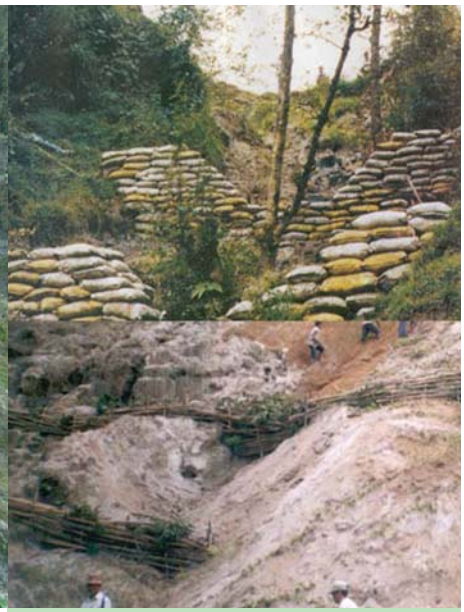

# Landslip and stream bank stabilisation

**Nepal:** बाँसको भाटा/मान्द्रा बाँधी

## Integration of vegetative and structural measures for landslip, stream bank and gully stabilisation on hillsides

A combination of measures were implemented by a group of neighbouring families in the middle hills of Nepal to mitigate the problems caused by landslips, gully formation, and stream bank erosion problems in a local area. These processes were affecting the stability of adjacent agricultural land and causing problems downstream. Small-scale farming is dominant in the area surrounding the treated land – which belongs to the government but is used by these families.

This pilot technological package is proving suitable in Nepal for steep/very steep slopes under humid subtropical climates within the altitudinal range of 1,000–1,500m. This type of intervention, combined with the active involvement of stakeholders (who contributed three-quarters of the costs), was introduced to Nepal under a watershed management programme co-funded by the European Commission (see 'Integrated watershed management QA NEP11').

Initially, contour ditches were built with bunds on the lower side. Then cement bags filled with cement, brick chips, sand, and/or earth, were built up in the gullies and along the stream banks to prevent further deepening of the channels. Wattle fences made from woven bamboo were also put in the gullies to check further erosion. The structures were complemented by vegetative measures with planting of Nepalese alder *(Alnus nepalensis)*, bamboo *(Dendrocalamus sp.),* cardamom *(Elettaria cardamomum),* and broom grass *(Thyosonaelana maxima)*. These species establish quickly on degraded sites and also control erosion, stabilise land, and serve as cash crops, and for fodder, fuelwood and timber. Alder (locally called utis) is a nitrogen-fixing multipurpose tree which helps restore soil fertility. The average annual gross production value of the land after the technology was applied increased by about US$ 500/ha.

These plants can provide farmers with economic benefits after only two years. The vegetative resources needed are locally available and cheap and local farmers know how to propagate them; the maintenance costs are negligible. Once established, stabilised and revegetated sites provide improved environments for birds and insects – thus favouring biodiversity – and help protect natural springs. In this case study, the economic returns from the cash crops mainly went to one family, other families extract common products (fodder, litter, timber) for domestic use. The location is regularly used as a demonstration site for farmers and soil and water conservation (SWC) specialists.

**Left:** case study area three years after treatment, left side of picture, and showing untreated area affected by steam bank erosion and landslips on the right (Hanspeter Liniger)
**Right:** Check dams made from cement bags filled with a mixture of sand, earth, cement; and brick chips at Indrayani, Gagalphedi, Kathmandu District (Top: P Mathema); woven bamboo fences positioned in gullies near Bajrayogrini Temple, Kathmandu District (Bottom: I.B. Malla). Both these sites are similar to the case study area.

**WOCAT database reference:** QT NEP11
**Location:** Sakhintar, Kathmandu/Bagmati watershed, Kathmandu district
**Technology area:** 0.14 km$^2$
**SWC measure:** Structural and vegetative
**Land use:** Wasteland (before) agrosilvopastoral ( after)
**Climate:** Humid subtropical
**Related approach:** Integrated watershed management, QA NEP11
**Compiled by:** Dileep K. Karna, Department of Soil Conservation and Watershed Management, District Conservation Office, Kathmandu, Nepal
**Date:** November 2003
**General comments:** This promising technology comprises a set of vegetative and structural measures for stabilisation of land where streams are cutting back into fields, or subsurface runoff is causing landslips. Income is generated from various plants. The technology focuses on a problem common to steep land in the tropics and sub-tropics and could be widely applicable both in Nepal and elsewhere.

The technology was documented using the WOCAT (www.wocat.org) tool.

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WOCAT

## Classification

### Land use problems

- Concentrated runoff from upstream agricultural areas
- Landslides, gullies, and stream bank erosion
- Gullies back-cutting into fertile agricultural land and threatening irrigation canals and homesteads

**Land use**

Wasteland: degraded shrub land (before)

Agro-silvopatoralism ( after)

**Climate**

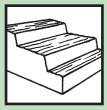
Humid subtropical

**Degradation**

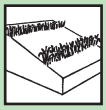
Water erosion: gullying, mass movement, river bank erosion

Chemical: fertility decline

**SWC measures**



Structural: ditches/bunds, cement bags, wattle fences



Vegetative: tree/shrub cover, grasses (dispersed/ aligned

**Technical function/impact**

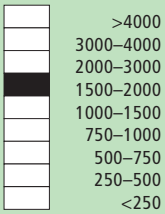
**Main:**
- impedes/retards concentrated runoff
- improves ground cover
- stabilisation of soil
- reduction of slope angle
- reduction of slope length

**Secondary:**
- drains/diverts concentrated runoff
- increases infiltration (due to improved groundcover)

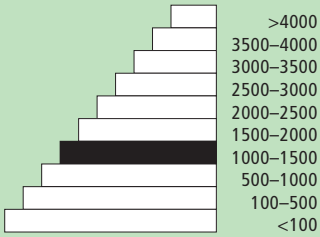
## Environment

### Natural environment

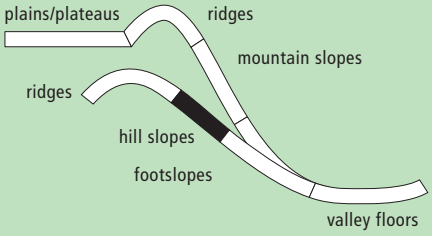
**Average annual rainfall (mm)**



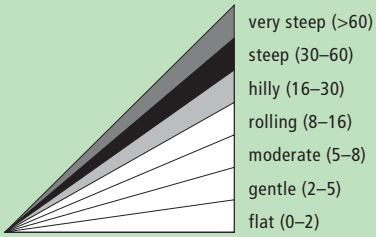

**Altitude (masl)**




**Landform**

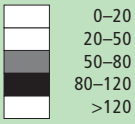



**Slope (%)**




Applied (large extent) Applied (medium extent) Applied (little extent)

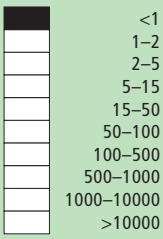
**Soil depth (cm)**



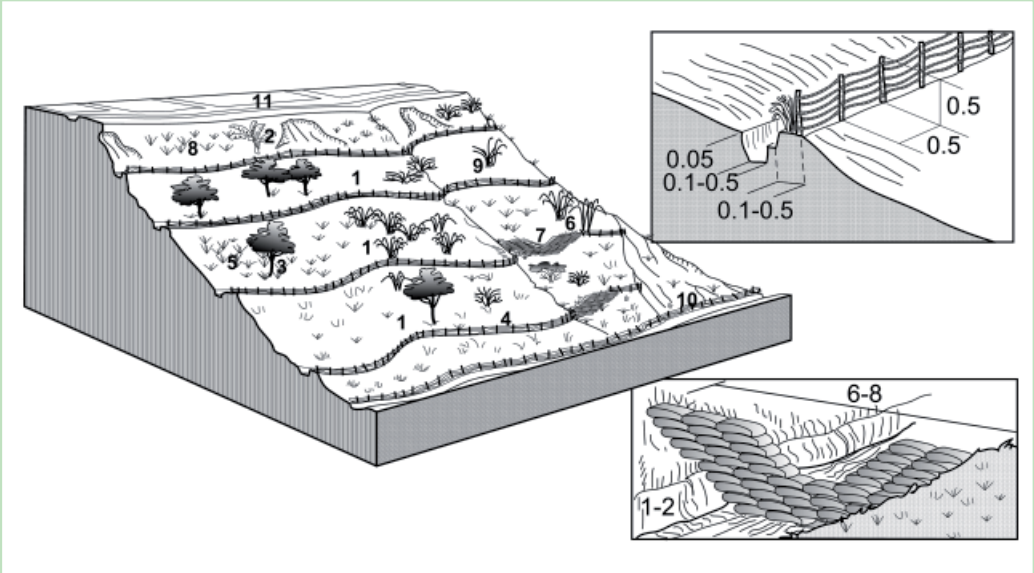

**Growing season:** 180 days (June to November); crops are grown the whole year round on surrounding irrigated areas
**Soil fertility:** mostly high, partly medium
**Soil texture:** mostly medium (loam), partly coarse (sandy)
**Surface stoniness:** no loose stone
**Topsoil organic matter:** medium((1-3%)
**Soil drainage:** medium
**Soil erodibility:** high

### Human environment

**Mixed land per household (ha)**




**Land use rights:** open access
**Land ownership:** state
**Market orientation**: subsistence and mixed (subsistence and commercial)
**Level of technical knowledge required:** field staff/extension worker: high during establishment period, low to moderate during maintenance; land user: high for establishment, moderate to high during maintenance
**Importance of off-farm income:** 10-50% of all income: occasionally teaching at farmers' schools; selling non-timber forest products in local market; some people work in markets/shops/on construction, sites, and similar




**Technical drawing**
Land slip and stream bank protection: an overview of the multiple and integrated vegetative and structural measures: cut-off drain

1. landslip area
2. banana trees
3. alder trees
4. bamboo wattle fences
5. cardamom
6. planting bamboo
7. cement bag check dams
8. broom grass
9. cutting bamboo
10. stream bank
11. agricultural fields in a flat area

Insert 1: Bamboo wattle fence combined with retention ditch and grassed bund to stabilise steep slopes and gullies.

Insert 2: Old cement bags filled to form checks in gullies

## Implementation activities, inputs and costs

### Establishment activities

1. Construction of contour bunds and ditches (January–April)
2. Stabilisation of slopes using bamboo wattle fences,and gullies using the check dams
3. Gully stabilisation as walls of cement bags are placed across the gullies and along stream banks (June)
4. Preparation of the site for planting (June)
5. Planting of alder *(Alnus nepalensis,)*, cardamom *(Elettaria cardamomum)*, bamboo *(Dendrocalamus sp.)* and broom grass *(Thyosonaelana maxima)* (July-August)
6. Watering of new plants using buckets (March-May, 1st year)
7. Application of farmyard manure at time of planting, and every December
8. Weeding (January)
9. Earthing up new plants with soil (January)

All activities are carried out manually using local and traditional tools: A-frame, digging axe, hoe, pipe, water pump, baskets, shovel, and hammer

Duration of establishment: 1 year

### Establishment inputs and costs per ha

| Inputs | Cost (US$) | % met by land user |
|---|---|---|
| Labour (1,560 person days) | 2,115 | 75% |
| Equipment | | |
| - Tools | 55 | 100% |
| - Empty cement bags (600) | 10 | 0% |
| Materials | | |
| - Cement bags (30) filled with earth/other material (50 kg each) | 125 | 0% |
| - Bamboo | 0 | |
| Agricultural | | |
| - Seeds (alder: 50g) | 0 | |
| - Seedlings (400 large cardamom slips) | 5 | 0% |
| - Alder: saplings (2,500/ha) | 40 | 100% |
| - Bamboo cuttings (600) | 565 | 50% |
| - Manure (1 t/ha) | 10 | 100% |
| **TOTAL** | **2,925** | **68%** |

### Maintenance/recurrent activities

1. Apply farmyard manure (January)
2. Weed (January)
3. Prepare land for further planting of large cardamom and broom grass (March-April)
4. Thin cardamom, bamboo, alder, broom grass with a knife: (May, June)
5. Replant cardamom, broom grass, bamboo that did not establish (June, July)
6. Earth up (August–September and January)
7. Prune alders (December, January)

All activities done annually and by manual labour needing no additional tools (see establishment)

### Maintenance/recurrent inputs and costs per ha per year

| Inputs | Cost (US$) | % met by land user |
|---|---|---|
| Labour (40 person days) | 55 | 100% |
| Equipment | | |
| - Tools | 10 | 100% |
| Agricultural | | |
| - Plant material (various) | 0 | |
| - Manure (500 kg) | 5 | 100% |
| **TOTAL** | **70** | **100%** |

**Remarks:** Labour costs: information based on oral information estimated by a farmer, exchange rate: US$1 = NRs 77 in 2003

## Assessment

### Acceptance/adoption

The technology was piloted in the case study area. In the meantime, other farmers have taken it up in other areas.

- 18 families (47%) took up the technology with the incentives of partly paid labour and free seedlings, bamboo culms, and cement bags.
- 20 relatively well-off families (53%) spontaneously adopted the technology because of its economic benefits on marginal land; this is a growing trend
- The land users have adequately maintained what has been implemented

### Benefits/costs according to land users

| Benefits compared with costs | short-term | long-term |
|---|---|---|
| establishment | negative | very positive |
| maintenance/recurrent | positive | very positive |

### Impacts of the technology*

**Production and socioeconomic benefits**

+ + + Increased fodder production and quality of fodder for livestock
+ + Increased wood production, including fuelwood
+ + Increased farm income: cash crop introduction

**Production and socioeconomic disadvantages**

- - - Increased inputs including labour constraints constrain the technology being established
- Increased inputs are required during maintenance of the technology

**Socio-cultural benefits**

+ + + Strengthened community institution by way of community resource mobilisation (e.g. as a result of common establishment activities and visits to the site by outsiders)
+ + + Improved knowledge about SWC and erosion
+ + Improved health (due to cardamom's medicinal value)
+ + Strengthened national institution (District Soil Conservation Office, Kathmandu)

**Socio-cultural disadvantages**

- - Socio-cultural conflicts
- - Other people may illegally extract non-timber forest products (because of remoteness)

**Ecological benefits**

+ + + Soil and water conservation along with improved cover
+ + + Reduced soil loss from approx. 200 t/ha/year to only 10 t/ha/year
+ + + Stabilised slopes
+ + Increased soil fertility
+ + Increased Soil moisture
+ + More efficient drainage of excess water
+ + Springs protected (increase of water quantity/more steady flow)
+ Enhanced biodiversity

**Ecological disadvantages**

- - Increased soil erosion and sediment transport (locally) during establishment of structural measures

**Off-site benefit**

+ + + Stabilisation of off-site agricultural land
+ + Reduced downstream siltation
+ + Reduced runoff/transported sediments
+ Reduced river pollution due to reduced turbidity
+ Increased stream flow in dry season
+ Reduced down stream flooding

**Off-site disadvantages**

- Grazing pressure will increase elsewhere as the SWC site is closed to grazing

* All changes in technology may have gender and equity implications and potentially affect the members of disadvantaged groups differently. This has not been assessed here but should be considered when recommending technology use.

## Concluding statements

| **Strengths** and →how to sustain/improve | **Weaknesses** and →how to overcome |
|---|---|
| The technology requires resources which are largely locally available and of low cost →Raise awareness that landslide threatened stream banks and steep slopes can be protected using local resources. | Establishment costs are high → Subsidise the cost (extension service, projects), reduce establishment costs by designing alternative structural measures that do not use cement |
| The technology addresses livelihood constraints →Raise awareness that the technology is profitable | Socioeconomic conflicts can arise when the value of land is raised →Take equity issues into account when implementing such a programme, and spread the benefits |
| Family members have learnt the technology; it is easy to replicate →Provide training to farmers to spread this information to others (e.g. through village initiatives supported by the government) | Establishment is very labour intensive |
| Better environment, increased biodiversity →As above | The technology is adopted more by better-off farmers →Government programmes should seek to involve poor farmers in land development with incentives for adopting recommended technologies |
| Soil and water conservation→ As above | |
| Fresh products, health benefits from cardamom → As above | |
| Income generation from cash cropping of cardamom, bamboo, broom grass → As above | |

**Key reference(s):** IBIWMP (2003) *Engineering Field Manual.* Kathmandu: Government of Nepal, Department of Soil Conservation and Watershed Management Programme, Bagmati Integrated Watershed Management ■ Howell, J. (ed) (1999) *Roadside Bio-engineering Reference Manual.* Kathmandu: Government of Nepal, Department of Roads

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