SITE IMPROVEMENT CATALOGUE

IOM UN MIGRATION | UNHCR The UN Refugee Agency | WFP World Food Programme | ISCG

CONTENTS

INTRODUCTION

Objective:

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

1. To avoid injuries or casualties on site
2. To follow good construction practice and avoid common errors
3. To make informed decisions as to what interventions are appropriate and cost effective
4. To ensure consistency with other SI actors across all camps

The guidance contained in this catalogue is applicable in all camps in Cox Bazaar district, including Teknaf camps.

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.

Site Improvement or Site Development?

Site Improvement: Small scale, low tech works implemented using casual labour, typically consisting of secondary and tertiary pedestrian access and drainage and low-risk slope stabilization.

Site Development: Technically complicated, large scale or high risk works, often involving machinery, such as vehicle roads or concrete retaining walls. Site Development works are generally implemented directly by IOM or SMEP or by UNHCR, WFP or LGED through contractors (not NGO partners). All Site Development works require full engineering design, to be submitted to the relevant Site Management Area Coordinator (i.e. IOM or UNHCR) for approval.

This catalogue is provided for Site Improvement works only. Agencies planning to implement Site Development works should coordinate with IOM/UNHCR (as appropriate), who can provide technical assistance.

HEALTH AND SAFETY

Supervision, Risk Assessments and Safety Inductions:

- All works should be supervised by a technically qualified construction worker
- Each site to be overseen by a trusted foreman who knows the safety procedure and has received basic First Aid training and has access to a First Aid kit
- At high risks 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 the site safety and ensure no public access
- Provide a safety induction tailored to the activity for all labourers, especially when working alongside machines. Explain how to use new tools & machines such as a generator or drilling tool

Protective Equipment:

- All workers should wear hi-visibility vests;
- Use appropriate Personal Protective Equipment suitable for the construction activity (i.e. gloves, goggles) or weather conditions
- As far as possible, encourage all labourers to wear closed shoes (not sandals); Rain boots should be worn while working in wet areas
- Use a mask, gloves and boots for clearing drains

Supervision, Risk Assessments and Safety Inductions:

- Avoid overcrowding sites. Only hire as many labourers as required for the task, and provide sufficient space for them to work
- Maintain tidy sites: Scattered materials and tools lying around present trip hazards
- Prevent the public and (and especially children) from entering the construction area using tape and/or warning signs as appropriate. Discuss access and safety issues with the local community prior to starting work
- Never leave deep excavations uncovered overnight
- Provide shade and drinking water for labourers
- Maintain clear separation of activities and access areas when working alongside machines
- In the case of soil instability, a qualified technical person should verify the 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 off from public
    - Provide rescue rope
    - Safety Induction

	High Risk Tools / Materials	Risks	Mitigation
Excavation	Spade, shovel, hoe, pick, etc.	Cuts & impact injuries	Safety induction Avoid overcrowding sites Ensure safe slopes
Deep Excavations	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 assesment 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 labourers 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
All Public Works	None	Risks to public	Segregate works using tape &/or hazard/information signs Discuss works with local community prior to starting

*refer to Protection Sector guidance on portering


DRAINAGE

DRAINAGE: STRATEGY

Guiding principles for stormwater management in the camps:

1. **Slow down the flow of water and promote infiltration in the less densely populated upstream half of the upstream half of the catchment area** to reduce flooding in congested downstream areas
    - Only use impermeable canal lining (brick, concrete, tarpaulin, etc.) where necessary, such as for high velocity flows or down steep slopes
    - Maintain a gentle slope in all drains by following contour lines as far as possible
    - Use check dams or steps on steep drains
    - Use silt traps to promote infiltration and prevent downstream drains & culverts from blocking.
    - Store water upstream using retention basins or ponds
    - Allow unpopulated valley floors to flood, in order to reduce peak flows downstream

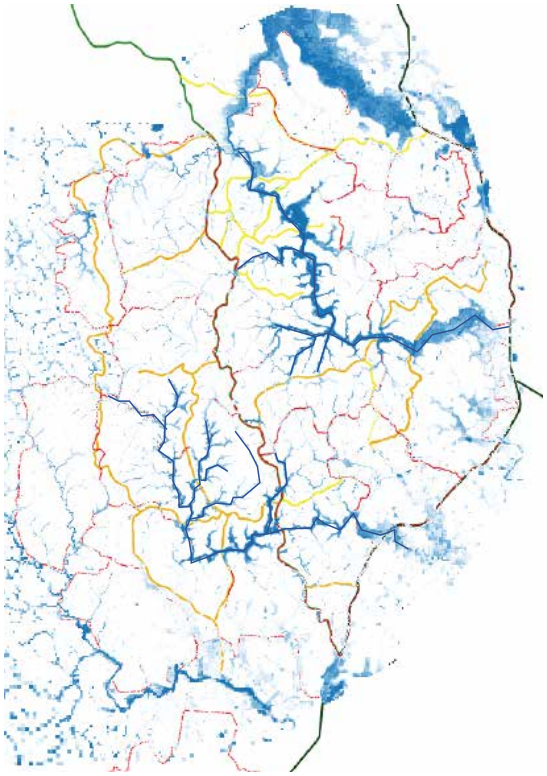
2. **Prevent surface erosion** to prevent silt washing off exposed slopes and blocking drains downstream
    - Plant grasses on exposed slopes to protect the surface
    - Use jute or geotextile roll to protect exposed soil if there is no time for grass to grow before monsoon
    - Use catch/ridgeline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

3. **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
    - Brick/concrete drains are prone to brittle failure and are difficult to repair

4. **Promote durable solutions**
    - Use soft/flexible infrastructure (not brick and concrete, which cannot accommodate ground movement) where possible, e.g. in open valleys
    - Plant vegetation along embankments to protect from erosion and prevent collapse

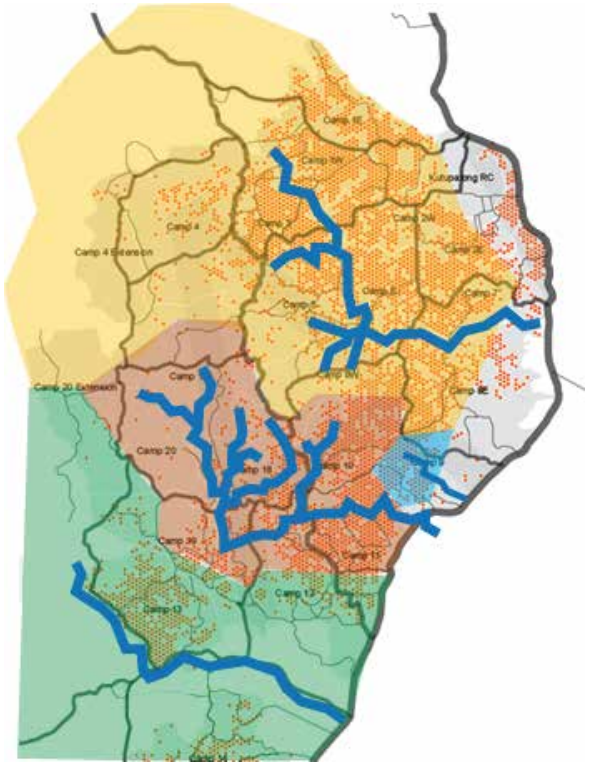
5. **Ensure networked drainage**
    - The drainage network must be considered as a whole, with connected drains from source to outlet
    - Drainage capacity should increase as you move downstream

DRAINAGE: MAPS



FLOOD MAP

POPULATION DENSITY



CATCHMENT AREAS

Note: Kutapalong-Balukhali Expansion camps shown for illustration purposes only. Detailed flood risk maps for all camps (including Teknaf) are available from ISCG Natural Hazards Task Force

FLOODING RISK MAP

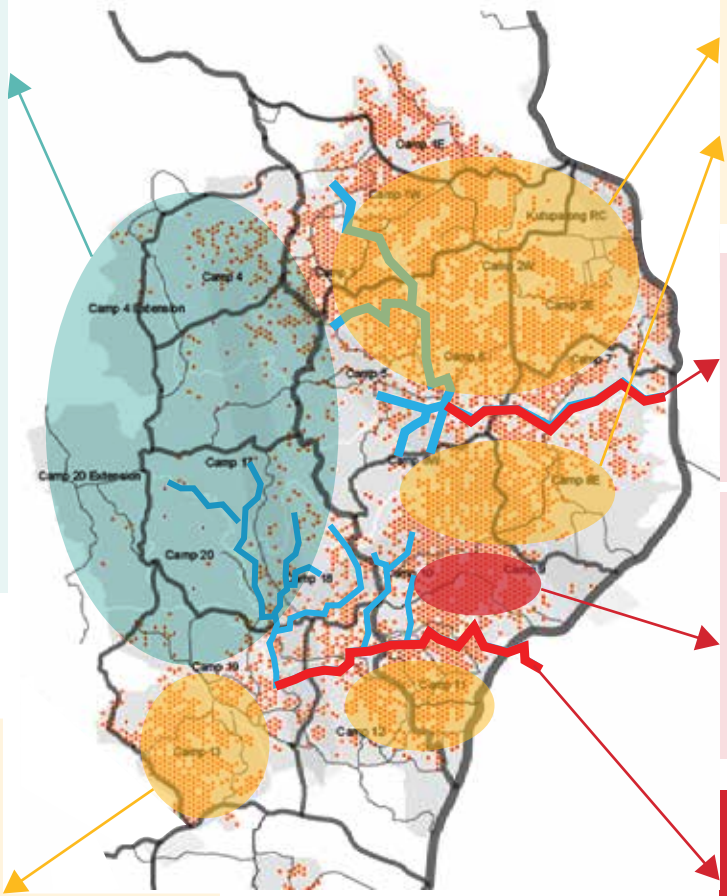
Camps 4, 4Ext, 17, 18, 20 & 20Ext:
Low risk
Low population density
Shelters on hills (not in flood plains)

Catchment area for major rivers:

Reduce flow speed and promote infiltration & retention

Use unlined drains & natural materials

Follow natural river curves
Use silt traps where possible, esp. at natural bottlenecks



Camps 11, 12 & 19:
Medium risk
High population density
Few shelters in flood plains

Use natural materials in open valleys
Use brick & concrete drains in congested areas

Camps 1-8:
Medium risk
High population density
Few shelters in flood plains
Use natural materials in open valleys
Use brick & concrete drains in congested areas

Mudhuchara River (Camps 6, 7 & 8):
HIGH RISK
Medium population density
High flood level
Fast flowing water

Camps 9 & 10:
HIGH RISK
High discomfort level
High population density
High water level & shelters in flood plains
Slow moving water

Camps 10 & 11 River:
VERY HIGH RISK
High population density
Low lying shelters & high flood level
Fast flowing water

DRAINAGE: KEY PRINCIPLES

1. RETENTION

Slow down & retain water in the sparsely populated upstream half of the camp to reduce peak flows in the rivers downstream

Use natural drains (unlined / jute bag / bamboo) to allow infiltration

Follow natural river curves

Retain water using retention basins, ponds or silt traps

Allow community gardens to flood

2. SURFACE EROSION & SILTATION

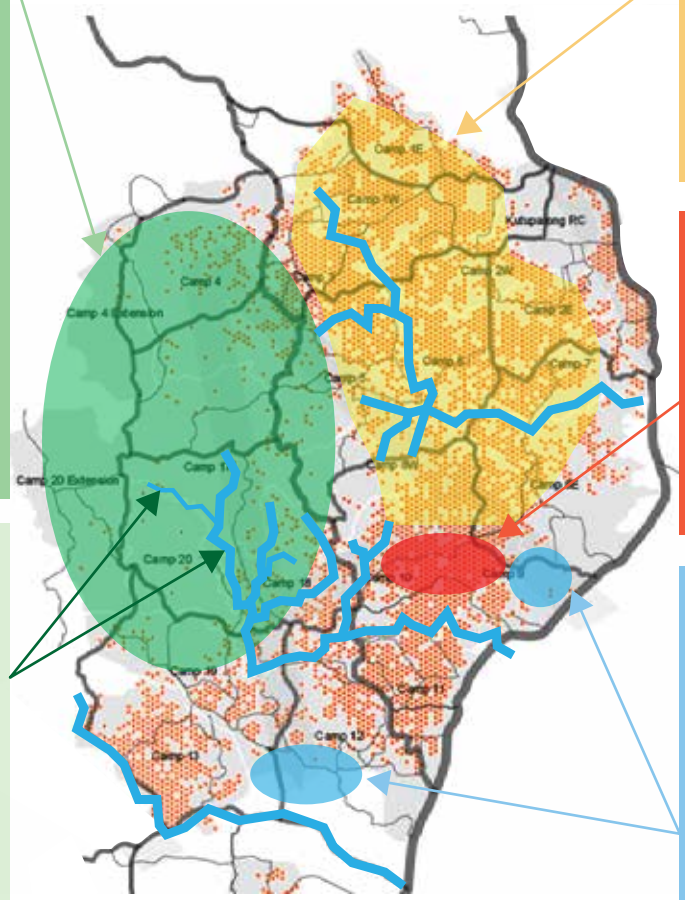
Prevent surface erosion - Silt washing off exposed slopes creates blockages downstream

Protect slopes with terracing, jute roll &/or planting

Use catch/ridgeline drains

Silt traps

Build small silt traps along drains in open valleys



3. BRICK & CONCRETE DRAINS IN SHELTER AREAS, NATURAL DRAINS IN OPEN VALLEYS

Robust, easy to clean brick drains in high density shelter areas prevent erosion & reduce blockages

Natural drains in open valleys promote infiltration and slow down flow

4. BRICK & CC DRAINS IN LOW LYING CONGESTED AREAS

Remove water quickly to minimize duration of flooding

Easy to clean brick drains maximize capacity in congested areas

Clean drain & choke points frequently

5. OVERFLOW INTO PADDY FIELDS

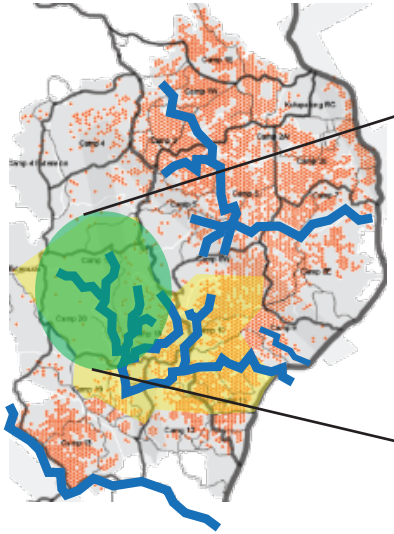
Paddy fields can store excess water from rivers which prevent water from backing up into the camps

Allow drains to overflow into paddy fields

N.B. CiC & UNO to negotiate with land owners

Note: Kutapalong-Balukhali Expansion camps shown for illustration purposes only. Detailed flood risk maps for all camps (including Teknaf) are available from ISCG Natural Hazards Task Force

1. RETENTION

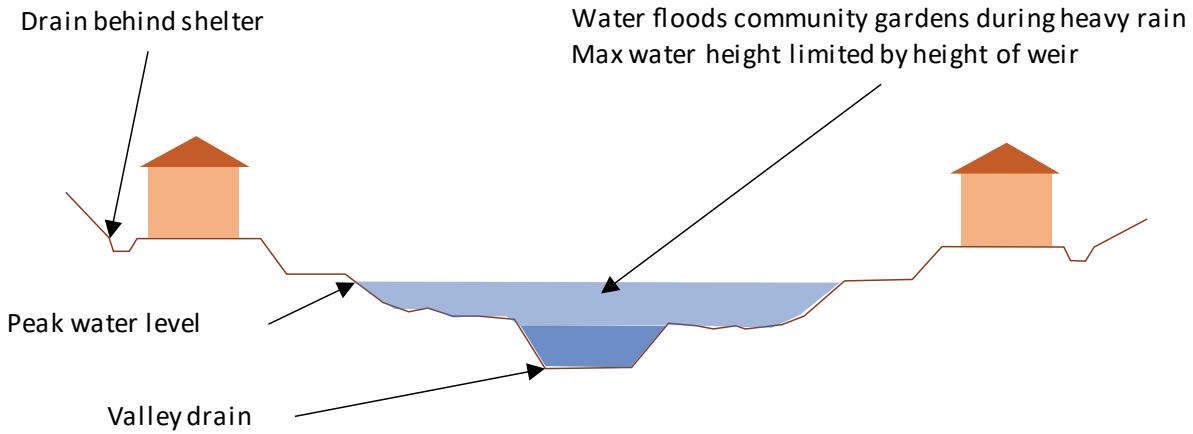


Camps 17, 18 & 20 (green) = approx. 30% of total catchment area (yellow)

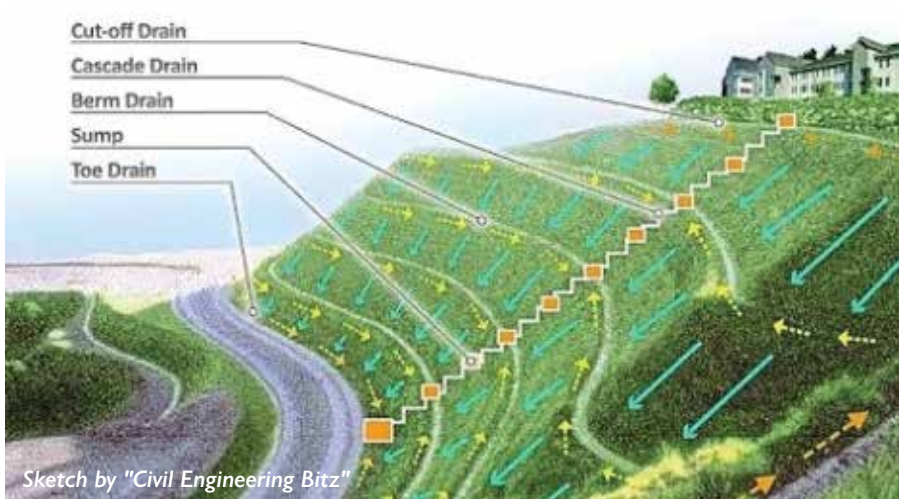
Unpopulated valleys can be used as retention basins

Install slow-draining dams every 50-100 m

Slow drains with natural materials



2. SURFACE EROSION & DESILTING



Planted terraces slow down surface water & prevents erosion
Drains along ridgeline & terraces link to cascade drain

Jute fabric prevents surface erosion while pants are still growing

Slow-draining barriers across valley floor to slow down water & prevent silt from clogging downstream drains:

Geotextile wrapped around loose rubble (use brick in Bangladesh)

Straw bale silt fence

3, 4 & 5. CONGESTED AREAS, PADDY FIELDS & DOWNSTREAM RIVERS

3.SECONDARY DRAINAGE:

Fast flowing brick & CC drains in low-lying congested areas to take water quickly out of the camp

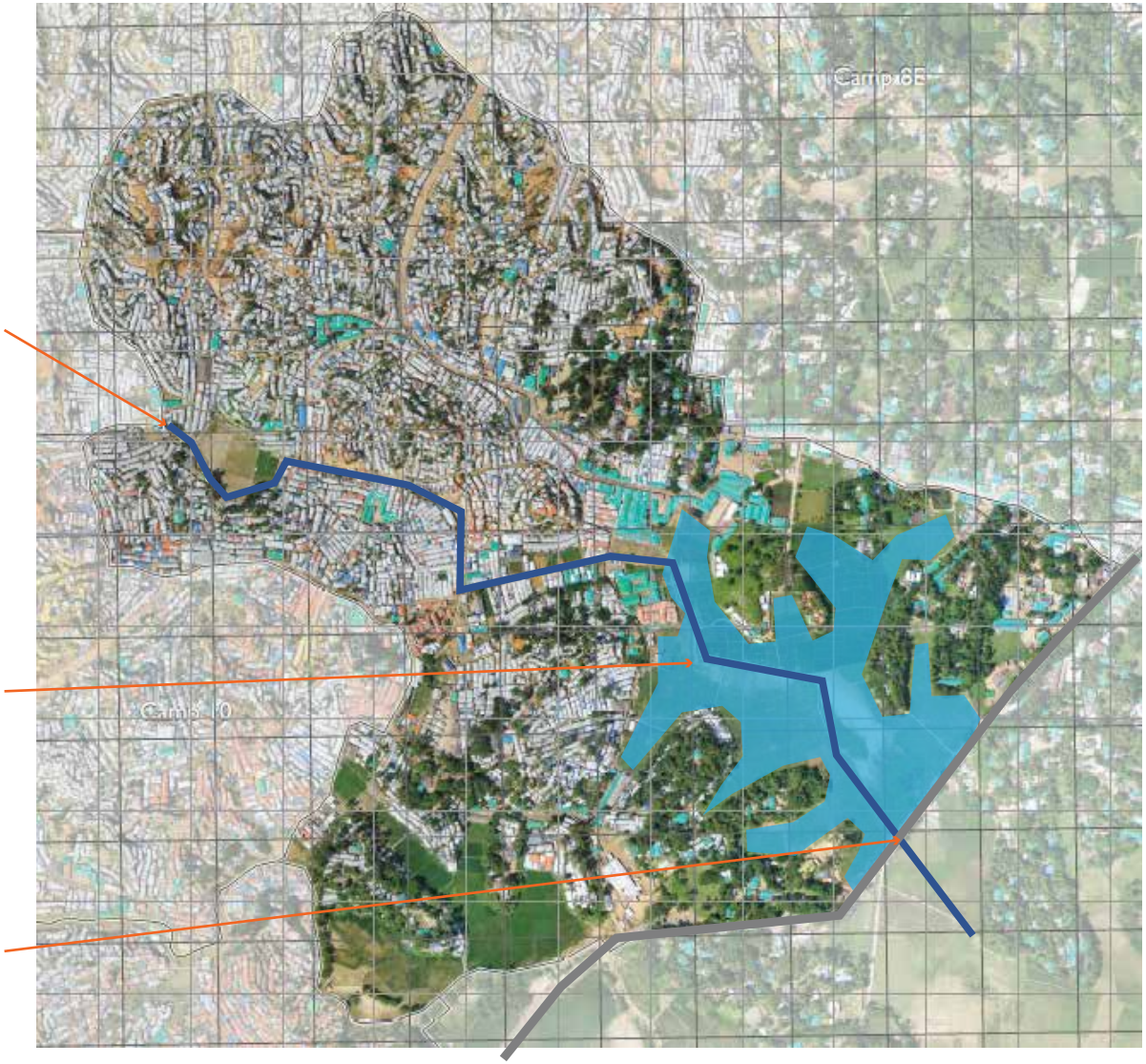
4. PADDY FIELDS:

Excess water can safely be stored in paddy fields to prevent flooding in shelter areas

Allow water to overflow into the paddy fields by breaking down the river banks at the start of the monsoon

5. DOWNSTREAM RIVERS:

Dredge river downstream of camp and clear culverts below main road



DRAINAGE: GUIDING PRINCIPLES

1. Slow water down

- 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 using ponds or silt traps
- Promote infiltration

2. Prevent erosion

- Silt washes off exposed slopes and blocks drains downstream
- Plant grasses on exposed slopes to protect surface
- Use jute fabric to protect loose soils if there is no time for grass to grow before monsoon season
- Use catch/ridgeline drains to prevent water flowing down the hill face

3. Durable does not necessarily mean brick/concrete

- 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
- Brick/concrete drains in flat areas create stagnant water in the dry season
- Brick/concrete drains cannot accommodate ground movements or settlement

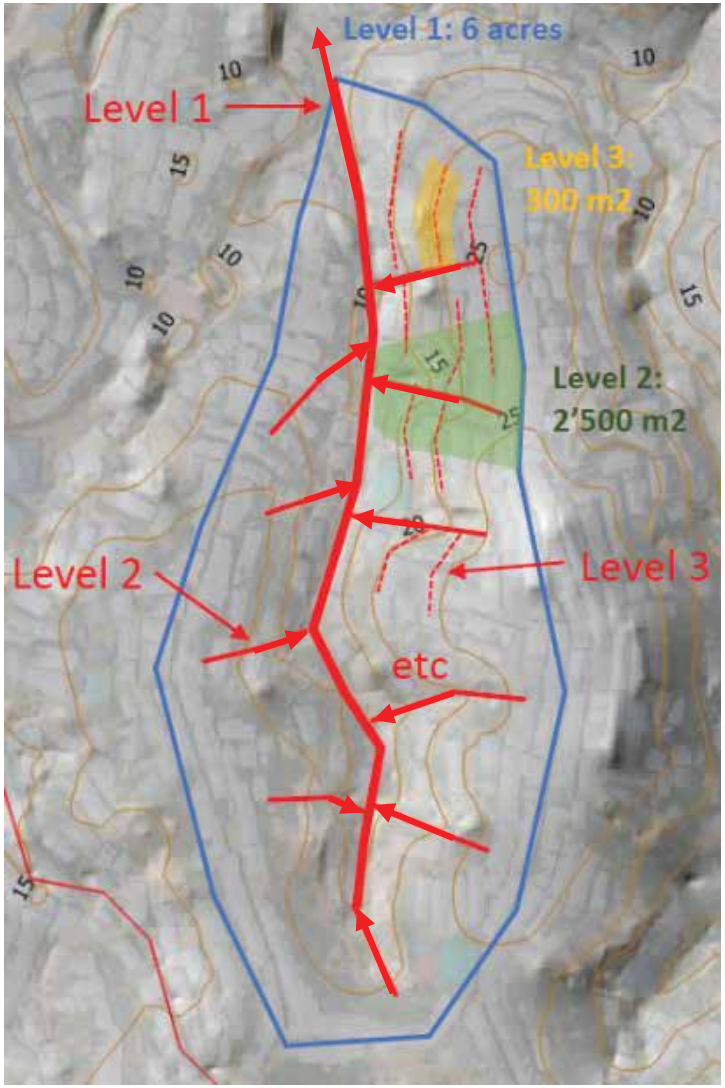
4. Dry season drainage & grey water

- 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

5. Always consider the full network

- Do not design drainage components in isolation
- The solution may lie upstream
- Ensure your intervention does not cause problems downstream

DRAINAGE: CAPACITY ESTIMATION



1. Drainage levels

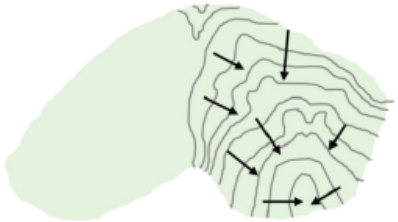
- Level 3 (tertiary): drains the household plots; connects to level 2
- Level 2 (secondary): drains water down the hill; connects the household drainage (L3) to the valley drainage (L1)
- Level 1 (primary): drains the water out of the secondary valleys; connects to primary valley drainage or river

2. Drainage positioning

- 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
- 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
- Level 1: follows the lowest line of the valley floor; collects all level 2 drains on the way out of the valley

DRAINAGE: CAPACITY ESTIMATION

1



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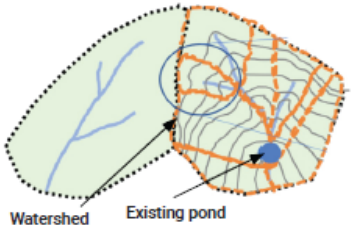

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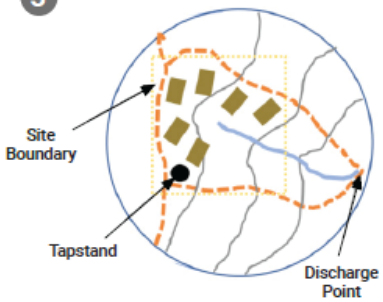

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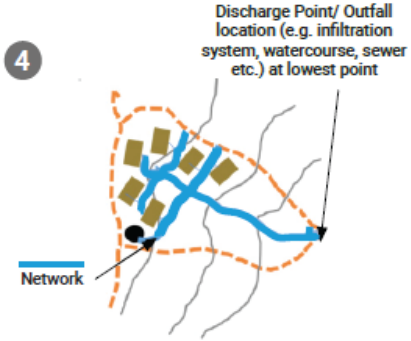


Source: ARUP Surface Water Management guide

1. Identify the topography and contours and flow paths (refer to p.17). Modelling software can produce this automatically from contour information, but it should be verified by a site walkover. Flow paths (direction of flow downhill) should be directed at 90° degrees from contours.

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

3. Identify existing natural and man-made drainage components and the catchments and the sub catchments

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

5

5. Identify hierarchy of the drains:
Tertiary (grey) – neighbourhood level
Secondary (black) – running past the site in to which the tertiary site drains discharge
Primary drain (blue) – a large drainage canal, stream or river in to which a secondary drain discharges.

1. Some typical figures (to be adapted to local context)

- Rain intensity: 0.5 mm/min for short time intervals (up to 3 hours)
- Surface area for level 3: 150 - 300 square meters (5-10 plots)
- Surface area for level 2: few thousand square meters
- Surface area for level 1: several acres (1-3 ha)

2. Minimum guiding values for drainage capacity (to be adapted to local context)

- Level 3 : 5-10 L/s; drain section of 1' x 1'
- Level 2: 40-80 L/s ; drain section of 1.5' x 1.5'
- Level 1: 300-600 L/s; drain section of 4' x 3'

3. 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

DRAINAGE: SCENARIOS & OPTIONS

1. Household & Pathway

a. Infiltration Drain
b. Bamboo & Basha Bera
c. Brick / Brick & CC

2. Catch / Ridgeline Drains

a. Overview
b. Precast Concrete

3. Cascade / Discharge Drains

a. General
b. Key Detail: Discharge Point

4. Stairways

a. Brick / Brick & CC

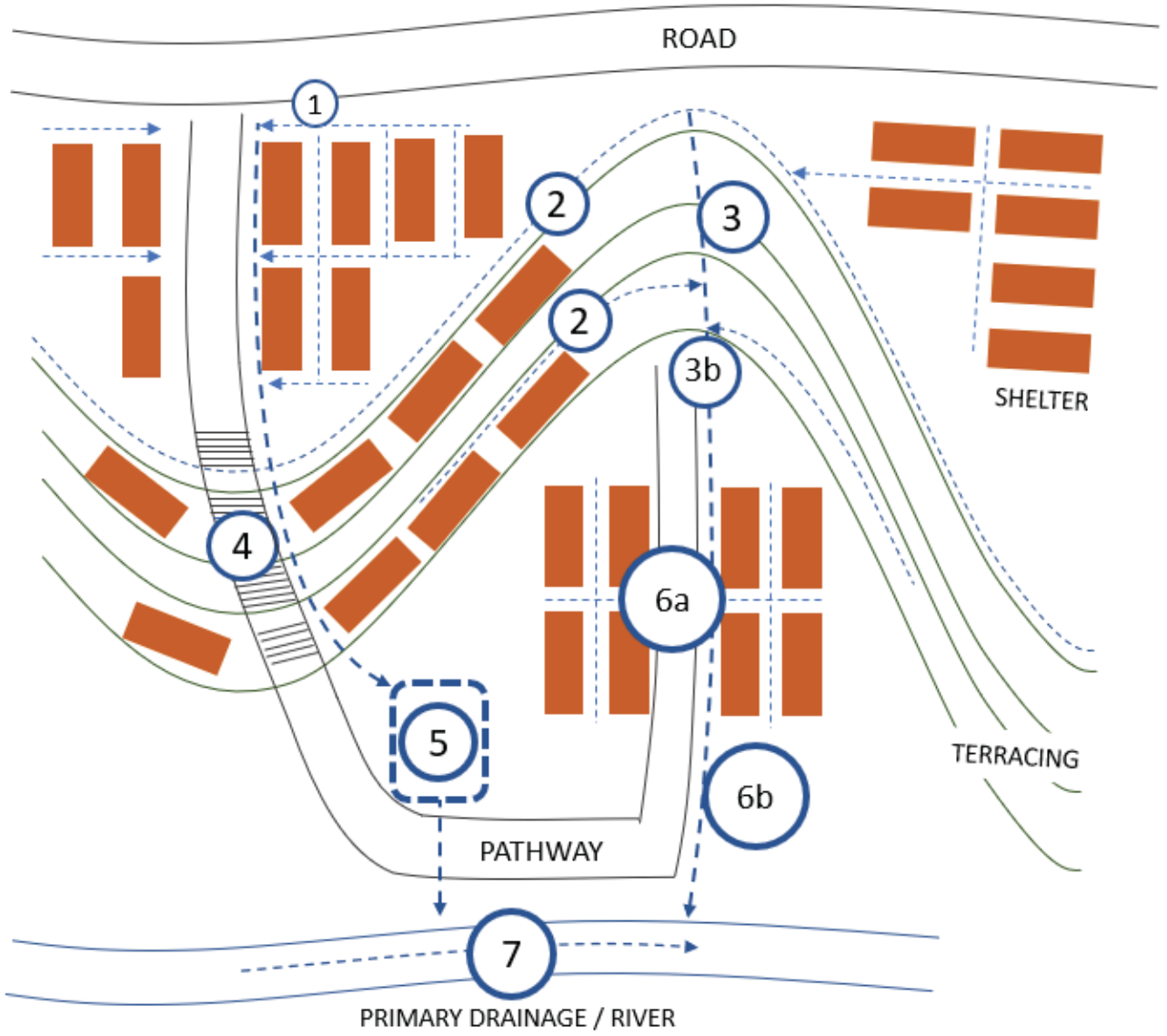
5. Slow &/or Store

a. Retention Basins
b. Silt Traps

6. Secondary

a. Congested: Brick & CC
b. Open: Bamboo & Basha Bera
c. Open: Jute Bag
d. Perforated Precast Panels

7. Primary

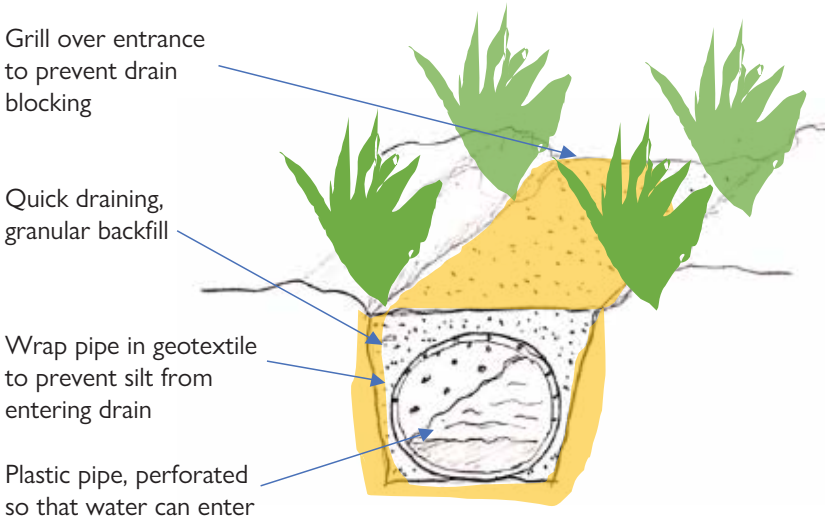


INDICATIVE COSTS

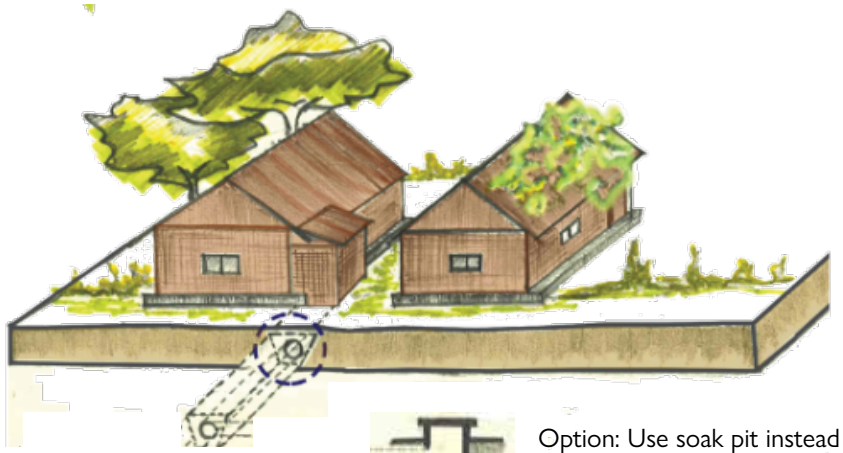
Category	Type / Material	Depth (ft)	Width (ft)	Materials BDT / m	Labour BDT/m	Porter cost	Total BDT/m	Durability	Notes
Household, Pathways & Catch Drain	Bamboo & basha bera	2	2	1100	300	Low	1400	Poor	
	5" Brick wall + 3" CC base	2	2	1200	1000	High	2200	Good	
Discharge	Jute bag with sand-cement	1.5	1.5	2200	200	High	2400	Moderate	
	Geotextile bag w. earth filling	1.5	1.5	1300	200	Low	1500	Good	Recommended
	Brick & CC	1.5	1.5	1000	1000	High	2000	Moderate	Recommended
	Precast concrete	1.5	1.5	2000	1200	High	3200	Good	
Secondary	Bamboo	3	-	2300	400	Low	2700	Poor	Plant along edge and through walls
	Jute bag & earth filling	3	-	1300	400	Low	1700	Poor	Plant along banks
	Jute bag with sand-cement	3	-	3900	500	High	4400	Moderate	Use geotextile instead
	Geotextile bag & earth filling	3	-	2000	400	Low	2400	Good	Plant along banks
	10" Brick wall + 3" CC base	3	3	3000	1300	High	4300	Good	Use up to 5' wide
	10" Brick wall + 3" CC base	3	6	3800	1800	High	5000		Not economic over 5' wide
Silt trap	Jute bag & earth filling	3	20'x20'	16,000	4000	Low	20,000		Plant along banks
	10" x 4' Brick wall w. earth base	3	20'x20'	40,000	5000	High	45,000		Not cost effective

1. HOUSEHOLD & PATHWAY

a) Infiltration Drain for Bathing Facilities



Sketch: Save the Children



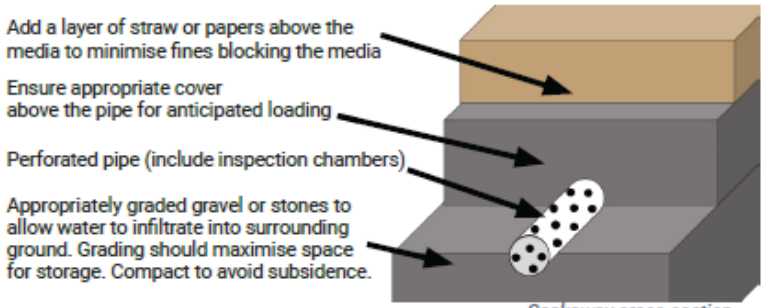
Infiltration trench

Option: Use soak pit instead (similar to a latrine pit but with porous walls and base)

Description	Perforated plastic pipe in channel surrounded by coarse aggregate
Key detail	Wrap pipe in geotextile to prevent silting upCut/drill small holes in pipe to allow water to soak in and out
Scope of Use	Connect to bathing units to prevent grey water entering main drainsBest in sandy soils. Increase size of trench / soak pit in silty soils
Advantages	Durable, invisible Efficient use of space Good for processing grey water from water points and bathing units
Disadvantages	High cost Difficult/technical construction Not suitable in clay or non-absorptive soils

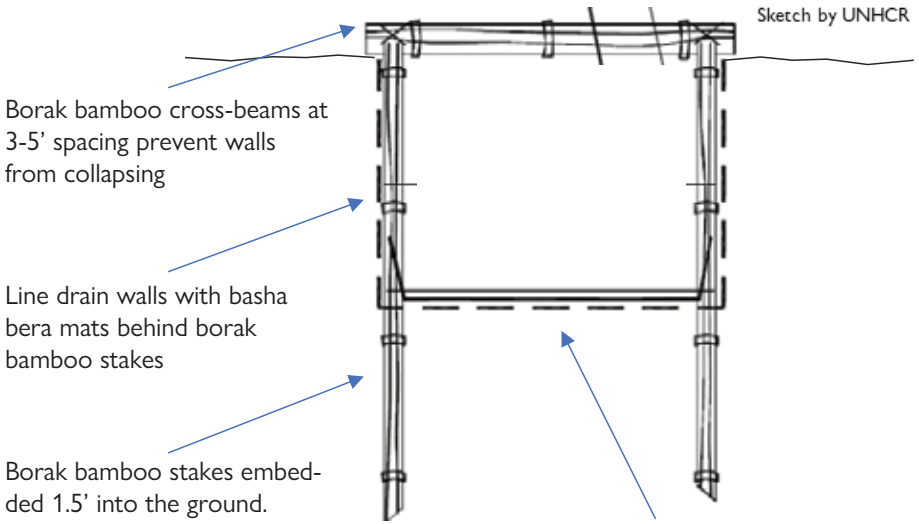
SIZING

- Calculations should account for volume loss due to gravel/media.
- Refer to Engineering in Emergencies (2002) p.175-178.
- Consider impact of lower than expected infiltration rates.



Soakaway cross-section

b) Bamboo & basha bera drain

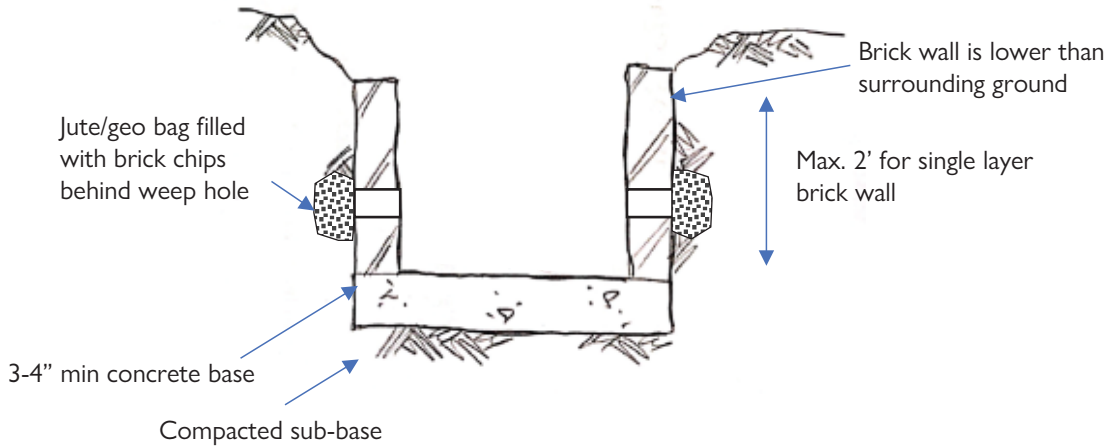


Description	Bamboo and tarpaulin household-level drain
Key detail	Compacted earth base Side walls are permeable Include check dams in steep areas
Scope of Use	Alongside minor pathways and ridgelines
Advantages	Simple to build & repair Efficient use of space with pathway above
Disadvantages	Needs to be replaced frequently Difficult to clean

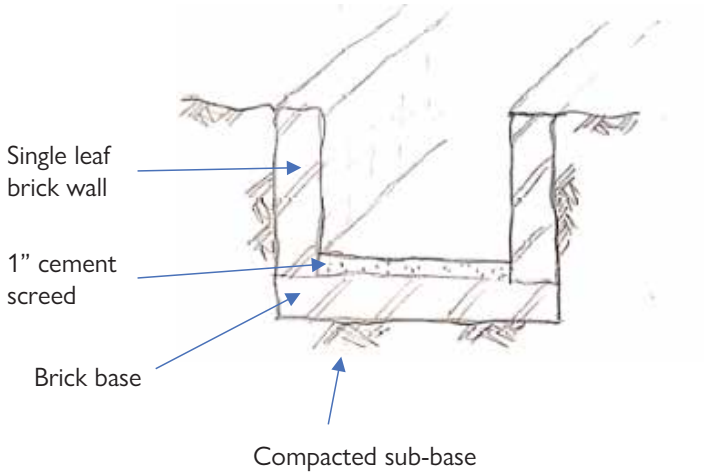
Option: Borak bamboo walkway above drain (N.B. use borak in cross direction) Efficient use of space but increased cost

c) Masonry, small capacity

Option 1: Concrete base



Option 2: Brick base

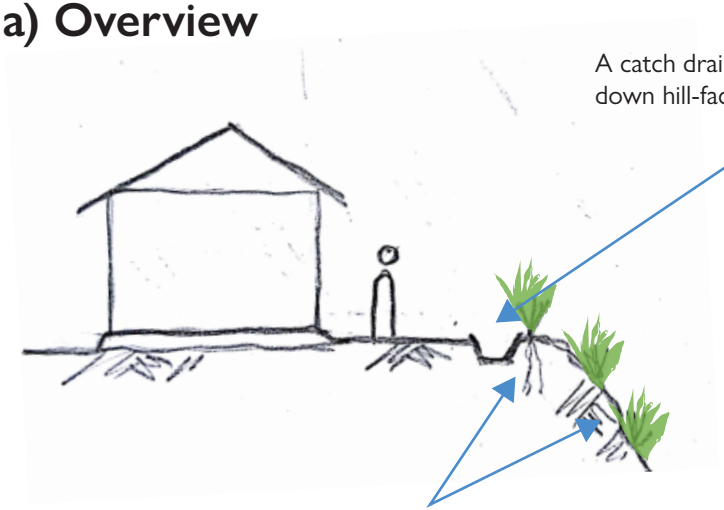


Description	Small brick & cc drain
Key detail	Install weep holes if wall is above 2' Drain edge is lower than surrounding ground (so water can flow in)
Scope of Use	Small drains alongside tertiary roads/pathways/stairways in congested areas
Advantages	Durable Simple to build & repair Good in congested areas
Disadvantages	High cost No infiltration & high flow velocity • Increased risk of flooding downstream • Use baffles to slow water on steep drains

Small drain alongside brick road.
Note that water can flow off pathway into drain

2. CATCH DRAIN / RIDGELINE DRAIN

a) Overview



A catch drain along edge of hilltop to prevent water running down hill-face. Connect to cascade drain at low point

Plant along ridgeline and protect exposed soil with planting & jute roll or terracing – see Stabilization

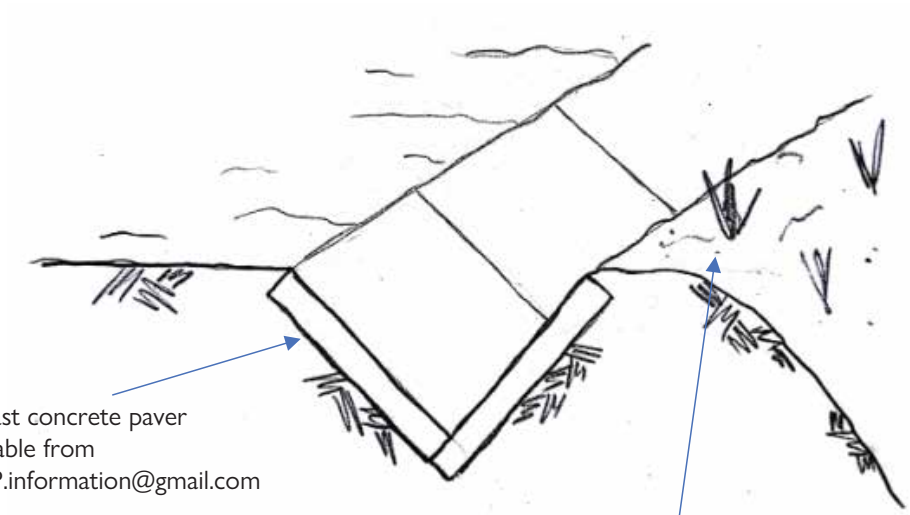
Drone image showing catch drain (red) around hilltop shelters, connected to cascade drains (dark blue) at intervals

Description	Drain along ridgeline to prevent water running over ridge and down hill-face
Key detail	Connect to discharge drains at low-points (look for natural ravines) Plant along ridgeline Drain can be any material (e.g. jute bag, bamboo, brick, etc.)
Scope of Use	Along the edge of hilltops or terraces to prevent water flowing down hill-face Connect to discharge drain

Natural materials allow infiltration and slow down water, but require annual repair

Brick: durable and easy to clean but can increase erosion downstream. Use steps to reduce water speed

b) Precast concrete V-drain



Precast concrete paver
Available from
SMEP.information@gmail.com

Recommended paver size: 3" x 1' x 2'
(to limit carrying weight)

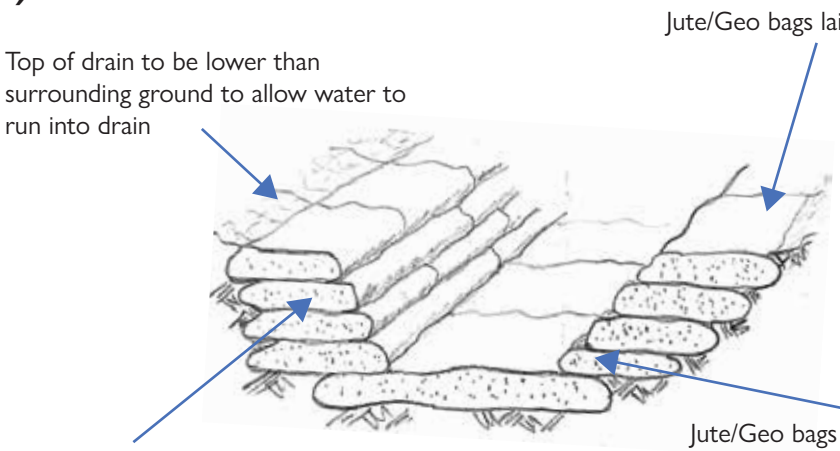
Plant along edge

Description	V-drain with precast reinforced concrete pavers mortared together
Key detail	Drain edge is lower than surrounding ground (so water can flow in) Chip edges of panels to create rough surface for mortar to bond to
Scope of Use	Alongside roads and pathways As catch drains alongside ridgelines or terraces, connected to discharge drains
Advantages	Durable Simple to build & repair Panels can be moved to a new location if necessary (e.g. site is re-planned)
Disadvantages	No infiltration & high flow velocity • Increased risk of flooding downstream

V-drain alongside pathway

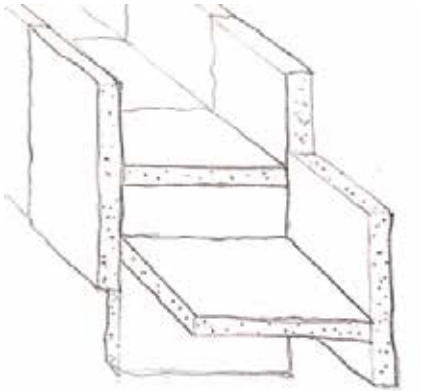
3. CASCADE / DISCHARGE DRAINS

a) General



Jute bag base with jute bag walls (Option: 5-10% cement for durability)
Rough, uneven surface of jute/geotextile bags reduces water velocity > reduced erosion

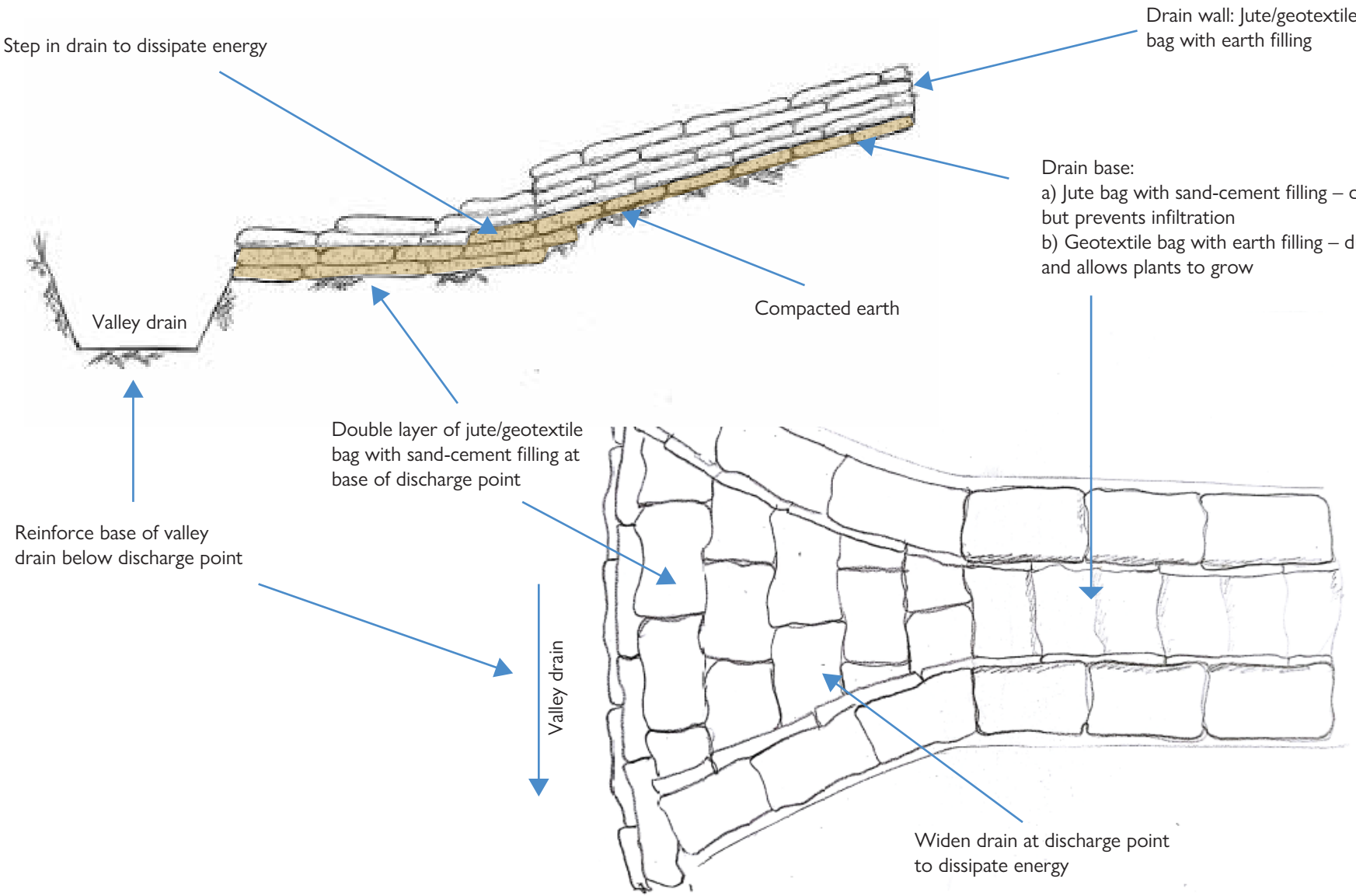
Description	Steep drain down hill-face, connecting hilltop drains to valley floor
Key detail	Drain top to be lower than surrounding ground to let water flow in Add check dams or steps to reduce velocity / dissipate energy Plant vegetation between bags to slow down flow and improve durability
Scope of Use	Connecting drains along terraces/ridgeline to valley drains Replacing natural ravines/gullies
Material Options	Jute bag & sand/cement: moderate durability, easy to repair Geotextile bag: Durable, easy to repair Brick: Moderate durability, difficult to repair Precast concrete: Durable, difficult to repair



Precast concrete panels from SMEP
Option: brick check dam to slow water

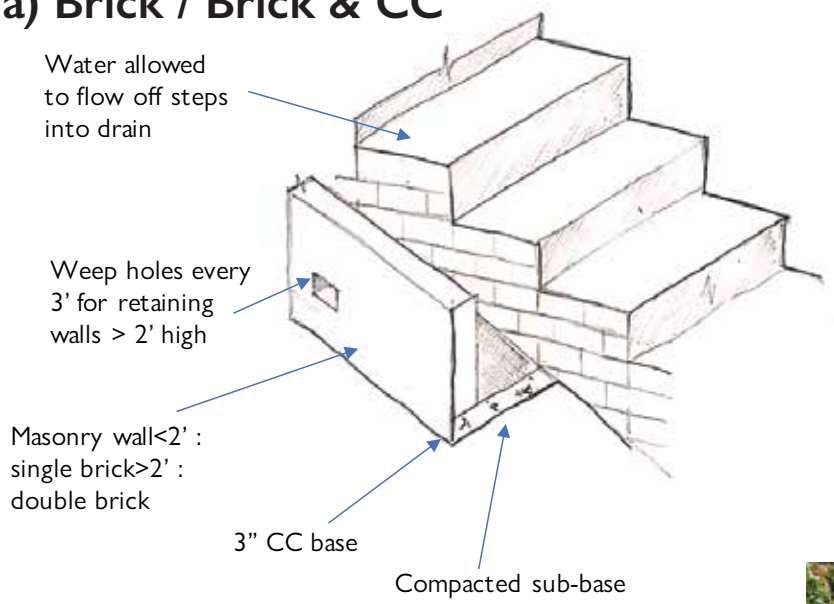
Brick and CC

b) Key Detail: Discharge Point



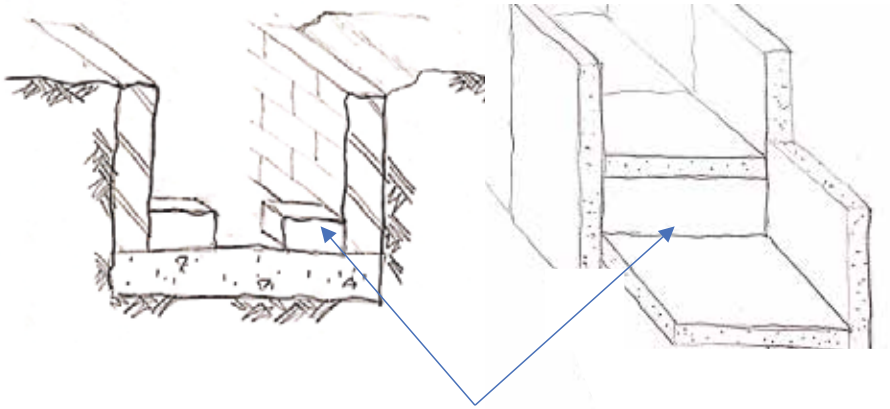
4. STAIRWAYS

a) Brick / Brick & CC



Description	Brick or Brick & CC drainage/retaining wall along stairways
Key detail	Steps or micro dams to slow water on steep slopes Allow water to flow off steps into drain Install weep holes through retaining wall Retaining wall should not be higher than the retained earth, to allow water to flow into drain
Scope of Use	Alongside stairways
Advantages	Durable and easy to clean
Disadvantages	More expensive & slower to build than jute bag with sand-cement mix alternative

Key detail: Check dam or steps to reduce flow velocity



Brick 'micro-dams' or steps to slow down water on steep slopes

- ✔ Weep holes in retaining wall
- ✔ Steps in drain to slow down water
- ✖ Backfill missing soil behind retaining wall

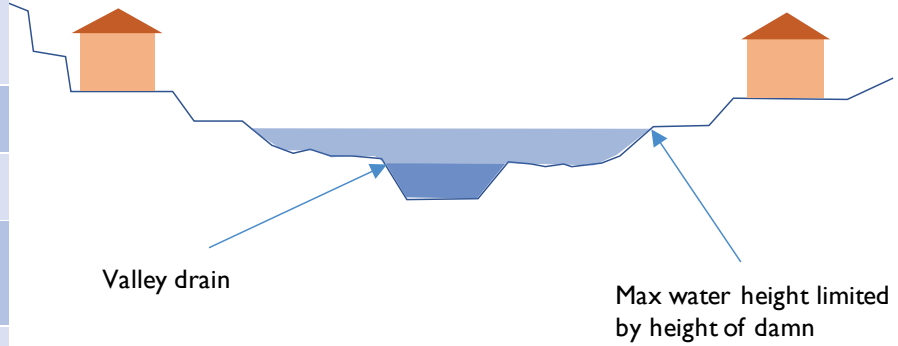
5. SLOW AND/OR STORE

a) Retention Basins - Large dry basins in upstream valleys

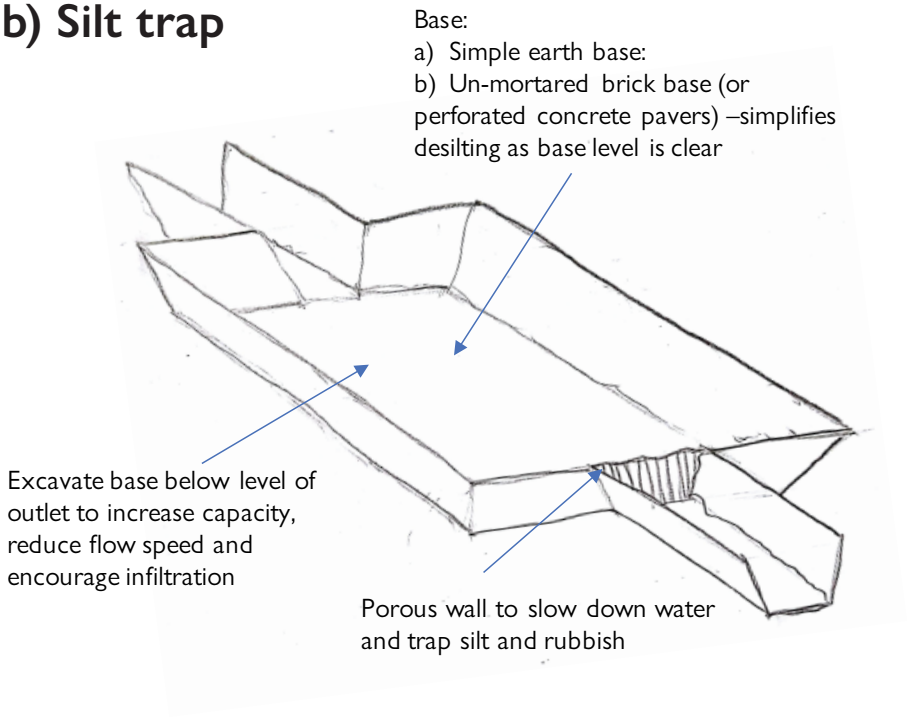
Deliberately flood community gardens using slow-draining dams at 50-100 m intervals

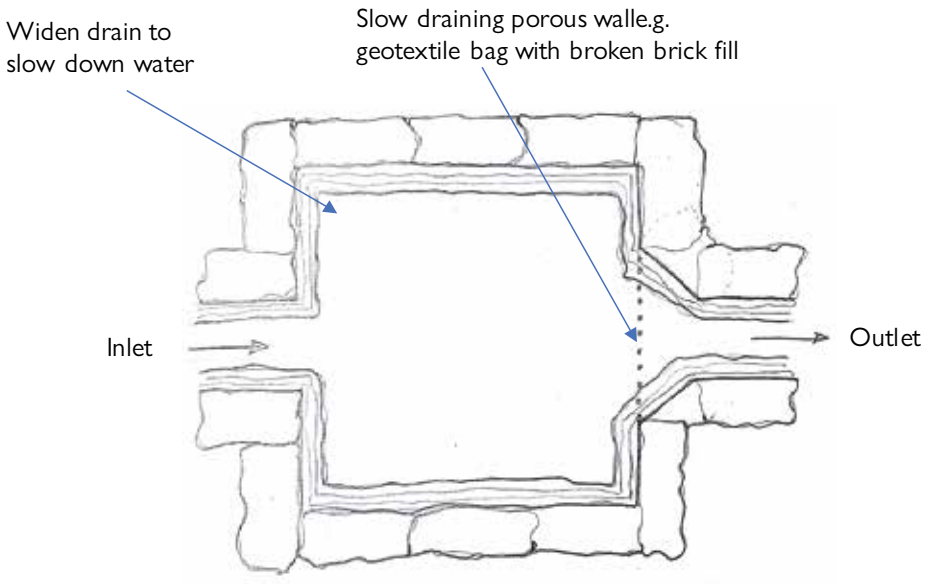
Retention basins reduce flooding downstream

Description	Flooding unpopulated upstream valleys reduces risk of flooding downstream in congested areas
Key detail	Encourage water to overflow banks into community garden areas by creating small dams. Flood level is controlled by the height of the dam. Multiple small dams along length of valley reduces risk of bursting Relocate shelters, latrines and facilities in flood plain
Scope of Use	Upstream valleys in underpopulated camps
Cost	Low cost, but depends on dam material
Advantages	Very cost effective. Reduces flooding in congested areas downstream and prevents downstream drains being blocked Trapped silt can be reused post-monsoon
Disadvantages	Requires possible relocation of low-lying shelters, latrines or facilities



b) Silt trap



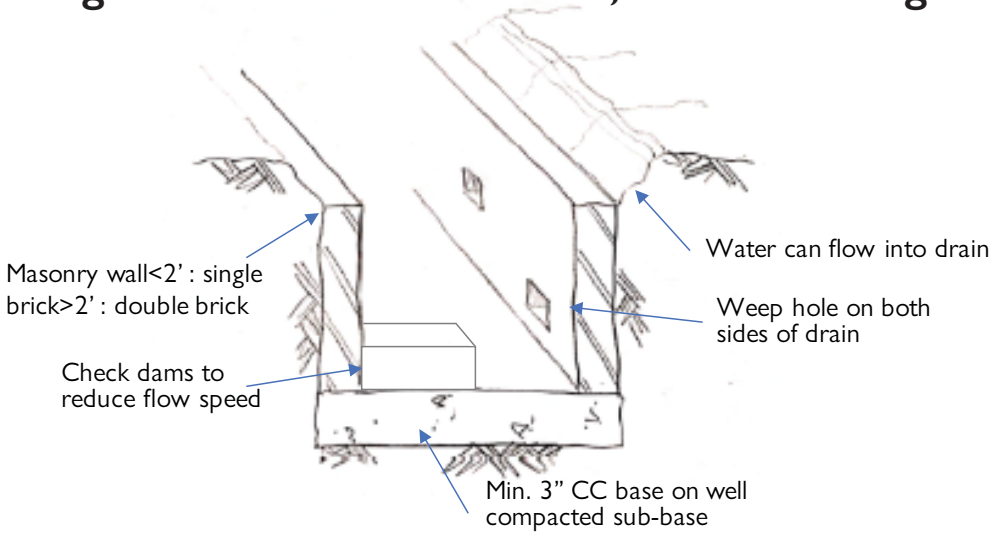


Plan showing jute/geotextile bag option

Description	Man-made basin where water slows down and deposits silt
Key detail	Allow water to drain slowly through the front wall to prevent stagnant water Porous wall options: Geotextile bags with broken brick filling; geotextile roll stretched across borak bamboo stakes; perforated brick wall, etc.
Scope of Use	In front of culverts Anyplace where there is unused land along the drain
Advantages	Prevents culverts from being blocked with silt Silt can be used as fill material Traps waste
Disadvantages	Requires space

6. SECONDARY DRAINAGE

a) Congested areas: Brick & CC, Medium-Large Capacity



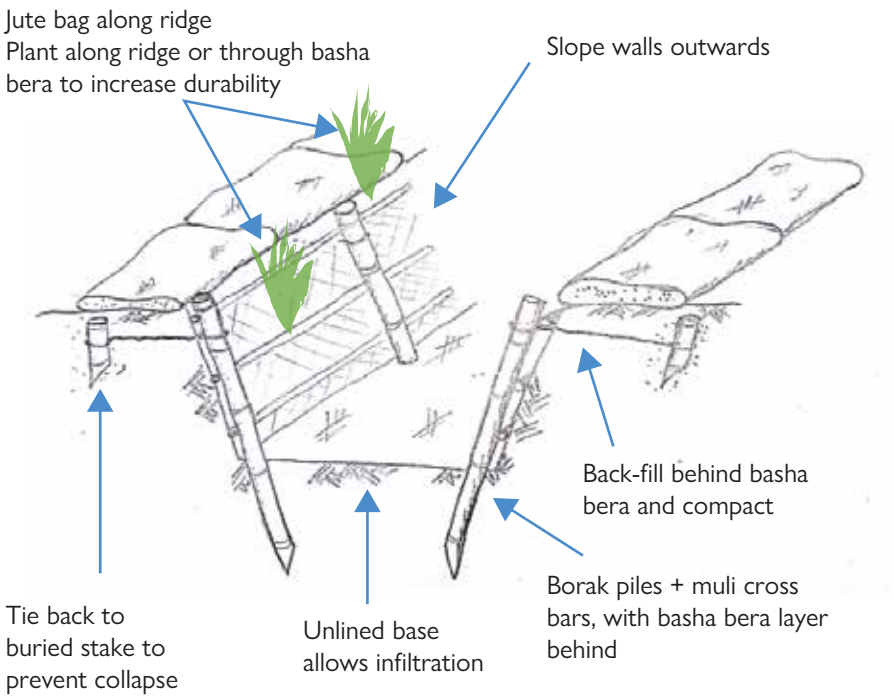
+ Easy to clean

Description	Medium to large size brick and CC drain
Key detail	3-4" concrete base. Concrete quality & thickness is key Weep holes at 3'-6' centres if wall is above 2' Brick wall sits on CC base. Extend CC base past brick walls to ensure good strength below wall (edge region is weakest) Sub-base is well compacted Surrounding path/road is higher than drain edge Install silt traps along drainage where possible
Scope of Use	Secondary drainage in congested areas
Advantages	Durable and easy to clean Cost effective up to 4-5' wide
Disadvantages	Difficult to repair Cannot accommodate ground movement » brittle failure

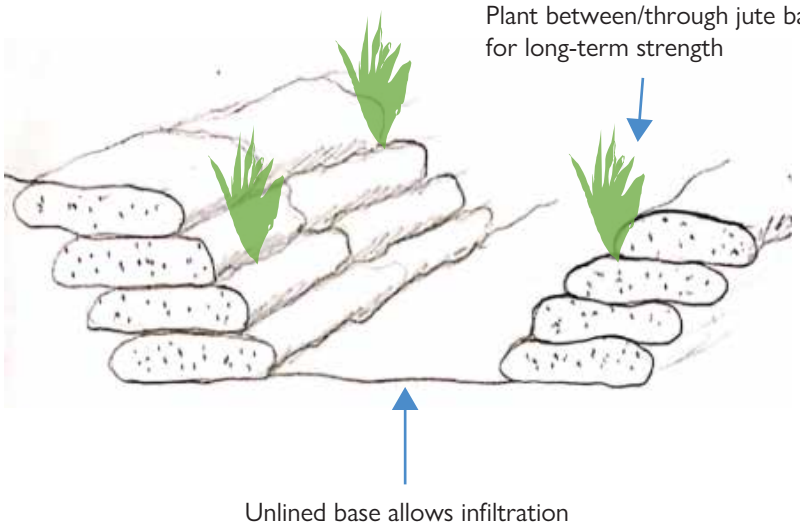
Need to raise road & shelter level to match top of drain

- ✔ Drain walls double as retaining walls to path and shelter
- Maximize capacity in congested spaces

b) Bamboo & Basha Bera

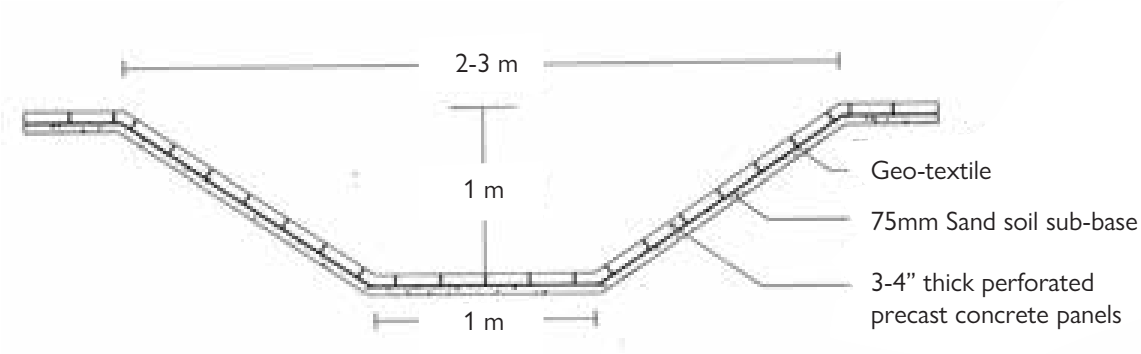


c) Jute Bags



Description	Large size open channel drainage in less congested areas
Key detail	Minimise spacing of borak & tie backs to buried stakes Slope walls outwards to prevent collapse Plant along edges to ensure long term durability (need to protect plants from foot traffic)
Scope of Use	Large capacity drains in valleys
Advantages	Low cost, flexible (no brittle failure) Allows infiltration
Disadvantages	Basha bera needs to be replaced frequently • Use jute or geotextile instead

d) Hollow/perforated precast concrete panels (LGED detail)



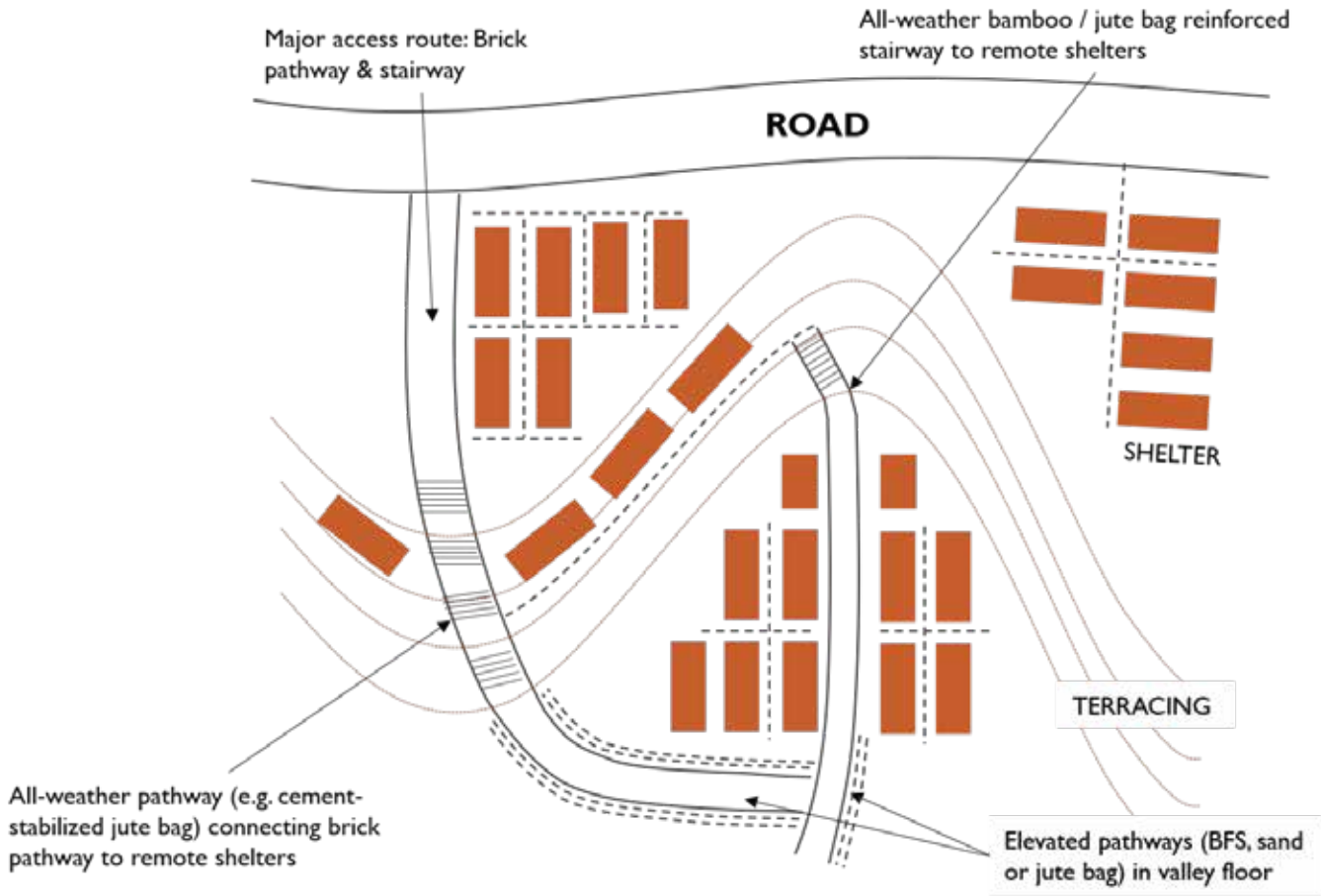
Description	Hollow/perforated precast concrete panels laid over an open ditch
Key detail	Geotextile layer prevents sand from eroding below panels Water can infiltrate through perforated panels into the ground (and vice versa, preventing collapse through hydrostatic pressure)
Scope of Use	Open valleys with fast flowing water, where erosion is a risk
Advantages	Durable Can be easily and safely dredged Allows infiltration. Plants can grow through holes in concrete panels
Disadvantages	Expensive


ACCESS

ACCESS: STRATEGY

Goal: All shelters are accessible from the road via 'all-weather' pathways

CONTENTS:



The access strategy for the first half of 2019 is a balance between **improving the durability of the main access routes and ensuring that all areas of the camp remain accessible during the 2019 monsoon season.**

Durable highways

- Herringbone brick paving on vehicle access routes
- Brick flat soling pathways and masonry stairways along pedestrian highways and paths to key facilities

All-weather access during 2019 monsoon season

- Cement-stabilized jute bag pathways and bamboo / jute bag reinforced stairways connecting all areas of the camp connecting to the nearest brick pathway
- Bamboo bridges across waterways

Pre-monsoon targets:
The targets for 2019 should be that all households are:

- Within 300 m of an all-weather* emergency vehicle access route**
- Within 150 m of a paved or quick-draining sand pedestrian access route
- Accessible from the nearest paved pathway via all-weather access routes***

*All-weather	:	Does not flood and is stable underfoot during rains
**Minimum standard	:	Stepless brick pathways over 10' wide
***Minimum standard	:	Cement-stabilized jute bag pathway/staircase

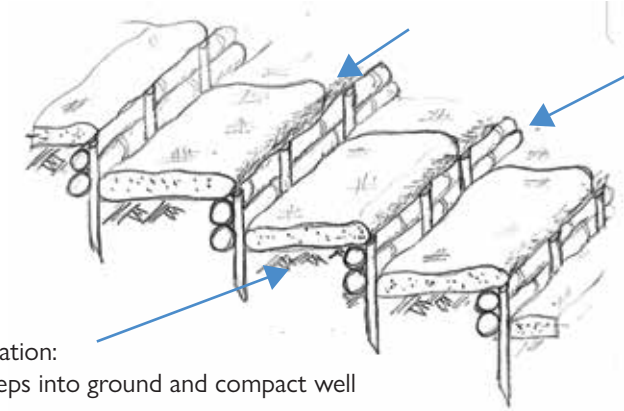
INDICATIVE COSTS

Category	Type / Material	Width (ft)	Materials BDT / m	Labour BDT / m	Total BDT / m	Durability	Notes
Stairway Tread = 12” Riser = 7” Width = 4’	Jute bag w. 10% cement	4	1000	300	1300		
	Geo bag w. 5% cement	4	1100	300	1400		
	Bamboo Riser w. Geobag & 5% cement tread	4	1900	400	2300		
	1 Brick riser brick tread	4	1600	900	2500		2 brick risers: add 800 BDT/m
	1 Brick riser w. 3” CC tread	4	1600	1000	2600		
	1 Brick riser w. 3” precast tread	4	2100	1200	3300		
Pathway	Jute bag w. sand-cement	6	1000	200	1200		
	Geo bag w. 5% cement	6	1100	200	1300		
	Brick flat soling	6	1550	350	1900		
	Herringbone (single layer)	6	2050	450	2500		
	Herringbone (two layer)	6	3300	700	4000		

1. STAIRWAYS

a) Bamboo & Jute/Geotextile Bag

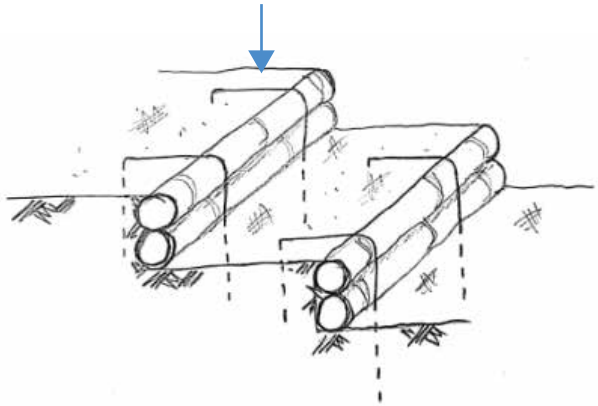
Tread:
Jute bag with 10:1 Sand-Cement mix
Geotextile bag with 15:1 Sand-Cement mix



Preparation:
Cut steps into ground and compact well

Riser :
Option 1: Borak bamboo riser held in place using half borak stakes

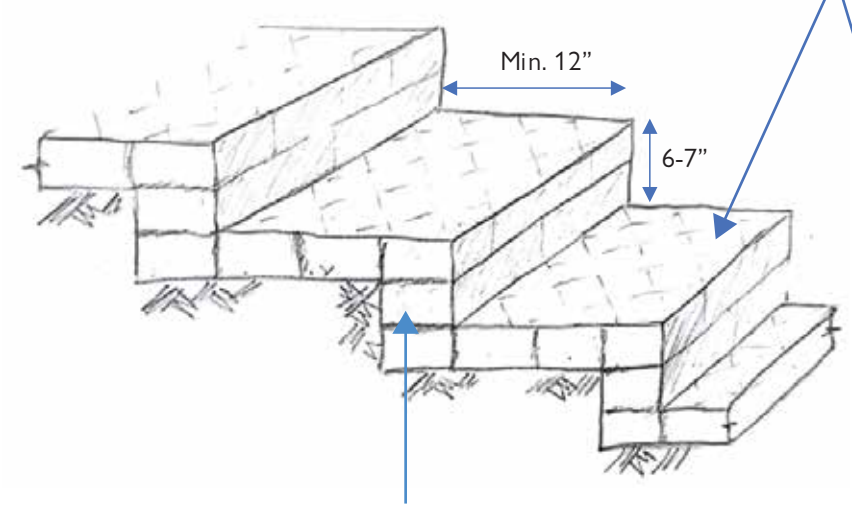
Option 2: Steel staple (made from 8mm reinforcement bar) embedded 1' into ground



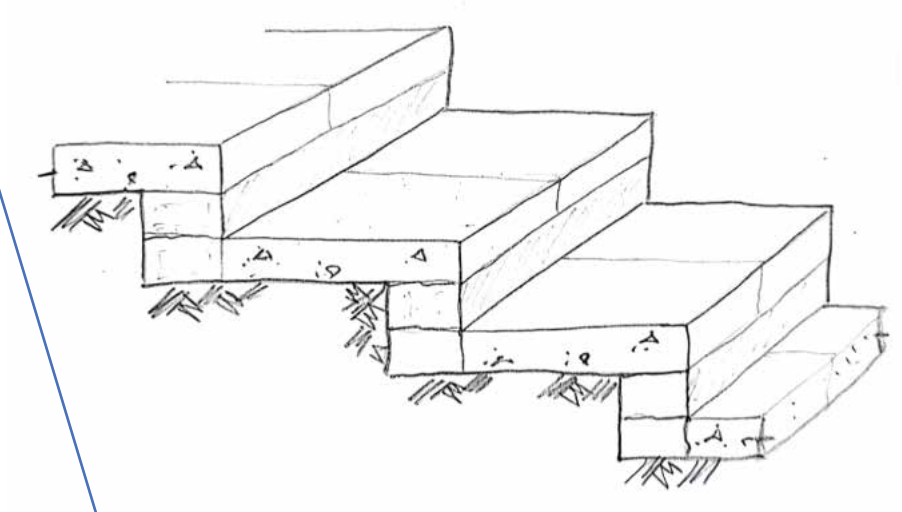
Key detail	Cut stairs into slope and compact before laying bags Add 5-10% cement to increase durability Use geotextile to increase durability
Durability	Jute: 6-12 months (longer with higher cement content) Geotextile: 1+ years
Advantages	Quick to build Geotextile with sand-cement could last a long time
Disadvantages	Jute bag is not durable. Surface is not flat. Trip hazard as materials wear out. Bamboo pegs present trip hazard Steel staples may be stolen

b) Brick

Score render to create rough surface for grip



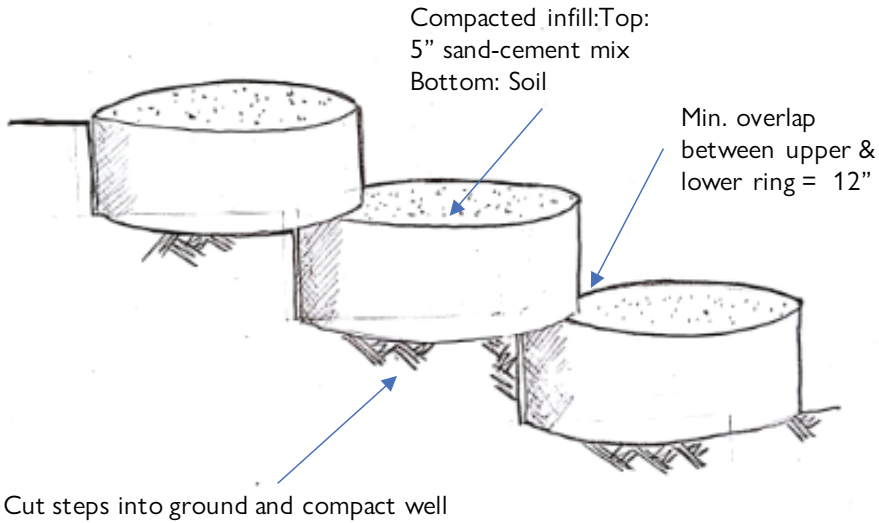
Riser (both options):
Minimum: 1 brick thick, laid flat, mortared
Recommended: Two-brick thick riser, laid in alternating courses
Lay foundation course at same level of lower tread, with top course of brick riser parallel to pathway

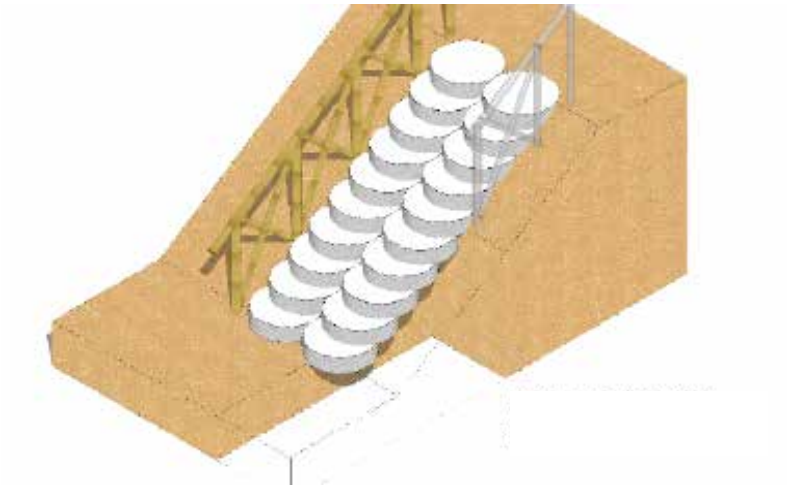


Option: Precast concrete tread (available from SMEP)
Durable and quick to install, but increased costCan reduce riser to one brick thick as precast paver protects top of riser

Key detail	Brick riser to be two bricks thick and laid in alternating courses Brick riser starts minimum 1 course below level of lower step
Durability	Highly trafficked pathways
Advantages	Durable, stable under foot
Disadvantages	Slow to build

c) Precast Concrete O-Ring





Axo view (Credit: DRC)

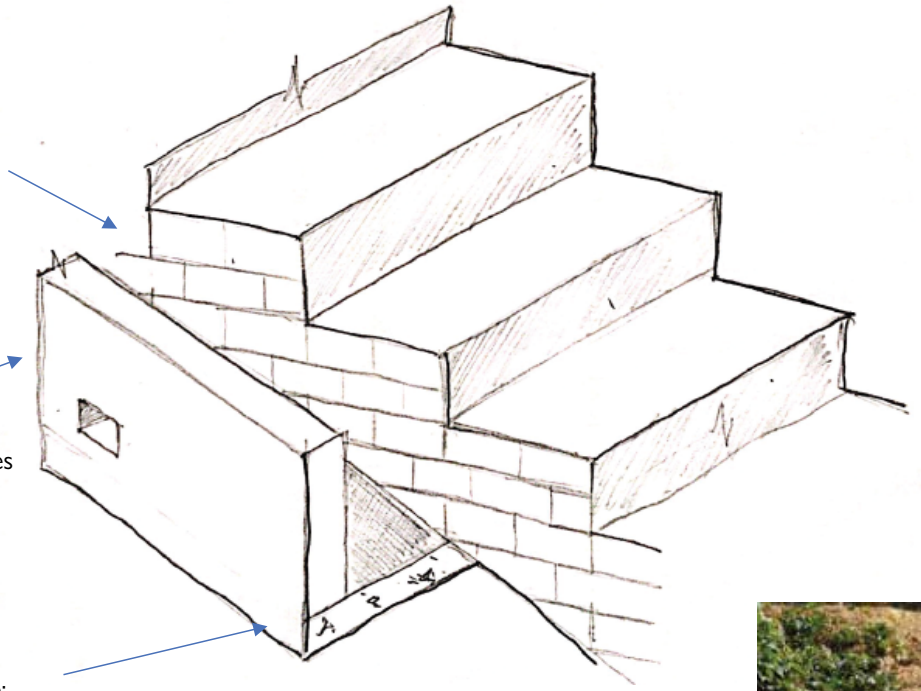
Key detail	Precast latrine rings with compacted infill Sand-cement top layer to create good walking surface Minimum 1' overlap between each ring
Scope of use	Narrow stairways in hard to reach locations
Advantages	Quick to install Durable
Disadvantages	Hard to transport O-Rings to site Narrow

Credit: DRC. Note side drain and handrail

d) Raised Brick Stairway

Side wall:
Two-brick thick wall, laid in alternating coursesWeep holes at 3' spacing to allow water to drain (if top surface of steps is porous)

Drain wall:
H < 2': One brick thick wall
H > 2': Two-brick wall, laid in alternating courses
Weep holes at 3' spacing to allow water into drain & prevent collapse of wall
Max height of retained soil = 4'
Top of wall is *lower* than retained soil

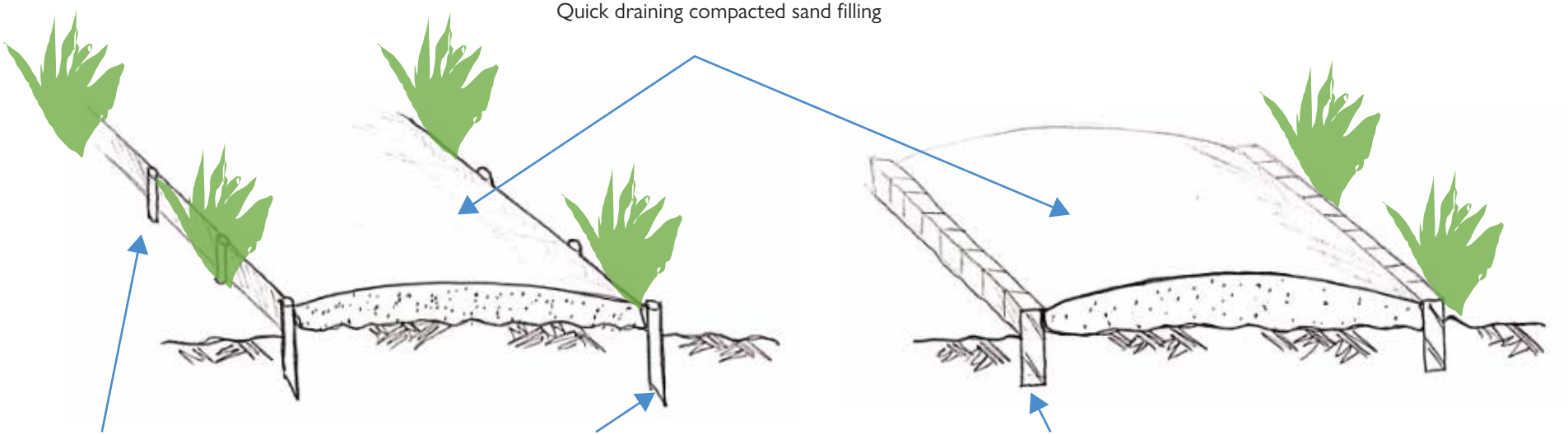


Drain base:
3" Cast concrete or masonry, laid over compacted soil

Key detail	Brick side wall required in congested areas when stairway is raised 0.5 m+ above surrounding level
Durability	Good
Advantages	Sidewall prevents edge of stairway from collapsing Brick sidewall necessary to prevent erosion cutting under stairs
Disadvantages	Slow to construct

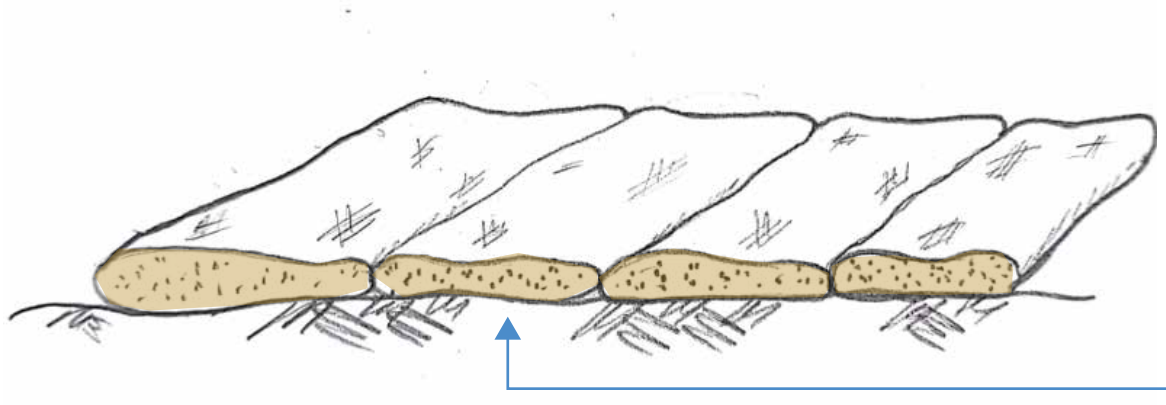
2. PATHWAYS - PEDESTRIAN

a) Raised Sand Pathway



Key detail	Sand pathway raised above surrounding ground to ensure water drains off path Sandy / quick draining soil required
Durability	Very poor
Advantages	Very cost effective. Quick to install
Disadvantages	Edge walls are easily damaged.

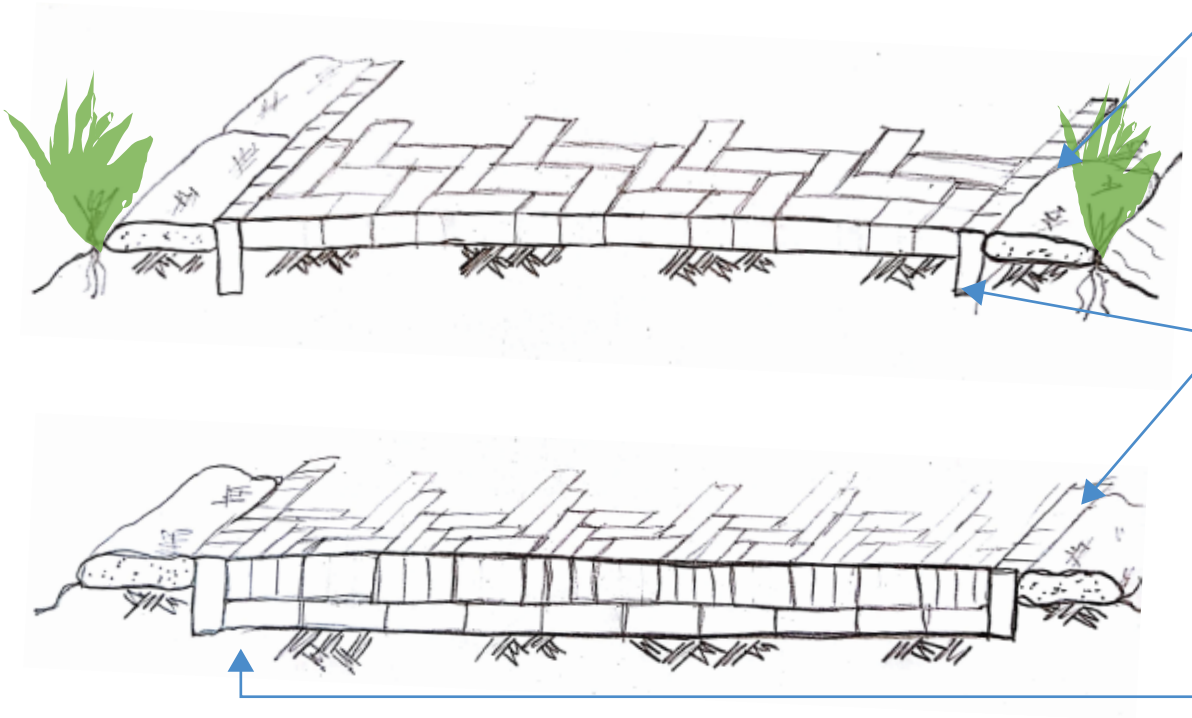
b) Cement Stabilized Jute Bag Pathway



Filling:
10:1 sand-cement
N.B. Needs good quality sand, not earth

Key detail	Jute bag pathway with sand-cement filling Do not over-fill bags Use good quality sand, not earth
Durability	6 -12 months
Advantages	Cost effective and quick to install • Quickest method to achieve all-weather access to all parts of the camp
Disadvantages	Needs replacing annually Undulating surface » trip hazard

c) Brick Pathways



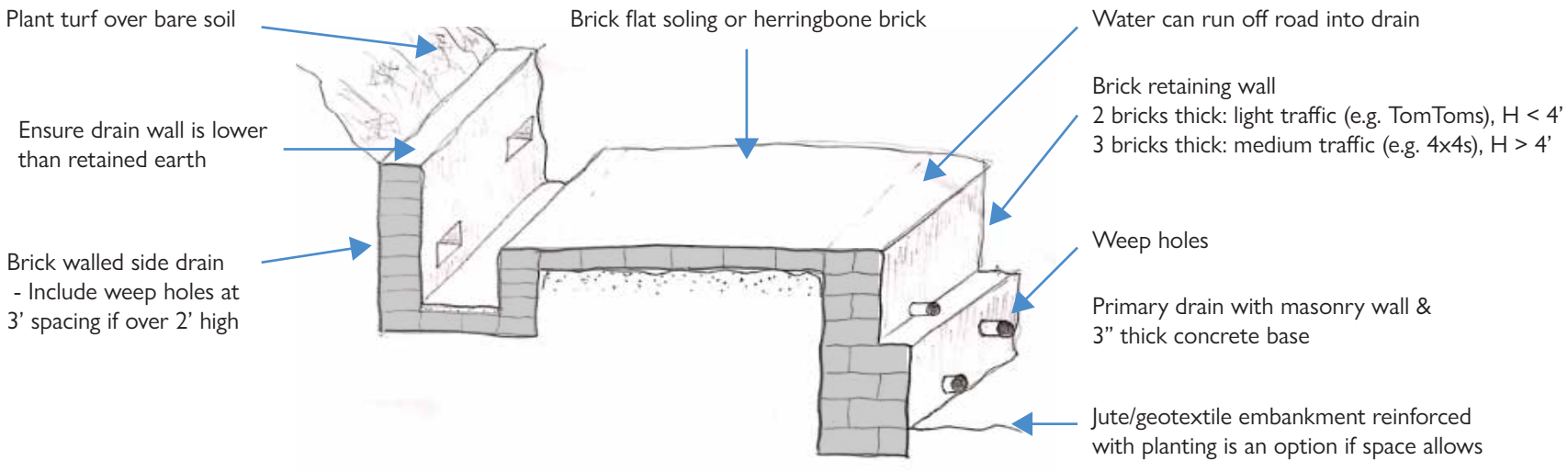
Jute bag with sand-cement to protect edge bricks

Edge bricks:
Embed min. 5” into ground
Lay face-to-face and mortar to increase strength

Top layer: lay bricks on narrow edge in herringbone (zig-zag) pattern
Bottom layer: lay bricks on wide edge in regular (parallel) bond

Name	Brick Flat Soling (BFS)	Herringbone Brick (HBB)
Key detail	Ground is well compacted before laying bricks Bricks laid flat in herringbone pattern Vertical edging bricks to restrain brick surface Provide sand-cement jute bag to protect edging bricks	Herringbone brick over BFS sub-layer Compacted sand sub-base if possible Vertical edging bricks to restrain brick surface Provide sand-cement jute bag to protect edging bricks
Scope of use	Pedestrian	Heavy vehicular

d) Brick Tertiary Road with Major and Minor Side Drains

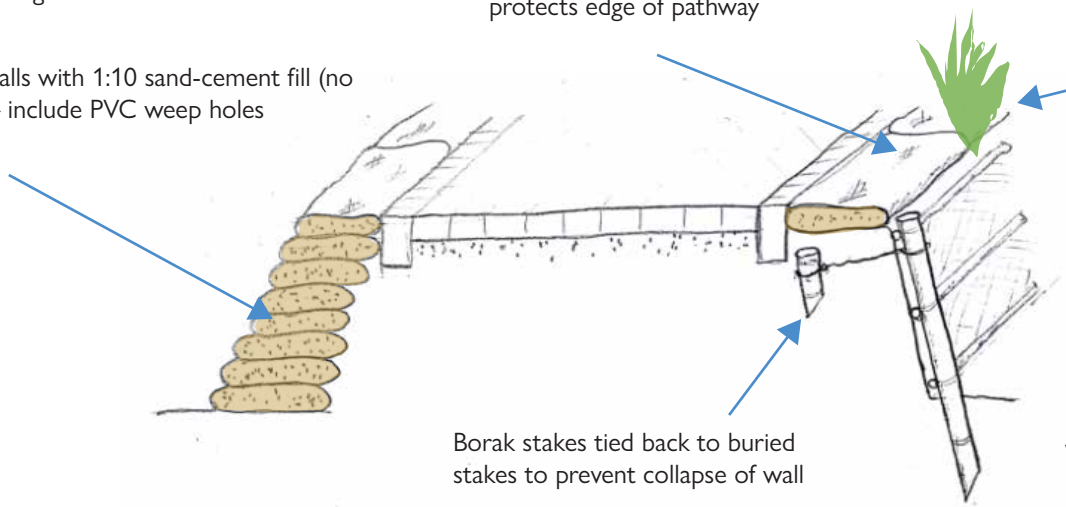


Key detail	Wall thickness depends on wall height and weight of traffic: 2 bricks thick: light traffic (e.g. tomtoms) or H < 4' 3 bricks thick: medium traffic (e.g. 4x4s) or H > 4' Weep holes in retaining wall to reduce water pressure
Durability	Good
Advantages	Good in congested areas Durable
Disadvantages	Expensive Slow to build

e) Raised Pathways with Jute Bag or Bamboo Retaining Wall

Retaining wall:

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



Vetiver plants along edge:

- Add small fence to protect from foot traffic
- Vetiver roots strengthen earth banks

Bamboo & basha bera retaining wall:

- Borak stakes at 3'-5' centres
- Muli 'cross beams' behind borak stakes
- Recommended: Borak capping beam connecting stakes (not shown)

Key detail	Max. slope of retaining wall = 2:1 a) Geo bag with earth infill (no cement). Add seeds or plant to improve durability b) Jute bag with 10:1 sand-cement to improve durability (N.B. clean sand, not earth). Add weep holes (PVC pipes) if using cement c) Bamboo & basha bera: Tie back to buried stakes to prevent collapse Minimise spacing of borak stakes
Durability	Jute bags: Moderate Geotextile and planting: Good
Advantages	Cost effective. Quick to install.
Disadvantages	Less easy to maintain. Requires more space than brick retaining wall


STABILIZATION

STABILIZATION: CONTENTS

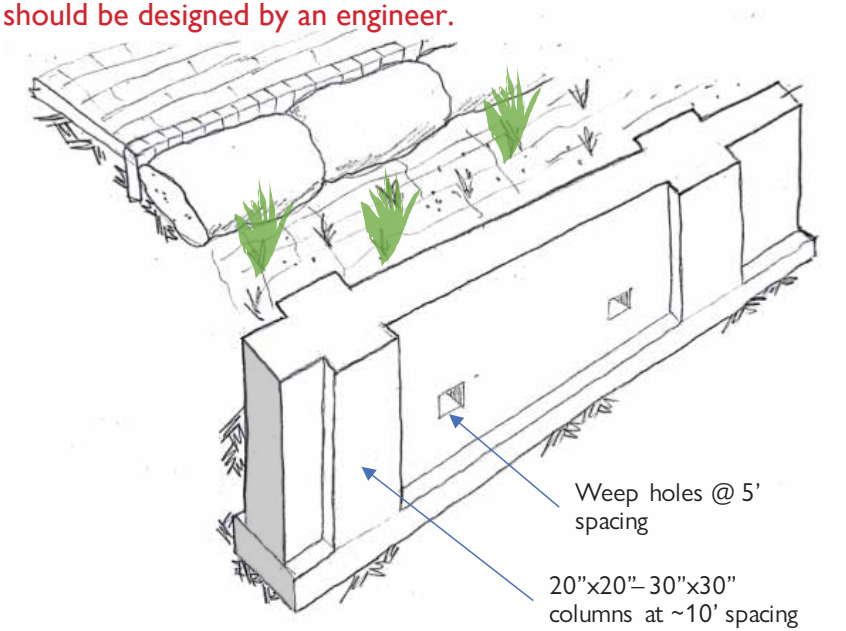
1. Small Retaining Wall
2. Mass Retaining Wall
3. Terracing
4. Planting on Slopes
5. Slope Protection

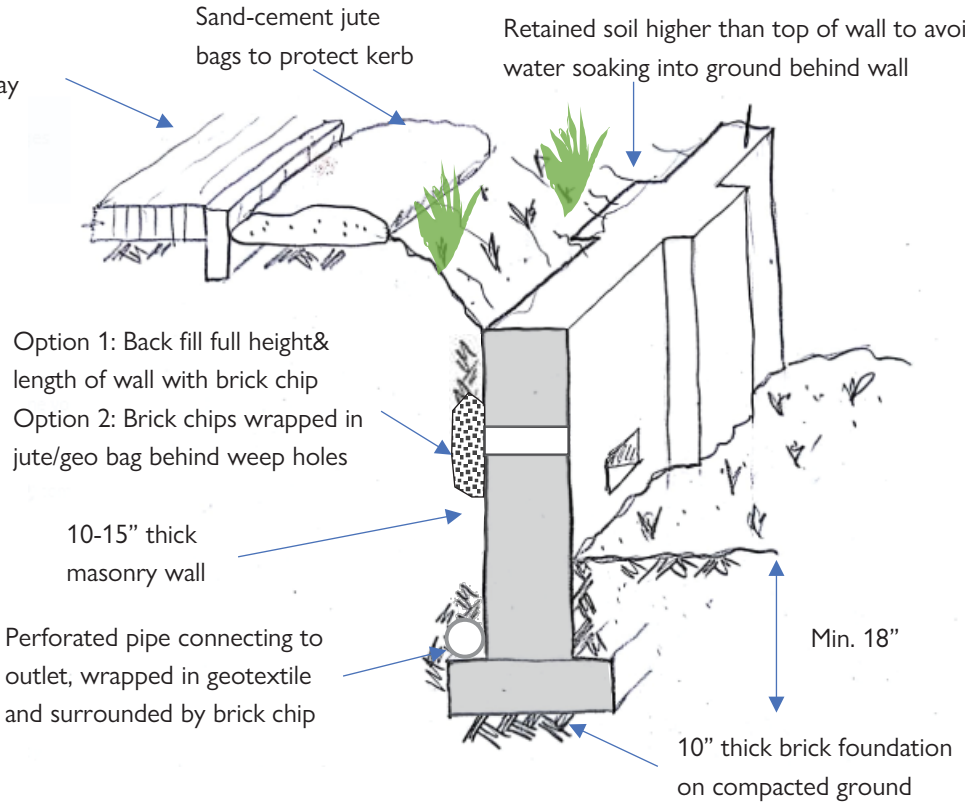
N.B. All retaining structures should be designed by an engineer.

Category	Type / Material	Height (ft)	Materials BDT / m	Labour BDT / m	Total BDT / m	Durability	Notes
1m retaining wall	Jute bag w. earth	4	8,000	1,000	9,000	Poor	
	Geo bag w. earth	4	10,000	1,000	11,000	Good if planted	
	10” Brick wall	4	14,500	2,500	17,000	Good	0.5m deep foundation

1. SMALL RETAINING WALL

N.B. Indicative dimensions only! All retaining structures should be designed by an engineer.





Key detail	Max. height: 4' above ground level (5' of retained soil) If H of retained soil > 5' : use mass retaining wall Adequate foundation depth required to prevent sliding Well compacted sub-base Weep holes to prevent hydrostatic pressure with brick chips wrapped in jute/geo bag behind to allow water to drain Expansion joints every 30'-40'
Durability	To retain loose soils e.g. alongside pathways in congested areas Alternative: consider using geotextile bags if there is sufficient space
Advantages	Durable
Disadvantages	Expensive

Collapsed retaining wall due to missing weep holes

2. BRICK MASS RETAINING WALL

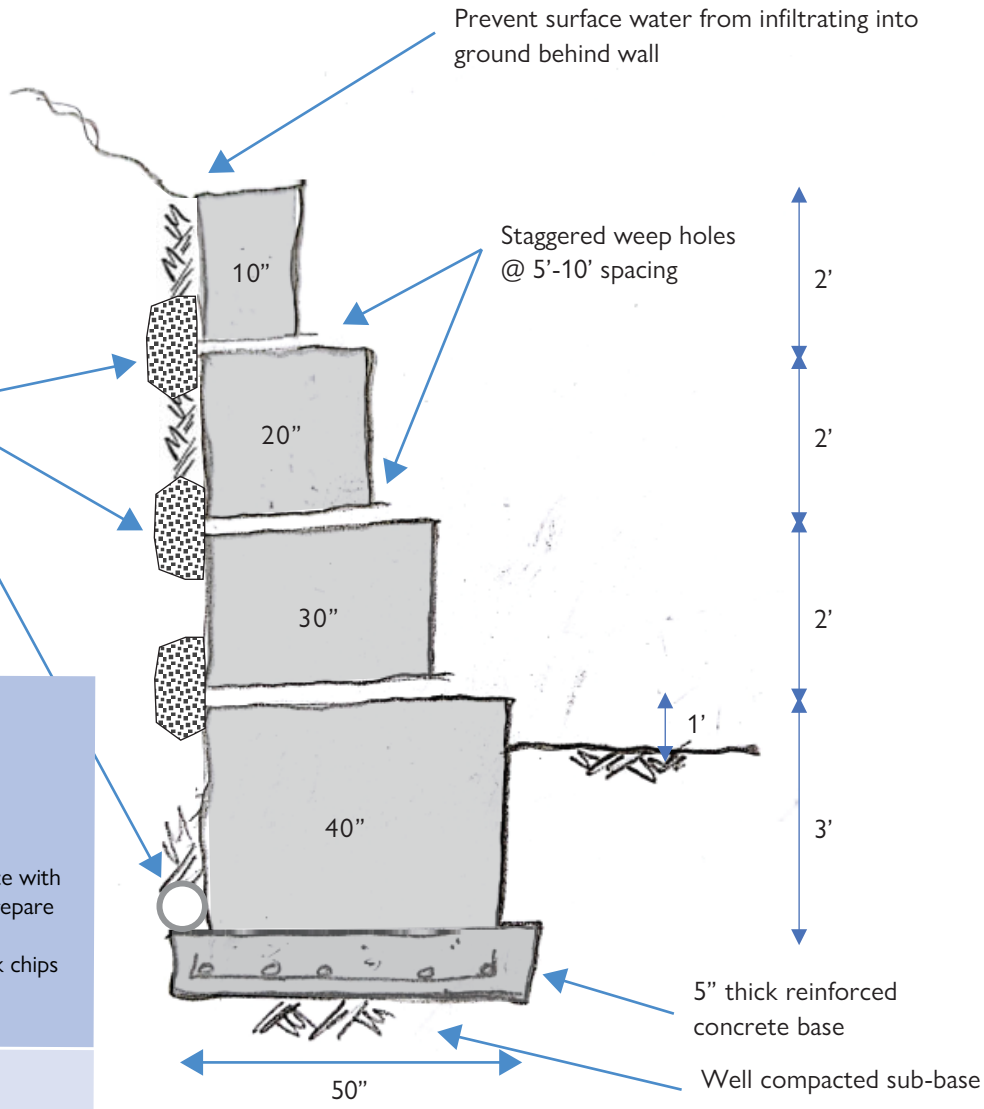
N.B. Indicative dimensions only! All retaining structures should be designed by an engineer.

Wall thickness depends many factors including the height of retained soil, soil properties and loading conditions.

Option 1 (preferred): Backfill with quick-draining brick chips

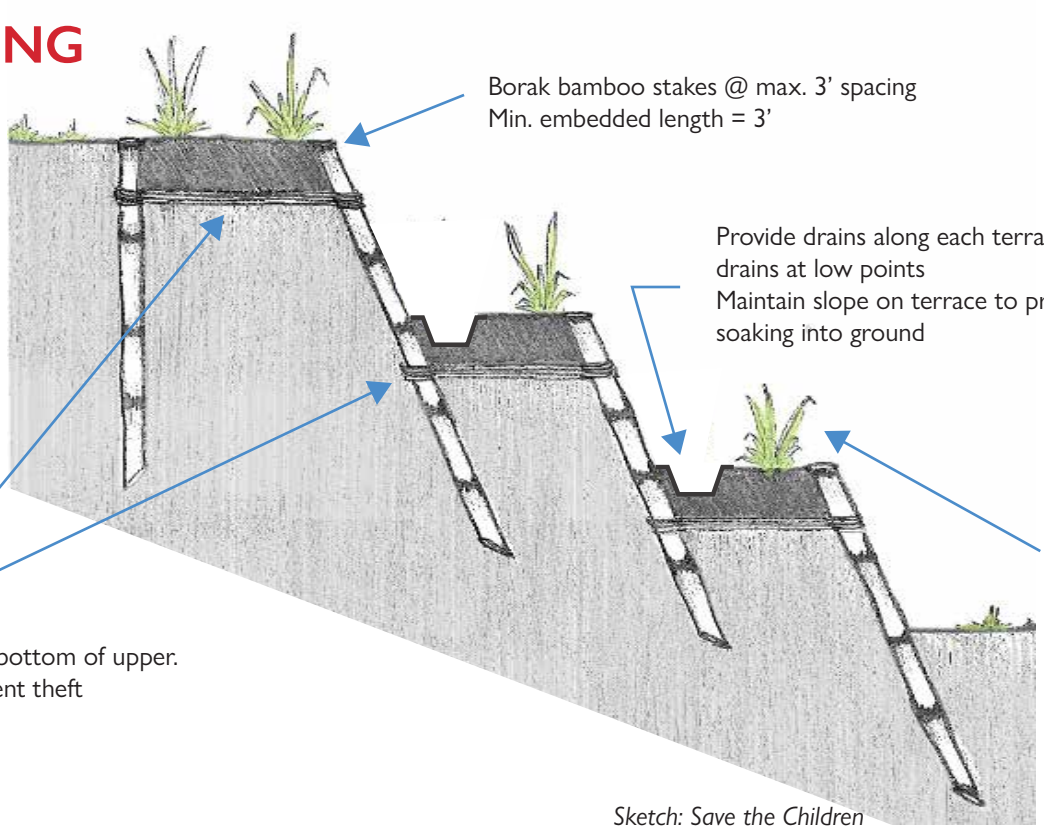
Option 2 (shown): Brick chips wrapped in geotextile bag behind weep holes

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



Key detail	Design for max. 8' height of retained soil H (soil) > 8': Consider other designs of retaining structures All retaining structures should be designed by an engineer. Adequate foundation depth to prevent sliding Well compacted sub-base with Reinforced concrete base slab If soft spots are found during excavation, remove the poor soil and replace with granular material or better fill soil, and then covered with geotextile to prepare the subbase Weep holes to prevent hydrostatic pressure with jute/geo bags with brick chips infilled behind weep holes to allow water to drain Expansion joints every 30'-40'
Application	To retain steep slopes in congested areas (e.g. alongside roads)
Advantages	Durable
Disadvantages	Expensive

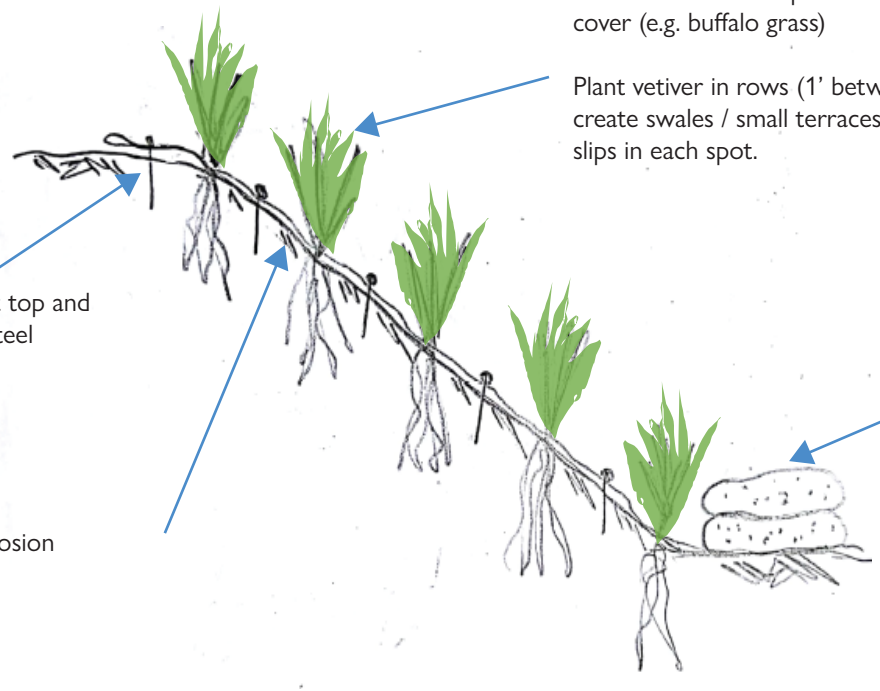
3. TERRACING



Sketch: Save the Children

Key detail	Combine with drains along each terrace, connected to discharge drains Maintain slope on terrace to prevent water ponding & infiltration Plant deep rooted vegetation (e.g. vetiver) at start of monsoon Bamboo stakes embedded in firm ground, not loose fill
Application	Exposed hillsides in areas without shelters
Advantages	Low cost Durable if combined with planting
Disadvantages	Bamboo will rot after 6 months

4. PLANTING ON SLOPES



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

Plant vetiver 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.

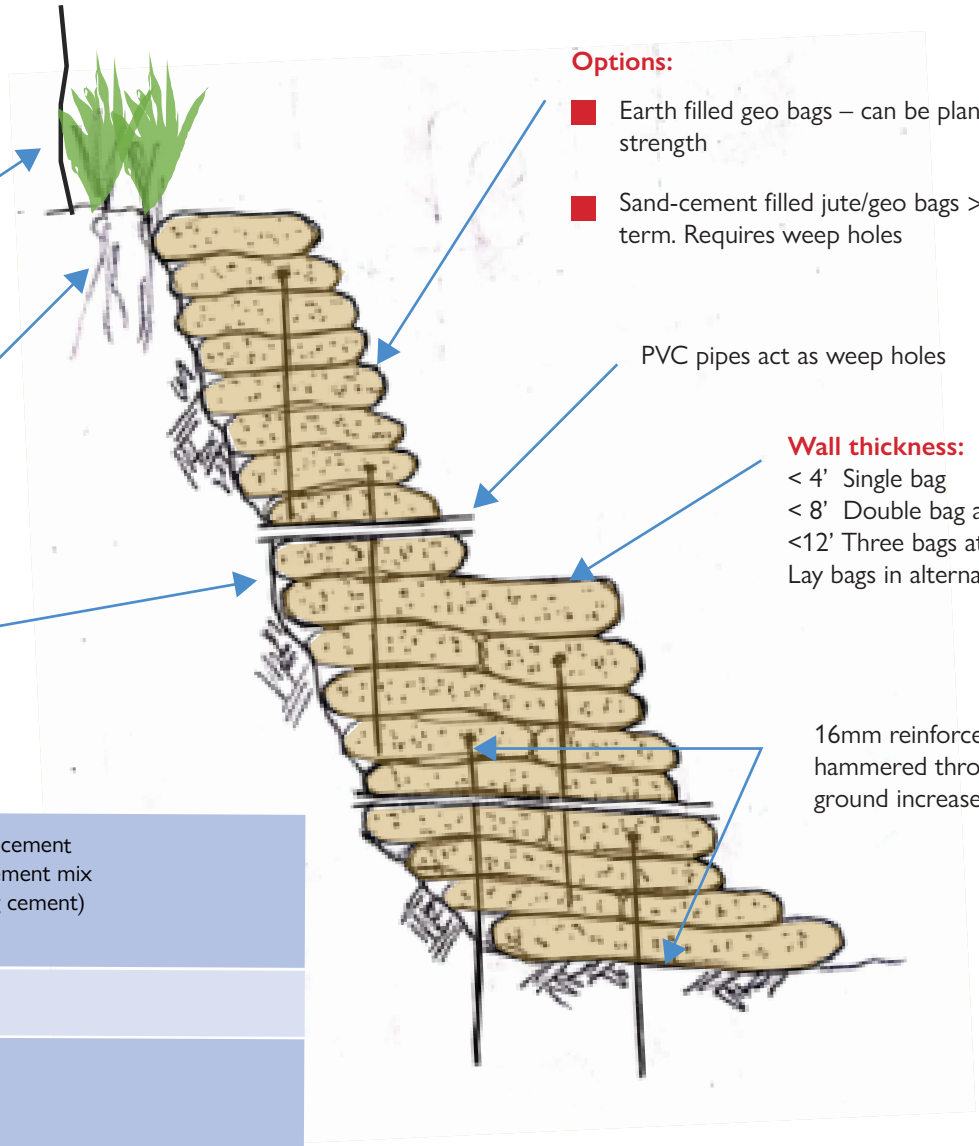
Option: Open-weave jute roll folded at top and nailed into the ground using bamboo/steel staples

Line of jute bags at base to trap any silt run-off and to secure jute roll

Compact loose soil to avoid surface erosion

Key detail	Plant mixture of deep-rooted and surface plants to ensure durability – follow FAO guidelines Combine with catch drain along ridgeline and across slopes Use planting to create swales (natural drains) along slope and connect to discharge drain at the gully location Compact loose soil. Use jute roll to protect soil surface. Use of open weave jute roll preferred as the tight weave prevents surface grass from growing
Application	Exposed hillsides in areas without shelters
Advantages	Cost effective and durable
Disadvantages	Doesn't provide structural support until after the vegetation takes root (~1 year)

5. SLOPE PROTECTION



Key detail	Provide weep holes (PVC pipes) if using sand-cement Use construction sand (not earth) for sand-cement mix Water each layer during construction (if using cement) Fence along ridgeline for protection
Application	To strengthen embankments
Advantages	Quick and easy to build Durable if combined with planting Protects surface from erosion
Disadvantages	Retaining capacity is limited compared to brick or concrete

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