PRODUCTION OF JUTE NETTING

Spinning raw jute into yarn for the production of jute netting

This annex describes the procedure for the purchase of raw jute, its spinning into yarn and weaving into the two types of netting used in roadside bio-engineering.

Jute supply

Raw jute should be purchased from merchants in the eastern Terai as soon as the harvest is under way and the price has dropped to its market low for the year. The harvest takes place in August and September, but early products are not usually high quality. Purchasing should be done in September as, by October, the price begins to rise.

Jute is produced regionally in the eastern Nepal and Indian Terai, and in Bangladesh. Since the late 1980s, there has been an increasing shortfall in supply. This appears to be due to increasing pressure for rice cultivation, and the rise in the number of sugar mills and cigarette factories offering better value for cash crops. Most of the jute produced in Nepal is exported. Although the market value of raw jute in villages in the Nepal Terai is often fairly low, the value in India may be twice this or more. Therefore the dealers use this to force up the price in sales of large quantities. There is not usually any discount for bulk purchases.

The material is available in a number of grades: middle grades are acceptable for weaving into netting, though it is preferred to buy tosa, a more expensive higher grade.

Jute purchased in September may not be fully dry, so it should be stored in an airy place and turned every few weeks until it is safely dry. It is extremely inflammable, and smoking must be banned from the area around its storage, as for fuel store.

Raw jute more than 12 months old should never be used to make netting. Old netting stocks unused through the monsoon after manufacture should be tested carefully to ensure that the strength is adequate. The general rule is that it should not be possible to break a single strand of standard yarn when pulled between the hands as hard as possible (a breaking strain of approximately 100 kg); if it can be broken, the netting should be composted or used as mulch.

In parts of Nepal far from sources of jute, it may be more cost effective to use other materials. One in the hills, which shows potential, is

allo or sisnu (*Girardinia palmata*). There are others, but few have the fine, high-quality fibres that make jute such a good geotextile.

The manufacturing process

The process involves spinning raw jute into yarn and weaving the yarn into lengths of netting, which are similar to a simple, loose-weave cloth.

The equipment required is a rain/sun shelter, a loom, weaving frame and shuttles. Some smaller tools, such as khukuris or chulesis, and sticks, are also required.

Raw jute fibres are teased out and then spun into yarn. Spinning is a simple hand process, twisting the fibres together into an even yarn, which is then wound on to sticks to form rolls. For standard netting, the yarn should be spun so that it is no less than 5 mm and no more than 8 mm in diameter when tightly wound. Loose yarn would be larger but it must be tight enough to have maximum strength. For wide mesh netting, the yarn should be between 3 and 5 mm in diameter.

The weaving loom consists of two parallel horizontal beams about 1.5 metres long and placed 12 metres apart. When the yarn has been prepared, it is placed on the loom to form the warp (the length-ways threads). For standard netting there should be 32 strands of warp, wound from end to end of the loom and passing through the weaving frame. For wide mesh netting there are 10 strands of warp.

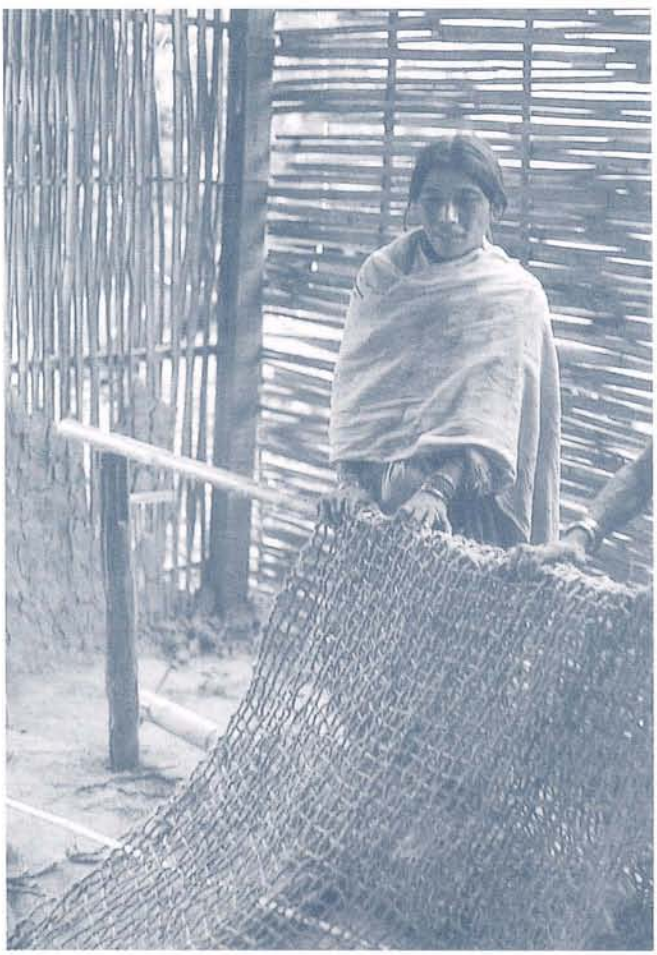
The weaving frame is a rectangular wooden frame 1250 mm long by 500 mm wide. Across it are placed 16 wires at regular intervals, each wire with a loop in the middle. Alternate strands of warp pass either through a loop or between two wires.

Once the warp is on the loom, it is tightened so that each strand is an equal distance (30 to 40 mm for standard and 150 mm for wide mesh netting) apart. Then the weaving of the weft (cross threads) can begin. Yarn wound on to a shuttle (a simple H-shaped board) is passed repeatedly backwards and forwards through the warp. With each pass, the frame is alternately raised and lowered so that the weft crosses the warp on alternate sides. Behind the shuttle, the weft threads are pushed up the warp by hand until they are evenly spaced 30 to 40 mm apart (500 mm apart for wide mesh netting. There should be 20 to 24 strands of weft per metre for standard netting, and 2 strands for wide mesh netting.

Once the end of the warp is reached, the net is complete. It is cut off the loom and the cut ends tied to prevent fraying. Each piece of woven netting should be not less than 1.10 metres and not more than 1.20 metres in width. It should be at least 10 metres in length but no more than 11.50 metres.

Experience has shown that a profit-shared contract employing five women weavers can be expected to produce 2 lengths of standard mesh jute netting per day, or between 24 and 28 lengths per fortnight. Experiments with other arrangements of weavers have not been so productive.

A length of completed jute netting is removed from the loom



Detailed specifications

The detailed specifications for standard jute netting are as follows. Standard jute netting is used for placing on bare slopes and is normally planted with grasses. [Note: warp ends are the length-ways threads and weft strands are the cross-ways threads]

(i)	Material:	High quality, 100 percent natural jute fibre from the latest harvest, properly treated and dried.
(ii)	Yarn:	Handspun 5 to 8 mm.
(iii)	Strip size:	minimum 1.0 × 10.0 metres; maximum 1.5 × 11.5 metres.
(iv)	Warp ends:	27 ends per 1000 mm.
(v)	Weft strands:	20 to 24 strands per 1000 mm.
(vi)	Mesh size:	40 mm square mesh holes.
(vii)	Weight:	0.8 to 1.2 kg per square metre.

The detailed specifications for wide mesh jute netting are as follows. Wide mesh jute netting is used for holding mulch on to slopes that have been sown with grass seed.

(i)	Material:	High quality, 100 percent natural jute fibre from the latest harvest, properly treated and dried.
(ii)	Yarn:	Handspun 3 to 5 mm.
(iii)	Strip size:	minimum 1.0 × 10.0 metres; maximum 1.5 × 11.5 metres.
(iv)	Warp ends:	7 ends per 1000 mm.
(v)	Weft strands:	2 strands per 1000 mm.
(vi)	Mesh size:	150 × 500 mm rectangular mesh.
(vii)	Weight:	0.2 kg per square metre.

Bitumenised jute netting

If jute netting is required to retain its strength for more than one year, it should be preserved by soaking in a solution of bitumen diluted with kerosene: this will preserve it sufficiently to retain its strength for about 3 years, or perhaps longer on hot, dry sites.

A large vat is filled with a mixture of 60:40 bitumen:kerosene. Rolls of new jute net are lowered into it from a bamboo tripod to soak for 30 minutes, then raised and allowed to drain. Once most of the surplus has run off, the netting is rolled in sand to reduce its stickiness. It can then be used in the normal way.

A bitumen:kerosene mixture gives better preservation than bitumen emulsion.

Other sources of jute netting

A number of slopes have been stabilised using products imported from jute mills in West Bengal. None of these have met the specifications described above, and therefore have not conformed to the standards of the Department of Roads. There appears to be no reason why any source cannot be used to provide jute netting, however, as long as quality control is strict.

The specifications given here, which are those adopted by the Department of Roads, are necessary to serve the functions required of jute netting. In the case of standard netting, the thickness and loose weave of yarn is essential to provide adequate surface armouring at the micro scale. Finer, more tightly spun yarns do not serve the function of the netting specified here.

LOW-COST TECHNIQUES THAT DO NOT WORK

Inert wattle fences are often too weak to support the weight of wet soil; erosion can just take place underneath

In the process of the experimentation that led to the production of this manual, a number of low-cost techniques were tried in the search for better solutions to the problems of slope instability and erosion that were encountered. Some of these were found not to work, or to work only in very limited situations. They have not been included in the *Site Handbook* for this reason. They are described here to provide a record, and to warn others against wasting resources using these methods.

Covering slopes with fine-mesh wire netting

Experiments with fine, small-mesh wire netting (as a possible alternative to jute netting) proved ineffective. It is virtually impossible to make it hug the surface as jute net or other, more flexible, geotextiles will. Even if it is touching the surface, it does not affect the rate of erosion and the slope will degrade just as fast. It adds nothing to the slope and therefore is not worth the expense.

Waterproof slope covers

This technique was mostly used on the brow of a slope to reduce continued failure. The slope is covered in a waterproof material (such as polythene or tar felt) to stop water infiltration and erosion. Although some materials will last for five years or more on some sites, this is only a temporary measure because the covering prevents the development of a long-term vegetation cover of the slope.

It is, however, very useful in emergencies for failures immediately below the road, where the road itself is in danger of collapse; and in certain situations on busy roads where failures on the slopes above threaten to block the carriageway. In these situations, waterproof coverings can be applied quickly during the monsoon. They must be removed soon after the rains stop and a per-

manent solution installed.

Other materials were also tried for slope covers, including bitumenised hessian and steel sheets. These tended to be subject to fires and theft respectively.

A further problem is that all waterproof slope covers tend to concentrate runoff into the slope section immediately below them, so that underscour takes place.

Hessian and jute bolsters

Bolsters, which are tubes of hessian or jute netting filled with stone, were placed along the contour. They were intended to act as scour checks and to reduce the surface movement of debris while a vegetation cover is established.

They are similar to gabion bolster cylinders but not nearly as strong. Although they were used on a number of sites, bolsters made using a skin of either hessian sheeting or jute netting either failed or at the very least simply disappeared when the skin material rotted away. They may have some application as a temporary measure and if made carefully might be expected to last for up to 18 months on gentle sites. Whichever skin material is used, it should first be strengthened by dipping it in bitumen emulsion. The construction technique was the same as for contour gabion bolster cylinders.

Dead wattle fences

Low fences are built along the contour to trap debris moving down the slope and to armour against surface scour. They can be made using wire or bamboo (or other plant material), but only those using steel have been found to be effective on most sites. Those using plant materials, which are the most common type of wattle fences, are usually only temporary measures. If they are to be used at all, wattle fences should be used only on slopes less than 35° with a restricted debris supply and composed of coarse, well-drained material. Fences made from bamboo or other plant materials should be restricted to very small and gentle sites, or where only a temporary measure is required.

The main problems with wattle fences are that they accumulate debris behind them over a period of one or two monsoons, during which time the structure decomposes; eventually the weight of debris is too much for the fence and it collapses. In fine-textured materials, the fences can give rise to an accumulation of weak, unconsolidated debris and an increase in the rate of infiltration. Under heavy rain this can lead to liquefied flow, which either pushes the fence over or simply flows underneath it. In weak sandy soils, gullies continue to develop underneath wattle fences because they do not interrupt the surface properly (unlike gabion bolster cylinders).

This technique has rarely been successful under Nepalese conditions. It is no match in terms of strength for many of the techniques described in the Site *H*andbook. Wattle fences do not have the flexibility of planted grass lines or the strength of gabion bolster cylinders. They should not be used except as a temporary measure in emergencies.

Sprayed bitumen

Bitumen was sprayed on to the slope surface to waterproof it and protect it from scour. The use of this technique assumed that there is no vegetation cover and that the surface being sprayed was clean and firm, and that it was best to remain in the same state. It was thought to hold potential on steep (> 50°) cut slopes less than 8 metres in height, particularly where climatic and rooting conditions were extremely poor for grass establishment.

This technique was not found successful and cannot be recommended. Trials showed that although it works well over very limited areas, it is not good except on perfectly homogeneous materials already resistant to weathering. Only a slight flaw is necessary to allow water to penetrate the bitumen skin and soften the material below. Even without this, weakening of the material seems to continue behind the bitumen, causing it to flake off with the material it is stuck to. Water can seep in from higher up the slope and then be trapped behind the surface, even when drainage measures are taken to reduce the effect of this. Hence it seems to be a temporary measure with limited applications. It may be useful to help stick seeds to the surface of fractured rocky materials.

Algal surface protection

A protective skin made up of algae and associated plants covers the surface of the soil or rock

and acts in the same way as sprayed bitumen. Scour by runoff on the surface is prevented. This may hold potential on steep (> 50°) cut slopes less than about 5 metres in height.

This has not actually been applied as a stabilisation technique in practice. It is mentioned here because of the prevalence of algal growths over many road cut-slope surfaces. These occur in many parts of Nepal, from the Terai to at least 2,500 metres altitude. They seem to occur most widely on highly micaceous rocks, but there is not necessarily a link. In many cases the disadvantages are the same as for sprayed bitumen, and weakening still continues under the algal crust.

Mycologists have variously identified the organisms present in samples but they seem to be green algae, or members of the phylum Chlorophyta. The matter has not been pursued on account of the technical difficulties of cultivating pure cultures of algae (which are considerable on a large scale).

ANNEX E: RATE ANALYSIS NORMS FOR BIO-ENGINEERING

In January 1996, the Geo-Environmental Unit of the Department of Roads first published the rate analysis norms, which are reprinted here (with minor corrections). These norms were approved by His Majesty's Government, Ministry of Works and Transport (at Minister level) on 25 December 1995. At the time of the publication of this manual, they were the most up to date norms on bio-engineering.

Before using these norms, the reader should check for updates. These will normally be available either as part of the complete norms of the Ministry of Works and Transport, or as part of a revision published by the Department of Roads or the Geo-Environmental Unit.

A Nepali version of these norms has been published by the Geo-Environmental Unit and is available from the Department of Roads on request.

RATE ANALYSIS NORMS

S No	WORK DESCRIPTION	UNIT	LEVEL	LABOUR UNIT	QUANTITY
27	**(1) Collection and preparation of seeds**				
	[a] Collection of grass seeds from sources within 1 km of the road, including separating and preparing seed for storage, and drying seed in the sun.	kg	Unskilled	nos	1.50
	[b] Collection of large shrub seeds (*e.g.* bhujetro) from sources within 1 km of the road including seed preparation for storage after drying.	kg	Unskilled	nos	0.45
	[c] Collection of medium-sized shrub seeds (*e.g.* keraukose) from sources within 1 km of the road, including seed preparation for storage after drying.	kg	Unskilled	nos	0.75
	[d] Collection of medium-sized shrub and tree seeds (*e.g.* areri, khayer, ghobre and rani salla, sisau) from sources within 1 km of the road, including seed preparation for storage after drying.	kg	Unskilled	nos	0.95
	[e] Collection of small shrub and tree seeds (*e.g.* dhanyero, dhusun, tilka, utis) from sources within 1 km of the road, including seed preparation for storage after drying.	kg	Unskilled	nos	2.50
	(2) Collection of grass and hardwood cuttings for vegetative propagation				
	[a] Collection of grass clumps (*e.g.* amliso, kans, khar) from sources within 1 km of the road, to make slips for multiplication in the nursery.	1000 slips	Unskilled	nos	1.50
	[b] Collection of cuttings of small bamboos (*e.g.* padang bans, tite nigalo bans), suitable for traditional planting, from sources within 1 km of the road. Material minimum 10 cm of rooted rhizome and 90 cm of culm	1000 nos	Unskilled	nos	3.00
	[c] Collection of hardwood cuttings (e.g. assuro, bains, kanda phul, namdi phul, saruwa, simali) from sources within 1 km of the road. Material minimum 30 cm in length and 2 cm in diameter.	1000 nos	Unskilled	nos	0.85

RESOURCES					
CONSTRUCTION MATERIALS			EQUIPMENT		
TYPE	UNIT	QUANTITY	TYPE	UNIT	QUANTITY
Sealed bag	nos	1.00	Khukuri	-	3% of labour cost
-	-	-	Khukuri	-	3% of labour cost
Sealed bag	nos	1.00	Nanglo	-	3% of labour cost
Sealed bag	nos	1.00	Nanglo	-	3% of labour cost
Sealed bag	nos	1.00	Nanglo	-	3% of labour cost
Adequate supply of appropriate clumps	-	-	Kodalo	-	3% of labour cost
Hessian jute	m^2	5.00			
Adequate supply of appropriate bamboos	-	-	Kodalo Khukuri	- -	3% of labour cost
Hessian jute	m^2	10.00			
Adequate supply of appropriate bushes	-	-	Khukuri	-	3% of labour cost
Hessian jute	m^2	5.00			

RATE ANALYSIS NORMS (continued)

S No	WORK DESCRIPTION	UNIT	LEVEL	LABOUR UNIT	QUANTITY
27-	**(3) Nursery operation and management (bed preparation)**				
	[a] Construction of seed beds for tree seedlings, including materials for beds and shades. Bed is 1 m wide × 17 cm high and made up of: 5 cm of washed gravel, 5 cm of unsieved forest soil, 5 cm of 1:3 mix of sieved forest soil and washed sand, 2 cm of washed, sieved and sterilised sand. [Add 5 % to the number of bricks to allow for normal wastage.]	5 m²	Skilled Unskilled	nos nos	1.50 2.00
	[b] Construction of stand out beds for tree seedlings in polypots, including materials for beds and shades. Bed is 100 cm wide × 15 cm high, with a 5 cm layer of gravel placed above the compacted ground. [Add 5 % to the number of bricks to allow for normal wastage.]	5 m²	Unskilled	nos	6.00
	[c] Construction of beds for grass seeds, grass slips (*i.e.* vegetative propagation) and tree stool cuttings, including materials and hessian cover. Bed is 100 cm wide × 25 cm high and made up of: 5 cm of washed gravel placed above the ground, 5 cm of 1:1 mix of sieved soil and compost, and topped with 15 cm of 3:1 mix of sieved forest topsoil and washed sand.	5 m²	Skilled Unskilled	nos nos	1.00 1.50
	[d] Construction of beds for propagation of bamboo culm cuttings, including materials and hessian cover. Bed is 100 cm wide × 30 cm high. The ground below the bed is dug to a depth of 30 cm. Bed is made with 10 cm unsieved soil and 20 cm sieved soil. A bund 10 cm high is formed around the edge.	5 m²	Unskilled	nos	2.00
27-	**(4) Nursery operation and management (seed sowing and transplanting; planting hardwood cuttings)**				
	[a] Tree seed sowing @ 10 grammes per m² (medium-sized seeds) or 2 grammes per m² (very fine seeds) into seed beds including pre-sowing seed treatment.	5 m²	Unskilled	nos	0.04
	[b] Preparing potting mix and filling polypots, including all materials for container seedlings. [Note. 1 kg of 200 gauge polypots (4' × 7' laid flat) = 464 bags; 200 gauge black polythene is preferred.]	1000nos	Unskilled	nos	10.00
	[c] Direct sowing of tree seeds into polypots including seed treatment, by sowing one seed in half the pots and two seeds in the other half.	1000 nos	Unskilled	nos	0.62
	[d] Pricking out young seedlings and transplanting into polypots.	100 nos	Unskilled	nos	0.18
	[e] Pricking out tree seedlings and transplanting into beds.	1000 nos	Unskilled	nos	0.12
	[f] Transplanting grass slips into beds, from clumps. Slips are planted at 10 cm centres in rows 25 cm apart.	m²	Unskilled	nos	0.12
	[g] Planting of hardwood cuttings of minimum 30 cm length to 20 cm depth into prepared beds. Cuttings spaced at 5 cm centres within rows, with 20 cm between rows.	1000 nos	Unskilled	nos	0.60

RESOURCES					
CONSTRUCTION MATERIALS			EQUIPMENT		
TYPE	UNIT	QUANTITY	TYPE	UNIT	QUANTITY
Bamboo poles	nos	9.00	Khanti	-	3% of labour cost
Polythene sheet	m^2	9.00	Shovel	-	
Bricks	nos	96.00	Pick axe	-	
Gravel	m^3	0.25	Screen mesh	-	
Unsieved soil	m^3	0.10			
Line string	m	13.00			
Binding wire	kg	3.00			
Bamboo	nos	15.00	Khanti	-	3% of labour cost
Bricks	nos	96.00	Shovel	-	
Line string	m	13.00	Pick axe	-	
Binding wire	kg	3.00			
Gravel	m^3	0.25			
Gravel	m^3	0.38	Shovel	-	3% of labour cost
Forest soil	m^3	1.46	Pick axe	-	
Compost	m^3	0.38			
Washed sand	m^3	0.46			
Hessian cover	m^2	10.00			
Gravel	m^3	0.38	Shovel	-	3% of labour cost
Forest soil	m^3	1.46	Pick axe	-	
Compost	m^3	0.38	Khukuri	-	
Bamboo poles	nos	6.00	Log saw	-	
Hessian jute	m^2	25.00			
Seed	g	50.00	Bowl	-	3% of labour cost
			Trowel	-	
Polypot	nos	1050.00	Sieve	-	3% of labour cost
Sand	m^3	0.46	Shovel	-	
Soil	m^3	0.70			
Compost	m^3	0.23			
Seed	nos	1500.00	Wooden peg	nos	1.00
-	-	-	Wooden peg	nos	1.00
			Tray	-	3% of labour cost
-	-	-	Wooden peg	nos	1.00
Hessian jute	m^2	0.30	Khukuri	-	3% of labour cost
			Shovel	-	
Hardwood cuttings	nos	1000.00	Khanti	-	3% of labour cost

RATE ANALYSIS NORMS (continued)

S No	WORK DESCRIPTION	UNIT	LEVEL	LABOUR UNIT	QUANTITY
27-	**(5) Preparation of raised materials for extraction from the nursery**				
	[a] Grass culm cutting production from nursery stock; single or double node (*e.g.* napier).	1000 nos	Unskilled	nos	0.70
	[b] Uprooting and preparing grass slips ready for site planting from nursery seedlings.	1000 nos	Unskilled	nos	0.63
	[c] Uprooting and preparing grass slips ready for site planting from nursery grass clumps raised from slips by vegetative propagation.	1000 nos	Unskilled	nos	0.33
27-	**(6) Compost and mulch production**				
	[a] Mulch production by collection and cutting of weeds and other vegetation such as tite pati, banmara *etc*, within 1 km of the road, and stacking along roadside.	m^3	Unskilled	nos	1.20
	[b] Compost production by collection and cutting of weeds and other vegetation such as tite pati, banmara *etc*, within 1 km of the road, including fine cutting and filling compost pit.	m^3	Unskilled	nos	1.20
	[c] Turning compost once per month.	m^3	Unskilled	nos	0.10
27-	**(7) Direct seeding on site**				
	[a] Broadcasting grass seeds on slopes <40°, seeding rate 25 g per m^2.	100 m^2	Unskilled	nos	0.17
	[b] Broadcasting grass seeds on slopes <40°, including cover with long mulch, seeding rate 25 g per m^2.	100 m^2	Unskilled	nos	5.00
	[c] Broadcasting grass seeds on slopes < 40-45°, including cover with long mulch and jute netting of mesh size 300 mm × 500 mm. Seeding @ 25 g per m^2. Operation includes pegging with suitable live pegs or hardwood cuttings (*e.g.* simali) @ 1 m spacing, jute net of 6.75m × 1m size.	100 m^2	Unskilled	nos	6.25
	[d] Sowing shrub or tree seeds on all slopes, at 25 cm intervals, including digging planting holes to 5 cm depth and covering with soil. Two seeds per planting hole.	100 m^2	Unskilled	nos	1.00
27-	**(8) Planting grass cuttings on site**				
	[a] Planting single node culm cuttings of grass (*e.g.* napier) on fill slopes < 45° and embankment slopes in plain areas. Approx length 15-20 cm, including digging planting hole 10-20 cm depth using a metal rod or hardwood peg,	100 nos	Unskilled	nos	0.20
	[b] Planting single node culm cuttings of grass (*e.g.* napier) on hard cut slopes < 45°. Approx length 15-20 cm, including digging planting hole 10-20 cm depth using a metal rod or hardwood peg,	100 nos	Unskilled	nos	0.35
	[c] Planting single node culm cuttings of grass (*e.g.* napier) on hard cut slopes > 45°. Approx length 15-20 cm, including digging planting hole 10-20 cm depth using a metal rod or hardwood peg,	100 nos	Unskilled	nos	0.50
	[d] Planting rooted grass slips on embankment slopes in plain areas, at 10 cm spacings within the row. The first row is 0.75 m from the edge of the pavement and subsequent rows are spaced at 1 m intervals down the embankment.	m	Unskilled	nos	0.02

RESOURCES					
CONSTRUCTION MATERIALS			EQUIPMENT		
TYPE	UNIT	QUANTITY	TYPE	UNIT	QUANTITY
Hessian jute	m^2	2.70	Khukuri	-	3% of labour cost
Hessian jute	m^2	1.35	Fork Pick axe Khukuri	- - -	3% of labour cost
Hessian jute	m^2	4.20	Shovel Khanti	- -	3% of labour cost
-	-	-	Hasiya Doko	- -	3% of labour cost
-	-	-	Doko	-	3% of labour cost
-	-	-	Shovel	-	3% of labour cost
Seed	kg	2.50	-	-	-
Seed Mulch	kg m^3	2.50 5.00	-	-	-
Seed Mulch Jute net Live pegs	kg m^3 m^2 nos	2.50 5.00 105.00 128.00	Khukuri Mallet (wooden hammer)	- -	3% of labour cost
Seeds	nos	3200.00	MS rod of 50 cm length	-	3% of labour cost
Grass cuttings Hessian jute	nos m^2	100.00 0.27	MS rod or hardwood peg of 50 cm length	-	3% of labour cost
Grass cuttings Hessian jute	nos m^2	100.00 0.27	MS rod or hardwood peg of 50 cm length	-	3% of labour cost
Grass cuttings Hessian jute	nos m^2	100.00 0.27	MS rod or hardwood peg of 50 cm length	-	3% of labour cost
Grass slips Hessian jute Line string	nos of drills m^2 m	11.00 0.14 1.00	MS rod or hardwood peg of 50 cm length	-	3% of labour cost

RATE ANALYSIS NORMS (continued)

S No	WORK DESCRIPTION	UNIT	LEVEL	LABOUR UNIT	QUANTITY
	[e] Planting rooted grass slips on slopes <45° including preparation of slips on site. Operation includes digging planting hole to a max of 5 cm depth with metal rod or hardwood peg, depending on nature of soil. The planting drills should be spaced 10 cm apart.	m^2	Unskilled	nos	0.20
	[f] Planting rooted grass slips on slopes 45-60° including preparation of slips on site. Operation includes digging planting hole to a max of 5 cm depth with metal rod or hardwood peg, depending on nature of soil. The planting drills should be spaced 10 cm apart.	m^2	Unskilled	nos	0.30
	[g] Planting rooted grass slips on slopes >60° including preparation of slips on site. Operation includes digging planting hole to a max of 5 cm depth with metal rod or hardwood peg, depending on nature of soil. The planting drills should be spaced 10 cm apart.	m^2	Unskilled	nos	0.40
27-	**(9) Planting shrub and tree seedlings and cuttings on site**				
	[a] Planting containerised tree and shrub seedlings, including pitting, transplanting, composting and placing tree guards, on toe of embankment slopes in plain areas, not less than 8 m from the road centre line. Pit size 30 cm diameter × 30 cm depth. Compost volume ¼ of the volume of the pit, mixed with original soil.	10 nos	Unskilled	nos	0.25
	[b] Planting containerised tree and shrub seedlings, including pitting, transplanting, composting and mulching, on slopes < 30°. Pit size 30 cm diameter × 30 cm depth. Mix compost with soil and backfill into pit, to ¼ of pit volume.	10 nos	Unskilled	nos	0.33
	[c] Planting containerised tree and shrub seedlings, including pitting, transplanting, composting and mulching, on slopes 30-45°. Pit size 30 cm diameter × 30 cm depth. Mix compost with soil and backfill into pit, to ¼ of pit volume.	10 nos	Unskilled	nos	0.40
	[d] Planting rooted tree stump cuttings and bare root seedlings, including pitting, transplanting, composting and mulching on slopes <30°. Pit size 10 cm diameter × 20 cm depth. Compost volume ¼ of volume of the pit mixed with original soil.	10 nos	Unskilled	nos	0.17
	[e] Planting rooted tree stump cuttings and bare root seedlings, including pitting, transplanting, composting and mulching on slopes 30-45°. Pit size 10 cm diameter × 20 cm depth. Compost volume ¼ of volume of the pit mixed with original soil.	10 nos	Unskilled	nos	0.25
	[f] Planting tree stump and bare root seedlings, including pitting, transplanting, composting and mulching on slopes >45°. Pit size 10 cm diameter × 20 cm depth. Compost volume ¼ of volume of the pit mixed with original soil.	10 nos	Unskilled	nos	0.33
27-	**(10) Vegetative palisade construction, brush layering and fascines**				
	[a] Collection of hardwood cuttings for planting material (*e.g.* assuro, namdi phul, simali) from sources within 1 km of road. Material to be approx 1 m in length and minimum 5 cm in diameter.	1000 nos	Unskilled	nos	0.85

RESOURCES					
CONSTRUCTION MATERIALS			EQUIPMENT		
TYPE	UNIT	QUANTITY	TYPE	UNIT	QUANTITY
Grass slips Hessian jute	nos of drills m^2	100.00 0.27	MS rod or hardwood peg of 50 cm length Khukuri	- -	3% of labour cost
Grass slips Hessian jute	nos of drills m^2	100.00 0.27	MS rod or hardwood peg of 50 cm length Khukuri	- -	3% of labour cost
Grass slips Hessian jute	nos of drills m^2	100.00 0.27	MS rod or hardwood peg of 50 cm length Khukuri	- -	3% of labour cost
Container seedling Compost Tree guard Green mulch	nos m^3 nos m^3	10.00 0.05 10.00 0.04	Khanti Mallet (wooden hammer) Doko	- -	3% of labour cost
Seedlings Compost Green mulch	nos m^3 m^3	10.00 0.05 0.04	Khanti Doko	- -	3% of labour cost
Seedling Compost Green mulch	nos m^3 m^3	10.00 0.05 0.04	Khanti Doko	- -	3% of labour cost
Seedling Compost Green mulch	nos m^3 m^3	10.00 0.03 0.04	Khanti	-	3% of labour cost
Seedling Compost Green mulch	nos m^3 m^3	10.00 0.03 0.04	Khanti	-	3% of labour cost
Seedling Compost Green mulch	nos m^3 m^3	10.00 0.03 0.04	Khanti	-	3% of labour cost
Adequate supply of bushes	-	-	Khukuri	-	3% of labour cost

RATE ANALYSIS NORMS (continued)

S No	WORK DESCRIPTION	UNIT	LEVEL	LABOUR UNIT	QUANTITY
	[b] Preparation and planting of live pegs of selected species (*e.g.* assuro, namdi phul, simali) of minimum 1 m length to 0.5 m depth into hard ground. Pegs spaced at 5 cm centres within rows, with 5 - 20 cm between rows, and interwoven with vegetation.	m	Unskilled	nos	0.17
	[c] Preparation and planting of live cuttings of selected species (*e.g.* assuro, namdi phul, simali) of minimum 1 m length to 0.5 m into soft debris. Pegs spaced at 5 cm centres within rows, with 5 - 20 cm between rows, and interwoven with vegetation.	m	Unskilled	nos	0.12
	[d] Site preparation for fascine laying: earth works in excavation of trench to 20 cm depth.	m	Unskilled	nos	0.06
	[e] Laying of live fascines, using live hardwood cuttings of selected species (*e.g.* assuro, namdi phul, simali) of minimum 1 m length, placed in bundles to give 4 running metres of cuttings per metre of fascine, including backfilling of trench and careful compaction.	m	Unskilled	nos	0.17
27-	**(11) Jute netting works**				
	[a] Standard jute netting for bare slopes and under planting with slips. Spinning raw jute from 100% jute fibre into yarn and weaving the yarn into netting. Hand spun yarn 5 to 8 mm in diameter, width of net 1.20 metres, warp strands 27 nos per 100 cm, weft strands 20-24 nos per 100 cm, mesh size 30-40 mm square and 1.25 kg/m weight at 1.20 m widths. [Note. A tosro is the weaving shuttle, normally made from a split large bamboo culm.]	m^2	skilled	nos	0.36
	b] Wide mesh jute netting for holding mulch on slopes. Spinning raw jute from 100% jute fibre into yarn and weaving the yarn into netting. Hand spun yarn 3 to 5 mm diameter 1.20 metre side and 11.2 m long. Mesh size 150 mm × 500 mm rectangular mesh and 0.25 kg/m at 1.20 m width. [Note. A tosro is the weaving shuttle, normally made from a split large bamboo culm.]	m^2	skilled	nos	0.15
	[c] Placing 30-40 mm square mesh jute netting on bare slopes (for later underplanting with grass slips), including pegging with live hardwood cuttings or split bamboo pegs and loosening tension so that the net hugs the slope throughout.	m^2	Unskilled	nos	0.15
	[d] Placing 150 × 500 mm mesh jute netting to hold mulch on slopes, including application of mulch and pegging wih live hardwood cuttings or split bamboo pegs and loosening tension so that the net hugs the slope throughout.	m^2	Unskilled	nos	0.10
27-	**(12) Fabrication of gabion bolster cylinders**				
	[a] Site preparation for 30 cm diameter bolster: earth works in excavation of trench.	m	Unskilled	nos	0.085
	[b] Site preparation for 60 cm diameter bolster: earth works in excavation of trench.	m	Unskilled	nos	0.36
	[c] Manufacture of bolster panels: 70 × 100 mm hexagonal mesh wire construction (10 swg frame and 12 swg mesh).	m^2	skilled	nos	0.10
	[d] Construction of 30 cm bolster cylinder: placing, stretching wire mesh, filling with boulders, closing and backfilling.	m	Unskilled	nos	0.375

RESOURCES					
CONSTRUCTION MATERIALS			EQUIPMENT		
TYPE	UNIT	QUANTITY	TYPE	UNIT	QUANTITY
Live pegs	nos	20.00	Crow bar	-	3% of labour cost
Live pegs	nos	20.00	Crow bar	-	3% of labour cost
-	-	-	Pick axe	-	3% of labour cost
			Shovel	-	
Hardwood cutting of at least 1 metre in lenght	m	8.00	Khukuri	-	3% of labour cost
			Shovel	-	
Raw jute	kg	1.25	Khukuri	-	3% of labour cost
			Bamboo sticks (10 nos)	-	
			Weaving frame	-	
			Tosro	-	
Raw jute	kg	0.26	Khukuri	-	3% of labour cost
			Bamboo sticks (10 nos)	-	
			Weaving frame	-	
			Tosro	-	
Woven jute net	m^2	1.00	MS rod of 50 cm length	-	3% of labour cost
Hardwood cutting or split bamboo pegs	nos	5.00	Mallet (wooden hammer)	-	
Cut mulch	m^3	0.05	MS rod of 50 cm length	-	3% of labour cost
Woven jute net	m^2	1.00	Mallet (wooden hammer)	-	
Hardwood cutting or split bamboo pegs	nos	5.00			
-	-	-	Pick axe	-	3% of labour cost
			Shovel	-	
-	-	-	Pick axe	-	3% of labour cost
			Shovel	-	
GI wire	kg	2.00	Gabion frame	-	3% of labour cost
			and tools	-	
Boulders	m^3	0.09	Gabion tools	-	3% of labour cost
			Doko	-	

RATE ANALYSIS NORMS (continued)

S No	WORK DESCRIPTION	UNIT	LEVEL	LABOUR UNIT	QUANTITY
	[e] Construction of 60 cm bolster cylinder: placing, stretching wire mesh, filling with boulders, closing and backfilling.	m	Unskilled	nos	0.75
	[f] Construction of 30 cm bolster cylinder: placing, stretching wire mesh over 20 gauge black polythene sheeting, filling with boulders, closing and backfilling.	m	Unskilled	nos	0.375
	[g] Construction of 60 cm bolster cylinder: placing, stretching wire mesh over 20 gauge black polythene sheeting, filling with boulders, closing and backfilling.	m	Unskilled	nos	0.75
	[h] Anchoring bolster: 12 mm diameter MS re-bar cut into 2 m lengths for anchorage and placed at 1 m intervals.	nos	Unskilled	nos	0.05
	[i] Laying of terram paper (geotextile).	m^2	Unskilled	nos	0.05
27-	**(13) Bamboo tree guards**				
	[a] Weaving bamboo tree guards using bamboo poles as uprights: 1.60 m in height; and weaving split bamboo with the outer wall intact around the posts. Dimensions of the guard are 0.60 m diameter × 1.30 m high.	nos	Unskilled	nos	0.25

RESOURCES					
CONSTRUCTION MATERIALS			EQUIPMENT		
TYPE	UNIT	QUANTITY	TYPE	UNIT	QUANTITY
Boulders	m^3	0.36	Gabion tools Doko	- -	3% of labour cost
Black polythene Boulders	m^2 m^3	0.40 0.09	Gabion tools Doko	- -	3% of labour cost
Black polythene Boulders	m^2 m^3	0.80 0.36	Gabion tools Doko	- -	3% of labour cost
MS rod	m	2.00	Sledge hammer	-	3% of labour cost
Terram paper	m^3	1.15	Khukuri	-	3% of labour cost
Bamboo	nos	2.20	Khukuri	-	3% of labour cost

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Alluvium Material, usually fine sand or silt with larger, rounded particles up to boulder size, deposited by a river, having been transported from elsewhere in suspension.
Annual Of plants that complete their life cycle from seed to reproduction, to death in one year.
Anticline The arch or crest of a fold in rock strata.

Bamboo A perennial grass with woody culms from rhizomes. The term is used loosely to cover a number of genera other than just Bambusa.
Basement rocks Older rocks underlying a specified stratum.
Bedding The layers of sedimentary rocks, as they were laid down. The layers are separated by 'bedding planes'.
Bio-engineering The use of living plants for engineering purposes.
Bolster A tube, usually of small-mesh gabion wire, containing stones. They are installed as scour checks or french drains, or both.
Botanical name The international system for the scientific naming of plants. These always consist of two words: first the genus name and then the species name. For example, utis is the species *nepalensis of the Alnus genus* (which contains all alders): hence *Alnus nepalensis.*
Breast wall A wall provided to protect a soil slope without considering retaining properties.
Broadcasting Where seed is thrown over the surface in as even a way as possible, but forming a totally random, loose cover.
Brush layering Live cuttings of plants laid into shallow trenches with the tops protruding. They are usually made to form a thick hedge and erosion barrier across the slope. This is different from a layering (see below).

Canopy The top layer of a forest, consisting of the crowns of trees.
Cataclasis A geological term to describe a process of dislocation-metamorphism where bands are formed through the distortion of minerals within the rock.
Check dam A physical obstruction provided in water courses to control gully erosion.
Chevron A pattern like the stripes of an army sergeant: <<<<< Grasses are sometimes planted in this pattern to lead water into rills of drains. It is a form of localised diagonal grass planting.
Clay Mineral material < 2 mm. Also applied to a class of soil texture, and used to describe the silicate clay minerals.
Climax community A plant community that has reached stability under the prevailing climate.
Cloche A temporary tunnel of clear polythene sheeting used in nurseries and horticulture farms during the winter. The tunnel produces a warm, sheltered micro-climate over young plants.
Colluvial slopes Slopes whose materials comprise mainly colluvium (see below).
Colluvium Angular debris, usually loose and unconsolidated, found on slopes below rock outcrops. Other names are scree and talus, although these are normally of pure fragmented rock while colluvium can also contain fine material.
Colonise The establishment of the first plants on bare ground
Community development The involvement of people in development activities at the local level. Often this takes the form of awareness-raising and the formation of user groups to manage common resources.
Conglomerates A sedimentary rock composed of rounded stones cemented together in a matrix of finer material.
Climax community An established group of plants living more-or-less in balance with each other and their environment; the group can be either natural or managed. There will be no appreciable change in the mixture of species, although the individual plants will grow, die and be replaced.
Compost Decomposed plant matter used as an organic fertiliser.
Continental drift The very slow, long term horizontal movement of sections 'plates' of the Earth's crust relative to each other and their position in relation to the poles.
Coppice A treatment in which the trunk of a tree is cut off about 30 cm above the ground to allow new shoots to come from the stump.
Cotyledon Part of the embryo of a seed plant. The cotyledon often becomes the first photosynthetic (green, light -gathering) organ of the young seedling.
Crust The thin upper layer of the Earth, consisting of solid silicate rocks. The continental sections are between 20 and 40 km thick. Crust rocks have a lower density (about 2.8 or 2.9) than the molten mantle rocks below.

Culm The stem of a grass.
Cutting Any part of a plant (stem, rhizome or root) that is used for vegetative propagation. See also **Grass slip** and **Slip cutting**.
Cyclonic rain Rain caused by a warm, moist air mass moving upwards over heavier, colder air.

Debris creep Gradual downward movement observed in unconsolidated debris masses on slopes (such as colluvium). It may range from a few millimetres to a few metres per year.
Deciduous Of plants which shed their leaves at least once a year and remain leafless for weeks or months.
Dendritic A pattern like the branches and stem of a tree. It is often used to describe a drainage system where branch drains feed into a main drain.
Dentition The filling of cavities, usually on steep cut slopes.
Dip The line of maximum slope lying in a rock plane. The angle of dip is measured with a clinometer and the bearing of dip is measured with a compass. The bearing can be any figure from 000° to 360°, always expressed with three digits, *e.g.* 048, to distinguish it from the inclination, which cannot exceed 90°. Conventionally the bearing of dip is written first, followed by the angle of dip, *e.g.* 115/35.
Direct seeding Where seeds are sown carefully by hand into specific locations in a slope, such as in gaps between fragmented rock.
Drill When grasses are propagated using vegetative parts, the planting drill consists of one or more grass slips or cuttings. See also **Planting drill.**

Ecology The study of organisms in relation to their environment.
Erosion The gradual wearing away of soil (or other material) and its loss, particle by particle.
Evaporation The loss of water from the soil or another surface into the air in the form of water vapour.
Evapotranspiration The total loss of water from the soil in the form of water vapour, either by direct evaporation or from plants by transpiration.
Exotic Of a plant that has been introduced from another area.

Fallow Where land is cultivated but left unplanted to restore its fertility.
Fascine Bundles of branches laid along shallow trenches and buried completely. They send up shoots and can be used to form a thick hedge and erosion barrier across the slope, or a living subsoil drain.
Fault A fracture in the Earth's crust along which movement has taken place, and where the rock strata on the two sides therefore do not match. The movement can be in any direction, but in the Himalaya the main faults are all thrust faults: this is where two rock masses have been pushed together and one has ridden over the other. In places this occurs when the rocks fracture as a result of extreme folding.
Field capacity The total amount of water remaining in a freely draining soil after the excess has flowed into the underlying unsaturated soil.
Fold A bend in rock strata caused by movements in the Earth's crust. The strata are bent into a series of arches (anticlines) and troughs (synclines).
Frankia Actinomycetes (micro-organisms) that form a symbiotic relationship with the roots of certain species, and which fix nitrogen.
Friable A term applied to soils that when either wet or dry crumble easily between the fingers.

Geomorphology The study of the physical features of the earth and of the relationship between them and the geological structures that give rise to them.
Gondwanaland The southerly of the two ancient continents which once comprised the Earth's two big land masses (the other was Laurasia). The continents broke apart and, through the process of continental drift, have re-formed into the land masses seen today. The Indian Shield continental plate was once part of Gondwanaland.
Grass A plant of the family Gramineae, characterised by long, thin leaves and multiple tubular stems. It is a very large family and contains all the cultivated cereals (rice, wheat, *etc.*).
Grass slip This term is used loosely to describe any parts of grasses used for vegetative propagation, including fibrous roots, rhizomes, and stem or stolon cuttings. See also **Slip cutting.**

Hardwood cutting A woody stem from a shrub or tree, inserted in the ground for vegetative propagation.
Herb A small plant without wood in the stems or roots.
Herringbone A pattern like the bones of a fish, with a spine and ribs: >>>>>>> It is often used in slope drainage, where there is a main drain running straight down the slope, with feeder arms coming in at 45°.
Humus The stable fraction of soil organic matter remaining after the major portion of added plant and animal residues have decomposed.

Igneous rocks Rocks that have solidified from molten or partly molten material originating from magma.
Isostasy The state of equilibrium that is thought to exist in the Earth's crust, where equal masses of matter underlie equal areas, whether of continental or oceanic crust rocks, to a level of hydrostatic compensation. An analogy is in wooden blocks floating in water: the bigger the block, the higher it rises above the surface and the deeper it goes below the surface: the thicker continental plates rise higher than the thinner oceanic plates.

Joints Cracks in rock masses, formed along a plane of weakness (the joint plane) and where there has been little or no movement, unlike a fault.

Klippen A series of nappes; a term derived from Alpine geology.

Lapse rate The cooling of air with altitude. The topographic environmental lapse rate is the reduction of the temperature of static air with height. It is generally considered to be 6.5°C per 1000 metres of altitude. However, the exact rate is determined partly by atmospheric moisture, as well as by the movement of air. It also varies seasonally.
Laterite A reddish rock material produced by long term, intensive weathering, usually in humid tropical conditions. It contains the hydrated oxides of iron and aluminium and sometimes has enough iron to be used as a source of that metal. It hardens on exposure to the atmosphere sufficiently to be used as a building material. The rato mato of Nepal are not fully developed laterites. True laterites are found, however, in some older landform areas of Karnataka and Andhra Pradesh.
Layering A plant that forms from the stem, stolon or rhizome of another plant. This can be used as a means of propagation. This is different from brush layering (see above).
Leaching The removal of soil materials and nutrients in solution or suspension.
Leat An irrigation channel (kulo in Nepali).
Legumes Used loosely to refer to a large family of plants (Leguminosae) which bear their seeds in pods which split open along a line. Beans, lentils, peas, clovers and acacias all belong to this family. Strictly, the word 'legume' refers to the pod of seeds.
Loam A soil with moderate amounts of sand, silt and clay, and which is therefore intermediate in texture and best for plant growth.
Lop Where the branches of trees are cut to provide fodder or small firewood.

Magma The molten material that exists below the solid rock of the Earth's crust, and sometimes reveals itself on its emission from a volcano. It does not always reach the surface, however, and may cool and solidify underground, among older rocks.
Mantle The layer of viscous, molten rocks underlying the crust of the Earth, and extending to about 2,900 km below the surface. Mantle rocks have a higher density (about 3.3) than the solid crust rocks above.
Material Used in the broad engineering sense to refer to any soil or accumulation of rock fragments.
Metamorphic rocks Any rocks derived from pre-existing rocks by mineralogical, chemical or structural change, especially in the solid state, in response to marked changes in temperature, pressure and the chemical environment at depth in the Earth's crust; that is, below the zone of weathering and cementation. Metamorphosis may be from contact (usually with a hot magma), where changes are usually at high temperature but low pressure; or dislocation, where changes occur under high pressure but low temperature. Changes due to both high temperature and high pressure are known as regional metamorphism. Most metamorphism in the Himalayas is dislocation metamorphism.

Minerals The naturally occurring crystalline chemical compounds found in rocks. Rocks are composed of aggregations of minerals.
Molasse A Swiss geological term to describe certain depositional materials found in fold mountain belts. Molasses are a continental (i.e. non-marine) deposit formed in marginal troughs and inter-montane basins during and after major tectonic movements. They are often cemented with calcareous and clay-rich materials. These materials are common in the Churia range.
Monsoon The name is derived from the Arabic word mausim, meaning season, which explains its application to a climate with large-scale seasonal reversals of the wind regime. In Nepal, 'monsoon' is usually used to describe the period of the south-west monsoon rains, which occur between June and September.
Mudstones A sedimentary rock composed of very fine (clay-sized) particles.
Mulch A layer of cut plant material placed on the soil surface to conserve moisture.
Mycorrhizae A living arrangement produced between special fungi and the roots of a plant, which increase the growth of the plant considerably. This is a form of symbiosis, where two organisms live together for mutual benefit. Soils from pine forests contain the necessary fungi to bring this about.
Mylonite A fine-grained metamorphic rock formed through extensive cataclasis.

Naike (Nepali) A nursery foreman.
Nappe A French geological term which describes a sheet of rocks which has slid right over another series of rocks as a result of extreme folding due to a thrust fault.
Node The point on a stem from which a leaf or branch grows.
Nurse species A tough species planted initially on a site, to improve conditions for the desired final vegetation cover.

Orography, Orographic rain Mountains, hills and ridges, or effects resulting from them. Orographic rain is caused by mountains in the path of moisture laden air: the air is forced to rise, which cools it and causes the moisture to condense and precipitate.
Orthodox Seeds which need to be dried and kept dry during storage.

Palisade The placing of cuttings or seedlings across a slope to form a barrier against soil movement.
Perennial Of plants which grow and reproduce for many years.
Phraetophyte A plant with a high rate of water usage.
Physiography The study of the physical features of the earth, their causes and their relation to one another. Generally taken to be the same as geomorphology.
Piedmont Literally, 'the foot of the mountain'. Usually used to describe the piedmont alluvial plain (in Nepal the Bhabar and Terai).
Pioneer species The first plants to colonise bare ground.
Planar sliding A mass slope failure on a slip plane parallel to the surface (i.e. not rotational). It is the most common type of landslide and is usually relatively shallow (less than 1.5 metres deep). It is also called a debris slide or a translational landslide.
Plant community Any group of plants living together, either naturally or as a result of planting.
Planting drill When grasses are propagated using vegetative parts, the planting drill consists of one or more grass slips or cuttings. (see also **Drill.**)
Pollard A treatment in which the main trunk of a tree is cut off, usually two to three metres above the ground, to allow new, smaller, shoots to grow.
Precipitation In meteorology, the deposits of water, as rain, hail or snow, which reach the Earth from the atmosphere.
Progression A regular movement by successive stages. In plant ecology, it refers to the development of repeated levels of plant communities, towards a climax. Regression is the return towards an earlier stage of development.
Prop wall A wall provided in a weaker portion of soil to give support to a stable portion above.
Prune To cut branches carefully in order to improve the shape of a plant or allow more light to penetrate.

Rato mato A red soil, normally of clay loam texture, formed from prolonged weathering (probably >100,000 years). It can be considered

semi-lateritic, as it does not have all the characteristics of true tropical laterites. Because of the length it takes to form, the presence of rato mato indicates an old and stable landform.

Recalcitrant Seeds which must not be dried but have to be kept moist during storage.

Regression See **Progression.**

Rhizobia The nitrogen-fixing bacteria that form nodules on the roots of many leguminous species, including those listed here.

Rhizome An underground stem that produces shoots and roots. Grasses naturally use rhizomes and stolons for vegetative propagation. Roots and shoots appear from the nodes on each and eventually they become individual plants.

Rill A small gully, up to about one metre deep.

Road neighbours People living close to roads, in the corridor of land where different uses of the land affect or are affected by the road.

Root collar On a seedling, the line below which the roots emerge. It normally corresponds with the surface of the soil and often shows a change of colour or a slight swelling.

Rupture plane The plane of failure in any mass movement. Sometimes there is no distinct plane of sliding, but instead a zone of failure due to a weakness in the material.

Sand Mineral or rock fragments in the diameter range of 2 to 0.02 mm. Also applied to a class of soil texture.

Sandstones A sedimentary rock composed of sand-sized particles.

Scour The physical removal of soil from the surface by erosion. In some text books it is used to describe erosion in broad, shallow rills which can coalesce to give sheet erosion.

Scrub Vegetation consisting of short trees and shrubs.

Sedimentary rocks Rocks resulting from the consolidation of loose sediments, or from chemical precipitation from solution at or near the Earth's surface.

Seedling Any plant raised from seed.

Shoot The general name for any stem above the ground.

Shrub A small woody perennial plant with branches from ground level upwards.

Silt Mineral particles in the diameter range of 0.02 to 0.002 mm (20 to 2 mm). Also used loosely to describe any accumulation of fine material, and applied to a class of soil texture.

Slip cutting A cutting made from a grass that has fibrous roots but no rhizome system. See also **Grass slip.**

Slumping A form of saturated flow of soil or debris. It occurs mostly in weak, poorly drained materials, when a point of liquefaction is reached following heavy rain. In effect, the addition of water to the material causes a reduction in cohesion to a point of limited friction. It is usually shallow (less than 500 mm deep).

Soil The collection of natural materials occupying parts of the Earth's surface that may support plant growth, and which reflect pedogenetic processes acting over time under the associated influences of climate, relief, living organisms, parent material and the action of man.

Soil capping The formation on the surface of a thin layer that is harder or less permeable than the soil below. In many bare soils in Nepal, cappings can be formed of clay through the effects of rain drops on surfaces unprotected by vegetation.

Stakeholder Any person, group or institution that has an interest in the activity in question. It applies to both beneficiaries and those who lose out, as well as those involved in or excluded from decision-making processes.

Stem The part of a plant with nodes, buds and leaves; usually above ground, but some (such as rhizomes) are underground.

Stolon A stem that grows along the ground, producing at its nodes new plants with roots and upright stems.

Stratum (*pl.* strata) A layer of rock, distinct from its neighbours, occurring as part of a series in rocks. It is usually applied only to s edimentary rocks, but some metamorphic rocks also have visible strata.

Strike The horizontal line contained in the plane of bedding, foliation, or jointing of rock. It is perpendicular to the dip, just as a contour is to the maximum slope of the ground. It is always expressed as a reading less than 180°.

Subsoil In a moderately or well developed soil, the layer(s) or horizon(s) below the topsoil. It is usually made up almost entirely of mineral constituents, and is less fertile than the topsoil. It is distinguished from weathered parent

material by the absence of any structural characteristics of the parent material.

Sward An area of vegetation consisting mainly of grasses; a low, dense mass of ground-covering vegetation.

Syncline The trough or inverted arch of a fold in rock strata.

Synclinorium A huge trough, in form resembling a syncline, each limb of which consists of a number of small folds.

Talus deposits Materials deposited from upslope, and usually found on slopes below rock outcrops. They are characterised by angular debris, and are usually loose and unconsolidated. Other names are scree and colluvium.

Tethys The ancient sea which separated two ancient continents. Marine deposits laid down in the Tethys Sea now form part of the Tibetan Plateau.

Texture In soils, the 'feel' of moist soil resulting from the mixture of different particle sizes and organic matter. Texture is classified into groups of soils with similar properties on the basis of the mineral component. For example, clay loam contain 27 to 40 percent clay, 15 to 55 percent silt and 20 to 45 percent sand.

Thin The removal of a proportion of the plants in a given area, to allow the others to grow bigger. This is a standard nursery and forestry procedure.

Thrust or thrust fault See **fault.**

Toe wall A wall of low height provided to protect the toe of a soil mass.

Topography A detailed description or representation of the features, both natural and artificial, of an area, often with special reference to the relief (differences of altitude).

Topsoil In a moderately or well developed soil, the darker, more fertile and organically rich upper layer or horizon of soil. In a cultivated soil, it is often the plough layer.

Translational landslide See **Planar sliding**

Transpiration The process by which plants, having taken in moisture through their roots, return it to the atmosphere through the pores in their leaves in the form of water vapour. This can cause a major loss of soil moisture.

Tree A woody perennial plant that usually grows with only one or two stems rising from the ground, and branches out higher up.

Turf The surface layer of soil, usually the top 100 mm, matted with the roots of grasses.

Understorey The part of a forest underneath the canopy, consisting of shrubs, saplings and herbs.

Viability The length of time that the majority of seeds remain able to germinate. After a certain period of storage, seeds will not germinate once sown. This varies for each species.

Warp In weaving, the length-ways threads first placed on the loom.

Weathering The physical and chemical alteration of minerals into other minerals by the action of heat, water and air,

Weft In weaving, the cross threads woven into the warp by passing the shuttle across the loom.

Xerophyte A plant that lives in a desert or other dry habitat.

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ROADSIDE Bio-engineering

Reference Manual

This reference book provides the background information needed to understand the use of vegetation in engineering in Nepal, and the geological and geomorphological basis of site assessment for works on steep slopes.

It makes specific reference to roads. The manual also contains background information on the management of vegetation, including aspects of community participation and the law. The main bio-engineering species are described in detail. Standard specifications and rate analysis norms are also provided.

It is intended that the Reference Manual cover all subjects that an engineer would need in the office. The companion Site Handbook provides all the information required on site.