WISIONS of sustainability

Factsheet Series:
Sustainability Solutions for Mountain People and Landscapes

# Slope stabilisation and flood prevention through bioengineering practices in mountain areas in Nepal

Landslide destroys road infrastructure in Nepal (Photo: Winrock, 2024)

## Introduction to the solution

Nepal is a country with plenty of freshwater resources, with the major sources of water being glaciers, rivers, natural spring sources, lakes, ponds and groundwater. Most of the large and perennial rivers originate from the high mountains through the melting of ice and snow. The mountainous physiography causing steep river gradients and convex shapes makes mountains highly susceptible to erosion, landslides and flooding.

In recent years, the frequency, intensity and extent of such disasters have increased in Nepal. Along with the regular floods, landslides and soil erosion, flash floods and dry landslides have become more frequent. This is causing lives and property to be lost in Nepal's mountain settlements and riverine areas. It devastates physical infrastructure, such as micro hydropower intakes, powerhouses and roads, degrades the environment and causes economic losses by damaging agricultural land and crops, directly threatening people's livelihoods.

Nature-based slope stabilisation and flood prevention solutions can have many benefits, ranging from ecological benefits, to reducing the loss and damage caused by disasters, to economic advantages. This factsheet focuses on multilayered bioengineering practices and reforestation for slope stabilisation and flood prevention.

# The solution: Low-cost bioengineering practices

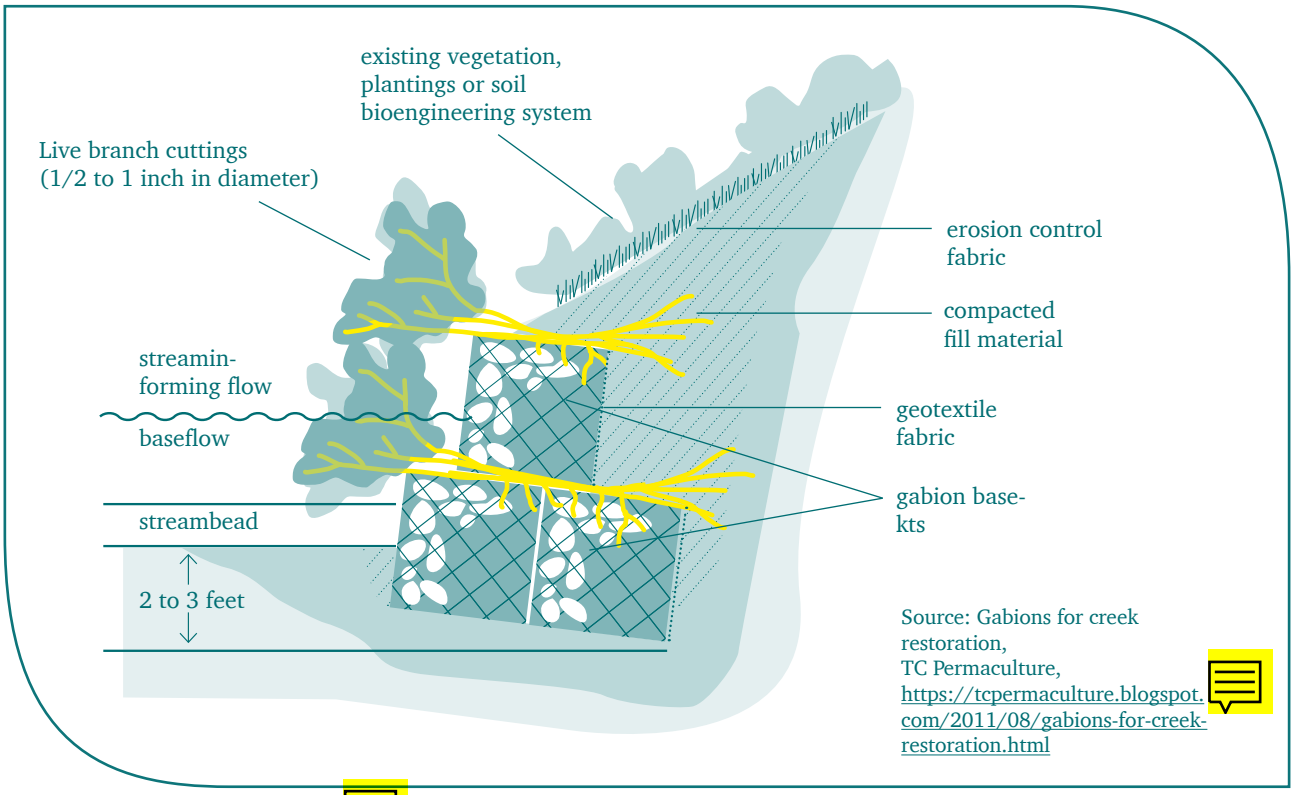
Bioengineering is an interdisciplinary approach that applies principles and methods from biology, engineering and other scientific disciplines to solve problems in agriculture, healthcare, and the environment. Bioengineering measures for slope stabilisation and flood prevention involve the strategic plantation of native vegetation. This forms a self-sustaining, stabilised structure by binding soil and reducing erosion, as well as providing additional ecological benefits such as biodiversity enhancement1. The most important advantage of bioengineering over civil engineering is how inexpensive it is and the significantly reduced maintenance requirements in the years that follow[2].

Multilayered bioengineering that integrates vegetation with deep root systems along with engineering techniques is highly suitable for stabilising slopes. This approach employs multiple layers of reinforcement to adapt to varying environmental conditions while providing stability and reducing erosion. In steep areas and on degraded land, a combination of land use planning, engineering and environmental management is required. Multilayered bioengineering practices often combine three types of components: Grasses, stone walls or gabions, and shrubs. Grasses with long, deep roots can stabilise the soil on slopes, provide surface cover, reduce surface runoff, and catch debris. Depending on the requirements and the topographic conditions of the area, different species of grasses can be used. For example, vetiver grass is used as an efficient bio-technology to protect slopes in many countries due to its long life, strong, long, finely structured root system, and its high tolerance of extreme climate conditions[3].

Branch of Prinsepia utilis, or Dhatelo, with its distinctive fruit. (Photo: RECOFTC Nepal, 2024)

Thysanolaena latifolia, known locally as 'broom grass' or 'amriso', is another species that is widely used in Nepal. It usually grows along damp river banks and steep slopes, serving to protect against soil erosion. Grasses offer multiple benefits. In addition to soil conservation, most of them can be also used as fodder for livestock. The broom grass flower is used in Nepali houses to sweep away dirt.

Stone walls or gabions are often installed in order to enhance the resilience of riverbanks against soil erosion. Gabions are metal mesh baskets that are filled with stones. Gabions provide stability to slopes, secure free drainage of water, catch debris and allow vegetation to grow. Planting dense shrub species or bamboos with fibrous root systems effectively reinforces soil and mitigates runoff. Moreover, shrubs and bamboos often have additional uses. For instance, Prinsepia utilis, commonly known as Dhatelo, is a spiny shrub that can be used for flood control but can also serve as a natural barrier around agricultural areas. In addition to this, an edible oil which has several applications can be extracted from its seeds to provide a source of income. Multilayered bioengineering technique: Wooden crib wall and check dam constructed in Jumla, Nepal to prevent agricultural lands from erosion.




Source: Gabions for creek restoration, TC Permaculture, https://tcpermaculture.blogspot.com/2011/08/gabions-for-creek-restoration.html

(Photo: RECOFTC Nepal, 2024)

# Managing the solution

The success of multilayered bioengineering depends not only on proper planning, design and implementation but also on ensuring regular monitoring and maintenance. To ensure long-term functionality, some important aspects need to be considered:

· Assessment of the site: Prior to any further action, it is essential that a site-specific assessment be conducted to gain an understanding of the specific hydrological and topographical characteristics of the site. Flood history, soil type and rainfall patterns should be considered before the necessary steps and design can be planned accordingly.

· Plantation pattern: The arrangement of plants to be used in the process should be given serious consideration when designing the layout. The mix of groundcover, shrub and tree species should be chosen to work together to stabilise the soil, absorb water and reduce runoff. Attention must be paid to using site-specific, native plants. Extensive root systems play an important role in soil stabilisation with this method. Plant species with extensive root systems are therefore essential.

· Community involvement: Local communities and their involvement in such activities enhance the success and longevity of the project. Ownership of the structure by communities ensures its sustainability. For this, plant species that can provide instant economic benefits or ensure benefits to the communities in coming years should be introduced. Some examples of these include broom grass (Thysanolaena), Dhatelo (Prinsepia utilis), etc.

Nature-based bioengineering solutions are cost effective because they can use locally available resources. If the local communities are provided with some capacity building training to implement the required bioengineering techniques, further skilled personnel need not be appointed. Therefore, people from the community can provide the human resources needed to implement the solution. This can be done in collaboration with stakeholders such as soil conservation offices, local government, other organisations working on similar topics, and local communities.

**2. Bioengineering cost**

| SN | Particulars | Unit | Unit rate | Unit no. | Days | Amount (USD) |
|---|---|---|---|---|---|---|
| 1 | Gabion boxes (3x1x1) (Including all materials required) | Box | 130 | 220 | 1 | 28,600* |
| 2 | Landscape restoration (Bains and Dhatelo plantation) | No | 1 | 3000 | 1 | 3,000 |
| 3 | Low-cost civil structures | No. of sites | 10,000 | 1 | 1 | 10,000 |
| 4 | Labour cost | Person | 10 | 15 | 20 | 3,000 |
| | **Total** | | | | | **44,600** |

* Boxes to be kept as per the requirement on site; estimation based on observations from field visit

The above estimate is for the implementation area in the Girikhola MHP catchment area in Jumla.
All the estimates are based on realistic market prices.

## Operation costs

The main operation costs of bioengineering measures are linked to the labour required to maintain the vegetable components of the system. Proper care and maintenance are particularly crucial in the initial stage. The plantations can be washed away or die due to over watering if planted in river banks. There is also a chance that they might die if planted on very dry, steep slopes. In order to reduce such risks, the location in which the bioengineering solution is to be implemented and the season should be considered. Once the vegetation has consolidated, regular care such as timely cutting, cleaning and pruning is needed. In addition to this, repairs to both the vegetation (e.g. repairing palisades or replanting vegetation) and the inert components (e.g. repairing wires, sealing cracks in walls) should also be taken into consideration.


Multilayered bioengineering technique: Wooden crib wall and check dam constructed in Jumla, Nepal to prevent agricultural lands from erosion (Photo: RECOFTC Nepal, 2024)

## Socio-economic and sustainability impacts

Landslides and floods pose significant threats to both human lives and infrastructure. One notable example is the flash flood that occurred along the Karnali river and its adjoining tributaries in 2022. This event devastated the micro hydropower intakes, the powerhouse facilities, and the properties of numerous local inhabitants living near Jumla. Nature-based bioengineering solutions can significantly reduce how vulnerable humans and socio-economic infrastructures are. In addition to this, bioengineering measures can integrate the planting of spices that have multiple uses, for instance as fodder, construction materials, and food. In this way, bioengineering can be combined with additional income-generating activities. That is the case with Prinsepia utilis, whose oil can be used for a myriad of purposes, for example medicine, cooking and making soap to wash clothes.

Nature-based solutions not only serve as a pathway to achieving socio-economic objectives but also offer numerous advantages for biodiversity and habitat protection in the specific areas targeted. Planting native species such as vetiver grass, Himalayan bamboo or Prinsepia utilis enhances ecological health. Vetiver grass can serve as a nurse plant in barren or degraded landscapes, fostering a microclimate conducive to the growth of other plant species. Prinsepia utilis, with its thorny and profuse branching system and its ability to grow in barren areas, can be used as natural fencing and improves soil fertility[4].

## Scaling-up potential

In Nepal, there are innumerable seasonal and big rivers. Moreover, all of the community-based Micro Hydropower Plants (MHPs) in the country depend on these rivers as their source of water for energy production. These MHPs also suffer both minor and major damage due to flooding every year. Therefore, in order to make the energy supply from the MHPs sustainable, there is an urgent need to reduce the impact of floods and landslides on them. This means that the scaling-up potential of bioengineering activities in Nepal is very high.

## Examples from the Nepalese context

The Department of Roads together with the Department of Forest and Soil Conservation have implemented bio-engineering practices along some roads and catchment areas. According to them, these solutions are highly cost effective, offering sustainable nature-based solutions.

**For further information see:**

https://boku.ac.at/fileadmin/data/H03000/H87000/H87400/Forschungsprojekte/endbericht_nepal_19-08-2008.pdf

https://swnepal.com.np/2023/10/27/mitigation-of-landslides-using-nature-based-solutions-nbs/

https://www.witpress.com/Secure/ejournals/papers/DNE120402f.pdf

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2. Polster, D. (25-28, May, 2003). Soil Bioengineering for Slope Stabilization and Site Restoration [Conference paper]. Mining and the Environment III, Laurentian University, Sudbury, Ontario, Canada. https://botanicgardens.uw.edu/wp-content/uploads/sites/7/2013/12/SoilBioengineeringForSlopeStabilizationAndSiteRestoration.pdf

3. Green Roads for Water. (n.d.). Bio-Engineering Measures for Road Side-Slope Stabilization. Available at: https://roadsforwater.org/guideline/conclusions-it-pays-off/1-bio-engineering-measures-for-road-side-slope-stabilization/

4. Kumar, P., Kumar, D., Singh, S., & Rout, S. (2021). Prinsepia Utilis Royle: Diversified and indigenous traditional uses of uncultivated multipurpose shrub. International Journal of Mechanical Engineering,6, 579-590. https://www.researchgate.net/publication/359002443_Prinsepia_utilis_Royle_Diversified_and_indigenous_traditional_uses_of_uncultivated_multipurpose_shrub

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This factsheet is part of the series "Sustainability Solutions for Mountain People and Landscapes," developed within the WISIONS Innovation Lab Nepal. The aim is to promote an integrated approach to strengthening the livelihoods of people living in mountain communities. Each factsheet provides information on specific sustainability solutions in the fields of energy and landscape management that have shown promising potential for improving the livelihoods of mountain people but have a low level of adoption in Nepal and other mountain regions. The information is tailored to the specific context of Nepal's mountain landscapes and offers practical insights and guidance for scaling up the application of these solutions. Additionally, it presents an integrated approach that begins with an understanding of the opportunities and challenges faced by mountain communities, enabling the systematic deployment of synergies between solutions from the energy and landscape sectors.

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