# 07 | Drainage systems

| | |
|---|---|
| Environmental impact | 3/3 |
| Risk protection | 2/3 |
| Durability | 2/3 |
| Affordability | 3/3 |

Natural and low tech drains

| | |
|---|---|
| Environmental impact | 2/3 |
| Risk protection | 3/3 |
| Durability | 3/3 |
| Affordability | 2/3 |

High and medium tech drains

## Intro

Drainage systems require a global planning at the different scales of a settlement, and a comprehensive understanding of the surrounding areas and (existing) drainage networks (see introduction “Surface Water Management”). Drainage networks can take many forms and include several techniques and materials such as:

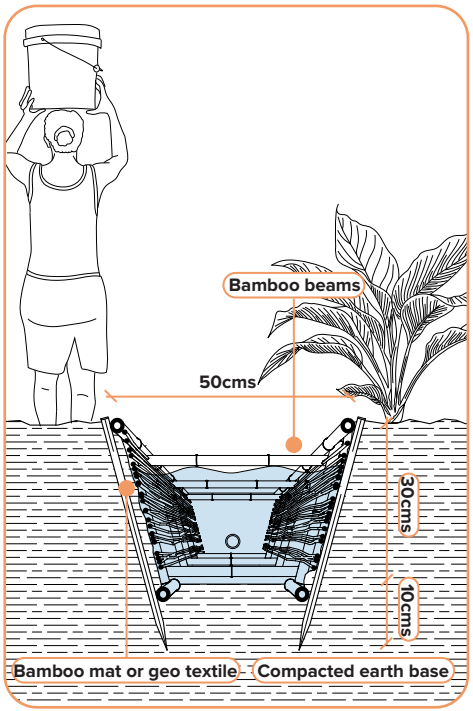
a. **Natural drains** (primary canals) are based on restorations of riparian vegetationand planting of trees and other shrubs. This nature-based measure comprises natural canals with low gradients where the water runs slowly.
b. **Low-tech drainage systems** can include interventions like bamboo drains (primary, secondary, tertiary drainage) and geotube/geobag embankment drains (primary, secondary, tertiary canals).
c. **Medium and high-tech drainage systems** describe measures such as masonry and precast concrete drains (secondary, tertiary canals). When using concrete ditches, re-infiltration through holes in the drainage bottom should be used wherever it is possible.
d. **Other interventions** include ridgeline and cascade drains, silt and waste traps, and microsoak pits.

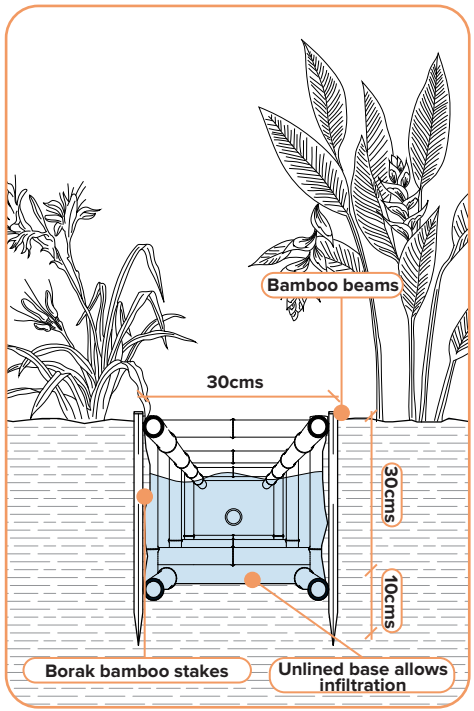
## Good practice

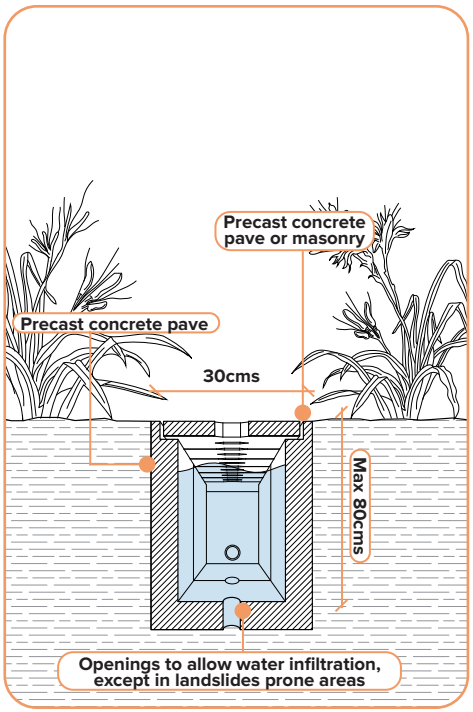
In general, if the drainage is not properly maintained and cleaned or the slope and infiltration effectively planned, there is a risk of stagnant water where mosquitos and will grow and transmit diseases.

a. **Natural drains:** Natural drainage is low in cost and eco-friendly. However, it is not recommendable in congested locations and there is the risk of erosion.
b. **Bamboo drains:** Bamboo drains are quickly installed and efficient during emergency situations, where this material is easily available. However, the bamboo does not last long and needs to be replaced frequently, so over time more durable solutions should be developed.
c. **Geotube/geobag embankment drains:** This low-tech measure is cost-and labor-effective. The base is made from well compacted earth which supports infiltration. However, the drains do not benefit highly dense areas.
d. **Masonry drains:** Masonry drains are beneficial for densely populated areas. In addition, their maintenance and cleaning are comparatively simple. However, the measure is costly and complex to install and repair. Also, the base (concrete/brick-based) may cause flooding downstream since there is no infiltration in the soil.

Precast concrete drains: The installation of precast concrete drains is best at road sides, ridge lines, or vehicular roads. Although they are installed relatively quickly, the material costs are high. Precast concrete drains are also at risk of accelerating the flow velocity and thus causing downstream flash floods. In general, very high-tech solutions are comparatively expensive and complex to build. That is the reason why they are seldom applied in refugee camp settings.



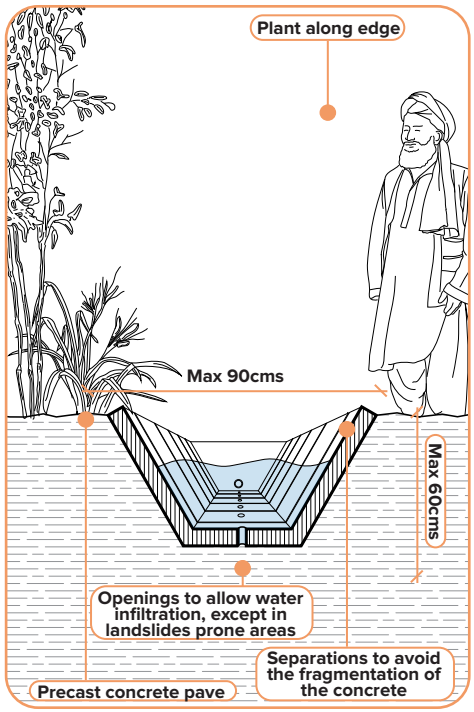




**Fig. 09**: *The SuDS management train under construction in the Gawilan Refugee Camp, Kurdistan Region of Iraq. Charlesworth et al. 2019, p.3505.*

## Overview of Criteria

**Type of Intervention:**
Engineered, nature-based, hybrid

**Scale of Intervention:**
Settlement, Supra-settlement

**Materials:**
**Bamboo drains:** (Borak) bamboo, bamboo mats, basha bera mats, geotextiles, earth base (can be complemented with cement screed or trapaulin for better waterflow)
**Geotube embankment:** Geotube/bags, sand, Alternatively: Jutebags, seeds
**Masonry Drain:** Bricks, jute/geotextile bags filled with brick chips, concrete, beams
**Concrete Drains:** Concrete, compacted earth

**Environmental Impact:**
Bamboo drains include sustainable materials and support infiltration. Geotube embankments foster infiltration, but the earth base can increase siltation and erosion. Masonry and concrete drains may prevent waterlogging but can disrupt habitats through excavation and vegetation removal before the implementation.

**Targeted Natural Hazard:**
Pluvial Flood, Coastal/Riverine Flood

**Targeted Vulnerable Assets:**
Buildings, Transport, Technical Infrastructure, Land Cover

**Strategy Type:**
Reduce Hazard Magnitude, Reduce Asset Vulnerability.

**Implementation Time:**
**Bamboo drains:** short (1 day – 1 month)
**Geotube embankments:** Short (1 day – 1 month)
**Masonry and Concrete Drains:** Medium (1 month - 1 year)

**Effect Duration:**
**Bamboo drains:** short-term (< 1 year)
**Geotube embankments:** medium-term (1 year to 10 years)
**Masonry and Concrete Drain:** medium-term (1 year to 10 years), long-term (>10 years)

**Investment Costs:**
**Bamboo drains:** low
**Geotube embankments:** low, medium
**Masonry and Concrete Drains:** medium, high

**Maintenance Costs (yearly):**
**Bamboo drains:** Low (<10% investment costs)
**Geotube embankments:** Low (<10% investment costs)
**Masonry and Concrete Drain:** Low (<10% investment costs)

**IOM UN Migration (2020)**
*Site Improvement Catalogue.*
*Available online at*
*https://www.humanitarianlibrary.org/resource/iscg-site-improvement-catalogue.*

**susDrain (2022)**
*Sustainable Drainage.*
*Available online at*
*https://www.susdrain.org/delivering-suds/using-suds/background/sustainable-drainage.html*

**Charlesworth, Susanne M; Mctough, Mitchell; Adam-Bradford, A (2021)**
*The Design, Construction and Maintenance of a SuDS management Train to Address Surface water Flows by Engaging the Community: Gawilan Refugee Camp, Ninewah Governate, Kurdistan Region of Iraq.*
*Journal of Refugee Studies 34, 3494–3510.*
*Available online at*
*https://doi.org/10.1093/jrs/fez082*

**susDrain (2022)**
*SuDS management train.*
*Available online at*
*https://www.susdrain.org/delivering-suds/using-suds/suds-principles/management-train.html*

# Flood Risk in Humanitarian Settlements: Compendium of Mitigation Measures

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