速　報

Uses of Vegetative Measures for Erosion Mitigation in Mid Hill Areas of Nepal [*1]

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Abstract

Nepal, a mountainous country is located in Himalayan range. It is extended in between 60 to 8848 m altitude. According to altitudinal variations, it is differentiated into High Mountain, Mid hill and Terai regions. In Mid hill region, shallow landslides, bank erosion, and surface erosion are common problems. This region occupies 35% of total country area and 46% of total population distribution. Due to the constructions of rural roads in the steeper terrain, erosion rate is accelerating, from which an estimated average of 500 m^3 /km/yr of debris, and up to 2000 m^3/km sediment are generated. Due to economic conditions of the country and fragile terrain conditions, constructions of larger civil engineering structures are not possible. To deal with erosion problems, different vegetative measures are adopted as a cost effective solution. In this study, an attempt is made to present about some vegetative measures adopted to manage erosion problems in Mid hill region. From field observation, it was revealed that locally available indigenous species were used for grass seeding and grass slips plantation. Some vegetative structures like live fence, palisade, fascines, jute netting were constructed by locally available species to manage degraded land, gully, and landslide problems.

Key words: erosion, revegetation technology, Mid hill, Nepal

Ⅰ. Introduction

Nepal, a mountainous country is suffering annually from mass movement and surface erosion because of its steep terrain, fragile geology and high rainfall characteristics (Mishra and Kayasta, 1998a). Physiographically, whole country is divided into High Mountain (8848-4877 m), Mid hill (4877-610 m) and Terai regions (<610 m) as shown in Fig- 1.

There is difference in topography, geology and major erosion problems in each regions (see Fig-1). In High Mountain glaciation, in Mid hill and Terai shallow landslides, surface erosion and bank erosion are major hazardous problems.

The Mid hill region occupies 35% of total country area and 46% of total population distribution. For the most parts, it is a rugged terrain of deeply dissected mountains and short ranges with sharp crests and steep slopes. The steep slopes (>30°), weak geologic conditions in combinations with high precipitation and frequent high intensity rainfall make the area susceptible. The population growth, deforestation, uncontrolled expansion of farming onto unsuitable marginal lands have led to enormous pressures on Mid hill environment. Typical view of Mid hill landscape is shown in Photo-1 a. This photograph shows relatively flat lands used for agricultural and residential purposes, steeper terrain dissected by rural roads and valley slope encroached by bank erosion. The disturbance in natural slope due to road construction, many gullies were also formed below the road side slopes (Photo- 1 b).

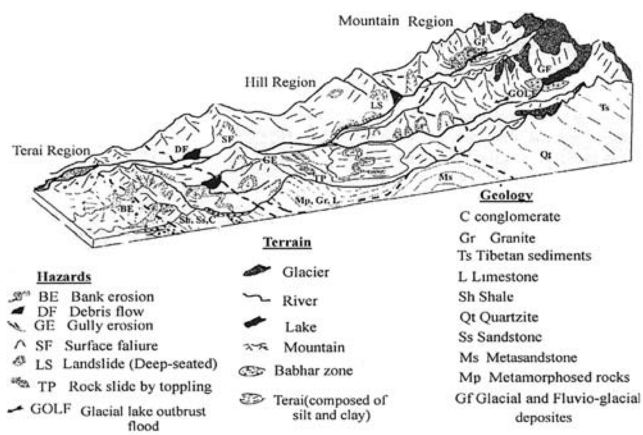

Fig- 1. Diagrammatic cross sectional map of Nepal showing hazards, terrain and geological conditions.
(after : Higaki, D. and Ghimire, S. K. 2004)

[*1] ビマラ　デビ　デボコタ，プレムホウデル，大村寛，久保田哲也，森田紘一：ネパール中央山岳地帯における浸食と植生工の応用に関する事例研究

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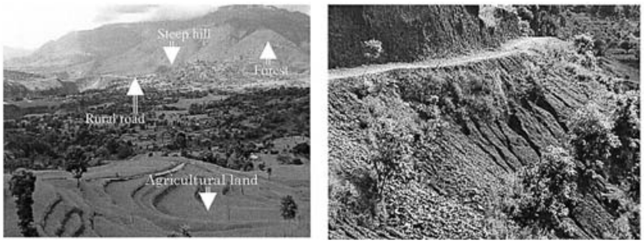


a　　　　　　　　　　　b

Photo- 1. Typical view of Mid hill landscape and gully formation near roadside slopes.

before　　　　　　　　　　after

Photo- 2. Glimpse of revegetation activities in lansdlide and gully control sites.

Ⅱ. Uses of Vegetative structures

Many people living in Mid hill region practice agriculture farming for their livelihood even in steeper slopes (> 30^{o}). It is estimated that only from sloping terrace land soil loss occurs at the rate of 60-70ton/ha/yr (HMG/JICA study report, 1998). It was also estimated that after construction of rural roads, could generate an average of 500 m^3 /km/yr of debris, and up to 2000 m^3/km sediment, which is 10 times greater than those expected under natural conditions (ODA, 1997). The shallow seated landslides, bank erosion and gully erosion are frequently occurred. Hence, it is becoming necessary to develop adequate and appropriate low cost methods to deal with increasing erosion and landslide problems. Due to the economic conditions and fragile terrain nature, constructions of large civil engineering structures are not possible. The establishment of plant communities in eroded or erosion prone areas either by natural or artificial means is becoming essential. In studied sites, plants were allowed to grow by natural, artificial or both means. Sometimes small vegetative structures were built up by using locally available plant materials. For protection of landslided, gully formation and bank erosion sites plant communities were grown as shown in Photo-2. In this case, fast growing, ***Alnus nepalensis, Dalbergia sissoo*** species was planted around the erosion sites. The vegetative structures were mixed along with gabion wall structures. Howell (1999) has stated that in some cases relative strength of vegetative measures become gradually higher than civil engineering structures (Fig-2). Although this principle might depend on site specific conditions and nature of civil engineering structures built up but sometimes it may happen where relative strength of hardware structures decreases due to either rusting or decaying. The vegetative strength may gains effectiveness after few years by covering the landscape surface and binding soil masses.

In the field following vegetation technology were adopted to mitigate the erosion problems.

1. Grass seeding and grass slips plantation

Grass seeds of local species were sown directly to the landslided or erosion prone sites by manual methods. In few road projects, hydro seeding technique was also applied.

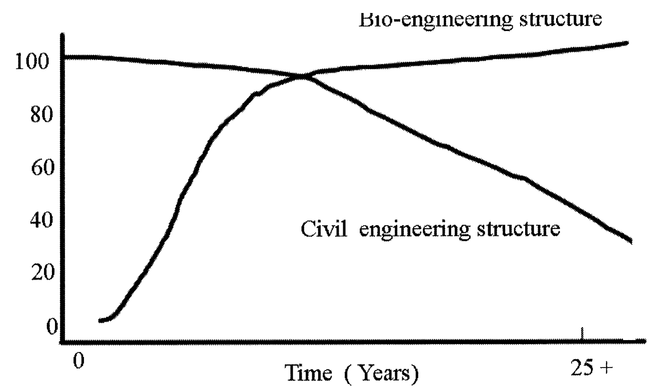


Fig- 2. Comparative effectiveness of vegetative and structural measures.
(Source : Howell, 1999)

However, it was known that the cost of hydro seeding was 30 times higher than manual seeding.

The grass slips (rooted cuttings) of locally available pants were planted in vertical, horizontal, diagonal or random lines. The slope gradients of sites were ranged from 35°- 65°. In horizontal lines the row spacing was about 10-50 mm. Mostly locally available plant species of ***Eulaliopsis binata*** and ***Saccharum spontaneum*** were used for grass seeding and slips plantation.

In some cases turfing method was applied to protect the eroded sites. In this method, turfs of ***Cynodon dactylon*** were placed and pegged.

2. Brush layering

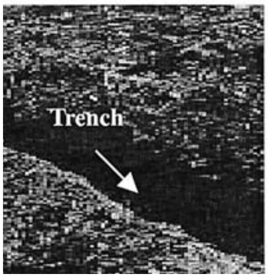
Woody cuttings of locally available plant species were laid in trenches lines across the slope with tops protruding above the surface. The cuttings were laid in double rows (Photo - 3 a). These structures were built to catch the debris materials flown from upper side. For this purpose ***Adhatoda vasica***, ***Salix tetrasperma, Garuga pinnata, Vitex negundo, Alnus nepalensis***, species were commonly used.

3. Palisade

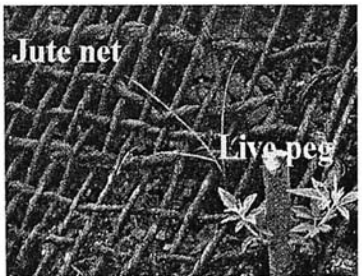
Woody cuttings were inserted in the ground with tips protruding above the surface. Palisades were generally used for protection of deep and narrow gullies. These structures may stabilize the gully floor by forming a strong barrier and trapping

a. Brush layering

b. Palisade



c. Fascine construction



d. Jute netting mixed with woody live peg

Photo- 3. Diferent vegetative techniques applied to manage erosional problem.

materials moving downwards. The slope gradients of the observed sites were ranged in between 30°- 45°. In some sites the cuttings were planted in double rows (Photo - 3b). For making this vegetative structures ***Lantana camara, Ipomoea fistulosa, Erythrina, Colquhounia coccinea*** species were commonly used.

4. Fascine constructions

Bundles of locally available live woody cuttings were laid in trenches just below the land surface (Photo - 3c).
For this purpose ***Alnus nepalensis, Lantana camara, Ipomoea fistulosa, Adhatoda vasica, Garuga pinnata*** species were used.

5. Jute Netting

Locally made Jute nets prepared from ***Corchorus capsularis*** species was placed on the shallow land slided sites. The vegetative woody plants (live pegs) were also used for providing additional strength as shown in (Photo - 3d).

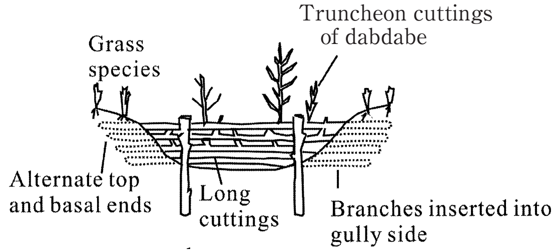
6. Live check dams

In some gully areas, a live check dam was constructed from the variety of woody cutting to prevent and stabilize the gully erosion. The slope gradient of gully bed was 35°.
The ***Adhatoda vasica, Ipomoea fistulosa, Vitex negundo*** species were commonly used.

Ⅲ. Root characteristics of some plant species

The suitability of plant for erosion control measures were selected considering the criteria: (1) locally available plants that can grow successfully on eroded sites (2) dense and deep rooting system which can add strength to the surface soil layers (3) fast and simple propagation.


a. Live check dam



b. Configuration

Photo- 4. Live check dam and its configuration used for gully control.

The root system of the plants plays an important role to stabilize the slopes (Abe and Ziemer, 1991). At the eroded sites the root types and penetrated depth of some species were assessed (Table -1). The roots of grass were mainly of adventitious and fibrous types and were concentrated at the land surface as seen in Cynodon dactylon and Eulaliopsis binata. The roots of shrubs and trees were penetrated more deeply. For convenient, the root types of shrub and tree species are categorized into four types, according to classification as proposed by Shrestha (2001). The types includes, Intensive main root type, (single main root with more lateral roots), main root divergent type (main root is bifurcated into two or more branches), lateral root dispersion type (shorter main root with few lateral roots) and lateral root concentration (numerous lateral roots are concentrating near the surface). Such root types might be effective for surface erosion protection. However, ***Melia azedarach***, ***Garuga pinnata*** species with deep roots (about 1 m) might be suitable for landslide, gully and bank erosion protection.

Ⅳ. Discussion

Due to steep slopes, weak geological conditions heavy rainfall during monsoon season Mid hill region is susceptible to erosion and landslide problems. The use of plant species either alone or in combination with civil engineering structures were contributed to surface erosion control and landslide problems by achieving following effects (1) preventing surface erosion and landslide through the soil binding, anchoring properties of roots (2) providing support to the base of the slopes and trapping material moving down the slope. In general, nitrogen-fixing

Table -1.　Approximated rooting depth and root types of some plant species.

Species name	Rooting depth (m)	Root type
Cynodon dactylon	0.01	Fibrous
Pennisetum clandestinum	0.03	
Saccharum spontaneum	0.68	
Eulaliopsis binata	0.79	Fibrous
Cymbopogon microtheca	0.86	
Bambusa nutans	1.0	Rhizome
Woodfordia fruticosa	1.02	Lateral root dispersion
Acacia pennata	1.25	Main root divergent
Butea minor	1.09	Main root divergent
Indigofera atroturpurea	1.30	Main root divergent
Melia azederach	1.8	Main root divergent
Shorea robusta	≥ 2	Intensive main root
Ficus cunia	≥ 2	Intensive main root

species with adventitious rooting ability might be suitable for soil improvement and rehabilitation of degraded lands. The root types and depth examination of individual plant species can provide important basis for selection of appropriate species suitable for effective surface erosion control and slope stabilization. For palisade, fascines, brush layering, use of fast growing species like *Alnus nepalensis* might be effective. The survival rate of each species is still unknown. The accelerating rate of erosion in Mid hill regions can be minimized through understanding of appropriate revegetation technology.

Ⅴ．Conclusion

The vegetative measures applied in Mid hill regions were simple and cost effective solution to address the different erosion problems. Where the vegetative structures were properly constructed, erosion problems were reduced remarkably. There is still need technical improvement for strengthening the effectiveness of vegetative measures. There is a clear need on scientific research on identification of suitable species, findings physical relationships between vegetation and erosion to achieve effective control measures.

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