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State of Vegetation, Erosion Climatic Conditions and Re–vegetation Technology in Mid Hill Area of Nepal

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Nepal is a mountainous country which is suffering from mass movements and surface erosion annually because of its steep terrain, fragile geology and high rainfall characteristics. The occurrence of shallow depth and translational landslides, gully erosion, bank erosion, surface erosion and flooding are the major erosional problems. In case of Nepal, the constructions of larger hard structures are not affordable due to the poor economic condition and rugged terrain nature. Therefore the use of re–vegetation technology is the cheapest and easy method for erosion control. Due to climatic variations the common hazards and vegetation types in each zone also differs. It is necessary to identify the suitable plant species and re–vegetation technology that can be used for erosion mitigation in Mid Hill region.

INTRODUCTION

Nepal, a mountainous country is extended 193 km in North–South and 885 km in east–west direction within the elevation range from 60 m in the southern plane area to 8848 m in the northern Himalayan region. The bio–geographic setting is varies in north–south and east–west stretch and divides the country into different eco–climatic zones. The vegetation and climatic conditions are vary with respect to altitudinal variations and endowed with almost all types of climatic conditions that are available from equator to arctic zones (Mishra, 1998 a). The forest types are varies from tropical to alpine. *Shorea robusta* is a major timber species in Terai region (tropical zone) and *Quercus* species in high altitude (alpine zone). The tree line is located at about 4500 m altitude. Mountainous regions are inherently unstable and prone to different types of erosion causing natural geohazards (Omura, 2000). Glaciation, the glacier lake outbursts in high mountain and surface erosion, landslide, rock fall and bank erosion in mid hill area are common problems. For example the scene of landslide and gully formation in Mid Hill area is shown in Fig. 1.

Owing to the rugged mountain topography, fragile nature of the geological structures, soft soil cover, high intensity of monsoonal rainfall and earthquakes, mountains are vulnerable to landslides. Due to steep terrain soil erosion is common and is accelerated by human activities like construction works, grazing, improper land use practices etc. To mitigate the erosional problems, use of re–vegetation technology is one of the most effective countermeasures. The study on co–relation between existing vegetation types and climatic conditions such as rainfall and temperature provides important information to apply the re–vegetation technology. For establishing the plant communities in specific area surrounding vegetation types, temperature and rainfall conditions have the greater influence. In this study, we attempt to

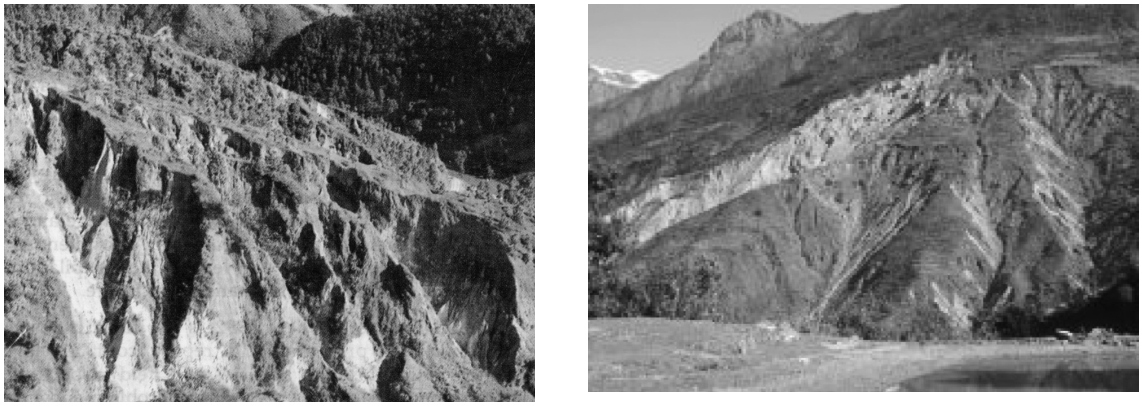

Fig. 1. Glimpse of landslides and gully problems in Mid Hill areas, Nepal.

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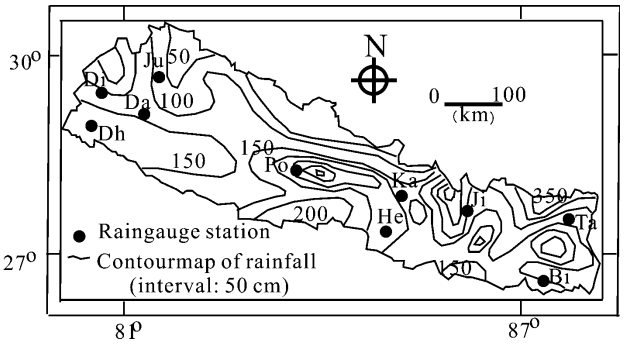
find out the vegetation types, climatic conditions and re–vegetation technology in different region of Nepal.

CLIMATIC CONDITIONS

The presence of the east–west trending Himalayan massifs to the north and the monsoonal alteration of wet and dry seasons contribute to the local variations in climate. The maximum mean monthly temperature during two months from April to May which as recorded about 35–40 ˚C at altitude of below 1000 m. Generally temperature reaches lowest in January which is about 14–16 ˚C at 1000 m altitude, 6–8 ˚C at about 2000 m altitude, 2 ˚C in 3000 m and above falls zero above 3000 m (Jackson, 1994).



Bi: Biratnagar, Ta: Taplejung, Ji: Jiri, Ka: Kathmandu, He: Hetauda, Po: Pokhara, Ju: Jumla, Da: Dailekh, Di: Dipayal, Dh: Dhangadhi.

Fig. 2. Rainfall distribution pattern in summer monsoon season.

The rainfall pattern over Nepal is much influenced by its topography (Shrestha, 2000). The spatial variation in annual rainfall across the country is shown in Fig. 2.

In the annual pattern there are particularly three regions with high rainfall (>3000 mm) namely in the central Mid Hill region near Pokhara and north eastern part. South part of these regions receives relatively less rain, which is lying in the lee side of the lower mountain range. In general, the eastern and central region receives more rainfall than western region. The most important factor for governing rainfall is summer monsoon. Hence the monsoon begins earlier in the east where apparently falls more rainfall. The main range of Himalaya is a considerable barrier to the monsoon. In the central and eastern Himalaya at the monsoon season, wind was deflected to the south–east. The mean annual rainfall for whole land amounts to 1767.5 mm almost same as that in Japan.

Not only the rainfall but the temperature also varies according to altitude. To know the spatial variations in temperature and rainfall in Nepal, ten weather stations representing in altitudinal ranges are selected which are corresponding to Fig. 2. Variations in temperature and rainfall in Fig. 3 shows the influence of altitude of mountain range. For example mean temperature and annual rainfall in Biratnagar located at 70 m from sea level are 25 ˚C and 1800 mm, respectively. While those in Jumla located at 2300 mm from sea level are 14 ˚C and 628 mm. Generally, temperature decrease with altitude. But range increase with altitude. Rainfall is affected by aspect of terrain other than altitude. If we take the references of these two locations, it can be estimated that there is difference of 1 ˚C temperature at approximately 200 m altitudinal range.

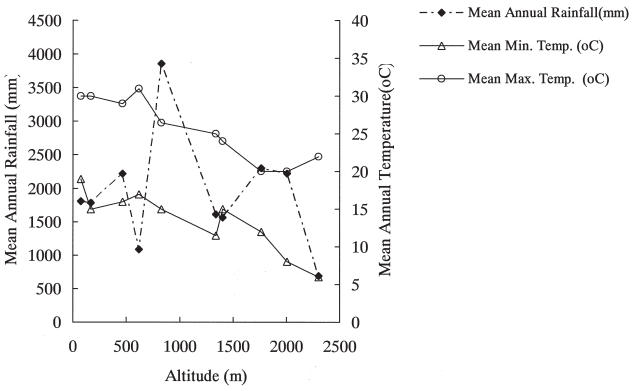
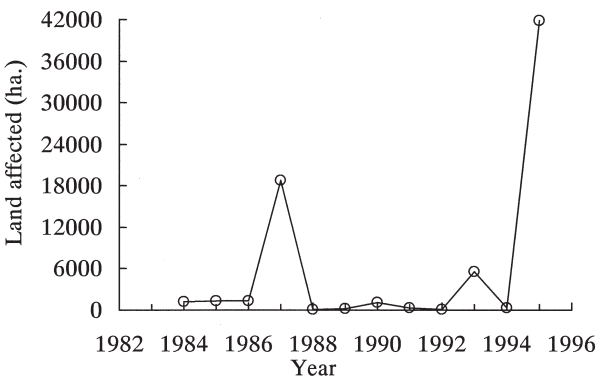


Fig. 3. Variations in temperature and rainfall in Nepal (1988–1999).

EROSION CONDITIONS

Soil erosion is one of the major environmental issues of Nepal. Geological process of erosion is more severe in the Mid Hill region because of the steeper terrain. Annually more than 1.7 mm of top fertile soil is lost from cultivated land. The annual soil erosion rates has been 2,000–5,000 tons/km^2/year and up to 20,000 tons in critical areas may get lost (Jha, 1992 a). The erosion rates in the specific areas depend on several factors such as rainfall intensity, types of land use and terrain. For instance in Mahabharat Lekh of central Nepal, where there is severe annual erosion which ranges in between 6,300–42,000 tons/km^2/year due to steepness. But in the protected forest of southern Kathmandu valley where the erosion rates are low ranging 800–900 tons/km^2/year (Mishra and Bista, 1998 b). The land surface is



(After: Forestry Master Plan, Soil sub sector, 1988)

Fig. 4. Land affected by erosion, landslide and flood for 10 years since 1984.

continuously affected by different erosion processes such as landslides, floods and surface erosion. These affects were examined and observed since 1984 to 1995, the results are shown in Fig. 4.

The soil loss from the land surface is influenced by the type of land use. The Forestry Master Plan prepared in 1988 has presented some soil loss rates estimated from different land uses. The results are summarized in Table 1, where the soil erosion rates are higher in degraded land and sloping terraces, while least in managed forested land.

Table 1. Estimated annual soil losses under various land uses

Land use	Soil loss (ton/ha)
Managed forest land	5– 10
Manages maize terraces	5– 10
Managed rice terraces	5– 15
Degraded range land	10–100
Poorly managed sloping terraces	20–100

VEGETATIVE CONDITIONS

The vegetation of Nepal exhibits a remarkable diversity, as a result of variation in the elevation and climate. Approximately 7000 species of flowering plant have been reported (Jha, 1992 b). The grazing is common in most of the grassland surfaces, and is one of the major causes of land degradation. Overgrazing impacts on re–growth and colonization of grass species, and ultimately may becoming causes of soil erosion.

Vegetation types are influenced by the altitudinal characteristics as shown in Fig. 5. In the lower elevation region, tropical and sub tropical zone such as *Shorea robusta*, *Terminalia tomentosa*, *Dalbergia sissoo*, *Acacia catechu* and *Albizia* species are common while in Mid Hill region, temprate zone *Schima wallichii* and *Castonopsis indica* are dominant species. But in high Himalaya region, sub alpine and alpine zone, *Quecus lamellose* forest, mixed forest of *Rododendron* species, *Betula utilis* and *Abies spectabilis* are common.

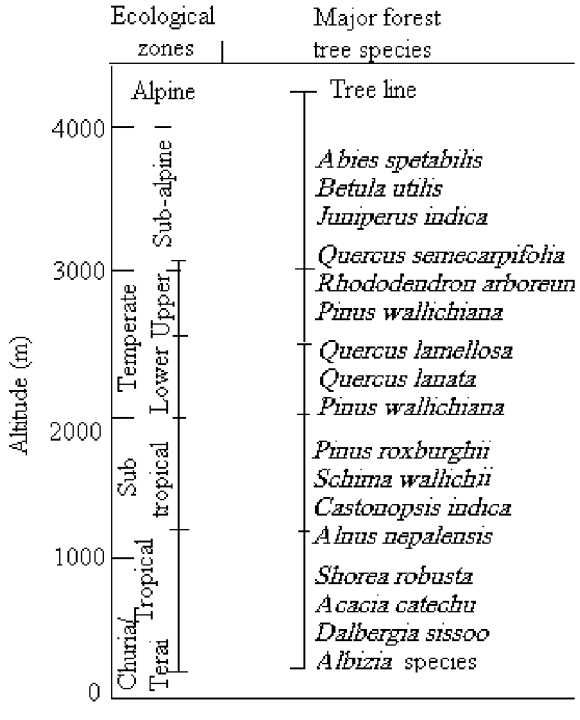
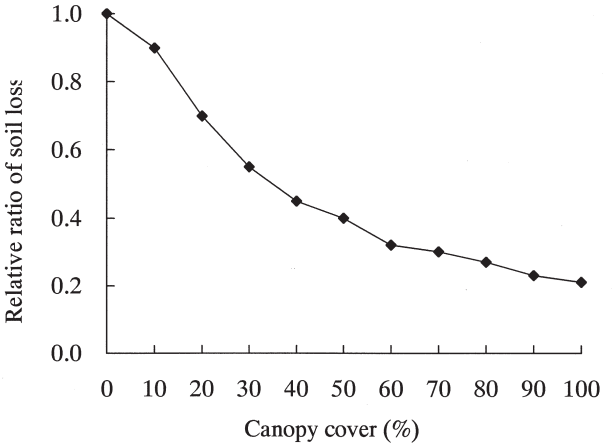


Fig. 5. Types of vegetation changes with altitude.

APPLICATION OF RE–VEGETATION TECHNOLOGY

A general trend of soil loss rates decreasing with vegetation cover fraction is widely accepted and is used in soil erosion prediction model. Vegetation's leaf canopy intercepts rain, root system act as anchors and reinforces to soil and provides the stability to the land surface. The erosion rate decreases as the canopy cover of the ground surface increases as shown in Fig. 6.



(After : Coppin and Richards, 1990)

Fig. 6. Relationships between canopy cover and relative ratio of soil.

The erosion rate in vegetated areas was less than that in bare and degraded areas (Table 1) due to the combination of surface roughness, infiltration and anchorage mechanisms and interception. The rate of erosion is increasing in Nepal due to the inherent topographic features and human activities. Because of the steep terrain nature and lack of resources, constructions of big structure as countermeasures are impossible. Alternatively uses of vegetative measures or application of re–vegetation technology is more essential to recover eroded areas. The restoration of plant communities by natural or artificial means help to stabilize soil layer and maintain the landscape. For sustainable restoration of vegetation, native plants which are adapted to local rainfall and temperature should be given priority. The use of local species reduces the cost and mortality rate. Owing to these advantages, so far possible uses of locally available techniques and species are recommended for vegetation technology as shown Fig. 7.

Due to the climatic and topographic variations the

a b

Fig. 7. Application of vegetative measures in landslide and gully erosion. (Photos source: H. Omura, 1998)

types of species used for re–vegetation in degraded or eroded sites depend on altitudinal range. Some of the species which are suitable to corresponding altitudes are summarized in Table 2.

The native plants once established do not need irrigation. It is unlikely that one species alone will fulfill all the site requirements to control the erosion. But mixted of different species with complementary characteristics allow vegetation to fill voids and respond to environmental conditions varying with sites and seasons. Grasses were selected as the main component of ground cover to prevent the surface erosion. In the area, where the cattle grazing restricted, vegetation was restored fully as shown in Fig. 8.

Fig. 8. Stabilization of gully and landslide sites by re–vegetation.

DISCUSSION

The vegetation, erosion and climatic conditions are mutually related components of the mountain environment. Vegetation is influenced by climatic conditions, so change of vegetation patterns indicates changes on climatic conditions and vice versa. Changes in surface properties influence the local vertical profiles of temperature and moisture as micro climate in the atmosphere, and the consequences for precipitation. The climatic factors have great influences on the re–vegetation activities. For example time of seeds sowing, seeds germination, selection of suitable species, germination rate and survival rates are closely linked with climatic conditions. For this reason, before carrying out re–vegetation works specific climate conditions in should be taken into account. According to the climatological records, mean monthly temperature is lowest during January and fall zero above 3000 m altitude. In

Table 2. Common species used for re–vegetation purpose in different altitudinal ranges

Species	Character	Altitude(m)	Propagation technique
Cynodon dactylon	Small creeping	70–1800	Stem cuttings
Eulalipsis binata	Medium sized clump	70–1500	Slip cuttings/seeds
Thysanolaena maxima	Large clumping	70–2000	Slip cuttings
Eragrostis tenella	Large spreading	500–1800	Slip cuttings
Saccharum spontaneum	Large clump, spreading	70–2000	Slip cuttings
Lantana camara	Shrub	70–1750	Hardwood cuttings
Colquhounia coccinea	Shrub	1000–2000	Hardwood cuttings
Jatropha curcas	Deciduous shrub	500–1300	cuttings
Agave americana	Large cactus	70–2400	Root suckers
Acacia pennata	Small thorny tree	500–1500	Seeds sowing
Vitex negundo	Small tree	70–1750	Hardwood cuttings
Garuga pinnata	Deciduous tree	70–1300	Hardwood cuttings
Melia azedarch	Deciduous tree	70–1800	Seeds
Salix tetraspema	Tree	70–2700	Hardwood cuttings
Alnus nepalensis	Tree	900–2700	Seed sowing

this cold season the seed sowing activities and seedling plantation are unfavorable. Similarly most of the parts receive higher rainfall during June–July, which is considered to be good time for seedling plantation. During 4 months from December to March, rainfall and temperature are low. In such cold and dry season it is not suitable to start vegetative works. Appropriate time should be kept in mind to start the re–vegetation works so as to increase the survival rate of the planted species.

The area affected by erosional activities is increasing annually (Table 1) in one side while in another side there is limit of available resources to cope the problems. These conditions clearly indicate the immediate necessity of low cost re–vegetation technology to mitigate the facing problems.

CONCLUSION

The vegetation, erosion and climatic conditions are mutually related components of the mountain environment, and vegetation is an important component of the climatic system. Rainfall amounts to the vegetation coverage are directly related to the erosion rate. The Mid Hill region of Nepal is facing mainly by landslides, gully and surface erosion. The erosion rates are in increasing trends but the resources to cope with the problems are limited. This paper clearly explores the necessity of low cost re–vegetation technology for erosion control. The knowledge on spatial variations in rainfall, vegetation types can be taken as important clues to implement the operational plan of re–vegetation activities.

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