: This system should be operated ensuring that the required constant amount of water is passed to all crops. Ensure there is no water loss through leaking pipes. Ensure there is no leakage. For this system to be effective, regular monitoring of its function is essential.

4.0 Climate-smart community access roads

Climate-smart community access roads are designed and implemented to enhance rural connectivity while increasing resilience of transport infrastructure to climate risks. Within the CSPW framework, these works provide both livelihood support through short-term employment of vulnerable households and long-term adaptation and mitigation benefits. Typical interventions include raising road levels to prevent flooding, installing effective drainage and erosion-control systems, clearing and stabilizing vegetation for improved visibility and safety, and constructing waterway channels to manage runoff and protect adjacent farmland.

Community access roads link villages to essential services such as markets, schools, and health centres. They are implemented using labour-based methods that maximize community participation, rely on locally available materials, and generate employment for poor and vulnerable groups. Integrating climate-smart principles in design and maintenance such as improved drainage spacing, vegetative stabilization of side slopes, and use of durable, low-emission materials ensures that roads remain functional during extreme weather events.

Community access roads can be categorized by their level of construction and surface treatment. Under CSPW, the most common types are earth roads, gravel roads, and stone roads. These roads are constructed primarily through labour-based methods using locally available materials, making them cost-effective and supportive of community employment. Each road type is suited to specific site conditions such as terrain, rainfall intensity, and availability of materials, ensuring sustainable and climate-resilient connectivity for rural communities. This manual will provide technical details for the following types of community access roads:

- Earth roads
- Gravel roads
- Stone roads.

Name of the Technology	EARTH ROADS (ER)

General Description

Earth roads are built from the natural soil of the area through which they pass (Figure 2.4.1). They are the most basic and affordable type of community access road, commonly used in rural villages. Labour-based construction makes them ideal for CSPW interventions, as they can be built and maintained using simple tools and local labour. Although they are economical, earth roads are prone to surface erosion and rutting during the rainy season and may deteriorate quickly under heavy traffic. To enhance resilience, the road should be constructed with an adequate camber to shed surface water, side drains to control runoff, and vegetative cover along shoulders and embankments to stabilize soils. Where possible, compacting with locally available gravel or soil stabilizers such as lime, sand, or clay improves surface strength, reduces dust, and extends service life.

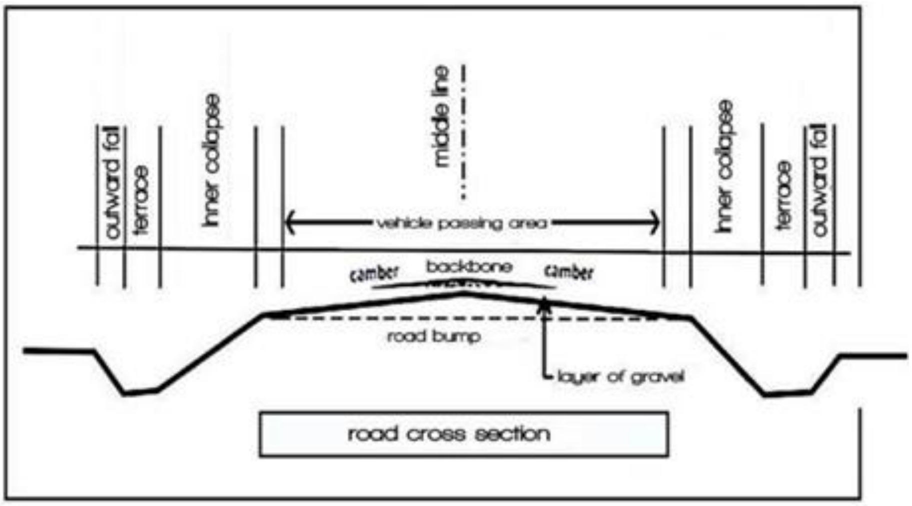


Figure 2.4.1. Typical cross-section of a community access road showing camber, middle line, drainage terraces, and side slopes.

Geographical Extent of Use

Suitable for rural villages and low-traffic areas where construction materials are locally available. Applied in areas with relatively stable soils and moderate rainfall conditions. Less suitable in steep terrain, flood-prone zones, or areas with prolonged wet seasons unless improved through gravel surfacing or soil stabilization measures.

Technical Standards

- Running-surface width: 3.50 – 4.50 m
- Compacted layer thickness: 12 – 15 cm
- Maximum backslope after compaction: 8%
- Constructed preferably during the dry season to ensure adequate compaction and stability

Measurements and Tools Requirements

- Construction uses simple hand tools including hoes, shovels, pickaxes, mattocks, and line levels.
- The number of tools required depends on soil type, terrain, and workforce size.
- Tools must be regularly checked, cleaned, and replaced as needed to maintain quality and safety during work.

Layout, Implementation Procedures, and Work Norm

- Site preparation: Clear vegetation, tree stumps, and obstacles along the alignment.
- Excavation: Remove unsuitable topsoil (20–30 cm) and level the base.
- Formation: Shape the road camber, compact the surface, and excavate side drains to direct water away safely.
- Finishing: Fill any depressions, compact again, and ensure uniform drainage slopes.
- **Work norm**: Typical work output for road layout and levelling is about 200 m per person-day, while ditch excavation averages 1.5 m^3 per person-day (Table 2.4.1).

Table 2.4.1. Work standards for labour-based community access road construction (including relevant earth road activities)

TYPE OF WORK	STANDARD	TYPE OF WORK	STANDARD
Road layout	200 m/pd	Internal side trimming of ditches	1.5 m^3/pd
Bush clearing on the project site	150-200 m^2/pd	Soil spreading	20 m^2/pd
Scrapping off unnecessary topsoil layer	1.5 m^3/pd	Horizontal road embankment construction	20 m^2/pd
Levelling	1.5 m^3/pd	Sprinkling water to the required quantity	40 m^2/pd
Excavation of ditches	1.5 m^3/pd	Compaction using hands	20 m^2/pd
External side trimming of ditches	1.5 m^3/pd	Compaction using a leg ridden compactor	130 -150 m/ pd

Management Guidelines

- Routine inspection and timely maintenance are essential to keep earth roads passable, especially after rainfall events.
- Community groups should clear drains, regrade the camber, and replant grasses or shrubs on eroded shoulders to maintain structural stability and reduce sediment loss.

Limitations

- Earth roads are vulnerable to erosion and rutting during heavy rains and may become impassable when drainage is poor.
- They are unsuitable for steep slopes or areas with prolonged wet seasons unless improved with gravel or other stabilizers.

Name of the Technology	GRAVEL ROADS (GRs)
General Description	
Gravel roads are improved versions of earth roads, formed by placing and compacting a gravel layer over the prepared subgrade. This surface strengthens the road and improves durability, allowing year-round use and reduced maintenance frequency. Gravel roads are suitable for areas with moderate to heavy traffic or where rainfall intensity makes earth roads unreliable. Climate-smart construction emphasizes proper drainage spacing, use of compacted gravel to resist erosion, and vegetative stabilization of roadside slopes to control sedimentation and runoff (Figure 2.4.1).	
Geographical Extent of Use	
Suitable for rural and peri-urban areas with moderate to heavy traffic demand. Recommended in areas where rainfall intensity is high and earth roads are prone to erosion and deterioration. Appropriate where gravel materials are locally available and drainage conditions can be properly managed.	
Technical Standards	
- Running-surface width: 3.50 – 4.50 m - Compacted gravel layer: 12 – 15 cm - Backslope after compaction: Less than 8% - Drainage spacing adjusted to local slope and rainfall intensity	
Measurements and Tools Requirements	
- Base preparation and gravel spreading require hand tools such as hoes, shovels, pickaxes, mattocks, and line levels. - Compaction is done using hand rollers or light mechanical rollers. - The number of tools depends on terrain, soil condition, haul distance, and workforce size. - Tools must be inspected regularly to maintain efficiency and safety.	
Layout, Implementation Procedures and Work Norm	
- Prepare the base by clearing vegetation and levelling the roadbed. - Place and spread gravel evenly, maintaining proper camber for surface drainage. - Compact the gravel layer thoroughly using hand rollers or light mechanical rollers. - Construct mitre drains and outlets to reduce erosion along the shoulders. - **Work norms**: A team of labourers can spread and compact approximately 8 m^3 of gravel per person-day, depending on haul distance and terrain.	
Management Guidelines	
- Regular grading maintains an even running surface and prevents pothole formation. - Vegetation should be maintained on side slopes and mitre drain outlets to slow runoff and reduce erosion. - Periodic re-gravelling may be required depending on traffic volume and rainfall intensity.	
Limitations	
- Requires periodic gravel replacement, which can be costly if material sources are distant. - Not suitable where gravel supply is limited or drainage is poor.	

Name of the Technology	STONE ROADS (SRs)

General Description

Stone roads (Figures 2.4.2–2.4.9) are constructed by laying a top layer of shaped stones over a compacted subbase. They are particularly suitable in areas where stones are readily available and transport costs are low. Stone roads are durable, erosion resistant, and well adapted to flood-prone or high-rainfall environments. Their construction relies on community labour under CSPW, offering both resilience benefits and employment opportunities. Implementation is most effective during the dry season when compaction is easier, and stone placement is more stable.

Figure 2.4.2. Typical community stone road constructed under CSPW using locally available materials

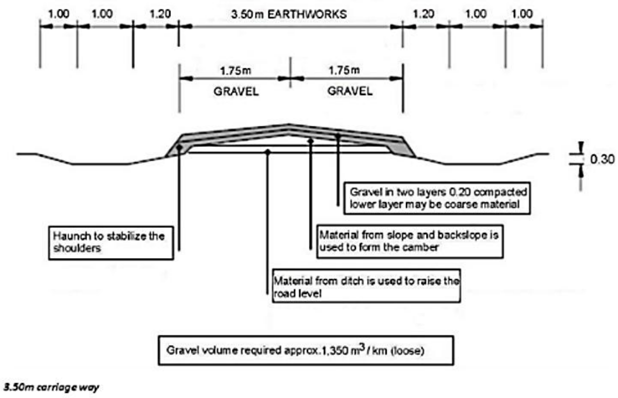
Geographical Extent of Use

Suitable in areas where stones are readily available and transport costs are low. Recommended for flood-prone or high-rainfall environments where erosion resistance and durability are required. Not suitable in flat, poorly drained terrain, or where stone materials are scarce.

Technical Standards

- Running-surface width: 3.50 – 4.50 m
- Minimum stone thickness: 15 cm
- Backslope after compaction: Not exceeding 8%

a)



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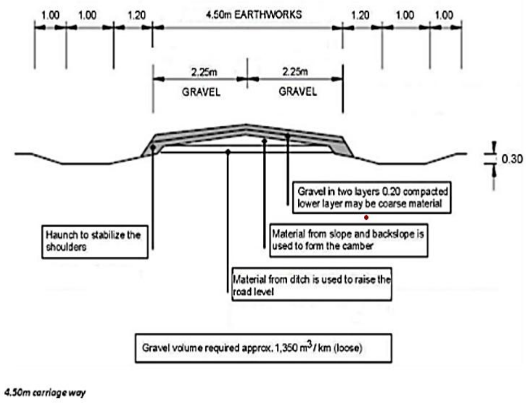


Figure 2.4.3. Typical design for roads on black-cotton soils showing raised camber and stabilized shoulders

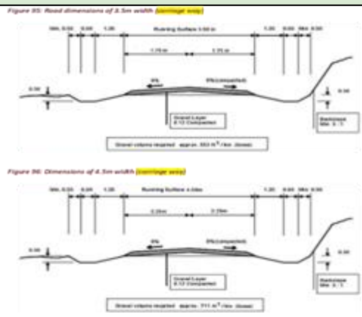
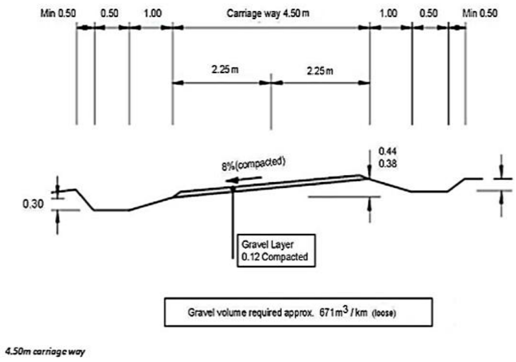


Figure 2.4.4. Typical road dimensions for 3.5 m and 4.5 m carriage-way cross-sections

a)



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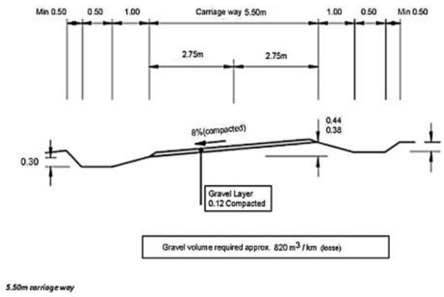


Figure 2.4.5. Cross-section showing super-elevation on bends for improved drainage

Measurements and Tools Requirements

- Construction requires site clearing, excavation, stone carving, spreading of murram and sand, and compaction.
- Tools include hoes, shovels, pickaxes, stone hammers, chisels for carving, hand compactors, and measuring tools for alignment and camber control.
- The quantity of tools depends on soil type, terrain, stone availability, and workforce size.

Layout, Implementation Procedures and Work Norm

- Site preparation: Clear the site of bushes, stumps, and grass; mark the alignment with pegs and rope.
- Excavation and base preparation: Remove topsoil (≈ 30 cm), level and compact the sub-base.
- Base formation: Fill with murram or gravel (≈ 15 cm), compact, and overlay with sieved sand (≈ 3 cm).
- Stone laying: Carve stones (≥15 cm thick) to uniform sizes; place side stones first, then fill the centre section tightly.
- Finishing: Fill joints with sieved sand, compact thoroughly, and remove loose material.

Work norms: Estimated daily labour outputs for major construction include:

- Road layout: 200 m²/pd
- Clear grass and bushes (light): 150–200 m²/pd
- Excavation (soft soils): 1.5 m³/pd
- Spread the murram/sand: 8 m³/pd
- Carving stones: 0.45 m³/pd
- Compact using hand compactors: 100–150 m²/pd
- Filling cracks with sand: 20 m²/pd

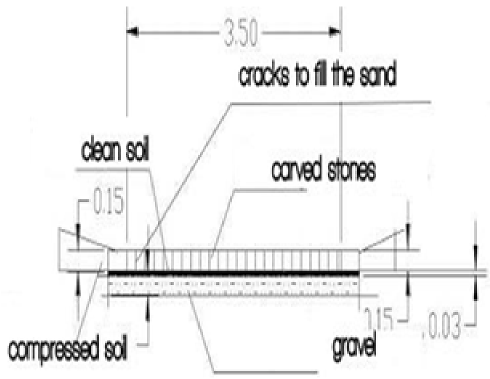


Figure 2.4.6. Standard cross-section of a stone road with compacted gravel and sand layers

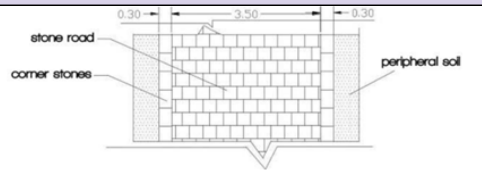


Figure 2.4.7. Top view of a stone road showing corner stones and peripheral soil boundaries.

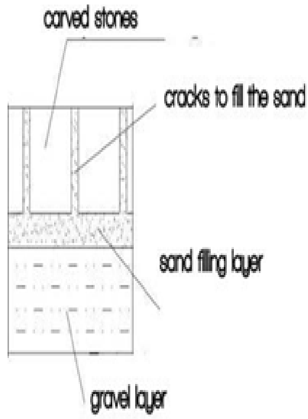


Figure 2.4.8. Cross-section illustrating gravel base, sand filling, and placement of carved stones

Figure 2.4.9. Community workers aligning and compacting stone surface under CSPW

Management Guidelines

- Regularly inspect and refill sand between stone joints to maintain a firm, sealed surface.
- Vegetation should be established alongside drains and embankments to reduce erosion.
- After heavy rainfall, clear any silt or debris from drains and ensure the camber remains intact.
- Local materials should be used for prompt, low-cost repair within CSPW community maintenance schedules.

Limitations

- Construction requires skilled stone carving and intensive labour.
- Stone roads are unsuitable in flat, poorly drained terrain or where stones are scarce.
- Work should be undertaken during the dry season to ensure compaction and quality finishing.

Name of the Technology	**ROAD DRAINAGE STRUCTURES (RDSs)** ***(Scour Checks, Mitre Drains, and Drifts/Causeways)***

General Description

Road drainage structures under CSPW include scour checks, mitre drains (turnout ditches), and drifts (causeways) (Figure 2.4.10–2.4.14). These structures are constructed to reduce flow velocity, control erosion, stabilize road embankments, and protect community access roads from damage during heavy rainfall or runoff events. Scour checks are small control structures constructed within roadside drains or water channels to dissipate stormwater energy and prevent washouts. Mitre drains are lateral channels constructed at intervals along the roadside to divert runoff safely into vegetated areas or natural waterways. Drifts (causeways) are low-level road drainage structures that allow stormwater or stream flow to pass over the road surface without causing structural damage. Incorporating climate-smart design is critical because intense and unpredictable rainfall events are becoming more frequent. Proper spacing, energy dissipation, vegetative stabilization, and use of locally available materials enhance resilience and extend the service life of rural roads.

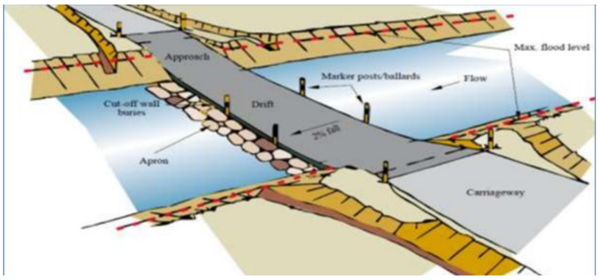


Figure 2.4.10. Typical layout of a drift (causeway)

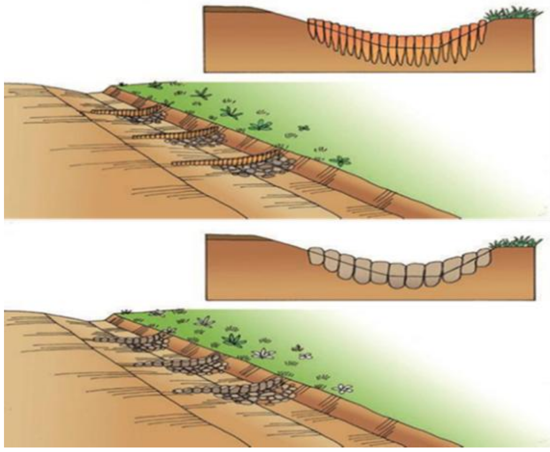


Figure 2.4.11. Gradient of road and required spacing for scour checks

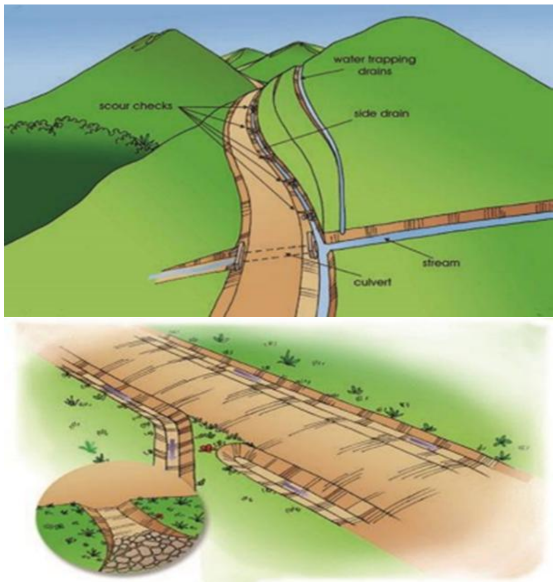


Figure 2.4.12. Integration of scour checks, mitre drains and culverts for runoff management

Geographical Extent of Use

Suitable for community access roads in areas with moderate to high rainfall, steep gradients (above 4%), erosion-prone soils, and seasonal streams or intermittent drainage lines. *Scour checks* are required on steep side drains where runoff velocity may cause erosion. *Mitre* drains are applied where runoff accumulates along roadside drains and requires controlled diversion into stable outlets. *Drifts* are suitable for shallow seasonal water crossings where permanent bridges or large culverts are not economically viable.

Technical Standards

Scour Checks

- Spacing depends on road gradient and soil condition.
- Constructed using:
- Wooden stakes (≈3 cm diameter, 40 cm long) woven with brushwood; or
- Stone structures arranged across the drain with a central spillway 10–15 cm lower than the sides.

Table 2.4.2. Recommended spacing of scour checks by road gradient

Gradient of the road	Erosion controls spacing
4% or less	Not required
5%	20m
8%	10m
10%	5m
12%	4m

Mitre Drains (Turnout Ditches)

- Spacing depends on gradient and drainage characteristics.
- Each mitre drain should:
- Branch at 30°–45° from the side drain
- Have depth 0.30–0.45 m
- Bottom width ≈0.50 m
- Discharge onto stable, vegetated ground or infiltration area

Drifts (Causeways)

- Designed where water flow depth does not exceed 40 cm.
- Key structural components include:
- Approach slope
- Running surface (stone pitching or reinforced concrete)
- Cut-off wall
- Apron (stones, concrete, or gabions)
- Marker posts

Table 2.4.3. Recommended spacing for mitre drains based on road gradient.

Gradient	Spacing (metres)
<4%	100
4% - 6%	80
6% - 7%	60

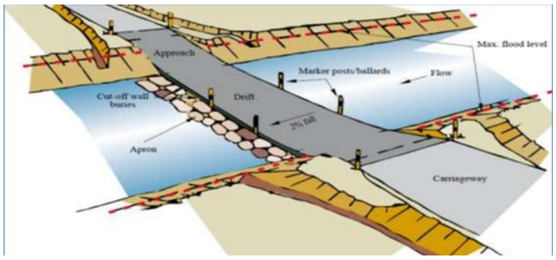


Figure 2.4.13. Layout of drift showing approach, running surface, cut-off wall and apron

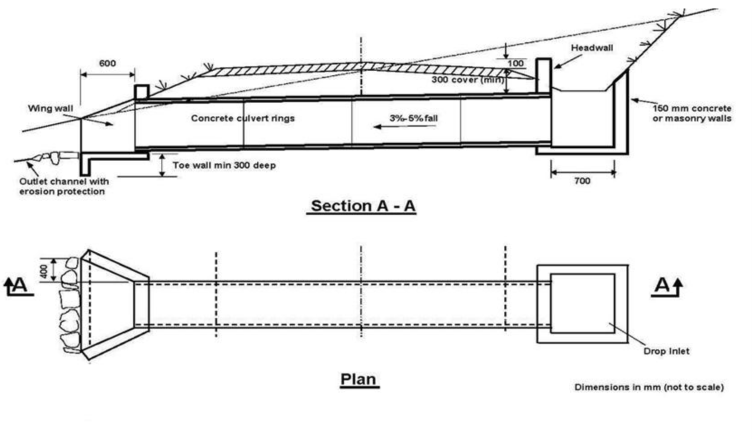


Figure 2.4.14. Cross-section of reinforced concrete drift

Measurements and Tools Requirements

Construction relies on labour-based methods using locally available materials and may include:

- Excavation tools: Hoes, shovels, pickaxes
- Masonry and stone tools: Hammers, chisels, trowels
- Levelling and alignment tools: Line levels, measuring tapes
- Compaction tools: Hand compactors
- Tool quantities depend on terrain, soil type, and structure size.

Layout, Implementation Procedures and Work Norm

Scour checks

- Identify steep drain sections (>4%).
- Excavate small foundations across the drain.
- Install brushwood or stone checks with central spillway.
- Compact downstream side and establish vegetation.
- **Work norms** (Table 2.4.4.)

Mitre drains

- Identify runoff accumulation points.
- Set out drains at recommended spacing.
- Excavate shallow channel (0.30–0.45 m depth).
- Form smooth gradient (~2%).
- Stabilize outlet with vegetation or stone pitching.
- Typical outputs include excavation (1.0–1.5 m^3 per person-day) and vegetative stabilization (~20 m^2 per day).

Drifts (Causeways)

- Clear and level stream-bed.
- Excavate foundation and prepare compacted base (10–15 cm gravel/sand).
- Construct running surface and cut-off wall.
- Install apron downstream.
- Vegetate embankments to stabilize slopes.
- Typical outputs include excavation (1.0–1.5 m^3 per person-day) and stone pitching (4–5 m per day).

Table 2.4.4. Daily work norms for labour-based construction of scour checks.

Activity	Standard	Activity	Standard
Excavation (Soft Soil)	1.5 m^3/pd	Collection of stones (less than 150 m distance).	1 m^3/pd
Excavation (Rocks)	0.5 m^3/pd	Collection of stones (more than 150 m)	0.7 m^3/pd
Erosion controls	2.0 No/pd	Breaking rocks	0.45 m^3/pd

Management Guidelines

- Inspect structures regularly, especially after heavy rainfall.
- Remove accumulated silt and debris from drains and outlets.
- Replace displaced stones and repair erosion immediately.
- Maintain vegetative cover at outlets and embankments.
- Integrate routine maintenance into CSPW community work schedules.

Limitations

- Ineffective if spacing standards are not followed.
- Poor outlet stabilization may lead to concentrated erosion.
- Drifts are unsuitable for perennial rivers or flows exceeding 40 cm depth.
- Require regular inspection and maintenance to remain effective.

Name of the Technology	CULVERTS (CVs)

General Description

Culverts are short drainage structures built to allow water to pass beneath roads, trails, or embankments, preventing washouts, erosion, and road surface damage by safely conveying runoff from one side to the other (Figures 2.4.15 and 2.4.16). Within the CSPW framework, they are small-to-medium structures constructed through labour-based methods using pre-cast concrete rings or masonry. Proper sizing and alignment are essential to minimize flood damage and maintenance costs, while the inclusion of headwalls, wing walls, vegetative cover on outlets, and aprons protected with riprap or gabions enhances stability and reduces sedimentation in adjacent streams. Culverts are particularly important in areas prone to flooding or heavy runoff, ensuring year-round accessibility and strengthening the resilience of rural infrastructure to climate variability.

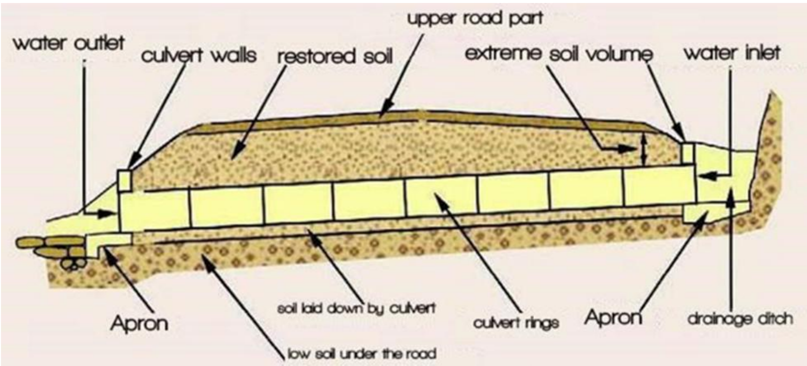


Figure 2.4.15. Basic components of a culvert show water inlet, culvert rings, and apron for outlet protection

Geographical Extent of Use

Suitable for community access roads in areas prone to flooding, heavy runoff, or where natural drainage lines intersect the road alignment. Applied in small, moderate, and large catchments where safe conveyance of stormwater beneath the road is required to prevent washouts, erosion, and embankment failure.

Technical Standards

- 60 cm diameter: Used for small catchments (<1 ha) and light runoff areas.
- 90 cm diameter: Common for moderate catchments (1–3 ha) and rural roads.
- 120 cm diameter: Used for large catchments (>3 ha) or frequent stormwater flows.

Construction parametres:
- Minimum road cover above culvert: 30 cm
- Gradient (fall) for drainage: 3–5%
- Masonry or concrete headwalls: ≥150 mm thick
- Wing walls: Extend 0.6–1.0 m beyond the road edge
- Toe wall: Minimum 300 mm deep
- Apron protection: Riprap or stone pitching (≥300 mm thick) on outlet side

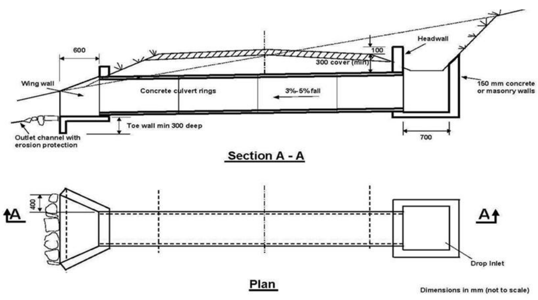


Figure 2.4.16. Cross-section and plan view of a standard concrete culvert installation

Measurements and Tools Requirements

- Excavation tools: Hoes, shovels, pickaxes
- Masonry tools: Trowels, hammers, chisels
- Leveling tools: Line levels, water levels, measuring tapes
- Compaction tools: Hand compactors

Layout, Implementation Procedures and Work Norm
- Identify the lowest point across the drainage line where water naturally accumulates. - Excavate the culvert trench to required width and depth, ensuring firm foundation and proper gradient. - Remove soft or loose material from the base. - Lay compacted gravel or sand base (10–15 cm thick) to ensure level bedding. - Check alignment with a water level to maintain required slope (3–5%). - Place pre-cast concrete rings (or masonry sections) sequentially, ensuring tight jointing. - Seal joints with mortar to prevent infiltration and loss of fines. - Construct headwalls and wing walls to anchor culvert ends. - Install toe wall (minimum 300 mm deep). - Provide riprap or stone-pitched apron downstream (extend 1–2 m depending on slope). - Refill around culvert rings with well-compacted soil in layers not exceeding 15 cm. - Maintain at least 30 cm compacted fill above the crown. - Shape the camber to guide water into side drains. **Work norms:** - Excavation: 1.0–1.5 m^3 per person-day - Masonry work: ~1.5 m^3 per person-day - Installation: Up to two culvert units (60–120 cm diameter) per day
Management Guidelines
- Inspect culverts regularly after heavy rainfall. - Remove silt, debris, or vegetation blocking inlet or outlet. - Repair cracks, displaced rings, or erosion near headwalls and aprons immediately. - Reinforce side slopes and outlet areas with grass or vetiver to minimize scouring. - Maintain clear drainage alignment between culverts and roadside ditches. - Integrate routine maintenance into CSPW community work schedules.
Limitations
- Improper sizing may result in overtopping or erosion. - Inadequate compaction or weak headwalls may lead to structural failure. - Require regular inspection and maintenance to ensure effective drainage performance.

Name of the Technology	BRIDGES (BRs)

General Description

Bridges are essential drainage and access structures that enable safe passage across rivers, streams, and seasonal watercourses (Figures 2.4.17 and Figure 2.4.18). Under CSPW, bridge construction focuses on small-scale, labour-based designs suitable for pedestrian and light-traffic use. Communities typically construct timber log and sawn timber footbridges using locally available materials, while reinforced concrete (RCC) and arch bridges are applied where more permanent, durable, and structurally resilient solutions are required. *Timber bridges* are low-cost and quick to construct. RCC bridges provide high structural strength, long service life (over 50 years), and reduced maintenance requirements. *Arch bridges* use compressive structural behaviour through curved geometry to distribute loads efficiently and provide stable, long-lasting crossings when properly constructed. Bridge location should minimize construction costs and maximize accessibility benefits. Sites must provide firm foundations, stable flow paths, and sufficient flood clearance, avoiding sharp bends and erosion-prone zones. Approaches should be well-drained and aligned with existing paths or tracks.

Figure 2.4.17. Community-built timber log footbridge (example of simple crossing)

Figure 2.4.18. Ongoing construction of an arch bridge

Geographical Extent of Use

Suitable for community access roads crossing rivers, streams, and seasonal watercourses where safe year-round passage is required. Timber log and sawn timber footbridges are appropriate for small spans, pedestrian use, livestock crossings, and light motorcycles, particularly where timber is locally available and traffic loads are low. Reinforced concrete bridges are suitable for high-traffic community roads, perennial streams, or flood-prone sites where wooden structures are easily damaged. Arch bridges are appropriate in narrow stream sections with stable foundations and where durable masonry-based solutions can be constructed using locally available stones. Bridge sites should avoid unstable riverbanks, sharp bends, deep scour zones, and areas with weak bearing capacity.

Technical Standards

Timber log footbridges

- Span: Typically, 8–12 m (extendable to 15–20 m where longer logs are available)
- 2–4 main log stringers depending on span and load
- Deck poles: 7–10 cm diameter nailed across stringers
- Handrails required for spans longer than 3–4 m

Sawn timber footbridges

- Beam-type structure using rectangular beams and planks
- Typical span: 5–8 m
- Extendable to 10 m with intermediate piers

Reinforced concrete (RCC) bridges

- Reinforced concrete deck supported by abutments or piers
- Designed for higher traffic loads
- Suitable for perennial streams and flood-prone crossings

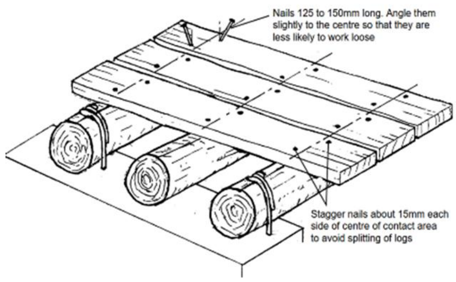


Figure 2.4.19. Deck arrangement for timber log footbridge

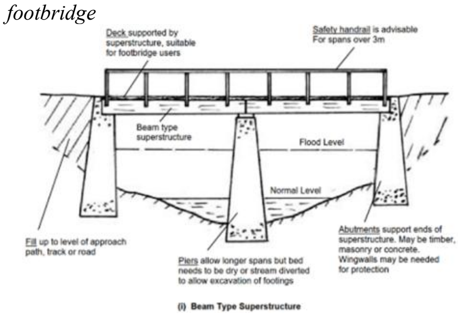


Figure 2.4.20. Beam-type sawn timber footbridge

Arch bridges
- Semi-circular masonry arch transferring load through compression (Figure 2.4.22)
- Headwalls: 30 cm thick stone masonry
- Wing walls constructed in stepped form (avoid continuous heights over 2 m)
- Minimum 30 cm compacted fill above arch ring
- Use large, strong, and angular stones (e.g., basalt, granite, gneiss, slate)

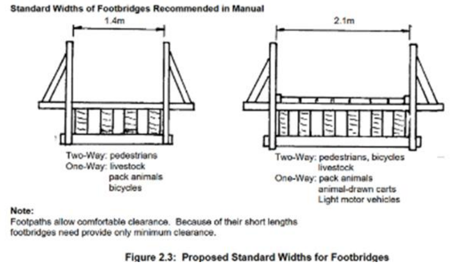


Figure 2.4.21. Standard footbridge widths recommended under CSPW

Table 2.4.5. Recommended size and spacing of logs for footbridges.

Span (m)	Size and Spacing of Logs			
	Up to 1.0m Wide	Up to 1.4m Wide	2.1m Wide	
	2 Logs at 600mm	3 Logs at 600mm	3 Logs at 800mm	4 logs at 600mm
	Size (mm)	Size (mm)	Size (mm)	Size (mm)
4	225	200	250	220
6	275	250	300	275
8	325	300	350	325
10	375	350	400	375
12	425	400	450	425

Notes: (1) The size is the diameter of the heartwood after the bark is removed and not including the sapwood.
(2) The size should be the minimum diameter over at least the middle 33% (one third) of the log stringer.

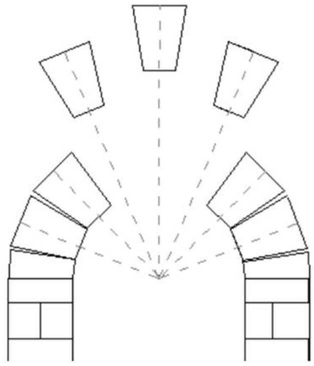


Figure 2.4.22. Placement of wedge-shaped stones converging toward the keystone

Measurements and Tools Requirements

- Excavation tools: Hoes, shovels, pickaxes
- Masonry tools: Trowels, hammers, chisels
- Carpentry tools: Saws, measuring tools
- Leveling tools: Line levels, measuring tapes
- Compaction tools: Heavy steel or jumping compactors
- Materials vary by bridge type and include timber, concrete components, reinforcement steel, large angular stones, coarse sand, and cement mortar.

Layout, Implementation Procedures and Work Norm

- Select the narrowest and most stable section of the stream to reduce span length and cost.
- Excavate foundations and compact trench base thoroughly.
- Construct abutments and wing walls.
- Install deck system (timber, RCC, or arch structure).
- For arch bridges, construct semi-circular wooden centring and place stones symmetrically from both sides toward the keystone.
- Backfill in compacted layers (10 cm layers for arch bridges).
- Provide adequate flood clearance and stable approaches.

Work norm:
- A 5 m span arch bridge (3.6 m width) typically requires 2 masons and 4 helpers working approximately 30 days (materials available on site).

Figure 2.4.23. Prefabricated wooden centring for arch construction.

Figure 2.4.24. Keystone placement completing the arch

Table 2.4.6. Recommended daily work norms for arch bridge construction under labour-based implementation

Activity	Standard	Activity	Standard
Bridge layout	200m^2/pd	Filling cracks with sand	20 m^2/pd
Clear grass and bushes (light)	400-1000 m^2/pd	Compact using hand compactors	130 – 150m
Clear grass and bushes (heavy)	150-200 m^2/pd	Collection of stones (less than 150m)	0.8 m^3/pd
Excavation (Soft soils)	1.5 m^3/pd	Collection of stones (more than150m)	0.5 m^3/pd
Excavation (Hard soils)	1.0m^3/ pd	Breaking rocks	0.4 m^3/pd
Excavation (Rocks)	0.5 m^3/pd		
Spread the Murram/ Sand	8 m^3/pd	Sieving sand	1 m^3/pd

Figure 2.4.28. Suitable and unsuitable stones for arch construction

Figure 2.4.25. Alignment control during stone placement

Figure 2.4.26. Filling of gaps between arch stones

Management Guidelines

- Inspect bridge decks, abutments, and wing walls regularly.
- Replace decayed timber elements promptly.
- Repair masonry cracks and erosion near foundations.
- Maintain vegetative stabilization along riverbanks and approaches.
- Clear debris accumulates after heavy rainfall.
- Integrate routine maintenance into CSPW community work schedules.

Limitations

Timber bridges:
- Durability depends on timber quality and treatment.
- Require frequent inspection and replacement of decayed elements.

Reinforced concrete bridges:
- High initial construction cost.
- Require technical supervision and skilled workmanship.

Arch bridges:
- Require skilled masonry and accurate centring.
- Sensitive to poor foundation conditions and improper stone selection.

5.0 Nutrition sensitive public works interventions

5.1 Introduction

Climate-Smart Public Works (CSPW) nutrition-sensitive interventions are sub-projects designed to simultaneously strengthen climate resilience, improve household nutrition, and create sustainable public and community assets. These interventions integrate the three pillars of CSPW increasing productivity, enhancing resilience, and reducing greenhouse gas emissions with explicit nutrition objectives aimed at improving the availability, accessibility, affordability, and consumption of diverse, nutrient-dense foods. Mainstreaming nutrition within CSPW is critical because many Public Works beneficiaries are vulnerable individuals, including elderly persons and households facing chronic poverty and food insecurity. By embedding nutrition outcomes into climate-smart livelihood activities, CSPW shifts from short-term wage support toward long-term improvements in dietary diversity, micronutrient intake, and household food system resilience.

Key examples of climate-smart nutrition-sensitive CSPW interventions include:

- **Fish Farming (Small-scale aquaculture)**
  Integrating fish farming into CSPW enhances access to high-quality animal-source protein and essential micronutrients while generating income. It supports climate-resilient food production systems and enables households to access additional nutrient-dense foods and meet other essential needs.
- **Beekeeping**
  Beekeeping improves agricultural productivity through pollination and provides nutrient-rich products such as honey, pollen, and royal jelly. It diversifies income sources, strengthens resilience during lean periods, and enhances the capacity of households to afford nutritious diets.
- **Permaculture systems**
  Permaculture promotes diversified, climate-resilient, and ecologically sustainable food production systems that address the underlying causes of malnutrition while enhancing environmental conservation and resource efficiency. Within CSPW, permaculture interventions include:
  - **Perma-gardens:** Simplified, bio-intensive household food systems designed to improve dietary diversity while conserving soil and water resources.
  - **Kitchen gardens:** Small-scale, intensive gardens located near households or institutions, providing year-round access to fresh vegetables, fruits, and herbs using water-efficient techniques such as drip irrigation and greywater recycling.
  - **Sack gardening:** A vertical, space-efficient food production system suitable for densely populated or land-constrained areas, enabling households to grow vegetables using minimal space and water while enhancing nutrition and climate resilience.

5.2 Fish farming

Fish farming in Tanzania is a fast-growing sector compared with the past years. This is due to the availability of many opportunities and resources as well as areas with sufficient water levels, land, and a variety of fish well known for its quick growth ability. We advocate that fish farming should be integrated with crops and animal farming for effective consumption of water and environmental conservation.

Water in the pond is changed regularly (about once per month) to ensure continuous supply of fresh water and good aeration (oxygen concentration). About 3 mg/litre (3 ppm) concentration of oxygen is considered ideal. Water discharged from a fishpond is rich in nutrients and can be recycled for vegetable gardening, rice farming, or irrigating vegetation (grass or trees) in areas around the pond, rather than released to pollute the environment. This climate-smart practice provides an opportunity to contribute to livelihood improvement and climate change adaptation and mitigation. Nowadays, a lot of emphasis is on commercial fish farming to ensure continuous food supply and employment.

Name of the Technology	**EARTHEN FISHPOND (EP)**
General Description	
An earthen fishpond is an excavated pond with constructed bunds and fitted inlet and outlet pipes designed to support fish survival, growth, and reproduction (Figures 2.5.1). The pond is constructed according to specific measurements to ensure proper water retention, drainage control, and structural stability. Construction is best carried out during the dry season or non-rainy period depending on regional weather conditions. Under CSPW, earthen fishponds contribute to livelihood improvement through aquaculture production, enhance household nutrition, and promote integrated farming systems where pond water supports other agricultural activities.	 *Figure 2.5.1. Earthen fishpond (EP) with stabilized bunds and controlled inlet and outlet systems to support aquaculture production and integrated farming*
Geographical Extent of Use	
Fish farming should be carried out in areas with a safe and reliable clean water source throughout the year. The site should have at least 20% clay soil to ensure water retention, medium slope, and good year-round accessibility. Vegetation should preferably be grass or low plants rather than trees, and the area should be secure against flooding and theft.	

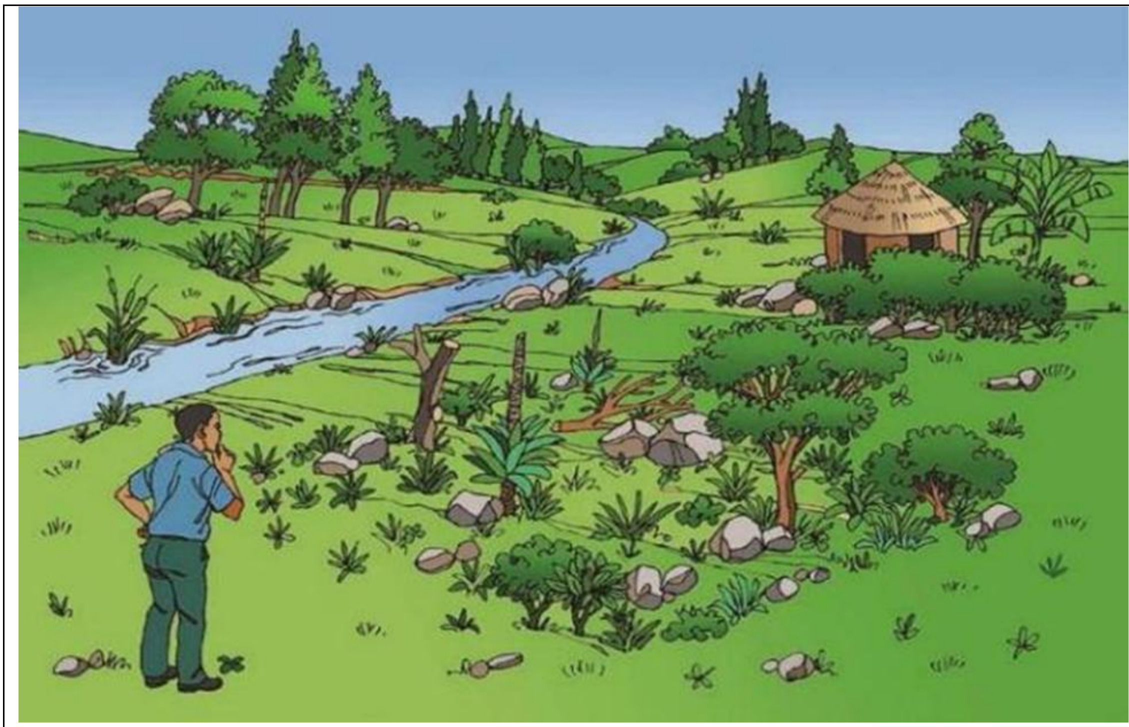


Figure 2.5.2: Assessment of landscape and water source for sitting an earthen fishpond.

Technical Standards

- **Pond dimensions**
- Pond depth: 1–2 m
- Medium size pond: 30 m length × 15 m width × 1–2 m depth
- Bund width: 1–2 m (depending on size and slope)
- Internal slope: 1:2
- External slope: 1:1
- Inlet pipe: Placed 20 cm above pond floor at deepest end
- Overflow outlet pipe: Placed 30 cm below bund crest

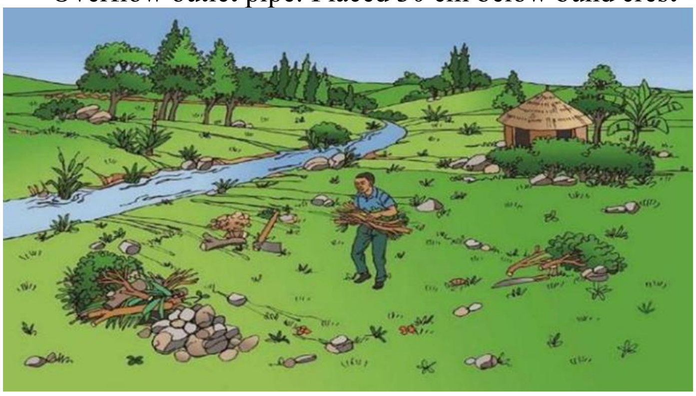


Figure 2.5.3. Site preparation and layout marking

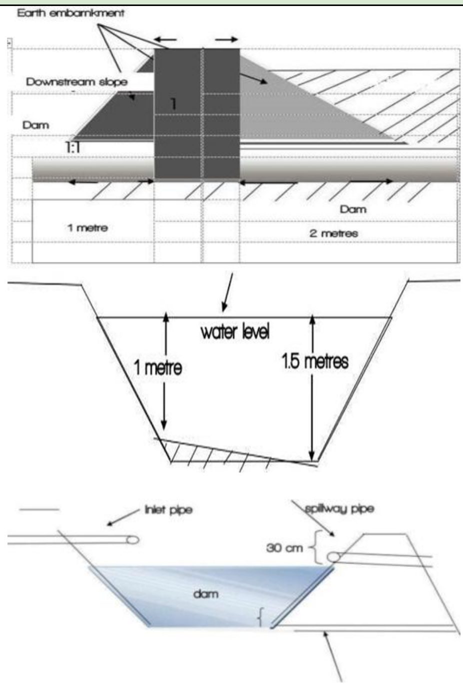


Figure 2.5.4. Typical cross-sections showing embankment, slopes, and pipe placement

Measurements and Tools Requirements

- **Construction Tools:** Tape measure, rope, water level, hammer, digging hoes, arch, wheelbarrows, machete/panga, axe, slasher, metal basins, compactors.
- **Protective Gear**: Gloves, gumboots, masks, first aid kit.
- **Structural Components:** Inlet and outlet pipes with filters, compacted clay soil for bund formation.

Layout, Implementation Procedures and Work Norm

Site Preparation
- Measure pond length, width, and depth accurately.
- Mark layout using pegs and rope.
- Clear shrubs, trees, roots, and grass.

Excavation and bund construction
- Remove topsoil (not exceeding 30 cm) and set aside.
- Excavate pond, heap soil at bund location.
- Compact soil after every 30 cm layer.
- Continue until bund reaches 1 m height and 1 m width (depending on slope).
- Moisten dry soil before compaction.
- Excavate to 1 m depth on shallow side and 1.5–2 m on deep side.

Topsoil replacement and vegetation
- Replace stored topsoil on bund surface.
- Plant grass to stabilize bund and reduce erosion.

Pipe installation
- Fix inlet and overflow outlet pipes.
- Install filters on both pipes to prevent entry or escape of unwanted organisms.

Work norm
- Pond excavation: 1.5 m³ per person-day
- Soil removal and bund heaping: 1.5 m³ per person-day
- Bund compacting: 1.5 m³ per person-day
- Grass collection and planting: 4 m² per person-day

Water filling and pond preparation
- Fill pond and leave for 1 week to check leakages.
- Repair leaks if present.
- Drain water, apply chalk, leave for 2–3 days, then refill.
- Apply cow dung manure to improve fertility until green coloration appears.

Stocking standards
- Stock fingerlings at 7–8 fingerlings per 1 m² of pond surface area.

Feeding standards
- Feed fish twice daily (9–10 am and 3–4 pm).
- Feeding rate: 5% of fish body weight.
- Sample fish weight monthly.

Harvesting procedures
- Stop feeding 2 days before harvesting.
- Harvest early morning to maintain fish quality.
- Reduce water level using outlet pipe.
- Use fishing nets for harvesting.
- Sort fish by size and place in clean containers.
- Rehabilitate pond after harvest for next stocking cycle.

Figure 2.5.5. Excavation and setting out of the check dam foundation using pegged guidelines, with initial placement of stones along the marked trench

Figure 2.5.6. Excavation and levelling of the check dam foundation area, showing clearance of soil and preparation of a uniform base along the pegged layout.

Figures 2.5.7. Excavation, compaction, bund formation, and structural protection

Figure 2.5.8. Vegetation establishment around a completed pond.

Figure 2.5.9. Community fish harvesting from managed pond.

Management Guidelines

- Frequently monitor water quality. - Maintain required water level; replace dirty water when necessary. - Remove weeds inside pond. - Cut surrounding grass regularly. - Use nets to remove frogs and harmful insects. **Rehabilitation** - Inspect bunds and pond floor for leaks or erosion. - Compact soil on weak or eroded sections. - Repair damaged inlet/outlet pipes and filters. - Remove excess mud from pond floor and channels. **Environmental Integration** - Promote mixed farming to reuse pond water for rice or garden irrigation. - Plant water-friendly vegetation such as castor and wild berries around pond.
Limitations
- Ponds may breed mosquitoes, monitor lizards, and insects. - Risk of small-scale irrigation misuse affecting water levels. - Requires consistent management to maintain productivity.

5.2 Beekeeping

Name of the Technology	BEEKEEPING (BK)
General Description	
Beekeeping involves establishing and managing beehives for production of honey, beeswax, propolis, and other hive products (Figure 2.5.10). Under CSPW, beekeeping is promoted as a low-cost livelihood activity that enhances household income while supporting biodiversity, pollination of crops, and environmental conservation. Communities construct and maintain hives, conduct routine inspections, harvest honey, and process hive products for household consumption or sale.	 *Figure 2.5.10. Beekeeping technology shows improved hives and apiary management practices for honey production and pollination support*
Geographical Extent of Use	
Beekeeping is suitable across a wide range of agro-ecological zones where flowering plants and natural vegetation provide continuous forage. Appropriate sites include forest edges, woodlots, agroforestry systems, riverine vegetation, rangelands, and homesteads with trees. Apiaries should be located away from busy roads, schools, and densely populated settlements to reduce human–bee conflict. The technology is particularly appropriate in areas with limited access to land or water since it requires minimal space and low daily labor input.	
Technical Standards	
Hive types - Top-bar hives - Langstroth hives - Tanzania traditional log hives Selection of hive type depends on local skills, materials, and management capacity. **Hive placement standards** - Hives mounted on strong stands 1–1.5 m above ground. - Secure roofing or rain protection to minimize moisture. - Apiary fenced or clearly marked to prevent disturbance. - Access to clean water source within flight range.	
Measurements and Tools Requirements	
- **Protective equipment:** Bee suit, veil, gloves, gumboots. - **Hive management tools:** Smoker, hive tools, buckets, harvesting knives. - **Construction materials** (where applicable): Timber, nails, roofing materials, stands, and fencing materials depending on hive type.	

Layout, Implementation Procedures and Work Norm
Apiary establishment - Select suitable forage-rich site. - Clear surrounding vegetation while maintaining shade trees. - Install hive stands and position hives securely. - Fence or demarcate apiary site. **Hive installation** - Construct and install 1–2 hives per person-day, depending on hive type and material availability. **Routine inspection and colony management** - Inspect 10–15 hives per person-day. - Check hive condition, pest presence, moisture, and colony strength. - Maintain cleanliness around apiary site (1 person-day per 0.25 acres). **Honey harvesting and processing** - Harvest from 5–8 hives per person-day. - Work during calm weather (early morning or evening). Filter and package honey using clean containers.
Management Guidelines
- Use full protective gear during inspection and harvesting. - Maintain shaded conditions to reduce heat stress on colonies. - Control pests and prevent hive disturbance. - Avoid excessive smoke that may stress colonies. - Keep first-aid kit at apiary site and train workers on responding to bee stings and allergic reactions. - Maintain adequate distance from settlements and livestock routes. - Protect surrounding vegetation to ensure continuous forage supply.
Limitations
- Risk of bee stings, particularly near homes or public paths. - Colonies may abscond due to pests, heat, fire, or disturbance. - Reduced forage availability during dry seasons lowers honey yields

5.3 Permaculture

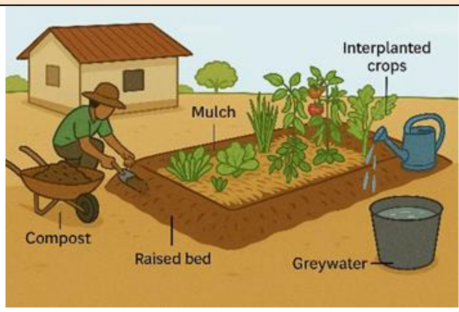
<table>
<tr><td>Name of the Technology</td><td>PERMA-GARDENS (PG)</td></tr>
<tr><td colspan="2">General Description</td></tr>
<tr><td>Perma-gardens are small, intensively managed household gardens established near homesteads to produce diverse crops throughout the year using sustainable land management practices (Figure 2.5.11). The system combines raised or sunken beds, compost application, mulching, and intercropping to improve soil fertility, conserve moisture, and enhance crop productivity. Under CSPW, perma-gardens support year-round vegetable and herb production, improve dietary diversity, enhance food security, and create income opportunities for women and youth. The technology promotes recycling of household organic waste into compost, efficient use of limited land, and sustainable water management through use of greywater, harvested rainwater, or nearby water sources.</td><td>

Figure 2.5.11. Illustration of perma-garden concept showing raised beds, compost use, mulching, and crop diversity</td></tr>
<tr><td colspan="2">Geographical Extent of Use</td></tr>
<tr><td colspan="2">Perma-gardens are suitable in rural, peri-urban, and urban settings where households have limited land but access to small water sources such as greywater, harvested rainwater, ponds, shallow wells, or rooftop catchments. In coastal areas such as Zanzibar, the system integrates perennial crops (banana, coconut) with vegetable sub-plots. In semi-arid areas such as Dodoma or Simanjiro, raised beds, sack gardens, or sunken beds are used to retain moisture and withstand dry spells. The technology performs best when located close to homesteads for daily management and protection.</td></tr>
<tr><td colspan="2">Technical Standards</td></tr>
<tr><td colspan="2">Bed design
- Raised beds: 30–60 cm height
- Bed width: 1–1.2 m for easy access
- Bed length: Depends on available space
- Sunken beds: Constructed in sandy or drought-prone areas to retain moisture
- Sack gardens: Used where space or soil quality is limited
Soil fertility management
- Compost and animal manure incorporated into top 20–30 cm soil layer
- Regular replenishment of organic matter
Water management
- Use of greywater, harvested rainwater, shallow wells, or ponds
- Light, regular irrigation especially during dry periods</td></tr>
<tr><td colspan="2">Measurements and Tools Requirements</td></tr>
<tr><td colspan="2">- Tools: Hoes, shovels, rakes, watering cans, buckets, tape measures.
- Organic inputs: Compost, animal manure, crop residues, ash, mulch materials (dry grass, leaves).
- Watering equipment: Buckets, watering cans, small drip or gravity-fed systems (where available).</td></tr>
<tr><td colspan="2">Layout, Implementation Procedures and Work Norm</td></tr>
<tr><td colspan="2">Site selection
- Select sunny, well-drained area near homestead.
- Ensure proximity to water source.
Bed construction
- Clear vegetation and mark layout.
- Construct raised or sunken beds according to soil type.
- Mix compost and manure into soil.</td></tr>
</table>

Work norms: - Site clearing: 150–200 m² per person- day - Bed construction and shaping: 10–15 m² per person-day - Compost preparation and incorporation: 1 m³ per person-day - Mulch application: 20 m² per person-day **Planting and intercropping** - Plant diverse crops (leafy vegetables, legumes, herbs, root crops). - Practice interplanting to optimize space and reduce pest pressure. - Apply mulch immediately after planting. **Irrigation** - Water gardens regularly using greywater or harvested rainwater. - Avoid overwatering to prevent nutrient leaching.
Management Guidelines
- Weed regularly to reduce competition. - Replenish compost periodically. - Rotate crops to maintain soil fertility. - Apply natural pest control methods (e.g., neem or garlic solutions). - Maintain mulch cover to conserve moisture and suppress weeds. - Monitor water use to ensure efficiency and prevent stagnation. - Encourage household participation (women, youth, family members).
Limitations
- Requires consistent household labour for daily management. - Limited water availability may reduce productivity in dry seasons. - Poor compost supply affects soil fertility. - Pest outbreaks may occur without regular monitoring.

Name of the Technology	KITCHEN GARDENS (KG)

General Description

Kitchen gardens are small home-based plots established primarily for daily household consumption (Figure 2.5.12). Typically located beside or behind the house, they integrate fast-growing vegetables such as amaranth, spinach, tomatoes, and onions with herbs and selected fruit trees such as papaya, banana, or citrus. These gardens are usually managed by women and family members and are designed for easy daily access for watering, harvesting, and maintenance. Under CSPW, kitchen gardens enhance household nutrition, improve dietary diversity, reduce food expenditure, and strengthen food self-reliance. They promote efficient use of limited space through containers, sacks, recycled materials, or small raised beds, especially in land-constrained environments. The system encourages recycling of compost, organic waste, and greywater, contributing to soil fertility improvement, microclimate enhancement around homesteads, and increased biodiversity.

Figure 5.2.12. Illustration of a backyard kitchen garden integrating vegetables, herbs, fruit trees, sacks, compost, and greywater use

Geographical Extent of Use

Kitchen gardens are suitable in rural, peri-urban, and urban settings where households have limited land but access to small water sources such as greywater, rooftop rainwater harvesting systems, or shallow wells. The technology adapts to sandy coastal soils, compacted peri-urban compounds, and semi-arid environments through use of raised beds, sacks, or containers. It performs best when established close to the kitchen or household water source to facilitate daily management.

Technical Standards

Garden layout

- Located within homestead boundary.
- Small fenced plot, container-based, or sack system.
- Fruit trees planted along borders with adequate spacing.
- Vegetables and herbs are intercropped between trees.

Soil fertility management

- Regular application of compost and organic residues.
- Continuous mulching using dry grass or crop residues.

Water use

- Irrigation using greywater, harvested rainwater, or shallow wells.
- Regular light watering to maintain soil moisture.

Measurements and Tools Requirements

- **Tools:** Hoes, rakes, watering cans, buckets, and hand forks.
- **Organic Inputs:** Compost, manure, mulch materials, and kitchen waste.
- **Protection Materials:** Fencing materials (wooden stakes, wire mesh, recycled materials), sacks, or containers for planting.

Layout, Implementation Procedures and Work Norm

Site selection and preparation

- Select sunny area near kitchen or water source.
- Clear and demarcate small garden space.

Work norm:

- Site clearing and layout: 100–150 m² per person-day
- Bed or container preparation

- Prepare raised beds or fill sacks/containers with fertile soil and compost. - Incorporate organic matter into topsoil. **Work Norm:** - Bed preparation: 10–12 m² per person-day - Sack/container preparation: 15–20 sacks per person-day **Planting** - Establish fruit trees at borders. - Interplant vegetables and herbs within available space. - Practice staggered planting for continuous harvest. **Mulching and irrigation** - Apply mulch after planting. - Irrigate regularly using greywater or harvested rainwater. **Work Norm** - Mulch application: 20 m² per person-day
Management Guidelines
- Water regularly to maintain soil moisture. - Weed frequently to reduce competition. - Rotate crops to maintain soil fertility. - Replenish compost periodically. - Apply organic pest deterrents where necessary. - Fence or shield garden from free-grazing animals. - Maintain continuous planting for year-round production.
Limitations
- Limited water availability may reduce productivity in dry seasons. - Requires consistent household labour. - Poor fencing may expose crops to livestock damage. - Nutrient depletion may occur without regular compost application.

Name of the Technology	VERTICAL GARDENS (SACK GARDENING) – VG

General Description

Vertical gardening, also known as sack gardening, is a space-efficient household food production system where vegetables are grown in sacks, containers, recycled buckets, wooden crates, wall-mounted pockets, or stacked vertical structures (Figure 2.5.13). The technology is particularly suitable in land-constrained environments such as Zanzibar, Pemba, Dar es Salaam, and peri-urban settlements where horizontal gardening space is limited. Under CSPW, vertical gardens improve household access to fresh vegetables and herbs year-round, enhance nutrition, and reduce food expenditure. The system promotes efficient use of greywater, compost, and recycled materials, reduces pressure on land, and minimizes soil-borne diseases through use of controlled growing media. It is an accessible entry-level technology for households adopting sustainable food production practices.

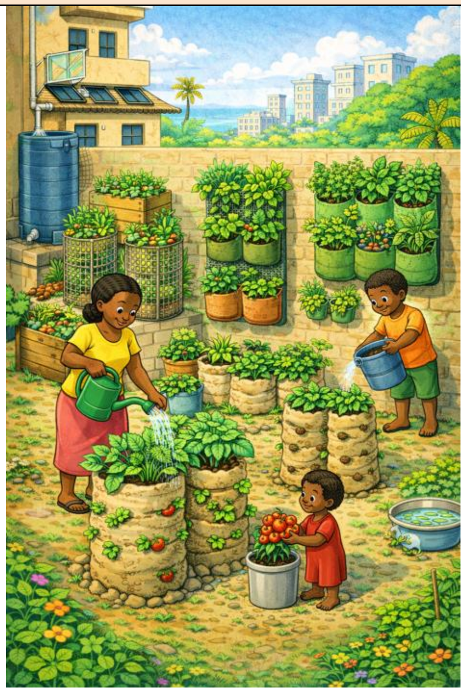


Figure 5.2.1. Vertical gardening systems using sacks, recycled containers, and wall-mounted structures

Geographical Extent of Use

Vertical gardens are suitable in urban, peri-urban, coastal, and densely populated rural areas where land availability is limited. They perform best where households have access to small quantities of compost or manure and reliable sources of greywater or harvested rainwater for frequent light irrigation. Units should be positioned to receive at least four to six hours of sunlight daily and located close to the household for easy maintenance.

Technical Standards

Container requirements
- Use durable sacks, buckets, wooden crates, recycled basins, or vertical frames.
- Ensure adequate drainage holes to prevent waterlogging.
- Stable placement to prevent tipping or collapse.

Growing media
- Mixture of topsoil, compost, manure, and leaf litter.
- Well-drained but moisture-retentive substrate.
- Organic matter renewed seasonally.

Crop selection
- Fast-growing vegetables: Amaranth, spinach, onions.
- Short-cycle crops: Tomatoes, peppers.
- Herbs: Basil, coriander, local herbs.

Measurements and Tools Requirements

- **Tools:** Hand hoe, trowel, watering can, bucket.
- Materials: Sacks or containers, compost, manure, topsoil, and mulch materials.
- Water Source: Greywater, harvested rainwater, or shallow well water.

Layout, Implementation Procedures and Work Norm

Site preparation
- Select sunny location receiving 4–6 hours of sunlight.
- Arrange containers securely to allow access for watering and harvesting.

Work norm:
- Site preparation and layout: 80–100 units per person-day (arrangement only).

Container preparation - Prepare soil mixture and fill containers. - Establish drainage holes. - Plant crops in top and side openings. **Work norm:** - Filling and planting: 10–15 sacks/containers per person-day **Mulching and irrigation** - Apply mulch to soil surface. - Water lightly and regularly. **Work norm:** - Mulch application: 15–20 units per person-day
Management Guidelines
- Irrigate frequently with small amounts of water. - Monitor moisture levels to avoid drying or waterlogging. - Replenish compost and organic matter each season. - Rotate crops to prevent pest buildup. - Replace damaged sacks or containers as needed. - Protect structures from strong winds and livestock interference.
Limitations
- Requires frequent watering due to limited soil volume. - Containers may deteriorate over time and need replacement. - Limited root space may restrict larger crop varieties. - Poor sunlight exposure reduces productivity.

6.0 Disposal of organic and inorganic wastes

Effective waste management involves the strategic handling of both inorganic and organic materials to protect human health and the environment. While both types represent unwanted substances, they require distinct disposal methods based on their physical properties and potential for reuse.

Organic waste consists of natural matter, such as food leftovers and garden clippings. Unlike inorganic items, organic waste is biodegradable and can be transformed into a valuable resource through composting. By disposing of these materials in dedicated pits or bins, they decompose into nutrient-rich manure that improves soil fertility.

In contrast, inorganic waste includes materials that do not easily decompose, such as used batteries, metals, and plastics. If handled improperly, these items can cause accidents, chemical leaks, or the spread of disease. However, many inorganic materials serve as valuable industrial raw materials when processed through recycling. Managing this waste requires specific tools such as rakes, shovels, and trolleys. Also, workers must prioritize safety by wearing helmets, gloves, and reflector jackets during collection and sorting.

Proper disposal of organic and inorganic waste directly supports the core objectives of the Climate Smart Public Works (CSPW) programme by enhancing environmental resilience, reducing greenhouse gas emissions from open dumping, and fostering community wellbeing and safety. In this context, this manual briefly describes the following waste disposal activities for implementation under the CSPW programme:

- Pit method of compost production
- Heap method of compost production
- Shed method of compost production (urban compost production)
- Urban compost production (shed method)
- Inorganic waste disposal (IWD)
- Inorganic waste sorting bay (IWS)

6.1 Organic waste management

Name of the Technology	PIT METHOD OF COMPOST PRODUCTION
General Description	
Compost manure production and application is essential for maintaining the capacity of soils to supply nutrients, retain water, and sustain plant growth (Figures 2.6.1–2.6.2). Compost manure is an organic fertilizer produced through controlled aerobic decomposition of plant and animal residues, forming a nutrient-rich and stable humus that promotes healthy plant growth. It enriches the soil with essential nutrients, improves soil structure, enhances water-holding capacity, and stimulates biological activity while supporting environmental cleanliness through recycling of household, farm, and market organic waste. Within the CSPW framework, compost manure contributes to the three climate-smart pillars. It improves productivity by increasing soil fertility, moisture retention, and crop yields; strengthens adaptation by enhancing soil resilience against drought and erosion; and supports mitigation by recycling organic matter, reducing methane emissions, and enhancing soil carbon sequestration. Compost can absorb 4–7 times its weight in water, acting as a natural water-harvesting mechanism, and creates livelihood opportunities through household- and community-level compost production. The pit method involves decomposing layers of crop residues, animal manure, ash, and soil inside an excavated pit that protects the mixture from excessive drying and wind erosion. The controlled environment conserves heat and moisture, allowing microorganisms to break down organic matter efficiently and produce high-quality compost within 3–5 months.	

Figure 2.6.1. Well-decomposed compost manure ready for field application.

Figure 2.6.2. Step-by-step illustration of pit excavation, layering, turning, and final use.

Geographical Extent of Use
The pit method is suitable for all agro-ecological zones in Tanzania where organic waste and livestock manure are available. It is particularly recommended in moisture-deficient, cold, or windy areas such as Dodoma, Shinyanga, Tabora, Singida, Simiyu, and parts of Zanzibar, where open compost heaps are prone to drying. Sites should be selected under shade, away from homesteads and livestock, and protected from flooding. Technology is most effective when integrated with other CSPW interventions such as contour bunding, agroforestry, and mulching.
Technical Standards

Tools and materials

- **Tools**: Hoes, shovels, pickaxes, rakes, tape measures, watering cans, buckets, and wheelbarrows
- **Protective gears**: Gumboots, gloves, masks, and overalls.
- **Raw materials**: Crop residues, grass, tree leaves, animal manure, household organic waste, and ash.

Work norm and implementation steps

Work norms

- Approximately 10 workers per day are required to prepare one pit (4 m × 2 m × 1.5 m).

Implementation steps

- Site selection and preparation
- Choose a shaded site protected from strong winds and livestock.
- Mark and excavate two pits side by side, each 4-m long, 2-m wide, and 1–1.5 m deep (Figure 2.6.3). One pit is for fresh materials, and another is for turning mature compost
- Construct a small drain channel to divert excess rainwater.
- Layering and filling the pit
- Turning and maturing

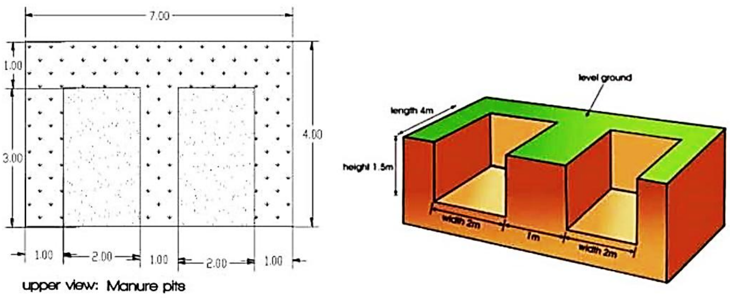


Figure 2.6.3. Layout and dimensions of standard compost pits (4 m × 2 m × 1–1.5 m) recommended for efficient organic matter decomposition

Layering and filling the pit

- Start with a 20 cm layer of coarse crop residues (e.g., small tree branches, maize cobs, or grass).
- Compact lightly and sprinkle three buckets of water.
- Add a thin layer (≈ 4 kg) of ash, followed by 32–40 spades of farmyard manure (FYM).
- Cover each layer with 1–2 cm of soil before repeating the sequence until the pit is full.
- Insert sticks or bamboo poles every 2 m to improve aeration.
- Covering and curing
- Cover the pit with dry grass or crop leaves to conserve moisture.
- Optionally, construct a simple shed (≈ 7 m × 5 m × 7 m height) to protect against rain (Figure 2.6.4)

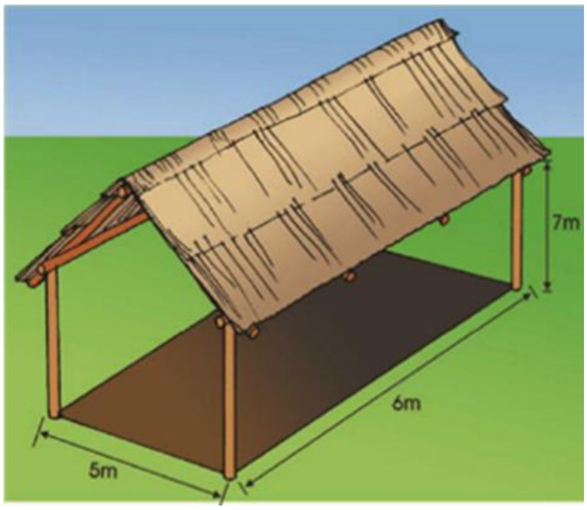


Figure 2.6.4. Simple protective shed structure used to shield compost pits from direct rainfall and excessive sunlight

Turning and maturing

- After one month, transfer and mix the compost into the second pit for uniform decomposition (Figure 2.6.5)
- Compost becomes ready after 3–5 months.
- Store under shade and cover with grass to minimize nutrient losses.

<table>
<tr><td></td><td>Figure 2.6.5. Turning and mixing compost between adjacent pits to enhance aeration and uniform decomposition</td></tr>
<tr><td colspan="2">Management and maintenance</td></tr>
<tr><td colspan="2">- Monitor temperature and moisture weekly; compost should feel moist but not wet.
- Keep the area free from livestock to avoid disturbance.
- Replenish decomposed material periodically to maintain continuous production cycles.
- Apply the finished compost at 5–10 t/ha or as needed for specific crops.</td></tr>
<tr><td>Benefits</td><td>Limitations</td></tr>
<tr><td>- Produces high-quality compost rich in nutrients and organic carbon.
- Improves soil structure, water retention, and biological activity.
- Reduces dependence on chemical fertilizers and lowers production costs.
- Promotes climate resilience by enhancing soil moisture and fertility.
- Supports waste recycling and environmental cleanliness.</td><td>- Labor-intensive during pit excavation and turning.
- Not suitable in flood-prone or poorly drained soils.
- Requires continuous moisture monitoring in dry environments.</td></tr>
</table>

Name of the Technology	HEAP METHOD OF COMPOST PRODUCTION

Description

The heap method of composting is a simple and widely used technique for converting organic materials into nutrient-rich manure, particularly suitable for humid or high-rainfall environments (Figure 2.6.6.). Unlike the pit method, decomposition occurs above ground in an open or partially covered heap. This allows for better drainage and aeration, enabling rapid microbial activity and efficient decomposition of organic materials. Within the CSPW, the heap method offers a practical approach for areas with high rainfall or shallow soils where pit composting is not feasible. It provides an efficient, low-cost way to recycle farm and household waste into valuable organic fertilizer that: Improves soil fertility and structure, enhances water-holding capacity, and reduces emissions by diverting organic waste from uncontrolled decomposition.

Figure 2.6.6. Above-ground compost manure prepared using the heap method (CP-H)

Suitability

- Suitable in moist or high-rainfall areas such as Mbeya, Njombe, Ruvuma, Arusha, and parts of Zanzibar.
- Recommended for farm households or community composting groups with access to organic waste.
- Select a shaded, non-windy site, away from homesteads and livestock movement.
- Avoid flood-prone or excessively compacted soils.

Technical Standards

Tools and materials

- **Tools**: Hoes, shovels, pickaxes, rakes, tape measures, buckets, watering cans, and wheelbarrows.
- **Protective Gear**: Gumboots, gloves, masks, and overalls.
- **Raw Materials**: Plant residues, tree leaves, grass, animal manure, ash, and a small amount of soil.

Work norm and implementation Steps

Work norms: About 10 workers per day preparing one compost heap (4 m long, 2 m wide, 1.5 m high)

Implementation steps:

- Site Selection and Layout
- Covering and curing
- Layering and construction
- Turning and maturing

1. Site Selection and Layout

- Identify a shaded area with good drainage and away from livestock.
- Mark out the heap area (approx. 4 m × 2 m × 1.5 m high) using pegs.
- Excavate a shallow trench (about 30 cm deep) at the base of the heap to collect leached nutrients and water.

2. Layering and construction

- Begin with a 20 cm thick layer of crop residues (tree branches, maize cobs, or grass).
- Add three buckets of water to moisten the material.
- Sprinkle ash (4 kg) evenly to provide potassium and control odours.
- Apply 32–40 spades of farmyard manure (FYM) to introduce microbes and nutrients.

3. Covering and curing

- Cover the heap with dry grass, banana leaves, or nylon sheets to conserve heat and moisture.
- Construct a temporary shed (approx. 7 m × 5 m × 7 m height) to protect the heap from heavy rain.
- Maintain adequate moisture by watering lightly once a week.

4. Turning and maturing

- After one month, turn and mix the compost into an adjacent heap to enhance uniform decomposition.

- Cover with 1–2 cm of soil to seal the layer and retain moisture. - Repeat the layering sequence until the heap reaches the desired height. - Insert sticks or bamboo poles every 2 m to improve air circulation.	- Continue monitoring moisture levels and maintain aeration. - Compost is ready after 3–5 months, when it appears dark brown, crumbly, and has an earthy smell.
Management and maintenance	
- Check the compost weekly for moisture and temperature. It should feel moist but not wet. - Re-cover after every inspection to conserve heat. - Replace or add more organic material as decomposition occurs to maintain the heap's volume. - Keep animals away to avoid disturbance or contamination.	
Benefits	**Limitations**
- Produces high-quality organic fertilizer using readily available materials. - Requires less labor and construction effort than pit composting. - Improves soil fertility, biological activity, and moisture retention. - Supports climate adaptation through enhanced soil structure and nutrient cycling. - Reduces waste and methane emissions, contributing to climate mitigation.	- Requires frequent moisture checks in dry spells to avoid drying out. - Not suitable in very cold or dry windy environments. - Nutrient leaching can occur if the heap is not well covered or protected from rainfall.

Name of the Technology	SHED METHOD OF COMPOST PRODUCTION (URBAN COMPOST PRODUCTION)

Description

The urban compost or shed method is an advanced form of the heap composting technique, designed for urban and peri-urban settings where space is limited, and proper waste management is essential (Figure 2.6.7). In this method, composting is carried out under a constructed shed with multiple composting rooms to ensure hygiene, moisture control, and optimize decomposition. The system promotes efficient use of urban organic waste such as market residues, food leftovers, and animal manure, while minimizing odour and runoff. Under the CSPW, this method supports the mitigation of greenhouse gas emissions by diverting organic waste from open dumping sites and enhancing adaptation by providing nutrient-rich compost for urban greening, tree planting, and home gardens. It also contributes to livelihood creation through community-based compost enterprises.

Figure 2.6.7. Urban composting sheds are constructed with concrete block chambers and iron roofing for controlled organic waste management

Suitability

- Ideal for urban and peri-urban areas with limited open land and high waste generation.
- Suitable for community composting centres, schools, and markets where waste segregation is feasible.
- Best implemented in areas with moderate to high rainfall but with proper drainage.
- Site should have access to water, be away from residential houses, and allow for safe waste handling.

Technical Standards

Shed structure

- Shed dimensions: 14.2 m long, 5 m wide, 4 m height (front), 3 m height (back)
- Roof slope approximately 19° for effective rainwater drainage
- Durable roofing materials (e.g., iron sheets)
- Proper foundation and drainage system

Compost rooms

- Room dimensions: 2 m × 2 m × 1.5 m
- Rooms spaced 1 m apart
- Ventilation openings using 150 × 230 mm blocks
- Door openings approximately 800 mm wide
- Drainage channels to manage excess water or leachate

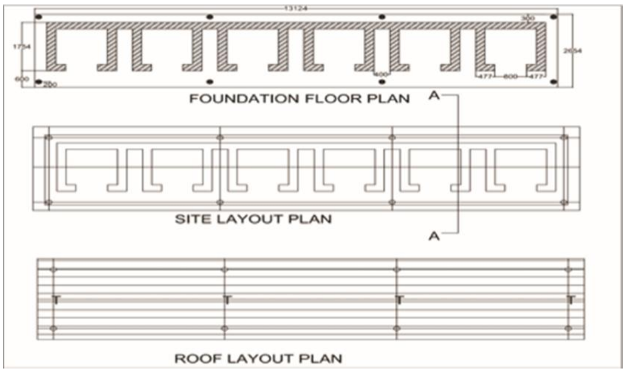


Figure 2.6.8. Composite plan of the composting shed showing foundation floor plan, site layout plan, and roof layout plan for a multichambered (≈ 14.2 m × 5 m) compost structure (**a**) and Sectional view (Section A-A) of a compost room showing 150 × 230 mm ventilation blocks, 19° roof slope, and 2800 mm wall height for effective aeration and moisture control (**b**)

Measurements and Tools Requirements

- **Construction materials:** Bricks, cement, iron sheets, nails, sand, wood or metal pipes for frames, and drainage materials for shed and chamber construction.
- **Field tools:** Hoes, shovels, pickaxes, rakes, tape measures, watering cans, buckets, and wheelbarrows for layering, mixing, and material handling.
- **Protective gear:** Gloves, gumboots, overalls, masks, and eye protection to ensure hygiene and occupational safety.
- **Raw materials:** Vegetable peels, fruit residues, manure, ash, sawdust, dry leaves, and other biodegradable household organic waste.
- **Work norm:** Approximately 10 workers per day for constructing four compost rooms (2 m × 2 m × 1.5 m each).

Layout, Implementation Procedures and Work Norm

Shed construction

- Construct shed (14.2 m × 5 m) with sloping roof for protection against rainfall and sunlight.
- Build composting rooms (2 m × 2 m × 1.5 m) spaced 1 m apart.
- Provide aeration openings and drainage channels to manage moisture.

Raw material collection and layering

- Collect and chop organic waste into small pieces.
- Layer materials in composting room as follows:
- 10 cm dry leaves or sawdust
- 30 cm food and fruit leftovers
- 2–5 cm animal manure
- 2 cm ash
- Repeat sequence until approximately 1.5 m height is reached.
- Spray Effective Microorganism (EM) solution to accelerate decomposition.

Turning and mixing

- Every 14 days, transfer compost from one room to the next to enhance aeration and uniform decomposition.
- Mix materials evenly using a hoe or rake.
- Maintain adequate moisture; compost should feel moist but not soggy.
- Compost Maturation and Storage
- Compost becomes ready within 56–63 days, appearing dark brown, crumbly, and odour-free.
- Transfer mature compost to a shaded storage area and cover with grass or plastic sheets to prevent nutrient loss.

Figure 2.6.9: Sectional view (A–A) showing ventilation blocks, 2800 mm wall height, and roof slope.

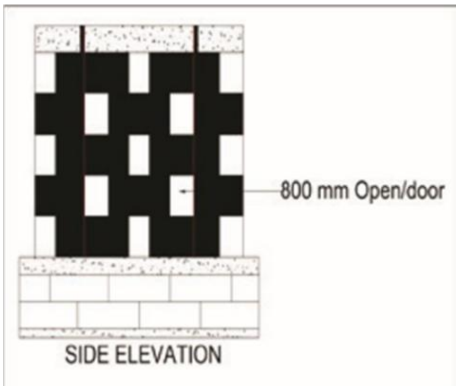


Figure 2.6.10: Side elevation showing door openings and aeration design.

Management Guidelines

- Monitor temperature and moisture regularly; optimal composting temperature is in the range of 57–70°C.
- Maintain proper air–water–heat balance to ensure effective aerobic decomposition:
- Adequate aeration prevents foul odour.
- Moisture should be sufficient but not excessive.
- Temperatures above 70°C should be controlled through turning.
- Avoid inclusion of inorganic or non-biodegradable materials such as plastics, glass, and metals.
- Maintain regular use of EM solutions to control odours and speed decomposition.
- Add animal urine or small amounts of urea fertilizer if materials are too dry.
- Ensure workers use protective gear and maintain hygiene practices.

- Maintain drainage systems and periodically disinfect composting rooms to prevent pests and leaching.
Limitations
- Requires initial investment for shed construction and compost rooms. - Requires consistent labor and technical supervision for turning and monitoring. - Leaching and odour problems may occur if poorly managed.

6.2 Inorganic waste management

<table>
<tr><td>Name of the Technology</td><td>INORGANIC WASTE DISPOSAL (IWD)</td></tr>
<tr><td colspan="2">General Description</td></tr>
<tr><td>Inorganic waste consists of non-biodegradable materials such as plastics, glass, metals, batteries, and other synthetic products that do not decompose naturally. Unlike organic waste, these materials require deliberate collection, sorting, and controlled disposal to prevent environmental pollution, blocked drainage systems, flooding, and health hazards (Figure 2.6.11). Under the CSPW framework, inorganic waste disposal improves public hygiene, reduces contamination of soil and water, prevents disease outbreaks, and minimizes environmental degradation. It also creates short-term employment opportunities through public works and supports recycling and circular-economy practices by recovering reusable materials.</td><td>
Figure 2.6.11. Inorganic waste disposal practices for safe collection, segregation, and environmental protection</td></tr>
<tr><td colspan="2">Geographical Extent of Use</td></tr>
<tr><td colspan="2">This intervention applies to urban and peri-urban settlements, markets, residential estates, road corridors, and public open spaces where inorganic waste accumulation is common. It is especially relevant in densely populated areas and locations prone to drainage blockage and localized flooding. The activity is suitable wherever organized collection, transport, and supervised sorting systems can be established.</td></tr>
<tr><td colspan="2">Technical Standards</td></tr>
<tr><td colspan="2">- Open areas / markets: 100 m × 50 m per group per day (depending on waste density).
- Roads / estates: 200 metres per person-day.
- Loading capacity: 1 m^3 per person-day.
- Transportation ($\leq$ 400 m): 1 m^3 per person-day.
- Transportation (> 400 m): 0.5 m^3 per person-day.
- Unloading at sorting bay: 1 m^3 per person-day.</td></tr>
<tr><td colspan="2">Measurements and Tools Requirements</td></tr>
<tr><td colspan="2">- Collection tools: Rakes, hoes, shovels, brooms, waste bags, wheelbarrows, carts, and trolleys.
- Protective gear: Helmets, gloves, dust masks/respirators, gumboots, reflector jackets, uniforms, and first-aid kits.
- Support equipment: Waste trucks (where available), labelled storage containers, fencing materials for sorting areas.</td></tr>
<tr><td colspan="2">Layout, Implementation Procedures and Work Norm</td></tr>
<tr><td colspan="2">Site layout
- Identify and demarcate target site.
- Allocate 100 m × 50 m per group (open areas).
- Allocate 200 m per person (roads/estates).

Collection
- Collect waste manually using standard tools.
- Centralize waste for loading.
- Ensure full use of protective gear.

Loading and transportation
- Load into trolleys, carts, wheelbarrows, or trucks.
- Apply 1 m^3 per person-day loading standard.
- Follow distance-based transport standards.
- Prevent spillage during transport.</td></tr>
</table>

Table 2.6.1. Standard daily work norm for inorganic waste handling

Activity	Standard
Site layout	200 m/ pd
Loading inorganic waste onto a trolley	1 m^3/ pd
Transportation to the sorting bay to 400m	1 m^3/ pd
Transportation to the sorting bay (more than 400m)	0.5 m^3/ pd

Work norm: 1m^3/pd.

Sorting and separation

- Unload and spread waste at sorting bay.
- Separate into metallic, plastic, glass, and mixed waste.
- Pack recyclables separately for reuse or sale.
- Fence and shade sorting area where possible.

Final disposal

- Transfer non-recyclables to designated landfill or disposal sites.
- Clean collection routes and sorting areas daily.

Table 2.6.2. Daily work norms for inorganic waste disposal activities (PSSN)

Activity	Standard
Site layout	200 m/ pd
Unloading inorganic waste from trolley or cart	1 m^3/ pd
Sorting/separating inorganic waste	1 m^3/ pd
Loading onto waste bags and putting them in a cage	1m^3/ pd

Work norm: 1m^3/pd.

Management Guidelines

- Enforce use of protective gear at all times.
- Handle hazardous materials (glass, batteries, sharp objects) separately.
- Inspect tools regularly.
- Provide hydration and shaded rest areas during hot weather.
- Suspend work during severe storms or lightning.
- Avoid open dumping and burning waste.
- Prevent blockage of drainage systems.
- Locate sorting areas away from water sources and residences.
- Fence sorting bays to prevent unauthorized access.
- Maintain continuous cleanliness to reduce disease vectors.
- Supervisors enforce safety and environmental compliance; workers follow procedures and report hazards.

Limitations

- Requires consistent supervision and coordination.
- Delays in transport or recycling may cause temporary accumulation.
- Inadequate safety enforcement increases health risks.
- Poor drainage maintenance may still cause localized flooding.

Name of the Technology	INORGANIC WASTE SORTING BAY (IWS)

General Description

Sorting of inorganic waste is a critical process that determines the effectiveness and value of waste management activities (Figure 2.1.12). It involves separating mixed waste materials into distinct categories based on their physical and chemical properties to enhance recycling efficiency, promote resource recovery, and reduce the volume of materials requiring final disposal. Under the CSPW framework, sorting improves safe handling of hazardous materials, increases the value of recyclable waste, supports community income generation, and strengthens environmental protection through organized segregation and controlled disposal systems.

Figure 2.6.12: Example of quickly rotting or mixed waste requiring safe disposal during sorting.

Geographical Extent of Use

Sorting bays are applicable in urban and peri-urban settlements, markets, residential estates, and public waste collection centres where organized inorganic waste disposal systems operate. They are particularly important in high-density areas and locations generating significant recyclable waste volumes. The facility should be located away from water sources and residential houses, with proper drainage and supervision arrangements.

Technical Standards

Layout and design

- Sorting bays serve as central facilities for segregation of collected inorganic waste.
- Layout must include distinct compartments and adequate working space for safe operations.

Structural requirements

- Minimum area: 1 km²
- Maximum area: 3 km² (depending on waste volume)
- Roofing: Durable roof to protect workers and waste from rain and direct sunlight.
- Flooring: Compacted soil or concrete to allow easy cleaning and drainage.
- Fencing: Wire mesh fence to prevent entry of livestock and unauthorized persons.

Segregation Compartments

- At least four designated sections labelled:
- R1: Quickly rotting or mixed waste
- R2: Metallic waste
- R3: Glass waste
- R4: Plastic waste

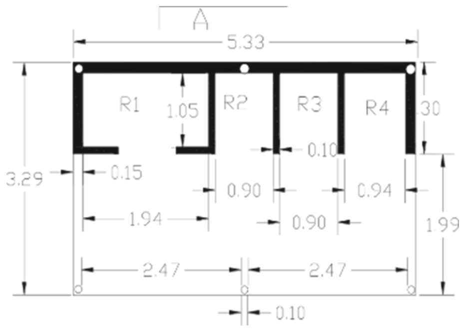


Figure 2.6.13: Top view layout of inorganic waste sorting bay showing compartments R1–R4.

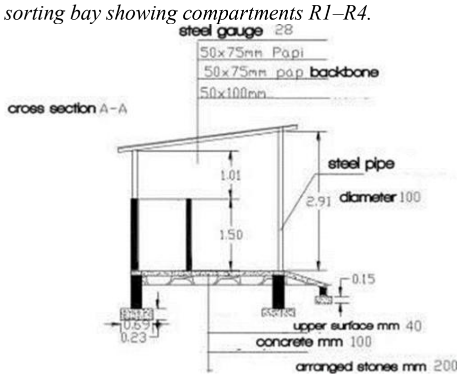


Figure 2.6.14: Cross-section A–A of a standard inorganic waste sorting bay showing structural design and construction details.

Measurements and Tools Requirements

- **Sorting tools:** Hoes, rakes, shovels, brooms, labelled containers or cages for segregated materials.
- **Protective gear:** Gloves, masks, gumboots, overalls, and eye protection for safe handling of waste materials.

- **Construction materials:** Bricks, cement, roofing sheets, fencing wire mesh, drainage materials.
Layout, Implementation Procedures and Work Norm
Waste reception and sorting - Receive collected inorganic waste at sorting bay. - Spread waste in designated working area. - Separate into R1–R4 categories. - Pack recyclable materials securely for storage or transport. **Cleanliness and environmental maintenance** - Remove residual waste daily. - Maintain clean and orderly working environment. - Stack recyclable materials securely to prevent scattering by wind or animals. - Maintain proper drainage to prevent waterlogging
Management Guidelines
- Ensure regular supervision and monitoring of sorting activities. - Remove sorted waste promptly to prevent accumulation and odour. - Maintain adequate ventilation to reduce unpleasant smells. - Handle hazardous materials (batteries, sharp objects, aerosols) separately and store in clearly labelled containers. - Avoid open burning of inorganic waste, especially plastics. - Maintain drainage systems to prevent flooding and standing water. - Provide shaded working areas and drinking water to reduce heat stress. - Adjust work schedules during extreme weather conditions. - Enforce proper use of protective gear at all times. - Supervisors are responsible for enforcing safety and environmental standards, while workers must follow established procedures and report unsafe conditions.
Limitations
- Accumulated waste may generate odour if not promptly removed. - Unmanaged waste attracts insects and disease vectors. - Hazardous materials may pose health risks if not properly segregated. - Delayed transport may create space constraints and secondary pollution. - Poor drainage may cause localized flooding during heavy rainfall.

7.0 Clean energy CSPW activities

7.1 Small-scale clean energy technologies

Tanzania has launched the National Clean Cooking Strategy (2024–2034) and the National
Tanzania has launched the National Clean Cooking Strategy (2024–2034) and the National
Clean Cooking Communication Strategy to guide a nationwide transition toward cleaner, safer, and more efficient household energy systems. In support of these strategies, the government is promoting labour-based approaches that expand access to clean cooking solutions, targeting 80% national adoption by 2034. These efforts aim to improve public health, protect the environment, and generate socio-economic benefits for households and communities. Ongoing initiatives include establishing national coordination frameworks, creating innovation funds, promoting energy-efficient appliances such as electric cookers, and encouraging the use of affordable small-sized liquefied petroleum gas (LPG) cylinders. Additional programmes focus on scaling clean cooking in public institutions and strengthening product standards to ensure safety and quality.

Within the TASAF PSSN III framework, CSPW provides an opportunity to integrate small-scale clean energy technologies that create employment while contributing to environmental sustainability. This chapter presents two labour-based clean energy options suitable for CSPW implementation: briquettes from biomass and household-level biogas systems. These technologies support climate-smart objectives by reducing pressure on natural forests, minimizing greenhouse gas emissions, and promoting circular use of organic waste resources.

Name of the Technology	BRIQUETTES FROM BIOMASS (BB)

General Description

Briquettes are compact fuel blocks produced by mixing charcoal dust with a binder such as soil, compost, paper, or starch and shaping the mixture into uniform pieces. They serve as an alternative cooking energy source to firewood and conventional charcoal (Figures 2.7.1–2.7.8). For small-scale production, raw biomass materials such as sawdust, wood residues, or agricultural waste are dried, shredded, and combined with the chosen binder before being compressed using hand palms, hand-operated presses, or simple mechanical equipment. Charcoal-based briquettes require carbonizing the raw material first, followed by grinding it into fine dust before mixing with water and a binder. The formed briquettes are then placed in direct sunlight and left to dry thoroughly until firm and ready for use as cooking fuel. By utilizing waste biomass and reducing reliance on firewood, briquettes contribute to climate-smart public works by lowering pressure on natural forests and promoting cleaner, more sustainable household energy practices.

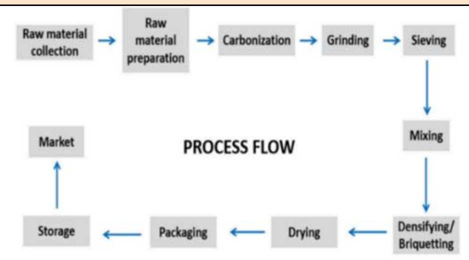


Figure 2.7.1. Process flow for briquette production from raw material collection to final storage.

Figure 2.7.2. Briquettes used in improved household stove.

Geographical Extent of Use

Suitable for rural and peri-urban communities where waste biomass such as sawdust, agricultural residues, coconut shells, charcoal dust, or organic by-products are available. Appropriate in areas where households depend on firewood and conventional charcoal and where climate-smart energy alternatives are promoted under CSPW.

Technical Standards

Composition of briquettes

- Fuel base: Charcoal dust, carbonized organic waste, or carbonized branches
- Binding material: Shredded paper, composted organic waste, soil, starch or cow dung
- Water: To form a workable mixture

Mixing ratios

Recommended combinations include:

- Charcoal dust + paper + water (7:1 dry weight ratio)
- Charcoal dust + soil + water (4:1)
- Charcoal dust + compost + water (4:1)
- Charcoal dust + cow dung + water (2:1 to 1:1)

Ratios may vary depending on binder type and charcoal particle size.

Figure 2.7.3. Key components used in briquette production.

Figure 2.7.4 (inside view of drum kiln showing carbonization).

Measurements and Tools Requirements

- Production uses simple hand-operated and locally available tools, including:
- Material preparation tools: Sieves, grinders, shredders
- Mixing tools: Basins, containers, buckets
- Compaction tools: Hand palms, recycled cans, manual presses, molds
- Drying platforms: Mats, racks, rooftops or open ground

Tool selection depends on production scale.

Layout, Implementation Procedures and Work Norm

Raw material collection and preparation
- Gather biomass such as sawdust, wood chips, agricultural residues, coconut shells, or charcoal dust.
- Dry thoroughly to reduce moisture content.
- Where charcoal dust is unavailable, carbonize fresh biomass using a drum kiln.

Binder preparation
- Prepare binders such as red clay soil, shredded paper, compost, or starch.
- Soak shredded paper for approximately three hours before mixing.

Sorting and grinding
- Sieve charcoal dust to remove impurities.
- Grind coarse particles into fine dust for uniform binding.

Binding test
- Squeeze a small amount of mixture between fingers.
- If it retains shape, binder is sufficient.
- If it crumbles, add more binder.

Briquette pressing or compaction
- Shape using hand pressing, manual presses, or improvised molds.
- Remove excess water by applying pressure.

Drying, packaging and storage
- Dry briquettes in direct sunlight for several days until fully hardened.
- Place on rooftops, shelves, mats, or raised racks with adequate airflow.
- Package in sacks, tins, or polythene bags for storage or transport.

Drum kiln construction (Carbonization)
- Prepare metal drum with tight-fitting lid.
- Create 5 cm × 5 cm ventilation window in lid.
- Install side handles and lower access door.
- Fix internal support stand (15 cm above base).
- Fit metal mesh (5 mm holes).
- Elevate drum approximately 30 cm off the ground.

Work norm: Task rates for briquette production include:
- Site clearance: 150–200 m^2/pd
- Collection of inorganic wastes: 1 m^3/pd
- Transportation (≤400 m): 1 m^3/pd
- Transportation (>400 m): 0.5 m^3/pd
- Preparation of binder materials: 10 kg/pd

Figure 2.7.5. Examples of raw biomass materials.

Figure 2.7.6. Sorted and ground biomass materials.

Figure 2.7.7. Sun-drying of briquettes.

- Mixing of raw materials: 0.5 m^3/pd
- Loading and pressing mixtures: 100 No/pd
- Transport to drying site: 200 No/pd

Figure 2.7.8. Simple metal drum kiln.

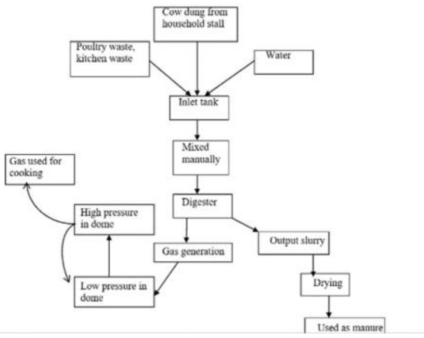
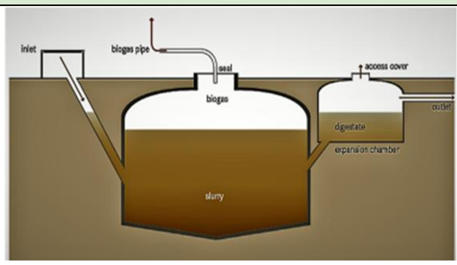
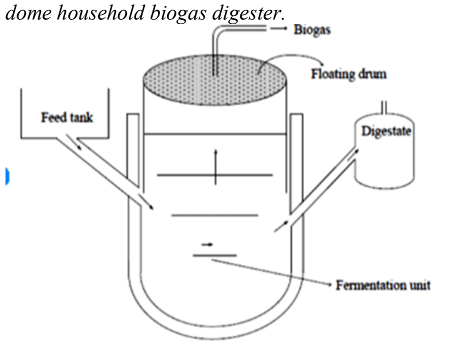
Management Guidelines

- Ensure complete drying before packaging to prevent mold or breakage.
- Store in dry, ventilated areas away from moisture.
- Maintain consistent mixing ratios for quality control.
- Monitor carbonization process to ensure efficient charcoal production.

Limitations

- Production depends on availability of biomass and binders.
- Sun drying may be affected by rainy conditions.
- Poor mixing ratios may reduce briquette strength and combustion efficiency.
- Requires proper carbonization to produce high-quality charcoal dust.

7.2 Biogas technology

Name of the Technology	BIOGAS TECHNOLOGY (BG)
General Description	
Biogas is a clean and renewable energy source produced when organic waste materials such as animal manure, food scraps, agricultural residues, sewage sludge, and plant biomass are decomposed by bacteria in an oxygen-free (anaerobic) digester (Figures 2.7.9). The gas generated consists primarily of methane and carbon dioxide, which can be used directly for cooking, heating, lighting, or small-scale electricity generation. Research indicates that a household keeping 5 to 10 cattle can produce enough biogas to meet the cooking and basic lighting needs of a typical rural family of six. Beyond energy supply, biogas systems improve household livelihoods through reduced expenditure on firewood, production of organic fertilizer (bio-slurry), and employment opportunities for biogas constructors and technicians. Biogas supports clean cooking and heating, produces nutrient-rich organic fertilizer as a by-product, reduces methane emissions from manure pits and landfills, improves sustainable management of organic waste, and enables small-scale electricity generation.	 *Figure 2.7.9. Process flow for household biogas generation, gas use and slurry management.*
Geographical Extent of Use	
Suitable for rural household settings where organic waste materials such as animal manure, food scraps, and agricultural residues are available and where households require energy for cooking, heating, lighting, or small-scale electricity generation. The biogas plant should be located with exposure to sunlight to maintain warm temperatures for anaerobic digestion, close to the cattle shed and water source to reduce labour requirements for daily feeding and cleaning, and at a short distance to the kitchen to minimize gas-pipe installation costs. The plant should be at least 10 m away from underground water sources to prevent contamination, and the site should support simple, low-cost construction and safe long-term operation, with accessibility within 20 minutes' walking distance from the water source.	
Technical Standards	
- **Types of small-scale biogas systems** - *Fixed-dome system:* Built partially underground with a concrete, dome-shaped digestion chamber connected to a waste-mixing chamber, inlet pipe, slurry overflow chamber, and outlet pipe; constructed in sizes ranging from 3 to 50 m³; durable with long service life and large waste-handling capacity; requires skilled construction and careful maintenance to avoid cracks or gas leaks. - *Floating-drum system*: Includes a concrete digestion chamber and a movable gas holder that rises and falls along a central guide pipe; visible gas-storage drum allows easy monitoring of gas levels; requires skilled labour and higher construction and maintenance costs. - *Floating-tank system:* Uses a high-density polyethylene (HDPE) tank as the digestion chamber and a smaller inverted tank as the gas reservoir; cost-effective and easy to install with locally available	 *Figure 2.7.10. Cross-sectional design of a fixed-dome household biogas digester.* 

materials; gas recovery efficiency generally lower compared to masonry-based systems.

- **Essential components (All Systems)**
- *Digestion chamber:* Airtight chamber where anaerobic decomposition occurs and biogas accumulates; sealing is critical for maintaining anaerobic conditions and maximizing gas production.
- *Inlet (mixing pit):* Where organic waste is mixed with water and fed into the digester to ensure even entry.
- *Outlet (hydraulic chamber):* Allows digested slurry to flow out; outlet level slightly lower than inlet to maintain one-way flow; slurry can be collected for use as organic fertilizer.

Figure 2.7.11. Schematic illustration of a floating-drum biogas system.

Figure 2.7.12. Floating-tank biogas digester constructed from HDPE materials.

Key Design Calculations and Reference Tables

- Daily gas production and feedstock requirements:

Table 2.7.1. Daily gas production and feedstock requirements for standard household biogas plant sizes.

No.	Plant Capacity (M^3)	Daily gas production (M^3)	Fresh dung required per day (Kgs)	Water required every day (Litre)
1	4	0.8-1.6	20-40	20-40
2	6	1.6-2.4	40-60	40-60
3	8	2.4-3.2	60-80	60-80
4	10	3.2-4.0	80-100	80-100

- Retention time: 50 days.
- Dung assumption: 1 cow produces 20–24 kg/day.

Gas demand calculation (sample household):
- Cooking: 0.227 m^3/person/day; household of 6 → 1.35 m^3/day.
- Lighting: 3 lamps × 3 hours × 0.125 m^3/hour = 1.13 m^3/day.
- Total gas required: 2.48 ~ 2.5 m^3/day.
- 1 kg fresh dung → 0.05 m^3 biogas; for 2.5 m^3/day → 50 kg dung/day; if each grazing cow gives 10 kg/day → 5 cows are needed.

Digester volume calculation:
- Vd = Vf × tr.
- Vf = M / Ψ; Ψ = 50 kg/m^3.
- 1 kg fresh dung = 0.18 kg dry dung; 50 kg fresh dung → 9 kg dry dung/day.
- Vf = 9/50 = 0.18 m^3/day; Vd = 0.18 × 30 = 5.4 m^3; add 10% safety factor → 5.94 m^3 → use 6 m^3.

Digester dimensions:
- Height–diameter ratio: H/D = 0.9.
- V = 0.785 × D^2 × H = 0.785 × 0.9 × D^3; calculated D = 2.04 m and H = 1.84 m.
- Dimensions for standard floating-drum biogas plants: (Table 2.7.2.)

Table 2.7.2: Dimensions of key components for different sizes of floating-drum biogas plants (4–10 m³).

Components	Label	Different sizes of biogas Plants			
		$4m^3$	$6m^3$	$8m^3$	$10m^3$
Length of outlet (cm)	A	140	160	170	190
Breadth of outlet(cm)	B	120	130	140	160
Radius of pit (cm)	C	140	160	175	200
Height of outlet(cm)	D	50	55	60	62
Depth of pit (Excavation) (cm)	E	160	170	180	190
Radius of digester	F	110	130	145	155
Radius of digester and main hole(cm)	G	203	219	140	252
Height of digester wall(cm)	H	80	85	90	95
Height of outlet passage(cm)	I	105	110	115	123
Inner height of digester and dome(cm)	J	145	155	165	175

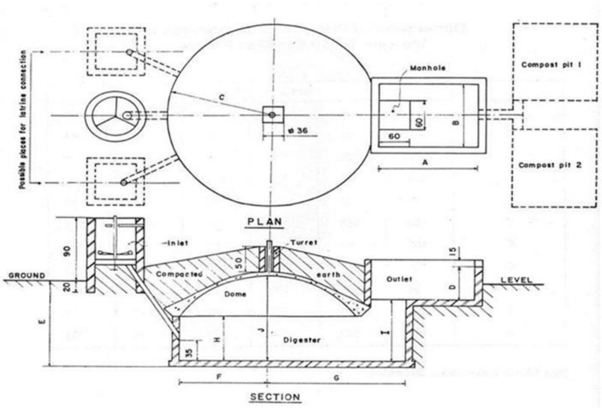


Figure 2.7.13. Technical design drawings for a standard dome-shaped household biogas plant.

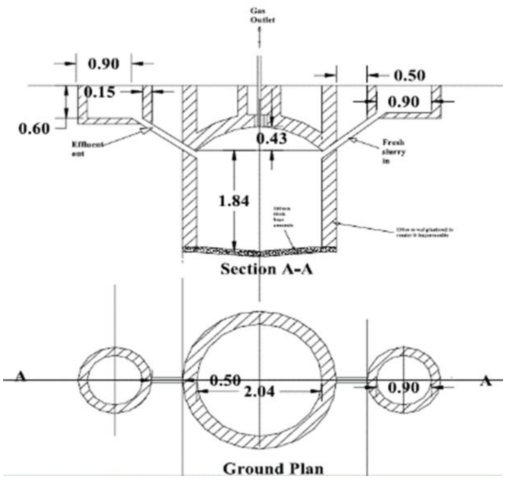


Figure 2.7.14. Engineering plan and section showing dimensions and flow paths for a standard household biogas digester

Measurements and Tools Requirements

- Construction materials: Bricks, stones, sand and cement; concrete foundation slab (grade 25); plastered impermeable digester walls; masonry slurry inlet tank; outlet chamber/manure pit; gas outlet pipe connected to the dome.
- System materials (as applicable): HDPE water tank and inverted tank for floating-tank system; movable gas-holder drum and guide pipe for floating-drum system; gas pipes and user appliances (burners, lamps, generators).
- Tools (categories): Excavation tools; masonry tools; plumbing/pipe-fitting tools; measuring and levelling tools (water level); compaction tools.

Layout, Implementation Procedures and Work Norm

- Excavation: Excavate or prepare an appropriately sized pit to install the digester at recommended depth.
- Digester construction: Construct a suitable airtight digester partially underground using bricks, stones, sand and cement to maintain stable temperatures for microbial activity.
- Install inlet and outlet pipes: Fit inlet pipe for daily dung–water mixture; install outlet slightly lower than inlet to maintain consistent flow and prevent backpressure.
- Gas collection and outlet system: Construct upper gas collection dome (fixed-dome) or install movable gas-holder drum (floating-drum); connect gas outlet pipe to appliances; ensure airtight connections.
- Backfilling and completion: Test for leaks by filling with water to check seepage; backfill with suitable soil and complete finishing work around inlet, outlet and gas lines.
- **Work norms**: Refer to Appendix D

Figure: 2.7.15. Excavation of pit for installation of household biogas digester.

Figure 2.7.16. Construction of the dome-shaped digestion chamber during installation.

Management Guidelines

- **Daily**: Feed the digester with consistent organic waste mixed with water; monitor gas production, temperature conditions and pH; inspect gas outlet pipe and valves; check digester body, joints and gas pipes for leaks.
- **Weekly**: Remove floating scum or foam; manage digestate by releasing slurry; inspect inlet and outlet chambers for damage or wear.
- **Periodic:** Clean the digester tank by removing settled sludge; inspect appliances (generators or burners); service fittings and valves by tightening or replacing seals and connectors.

Limitations

- Small-scale systems may experience reduced gas production during cold periods.
- Blockages may occur in inlet or outlet pipes.
- Leaks may be caused by poor sealing or aging fittings.
- Regular feeding and proper maintenance are required to sustain performance.
- Households with limited livestock may not produce enough feedstock.
- Construction quality and availability of skilled masons influence system durability and efficiency.

PART III: APPENDICES

Appendix A: Construction and Rehabilitation Procedures for Earth Fill Dams (Charco Dams)

The construction of small earth fill dams and other water impoundment structures requires great attention and skills. Poorly constructed or rehabilitated earth fill dams can easily break and cause flooding, resulting in the great loss of beneficiaries' labour. Construction or rehabilitation of an earth fill dam should never be executed without an expert's advice. The construction should be carried out during the dry period. This appendix gives the steps to be followed when constructing an earth fill dam using labour.

Step 1: Materials required

A technical drawing of the dam. The map will show the location of the dam, its access roads, the watershed area, and communities surrounding the watershed. A list of all tools and materials required should be available before commencement of the construction and a detailed cross-section of the dam showing the upstream and downstream slopes.

Step 2: Divert the flow of water

If the dam is to be constructed across a river stream, divert the flow of water away from the dam construction site, for example by excavating a diversion ditch.

Step 3: Site clearance

Clear all the trees, dry leaves, branches, logs, stumps, roots, and other debris from the area that will be covered by water. Special care must be taken so that percolation and possible embankment leakage and failure do not occur.

Step 4: Setting out the dam body

Using the design drawing provided, mark out the area to build the dam body using pegs. Mark the proposed water lines using a line water level. A string across the valley should mark the high point of the dam.

Step 5: Obtain and test materials for the embankment

Good and suitable earth fill materials should be tested to check if they are suitable for dam construction. It is preferable for the materials to be obtained from the upstream of the dam body. Excavation of these materials will deepen the dam.

The easiest way of checking is by taking three to four samples and testing them by rubbing a sample of sub-soil between the hands; then wet a small amount of it in one palm and spread it over thinly. Then let it dry before trying to brush it off from the hands. Clay soil containing some silt and sand is preferred.

Make sure you use uniform soil material for both the core trench and embankment. If you are not sure of the type of soil, consult the experts, who will take the material to the soil laboratory for analysis and select the suitable soil.

Step 6: Determine the width of the embankment

Determine the width of the embankment at its widest point, which is always the lowest point of the dam. Dam width is equal to the height of the dam multiplied by the upstream slope added to the height of the dam multiplied by the downstream slope. For example, for a dam with a height of 3.0 m, top width of 3.0 m, and upstream slope of 3.5:1 and downstream slope of 3:1, follow Table A1.:

TableA1: Width of a dam embankment at different fill heights

Fill height above ground (m)	Embankment width (m)
Base/Bottom	22.5
0.5	19.25
1.0	16.0
1.5	12.75
2.0	
2.5	
3.0 (top level)	
9.5	
6.25	
3.0	

The width of the dam should be continually checked to ensure proper slope and width of the dam.

Step 7: Dig the core trench of the dam

Dams lose water through evaporation and seepage. Little can be done to prevent evaporation losses, but with good construction methods seepage losses can be reduced. One critical aspect is the construction of the cut-off trench. The core trench will minimize seepage under the embankment and increase the stability of the dam. It should be sunk down to a minimum of 600 mm into the impervious soil and rock, and backfilled with the appropriate quality clay soil that is thoroughly compacted. It should extend for the length of the embankment including the hillside flanks, but does not need to be extended under the spillway where the spillway is cut into rock. Dig the core of the trench according to the drawing, and fill with fresh selected earth material that will also be used to construct the embankment. Spread the borrow material of soil for filling the core trench in layers not exceeding 15 cm thick. The layers should be compacted using a hand hammer after adding the required quantity of water.

Step 8: Embankment construction

Before constructing the embankment, fix the drainpipe on the base which will be used to fetch water. Ensure proper compaction around the drainpipe as this is the main point of weakness. If possible, the pipe should be fixed with an anti-seepage collar to prevent the soil around the pipe from being worn away. Before construction of the embankment begins, ensure that adequate quantities of soil are excavated from the borrow site. Good soil obtained from the nearest possible site will reduce hauling costs. Soil from dam excavation and the spillway can be sufficient. The fill material should be spread in continuous layers across the entire length and width of the dam. Each layer should be 100–150 mm thick before compaction. Compact each layer carefully and thoroughly before adding another layer. The dry soil should be wetted to reach the desired level of moisture content. The beneficiaries can walk over the soil and compact it using their feet. However, the preferred option is to use hand hammers. Continue to build the dam up layer by layer until the desired height and dimensions are reached.

Step 9: Finalizing the embankment

Once the embankment is completed, erosion preventive measures should be fixed. To prevent erosion on open surfaces of the embankment, couch grass should be planted on the downslope, at the peak, and on the upper side of the upstream slope that is not covered by water. On the upstream part, erosion can be caused by waves. Hence, build that section using scrape stones up to approximately 0.6 m above water level. Fill the spaces between the big stones using small hard stones so that water accesses fewer spaces.

Step 10: The spillway

The spillway is among the most important features of a dam design. It diverts water out of the dam whenever there is an overflow, hence preventing the dam from spilling water over the embankment. Dig a spillway on hard soil, far from the dam edges. Continue digging beyond the lower edge of the base to prevent erosion. Build the upper side of the spillway using stones to prevent erosion.

Appendix B: Road Classification, Design Standards, and Typical Cross-Sections

Generally, there are 4 classes of roads.

1. Trunk road
2. Regional roads
3. District roads
   a) Feeder roads
   b) Urban roads
   c) Community roads

Road widths are determined from consideration of the following factors(Table B2):

1. Type of road
2. Topography
3. Traffic volume.

Table B2: Recommended road widths		
Traffic volume per day (Tvpd)	Shoulder width (m)	Carriage way width (m)
0 -20	1.00	3.50
20-50	1.00	4.50
50-200	1.50	5.50
Over 200	1.50	6.50

Cross-section

Five (5) types of standard cross sections to unpaved roads, for example by concrete or tarmac.

Cross-section A. Flat or undulating terrain

Cross-section B. Hilly/ mountainous terrain – reduced cross-section

Cross-section C. Super road elevation on bends

Cross-section D. Embankment

Cross-section E. Black cotton soil

Appendix C: Implementation Stages and Standard Procedures for Climate-Smart Community Access Roads

1. **Stages of Implementation**

Setting out, site clearance, grubbing, excavation and road formation, ditch excavation, camber formation, drainage structures, gravelling, finishing and environmental issues.

2. **Description of the Technology and Steps**

Setting Out

This activity is carried out to ensure the road is constructed to the designed alignment and measurement.

a) Set a centreline of the road and insert centreline pegs at 100m interval and then intermediate pegs at 10m intervals.
b) Set pegs at the edges of the side drains as done to the centreline.
c) Check the alignment and curvature of the road using ranging roads or strings.

Site Clearance

This activity is normally carried out within the width of construction/rehabilitation plus 1 – 2 m on either side, that is 11 m for a reduced section of 4.5 m running surface.

a) Remove all bushes, grass, trees and stumps from the areas the road is to be constructed and make the site clear.
b) Each laborer is normally given their piece of work as per developed task rate of 250 m^2/day (adjusted depending on the bush density).

Grubbing and Stripping of Topsoil

This activity entails removal and clearance of all organic materials (roots of grasses and bushes) from the whole width of the road. If the topsoil contains much organic materials, it is to be removed by stripping the topsoil.

Excavation to Level (ETL)

This activity involves cutting and filling the road to achieve a transversely level terrace. It balances cutting and filling over a cross-section of the road. Special attention should be given to the compaction of ETL which is normally done in layers of not more than 150mm after watering to optimum moisture content.

Ditch Excavation

Ditches are essential for collecting water from the carriage ways and adjoining land and transporting it to a convenient point of disposal. Ditch excavation entails:

a) Setting out the extents of the ditch using pegs and ropes,
b) Excavating materials and placing the excavated materials at the centre of the road, spreading them out, watering and compacting to a flat platform.
c) Controlling ditch excavation using a ditch template

Back sloping and spreading

After ditching is completed, the back slope is cut as per design.

a) Mark specified widths and slopes using pegs and strings, and ensure the cuts are done straight to the ditch bottom,
b) Place all excavated materials at the centre third of the road formation width
c) Make sure strings are used during the cutting of the back slopes to ensure straight lines.

Fore sloping

a) Set the slope to specification and mark accordingly
b) Make use of strings and ditch/slope templates to ensure straight lines of work
c) Straight cut from camber edge to ditch bottom
d) Place all excavated materials at the centre third of the formation width

Camber Formation

This is the final task in the road formation.

a) Form the embankment using materials from the back slope and the fore slope or selected soils to form a slope of 8%.
b) Rake the materials symmetrically back to both edges of the road. Use the heavy duty and extra wide garden rake.
c) Apply sufficient water to the materials to the optimum moisture content.
d) Preferably use a pedestrian roller in 8 passes to compact or use any other light equipment, that is, animal- or tractor-drawn deadweight rollers and hand hammer.
e) Cross check the compliance of the camber slope by using a camber board and a line water level.

Construction of Drainage Structures

High water content in road pavements may lead to low carriage capacity. Therefore, the pavements must be protected. Rainwater should be channelled away from the road at regular intervals and at any appropriate location using drainage structures. Drainage structures consist of side drains, mitre drains, cross drains, catch water drains, and erosion controls.

Stages for construction and guidelines are as follows:

1. Excavation of drainage structures other than side drains (mitre drains, catch water drains and culvert discharge drains, culvert trenches, culvert inlet and outlets)
2. Construction of erosion controls
3. Supply and installation of culverts
4. Masonry works
5. Stone pitching
6. Concrete works

Gravelling, Watering, and Compaction

Gravel surfacing protects the road and improves the capacity of subsoil to carry traffic wheel loads and reduces tyre damage to the camber.

Engineering of gravelling should normally be carried out immediately after the earth road formation is compacted. Natural gravel consisting mainly of stones and coarse sand with finer particles is mostly preferred for compaction to produce strong running surfaces. Lateritic gravels, corals, and other materials with natural cementing materials may be used.

Gravel should be laid to a minimum compacted thickness of 12 cm (15 cm loose).

In particular situations, for example, where naturally weak in situ soils prevail, heavy traffic and steep slopes may require that more gravel be placed on the road. Recommended thickness in this situation is 20 cm compacted (25 cm loose). It is necessary to adjust moisture content of the soil by watering to achieve adequate compaction.

Appendix D: Task Rates for Different Types of Potential CS-PW Interventions

THE UNITED REPUBLIC OF TANZANIA

TANZANIA SOCIAL ACTION FUND (TASAF)

PRODUCTIVE SOCIAL SAFETY NET THIRD PHASE (PSSN III)

Introduction

In a CSPW, norms form the direct basis for setting task rates, ensuring fairness, consistency, and efficient project planning. Task rates are specific, defined units of work activity that require a significant amount of human physical effort and manual labour to produce an output. Also, the task rates translate the expected daily output (the norm) into a concrete payment amount for a specific quantity of work completed, independent of the actual time spent.

Under CSPW sub-projects, the agreed task rates and work norms will be considered during design, implementation, operation, and maintenance in order to ensure the sub-projects will comply with the labour policies, sector standards, and the objectives of PSSN III.

During implementation of CSPW sub-projects under PSSN III, participants' households will attend work sessions for four (4) hours in a day, ten (10) days in a month, and sixty (60) workdays to complete the sub-projects. The daily wage rate is TZS 4,000. The local service provider (LSP) is a person within the locality of a sub-project implementation site with specific skills on the type of works to be carried out by participant households during the sub-project's implementation. The LSP is responsible to plan and decide on activities to be carried out on a daily basis with reference to the agreed task rates and work norms.

The following are work norms to be used during work sessions for labour-based sub-projects:

Table D1: CSPW interventions and task rates

S/N	Description of Interventions	task rates
1	Vegetative waterways	- Site clearance: 150-200 m^2/pd -Setting out 200 m -Excavation: 1.5 m^3/pd -Soil removal: 1.5 m^3/pd -Soil compaction: 20 m^2/pd -Scour checks construction 5No/pd -Revegetation along the waterways: 8m^2/pd
2	Cutoff drains	-Setting out 50m/pd -Site clearance 150m2/pd -Excavations 1.5 m^3/pd -Shaping and compaction of embankment 20m2/pd -Provision of scour check-5No/pd
3	Stone bunds	-Clearance 150-200 m^2/pd -Stones collection 0.8 m^3/pd -Breaking big stones: 0.4 m^3/ per day -Loading of stones 0.8 m^3/pd - Stones Transportation distance less than 150m :0.8 m^3/pd -Stones Transportation distance more than 150m :0.5 m^3/pd -Scour checks construction 5No/pd - Laying stones 25 m^2/pd
4	Contour bunds	-Site clearance 150-200 m^2/pd -Setting out 200m -Excavation: 1.5 m^3/pd -Soil removal: 1.5 m^3/pd - Shaping and compaction of bund :20 m^2/pd -Soil Compaction: 20m^2/pd -Revegetation along the bund: 8m^2/pd
5	Graded soil bunds construction	- Site clearance: 150–200 m^2/pd - Setting out: 200 m - Excavation: 1.5 m^3/pd - Soil removal: 1.5 m^3/pd - Shaping and compaction of bund: 20 m^2/pd - Compaction: 20 m^2/pd - Revegetation along the bund: 8 m^2/pd
6	Graded risers' construction	- Site clearance 150 m^2/pd

		-Setting out 200 m -Excavation: 1.5 m^3/pd -Soil removal: 1.5 m^3/pd - Shaping and compaction of bund :20m/pd -Compaction: 20 m^2/pd -Revegetation along the bund: 8 m^2/pd
7	Construction of Underground rainwater water harvesting water tank	-Excavation: 1.5 m^3 /pd for hard soil and 2 m^3 /pd for soft soil -Removing topsoil – 100 m^2/pd -Stones collection: 0.8 per m^3 /pd -Breaking of big stones: 0.4 m^3 /pd -Crushing of stones into aggregates :0.01 m^3/pd -Stones transportation for a distance not exceeding 150m: 0.8 m^3 /pd -Stones transportation for a distance exceeding 150m: 0.5 m^3 /pd -Stones arrangement for building a stone wall: 1.5 m^3 /pd -Concrete tasks: 0.4 m^3/pd
8 9 10	-Charco dams -Earth fill dam -Micro ponds	- Site clearance 150-200 m_2/pd - Removing topsoil – 100 m^2/pd -Stump/trees removal-depends on size -Setting out 200m -Excavation: 1.5 m^3/pd -Loading of Soil: 1.5 m^3/pd -Transportation of excavated soil 1.5 m^3/pd -Fetching water 100 litrers/pd -Compaction including formation of embankment, watering and compaction in layers of 15sm depth: 20 m^2/pd -Stone collection: 0.8m3/pd -Breaking of big stones: 0.4 m^3/pd -Stones transportation for a distance not exceeding 150m: 0.8 m^3/pd -Stones transportation for a distance exceeding150m; 0.8 m^3/pd -Stones arrangement at the spillway: 2 m^2/pd -Crushing of stones into aggregates :0.01 m^3/pd -Concrete works at spillway: 0.4 m^3/pd -Revegetation of cover grasses along the embankment and spillway: 8 m^2/pd
	Shallow well	- Site clearance 150 m^2/pd -Excavation up to depth of 5m: 1.5m^3/pd -Excavation up to 6m to 10m: 1m^3/pd - Excavation up to 11m to 15m: 0.5 m^3/pd

11		-Loading of soil:1m^3/pd -Removal soil from the well 1m^3/pd -Spreading soil: 1.5 m^3/pd -Compaction of soil: 20 m^2/pd -Collection of stones (less than 150m): 0.8 m^3/pd -Collection of stones (more than150m): 0.5 m^3/pd -Crushing of stones into aggregates :0.01 m^3/pd -Concrete work - 0.4 m^3/pd -Revegetation around the shallow well: 8m^2/pd
11	Construction of semi-circular bunds	-Site clearance: 150-200 m^2/pd - Removing topsoil - 100 m^2/pd -Excavation of stumps: No stumps/pd -Soil loosening: 400 m^2/pd -Setting out of bunds: 10No/pd -Preparation of oval shaped bunds and raise buds: 5No/pd -Loading of manure 0.25 m^3/pd -Transportation of manure0.25 m^3/pd -Spreading manure into bunds 0.2 m^3/pd
13	Construction of fish ponds	- Site clearance 150-200 m^2/pd - Removing topsoil - 100 m^3/pd -Stump/trees removal-depends on size -Setting out 200m -Excavation: 1.5 m^3/pd -Loading of Soil: 1.5 m^3/pd -Transportation of excavated soil 1.5 m^3/pd -Fetching water 40litrers/pd -Compaction including formation of embankment, watering and compaction in layers of 15sm depth: 20 m^2/pd -Collecting and planting grass: 8 m^2/pd
14	Construction of small-scale irrigation scheme	- Site clearance 150-200 m^2/pd - Removing topsoil - 100 m^2/pd -Stump/trees removal-depends on size -Setting out 200m -Excavation: 1.5 m^3/pd -Loading of Soil: 1.5 m^3/pd -Transportation of excavated soil 1.5 m^3/pd -Compaction of soil: 20 m^2/pd -Collecting and planting grass: 8 m^2/pd -Collection of stones - 0.8 m^3/pd

		-Stone masonry - 0.4 m^3/pd -Concrete work - 0.4 m^3/pd -Crushing of stones into aggregates :0.01 m^3/pd -Formation of canal shape - 1.5 m^3/pd; -Building canals at the cement level - 2.0 m^2/pd
15	Construction of drip irrigation system	-Site clearance: 150-200 m^2/pd -Excavation: 1.5 m^3/pd -Laying of pipes: 50m /pd -Covering of pipes: 1.5 m^3/pd -Stump/trees removal- No/pd -Filling soil and compaction 20m^2/pd
16	Tree seed collection	General task rates should be 50 g of clean tree seed /pd but for Grevillea robusta the task rates should be 15 g/pd.
17	Tree nursery preparation	-Collection of (topsoil, manure, sandy soil) 1.5m^3/pd. -Sieving and mixing of ingredients 1.2 m^3/pd. -Cutting and filling polythene tubes: 350 No/pd. -Preparation and mulching of a 1 × 6 m seedbed 1No/pd. -Watering and weeding 1 person per 20 seedbeds/day -Uprooting and transplanting seedlings 800Na/pd. -Pruning, weeding, and pest/disease protection 800 seedlings/Pd.
18	Tree planting (Woodlot)	-Pitting/Digging holes: 10 holes/pd -Tree planting: 20 trees/pd -Weeding: 20 trees/pd -Fire break making: 5-m/pd -Pruning: 10 trees/pd -Thinning/Cutting trees: 5 trees/pd
19	Insitu Rainy water harvesting interventions	-5 micro basins/ pd -2 eyeblow basins/pd -5 herring bones/pd -3 micro-trenches/pd -5 improved pits/pd
20	Climate-Smart Public Works community access road	-Site clearance 150-200 m^2/pd -Layout 200m/pd -Grubbing topsoil 100 m2/pd -Scrapping off unnecessary topsoil layer 1.5 m^3/pd -Soil spreading 8 m^3/pd

		-Levelling of road surface 40 m^2/pd -Excavation of ditches 1.5 m^3/pd -External side trimming of ditches 1.5 m^3/pd -Internal side trimming of ditches 1.5 m^3/pd -Horizontal road embankment construction 20 m^2/pd -Sprinkling water to the required quantity 40 m^2/pd -Compaction using hand tool 20 m^2/pd • Compaction using a leg ridden compactor 100 m^2/ pd
21	Stone road construction	-Road layout 200m/pd -Clear grass and bushes (light) 200 m^2/pd -Clear grass and bushes (heavy) 150 m^2/pd -Excavation (Soft soils) 1.5 m^3/pd -Excavation (Hard soils) 1.0 m^3/ pd -Excavation (Rocks) 0.5 m^3/pd -Spread the Murram/ Sand 8 m^3/pd -Filling cracks with sand 20 m^2/pd -Compact using hand compactors 100 m^2/pd -Collection of stones (less than 150m) 1 m^3/pd -Collection of stones (more than150m) 0.7 m^3/pd -Breaking rocks 0.4 m^3/pd -Carving stones 0.4 m^3/pd -Sieving sand 1 m^3/pd
22	Scour check construction	-Excavation (Soft Soil) 1.5 m^3/pd -Excavation (Rocks) 0.5 m^3/pd -Erosion controls 2No/pd -Collection of stones (less than 150m) distance: 1 m^3/pd -Collection of stones (more than 150m) 0.7 m^3/pd -Breaking rocks 0.4m3/pd Revegetation of cover grasses: 8 m^2/pd
23	Arch bridge construction	-Bridge layout: 200m2/pd -Clear grass and bushes (light): 1000 m^2/pd -Clear grass and bushes (heavy): 150-200 m^2/pd -Excavation (Soft soils): 1.5 m^3/pd -Excavation (Hard soils): 1.0m^3/ pd -Excavation (Rocks): 0.5 m^3/pd -Spread the Murram/ Sand: 8 m^3/pd -Filling cracks with sand: 20 m^2/pd -Compact using hand compactors: 130 – 150m

24		-Collection of stones (less than 150m): 0.8 m^3/pd -Collection of stones (more than150m): 0.5 m^3/pd -Breaking rocks: 0.4 m^3/pd -Sieving sand: 1 m^3/pd
24	Disposal of Inorganic wastes	-Site layout: 200 m/ pd -Loading/unloading inorganic waste onto a trolley or cart: 1m3/ pd -Sorting/separating inorganic waste: 1 m^3/ pd -Transportation to the sorting bay to 400m: 1 m^3/ pd -Transportation to the sorting bay (more than 400m): 0.5 m^3/ pd
25	Clean energy (Making briquettes)	-Site clearance :150-200 m^2/pd -Collection of inorganic wastes :1 m^3/pd -Loading inorganic wastes onto wheelbarrow:1 m^3/pd -Transportation to distance up to 400m : 1 m^3/pd -Transportation to distance more than 400m:0.5 m^3/ pd -Sorting of inorganic wastes: 0.5 m^3/Sieving of inorganic wastes: 0.25m3/pd -Preparation of binder materials: 10kg/pd -Mixing of briquettes raw materials: 0.5 m^3/pd -Loading and pressing the mixtures to form briquettes :100No/pd -Loading and transportation of briquettes into the drying site: 200No/pd
26	Small scale biogas system construction	-Site clearance :150-200 m^2/pd -Excavation of soil: 1.5 m^3/pd -Collection of stones (less than 150m): 0.8 m^3/pd -Collection of stones (more than150m): 0.5 m^3/pd -Crushing of stones into aggregates :0.01 m^3/pd -Collection of organic wastes for feeding into digester: 1m^3/pd -Loading inorganic wastes onto wheelbarrow:1 m^3/pd -Transportation of inorganic wastes to distance up to 400m: 1 m^3/pd -Transportation of inorganic wastes to distance more than 400m: 0.5 m3/ pd -Sorting of inorganic wastes before feeding into the digester: 0.25 m^3/pd -Feeding of inorganic wastes into the digester: 0.1 m^3/pd

Appendix E: List of Climate-Smart Public Work Sub-Project and Activities along with their Potential Contribution to Climate-Smart Outcomes

Appendix E1: Summary Major Climate-Smart PW Sub-Projects

Sub-Code	Major Sub-Projects	Units
1.0	Natural Resources Management (NRM) interventions for land rehabilitation	Ha, M
2.0	Water related sub-projects	M^3
3.0	Small Scale Irrigation development	Ha
4.0	Climate-Smart Community Road construction/Rehabilitation	Km
5.0	Nutrition sensitive PW	No
6.0	Disposal of inorganic wastes	M^3
7.0	Clean Energy CS-PW activities	No

Appendix E2: Types of Interventions for Climate-Smart PW

Code	Type of sub-projects	Units
1.0	**NRM INTERVENTIONS FOR LAND REHABILITATION**	
1.1	**Physical Soil Water Conservation (SWC) Interventions**	**ha**
1.1.1	Hillside Terrace	km
1.1.2	Hillside terrace with trench	km
1.1.3	Bench terracing	km
1.1.4	Soil bund (level or graded)	km
1.1.5	Stone bund	km
1.1.6	Stone bund with trench	km
1.1.7	Stone check dams	km
1.1.8	Fanya juu (level or graded)	km
1.1.9	Cut-off drains	m^3
		km
1.1.10	Waterway cons (vegetative)	m^3
		km
1.1.11	Water way construction (unpaved)	m^3
		km
1.1.12	Water ways (stone paved)	m^3
		km
1.1.13	Half-moon (large or small) or semicircular bunds	No.
1.1.14	Deep Trenches	No.
1.1.15	Micro trenches	No.
1.1.16	Micro basins	No.
1.1.17	Eyebrow basins	No.
1.1.18	Herring bones	No.

1.1.19	Semicircular Bunds	m^3
1.1.20	Sea bund	m^3
1.1.21	Plot bunds	m^3
1.1.22	Paving blocks	no
1.1.23	Flood control measures	No
1.2	**Biological Soil Water Conservation (SWC) Interventions**	
1.2.1	Planting of cover grasses- Vetiver glass	m^2
1.2.2	Grass Strips Along the Contours	ha
1.2.3	Hedgerows of Shrubs /Grasses	ha
1.2.4	Stabilization of Physical Structures	km
1.3	**Gully control interventions**	ha
1.3.1	Loose Stone check dams	M^3
1.3.2	Brushwood check dams	Lm
1.3.3	wooden check dams	Lm
1.3.4	Sandbag check dam	m^3
1.3.5	Gully head and sides reshaping	m^3
1.3.6	Gully revegetation	ha
1.3.7	Gabion Check dam	m^3
1.3.8	Sediment Storage Dam (SSD)	m^3
		No.
1.3.9	Arc-weir check dam	m^3
1.3.10	Bamboo –mat check dam	m^3
1.3.11	Riverbank-stabilization	M
1.3.12	Stone collection and transportation	m^3
1.4	**Forestry and Agro-Forestry**	ha
1.4.1	Seedling production in nursery	No.
1.4.2	Mangroves Seed collection and planting	No
1.4.3	Seedling plantation	No.
		Ha.
1.4.4	Seed collection	Kg
1.4.5	Nursery site establishment	No.
1.4.6	Nursery running (existing nursery)	No.
1.4.7	Pitting including improved one	No
1.4.8	Post Mgt (Weeding, Cultivation, watering etc.)	ha
2.0	**WATER RELATED SUB-PROJECTS**	No
2.1	Community hand dug well	no
2.2	Community pond Construction	no
2.3	Geomembrane Lined Pond	no
2.4	Farm dam/Small Earth Dam/	no
2.5	Spring Improvement	no
2.7	Rainwater Storage Cisterns	no
2.8	Charco dam construction/rehabilitation	m^3

2.9	Tanker/night storage	no
2.10	Cattle trough construction	No.
3.0	**SMALL SCALE IRRIGATION (SSI) DEVELOPMENT**	Ha
3.1	Irrigation canal construction-lined or unlined	km
		m
3.2	Diversion weir design and construction	No.
3.3	Traditional river diversion	No.
		m
3.4	Night storage	No.
		Ha
3.5	Community Pond construction for irrigation	No.
3.6	Spring development for irrigation	No.
3.7	Check dam pond for irrigation	no
3.8	Earth dam/farm dam/ for irrigation	no
3.9	Masonry Dam	No.
3.10	Intake structure with canal	No.
		Ha
4.0	**Climate-Smart Community Roads Construction or Rehabilitation**	km
4.1	Earth road on flat and rolling terrain (R1)	km
4.2	Earth road on mountainous terrain (R2)	km
4.3	Gravelled road on flat and rolling terrain sandy or weak soil (R3)	km
4.4	Gravelled road on mountainous terrain weak soil (R4)	km
4.5	Gravelled road on flat and rolling terrain black cotton soil (R5)	km
4.6	Road on escarpment (R6)	km
4.7	Bridges (concrete >6 m)	No.
4.8	Bridges (wooden)	No.
4.9	Culverts (pipe, slab, box < 6m)	No.
4.10	Fords	No.
4.11	Foot path construction and/or improvement	km
5.0	**NUTRITION SENSITIVE PW INTERVENTIONS**	
5.1	Construction/Rehabilitation of small-scale fishpond	m^3
5.2	Preparation and management of home gardens	No
5.3	Hand dug well for small scale irrigation	No
6.0	**DISPOSAL OF INORGANIC WASTES**	m^3
6.1	Construction of inorganic waste collection/sorting bay (unit)	No
7.0	**CLEAN ENERGY CS-PW ACTIVITIES**	
7.1	Small scale making of briquettes from biomass	No
7.2	Small scale Biogas development	No

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