RRRC

SITE DEVELOPMENT CATALOGUE 2.1

April 2023

ISCG | Inter Sector Coordination Group

SITE MANAGEMENT AND SITE DEVELOPMENT SECTOR COX'S BAZAR

ENERGY & ENVIRONMENT

Acknowledgement:

The development of this document has been coordinated by the Site Management and Site Development (SMSD) Sector of Cox's Bazar, Bangladesh with IOM Site Development team as the main contributor and the support from other Site Development and Energy & Environment Technical Working Group (EETWG) partners.

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Disclaimer:

This is a live document and will be updated regularly when more technical information from the field experience or policies are available.

RRRC

Words of acknowledgment from the Refugee Relief and Repatriation Commissioner (RRRC)

After the influx in August 2017 of 745,000 Forcibly Displaced Myanmar Nationals (FDMNs), 8,000 hectares of reserved forestland in Ukhiya and Teknaf upazilas became one of the largest refugee settlements in the world. Since then, the Government of Bangladesh, through the Office of the Refugee Relief and Repatriation Commissioner (RRRC), and humanitarian actors have been working together to provide them with relief and support.

This catalogue shows the joint journey in overcoming the challenges of land exposed to several hazards – fire, flash flood, landslide, and cyclone - and documents the best practices and technologies developed specifically for the context. Over these last five years, we have worked together to find the balance between ensuring lifesaving humanitarian assistance to the Rohingyas while preserving the environment and our beautiful forests and ensuring the sustainability of the interventions. These lessons might contribute to strengthening the Disaster Risk Reduction interventions in the host community and beyond.

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April 2023

Cox's Bazar, Bangladesh


28 February 2018

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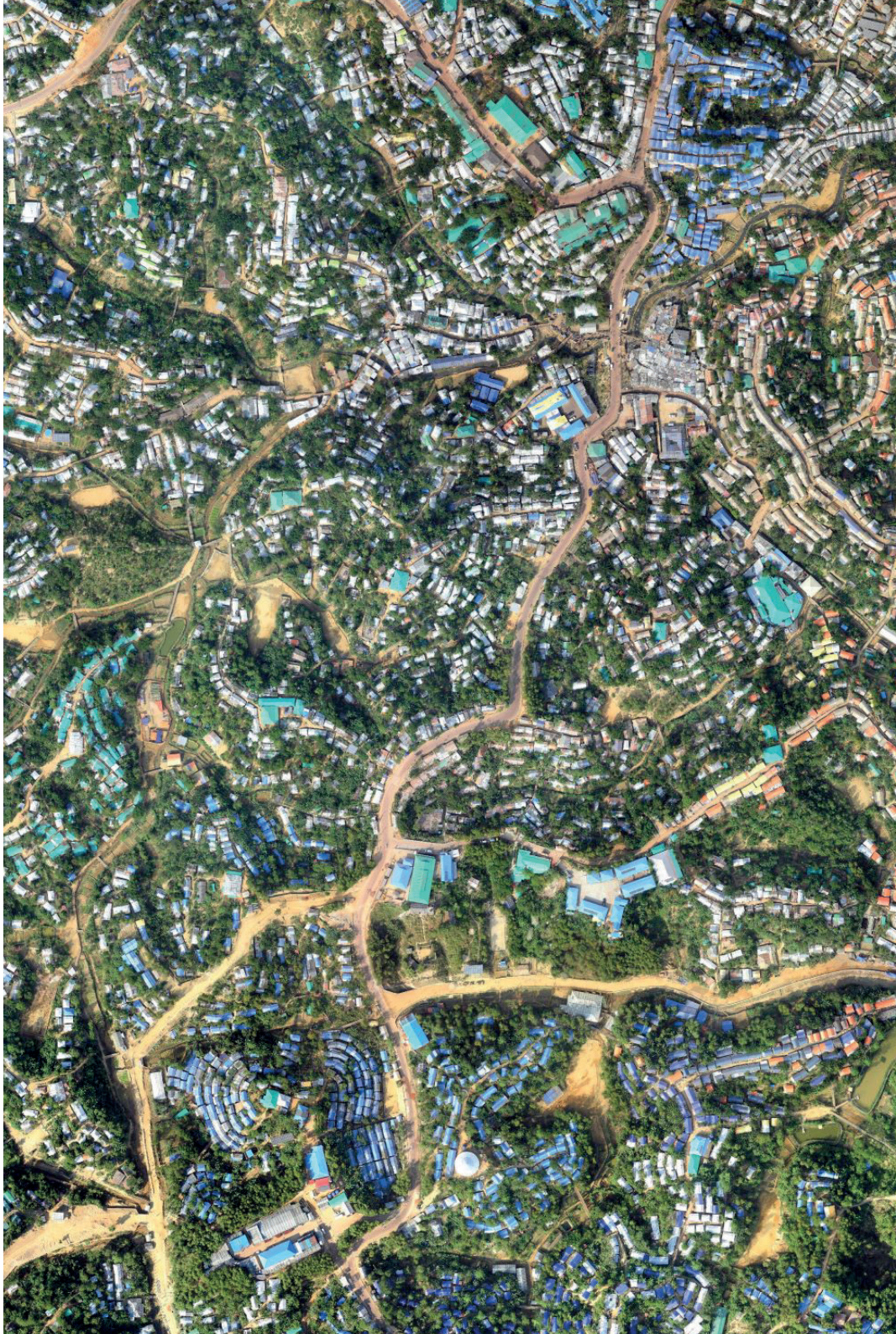


INTRODUCTION

Why has the Site Development catalogue been revised?

This catalogue builds on the previous version of site improvement catalogue developed in 2018 to:

1. Integrate lessons learnt from implementation since 2018;
2. Incorporate new techniques and innovations;
3. Mainstream environmental considerations and emphasize nature-based solutions;
4. Strengthen the links between field assessment and site planning and improve the prioritization of works.

What is the purpose of the catalogue?

This catalogue has been produced to assist site improvement actors in the following ways:

1. To provide design standards and technical guidance tailored to the Cox's Bazar camp context to ensure good construction practice and avoid common errors;
2. To make informed decisions as to what interventions are appropriate and cost effective in terms of value engineering solution and ensure planning principles are incorporated into the design process;
3. To ensure consistency with other SI actors across all camps;
4. To avoid injuries or casualties on site and ensure safe and respectful engagement of communities under the principle of do no harm.

The guidance contained in this catalogue is applicable to all camps in Cox's Bazar district.

What is Site Development?

Small-scale, low-tech works implemented using casual labor, typically consisting of pedestrian access, drainage and slope stabilization. In most cases the Site Development interventions are identified by communities and respond to urgent needs to avoid risk and ensure access to lifesaving services. This catalogue is provided as guidance for small scale Site Development works.

In some instances, some more works, often involving machinery, such as vehicle roads or concrete retaining walls are planned for and implemented as they are needed to maintain or extend the networks. These higher scale works require a full engineering design, to be submitted to the relevant Site Development Area Coordinator (i.e. IOM or UNHCR) for approval.

Site Development works are implemented directly by IOM or SMEP; by UNHCR, WFP or LGED through contractors (not NGO partners) or by NGO partners to ensure an adequate technical supervision. However, all Site Development works require coordination with the Site Development focal at camp level IOM/UNHCR (as appropriate) to ensure prioritization, alignment with site planning and avoid overlaps.

Important Note:

The sketches/designs in this catalogue are for guidance purposes only; they are not a substitute for engineering design. All site improvement works should be designed and overseen by a qualified engineer.

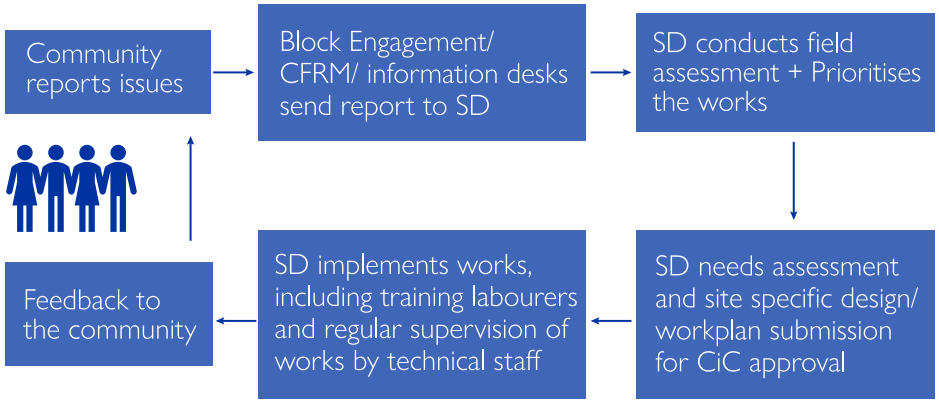
LGED: Local Government Engineering Department
SMEP: Site Maintenance Engineering Project (IOM, UNHCR and WFP initiative)

ACTIVITY IDENTIFICATION AND PRIORITIZATION

Site improvement activities aim at responding at the most immediate needs. The identification of needs can come from several channels including:

- Community requests: through CFRM, FIC, block engagement meetings, focus group discussions, and other community engagement sessions. Most of the site improvement activities are identified by communities;
- Technical assessments: from the Site Development or Site planning teams (linked to Macro Settlement Plan and other site planning/ re-planning);
- SMS and other sector's request: including the referrals from WASH and shelter partners or other camp actors for site preparation;
- CMO/CiC request for particular needs identified.

In all cases, it is important to prioritize the interventions and ensure an adequate feedback to ensure the accountability to the affected populations.



CFRM: Community Feedback Response Mechanism
FIC: Feedback and Information Centre
SMS: Site Management Support
WASH: Water, Sanitation and Hygiene
SD: Site Development
CMO: Care and Maintenance Officer
CiC: Camp in Charge

How to prioritize the site development works?

The prioritization of the site improvement works should ensure that interventions are:

Cost Benefits

Ensuring the most adequate use of resources.

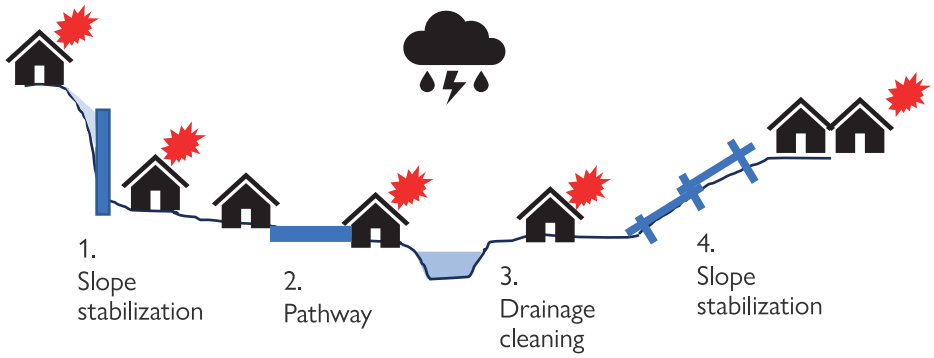
Timely

Depending on the season, some works might not be posible and some other interventions might be more important.

Strategic

Ensure that the interventions cover the access to services, general interest ans are aligned with planning strategies.

The prioritization criteria should be conveyed to the community and other stakeholders so there is clarity on what site development/ site improvement partners can respond to.



The scheme shows how particularly in Monsoon season, works preventing risk should be prioritized

Activity Prioritization Criteria

Activity prioritization criteria should include:

- **Beneficiaries:** Number of direct beneficiaries (individuals or households).
- **Budget:** Availability of labour and materials.
- **Site condition:** the site condition might affect the feasibility or the urgency of some interventions. (e.g. design might or might not be built under current weather conditions without compromising quality.)
- **Risk:** while several interventions might be needed not all are as effective in addressing the households at risk, particularly the landslide and flood risks.
- **Number of vulnerable people** particularly affected (including Extremely Vulnerable Individuals (EVI) or People with Special Needs (PSN)
- **Access to key services** such as health facilities or other key infrastructure.

In addition to these prioritization criteria there might be other factors involved:

- Approvals/suggestion from Government or other counterparts.
- Referred to other agency: some projects have already been referred to other stakeholder who is in the process of completing it.

EVI: Extremely Vulnerable Individuals
PSN: People with Special Needs

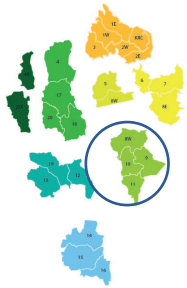

IOM
UN MIGRATION
সুশীলন
Shushilan
ইটের রাস্তা নির্মাণ, ব্লক-এ-০১, ক্যাম্প-২২
BFS Pathway Construction at Block-A-01, Camp-22
SITE DEVELOPMENT PROJECT
ROHINGYA
RESPONSE PROJECT

SITE PLANNING STANDARDS AND FRAMEWORKS

SPATIAL PLANNING FRAMEWORKS

The spatial planning in the camp area are done in 3 levels- macro, meso and micro scale.

Macro



Meso

Micro

Macro Settlement Plan

The Macro Settlement Plan (MSP) is a spatial strategy aiming to structure the Kutupalong- Balukhali mega camp through an incremental re-planning process focusing on 3 layers. The MSP gives direction on developing meso-level strategic plans and medium to short-term actions to ensure that investments made now serve the larger interests of the local community and Government of Bangladesh, while meeting the short-term needs of the refugee population and local host community.

Meso Plans

Meso level planning provides spatial planning guidance to multiple camps that are closely connected and sets the linkages between macro scale strategy and micro scale site planning and development work. The meso zones are selected based on accessibility, topography, environmental risks, density and the proximity to host community.

Micro planning

Micro planning must be done only when immediately needed for implementation. This can include the re-planning of sections of camps affected by fire, the planning for new shelter construction in empty areas or watershed management implementation plans for holistic restoration in areas that are particularly vulnerable.

All planning scales consider the three main layers:

Blue-green Network

The blue-green network connects all blue and green spaces, natural and semi-natural areas and natural processes into an integrated functioning network. This will be particularly important to guide the watershed management interventions.

The Kutupalong Watershed Management Plan is a reference framework for the blue green network

Infrastructural Corridor

Infrastructural corridor includes road network, electricity and water network that work as the skeleton for the settlement and remain as a future asset for host community.

Buildable Land

Buildable land includes the areas that can be developed for shelters and facilities. The areas are selected based on the topography, risk and natural hazard risk, accessibility and environmental impact.

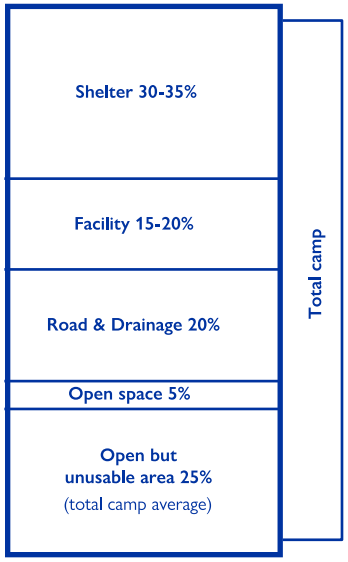
Engaging communities in spatial planning is essential.

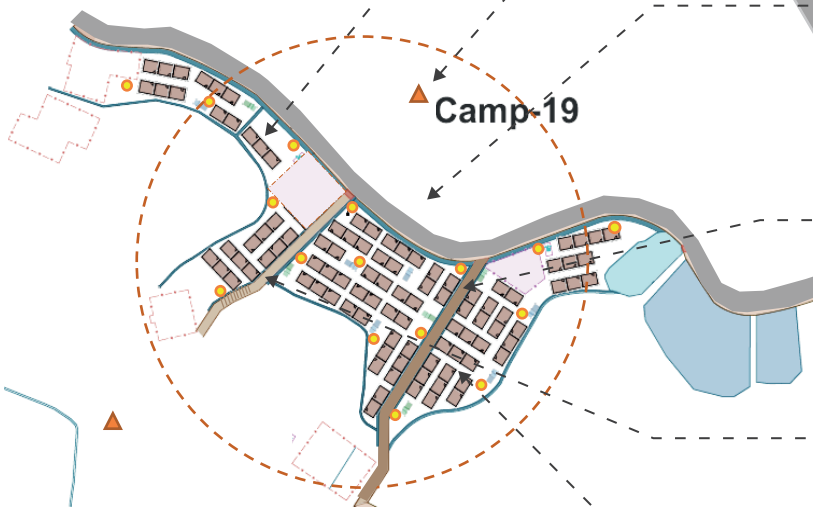
This includes messaging to ensure that the community is aware of what are the objectives and the process of planning and the consultation of community for the validation of the plans. This can be achieved through door-to-door consultations, community open discussions and participatory planning.

On-site planning through hand sketches and close collaboration with Site Management and Shelter and WASH partners is essential to integrate community requests in a flexible way in the plans.

SITE PLANNING STANDARDS

"The Sphere Minimum Standards for Shelter and Settlement are a practical expression of the right to adequate housing in humanitarian contexts. The standards are grounded in the beliefs, principles, duties and broader rights declared in the Humanitarian Charter. These include the right to life with dignity, the right to protection and security, and the right to receive humanitarian assistance on the basis of need." (The Sphere Standard, 2018 Edition). In a typical camp response, the Sphere standards can be regarded as the benchmark to guide technical decision making. However, in Cox's Bazar, population density and land constraints require an adapted framework. The Site Planning and Site Development Working Group has drafted contextualized standards for this context.





Macro planning considerations:

A breakdown of suggested land use distribution considering KTP camp context, showing the approximate area that should be allocated for different functions.

Solar streetlight: at 20- 30 m (65'-98') intervals, to be placed near WASH facilities and access corridors.

Lightning arrestors: coverage of 80-100m (262'- 328') radius (vertical coverage radius10m (33') height, preferable on hilltops and not close to shelter.

Major Vehicular Road: HBB road that can be accessed by a truck or other large vehicles. Paved width of 5-6 m (16'-20')

Minor Vehicular Road: HBB road that can be accessed by car, pickup or any light vehicle. Paved width of 3.7m (12').

Emergency Light Vehicular Road: block-to-block connection for emergency light vehicle access with paved width of 2.5 m (8'). Primary pathways can also be used as emergency access if it is stair-free and has adequate width.

Major pathway: Major Pathways should be 2-2.5m (6'-8') of paved width in between cluster of shelter serving more than 20 shelters or connecting to facilities/other clusters of development.

Minor Pathway: Minor Pathways are in between shelter rows serving fewer than 20 shelters and not serving as thoroughfares. Paved width of minor pathway should be1.5m (5')

For more information: The Sphere Standard, 2018 Edition: https://spherestandards.org/handbook-2018/

CONSTRUCTION MODALITIES

CASH FOR WORK (CFW)

How does this modality work?

Community members engaged in Cash for Work (CfW) are usually engaged 8 hours a day in rotations; materials and technical supervision are provided by the humanitarian agency engaging the labours. CfW are given training by a skilled volunteer or technical officer and works are regularly monitored to ensure that materials are used as intended and technical standards are maintained. Beneficiaries receive an incentive according to their attendance and participation to the CfW activities. Beneficiaries should be above 18 years to be eligible for CfW.

Advantages

- Supports communities with resources complementary to the humanitarian assistance.
- Enables construction works of all scales to cover all needs.
- Creates a feeling of ownership among the community.
- Improves technical capacity of the community.

Limitations

Monitoring required to maintain good workmanship, as the community people may not have construction skills.

Best practices

- Maintain engagement based on rotations to ensure equal opportunities amongst the community.
- Ensure the engagement of different groups (i.e. male-female, host-Rohingya, people with special needs, etc.) with adequate practices and under the DO NO HARM principle.
- The selection of beneficiaries for the participation in CfW should be done by the Site Management agency Information Management team – i.e. not selected at camp level - to avoid corruption and ensure fair engagement of all eligible beneficiaries.

COMMUNITY CONSTRUCTION

How does this modality work?

Agencies provide materials and technical support to the community to implement works on a voluntary basis without any cash incentives. Participants are given training and works are regularly monitored to ensure that materials are used as intended.

Advantages

- Develops ownership of the community to the works and increases the likelihood of community contributing to the maintenance of such works.
- Reduces labour costs.
- Allows directly-affected community members to immediately undertake urgent works rather than waiting for agencies to respond.

Limitations

- Households that do not have eligible member may not be able to contribute to voluntary labour.
- Labour-intensive works will require coordination between multiple households who may not easily agree on the division of responsibilities.
- Unsuitable for complex designs that require technical skills as skilled labours might not be found in the community group implementing the activities.
- Difficult to mobilise community members for works that do not directly benefit specific households so not suitable for secondary infrastructure.

Best practices

- Clear explanation about community roles and responsibilities is needed to avoid misunderstandings and conflict. This is especially important where other construction modalities (i.e. CfW) are being implemented.
- Identify community members with construction experience from previous humanitarian infrastructure activities to lead the construction process. Many households have members who have received technical training from CfW opportunities.
- Works that directly benefit 2-3 neighbouring households are the most suitable for this modality.
- A skilled volunteer or staff member should be assigned to supervise a maximum of 10 works so that there is adequate oversight of construction quality and material usage.
- Community construction committees must be formed to manage the construction of complex, shared infrastructure. Investing time into gaining community acceptance is essential to implement this modality.

Community groups (skilled, unskilled and women) are being oriented before the project starts

EVALUATION AND MAINTENANCE OF COMPLETED WORKS

Evaluation of completed works

Community feedback for the completed works should be collected to correct if needed the works in place or to be considered in future works.

Community evaluation of implemented works can be done through gender- and age-segregated sessions or other community meetings at block level ensuring that the consultations reach different users and do no harm.

Humanitarian actors should ensure that community feedback is responded to by adjusting works wherever possible or explaining limitations.

Maintenance best practices

To foster ownership and protect the durability of works, humanitarian actors should encourage community support in monitoring and maintaining completed works. Repairs of works and other activities requiring technical expertise or materials should be managed by humanitarian actors.

- Setting up block-level Care and Maintenance Committees can make it easier for communities to regularly monitor works and ensure basic maintenance. To avoid undermining the efforts of some humanitarian actors to encourage household responsibility over small works, Care and Maintenance Committees should ideally focus on larger-scale, shared infrastructure that is not being monitored by households that directly benefit from them.
- Technical training should be offered to Care and Maintenance Committees so that they can perform simple maintenance tasks as needed.

For more information: see Annex Project completion checklist.

WOMEN AND PSN IN CFW

Why engage women in CfW?

Engaging women in CfW is key to empowering women considering that there are few opportunities for them to generate income in the camp context. When women and girls have safe and equal access to CfW they are much better positioned to meet their basic needs and less vulnerable to sexual exploitation and abuse.

Ensuring a safe working environment for women in CfW

Ensuring safe working conditions is key to accessible and sustainable CfW activities period.. The principle of DO NO HARM should be ensured as women engaged in CfW can be exposed to harassment, reprisals or loss of honor if cultural considerations are not taken into account Considerations should include:

Women-only labor groups.

- Form women-only or women-dominated labor groups
- Train skilled women laborers to act as supervisors to avoid need for men to supervise.
- Assign women engineers to supervise women labor group

Work environment for women CfW laborers

- Avoid assigning women to tasks in busy, public spaces such as major pathways, markets, etc. where they are on display to passersby.
- Whenever possible, assign women to work sites that are close to their shelters, especially for breast-feeding women.
- Allocate flexible tasks that can be done indoors to women (bamboo weaving, sewing, etc.) so they can be done in an institutional facility (e.g., community center, SD warehouse) or inside their shelters
- Ensure that work sites have access to gender-segregated WASH facilities.

Culturally and PSN appropriate tasks

- Certain tasks are considered only appropriate for men and may cause women to lose honor within their community. It is important to consult women and PSN to identify the most suitable CfW tasks for them.
- Appropriate tasks include planting vegetation, laying brick pathways, repairing bamboo bridges, fetching water, record keeping, etc.

Consultations and feedback:

- Women labours should have access to complaints and feedback mechanisms to raise issues & make complaints. Gender-segregated CfW briefings and feedback sessions conducted by women staff can ensure that women labours are more comfortable raising sensitive issues.
- Humanitarian actors should hold focus group discussions with women and PSN CfW labours to understand their experiences and collect feedback. Separate meetings with community leaders should be held to understand their concerns and explain measures actors are taking to make CFW tasks safe and & appropriate for women and PSN.
- Before tasks are allocated women labours should be informed of the risks of carrying out some tasks while pregnant and should be encouraged to share if they have any physical limitations so that suitable tasks can be identified. This also applies to PSN (people with disabilities and the elderly).
- Babies/children should not be allowed on work sites. Women should be encouraged to arrange for childcare with relatives, neighbors or in children-friendly spaces.

PSN: Persons with Special Needs
CfW: Cash for Work

HEALTH, SAFETY AND ENVIRONMENT

Supervision and safety inductions:

- Supervision: All works should be supervised by a technically qualified construction worker and each site must be overseen by a trusted foreman who knows safety procedures, has been trained for first aid and has access to a first aid kit.
- Safety induction: Provide a safety induction tailored to the task for all laborers, especially if they will be working alongside machines. Explain how to use tools and machines such as a generator or power drill. In high-risk sites (e.g. where there are machines, deep or fast flowing water, deep excavations or large soil retention activities), conduct a risk assessment and allocate a dedicated safety warden to monitor site safety and ensure no public access.
- Avoid overcrowding of sites: Only hire as many laborers as required for the task and provide sufficient space for them to work.
- Maintain tidy sites: Scattered materials and tools cause tripping hazards. Maintain clear separation of tasks and circulation routes when working alongside machines.
- Site closure and hazard signage: Prevent the public (especially children) from entering the work site using tape, rope and/or warning signs as appropriate. Discuss restricted site access and safety issues with the local community prior to starting work. Never leave deep excavations uncovered overnight.
- Excavations: In the case of soil instability, a qualified technical person should verify site safety. Sides of excavations, where volunteers/workers are exposed to danger from moving ground, should be made safe by sloping, shoring or other effective means.
- Deep water: Fence out from public or signal areas with steep drops; Whenever possible provide a safe access to water (steps or other). Provide rescue rope or sensitize communities around about the hazards.

Protective equipment and health considerations:

- All laborers should wear high-visibility vests;
- Use appropriate Personal Protective Equipment suitable for the construction task (i.e., gloves, goggles) and weather conditions
- All laborers should wear closed shoes (not sandals) when on a work site. Rain boots should be worn when working in wet conditions
- Laborers should wear a mask, gloves and boots when clearing drains
- Laborers should have access to shade and drinking water on work sites.

Monitoring of incidents:

A system for monitoring incidents in CfW and construction activities should be put in place. This will enable to record the incidents, to monitor what are the most common causes and to identify mechanisms to avoid them.

Health and Safety and Environment:

- Ensure proper management of construction waste and disposal;
- Solid waste generated from drainage cleaning should be transported/taken to the nearest solid waste management disposal facility;
- Do not incinerate waste in the camps
- Properly manage fuel/oil/chemical storage;
- Ensure dust management during dry weather condition;
- Minimize noise and vibration from construction machines.
- Waste management induction: provide general information on the waste management plan of the intervention and ensure proper measures/waste designated areas to store and avoid waste littering.

Suggested to use environmental project-level screening tools for DRR interventions such as Nexus [*The Nexus Environmental Assessment Tool (NEAT+) - Resources (eecentre.org)*]

HEALTH, SAFETY AND ENVIRONMENT

	High Risk Tools / Materials	Risks	Mitigation
Excavation	Spade, shovel, hoe, pick, etc.	Cuts & impact injuries	Safety induction Avoid overcrowding sites Ensure safe slopes
Deep Excavation	Latrine pits & similar	Falling & drowning	Use warning tape to secure area Cover pits over night Secure sites at night &/or provide a guard
Portering*	Bag, Bucket, Wheelbarrow	Back injuries	Max. load = 25 kg Share heavier loads Safe lifting training
Unloading	Heavy materials	Impact injuries from falling materials	Safety induction
Sandbag Works	None	Back injuries	Safety induction
Bamboo Works	Machete, saw, drill	Cuts	Clear Safety induction Remove cutting tools from anyone seen using them dangerously
	Unstable structures	Falling bamboo	Brace temporary structures
Brick Works	None	Dropping bricks on feet	Avoid overcrowding sites Wear shoes
		Brick dust in eyes	Wet brick chips
Concrete Works	Wet concrete	Alkali burns	Use gloves and boots (if standing in concrete) Provide water for people to wash hands
Reinforcement Works	Tie wire & sharp edges	Cuts & scratches	Wear gloves
		Trip hazards	Maintain clean sites avoid overcrowding

	High Risk Tools / Materials	Risks	Mitigation
Working at Heights	Ladders	Falling	Extra person to hold ladder Use scaffolding if possible No sarongs for people working at heights
	None	Falling tools or materials	Helmets for staff working below
Grinding Works	Hand grinder	Cuts	Wear gloves
		Eye injuries	Wear goggles
Working on Slopes	Loose fill	Tripping / Falling Ankle sprains Landslides	Avoid overcrowding sites Ensure safe slopes
Working in High Temperatures	None	Sun stroke & dehydration	Provide shade, water risk assessment and frequent breaks
Working Alongside Machines	Excavators, bulldozers, etc.	Running over feet, crushing against walls, etc.	Avoid overcrowding sites Maintain 'no go' areas around machines
Working Close to Water	Unseen hazards	Slips and falls Cuts from hidden objects	Safety induction Avoid fast flowing water Provide boots and gloves
	Deep or fast flowing water	Drowning	Avoid fast flowing water Use laborer who can swim near deep water Provide rescue rope
Clearing Drains	Dirty water	Slips Cuts Infections	Use mask, boots & gloves
Waste Management	None	Cuts Infections	Provide mask, gloves & overalls

**refer to Protection Sector guidance on portering*

MATERIAL QUALITY, FIELD TESTS AND DISPOSAL

BRICK

Colour	Uniform crimson red
Size	240 X 114 X 70 mm (Min 232 X 109 X 67 mm)
Shape	Sharp edge & plain surface
Sound	Knocking two bricks with each other should give metallic sound.
Nail Test	Should not have any fingernail impression upon scratching.
T-test	Should not break after dropping from 1.8 m (6') height, two bricks at T-shape.
Absorption	Water absorption by 24-h submerged condition in fresh water should not exceed 20% of dry weight. Water Absorption by 5-h Boiling should not exceed 22% [ASTM C62]. Supplier should submit certificate from reputed lab, not older than 3 months.
Strength	Min. 17.2 MPa (2500 psi) compressive strength; The manufacturer should provide test results from reputed laboratory, not older than 3 months.

BRICK CHIPS

Colour	Uniform crimson red
Size	20±3 mm down graded, conforming to ASTM C33. – Particles contents finer than 9.50 mm should not be more than 50%. – Particles finer than 4.75 mm should not be more than 10%.
Shape	Angular and cuboidal. Should not be flaky or spherical.
Hardness	Should not break under finger pressure
Cleanliness	Should be free from dirt, organic materials, debris, etc.

SAND

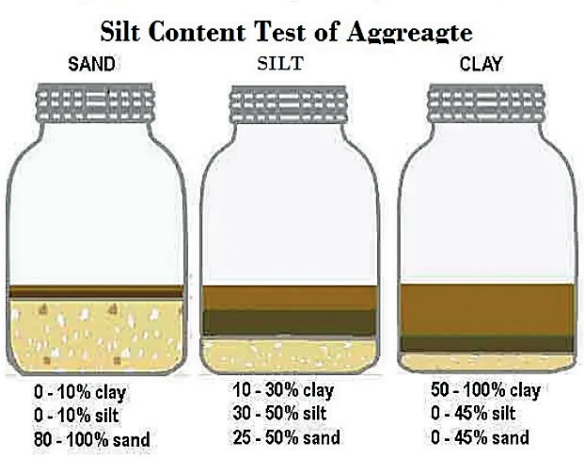
Colour	Should be yellowish brown. Black or grey colours indicate presence of deleterious material
Size	Should conform with ASTM C33. Min. Fineness Modulus (FM) 2.3. – 95-100% passing through 4.75 mm sieve. – 25-60% passing through 600 mm sieve – 0-10% passing through 150 mm sieve
Shape	Angular. Should not be spherical.
Cleanliness	Should be free from salt, dirt, organic materials, debris, etc.
Test of slit or clay	Take sand & water into a transparent container and stir it. After one hour of standing still, the cleanliness of top water will indicate the presence of silt or clay in the sample.

CEMENT

Colour	Uniform grey
Standard	Portland Composite Cement (PCC) conforming to ASTM C150 Type I or EN 197 CEM II, CEM IIIA or CEM IIIB, grade 42.5 MPa.
Smoothness	Should be free from grains or lumps
Packaging	Every packet should be in good condition, intact and dry, showing cement type, net weight, date of manufacturing.
Float test	If a small amount spread on water, it should float for some time before sinking.
Age	Cement should not be kept in bulk storage for more than 6 months or in bags in local storage in the custody of a vendor for more than 3 months.
Certification	The manufacturer should provide relevant certificates and test results from reputed laboratory, not older than 3 months.

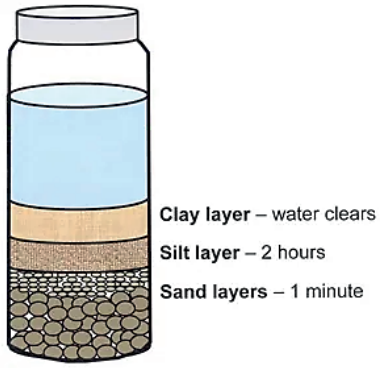
Field tests for sand

The test involves placing 50 mL of 1% solution of common salt water in a 250 mL measuring cylinder. Sand is added slowly until the 100 mL mark is reached. Further solution is then added to bring the level to 150 mL. The cylinder is then shaken and allowed to settle for 3 hours. If the thickness of the silt layer is less than 10% of the sand layer, the sand is classed as acceptable. [Gorse Christopher, David Johnston and Martin Pritchard. "field settling test". In A Dictionary of Construction, Surveying and Civil Engineering. : Oxford University Press, 2012.]



REINFORCEMENT BAR

	8 mm	10 mm	12mm	16mm
Colour	Uniform grey			
Appearance	Should be free from surface imperfections (i.e. include, but are not limited to, rust, laps, seams, scabs, slivers, cooling or casting cracks, and mill or guide marks, etc.)			
Diameter	8 mm (min 7.8 mm)	10 mm (min 9.8 mm)	12 mm (min 11.7 mm)	16 mm (min 15.7 mm)
Nominal mass	0.395 kg/m (min 0.364 kg/m)	0.617 kg/m (min 0.586 kg/m)	0.888 kg/m (min 0.844 kg/m)	1.578 kg/m (min 1.499 kg/m)
Strength	280 MPa (40 ksi) or 420 MPa (60 ksi). The manufacturer should provide test results from reputed laboratory, not older than 3 months.			
Bending test		180° bend around a pin of 35 mm diameter should not cause any crack on the outside radius [ASTM A615]	180° bend around a pin of 42 mm diameter should not cause any crack on the outside radius. [ASTM A615]	180° bend around a pin of 56 mm diameter should not cause any crack on the outside radius. [ASTM A615]
Deformation pattern	Hard / Soft	Max Avg deformation spacing 7.00 mm. Min Avg deformation height 0.40 mm [ASTM A615]	Max Avg deformation spacing 8.40 mm. Min Avg deformation height 0.48 mm [ASTM A615]	Max Avg deformation spacing 11.20 mm. Min Avg deformation height 0.72 mm [ASTM A615]



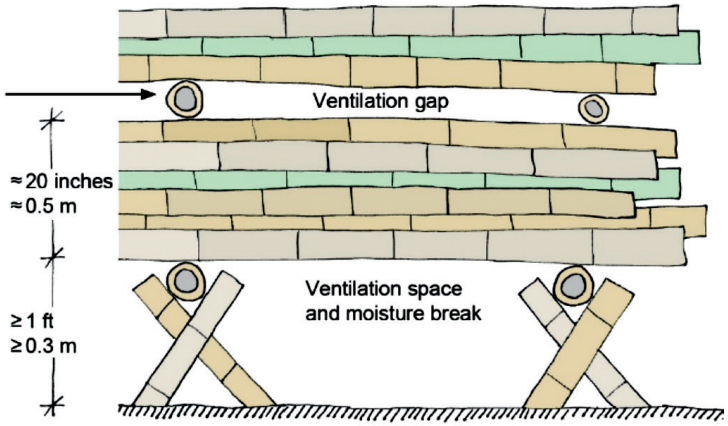
BAMBOO

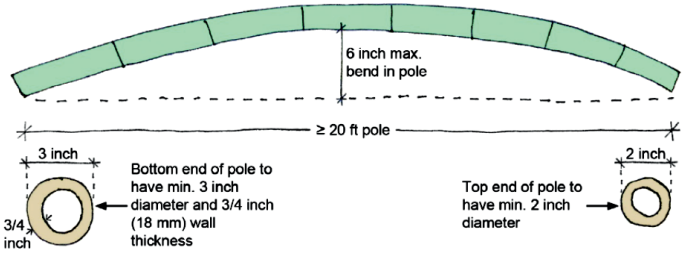
	Borak	Muli
Length	6 ±0.1 m (20 feet ±4 inch) ±5%	4.6 ±0.05 m (15 feet ±2 inch)
Diameter	−Top: 50 mm (2 inch) ±5% −Bottom: 90 mm (3.5 inch) ±5%	−Top: 30 mm (1.15 inch) ±5% −Bottom: 40 mm (1.5 inch) ±5%
Thickness (bottom)	20 mm (0.75 inch) ±5%	6.5 mm (0.25 inch) ±5%
Straightness	Maximum deflection 100 mm (4 inch)	Maximum deflection 50 mm (2 inch)
Quality	Naturally matured. Neither fully raw nor fully ripe/dry, insect free, no major defects and no protective sheath.	
Age	3-5 years	
Tolerance	Any batch should not have more than 5%bamboo failing these criteria	

- Bamboo with less than 3 years of growth should not be used for construction. It will be structurally weak and, when not treated, more susceptible to rot and insect attack than bamboo 3 to 5 years of age.
- If bamboo has a green surface it has usually been freshly cut. A green surface does not provide a reliable guide to the plant's age.

Bamboo surface texture at different growth stages (image sourced by K. Rowell)

Bamboo storage recommendations





Source: "Shelter/NFI Sector Technical Guidance: Bamboo Selection, Storage and Handling", December 2019

DISPOSAL OF MATERIALS

This section aims at providing guidance on the safe reuse, recycling and/or final disposal of old materials for environmental sustainability.

Reuse:

Materials in good condition: can be reused for other projects. For instance, damaged sandbags can be reused to collect waste.

Waste conversion

Bamboo: can be sent to the nearest material recovery facility (MRF). Please find a map of all mrfs here and make sure to coordinate with the nearest WASH partner before bringing the waste. Bamboo can also be made into biochar.

Bricks: broken bricks can be made into brick chips. The breaking of bricks into bricks chips is a good opportunity to engage female laborers as this activity can be done within the storage area.

Scrap metal: can be sold to scrap dealers in host community.

Concrete: can be crushed and used as aggregate to make new concrete (up to 30 percent should be mixed into the new mix) and as sub-base for roads and hard paved areas.

Recycling and safe disposal

Solar equipment: safe disposal of batteries and solar panels should be ensured, and partners should have a waste management plan for the disposal of broken and end-of-life electric equipment. Non-functional spare parts and batteries can be donated to scrap dealers with the condition that they reuse and recycle non-reusable parts.

PLEASE NOTE:

Partners should ensure proper management of waste to **avoid open dumping**. Partners should not burn or bury any waste. Partners should first check if local scrap dealers are interested in collecting the items: *https://tudealersassociation.com/contact-us/*. The sanitary landfill (Camp 20 ext) should be used as a last resort for disposing of residual waste.

Sorting different materials **on-site** is key to enabling recycling and re-use. Brief induction on waste best practices to workers is advisable.

For more technical information on Solid Waste Management practices see the WASH Sector SWM Strategy (6th Draft, September 2021)

DRAINAGE

DRAINAGE STRATEGY

Guiding principles

1. Always consider the full network

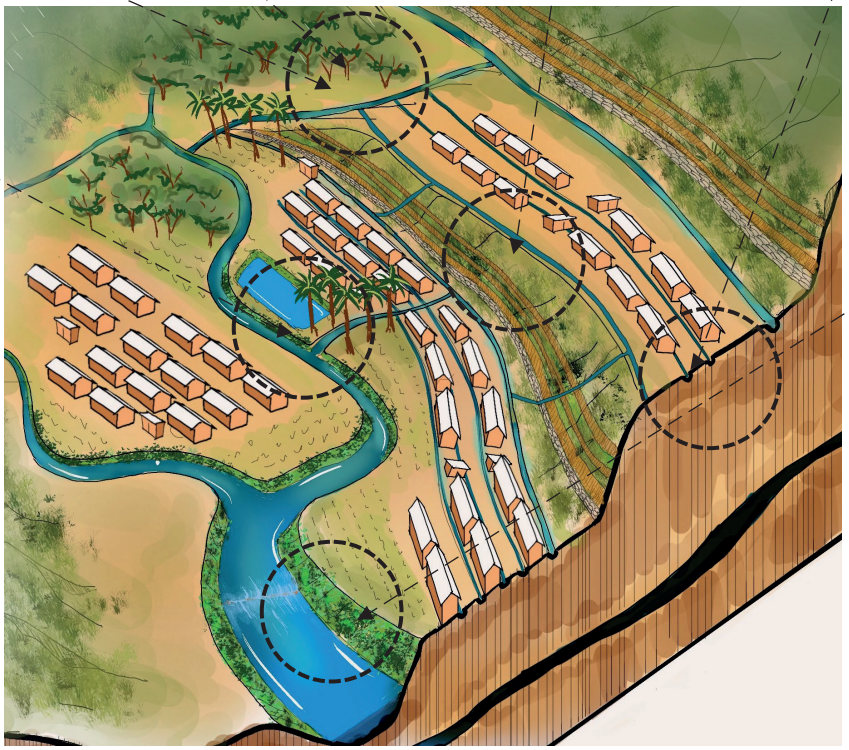
Do not design drainage components in isolation. The drainage network must be considered as a whole, with connected drains from source to outlet. Drainage capacity should increase as you move downstream. Ensure your intervention does not cause problems downstream.

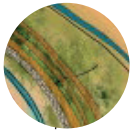
2. Slow water down and promote infiltration

- Flooding downstream is caused by quick run-off upstream.
- Maintain a gentle slope in all drains and avoid drains running straight down slopes if possible. Run drainage along contours to make sure that drainage has manageable gradients.
- Use check dams or steps on steep drains.
- Store water upstream using retention basins or ponds.
- Allow unpopulated valley floors to flood.
- Promote infiltration and ground water recharge.

3. Water quality and infiltration

- Promote infiltration to avoid stagnant water.
- Separate grey water (from bathing & laundry areas) from main drains.
- Use infiltration drains for bathing & laundry spaces.
- Plant in drains and along edges to clean water.





4. Prevent surface erosion

- Silt washes off exposed slopes and blocks drains downstream.
- Plant grasses on exposed slopes to protect the surface.
- Use jute or geotextile roll to protect exposed soil if there is no time for grass to grow before monsoon.
- Use catch/ridgeline drains connected to discharge drains to prevent water flowing over the hill face.

5. Use robust brick & concrete drainage in densely populated areas on steep slopes

- Brick/concrete drains are easy to clean and provide maximum capacity in congested areas.
- Robust drains prevent scouring and erosion.

6. Promote sustainable solutions

- Use flexible infrastructure (not brick and concrete, which cannot accommodate ground movement) where possible, e.g., in open valleys.
- Plant vegetation along embankments. Grass planted drains or swales are durable, cheap, slow water down, and allow infiltration (reducing flow volume).
- Brick/concrete drains speed up water flow which can increase flooding downstream and when used in flat areas create stagnant water in the dry season.

DRAINAGE STRATEGY

Drainage elements:

- Primary drains: drains the water out of the secondary valleys; connects to a main valley drainage or canal.
- Secondary drainage: drains water down the hill; connects the household drainage to the valley drainage;
- Tertiary drainage: drains the household plots;

Other components:

- Ridgeline drains
- Cascade drains
- Silt trap
- Retention pond
- Waste trap
- Micro soak pit

Tertiary drainage

Household level drainage (done by shelter or site improvement).

Options include:

a. Open: Geo-tube/Geo-bag

b. Moderate: Bamboo & Geo-textile

c. Congested: Masonry

Secondary drainage

Options include:

a. Open: Unlined earth

b. Moderate: Geo-tube/Geo-bag

c. Moderate: Bamboo & Geo-textile

d. Congested: Masonry

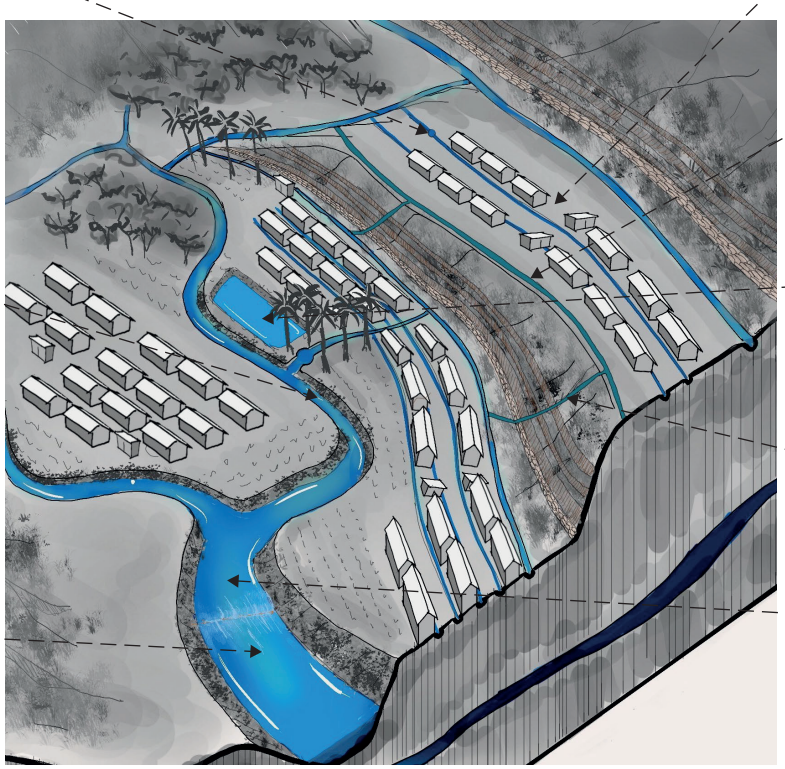
Primary drainage or canal

Options include:

a. Open: Unlined earth

b. Moderate: Geo-tube/Geo-bag

c. Congested: Bamboo & Geo-textile



Micro soak pit

To promote infiltration, recharge of underwater reservoirs and water cleaning.

Ridgeline/catch drain

To catch the water from the surface and allow safe passage through cascade drain.

Retention pond

To promote ground water recharge, improves water quality, provide livelihood opportunity, etc.

Cascade drain

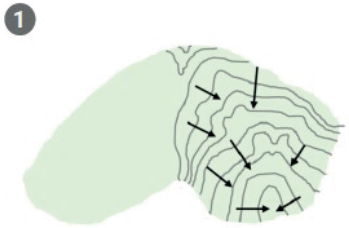
To safely discharge water to the valley form top of the hill.

Silt trap

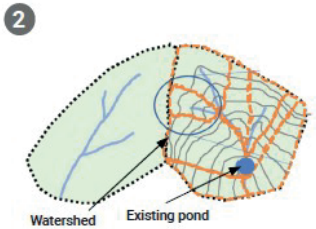
To trap the silt at an easy-to-clean location and prevent loss of depth and clogging due to siltation in the down stream.

DRAINAGE STRATEGY

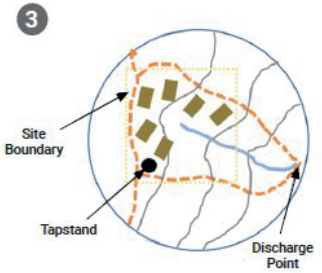
Drainage hierarchy and capacity estimation



1. Identify the topography and contours and flow paths. Flow paths should be directed at 90° from contour lines.



2. Identify existing natural and man-made drainage components and the catchment (black dotted line) and the sub-catchments (orange).



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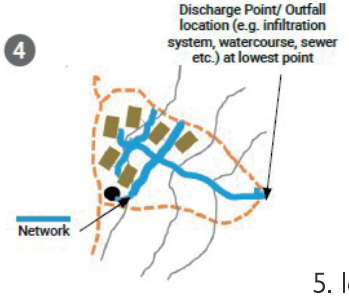
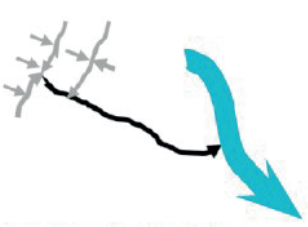


4. Identify the drainage network (if all the water cannot be prevented or used at the source.



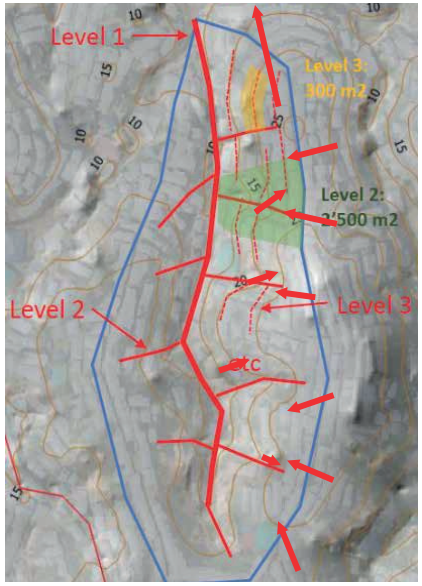
5. Identify hierarchy of the drains:

Tertiary (grey) – neighborhood level

Secondary (black) – running past the site into which the tertiary side drains discharge

Primary (blue) – a large drainage canal, stream or river into which secondary drains discharge.

Source: ARUP Surface Water Management guide



Drainage positioning:

Tertiary drainage (level 3): around plot with main drain along the hill side; plan for 1% slope to maintain flow but minimize velocity; water from roofs should fall directly into the drainage, not onto the slope

Secondary drainage (level 2): follows topography as much as possible: along contours in open areas, or down ravines or alongside stairs in built-up areas; collects all level 3 drains on the way down; water needs to be slowed down (e.g. use steps or check dams); no borders above ground on the sides of the drains

Primary drainage (level1): follows the lowest line of the valley floor; collects all level 2 drains on the way out of the valley.

Some typical figures (to be adapted to local context)

Rain intensity:

0.5 mm/min for short time intervals (up to 3 hours)

Level	Catchment area (sq. m)	Min. Section size (m)	Flow capacity (L/s)
Tertiary (level 3)	150 – 300 (5 – 10 plots)	0.30 X 0.30	5 – 10
Secondary (level 2)	1,000 – 3,000	0.45 X 0.45	40 - 80
Primary (level 1)	10,000 – 30,000	1.20 X 1.00	300 – 600

Consider exceedances

what happens if the capacity is exceeded?

High impact/risk (e.g. culvert with housing upstream) – oversize component with a safety factor

Low impact (e.g. valley drain surrounded by community gardens) – no need to oversize.

FLOODING RISKS

Flood Hazard .06 to 0.5m. It is possible for facilities and shelters to be constructed in these areas with plinth, raised access and well-designed drainage if the correct mitigation measures are taken.

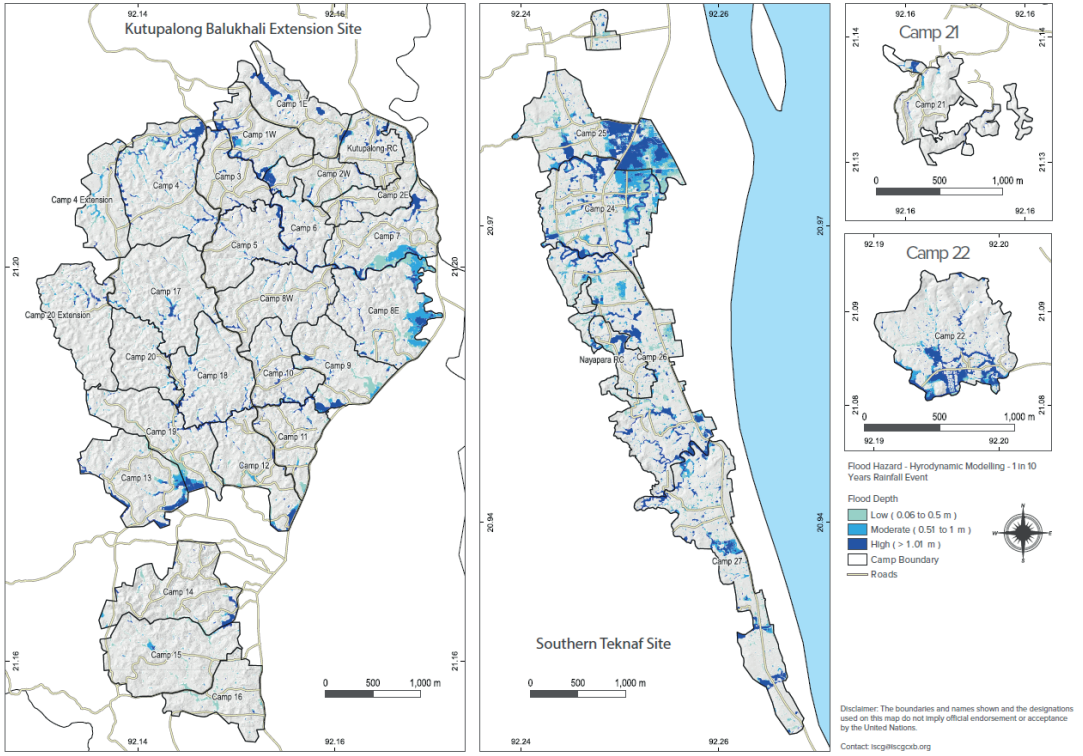
Flood Hazard 0.5-1m and Flood Hazard >1.0m. It is not recommended to construct shelters or facilities in areas of moderate and high risk. Major mitigation measures must be taken in case of using these areas.

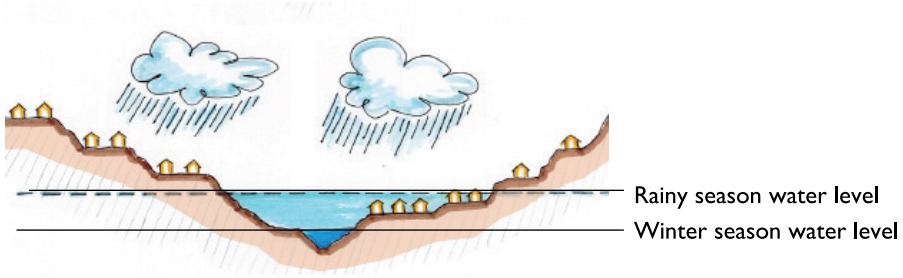
In general, building shelters or facilities in all areas that are in or around potential flood hazard areas should not proceed until the advice of a site planning/site development agency (UNHCR/IOM) has been sought out, and a comprehensive risk assessment carried out.

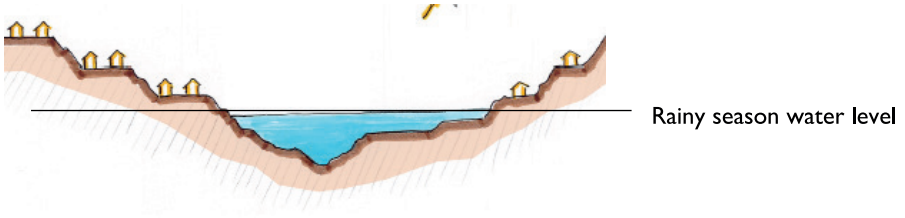
While doing the site assessment for flood prone area community feedback needs to be taken regarding the past years flooding condition. Since there is frequent changes in the built environment the geo spatial analysis is not always accurate. Shelters or facility should consider the monsoon season water level.

Map Source:
https://www.humanitarianresponse.info/en/operations/bangladesh/infographic/coxs-bazar-natural-hazard-products-2022

For more information on camp level flooding see the camp wise flood hazard maps (July 2022) developed by SMSD Sector, Shelter Sector and EETWG.







SELECTION PRINCIPLES

Category	Type / Material	Time to build	Skilled labor	Construction cost (material ---- CfW)	Annual Maintenance costs	Recommendations
Primary (dimension used for calculation:1.2 x 0.9 m or 47" x 35")	Natural drain	+	+			Where space is available
	Geo-tube embankment	++	++			If not enough space for earthen drain, but enough for geo-tubes
	Geo-bag embankment	++	++			
	Bamboo & geo-textile	++	++			If not enough space/time for geo-tubes
Secondary (dimension used for calculation :0.8 x 0.7 m or 32" x 28")	Natural drain	+	+			Where space is available
	Geo-tube embankment	++	++			If not enough space for earthen drain, but enough for geo-tubes
	Geo-bag embankment	++	++			
	Bamboo & geo-textile	++	++			If not enough space/time for geo-tubes
	Masonry & CC base	++++	++++			Suitable for congested area
Tertiary (dimension used for calculation: 0.5 x 0.5 m or 20" x 20")	Bamboo & geo-textile	++	++			
	Masonry & CC base	++++	++++			Suitable for congested area
Ridgeline drains						Depending on technique used and location – reference for tertiary drainage can be used
Cascade drains & drains along stairs						Depending on technique used and location – reference for tertiary drainage can be used
Silt trap	Jute bag & earth filling					Plant along banks
	10" x 4' Brick wall w. earth base					Not cost effective
Retention pond						To avoid flooding downstream
Waste trap						
Micro soak pit						Laundry points and bathing areas.

Where more "+" sign indicates more resources required. Dimensions used for drainage hierarchy are estimated for reference cost calculation purposes only.

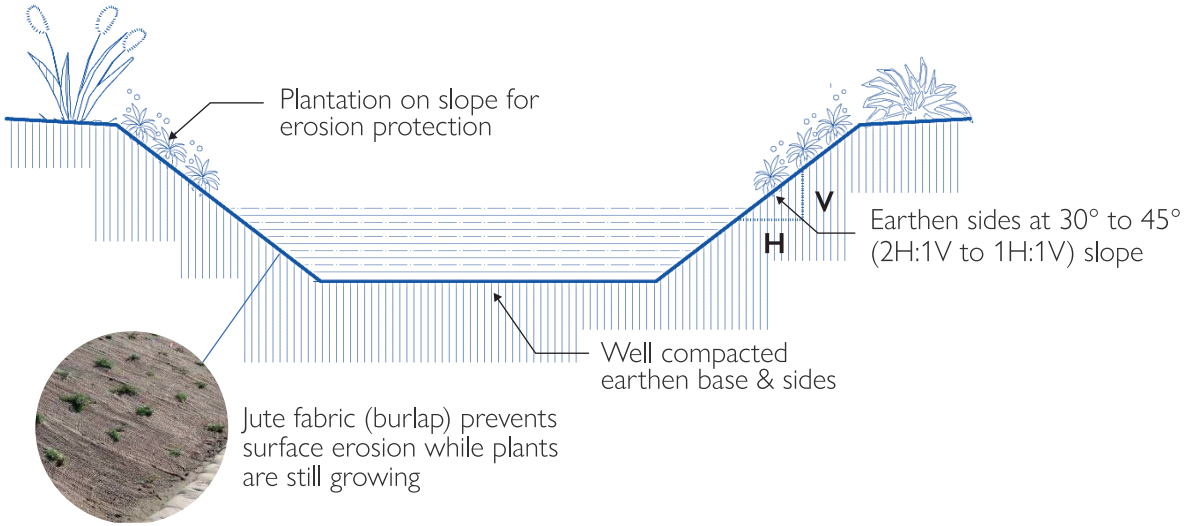
Reinforced concrete (RC) drainage are more durable but not suitable for camps.

Material cost CfW cost Annual maintenance cost

**construction (CfW / material ratio) and maintenance costs shown as relative proportions for prioritization purposes. Actual costs are subject to filed assessment and field conditions.*

NATURAL DRAIN WITH RIPARIAN RESTORATION

Riparian restoration is recommended for primary canals where space is available, low gradient, slow water flow with reduced erosion risk. It is the most cost effective and environmentally sustainable technique.



Natural canal

Riparian plantation

Benefits

- √ Low-cost and nature-based technique.
- √ Simple implementation, no need any skilled worker.
- √ Earthen base and sides promote infiltration and ground water recharge.
- √ Increase water filtration and improve ecological condition.

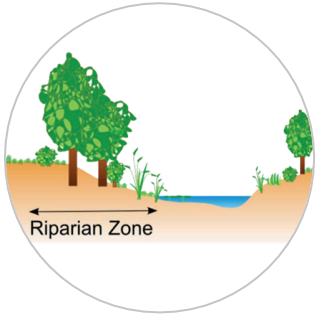
Drawbacks

- × Unsuitable for congested area.
- × Earthen base and sides have the risk of siltation and erosion.

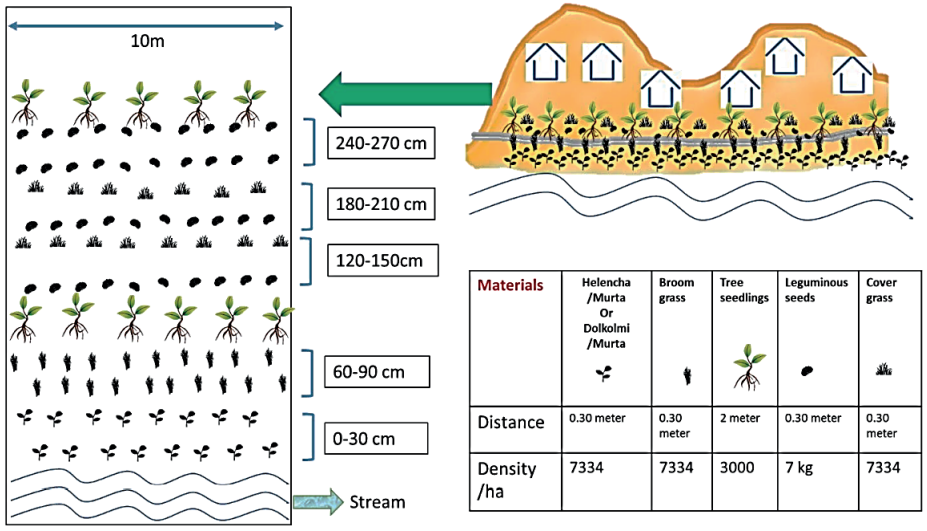
For more technical information, see pp. 21-25 of the EETWG and FAO Technical Specification for land stabilization & Greening in Cox's Bazar south forest division (updated December 2021)

PLANTATION FOR RIPARIAN RESTORATION

For reducing siltation and bank erosion considering the congested settlement, special focus should be given to both banks of the riparian areas. The main canals in the camps should be restored and protected using nature-based solutions which include riparian plantation.



Tree Species	Jarul (Lagerstroemia speciosa), Kadam (Neolamarckia cadamba), Bandorhola (Duabanga grandiflora), Vadi (Lannea coromandelica/ Garuga pinnata), Bura (Macaranga dendiculata), Barun (Carteva magna), Pitali (Mallotus nudiflorus), Pitraj (Aphnamixis polystachya), Kainjol Vadi (Bischofia javanica), Kerong (Pongamia pinnata), Chalta (Dillenia indica), Hijol (Barringtonia acutangula).
Leguminous Species	Pigeon pea (Cajanus cajan), Sesbania (Sesbania bispinosa), Tephrosia (Tephrosia candida).
Grass Species	Bermuda grass (Cynodon dactylon), Chapra grass (Stenotaphrum secundatum), Ulu grass/Pahari Kash. (Saccharu arundainaceum), Broom grass/Tiger grass (Thysanolaena maxima), Bamboo (Melocanna baccifera, Bambusa nutans).
Water Herb	Helencha (Enydra fluctuans), Dhol Kolmi (Ipomoea fistulosa), Murta/Patipata (Schumannianthus dichotomus).



Materials	Helencha /Murta Or Dolkolmi /Murta	Broom grass	Tree seedlings	Leguminous seeds	Cover grass
Distance	0.30 meter	0.30 meter	2 meter	0.30 meter	0.30 meter
Density /ha	7334	7334	3000	7 kg	7334

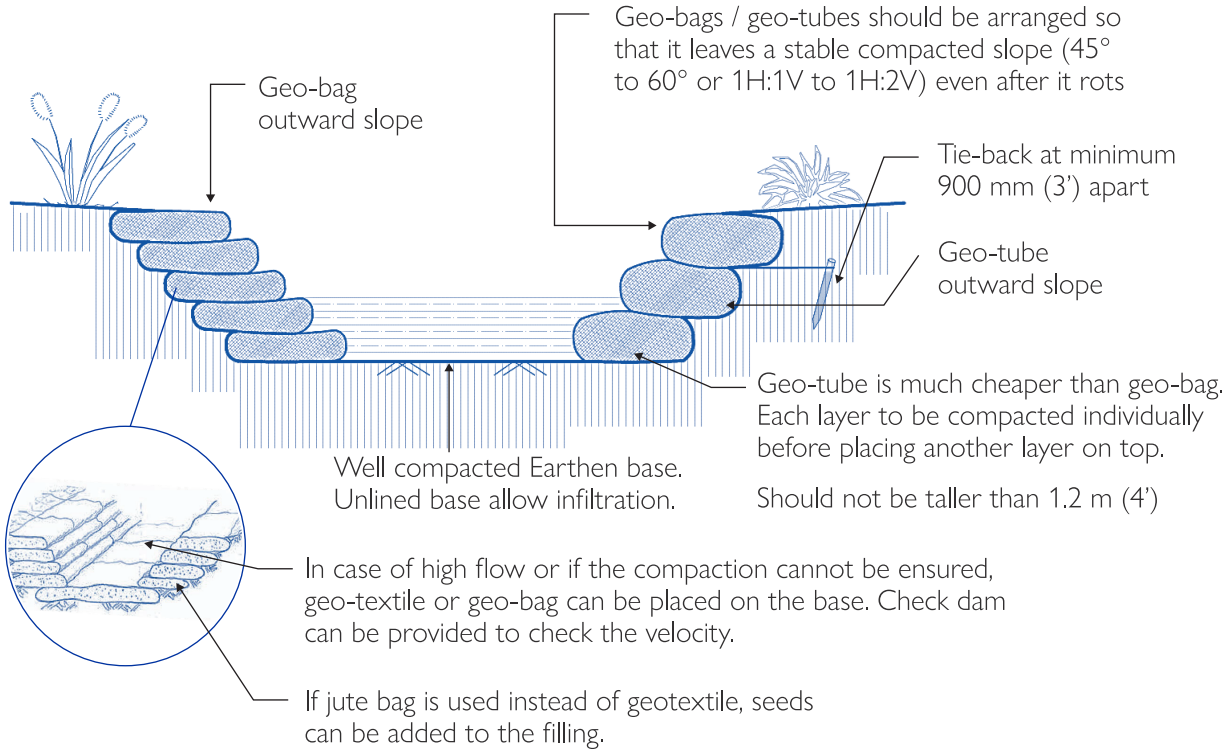
ALL plantation should follow approved Forest Department list of species (found here).

ALL plantation should be done in coordination with the EETWG and within the recommended season.

Source: FAO Technical Specification for land stabilization & Greening in Cox's Bazar south forest division (updated December 2021)

GEO-TUBE EMBANKMENT DRAIN

Geo-tube embankment is suitable for primary canals where not enough space for riparian restoration and secondary drains where space is available. Earth base is for low gradient, slow water flow with reduced erosion risk.



Geo-tube drain

Geo-bag drain

Benefits

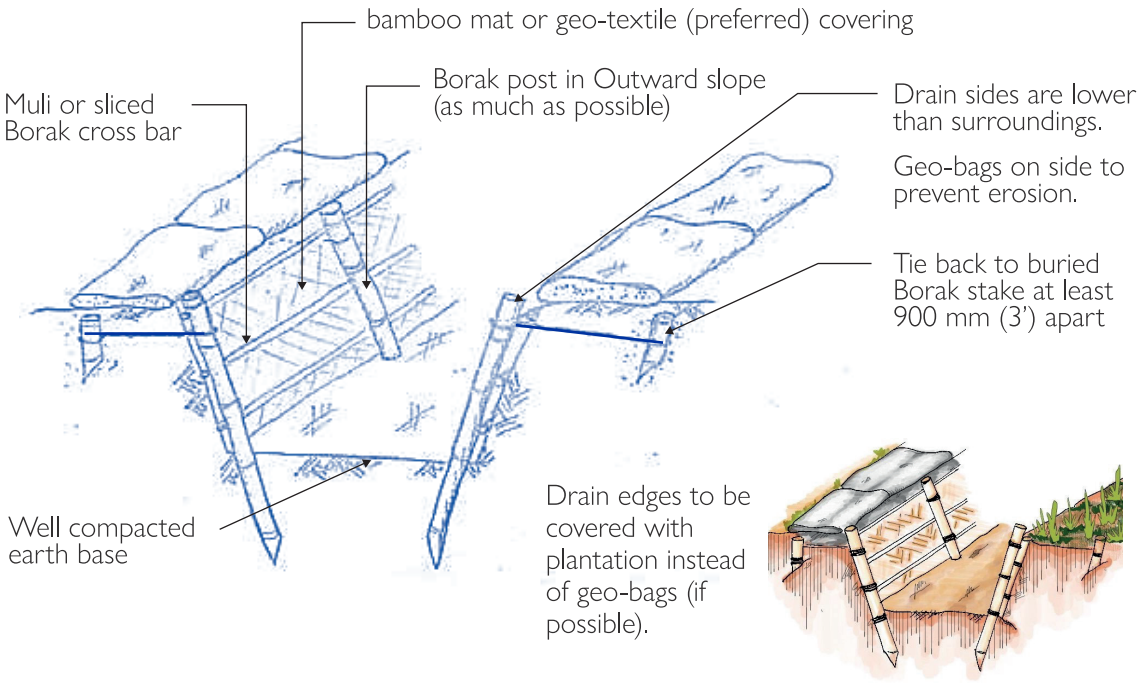
- √ Low-cost and simple technique
- √ Flexible structure (no brittle failure)
- √ Earthen base promotes infiltration
- √ If coupled with plantation, can sustain with little maintenance

Drawbacks

- × Unsuitable for congested area
- × Earthen base have the risk of siltation and erosion

BAMBOO DRAIN

Bamboo can be used for all three drainage types. Due to the limited durability of this type of drainage it should only be used in a limited manner and only in emergency situations.



Benefits

- √ Low-cost and flexible (no brittle failure)
- √ Allows infiltration
- √ Faster to implement
- √ Can plant on drain edge
- √ Sustain longer if geo-textile is used on the drainage wall together with bamboo?

Drawbacks

- × Bamboo needs frequent replacement

Bamboo drain

Option: Borak bamboo walkway above drain (N.B. use borak in cross direction) Efficient use of space but increased cost

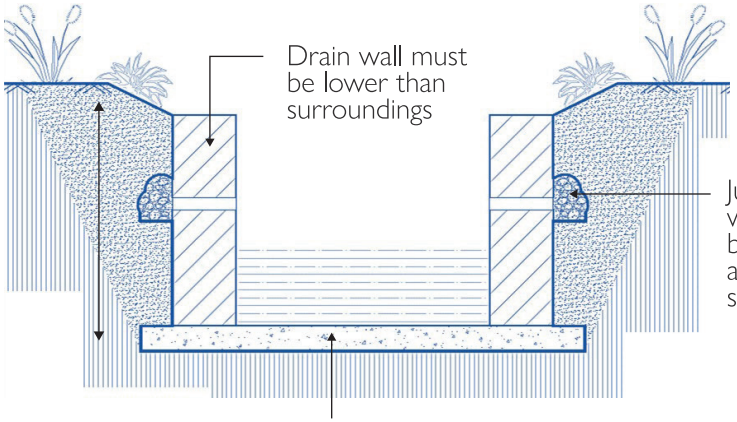
MASONRY DRAIN

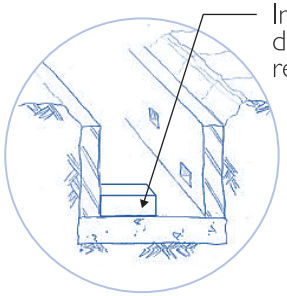
Masonry drains are suitable in congested areas, where natural materials cannot be used. Masonry wall can be combined with earth or plain concrete (CC) or brick & screed base. The drain walls must be designed and constructed following the rules of retaining wall.

Option 1. Max. 450 mm (1.5') height for single layer brick wall.

Option 2. Max. 750 mm (2.5') height for double layer brick wall.

Taller walls to be deigned as retaining wall.



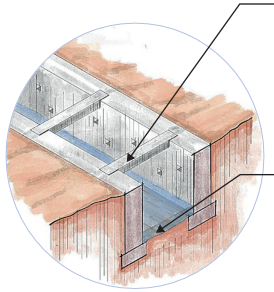


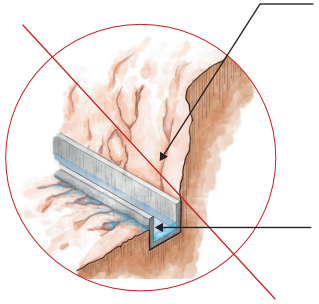
Option 1: Min. 75 mm (3") concrete base on compacted earth

Option 2: Brick base on compacted earth and 25 mm (1") cement screed on brick

These options are NOT economical above 1.5 m (5') width (another drainage design should then be used)

Option 3: Earthen base if the flow velocity is low





Common mistakes

Benefits

- √ Less maintenance required and easy to clean.
- √ Earthen base promotes ground water recharge
- √ Plain concrete (CC) or brick-screed base are easy to clean

Drawbacks

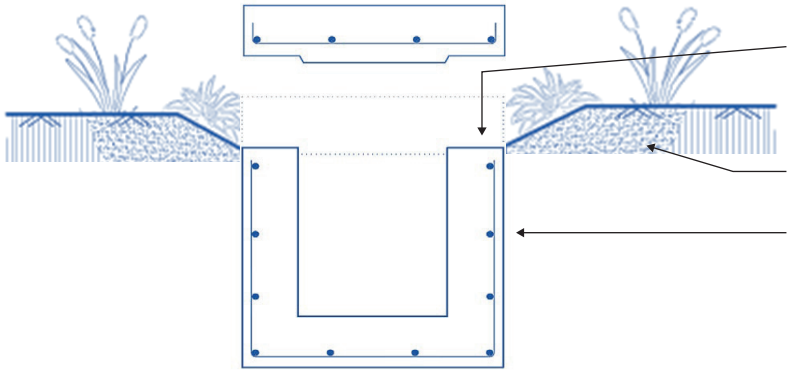
- × Difficult and expensive to construct & repair
- × Brittle structure, very weak to base settlement
- × Earthen base has the risk of base erosion & siltation
- × CC or brick-screed base have the risk of flooding downstream due to no infiltration & high flow velocity

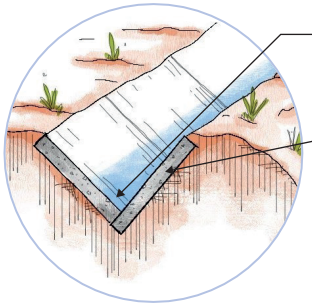
Drain with stepped masonry wall and cross beam

Drain wall height according to the height of surrounding ground and grass covering

PRECAST CONCRETE DRAIN

Pre-cast reinforced concrete (RC) drain can be built using pieces of different sizes and shapes. Suitable for Road-side or cross drains of vehicular road, along ridge-line as catch drain and any location where on-spot construction is challenging.





Precast concrete drain designs. Available from SMEP.information@gmail.com

Benefits

- √ Long service life with little maintenance
- √ Fast installation and little on-site work
- √ Casting yard allows better quality control and deployment of workers from vulnerable groups
- √ Reusable after decommissioning

Drawbacks

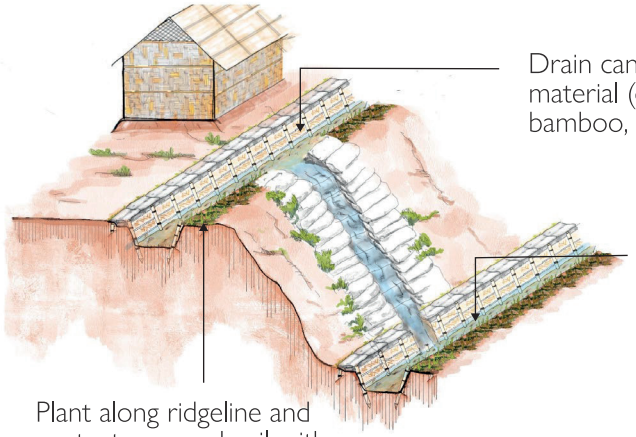
- × Needs skilled workers and high material cost
- × No infiltration & high flow velocity poses risk of flush flood in downstream

V-drain alongside pathway

RIDGELINE (CATCH) AND CASCADE DRAIN

Drains along the ridgelines prevent the water running over the ridge and down hill-face. When placed along the edge of hilltops or terraces, the ridgeline drains prevent water flowing down hill-face. It is important to connect the ridgeline drains to the discharge drain such as steep drain down hill-face (to connect hilltop drains to valley floor).

Cascade drains are suitable in landslide prone hill areas. Elements to reduce the speed of water to be incorporated as high flow velocity causes erosion and will damage the cascade drain.



Benefits

- √ Support drainage system
- √ Prevents water accumulation and provide safe passage of storm water
- √ Reduces soil erosion

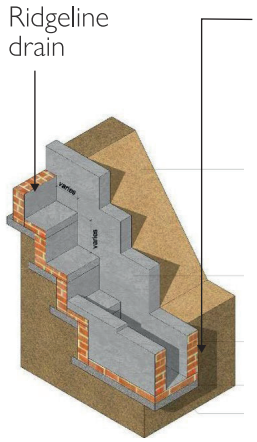
Drawbacks

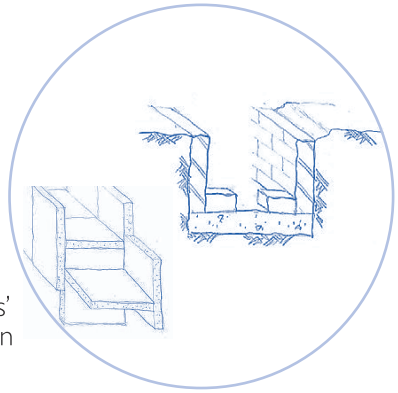
- × Expensive
- × Regular maintenance to ensure proper functionality
- Labour intensive – skilled labours are required (for cascade drains)

Drone image showing catch drain (red) around hilltop shelters, connected to cascade drains (dark blue) at intervals

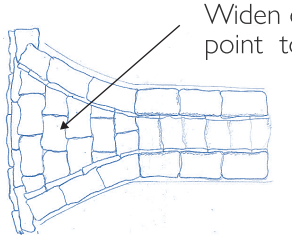
Combination of ridge line and stepped to slow down the flow

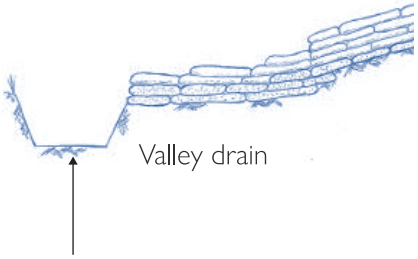
Rigid structures often collapse in such applications, flexible materials (i.e. bamboo, tarpaulin, etc.) are preferred

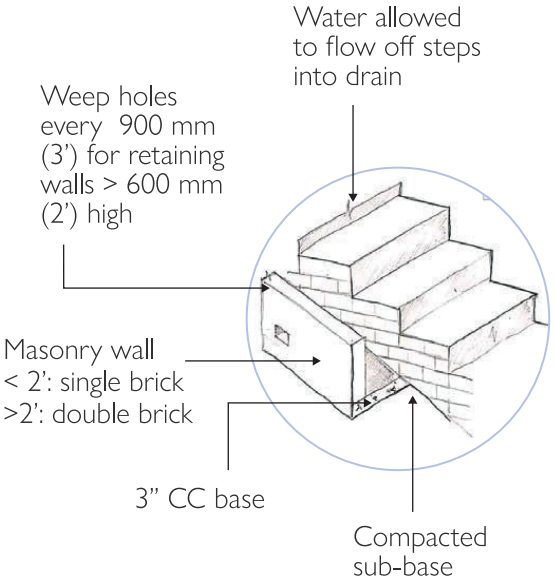




Drainage along stairs – similar to cascade drain in terms of water speed reduction



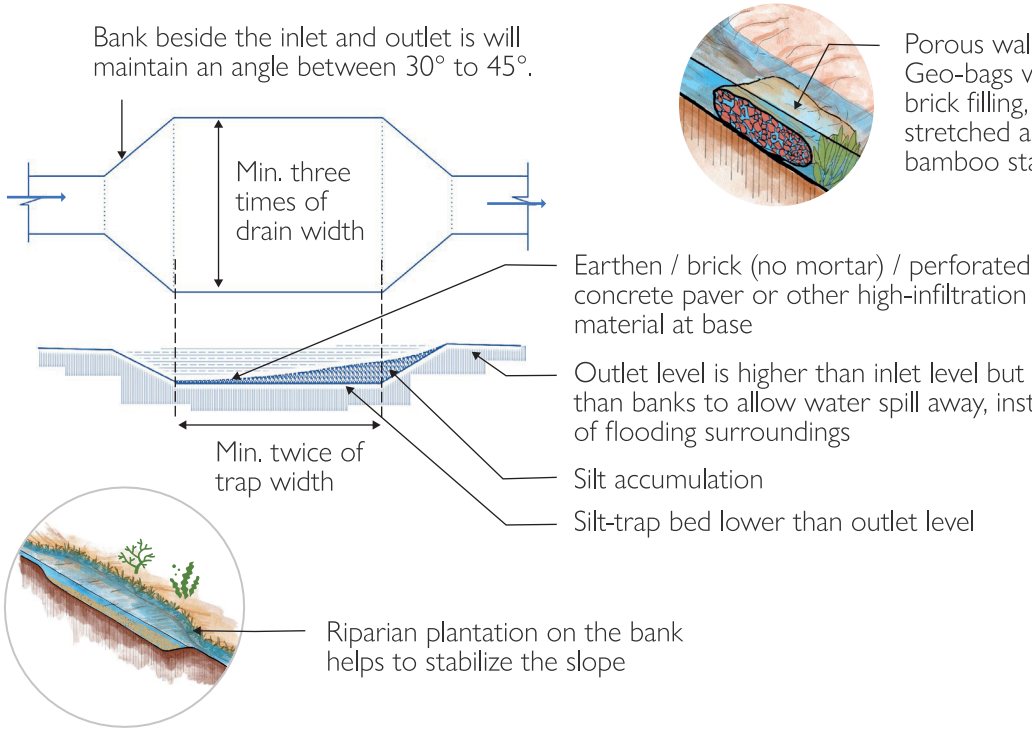




Brick and CC cascade drain

SILT TRAP

Silt traps are designed to slow down water flow and deposit silt. Suitable for any location with available space along the drain, preferably before of or in combination with culverts, as siltation often blocks the opening. Different techniques can be used for different locations depending on the volume of silt expected (related to the catchment of the drain and erosion in the area) and on the space availability.



Benefits

- √ Prevents culverts from being blocked with silt
- √ Allows desilting at one location instead of total drain length
- √ Collected silt can be used for construction infill
- √ Traps waste and allows infiltration
- √ Reduces the water speed

Drawbacks

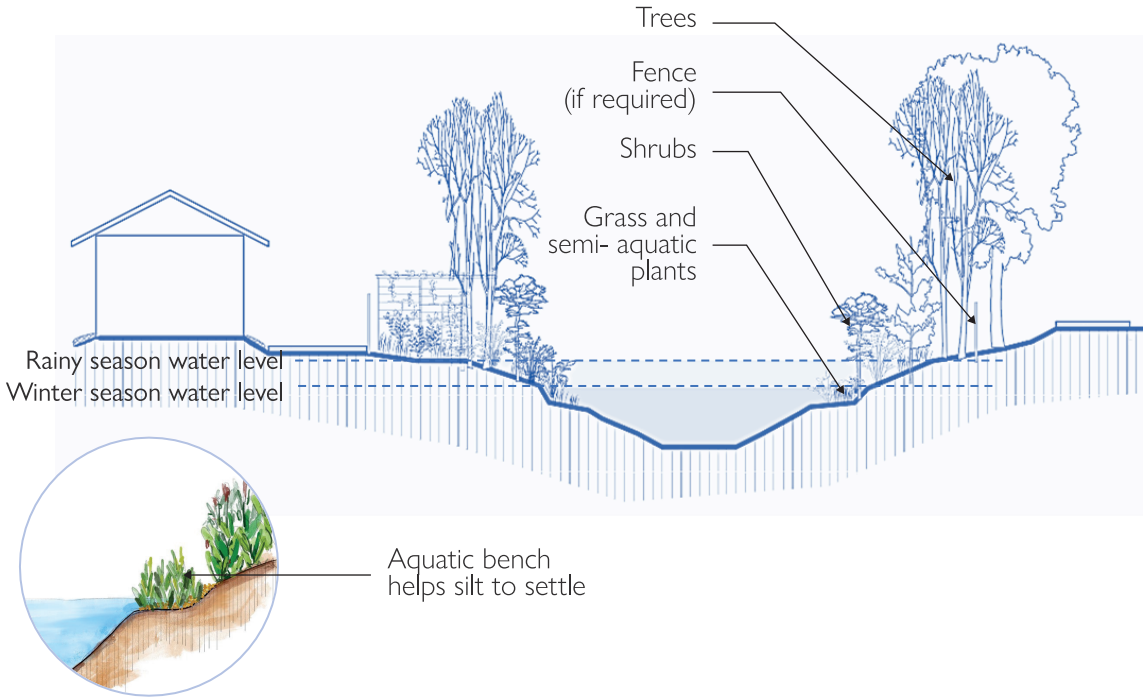
- × Occupies a significant amount of space
- × Without regular cleaning, it may become hazardous to human health
- × Additional cost

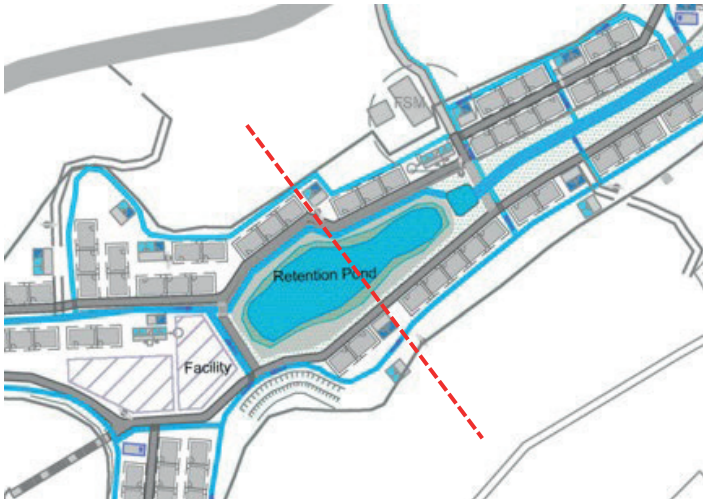
Silt trap with natural materials

Earthen-base masonry silt trap

RETENTION POND

Creating retention ponds in natural basin to flood unpopulated area enables to protect congested downstream areas. Suitable for unpopulated valley in the upstream to hold the water in the event of intense rain.





Benefits

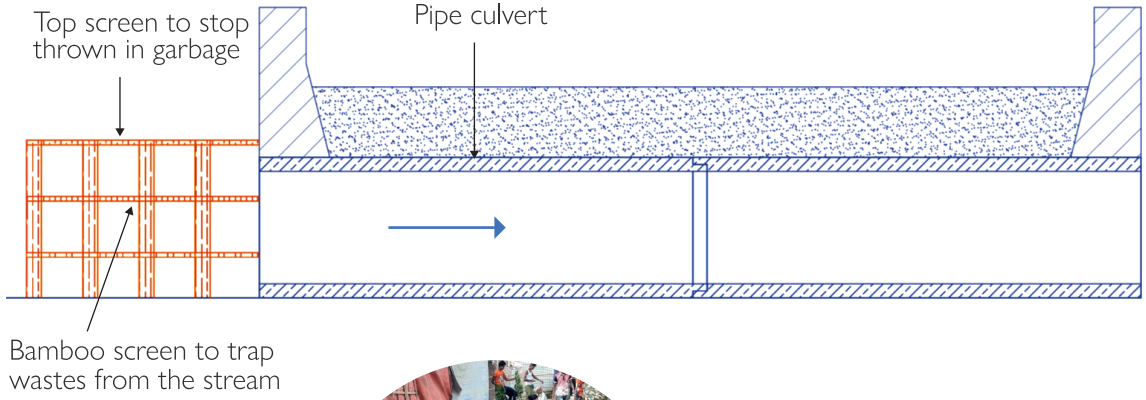
- √ Low-cost solution
- √ Promotes infiltration and aid ground water recharge
- √ Provides livelihood opportunities like fish culture, irrigation for household gardening, etc.
- √ Very effective in protecting downstream localities
- √ Trapped silt can be used as filling material

Drawbacks

- × Annual maintenance required
- × Dam failure may cause sudden flood
- × Ineffective without proper land use plan

WASTE TRAP

Waste traps are designed to trap waste at an easy-to-clean location of a stream and avoid blockage at undesirable locations (i.e. inside pipe culverts, etc.) and limit waste in drains downstream and outside of the camps.



Nets can be placed to trap the waste falling directly on the drainage

Note: Make sure not to remove green/natural vegetation unless it is blocking the flow of water while cleaning the drainage.

Benefits

- √ Accumulates wastes at a defined location, makes it easy-to-clean
- √ Prevents blockage of stream

Drawbacks

- × Without regular cleaning, it may itself cause unwanted blockage
- × Too much waste can cause waste trap to break

Drainage Cleaning

The care and maintenance of drains in the camps is the responsibility of Site Development partners who coordinate and perform the drainage cleaning activities at camp level. WASH partner also contribute significantly to the drainage cleaning efforts. Similarly, in case of fire, debris removal is the responsibility of SD partners.

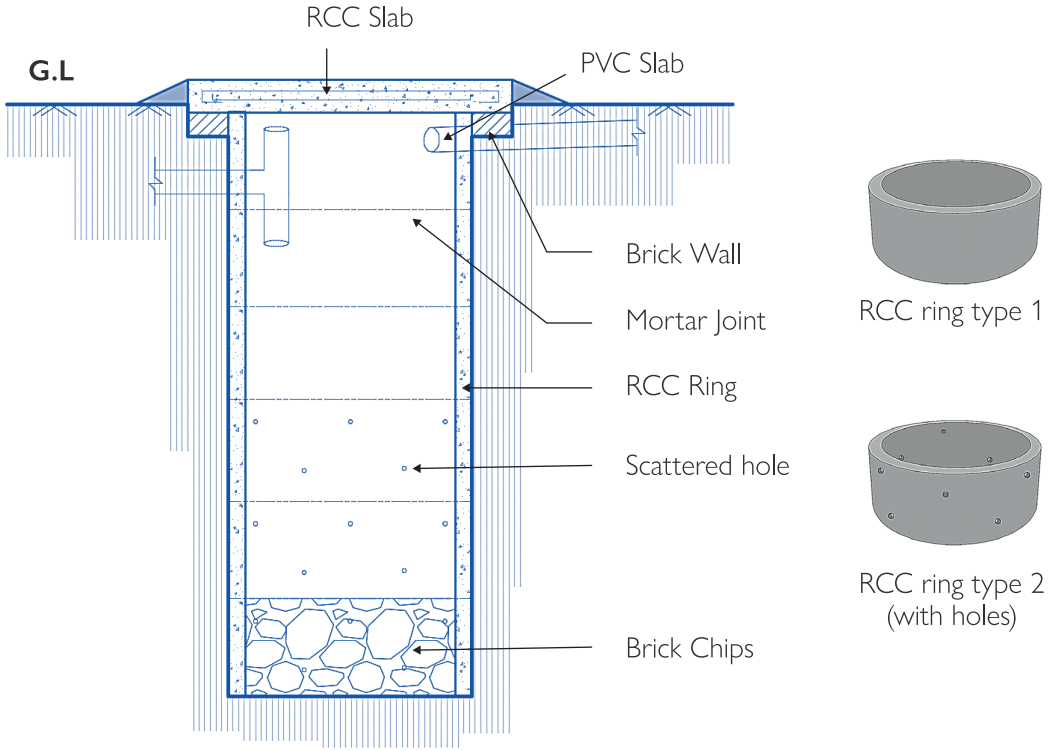
All partners performing drainage cleaning must ensure that the adequate tools and PPE are provided to the labors.

Once the waste is taken out from the drains and separated from the silt and sand, WASH partners in the camps are responsible of the handling of the waste and its safe disposal. The silt can be used in backfilling for site improvement activities.

Bamboo waste trap installed to avoid the blockage of the pipe culvert

MICRO SOAK PIT

Micro soak pits allow the infiltration of grey water and avoid the creation of mud in non rainy season. Suitable location for micro-soak pits are communal kitchen, laundry points, bathing facilities, etc.



RCC ring type 1

RCC ring type 2 (with holes)

Benefits

- √ Reduction of standing water in laundry points and bathing areas.
- √ Discharge partially treated or non-harmful water into the surrounding soil.
- √ Promotes ground water recharge.

Drawbacks

- × Difficult in cleaning if filled with silt or waste.

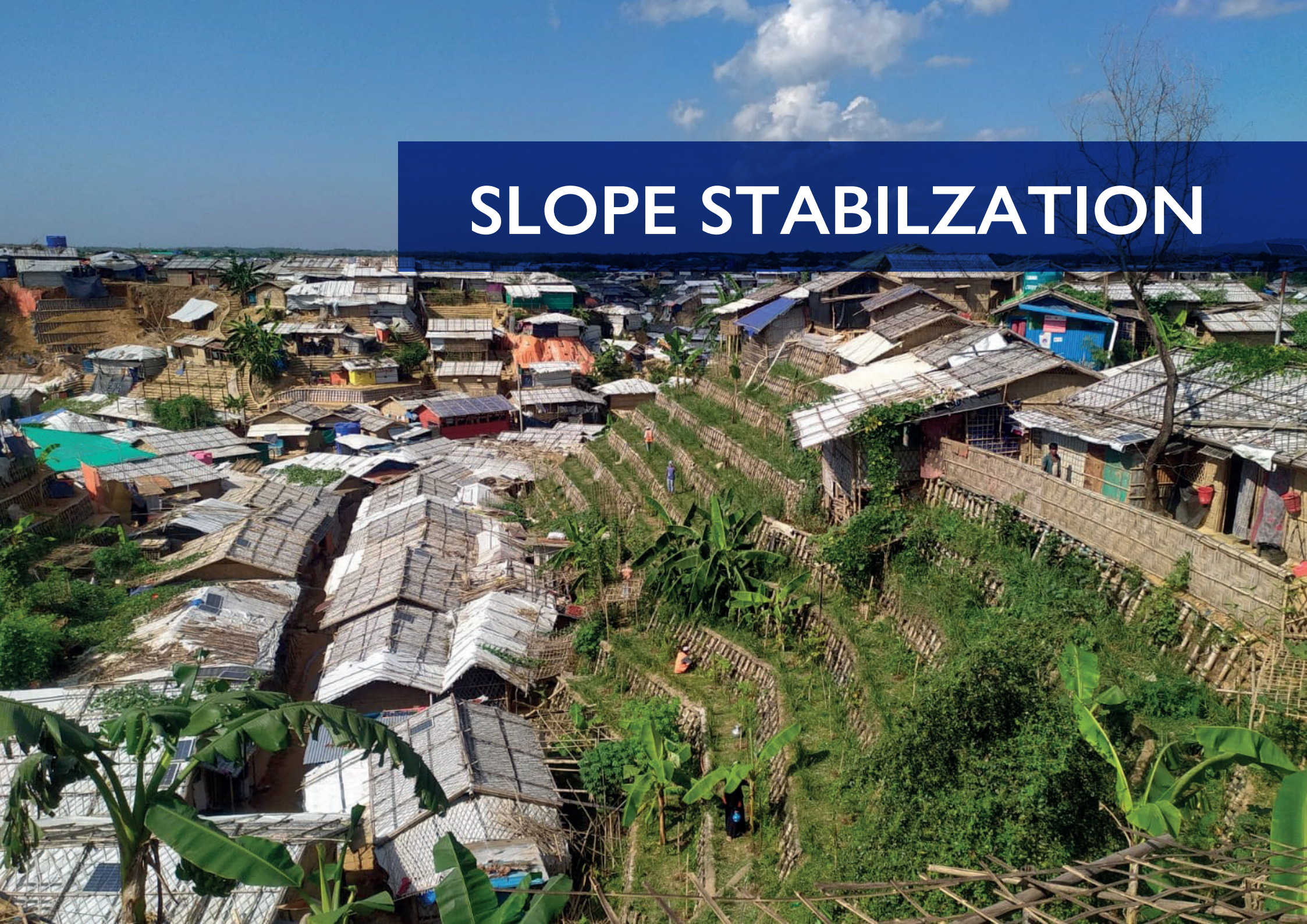
PVC pipes are often used to channel household level washing water over slopes. It is important to ensure that erosion is avoided at the dripping point (the end of the PVC pipe) is protected with tarpaulin or geotextile and drop-point is reinforced.

Nature based solutions (Nbs) are not about the materials and tools we use but about how we use them to restore ecological processes affected by human and climate change impacts.

When designing a Nbs it is important to understand how it addresses an issue as well as how it will improve ecological processes and contribute to the natural stability. For example, when stabilizing a slope using a bamboo crib wall, it is important to consider how to improve the soil used for backfilling so it supports a variety of plants and ensuring that the profile of the slope can be stable in the future through plantation.

In this case, the bamboo crib wall could be considered an engineering solution supporting Nbs, i.e., the soil improvement which will encourage and support healthy plant root growth to stabilize soil and vegetation growth to reduce the impact of the rain and runoff on the soil.

SLOPE STABILZATION



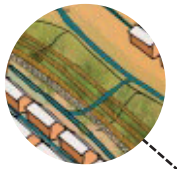
SLOPE STABILIZATION STRATEGY

Guiding principles

1. Guide the water

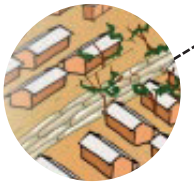
Water can considerably increase the pressure of the soil behind a retention structure and lead to its collapse!

- Ensure that all retention structures have weep holes if they are non permeable to water.
- Ensure drainages on top of the slope stabilization to avoid that excessive water gets to the soil behind it.



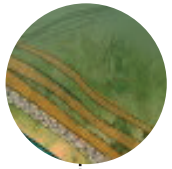
2. Prioritize risk reduction

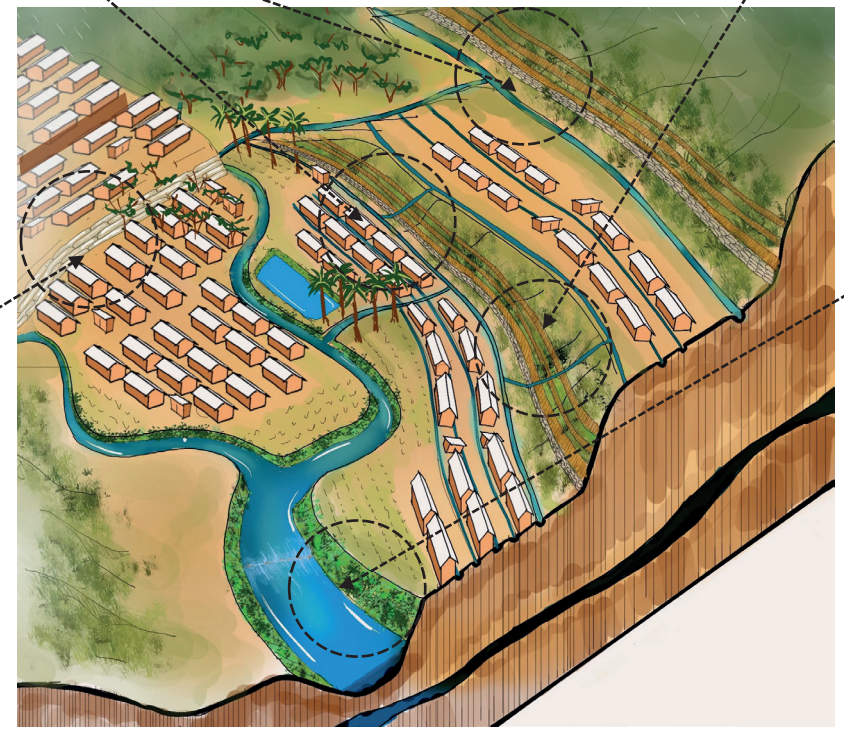
Slope stabilization aims at reducing the risk for landslides in the monsoon season. Prioritize the stabilization of slopes that pose risks to a big number of shelters. Shelters at risk include the shelters above and below the slopes. Always consider the cost / benefit.



3. Stabilize in levels

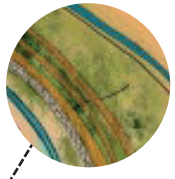
Break down high slopes in different stages/ levels. Start ensuring stability of the lower level; create a terrace and stabilize the next level. You might change the technical solutions between the levels. Always consider the full height and weight of the soil above that level for your calculations of the strength needed. Often retention walls are calculated only for the height of soil behind them and not for all the soil above.





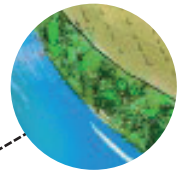
4. Prevention vs. repair

- Identify slope erosion as early as possible. Early warning signs include the apparition of erosion channels in the surface. Stop the causes of erosion as early as possible to contribute to maintaining the natural stability of the slopes.
- Protect slopes in monsoon with tarpaulin.



5. Promote nature-based solutions

Whenever space is available respect as much as possible the natural slope and incorporate nature-based solutions to promote the natural stability as the materials used for slope stabilization will decay with time.



SLOPE STABILIZATION STRATEGY

Slope stabilization elements

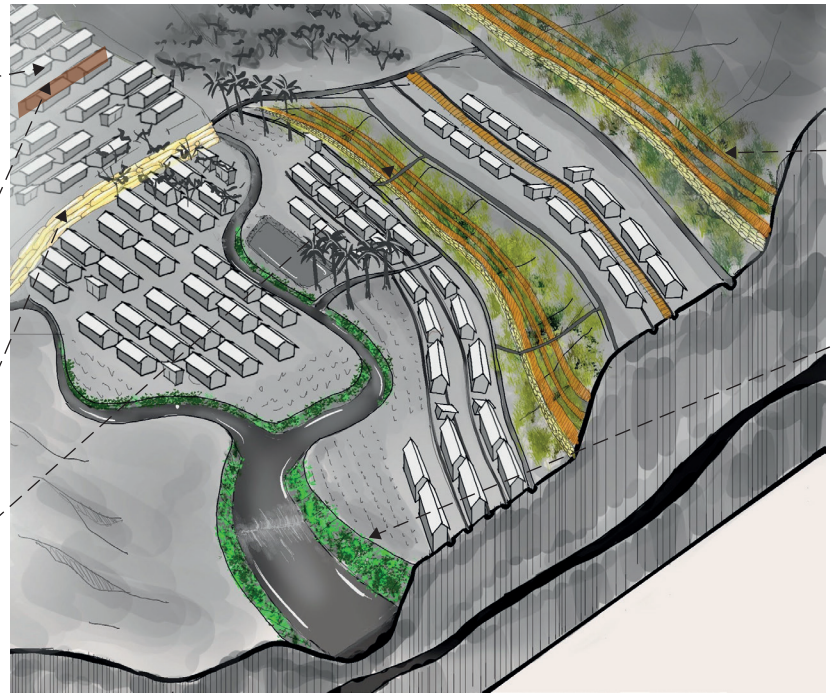
- Plantation: Locations with compacted / undisturbed soil and low erosion risks (<30° for sandy soil or <45° for clay) are usually suitable for stabilization with only plantation.
- Erosion protection and bamboo micro terracing: Loose / filled-up soil with mild slope (30° to 45° or 2H:1V to 1H:1V) and high erosion risks (e.g. canal banks) need additional protection on top of plantation. Jute fabric (burlap) or bamboo micro-terrace to prevent erosion of exposed soil while plants are not grown enough to provide the protection. Once the plants grow, it can sustain naturally.
- Geo-tube: Geo-tube is fabricated by sewing geotextile, filled with sand. Geo-tube was chosen for its simplicity, cheap and abundant raw materials, resilience and eco-friendliness. This technique is suitable for slope of 45° to 60° or 1H:1V to 1H:2V with enough filling material and space for geo-tube placement.
- Bamboo crib wall: If space for geo-tube placement is not available, bamboo crib wall can be provided at 45° to 60° or 1H:1V to 1H:2V slope locations. It should be coupled with plantation and proper drainage.
- Masonry retaining wall: In congested areas where previously discussed techniques cannot be used. Masonry wall can be designed as uniform thickness wall, wall with columns or stepped wall. Well compacted base soil is required as base settlement will cause collapse. Maximum retaining height 2.5 m (8').
- Precast concrete retaining wall: Congested area where on-site work is challenging or needs reinstallation after decommissioning. Usually, this design is more resistant to base settlement than masonry wall. For height more than 1.8 m (6') precast concrete is more economical than masonry wall.

Precast concrete retaining wall
Congested area

Masonry retaining wall and mass wall
Congested area

Geo-tube
Availability of filling material & space

Bamboo crib wall
Steep slope



Erosion protection and bamboo micro terracing
Mild slope

Plantation
Very mild slope

LANDSLIDE RISK ASSESSMENT

Key Factors

The likelihood and severity of landslides is governed by three key factors:

Slope angle (ϕ)

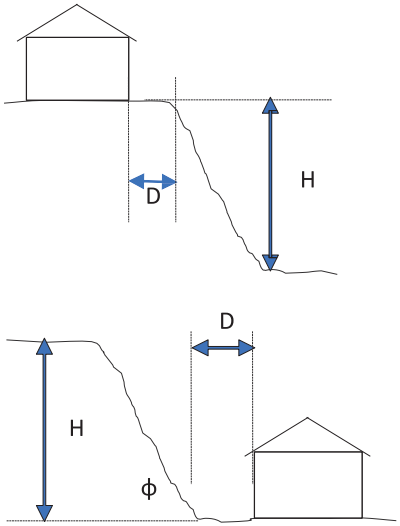
The soils in Kutapalong - Balukali are generally stable up to approximately 30° (1V:2H slope). Slopes above 45° (1V:1H) are most likely to fail due to surface erosion.

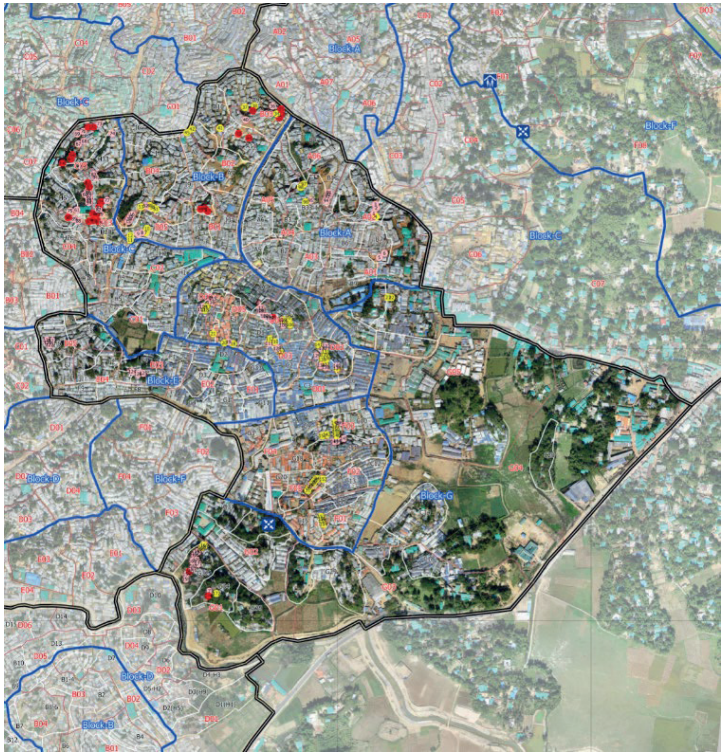
Slope height (H)

Taller slopes are both more likely to fail (due to higher soil loads and greater risk of surface erosion) and are more dangerous if they do fail. Steep slopes above 3.6 m (12') tall are not generally possible to mitigate using the techniques, materials and budget available in the Rohingya refugee camps.

Distance to the slope edge (D)

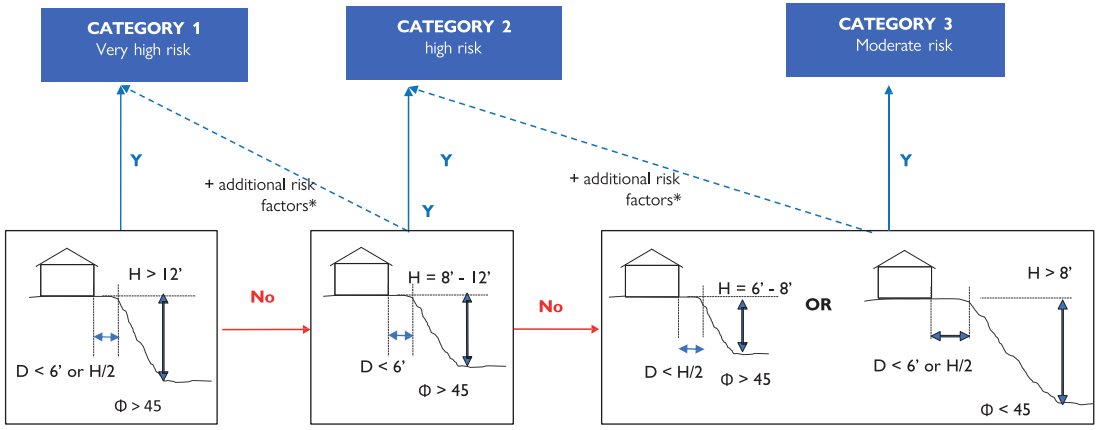
The likelihood that a landslide will affect people is directly linked to how far they are from the slope edge. Shelters within 1.8 m (6'), or half the height of the slope, are particularly at risk.





Landslide Risk Assessment Map_ camp 09_2022

Very High Risk High Risk Moderate Risk



Additional risk factors:

There are addition risk factors like Loose soil, Seepage, Latrines, Water ponding, Clay layers, Surface erosion, Progressive collapse, Bulging/cracked/misaligned infrastructure, Human activities, e.g., excavation, additional loads.

Use engineering judgement to determine impact of risk factors.

SELECTION PRINCIPLES

Type / Material	Time to build	Skilled labor	Construction cost (material ---- CfW)	Annual Maintenance costs	Recommendations
Erosion Control	+	+			Suitable for mild slopes. Labor intensive process.
Bamboo Micro-terracing	++	++			Suitable for mild slopes.
Geo-tube stabilization	++	++			Needs space for placement, enough filling material and slope not steeper than 45°
Bamboo Crib wall [upper layer tie-back]	++	++			
Bamboo Crib wall [extra peg tie-back]	++	++			
Masonry Wall - Uniform	+++	+++			Maximum 0.9 m (3') high.
Masonry Wall with pier	+++	+++			Maximum 1.5 m (5') high.
Masonry Wall - Stepped	+++	+++			Maximum 2.5 m (8') high.
Pre-cast RC wall	+++	++++			Maximum 2.5 m (8') high. Min. on - site work.

Where more "+" sign indicates more resources required.

Material cost CfW cost Annual maintenance cost

Reinforced cast concrete retaining walls are a more durable alternative for slope stabilization but not adequate for the Cox's Bazar camp context.

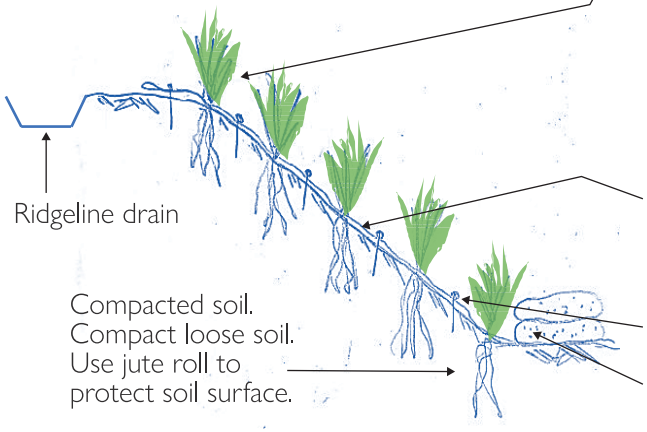
**construction (CfW / material ratio) and maintenance costs shown as relative proportions for prioritization purposes. Actual costs are subject to filed assessment and field conditions.*

Reduced maintenance costs for bamboo crib wall and geo-tube stabilization are based on the assumption that medium term stability will be achieved through plantation.


OIM
UNHCR

BAMBOO MICRO TERRACING AND EROSION CONTROL

Bamboo micro terracing can be used in slopes that can be stable with limited intervention in combination with plantation to promote the recuperation of the natural stability of a slope.



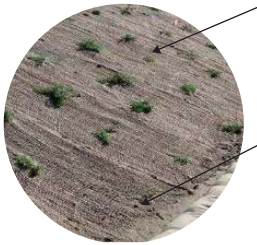
Plant mixture of deep-rooted plants (e.g. tree saplings or broom grass) and surface cover (e.g. buffalo grass).

Plant broom grass in rows (1' between plants along the row, 2'-3' between rows) to create swales / small terraces that channel water sideways along slope. Plant 2-3 slips in each spot.

Open-weave (tight weave may prevent surface grass from growing) jute textile folded at top and nailed into the ground.

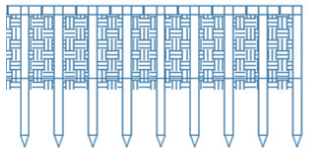
Bamboo peg to hold jute textile

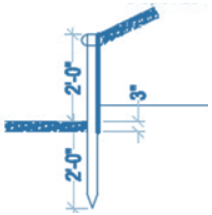
Line of jute bag at base to trap any silt run off



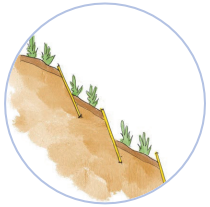
Combine with catch drain along ridgeline and cascade drain across slopes.

Use of open weave jute roll preferred as the tight weave prevents surface grass from growing.

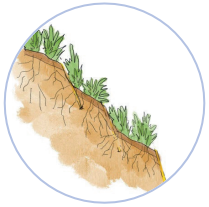




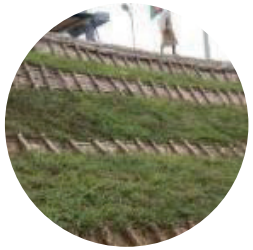
Bamboo micro terracing



Phase 1. The stability of the slope depends uniquely on the bamboo.



Phase 2. Plants have grown and support the stability of the slope.



Bamboo micro terracing can be used to protect and stabilize slopes along with plantation.

Avoid:

Using drum sheet for slope stabilization!

Bamboo micro terracing combined with plantation

Benefits

- √ Very economical and simple technique.
- √ Nature-based solution, if done properly, will stay stable without any further maintenance.

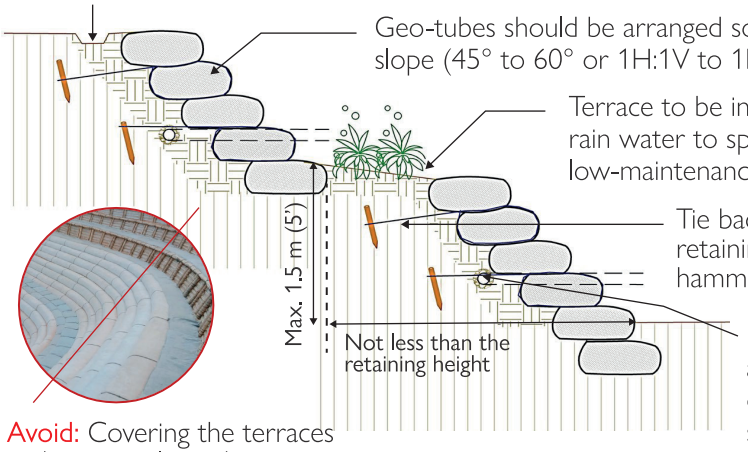
Drawbacks

- × Needs bigger space.

GEO-TUBE STABILIZATION

Geotextile is suitable for any location with enough filling material and space for proper placement. Cascade drains and ridgeline drains should be considered in the geo-tube slope stabilization.

Ridge-line (catch) drain, connected to discharge drains at low points or every 5 m.



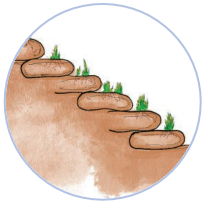
Geo-tubes should be arranged so that it leaves a stable compacted slope (45° to 60° or 1H:1V to 1H:2V) even after it rots.

Terrace to be inclined outward (min. 5%) to allow the rain water to spill away. Long-rooted, fast-growing, low-maintenance plants to be planted increase stability.

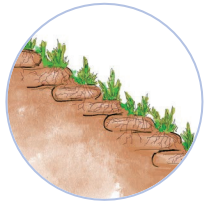
Tie back at a distance not less than the retaining height or min. 1.2 m (4'), hammered into undisturbed hard soil.

Perforated pipe, covered with coarse aggregate, connected to outlet pipe to discharge water into cascade drain at suitable locations or every 5 m.

Avoid: Covering the terraces with geotextile as these spaces can be planted!



Phase 1.
The stability of the slope depends uniquely on the geotextile.



Phase 2.
Plants have grown and support the stability of the slope.

Leaving open sections in the geotextile so roots of the plants can reach to bottom soil can be considered to improve the natural stability of the geotextile slope stabilization.

Benefits

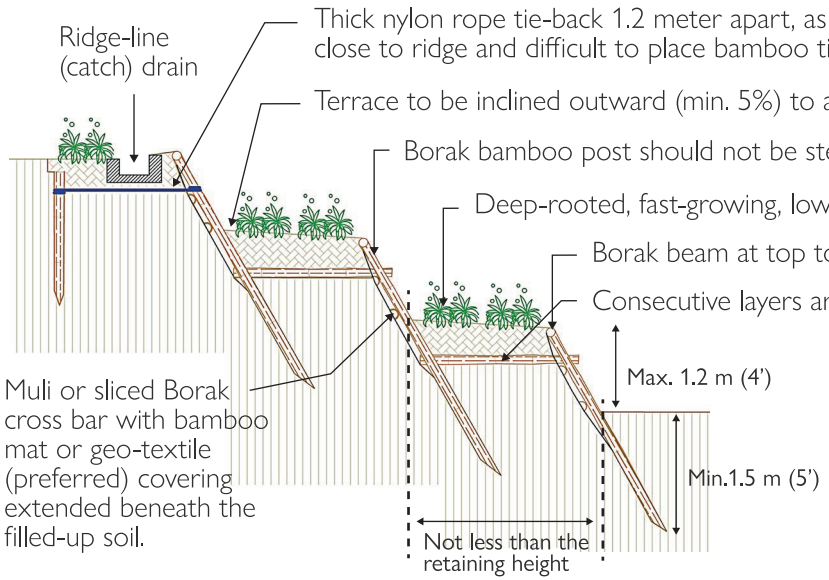
- √ Simple and low-cost technique.
- √ Increases construction speed.
- √ Lighter in weight which makes it easier handling and laying on site.
- √ Retain soil moisture by reducing evaporation thus promotes vegetation survival.
- √ Flexible structure, sustains base settlement., no brittle failure.
- √ Geo-textile sustains longer than bamboo.

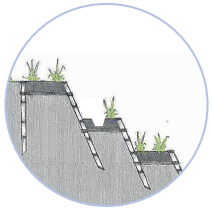
Drawbacks

- × Needs filling material.
- × Placement needs more space than other techniques.

BAMBOO CRIB WALL

Multiple steps of bamboo frame and bamboo mat or geotextile lining can be used for slope stabilization in a wide range of locations. As bamboo rots in few months, the shape should be such so that it can stay stable even after the bamboo is gone. Drains along each terrace, connected to discharge drains can prevent water ponding and infiltration into the soil. Deep rooted plants are recommended for more stability.





Using a more gradual (diagonal) profile with sloped terraces between the levels of the bamboo crib wall instead of a stepped profile can contribute to building back the natural stability of the slope.

Live cut bamboo can be used for further stability.

Avoid:
Covering the terraces with geotextile as these spaces can be planted!

Benefits

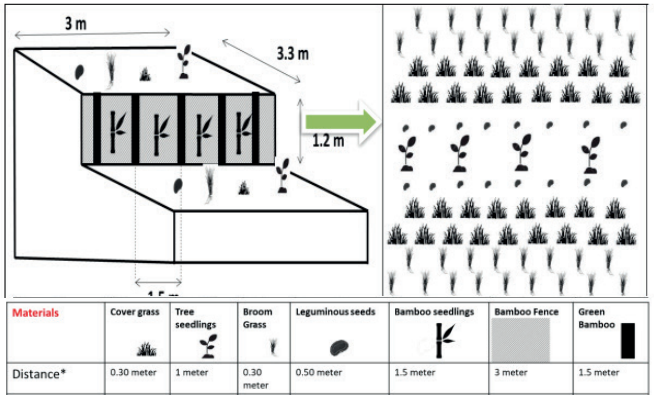
- √ Low cost
- √ Long lasting if combined with planting
- √ Fast implementation

Drawbacks

- × Bamboo rots in 6-8 months

SLOPE PLANTATION AND BIO-ENGINEERING

To stabilize the slope areas where chances of erosion are high and need to stabilize the land quickly.



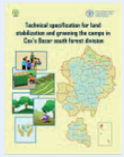
Materials	Cover grass	Tree seedlings	Broom Grass	Leguminous seeds	Bamboo seedlings	Bamboo Fence	Green Bamboo
Distance*	0.30 meter	1 meter	0.30 meter	0.50 meter	1.5 meter	3 meter	1.5 meter

Tree Species	Gamar (Gmelina arborea), Chatim (Alstonia scholaris), Arshol (Vitex glabrata) Amloki (Phyllanthus emblica), Kadam (Neolamarckia cadamba), Haritaki (Terminalia chebula), Bahera (Terminalia bellirica), Dhakijam (Syzygium grande), Chikrasshi (Chukrasia tabularis), Toon (Toona ciliata), Bandorhola (Duabanga grandiflora), Champa (Michelia champaca).
Cover Crop/ Leguminous Species:	Pigeonpea (Cajanus cajan), Sesbania (Sesbania bispinosa), Tephrosia (Tephrosia candida), Grass pea (Lathyrus satibus).
Grass Species	Broom grass/Tiger grass (Thysanolaena maxima), Bermuda grass (Cynodon dactylon), Chapra grass (Stenotaphrum secundatum), Ulu grass/Pahari Kash (Saccharum arundainaceum), Bamboo (Melocanna baccifera, Bambusa nutans, Bambusa polymorpha, Neohouzeaua dulloa, Melocalamus compactiflorus).

Make sure that the plants have enough space to develop their roots. Planting in confined spaces is NOT recommended.

Planting long rooted plant (broom grass) in bamboo slope stabilization can be effective to hold the ground. Other plants such as banana trees do not support on the stabilization of the slope and should be discouraged. Messaging to the community is needed.

Do NOT plant trees next to masonry/CC slope stabilization. These structures have not been designed to hold the pressure and the roots will break them.



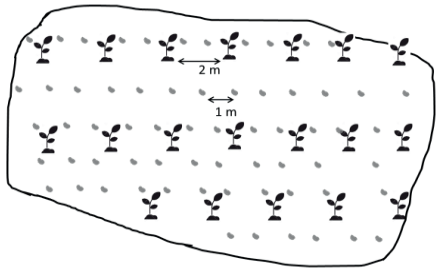
For more technical information, see pp. 13-15 of the EETWG and FAO Technical Specification for land stabilization & Greening in Cox's Bazar south forest division (updated December 2021)

ALL plantation should follow approved Forest Department list of species (found here).

ALL plantation should be done in coordination with the EETWG and within the recommended season.

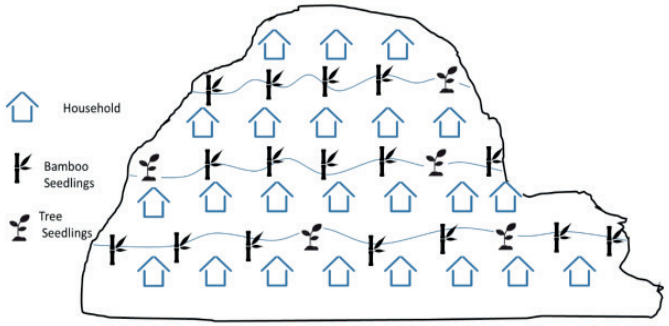
HOUSEHOLD LEVEL / AFFORESTATION / REFORESTATION PLANTATION

To reduce soil erosion and for accelerating the development of forest structure with canopy.



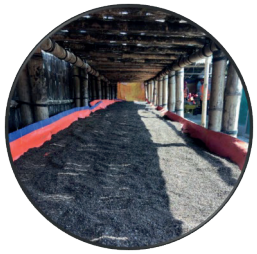
Materials	Tree seedlings	Leguminous seeds
Distance*	2 m	1 m
Density/ha	2500	40000

Specification for afforestation/reforestation



Specification for homestead plantation on slopes

Tree Species	Champa (Michelia champaca), Gamar (Gmalina arborea), Chatim (Alstonia scholaris), Shimul (Bombax insigne), Koroi (Albizia spp), Kanchan.
Leguminous Species	Pigeon pea (Cajanus cajan), Sesbania (Sesbania bispinosa), Tephrosia (Tephrosia candida).
Grass Species	Bermuda grass (Cynodon dactylon), Chapra grass (Stenotaphrum secundatum), Broom grass/Tiger grass (Thysanolaena maxima).



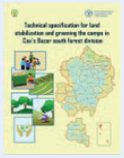
Approximately 200 grams of compost should be used for each seedling during plantation. Partners can use compost produced in MRFs (in coordination with WASH Partners).

It is encouraged to plant from June to September, however if partners which to plant during the dry season they should do so in coordination with the EETWG and use earthen cocoons to hold the water.

It is encouraged to integrate retention works in the plinth of shelters with the plantation (either household level gardening or grass turfing or vetiver or the combination of any) as per the site condition.

NEVER remove existing plants and natural elements to do a new plantation! These are important for the soil stability and diversity of nutrients. Focus on filling the gaps!

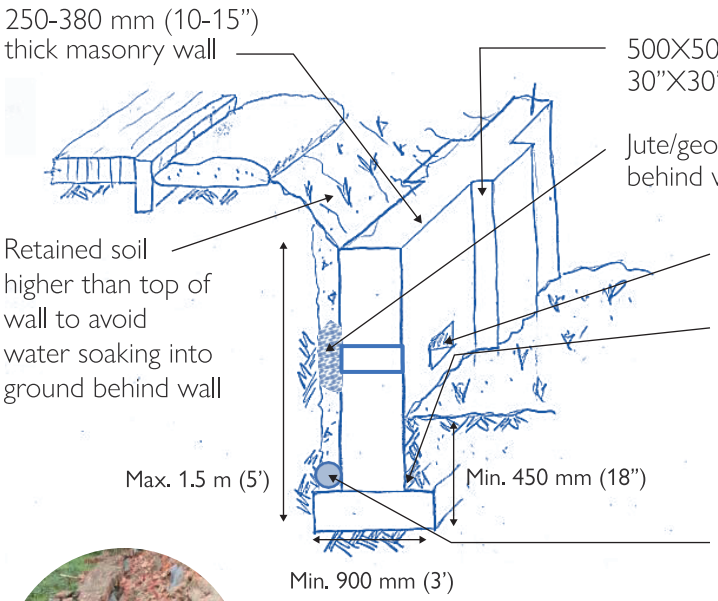
Good practice for grass plantation (leaving spaces between tiles to allow for growth and maximize resources)



For more technical information, see pp. 17-21 of the EETWG and FAO Technical Specification for land stabilization & Greening in Cox's Bazar south forest division (updated December 2021)

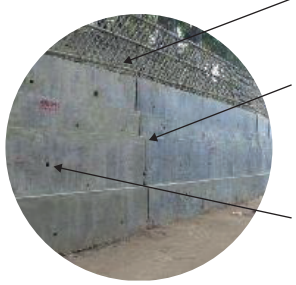
MASONRY WALL

Masonry walls are suitable in congested area where using natural materials are not possible. Masonry walls can be of consistent thickness, with columns or stepped.



Collapsed retaining wall due to missing weep holes

Drain prevents erosion at toe



Handrails and fencing along top edge

Expansion joint at 5 m (16') spacing to accommodate expansion due to temperature changes

Weep holes at each level to release hydrostatic pressure on the walls

Benefits

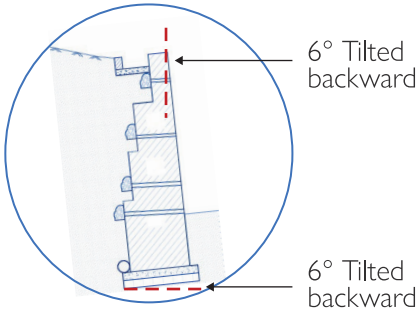
- √ Brick design is flexible. So, we can design as per the site condition and height.
- √ Can stand up well to both moisture (no rusting) and the weather.
- √ Easy Workmanship and repair.
- √ Compressive strength is good.

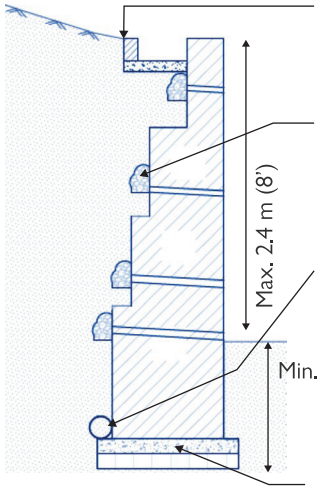
Drawbacks

- × High labour cost for pottering materials
- × Vulnerable to base settlement
- × Low tensile strength.

MASONRY STEPPED WALL

Masonry walls taller than 1.5 m (5') should be stepped.





Retained soil higher than top of wall and ends at a catch drain o avoid water soaking into ground behind wall

Staggered weep hole at 1-2 m (3-6') spacing. Jute/geo bag filled with brick chips behind weepholes

Perforated pipe connecting to outlet, wrapped in geotextile and surrounded by brick chip

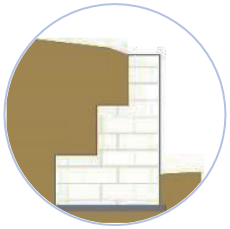
Concrete foundation on well compacted soil. For very soft soil, natural soil to be replaced with 300 mm (12") engineered fill with 98% compaction

Benefits

- √ Flexible design.
- √ Simple technique.
- √ Can stand up well to both moisture (no rusting) and the dry weathe

Drawbacks

- × Vulnerable to base movement.
- × High cost.
- × Rigid structure, subjected to brittle failure.



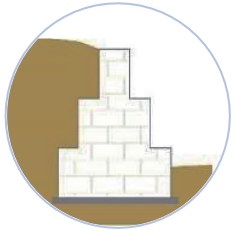
GOOD

Advantages:

- √ Weight of retained soil prevents overturning

Disadvantages:

- × More fill material required
- × Weight of retained soil increases soil pressure on toe



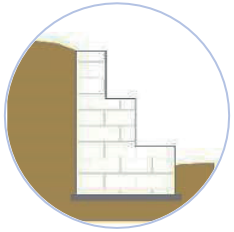
GOOD

Advantages:

- √ Good resistance against overturning without creating high soil pressure
- √ Less backfill required

Disadvantages:

- × Lower resistance against sliding



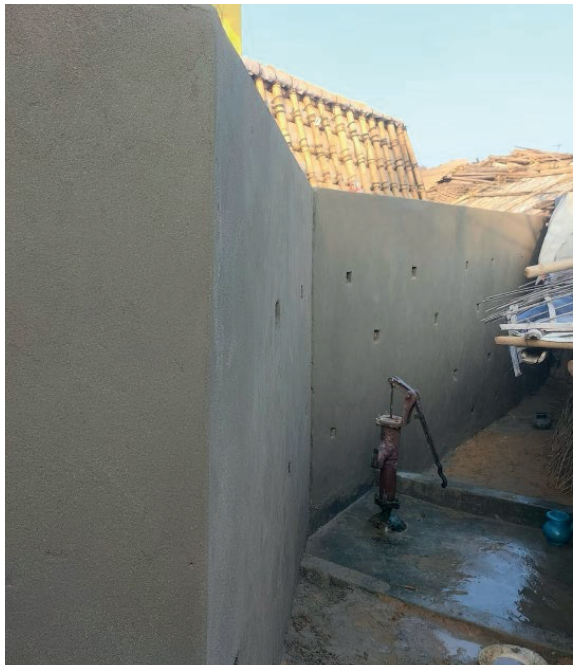
AVOID

Advantages:

- √ Minimum backfill required

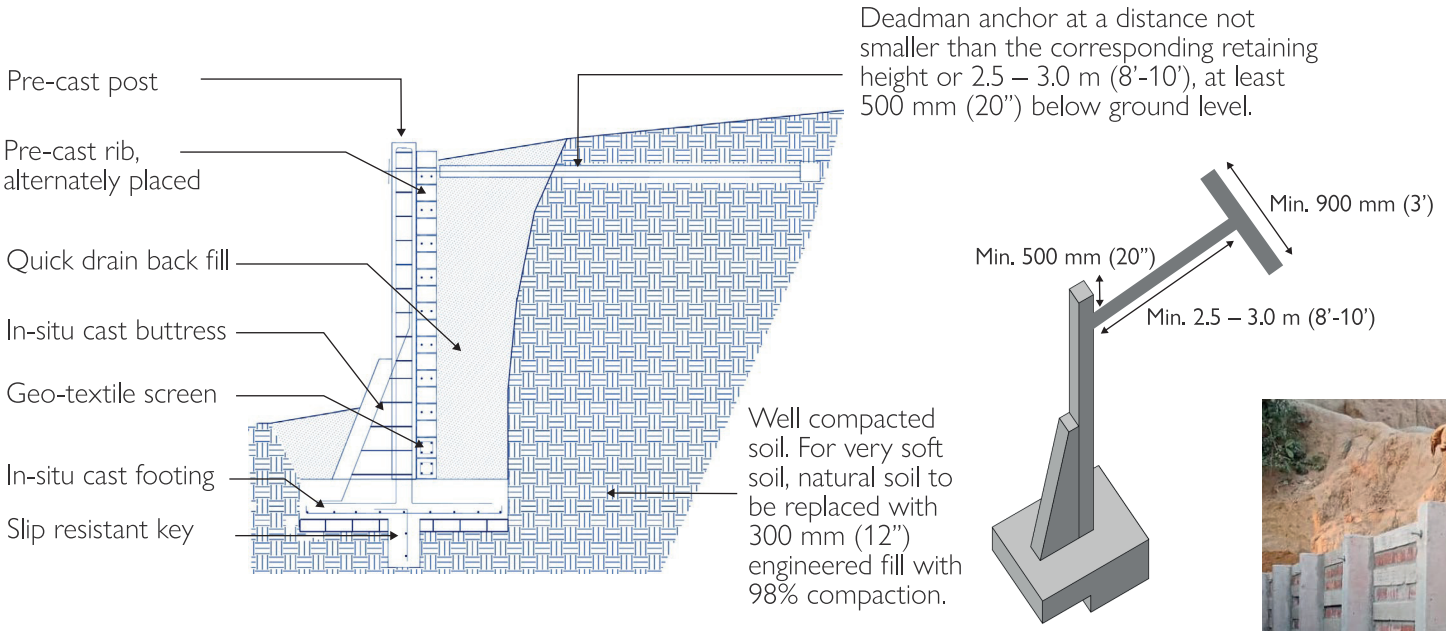
Disadvantages:

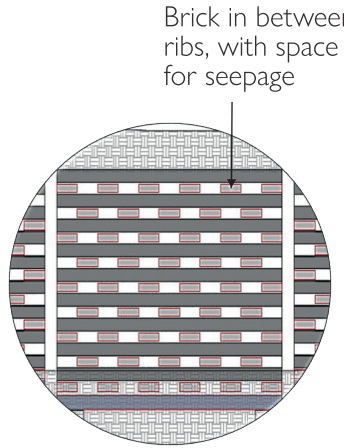
- × Low resistance against overturning and sliding



PRECAST RETAINING WALL

Pre-cast reinforced concrete (RC) structure design comprises of vertical posts, horizontal ribs, footings, buttresses and geotextile screen. The vertical posts and horizontal ribs are pre-cast while footing and buttresses are cast-in-situ. This technique is suitable for locations where on-site construction is challenging or re-use after decommissioning is intended.





Benefits

- √ Durability – has longer service time period and minimal maintenance
- √ Minimum on site works.
- √ Casting in controlled environment allows better quality control/quality assurance and engagement of vulnerable people.
- √ Can be reused after decommissioning.
- √ Risk of collapsing is low due to minimum/zero lateral hydrostatic force behind the wall

Drawbacks

- × High initial investment
- × Construction and installation require skilled workers
- × Carrying pre-cast parts to the congested site is challenging

Different techniques for slope stabilization can be combined to protect the same slope. If techniques are combined, it is advisable to place the geotextile stabilization in the bottom part of the slope and bamboo crib wall in the upper part of the slope.

For high slopes (above 10m) total height and high inclination (close to 45`) the use of masonry or precast wall in the lower level is advised to prevent slope failure due to sliding thereby improving the stability of the overall slope.

In all cases proper drainage – in the ridgeline, the bottom of the slope and in the terraces through the sloping of the terrace and the construction of cascade drains is key to ensure the long-term stability of the slopes.

ACCESS

ACCESS STRATEGY

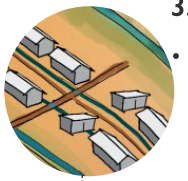
Guiding principles

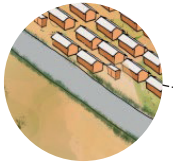
1. Access should be a network with a hierarchy

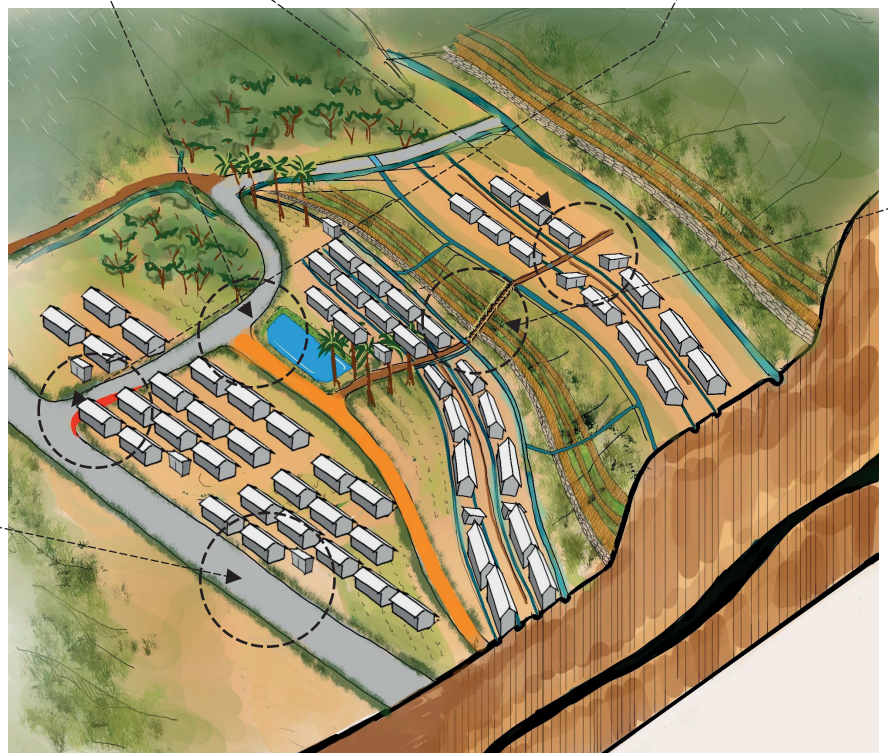
- Do not design access components in isolation. Site planning can be of great support to identify the relative importance and hierarchy of a road or pathway.
- The hierarchy of the road and the type of transit it enables (major vehicular to pedestrian only) needs to be matched with the technique used to build the road. Prioritize resources for BFS for pathways that are used by a bigger number of households or ensure that HBB or other techniques suitable for minor vehicular transit are used in roads wide enough and not in pedestrian only accesses.

2. Roads are fire breaks

Main roads act as effective fire breaks. The size of the fire compartments between major roads can also be a criteria for the prioritization of a road.

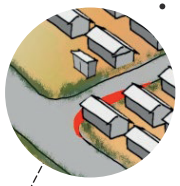






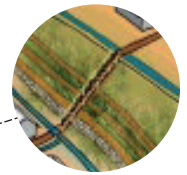
3. Ensure access to services

- Prioritize the roads which are key to ensure safe access to services and enable access of emergency response (such as firefighting and ambulances).
- Installing Solar Street Lights on the roads and key facilities (including WASH) is key to avoid protection issues and ensure safe access to lifesaving services.



4. Avoid bottlenecks but be flexible with the section

- If one road is transitable by vehicles in all its section except for one point, the connectivity will not be achieved. However, the whole length of a road does not need to have the same section. Consider including shoulders in some locations only so bigger vehicles can safely take over.
- Leaving space for roadside plantation is a good strategy to leave some space for pedestrians when a bigger vehicle is transiting without needing to pave the full section of the road.



5. Prioritize the needs of the most vulnerable

- Ensure safety in access. Installing railings is important in all stairs and ramps and level drops.
- While there are limited wheelchairs in the camps, the minor vehicular network is key to improve the access to services of people with disabilities or limited mobility.

ACCESS STRATEGY

Access network

- Major Vehicular Road: Major vehicle road is accessible for truck and larger vehicles connecting more than one camps.
- Minor vehicular road: Minor vehicular roads are accessible by car, pickup or any light vehicle and usually serves within camp.
- Emergency light vehicle road: for block-to-block connection and emergency access of small vehicles (e.g. tom-tom and ambulance).
- Major pathway: Major Pathways serves more than 20 shelters or connects to facilities/other clusters of development
- Minor pathway: Minor Pathways are in between shelter rows serving fewer than 20 shelters and not serving as thoroughfares
- Stairs and ramps: stairs and ramps serves different types of pathways with diverse hierarchy.
- Vehicular water crossing: in roads
- Pedestrian water crossing: pedestrian water crossings area in pathways with different hierarchy.

Major vehicular road

HBB

Minor vehicular road

HBB
Concrete permeable block

Major pathway

Concrete permeable block
BFS

Minor pathway

Macadam
Compacted soil
Jute bag

Vehicular water crossing

Box culvert
Pipe culvert

Pedestrian water crossing

Bamboo bridge
Timber bridge
Drainage cover slabs

Stairs and ramps

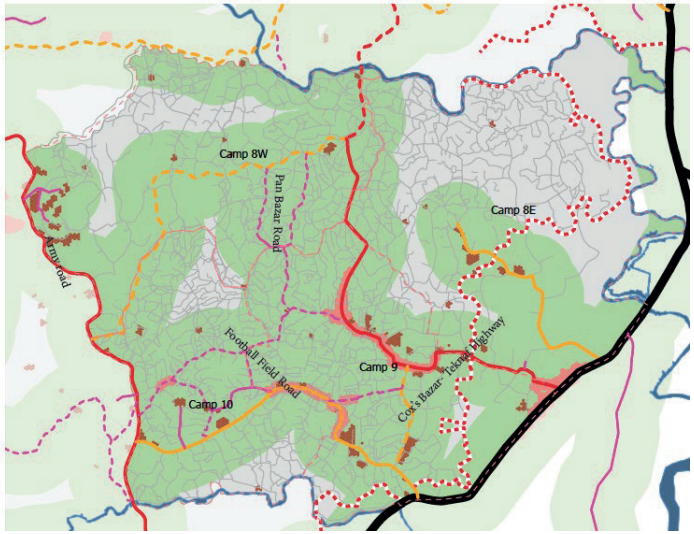
Masonry stairs
O-Ring stairs
Bamboo stairs

ACCESS COVERAGE AND STANDARDS

Standard

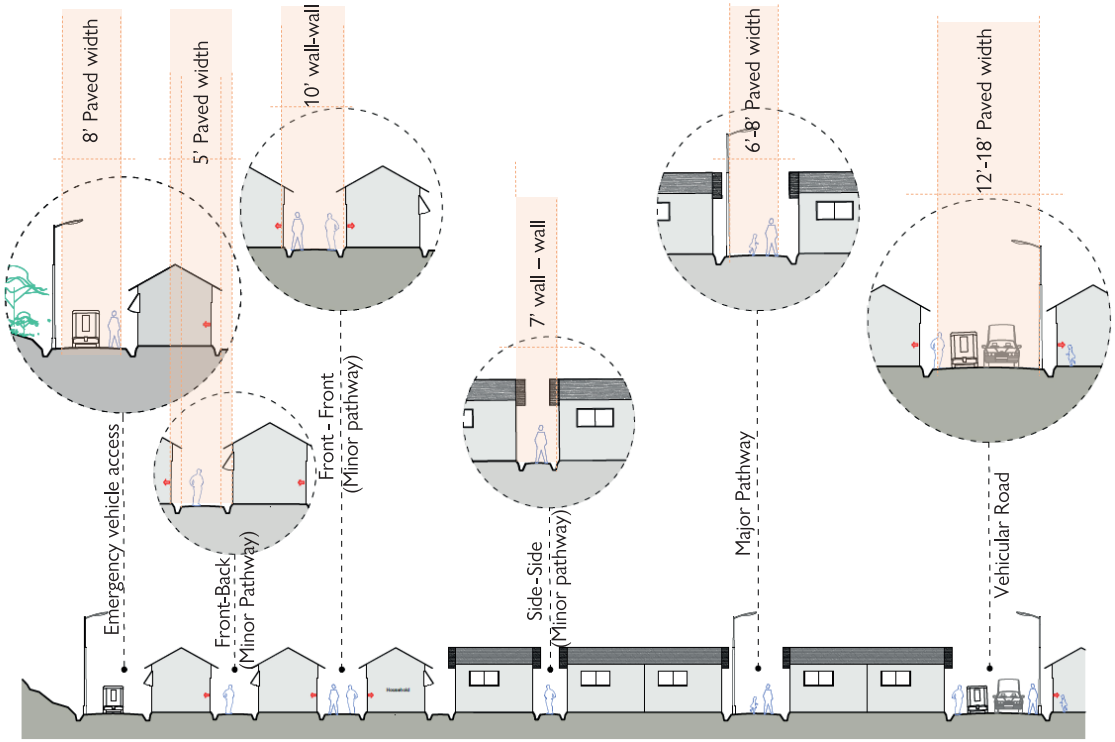
All shelters should be within 300 m (984') of vehicular access and within 50 m (165') of emergency vehicle access.

- Major Vehicular Road: Major vehicle road should be HBB road of 5-6 m (16'-20') paved width which is accessible for truck and larger vehicles connecting more than one camps.
- Minor vehicular road: Minor vehicular roads should be HBB road of 3.7 m (12') which are accessible by car, pickup or any light vehicle and usually serves within camp.
- Emergency light vehicle road: for block-to-block connection and emergency access of small vehicles (e.g. tom-tom and ambulance) with paved width minimum 2.5 m (8') width (HBB). Primary pathways can also be used as emergency access if it is stair-free and has adequate width.



Map: gap analysis of vehicular access- Green areas are within the 300 m of vehicle access.

- Major pathway: Major Pathways should be 2-2.5 m (6'-8') of paved width in between cluster of shelter. Pathways serving more than 20 shelters or connecting to facilities/other clusters of development (longer pathways have higher traffic) should be a major pathway.
- Minor pathway: Minor Pathways are in between shelter rows serving fewer than 20 shelters and not serving as thoroughfares. Paved width of minor pathway should be 1.5 m (5').
  - The minimum wall-to-wall distance between Side-Side and front-Back shelter should be 2.5 m/ 8' and Front-Front shelters should be 3 m/10' including pathways and catch drains in both sides. Minimum wall-to-wall distance is to be maintained to ensure proper light and ventilation of the shelters.



SELECTION PRINCIPLES

Category	Type / Material	Time to build	Skilled labor	Construction cost (material ---- CfW)	Annual Maintenance costs	Recommendations
Road	Herringbone Bond Brick (HBB)	+++	++			Light vehicle access
	Brick Flat Soling (BFS)	++	++			Busy pedestrian access
	Permeable pavement block	++	+++			Minor pedestrian access, high maintenance
	Geo-bag pathway	+	+			Quick construction
Stair & Ramp	Stair – Bamboo & geo bag	++	++			Minor access, high maintenance
	Stair – Masonry	+++	+++			Busy access
	Ramp	++++	++++			Wheelchair access
Water Crossing	Bamboo bridge	++	++			High maintenance
	Drainage cover – reinforced concrete	++	+++			

Where more "+" sign indicates more resources required.

Material cost CfW cost Annual maintenance cost

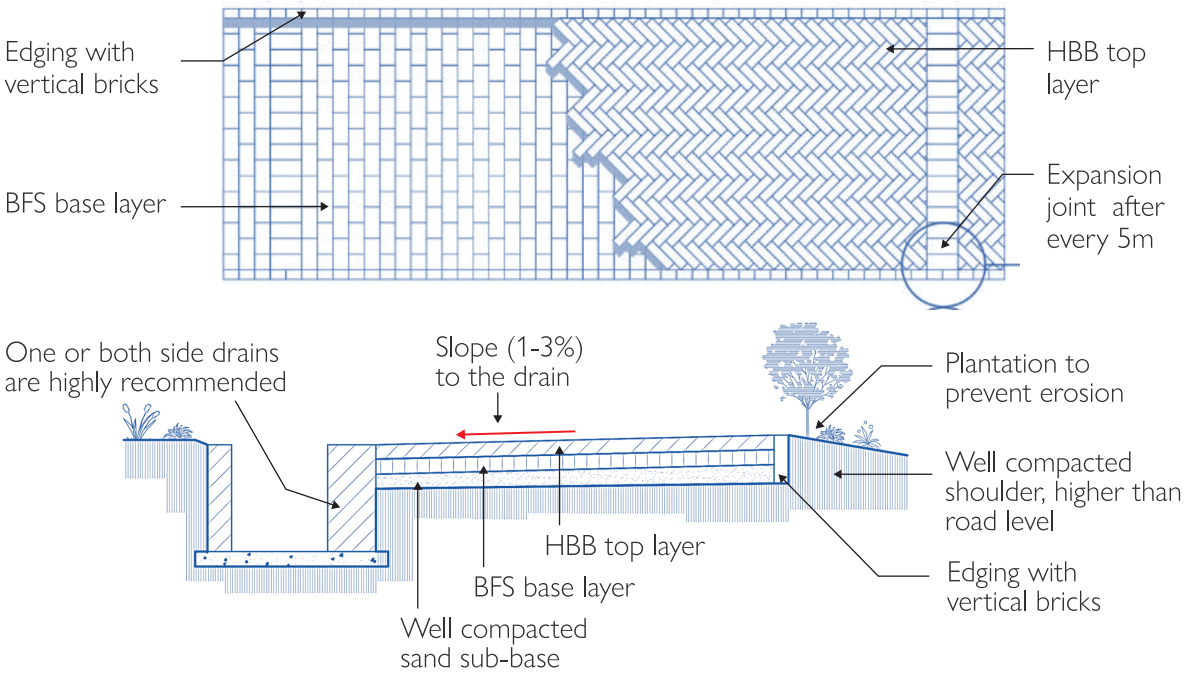
**construction (CfW / material ratio) and maintenance costs shown as relative proportions for prioritization purposes. Actual costs are subject to filed assessment and field conditions.*

Tarmac and concrete roads are more durable solutions for vehicular access but not adequate for the Cox's Bazar camp context.

Reinforced concrete structures for stairs and access are more durable solutions but not adequate for the Cox's Bazar camp context.

HERRINGBONE BOND BRICK (HBB)

Herringbone Bond Brick (HBB) consists in laying bricks on narrow edge in Herringbone (zig-zag) pattern. HBB on a BFS base layer is suitable for heavy vehicular road.



Benefits

- √ Simple technique, does not require skilled workers

Drawbacks

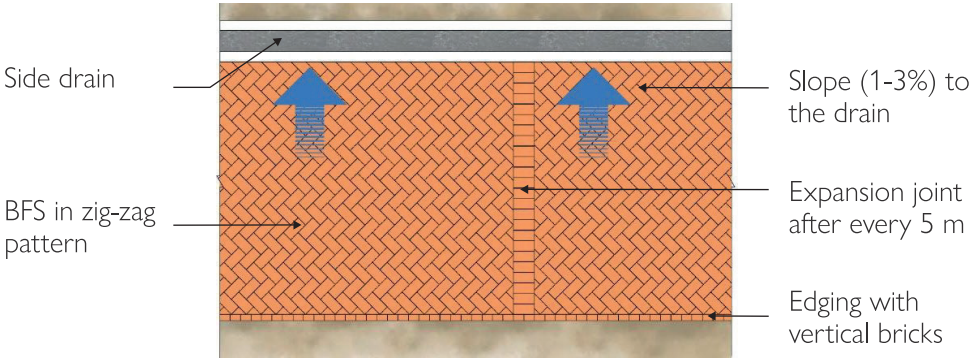
- × Bricks require replacement if there are frequently heavy vehicles passing over.
- × Bumpy and slower vehicle movement.
- × Very vulnerable to erosion without well compacted base and shoulder.
- × Needs to be replaced often if there is inadequate drainage.

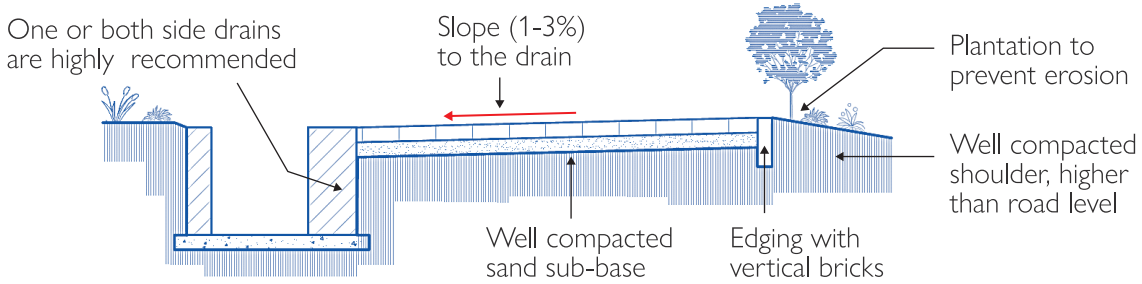
Vehicular road with side drainage

Herringbone Bond Brick toad

BRICK FLAT SOLING (BFS)

Brick Flat Soling (BFS) consists in laying bricks on wide edge. This technique is suitable for pedestrian pathways.





Benefits

- √ Simple technique, does not require skilled workers

Drawbacks

- × Very vulnerable to erosion without well compacted base and shoulder
- × If not coupled with proper drainage, cannot sustain long.
- × Without on-time repair, loss of single brick may cause total disintegration.

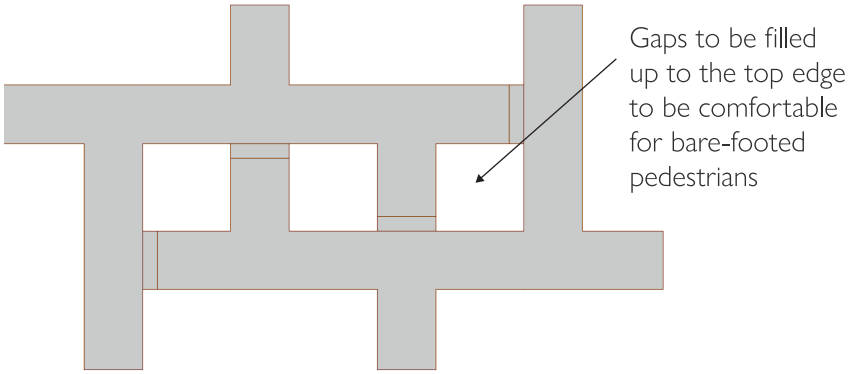
BFS pathway

CONCRETE PAVEMENT BLOCK

Plain concrete (CC) pavement blocks are designed to keep provision for space for infiltration and vegetation. Some designs are resistant for emergency light vehicular access.

Shape and dimensions of the block should be suitable for

- Walking on it with ease
- Carrying blocks manually
- To form a continuous surface
- Proper edging



Bricks can also be used to create patterns that promote infiltration.

Permeable pavement blocks in camp

Benefits

- √ Economic and eco-friendly than fully covered pavement
- √ Separate casting site allows engagement of vulnerable groups and better-quality control
- √ Promotes infiltration through open apertures (Pic1 turfstone has 40% open apertures)

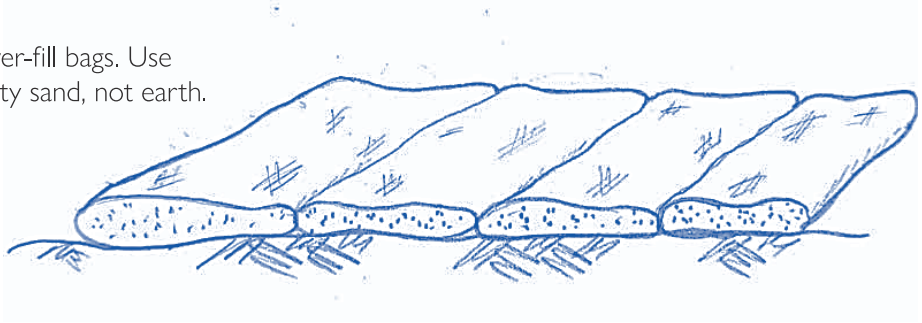
Drawbacks

- × Over-sized gaps may cause inconvenience for users
- × Presence of gaps may result into insufficient bonding and loss of blocks
- × Over-sized blocks may not be suitable for human hauling

GEO-BAG PATHWAY

Geo-bag or jute bag filled with sand. Avoid unless in case of emergency due to reduced durability.

Do not over-fill bags. Use good quality sand, not earth.



Geo-bags or geotextile rolls can be laid down across the road section to catch the silt that is carried by the water during the monsoon. This enables to reduce the amount of silt deposited in drains and to build back the level of the road whenever if the soil has been washed out in previous rains or if any backfilling is needed.

Benefits

- √ Simple technique, does not require skilled workers
- √ Lowest cost and quickest implementation

Drawbacks

- × Labour intensive process.
- × Needs frequent maintenance and has reduced durability (6-12 months).
- × The undulating surface might pose a tripping hazard.
- × Not suitable for the areas that has foot traffic.

SMALL RETENTION STRUCTURES FOR ELEVATED PATHWAYS

Pathways are often elevated and have drainages to the side. The techniques used to stabilize the side of pathways and roads are often linked to the drainage type chosen but some are summarized here.

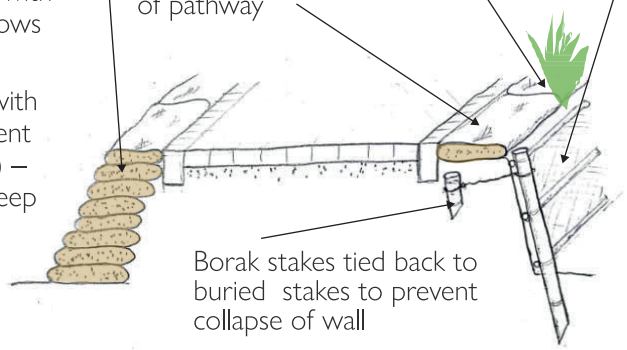
Geotextile retaining wall:

- Geotextile bag with earth infill > allows planting
- Jute bag walls with 1:10 sand-cement fill (no planting) – include PVC weep holes

Sand-cement jute bag protects edge of pathway

or

broom grass plants along edge



Borak stakes tied back to buried stakes to prevent collapse of wall

Bamboo & basha bera retaining wall:

- Borakstakes at 3'-5'centres
- Muli'cross beams' behind borakstakes
- Recommended: Borakcapping beam connecting stakes (not shown)

Wide drain or rice paddy

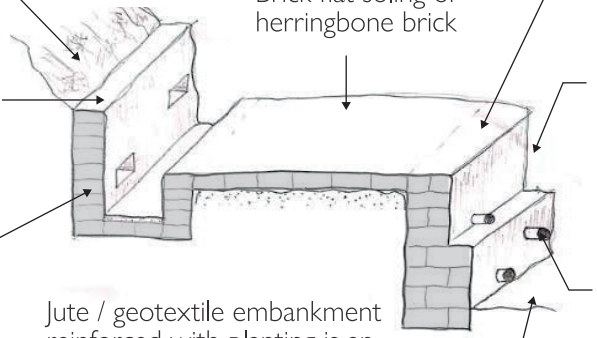
Masonry retention wall

Plant turf over bare soil

Ensure drain wall is lower than retained earth

Brick walled side drain

Include weep holes at 3' spacing if over 2' high



Jute / geotextile embankment reinforced with planting is an option if space allows

Brick flat soling or herringbone brick

Water can run on road into drain

Brick retaining wall

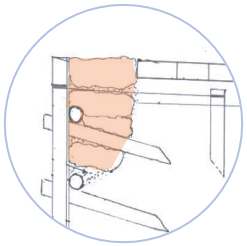
- 2 bricks thick: light trafic (e.g. TomToms), H < 4'.
- 3 bricks thick: medium trafic (e.g. 4x4s), H > 4'.

Weep holes

Primary drain with masonry wall & 3" thick concrete base

Wall thickness depends on wall height and weight of traffic:

- 2 bricks thick: light traffic (e.g. tomtoms) or H < 4'.
- 3 bricks thick: medium traffic (e.g. 4x4s) or H > 4' Weep holes in retaining wall to reduce water pressure.



Filling the back of retaining strcuture for elevated pathways with geobags full of brick chips instead of sand Will reduce weight in monsson and collapse.

Benefits

√ Effective for keeping pathways above flood level.

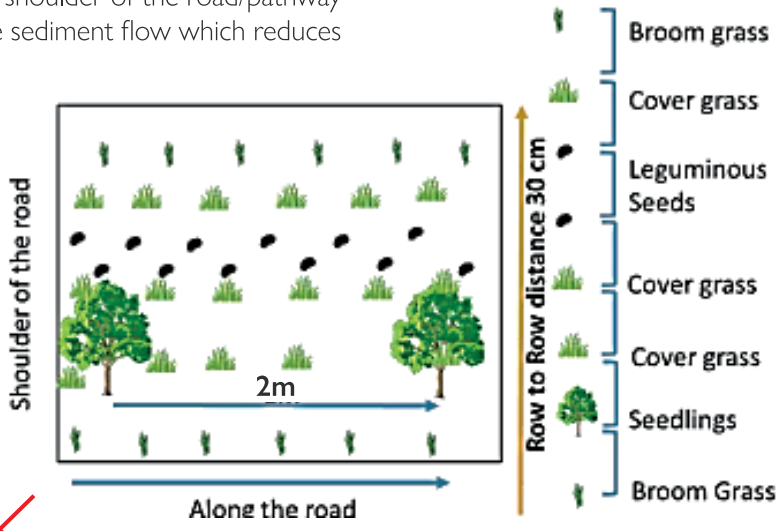
Drawbacks

× Improper water management may cause failure of the structure.

× Higher construction cost.

ROADSIDE PLANTATION

For stabilizing the shoulder of the road/pathway and to reduce the sediment flow which reduces soil erosion.



Proper care and maintenance are crucial for the success of plantation.

Materials	Broom grass	Tree seedlings	Cover grass	Leguminous seeds
Distance	0.30 meter	2 meter	0.30 meter	0.30 meter
Density/km	8000	1000	8000	4 kg

Tree seedlings	Champa (Michelia champaca), Gamar (Gmalina arborea), Chatim (Alstonia scholaris), Shimul (Bombax insigne), Koroi (Albizia spp), Kanchan.
Leguminous Species	Pigeon pea (Cajanus cajan), Sesbania (Sesbania bispinosa), Tephrosia (Tephrosia candida).
Grass Species	Bermuda grass (Cynodon dactylon), Chapra grass (Stenotaphrum secundatum), Broom grass/Tiger grass (Thysanolaena maxima).

Source: FAO Technical Specification for land stabilization & Greening in Cox's Bazar south forest division (updated December 2021)

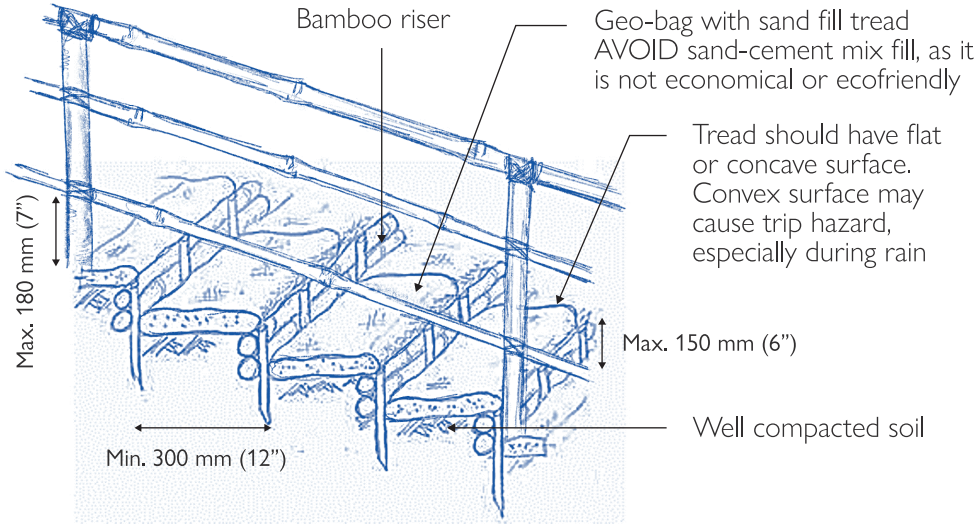
For more technical information, see pp. 13-15 of the EETWG and FAO Technical Specification for land stabilization & Greening in Cox's Bazar south forest division (updated December 2021)

ALL plantation should follow approved Forest Department list of species (found here).

ALL plantation should be done in coordination with the EETWG and within the recommended season.

BAMBOO – GEO BAG STAIRS

Bamboo stairs should only be used in case of emergency as they have limited durability and significant costs.



Benefits

- √ Simple technique, compared to masonry stair
- √ Quick implementation

Drawbacks

- × Bamboo rots in 6-8 months, needs frequent replacement. To be used only in case of emergency due to the limited durability.
- × Not suitable for busy pathways
- × Difficult to provide side drain

Installing handrails in stairs and ramps

- Ramps and stairs should have handrails ideally on both sides so that they can be safely used and to facilitate the use by people with special mobility requirements.
- The height of the handrails should be defined considering all age groups (recommended 850 - 950 mm or 33"-38"). Ideally, three handrails should be installed: one at the bottom for children, and two at an appropriate height for adults.
- The finishing of the handrail should facilitate a safe grip and prevent hand injuries especially for the elderly and persons with visual impairment.
- Handrails painted in bright colors facilitate the circulation of persons with visual impairment.
- Different technical solutions can be used to build handrails. These include using bamboo for the pole and railing; combining cement poles (caste in PVC pipes) or doing the handrail and pole with cement. This decision will impact on the durability and the likelihood of theft of the materials.

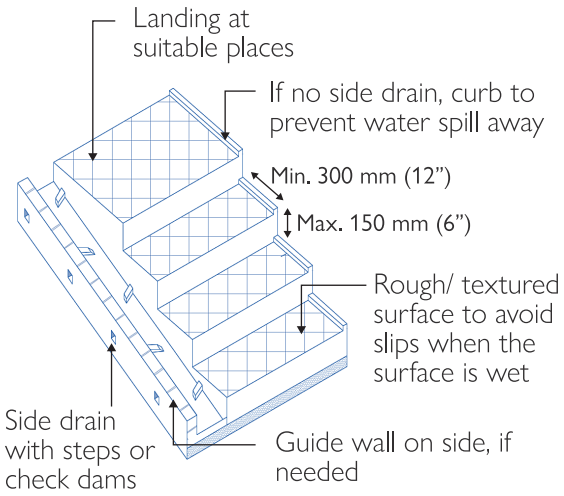
Bamboo handrail and pole

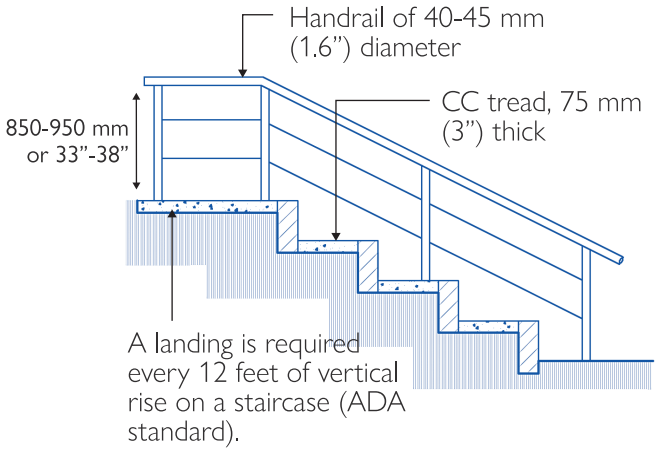
Bamboo handrail and cement pole. The linking between pole and handrail is done through a rebar

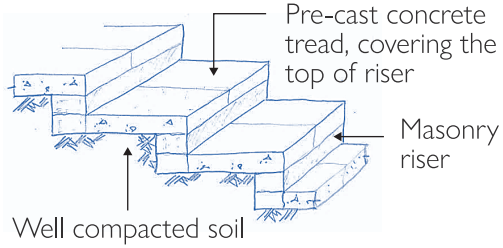
Cement handrail and pole

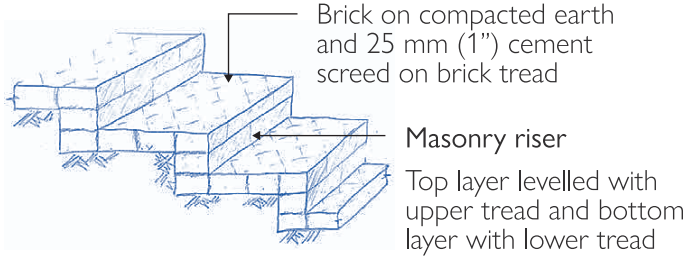
MASONRY STAIRS

Masonry stairs are suitable for most locations and can cater for regular pedestrian transit.









Handrails and risers should be painted in bright colours (e.g. yellow, orange, white) with textured surfaces to facilitate use by people with visual impairments.

Benefits

- √ Long service life with minimum maintenance
- √ Suitable for heavy traffic pathway

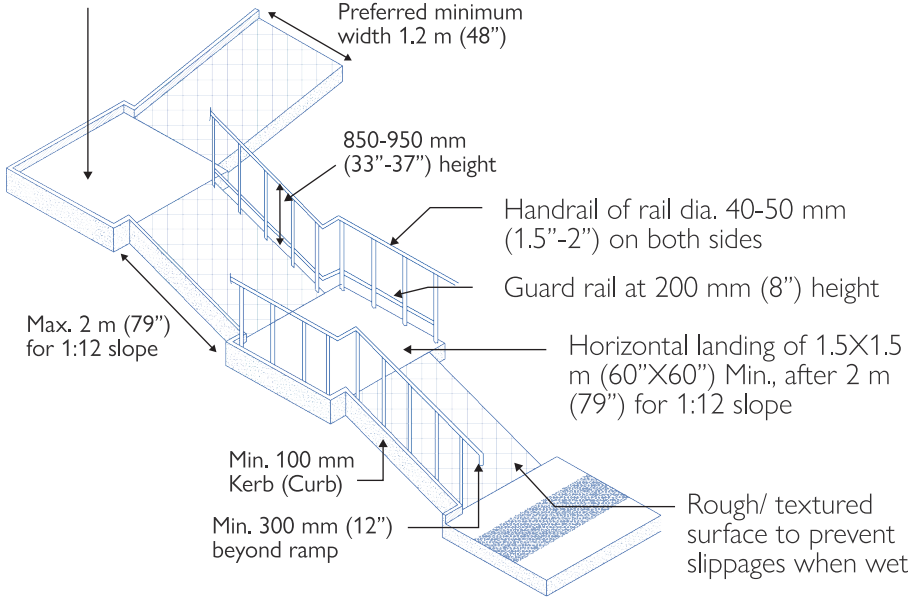
Drawbacks

- × Slow construction
- × Needs skilled mason
- × Rigid structure, can't accommodate ground movement
- × Difficult & expensive to repair

RAMP

Ramps can be used in sloping walkway connecting different levels. Suitable for any location where wheelchair access to be ensured or any locations with level difference and enough space for ramp.

Horizontal landing of 1.5X1.5 m (60"X60") Min., at turning. Curved turning is not recommended.



Source: *Accessibility for the Disabled: A Design Manual for a Barrier Free Environment*

Ensure proper slope gradient with landings incorporated at regular intervals to facilitate ease of movement.

Maximum slope	Maximum length	Maximum rise
1:20 or 5%	-	-
1:16 or 6%	8.00 m	0.50 m
1:14 or 7%	5.00 m	0.35 m
1:12 or 8%	2.00 m	0.15 m
1:10 or 10%	1.25 m	0.12 m
1:8 or 12%	0.50 m	0.06 m

Benefits

- √ Eases access for people with mobility limitations (people with wheelchair and other)
- √ Offers more comfort than stairs

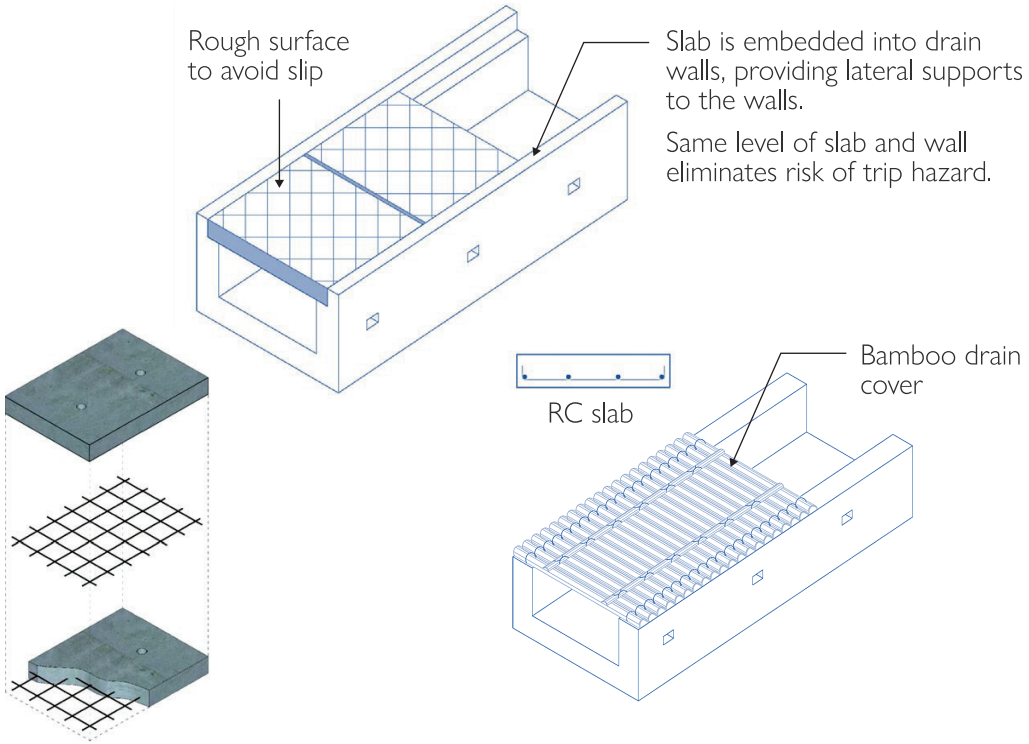
Drawbacks

- × Needs more space than stairs
- × Costly

While wheelchairs are not so common in the Cox's Bazar camps, ramps also improve accessibility for the persons with special needs.

DRAINAGE COVER

Drainage covers provide connectivity across the drains. For placement, access to facilities and connectivity of pathways should be prioritized.



Benefits

- √ Provides access to the drain side shelter or facility
- √ Can be used to make a pathway over a drain in congested locations
- √ Easy to relocate

Drawbacks

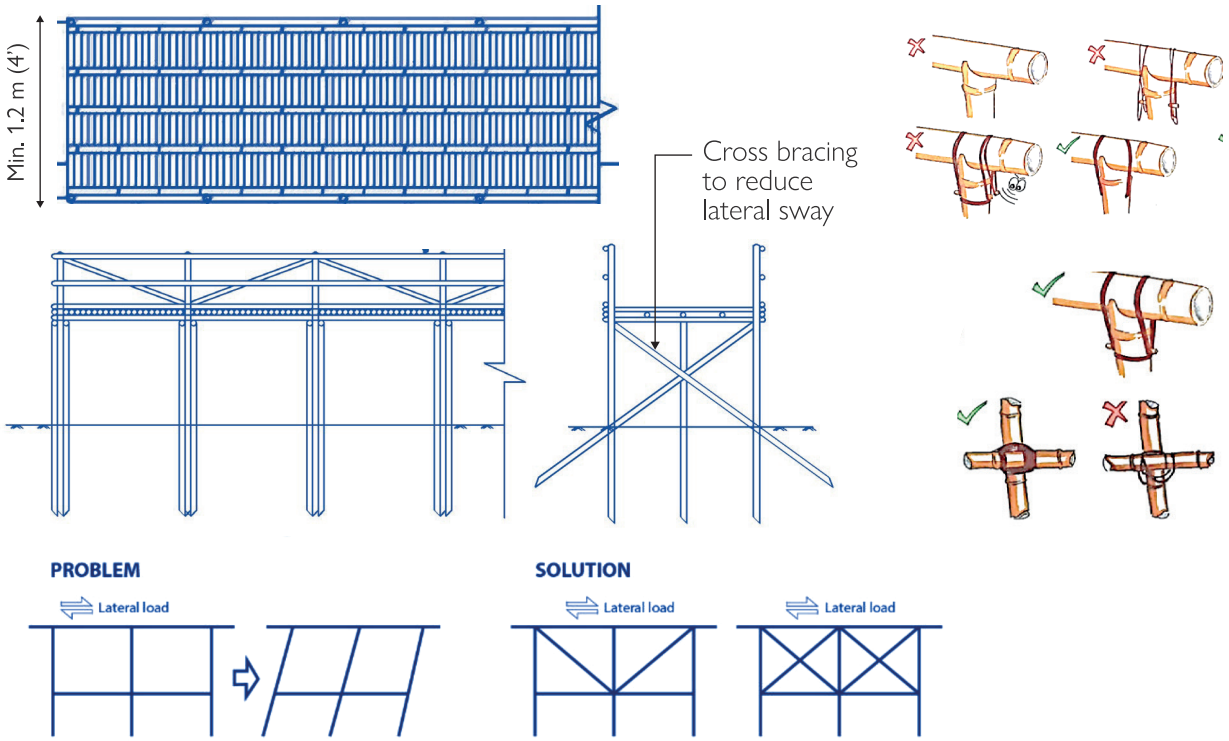
- × Can be easily stolen
- × If done in bamboo, limited lifespan
- × May cause trip hazard if not placed properly

Bamboo drain cover

Concrete drain cover

BAMBOO / TIMBER BRIDGE

Bamboo or/and timber bridges are suitable for pedestrian water crossings. Timber decking with bamboo posts and beams are used for increased life-span.



Option: Bamboo bridge with timber deck to reduce maintenance costs!

Bamboo bridge

Benefits

- √ Easy and quick construction.
- √ Timber has longer life and provide flat waling surface. Timber decking can be used even for bamboo bridges to extend the durability of the structure.

Drawbacks

- × Bamboo and timbre have a limited lifespan and need frequent repair and maintenance.
- × Timber is a bit costlier than bamboo
- × Only suitable for pedestrian use, but motorbikes sometimes use it anyways which causes rapid material deterioration.

SOLAR STREET LIGHTS

Solar Street Lights are key to ensure safe access to lifesaving services. SSL should be functional and properly maintained in all key locations including access to sub-block level WASH facilities and main facilities and distributed along main pathways at every 20-30 meters. It is estimated that every SSL benefit five to eight households.

Installation:

- The location for the SSL installation must be coordinated with the AoR agencies' Site planning teams and EETWG. Consultations with communities and with Site Management and Protection actors will be key to identify the most priority locations.
- The technical specifications and design should be coordinated through the EETWG.
- Installation should be done with appropriate technical supervision.
- During the installation, ensure the suitability of the location. SSL should not be installed in:
  - Shaded areas
  - Isolated areas (Avoid creating isolated points of light surrounded by darkness as moving through dark areas to reach well-lit places can increase protection risks)
  - Oriented properly (panel oriented towards South and light perpendicular to the road)
- Anti-theft devices should be ensured during installation

Maintenance and handover:

- Partners installing SSL should consider the maintenance costs in their planning.
- In case an organization is not able to ensure proper care and maintenance adequate handover to a partner should be discussed and agreed upon.

Community engagement and sensitization:

- Consider the safety risks while engaging communities in installation, repairs and maintenance. Most of these activities require some level of training and must not be done without proper technical supervision.
- Considering the high rate of theft of components of SSL across the camps, the sensitization of communities should be improved.

Systems need to be put in place for the monitoring and maintenance of the SSLs. Regular assessment and feedback/ complain mechanisms are also established to ensure proper monitoring of the SSLs. Tagging of the SSL enables to maintain a data base on the functionality.

All partners engaging in the installation and care and maintenance of SSL should coordinate with the EETWG and follow the Solar Lighting Guidelines.

Solar panels need to be regularly cleaned in the dry season to ensure the proper functioning of the SSL.

ANNEXES

POST CONSTRUCTION CHECKLIST FOR SITE IMPROVEMENT INTERVENTIONS

What is the purpose of this checklist?

This checklist is to be maintained by the field officers before and during the intervention. Then after completion post construction check will be done. Need a weighted score for each checklist question to come to a decision on the overall quality of the structure.

General checklist for all interventions:

1. Community surrounding the intervention was consulted prior to beginning works on the following:
   - ☐ The streamway of the intervention with start and end point
   - ☐ Materials to be used
   - ☐ Intervention design

2. Request referral pathway is clear to community or not

3. Are there additional interventions needed? (e.g. drain beside a pathway or staircase, retaining wall beside a drain or staircase). If yes, list below:

_____

4. Is the quality and quantity of the material adequate?
   - ☐ Yes
   - ☐ Partially. Explain why _____
   - ☐ No. Explain why _____

5. Does the intervention design match with the SD catalogue?
   - ☐ Length is correct
   - ☐ Width is correct
   - ☐ Height is correct
   - ☐ Connections are correct

Cost-benefit:

1. Was the intervention constructed within the budgeted unit cost?
   - ☐ Yes. Please record unit cost: _____
   - ☐ No. Explain why _____

2. How many beneficiaries does this intervention directly serve?
   - ☐ Number of individuals: _____
   - ☐ Number of households: _____

DRAINAGE

Questions for Drainage:

1. Drainage covers all surrounding household and catchment or not?
2. Slab provided where needed or not?(Household, road, any facility, children playground etc.)
3. Drain slope maintained or not?
4. Weephole provided on the wall or not? (1-1.5m spacing)
5. Finishing and plastering is good enough or not? (Drain inside and outside plastering is recommended to plaster at least 5" or 1 Bricks layer and full plastering where outside of drain is visible)
6. Silt trap provided where needed or not?
7. Drain level is below the ground level or not?
8. Drainage network is maintained or not?
9. Is the quality of workmanship satisfactory?
10. Slab is levelled with the drain height or not? (Precast slab having ring and hole (as necessary) should be used)
11. Recommended to make soak pit where needed and according standard.
12. Recommended to follow the standard of Plastering on BFS.
13. Proper curing has been initiated or not?
14. Energy dissipater block or Step is provided in case of steep slope or not?

SLOPE STABILIZATION

Questions for Soil Retention Wall:

1. RCC/CC Foundation is provided in the Brick/RCC wall or not?
2. Weep hole provided in the Brick/RCC wall or not?
3. Household is the safe distance of the wall?
4. Proper curing has been initiated in the Brick/RCC wall or not?
5. Bamboo anchoring or tie with GI wire provided on the bamboo wall or not?
6. Proper Horizontal space kept between two layers/steps of bamboo-geo bag wall or not?
7. Any tree planted on the horizontal surface or not?
8. Proper backfilling with compaction has been done or not?
9. Proper inclination and slope maintained or not?
10. Is the quality of workmanship satisfactory or not?

Further recommendations

1. Place columns at proper distance with one third beneath the ground.
2. Recommended to use Geo Textile instead of Geo-bag or plastering.
3. Recommended to bind edge of Soil Retention Properly.
4. Plaster should be standard and well finished.
5. Need to keep proper covering in the RCC Column or slab.

ACCESS

Questions for roads and pathways:

1. Is the access bed arrangement plain and strong enough?
2. Are there joints in every 3.5 m of brick pathway?
3. Edging with brick, bamboo or mortar is provided or not?
4. Is the surface rough enough to resist slips?
5. Are the Side drainage provided where necessary?
6. Is the slope protection done where necessary?
7. Is the quality of workmanship satisfactory?

Questions for stairs:

1. Is there a handrail?
2. Are the risers 150 mm (6") or less?
3. Are the treads at least 300 mm (12")?
4. Are there landings after every 10 to 12 steps?
5. Are the surface of the steps rough enough to prevent slips?
6. Any sharp edge remains in bamboo of steps and railing?
7. Proper compaction of soil is done or not?
8. Mix ratio is maintained or not?
9. Steps are horizontally level or not?
10. Are the Side drainage provided where necessary? If not, are there curbs on the edges to prevent water spill away from the steps?
11. Is the slope protection done where necessary?
12. Is the quality of workmanship satisfactory?
13. Plastering is done on the outer surface or not?
14. Proper curing has been initiated or not?

Questions for bridges:

1. Bridge surface is levelled (timber/bamboo spacing, bamboo mat) properly or not?
2. Is the width reasonable?
3. Is the bridge stable without any shaking or sway in any direction?
4. Proper rope bindings and nailing are provided or not?
5. Entry and exit point (stair or approach road) of bridge is smooth or not?
6. Railing has provided or not?
7. Any sharp edge remains in bamboo on walkway and railing?
8. Is there proper finishing and workmanship?

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