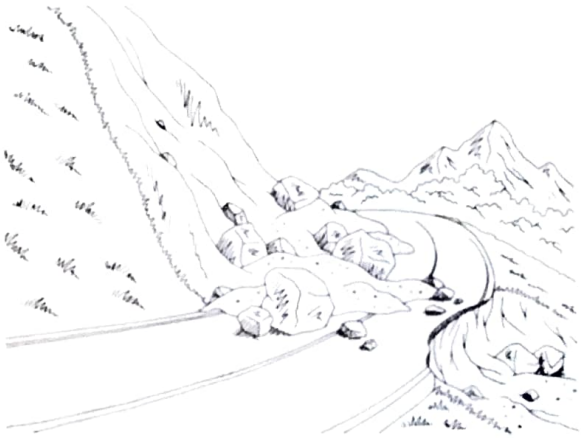
Demonstrating Nature-based Solutions (NbS) for Landslide Restoration

A case of Bimire Village, Neelakantha-4, Dhading

1. Introduction

The landscape of Nepal's hilly terrain is highly vulnerable in terms of slope failure as the slope is too steep and underlying geology is often incompetent and fragile. On the other hand, anthropogenic activities such as unplanned rural roads and rapid changes of land cover have exacerbated the occurrence of landslides in the mountainous terrain of the country. Most often, conventional engineering techniques are applied to mitigate and reduce the landslide risks. The techniques are generally costly, less sustainable, and environmentally unfriendly. The strength of such structures reduces over time considerably turning the slope unstable. Sometimes, the poorly designed and constructed conventional practices increase instability of slope due to increased surcharge. In order to stabilize the slope in a sustainable manner, Nature-based Solutions (NbS) which is also referred to as "soil-bioengineering" in the country, has been gaining popularity. The NbS is regarded as one of the most feasible and cost-effective alternatives in slope protection. However, there are limited success stories of soil-bioengineering reported in Nepal which is typically attributed to limited regular maintenance activities and improper selection of flora species used.

More recently, the NbS is however, gaining popularity around the globe because it applies the technique of using vegetation alone or in combination with simple civil engineering structures for slope protection and landslide restoration. Plant species having higher amounts of above and below-ground biomass are important in protecting the unstable slopes. A higher amount of above-ground biomass reduces the initial abstraction leading to less amount of rain reaching the soil surface, and that of the below-ground biomass increases the soil's shear strength due to root cohesion. Because of the multiple co-benefits that the NbS could bring at the local level such as fodder, fuel wood, employment opportunities, and protection of water resources and the ecosystem among others, it was decided to demonstrate NbS technology to restore a landslide at Bimire Village of Neelakantha.



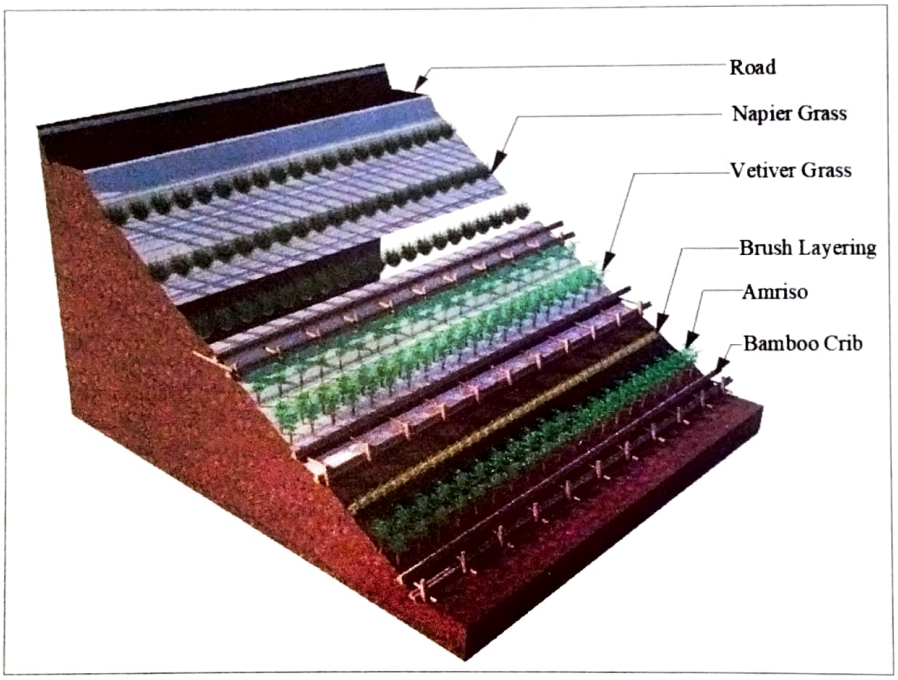
This demonstration was possible because of the grant provided by USAID through TAYAR Nepal to FEED (P) Ltd. At the Bimire Village in Neelakantha-4, the roadside landslide was triggered during the July 2022 rain which damaged cultivable agricultural

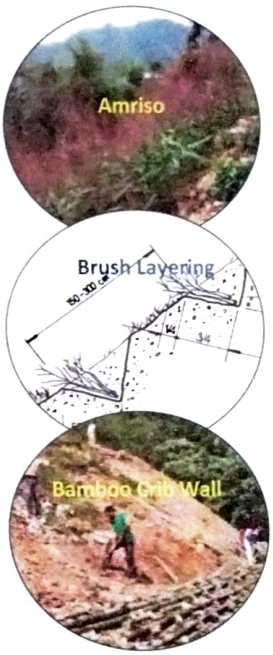
land, disrupted the road for several days, and was a risk to the houses situated along the downslope. The implementation of the NbS measures aimed to restore the landslide and enhance the community's awareness of NbS through demonstration.

2. NbS Implementation Process

The technical research team jointly with the municipality and community people assessed and observed several potentially unstable slopes and existing landslide sites to apply NbS in the upstream catchment of Arunkhola in Ward No-4 of the municipality. The observations were focused on the size, shape, underlying casual and triggering factors of the landslides, available resources, and accessibility to the demonstration site.

Initially, the local community people were hesitant to go for the NbS as it was new to them. They thought that slope protection was only possible by constructing conventional engineering measures such as gabion, and stone masonry walls. The research team demonstrated the success stories of NbS and its likely co-benefits aiming to motivate them.



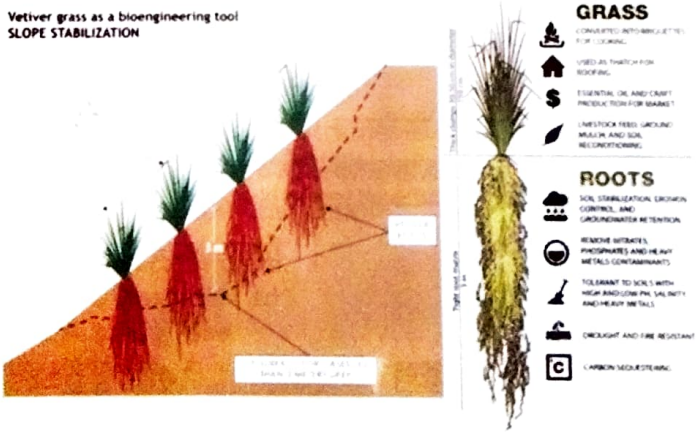


A suitable roadside landslide in Bimire Village was found for the NbS demonstration. The identified landslide was 25 m wide and about 20 m long with the slope ranging from 35-40 degrees. The triggering and casual factors of the landslides were rainstorms and topographic attributes respectively and soil physical properties. Knowing the factors that caused the landslides, the technical team discussed and finalized various components and techniques of the NbS specific to the site. The research team closely worked with the Landslide Early Warning System User Committee (LEWS-UC), which was formed to take care of the LEWS's operation and maintenance. Various components of the measures were designed and subsequently a Bill of Quantities (BoQ) was prepared with the disaggregated data of the required construction materials and labor cost. A half-day-long orientation was delivered to the LEWS-UC and local community people in the presence of the local engineer. The LEWS-UC members were mobilized to collect the local construction materials and workforce.

Considering the nature of the landslide, the technical team decided to use multiple techniques of intervention such as 1) Construction of Roadside Drain, 2) Bamboo Crib Wall, 3) Brush-Layering, 4) Stone Rip-Rap, 5) Vetiver System, and 6) Amriso Plantation.

3. Outcomes of the NbS Application

Among the suggested NbS measures, Vetiver Grass (Chrysopogon zizanioides) was brought from Kathmandu, Amriso (Thysanolaena maxima), Nepiyar Grass (Pennisetum purpureum), Simali (Vitex negundo), Bamboo (Bambusa vulgaris) were purchased locally from the community. Bamboo Crib Walls were applied aiming to provide immediate stability to the slope while others would reinforce the slope in a gradual manner upon their growth and root systems developed.



These plant species were selected considering the nature of rooting depth, diameter, and strength to hold soil mass. Moreover, the selected plant species are climate-resistant, fast-growing, and have finer and stronger root systems. The finer the root system, the higher is the root cohesion leading to the increased slope stability. The root system of Amriso is measured to be more than one meter into the sub-surface and the roots are finer (~1-2 mm diameter) and owed considerable root cohesion (~8 kPA: tensile strength of root) and contribute to increase the soil cohesion thereby the slope stability. Vetiver System (VS) is a technique of planting Vetiver grass in a contour line aiming to increase the soil cohesion that acts like a soil nail. Vetiver has a finer (~1-2 mm diameter), deeper (~3-4 meters deep), and stronger (~12-14 kPA of tensile strength) root system among all the species known for its higher survivorships. All the species applied are fast-growing types which can also provide better ground coverage and reduce surface erosion during intense rainstorms. The plantation and brush layering were undertaken in a contour line with a mixture of different plant species that will collectively reinforce the slope.

4. Remarks

The adopted NbS technique at the Bimire landslide site was a hybrid model with different plant species with varying characteristics such as 1) survival rate, 2) root depth, 3) root strength, 4) above and below-ground biomass, and techniques for immediate slope protection such as 1) bamboo crib wall and 2) surface water management by constructing roadside drainage.

The construction of bamboo crib walls and surface drains provides immediate stability to the slope before the plant species are fully grown. As the plants grow on the slope, the root system will develop that acts like soil-nailing ensuring the similar action of steel-nailing for the soil slope protection under conventional engineering. With the longer and stronger rooting system, it is possible to replace the steel nailing with plant species, which is cost-effective, sustainable, and can be managed by the local community people. Further, there are ample co-benefits of NbS such as brooms and fodder from Amriso, fodder from Napier, and Vetiver, and fuel wood from Simali and Amriso from which the local people can generate additional income and save time in terms of searching for fuel and fodder. In addition, the above-ground biomass of Vetiver grass can be used for handicraft production. Integration of different plant species while performing NbS improves the local ecosystem, improves the quality of water resources, reduces soil erosion, and increases soil productivity.

The limited success stories of NbS in Nepal are mainly due to 1) less or no consideration of the engineering functions of the flora species used, 2) ignoring social and co-benefits of the plant species used, and 3) limited maintenance of the applied NbS.

The selection of the plant species and adopted techniques have made the Bimire Landslide restoration and NbS demonstration unique and cost-effective. The adopted techniques can be used to restore many similar shallow landslides in the municipality and beyond.

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