

BIO-ENGINEERING INFORMATION

RATE ANALYSIS NORMS (INTERIM) STANDARD SPECIFICATIONS (INTERIM) LISTS OF SPECIES AND SUPPORTING INFORMATION



His Majesty's Government of Nepal

MINISTRY OF WORKS AND TRANSPORT

DEPARTMENT OF ROADS

GEO-ENVIRONMENTAL UNIT

Reprint, July 1999

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GEO-ENVIRONMENTAL UNIT

Second edition, December 1997

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FOREWORD

The Department of Roads' mission is to provide a high quality service to the users of the nation's roads. The protection of slopes is of critical importance to minimise the risk of road blockages. In the constantly evolving physical environment of Nepal, with steep slopes, weak and disturbed materials and the heavy monsoon rains, this is no easy task. Among the world's most active mountains, it is necessary to use special measures to counter the extreme and unique problems we face.

Over the years there has been much research into effective solutions for these severe difficulties. We have discovered that we need to use extensive geotechnical engineering measures in many locations. Similarly, it has gradually become apparent that specific forms of biotechnical engineering (or bio-engineering) are also required. These complement the more traditional civil engineering structures and help to resolve most of the particular difficulties faced on the roadlines. Only by the judicious use of all the measures at our disposal can we hope to safeguard the enormous investment in the national infrastructure.

Bio-engineering techniques appropriate to Nepal have been under development in the road sector for over ten years. Several donor agencies, particularly the British and Swiss Governments, have taken a keen interest in this. On many roads, these measures have been tried and tested under rigorous natural conditions. The Department of Roads now implements bio-engineering works on a routine basis throughout the strategic road network.

In January 1996, the Geo-Environmental Unit of the Department of Roads first published the interim rate analysis norms which are reprinted here. These norms were approved by His Majesty's Government, Ministry of Works and Transport (at Minister level) on 25 December 1995. A complete set of interim standard specifications for bio-engineering works was produced in July 1996.

The norms and specifications are reprinted here with minor corrections, since stocks had been exhausted by heavy demand. As well as these data, this document contains a revised set of information on bio-engineering plants and other important material. These give many of the details required by Engineers in the field, to implement the full range of bio-engineering operations. All staff of the Department of Roads are encouraged to apply bio-engineering works wherever necessary, and to feed comments back to the Geo-Environmental Unit for the gradual enhancement of this information.



B Sharma,
Director General,
Department of Roads.

December 1997

BIO-ENGINEERING WORKS - 27

RATE ANALYSIS NORMS

S No	WORK DESCRIPTION	UNIT	RESOURCES									
			LABOUR		CONSTRUCTION MATERIALS		EQUIPMENT		TYPE	UNIT	QUANTITY	3% of labour cost
			LEVEL	UNIT	QUANTITY	TYPE	UNIT	QUANTITY				
27-	(1) Collection and preparation of seeds	kg	Unskilled	nos	1.50	Sealed bag	nos	1.00	Khukuri	-	1.00	3% of labour cost
	[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	0.45	-	-	-	Khukuri	-	-	3% of labour cost
	[b] Collection of large shrub seeds (eg bhujetro) from sources within 1 km of the road including seed preparation for storage after drying.	kg	Unskilled	nos	0.75	Sealed bag	nos	1.00	Nanglo	-	1.00	3% of labour cost
	[c] Collection of medium-sized shrub seeds (eg keraukose) from sources within 1 km of the road, including seed preparation for storage after drying.	kg	Unskilled	nos	0.95	Sealed bag	nos	1.00	Nanglo	-	1.00	3% of labour cost
	[d] Collection of medium-sized shrub and tree seeds (eg 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	2.50	Sealed bag	nos	1.00	Nanglo	-	1.00	3% of labour cost
27-	(2) Collection of grass and hardwood cuttings for vegetative propagation	1000 slips	Unskilled	nos	1.50	Adequate supply of appropriate clumps	-	5.00	Kodalo	-	5.00	3% of labour cost
	[a] Collection of grass clumps (eg 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	Adequate supply of appropriate clumps	-	5.00	Kodalo	-	5.00	3% of labour cost

RATE ANALYSIS NORMS

S No	WORK DESCRIPTION	UNIT	RESOURCES									
			LABOUR		CONSTRUCTION MATERIALS		EQUIPMENT		TYPE	QUANTITY	UNIT	QUANTITY
			LEVEL	UNIT	QUANTITY	TYPE	UNIT	QUANTITY				
27-	[b] Collection of cuttings of small bamboos (eg 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	Adequate supply of appropriate bamboos Hessian jute	- m ²	- 10.00	Kodalo Khukuri	- -	- -	3% of labour cost
	[c] Collection of hardwood cuttings (eg 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	Adequate supply of appropriate bushes Hessian jute	- m ²	- 5.00	Khukuri	-	-	3% of labour cost
	(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 x 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 m ²	Skilled Unskilled	nos nos	1.50 2.00	Bamboo poles Polythene sheet Bricks Gravel Unsieved soil Line string Binding wire	nos m ² nos m ³ m ³ m kg	9.00 9.00 96.00 0.25 0.10 13.00 3.00	Khanti Shovel Pick axe Screen mesh	- - - -	- -	3% of labour cost
	[b] Construction of stand out beds for tree seedlings in polypots, including materials for beds and shades. Bed is 100 cm wide x 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 m ²	Unskilled	nos	6.00	Bamboo Bricks Line string Binding wire Gravel	nos nos m kg m ³	15.00 96.00 13.00 3.00 0.25	Khanti Shovel Pick axe	- - -	- -	3% of labour cost

RATE ANALYSIS NORMS

S No	WORK DESCRIPTION	UNIT	RESOURCES									
			LABOUR			CONSTRUCTION MATERIALS				EQUIPMENT		
			LEVEL	UNIT	QUANTITY	TYPE	UNIT	QUANTITY	TYPE	UNIT	QUANTITY	
	[c] Construction of beds for grass seeds, grass slips (ie 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 m ²	Skilled Unskilled	nos nos	1.00 1.50	Gravel Forest soil Compost Washed sand Hessian cover	m ³ m ³ m ³ m ³ m ²	0.38 1.46 0.38 0.46 10.00	Shovel Pick axe	- -	3% of labour cost	
	[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 m ²	Unskilled	nos	2.00	Gravel Forest soil Compost Bamboo poles Hessian jute	m ³ m ³ m ³ nos m ²	0.38 1.46 0.38 6.00 25.00	Shovel Pick axe Khukuri Log saw	- - - -	3% of labour cost	
27-	(4) Nursery operation and management (seed sowing and transplanting; planting hardwood cuttings)											
	[a] Tree seed sowing @ 10 grammes per m ² (medium-sized seeds) or 2 grammes per m ² (very fine seeds) into seed beds including pre-sowing seed treatment.	5 m ²	Unskilled	nos	0.04	Seed	g		50.00	Bowl Trowel	- -	3% of labour cost
	[b] Preparing potting mix and filling polybags, including all materials for container seedlings. [Note. 1 kg of 200 gauge polybags (4" × 7" laid flat) = 464 bags; 200 gauge black polythene is preferred.]	1000 nos	Unskilled	nos	10.00	Polypot Sand Soil Compost	nos m ³ m ³ m ³	1050.00 0.46 0.70 0.23	Sieve Shovel	- -	3% of labour cost	

RATE ANALYSIS NORMS

S No	WORK DESCRIPTION	UNIT	RESOURCES									
			LABOUR			CONSTRUCTION MATERIALS			EQUIPMENT			
			LEVEL	UNIT	QUANTITY	TYPE	UNIT	QUANTITY	TYPE	UNIT	QUANTITY	
	[c] Direct sowing of tree seeds into polybags including seed treatment, by sowing one seed in half the pots and two seeds in the other half.	1000 nos	Unskilled	nos	0.62	Seed	nos	1500.00	Wooden peg	nos	1.00	
	[d] Pricking out young seedlings and transplanting into polybags.	100 nos	Unskilled	nos	0.18	-	-	-	Wooden peg Tray	nos	1.00 3% of labour cost	
	[e] Pricking out tree seedlings and transplanting into beds.	1000 nos	Unskilled	nos	0.12	-	-	-	Wooden peg	nos	1.00	
	[f] Transplanting grass slips into beds, from clumps. Slips are planted at 10 cm centres in rows 25 cm apart.	m ²	Unskilled	nos	0.12	Hessian jute	m ²	0.30	Khukuri Shovel	- -	3% of labour cost	
	[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	Hardwood cuttings	nos	1000.00	Khanti	-	3% of labour cost	
27-	(5) Preparation of raised materials for extraction from the nursery											
	[a] Grass culm cutting production from nursery stock; single or double node (eg napier).	1000 nos	Unskilled	nos	0.70	Hessian jute	m ²	2.70	Khukuri	-	3% of labour cost	
	[b] Uprooting and preparing grass slips ready for site planting from nursery seedlings.	1000 nos	Unskilled	nos	0.63	Hessian jute	m ²	1.35	Fork Pick axe Khukuri	- - -	3% of labour cost	
	[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	Hessian jute	m ²	4.20	Shovel Khanti	- -	3% of labour cost	

RATE ANALYSIS NORMS

S No	WORK DESCRIPTION	UNIT	RESOURCES										
			LABOUR			CONSTRUCTION MATERIALS			EQUIPMENT				
			LEVEL	UNIT	QUANTITY	TYPE	UNIT	QUANTITY	TYPE	UNIT	QUANTITY		
27-	(6) Compost and mulch production												
	[a] Mulch production by collection and cutting of weeds and other vegetation such as tite pati, bannara etc, within 1 km of the road, and stacking along roadside.	m ³	Unskilled	nos	1.20	-	-	-	Hasiya Doko	-	-	3% of labour cost	
	[b] Compost production by collection and cutting of weeds and other vegetation such as tite pati, bannara etc, within 1 km of the road, including fine cutting and filling compost pit.	m ³	Unskilled	nos	1.20	-	-	-	Doko	-	-	3% of labour cost	
	[c] Turning compost once per month.	m ³	Unskilled	nos	0.10	-	-	-	Shovel	-	-	3% of labour cost	
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	Seed	kg	2.50	-	-	-	-	
	[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	Seed Mulch	kg m ³	2.50 5.00	-	-	-	-	
	[c] Broadcasting grass seeds on slopes < 40-45°, including cover with long mulch and jute netting of mesh size 300 mm x 500 mm. Seeding @ 25 g per m ² . Operation includes pegging with suitable live pegs or hardwood cuttings (eg simali) @ 1 m spacing, jute net of 6.75m x 1m size.	100 m ²	Unskilled	nos	6.25	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	

RATE ANALYSIS NORMS

S No	WORK DESCRIPTION	UNIT	RESOURCES							
			LABOUR		CONSTRUCTION MATERIALS			EQUIPMENT		
			LEVEL	UNIT	QUANTITY	TYPE	UNIT	QUANTITY	TYPE	UNIT
27-	[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	Seeds	nos	3200.00	MS rod of 50 cm length	-
	(8) Planting grass cuttings on site									
	[a] Planting single node culm cuttings of grass (eg 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	Grass cuttings Hessian jute	nos m ²	100.00 0.27	MS rod or hardwood peg of 50 cm length	-
	[b] Planting single node culm cuttings of grass (eg 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	Grass cuttings Hessian jute	nos m ²	100.00 0.27	MS rod or hardwood peg of 50 cm length	-
	[c] Planting single node culm cuttings of grass (eg 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	Grass cuttings Hessian jute	nos m ²	100.00 0.27	MS rod or hardwood peg of 50 cm length	-
	[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	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	-

RATE ANALYSIS NORMS

S No	WORK DESCRIPTION	UNIT	RESOURCES							
			LABOUR		CONSTRUCTION MATERIALS		EQUIPMENT		TYPE	QUANTITY
			LEVEL	UNIT	QUANTITY	TYPE	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.	m²	Unskilled	nos	0.20	Grass slips Hessian jute	nos of drills m²	100.00 0.27	MS rod or hardwood peg of 50 cm length Khukuri	3% of labour cost
[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.	m²	Unskilled	nos	0.30	Grass slips Hessian jute	nos of drills m²	100.00 0.27	MS rod or hardwood peg of 50 cm length Khukuri	3% of labour cost
[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.	m²	Unskilled	nos	0.40	Grass slips Hessian jute	nos of drills m²	100.00 0.27	MS rod or hardwood peg of 50 cm length Khukuri	3% of labour cost

RATE ANALYSIS NORMS

S No	WORK DESCRIPTION	UNIT	RESOURCES									
			LABOUR		CONSTRUCTION MATERIALS				EQUIPMENT			
			LEVEL	UNIT	QUANTITY	TYPE	UNIT	QUANTITY	TYPE	UNIT	QUANTITY	
27-	(9) Planting shrub and tree seedlings and cuttings on site	10 nos	Unskilled	nos	0.25	Container seedling Compost Tree guard Green mulch.	nos m³ nos m³	10.00 0.05 10.00 0.04	Khanti Mallet (wooden hammer) Doko	- - -	3% of labour cost	
	[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.											
	[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	Seedlings Compost Green mulch	nos m³ m³	10.00 0.05 0.04	Khanti Doko	- -	3% of labour cost	
	[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	Seedling Compost Green mulch	nos m³ m³	10.00 0.05 0.04	Khanti Doko	- -	3% of labour cost	
	[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	Seedling Compost Green mulch	nos m³ m³	10.00 0.03 0.04	Khanti		3% of labour cost	

RATE ANALYSIS NORMS

S No	WORK DESCRIPTION	UNIT	RESOURCES								
			LABOUR			CONSTRUCTION MATERIALS			EQUIPMENT		
			LEVEL	UNIT	QUANTITY	TYPE	UNIT	QUANTITY	TYPE	UNIT	QUANTITY
27-	[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 x 20 cm depth. Compost volume ¼ of volume of the pit mixed with original soil.	10 nos	Unskilled	nos	0.25	Seedling Compost Green mulch	nos m³ m³	10.00 0.03 0.04	Khanti	-	3% of labour cost
	[f] Planting tree stump and bare root seedlings, including pitting, transplanting, composting and mulching on slopes >45°. Pit size 10 cm diameter x 20 cm depth. Compost volume ¼ of volume of the pit mixed with original soil.	10 nos	Unskilled	nos	0.33	Seedling Compost Green mulch	nos m³ m³	10.00 0.03 0.04	Khanti	-	3% of labour cost
	(10) Vegetative palisade construction, brush layering and fascines	1000 nos	Unskilled	nos	0.85	Adequate supply of bushes	-	-	Khukuri	-	3% of labour cost
	[a] Collection of hardwood cuttings for planting material (eg 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.	m	Unskilled	nos	0.17	Live pegs	nos	20.00	Crow bar	-	3% of labour cost
	[b] Preparation and planting of live pegs of selected species (eg 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.										

RATE ANALYSIS NORMS

S No	WORK DESCRIPTION	UNIT	RESOURCES								
			LABOUR		CONSTRUCTION MATERIALS			EQUIPMENT			
			LEVEL	UNIT	QUANTITY	TYPE	UNIT	QUANTITY	TYPE	UNIT	QUANTITY
27-	[c] Preparation and planting of live cuttings of selected species (eg 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	Live pegs	nos	20.00	Crow bar	-	3% of labour cost
	[d] Site preparation for fascine laying: earth works in excavation of trench to 20 cm depth.	m	Unskilled	nos	0.06	-	-	-	Pick axe Shovel	-	3% of labour cost
	[c] Laying of live fascines, using live hardwood cuttings of selected species (eg 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	Hardwood cuttings of at least 1 metre in length	m	8.00	Khukuri Shovel	-	3% of labour cost
	(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 toroso is the weaving shuttle, normally made from a split large bamboo culm.]	m²	Skilled	nos	0.36	Raw jute	kg	1.25	Khukuri Bamboo sticks (10 nos) Weaving frame Tosro	-	3% of labour cost

RATE ANALYSIS NORMS

S No	WORK DESCRIPTION	UNIT	RESOURCES									
			LABOUR			CONSTRUCTION MATERIALS			EQUIPMENT			
			LEVEL	UNIT	QUANTITY	TYPE	UNIT	QUANTITY	TYPE	UNIT	QUANTITY	
	[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 x 500 mm rectangular mesh and 0.25 kg/m at 1.20 m width. [Note. A toso is the weaving shuttle, normally made from a split large bamboo culm.]	m ²	Skilled	nos	0.15	Raw jute	kg	0.26	Khukuri Bamboo sticks (10 nos) Weaving frame Tosro	- - - -	3% of labour cost	
	[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	Woven jute net Hardwood cuttings or split bamboo pegs	m ² nos	1.00 5.00	MS rod of 50 cm length Mallet (wooden hammer)	- -	3% of labour cost	
	[d] Placing 150 x 500 mm mesh jute netting to hold mulch on slopes, including application of mulch and pegging with live hardwood cuttings or split bamboo pegs and loosening tension so that the net hugs the slope throughout.	m ²	Unskilled	nos	0.10	Cut mulch Woven jute net Hardwood cuttings or split bamboo pegs	m ³ m ² nos	0.05 1.00 5.00	MS rod of 50 cm length Mallet (wooden hammer)	- -	3% of labour cost	
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	-	-	-	Pick axe Shovel	- -	3% of labour cost	
	[b] Site preparation for 60 cm diameter bolster: earth works in excavation of trench.	m	Unskilled	nos	0.36	-	-	-	Pick axe Shovel	- -	3% of labour cost	

RATE ANALYSIS NORMS

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			LABOUR			CONSTRUCTION MATERIALS			EQUIPMENT		
			LEVEL	UNIT	QUANTITY	TYPE	UNIT	QUANTITY	TYPE	UNIT	QUANTITY
	[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	GI wire	kg	2.00	Gabion frame and tools	-	3% of labour cost
	[d] Construction of 30 cm bolster cylinder: placing, stretching wire mesh, filling with boulders, closing and backfilling.	m	Unskilled	nos	0.375	Boulders	m ³	0.09	Gabion tools Doko	-	3% of labour cost
	[e] Construction of 60 cm bolster cylinder: placing, stretching wire mesh, filling with boulders, closing and backfilling.	m	Unskilled	nos	0.75	Boulders	m ³	0.36	Gabion tools Doko	-	3% of labour cost
	[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	Black polythene Boulders	m ² m ³	0.40 0.09	Gabion tools Doko	-	3% of labour cost
	[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	Black polythene Boulders	m ² m ³	0.80 0.36	Gabion tools Doko	-	3% of labour cost
	[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	MS rod	m	2.00	Sledge hammer	-	3% of labour cost
	[i] Laying of terram paper (geotextile).	m ²	Unskilled	nos	0.05	Terram paper	m ²	1.15	Khukuri	-	3% of labour cost
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	Bamboo	nos	2.20	Khukuri	-	3% of labour cost

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	कार्यको विवरण	एकाई	श्रोत साधन								कैफियत	
			श्रमिक		निर्माण सामग्री		यान्त्रिक उपकरण					
			तह	एकाई	परिमाण	क्रिसिम	एकाई	परिमाण	क्रिसिम	एकाई		परिमाण
२७	(१) विउ तयार तथा संक्लन गर्ने (क) सडकको १ कि. मि वरिपरिवाट घासको विउ संक्लन गर्ने र घाममा सुकाइ, छुट्याई धन्कउने । (ख) सडकको १ कि.मि वरिपरिवाट ठुलो खालको फाडीको वोट (जस्तै: मुजेत्रो)वाट विउ संक्लन गर्ने र सुक्न धन्कउने (ग) सडकको १ कि. मि वरिपरिवाट मफौला खालको फाडीको वोट (जस्तै: केराउकोसे)वाट संक्लन गर्ने तथा सुक्न धन्कउने । (घ) सडकको १ कि.मि वरिपरिवाट मफौला खालको फाडीको वोट (जस्तै: जररी, खयर, गोब्रे र रानीसल्ला, सिसौ) को विउ संक्लन गर्ने तथा सुक्न धन्कउने । (ङ) सडकको १ कि.मि वरिपरिवाट सानो वोट (जस्तै: धपरो, धुसुम, तिलक, उत्तिस) को विउ संक्लन गर्ने तथा सुक्न धन्कउने ।	के.जी	ज्यामी	संख्या	१.५०	फोला	संख्या	१.००	बुकुरी	अमिक बर्षको ३ %		
		के.जी	ज्यामी	संख्या	०.४५			बुकुरी	-	अमिक बर्षको ३ %		
		के.जी	ज्यामी	संख्या	०.७५	फोला	संख्या	१.००	नांगलो	अमिक बर्षको ३ %		
		के.जी	ज्यामी	संख्या	०.९५	फोला	संख्या	१.००	नांगलो	अमिक बर्षको ३ %		
		के.जी	ज्यामी	संख्या	२.५०	फोला	संख्या	१.००	नांगलो	अमिक बर्षको ३ %		

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	कार्यको विवरण	एकई	श्रोत साधन								कैफियत
			श्रमिक		निर्माण सामग्री		यांत्रिक उपकरण				
			तह	एकई	परिमाण	क्रिसिम	एकई	क्रिसिम	एकई	परिमाण	
२७	(२) पेन्टेडिप प्रपोजेबनको लागि घास तथा हाईबुड कटिंग जम्मा गर्ने (क) सडकको १ कि.मि वरिपरिबाट घास (जस्तै: अमलिसो, कस, बर) को कसप सक्कल गर्ने तथा स्लिप छुट्याइ नर्सरीमा पल्टिप्लकेबनको लागि राख्ने । (ख) सडकको १ कि.मि वरिपरिबाट निगलो, बास आदिको कटिंग आवश्यकता अनुसार सक्कल गर्ने । (ग) सडकको १ कि.मि वरिपरिबाट हागाहरु (असुरो, बास , कौडांफुल, नाम्दीफुल, सरवा, सिमली) सक्कल गर्ने काम हागा कम्तिमा ३० से. मी. लामो र २ से.मि पाटो हुनु पर्ने ।	१००० स्लिप १००० गोटा १००० गोटा	ज्यामी	संख्या	१.५०	हेसेनजुट	ब.मि	५.००	केवालो	श्रमिक खर्चको ३ % श्रमिक खर्चको ३ %	आवश्यक मात्रामा कसप सप्साइ हुनु पर्ने "
			संख्या	३.००	हेसेनजुट	ब.मि	१०.००	केवालो बुकुरी	श्रमिक खर्चको ३ %	"	
			संख्या	०.५५	हेसेनजुट	ब.मि	५.००	बुकुरी	श्रमिक खर्चको ३ %	"	

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	कार्यको विवरण	एकई	श्रोत साधन									कैफियत	
			श्रमिक		निर्माण सामग्री			यान्त्रिक उपकरण					
			तह	एकई	परिमाण	किसिम	एकई	परिमाण	किसिम	एकई	परिमाण		
२७	(३) नर्सरी संचालन र व्यवस्थापन (वेड बनाउने)						वासकोपोल	संख्या	ब.मि	१.००	खन्ती	श्रमिक खर्चको ३ %	
	(क) रुखको विरवाको लागि विउ छर्ने, वेड बनाउने काम, वेडको सामान र सेड बनाउने काम सहित १ मि चौडा, १७ से मि अग्लो ५ से.मि. छोएको ग्रामेल ५ से मि मलिलो माटो र ५ से मि सफा माटो वालुवा र २ से मि सफा छोएको, चालेको वालुवा	५ ब.मि	सिपालु ज्यामी	संख्या संख्या	१.५० २.००	वासकोपोल पोलिथिन ईटा ग्रामेल माटो धागो बाट्ने तार	संख्या ब.मि गोटा घ.मि घ.मि मि के.जी	१.०० १६.०० ०.२५ ०.१० १३.०० ३.००	खन्ती वेल्वा नैची जाली	- - - -			
	(ख) पोलिपटमा रुखको विरवा राख्ने वेड तयार गर्ने सेड बनाउने र आवश्यक मालसामान उपलब्ध गर्ने काम सहित । वेड १०० से.मि चौडा र १५ से.मि अग्लो हुनेछ साथै जमिन पन्डा माथि ५ से.मि ग्रामेल राखेको हुनु पर्ने ।	५ ब.मि	ज्यामी	संख्या	६.००	वास ईटा धागो बाट्ने तार ग्रामेल	संख्या संख्या मि के.जी घ.मि	१५.०० १६.०० १३.०० ३.०० ०.२५	खन्ती वेल्वा नैची	- - -			
	(ग) घासको विउ तथा स्लिप रोप्ने (मेजिटेडम प्रोपेगेशन), वेड तयार गर्ने मालसामान उपलब्ध गर्ने आदि संपूर्ण काम वेड साइज: १०० से मि चौडा २५ से मि उचाई जमिन माथि ५ से.मि ग्रामेल १:१ को अनुपातमा छानेको माटो र मल राख्ने साथै माथिल्लो पागमा १५ से.मि ३:१ को अनुपातमा छानेको मलिलो माटो र छोएको वालुवा राख्ने	५ ब.मि	सिपालु ज्यामी	संख्या संख्या	१.०० १.५०	ग्रामेल मलिलोमाटो कम्पोष्ट वालुवा हेरेन कम्पर	घ.मि घ.मि घ.मि घ.मि ब.मि	०.३८ १.४६ ०.३८ ०.४६ १०.००	वेल्वा गल्लीबचरो	- -			

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	कार्यको विवरण	एकई	श्रोत साधन								कैफियत	
			श्रमिक		निर्माण सामग्री		यान्त्रिक उपकरण					
			तह	एकई	परिमाण	किसिम	एकई	परिमाण	किसिम	एकई		परिमाण
२७	(घ) कम्प कटिंगबाट बासको विरवा बनाउनको लागि वेड तयार गर्ने काम एवं मालसामान उपलब्ध गर्ने वेड १०० से.मि चौडा र ३० से.मि अग्लो जमिन देखि ३० से.मि गहिराइ सम्म खन्नु पर्ने, खानेको ठाउँमा १० से.मि नखानेको माटो राख्ने र २० से.मि छानेको माटो राख्ने वेडको चारैतिर १० से.मि अग्लो बनाउने ।	५ व.मि	ज्यामी	संख्या	२.००	ग्रामेल मलिलोमाटो कम्पोष्ट बास हसेनबुट	घ.मि घ.मि घ.मि संख्या व.मि	०.३८ १.४६ ०.३८ ६.०० २५.००	बेल्वा मैची खुकुरी कठकोपेग	- - - -	श्रमिक खर्चको ३ %	
	(४) नर्सरी संचालन तथा व्यवस्थापन (विउ छर्ने र सार्ने: हार्डबुड कटिंग सार्ने) (क) विरवाको विउ वेडमा रोप्ने मफौला बालको विउ १० ग्राम प्रति व.मि वा परिस्रो विउ २ ग्राम प्रति व. मि मा	५ व.मि	ज्यामी	संख्या	०.०४	विउ	ग्राम	५०.००	वाटा बेल्वा	- -	श्रमिक खर्चको ३ %	
	(ख) पोलिथिन व्यागमा स्पेसिफिकेशन अनुसार माटो मर्ने र मालसामान उपलब्ध गर्ने (नोट: १ के जी २०० गैजको पोलिपट (४ x ७ फ्लाट) : ४६४ व्याग)	१००० गोटा	ज्यामी	संख्या	१०.०	पोलिपट वालुवा माटो मल	संख्या घ.मि घ.मि घ.मि	१०५०.०० ०.४६ ०.७० ०.२३	जाली बेल्वा	- -	श्रमिक खर्चको ३ %	
	(ग) सिधै पोलिथिन व्यागमा विउ रोप्ने काम विउको डिटेपेट सहित आधा पोलिपटमा एक विउ र बाँकी आधामा दुई विउ राख्ने ।	१००० गोटा	संख्या	ज्यामी	०.६२	विउ	गोटा	१५००	कठकोपेग	गोटा	१.००	
	(घ) सानो विरवालाई पोलिथिन व्यागमा सार्ने काम	१०० गोटा	संख्या	ज्यामी	०.१८				कठकोपेग वाटा	गोटा -	१.०० श्रमिक खर्चको ३ %	

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	कार्यको विवरण	एकई	श्रोत साधन						कैफियत			
			श्रमिक		निर्माण सामग्री		यान्त्रिक उपकरण					
			तह	एकई	परिमाण	क्रिसिम	एकई	परिमाण		क्रिसिम	एकई	परिमाण
	(ड०) रुखको विरवालाई वेडमा सार्ने काम ।	१००० गोटा	संख्या	ज्यामी	०.१२				कठकोपेग	गोटा	१.००	
	(घ) क्लम्पवाट घासको सानो सानो स्लिपलाई वेडमा सार्ने काम । स्लिपलाई १० से.मि को दुरीमा २५ से.मि टाखा वेडमा ।	ब.मि	ज्यामी	संख्या	०.१२	हेसियनजुट	ब.मि	०.३०	बुट्टी वेल्वा	- -	श्रमिक खर्चको ३ %	
	(ङ) कम्तिमा ३० से.मि लामो २० से.मि गहिरो वेड तयार गरि हाईड्रडको कटिंगहरू रोप्ने काम । वेडको दूरी २० से.मि र रोप्ने दूरी ५ से.मि	१००० गोटा	ज्यामी	संख्या	०.६०	हाईड्रड कटिंग	संख्या	१०००	खन्ती	-	श्रमिक खर्चको ३ %	
२७	(५) नर्सरीवाट फिक्नको लागि रेज्ड भेटेरियल तयार गर्ने ।											
	(क) नर्सरीवाट प्राप्त क्लम कटिंग तयार गर्ने काम सिंगल वा डबल नोड (जस्तै: नोपियर)	१००० गोटा	ज्यामी	संख्या	०.७०	हेसियनजुट	ब.मि	२.७०	बुट्टी	-	श्रमिक खर्चको ३ %	
	(ख) नर्सरीवाट घासको विरवा फिक्नेर स्लिप बनाई रोप्न तयार गर्ने	१००० गोटा	ज्यामी	संख्या	०.६३	हेसियनजुट	ब.मि	१.३५	फर्क नैमी	-	श्रमिक खर्चको ३ %	
	(ग) मेजेटेपि प्रोगेसनको लागि घासको क्लम्पवाट तयार पार्नको विरवाहरूलाई फिर्क माइटमा रोप्न तयार बनाउने ।	१००० गोटा	ज्यामी	संख्या	०.३३	हेसियनजुट	ब.मि	४.२०	बुट्टी वेल्वा खन्ती	-	श्रमिक खर्चको ३ %	

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	कार्यको विवरण	एकई	श्रोत साधन								कैफियत	
			श्रमिक		निर्माण सामग्री		यांत्रिक उपकरण					
			तह	एकई	परिमाण	किसिम	एकई	परिमाण	किसिम	एकई		परिमाण
२७	(६) कम्पोजिट मल र मल्य उत्पादन (क) सडकको १ कि.मि वरिपरिबाट घाँसपातहरू (जस्तै: तित्तेपाटी, वनमारा आदि)कटौ संकलन गरी मल्य बनाउने काम र सडकको छेउमा जम्मा गरी राख्ने (ख) सडकको १ कि.मि वरिपरिबाट घाँसपातहरू (जस्तै: तित्तेपाटी, वनमारा आदि) जम्मा गरि कम्पोजिट मल बनाउने, मसिनो पारी काट्ने र बाल्टोमा भर्ने काम सहित । (ग) महिनामा एक पटक मल पल्टाउने काम	घ.मि	ज्यामी	संख्या	१.२०				हसिया डोको	-	श्रमिक खर्चको ३ %	
		घ.मि	ज्यामी	संख्या	१.२०				डोको	-	श्रमिक खर्चको ३ %	
		घ.मि	ज्यामी	संख्या	०.१०				बेल्ला	-	श्रमिक खर्चको ३ %	

दर विश्लेषण नमस्

समूह २७ : वायो इन्जिनियरिंगको काम

	कार्यको विवरण	एकई	श्रोत साधन							कैफियत			
			श्रमिक		निर्माण सामग्री			यांत्रिक उपकरण					
			तह	एकई	परिमाण	किसिम	एकई	परिमाण	किसिम		एकई	परिमाण	
२७	(७) सिधै साइटमा विउ छर्ने												
	(क) २५ ग्राम प्रति ब.मि क्क दरले ४०° पन्धा कम स्लोपमा घासको विउ छर्ने काम ।	१०० ब.मि	ज्यामी	संख्या	०.१७	विउ	के.जी	२.५०	-	-	-	-	
	(ख) २५ ग्राम प्रति ब.मि क्क दरले ४०° पन्धा कम स्लोपमा घासको विउ छर्ने र माटोले ढाक्ने काम सहित ।	१०० ब.मि	ज्यामी	संख्या	५.००	विउ मल्व	के.जी घ.मि	२.५० ५.००	-	-	-	-	
	(ग) २५ ग्राम प्रति ब.मि क्क दरले ४५° पन्धा कम स्लोप भएको ठाउँमा घासको विउ छर्ने, मल्व राख्ने ३०० मि.मि x ५०० मि.मि मेस साइजको जुटनेट (६.७५ मि x १ मि) ले ढाक्ने काम, १ मि को दुरीमा उचित लाइमपेग वा हार्डबुड कीटाग (जस्तै: सिमली) को पेग राख्ने ।	१०० ब.मि	ज्यामी	संख्या	६.२५	विउ मल्व जुटनेट लाइमपेग	के.जी घ.मि ब.मि संख्या	२.५० ५ १०५ १२८	खुट्टी म्यालेट	- -	-	श्रमिक बर्षको ३ %	
	(घ) सबै किसिमको स्लोपमा सानो सानो रुखको विउ रोप्न २५ से.मि को दुरीमा र ५ से.मि को गहिराइमा खाल्टो खन्ने र गजुरै खाल्टोमा दुइ वटा विउ राखि रोप्ने काम ।	१०० ब.मि	ज्यामी	संख्या	१.००	विउ	संख्या	३२००	५० से.मि लामो एम एस रड	-	-	श्रमिक बर्षको ३ %	

समुह २७ : वायो इन्जिनियरिंगको काम

	कार्यको विवरण	एकाई	श्रोत साधन										कैफियत
			श्रमिक		निर्माण सामग्री			यांत्रिक उपकरण					
			तह	एकाई	परिमाण	किसिम	एकाई	परिमाण	किसिम	एकाई	परिमाण		
२७	(न) घाँसको कटिंगलाई साइटमा रोप्ने (क) घाँसको सिंगल नोड कटिंगलाई (जस्तै: नेपियर) ४५° पंढा कम स्लोप भएको फिलिग गरेको ठाउँमा रोप्ने, १५ देखि २० से मि लम्वाई भएको कटिंगलाई जमिनमा १० देखि २० से मि को गहराईमा फलामको इण्डी वा हार्डवुड पेगबाट खाल्टो बनाई रोप्ने काम सहित । (ख) घाँसको सिंगल नोड कटिंगलाई (जस्तै: नेपियर) ४५° पंढा कम स्लोप भएको कडा माटो कट स्लोप रोप्ने, १५ देखि २० से मि लम्वाई भएको कटिंगलाई जमिनमा १० देखि २० से मि को गहराईमा फलामको इण्डी वा हार्डवुड पेगबाट खाल्टो बनाई रोप्ने काम सहित । (ग) घाँसको सिंगल नोड कटिंगलाई (जस्तै: नेपियर) ४५° पंढा कम स्लोप भएको कडा माटो कट स्लोप रोप्ने, १५ देखि २० से मि लम्वाई भएको कटिंगलाई जमिनमा १० देखि २० से मि को गहराईमा फलामको इण्डी वा हार्डवुड पेगबाट खाल्टो बनाई रोप्ने काम सहित । (घ) समतल खण्डको सडकमा फिलिग गरेको इम्बाकमेण्टमा जरासँगै उडेलेको घाँसको विरवा १० से मि को दुरीमा रोप्ने । पहिलो लाइन पेमेण्टको छेउ वाट ०.७५ मी टाढा र अन्य लाइन १ मि को दुरीमा इम्बाकमेण्टको तल तिर वढाउँदै लाने ।	१०० गोटा	ज्यामी	संख्या	०.२०	घाँसको कटिंग हेसियनजुट	संख्या ब.मि	१०० ०.२७	फलामको रड वा कठको पेग ५० से मि लामो	-	श्रमिक खर्चको ३ %		
		१०० गोटा	ज्यामी	संख्या	०.३५	घाँसको कटिंग हेसियनजुट	संख्या ब.मि	१०० ०.२७	फलामको रड वा कठको पेग ५० से मि लामो	-	श्रमिक खर्चको ३ %		
		१०० गोटा	ज्यामी	संख्या	०.५०	घाँसको कटिंग हेसियनजुट	संख्या ब.मि	१०० ०.२७	फलामको रड वा कठको पेग ५० से मि लामो	-	श्रमिक खर्चको ३ %		
		मि	ज्यामी	संख्या	०.०२	विरवा हेसियनजुट धागो	संख्या ब.मि मि	११ ०.१४ १.००	फलामको रड वा कठको पेग ५० से मि लामो	-	श्रमिक खर्चको ३ %		

दर विश्लेषण नर्मस्

समुह २७ : वायो इन्जिनियरिंगको काम

	कार्यको विवरण	एकई	श्रोत साधन								कैफियत	
			श्रमिक		निर्माण सामग्री		यान्त्रिक उपकरण					
			तह	एकई	परिमाण	किसिम	एकई	परिमाण	किसिम	एकई		परिमाण
	(ड०) घाँसको विरवालाई ४५° पन्दा कम स्लोप भएको ठाउँमा स्लप बनाई रोप्न रडद्वारा ५ से. मि. गहिराइको खाल्डो १० से. मि. को दुरीमा बनाउने काम समेत ।	ब.मि	ज्यामी	संख्या	०.२०	स्लप हेसियनजुट	संख्या ब.मि	१०० ०.२७	५० से मि लामो रड खुकुरी	- - - श्रमिक खर्चको ३ %		
	(च) घाँसको विरवालाई ४५° देखि ६०° को विचको स्लोप भएको ठाउँमा स्लप बनाई रोप्न रडद्वारा ५ से. मि. गहिराइको खाल्डो १० से. मि. को दुरीमा बनाउने काम समेत ।	ब.मि	ज्यामी	संख्या	०.३०	स्लप हेसियनजुट	संख्या ब.मि	१०० ०.२७	५० से मि लामो रड खुकुरी	- - - श्रमिक खर्चको ३ %		
	(छ) घाँसको विरवालाई ६०° पन्दा वढी स्लोप भएको ठाउँमा स्लप बनाई रोप्न रडद्वारा ५ से. मि. गहिराइको खाल्डो १० से. मि. को दुरीमा बनाउने काम समेत ।	ब.मि	ज्यामी	संख्या	०.४०	स्लप हेसियनजुट	संख्या ब.मि	१०० ०.२७	५० से मि लामो रड खुकुरी	- - - श्रमिक खर्चको ३ %		

समुह २७ : वायो इन्जिनियरिंगको काम

क्र.सं.	कार्यको विवरण	एकई	श्रोत साधन						कैफियत			
			श्रमिक		निर्माण सामग्री		यांत्रिक उपकरण					
			तह	एकई	परिमाण	किसिम	एकई	परिमाण		किसिम	एकई	परिमाण
२७	(१) सानो ढुलो रबको विरवा कटिंग रोप्ने (क) समतल ठाउँमा सानो ढुलो रबको कन्टेनराइज्ड विरवा रोप्ने (सडकको केन्द्रबाट कम्तिमा ८ मि को दुरीमा) बन्ने, विरवा सार्ने, मल हाल्ने दि गाई राख्ने काम सहित, बाल्टोको साइज ३० से मि गहिरो र ३० से मि डायामिटर भएको हुनुपर्ने । बाल्टाको परिमाणको एक चौथाइ भाग मल र बाँकी माटो त्यही ठाउँमा मिलाउने र बाल्टो पार्ने (ख) ३०° पन्धा कम स्लोप भएको ठाउँमा सानो ढुलो रबको कन्टेनराइज्ड विरवा रोप्ने (सडकको केन्द्रबाट कम्तिमा ८ मि को दुरीमा) बन्ने, विरवा सार्ने, मल हाल्ने दि गाई राख्ने काम सहित, बाल्टोको साइज ३० से मि गहिरो र ३० से मि डायामिटर भएको हुनु पर्ने । बाल्टाको परिमाणको एक चौथाइ भाग मल र बाँकी माटो त्यही ठाउँमा मिलाउने र बाल्टो पार्ने । (ग) ३०° देखि ४५°सम्मको स्लोप भएको ठाउँमा सानो ढुलो रबको कन्टेनराइज्ड विरवा रोप्ने(सडकको केन्द्रबाट कम्तिमा ८ मि को दुरीमा)बन्ने, विरवा सार्ने, मल हाल्ने दि गाई राख्ने काम सहित बाल्टोको साइज ३० से मि गहिरो र ३० से मि डायामिटर भएको हुनु पर्ने ।बाल्टाको परिमाणको एक चौथाइ भाग मल र बाँकी माटो त्यही ठाउँमा मिलाउने र बाल्टो पार्ने ।	१० गोटा	ज्यामी	संख्या	०.२५	विरवा कम्पोष्ट दि गाई ग्रीन मल	संख्या घ.मि संख्या घ.मि	१०.०० ०.०५ १०.०० ०.०४	बन्ती म्यालेट डोको	श्रमिक खर्चको ३ %		
		१० गोटा	ज्यामी	संख्या	०.३३	विरवा कम्पोष्ट ग्रीनमल	संख्या घ.मि घ.मि	१०.०० ०.०५ ०.०४	बन्ती डोको	श्रमिक खर्चको ३ %		
		१० गोटा	ज्यामी	संख्या	०.४०	विरवा कम्पोष्ट ग्रीनमल	संख्या घ.मि घ.मि	१०.०० ०.०५ ०.०४	बन्ती डोको	श्रमिक खर्चको ३ %		

दर विश्लेषण नर्मस

समुह २७ : वायो इन्जिनियरिंगको काम

	कार्यको विवरण	एकाई	श्रोत साधन									कैफियत
			श्रमिक		निर्माण सामग्री			यांत्रिक उपकरण				
			तह	एकाई	परिमाण	किस्म	एकाई	परिमाण	किस्म	एकाई	परिमाण	
(घ)	३०° भन्दा कम स्लोप भएको ठाउँमा जरा भएको वा नभएको रूखको स्टम्प कटिग सार्ने, खाल्डो खन्ने मल हाल्ने र मलिंगा आदि संपूर्ण काम, खाल्डाको साइज १० से.मि डायमिटर २० से.मि गहिरो । खाल्डाको परिमाणको एक चौथाइ भाग मल र बाँकी त्यही ठाउँको माटोमा मिलाई खाल्टो पुर्ने काम ।	१० गोटा	ज्यामी	संख्या	०.१७	विरवा कम्पोष्ट ग्रीनमल्व	संख्या घ.मि घ.मि	१० ०.०३ ०.०४	खन्ती	-	श्रमिक खर्चको ३ %	
(ङ०)	३०° देखि ४५° सम्म स्लोप भएको ठाउँमा सानो ठूलो रूखको स्टम्प कटिग वा जरा नभएको विरवा रोप्ने (सडकको केन्द्रबाट कम्तिमा ८ मि को दुरीमा) खन्ने,विरवा सार्ने,मल हाल्ने दि गाई राख्ने काम सहित खाल्टोको साइज ३० से मि गहिरो र ३० से मि डायमिटर भएको हुनु पर्ने । खाल्टाको परिमाणको एक चौथाइ भाग मल र बाँकी त्यही ठाउँको माटो मिलाई खाल्टो पुर्ने ।	१० गोटा	ज्यामी	संख्या	०.२५	विरवा कम्पोष्ट ग्रीनमल्व	संख्या घ.मि घ.मि	१० ०.०३ ०.०४	खन्ती	-	श्रमिक खर्चको ३ %	
(च)	४५° भन्दा बढी स्लोप भएको ठाउँमा ठूलो सानो रूखको स्टम्प कटिग वा जरा नभएको विरवा रोप्ने (सडकको केन्द्रबाट कम्तिमा ८ मि को दुरीमा) खन्ने,विरवा सार्ने,मल हाल्ने दि गाई राख्ने काम सहित खाल्टोको साइज ३० से मि गहिरो र ३० से मि डायमिटर भएको हुनु पर्ने । खाल्डाको परिमाणको एक चौथाइ भाग मल र बाँकी त्यही ठाउँको माटो मिलाई खाल्टो पुर्ने ।	१० गोटा	ज्यामी	संख्या	०.३३	विरवा कम्पोष्ट ग्रीनमल्व	संख्या घ.मि घ.मि	१०.०० ०.०३ ०.०४	खन्ती	-	श्रमिक खर्चको ३ % ३ %	

समुह २७ : वायो इन्जिनियरिंगको काम

	कार्यको विवरण	एकाई	श्रोत साधन								कैफियत	
			श्रमिक		निर्माण सामग्री		यान्त्रिक उपकरण					
			तह	एकाई	परिमाण	क्रिसिम	एकाई	परिमाण	क्रिसिम	एकाई		परिमाण
२७	(१०) मेजेटेप पोलिसेड, ब्रस तैयारिग र फेसिसनस् निर्माण (क) सडकको १ कि मि वरिपरिवाट रोप्नको लागि हाईउड कटिंग जम्मा गर्ने काम (जस्तै: असुरो, नाम्दी फुल, सिमली) विरवा १ मिटर लामो र कम्तिमा ५ से मि डायमिटर भएको हुनु पर्ने । (ख) तोकिएको स्पेसिसहरुको (जस्तै: असुरो, नाम्दी फुल, सिमली) लाइम पेगल तयार गरी कडा माटोमा रोप्ने काम । पेग १ मि लामो र ०.५ मि गाड्नु पर्ने । लाइन मिलाइ ५ से मि दुरीमा रोप्ने र लाइनको दुरी ५ देखि २० से.मि.को हुनु पर्ने र मेजेेशनवाट इन्टरवोपेन भएको हुनु पर्ने । (ग) तोकिएको स्पेसिसहरुको (जस्तै: असुरो, नाम्दी फुल, सिमली) लाइम पेगल तयार गरी नरम माटोमा रोप्ने काम । पेग १ मि लामो र ०.५ मि गाड्नु पर्ने । लाइन मिलाइ ५ से मि दुरीमा रोप्ने र लाइनको दुरी ५ देखि २० से.मि.को हुनु पर्ने र मेजेेशनवाट इन्टरवोपेन भएको हुनु पर्ने । (घ) फेसिसन निर्माणको लागि साइट तयार गर्ने, २० से मि गहिरो टेन्च बनाउने काम सहित ।	१००० गोटा मी मी	ज्यामी ज्यामी ज्यामी	संख्या संख्या संख्या	०.८५ ०.१७ ०.१२	लाइम पेगल लाइम पेगल	संख्या संख्या	२० २०	बुङ्दुरी कोबार कोबार मैसी बेल्ला	- - -	श्रमिक खर्चको ३ % श्रमिक खर्चको ३ % श्रमिक खर्चको ३ % श्रमिक खर्चको ३ %	आवश्यक मात्रामा कटिंग उपलब्ध हुनु पर्ने

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समुह २७ : वायो इन्जिनियरिंगको काम

	कार्यको विवरण	एकाई	श्रोत साधन						कैफियत			
			श्रमिक		निर्माण सामग्री		यान्त्रिक उपकरण					
			तह	एकाई	परिमाण	क्रिसिम	एकाई	क्रिसिम		परिमाण	एकाई	क्रिसिम
२७	(ड०) तोकिएको स्पेसिज (जस्तै: असुरो, नाम्दी फूल, सिमली) को हाईबुड कटिंग प्रयोग गरि लाइभ फेसिसन राख्ने काम १ मि लामो कटिंगलाई वण्डल पारी १ मिटरमा ४ मिटर लाग्ने गरी राख्ने, माटोले पुर्ने र कम्पैक्सन गर्ने जस्ता सम्पूर्ण काम ।	मी	ज्यामी	संख्या	०.१७	कटिंग	मि	८.००	खुकुरी बेल्वा	- -	श्रमिक खर्चको ३ %	(नेट: जाली बुन्ने काममा टोको प्रयोग गरिन्छ । यस्तो सार सामान्यतया नोटो वास्तलाई चिरी बनाएकै हुन्छ
	(११) जुटको जाली बुन्ने काम (क) नांगो स्लोप र पहिरोमा विरवा रोप्नको निमित्त कच्चा जुटबाट धागो डोरी निकाली त्यसबाट स्टाण्डर्ड जाली बुन्ने काम । ५ देखि ८ मि मि व्यासको हात बुना धागो डोरीबाट, १.२० मी चौडाइको जाली, प्रति १०० से.मि मा २७ वटा डोरी राख्ने प्रति १०० से.मि मा २० देखि २४ वटा छड्के डोरी र मेज साइज ३० देखि ४० मि मि को वर्गाकार, र १.२० मि चौडाईमा प्रति मिटर १.२५ के.जी तौल भएको ।	ब.मि	सिपालु	संख्या	०.३६	कच्चा जुट	के.जी	१.२५	खुकुरी वासकोडण्डी (१०गोटा) बुन्ने फ्रेम टोसरो	-	श्रमिक खर्चको ३ %	
	(ख) स्लोपमा मल्व अड्याउने कामको निमित्त कच्चा जुट वाट धागो डोरी बनाउने वाइड मेस जाली बुन्ने, यस्तो जाली ३ देखि ५ मि मि व्यासको धागो डोरीले बुनेको १.२ मि चौडाइ र ११.२० मि लम्वाई साइजको जालीमा १५० मिमि ^२ ४०० मिमि मेस साइज र प्रति १.२० मी लम्वाईमा ०.२५ के जी तौल भएको हुनु पर्ने ।	ब.मि	सिपालु	संख्या	०.१५	कच्चा जुट	के.जी	०.२५	खुकुरी वासकोडण्डी (१०गोटा) बुन्ने फ्रेम टोसरो	-	श्रमिक खर्चको ३ %	

समूह २७ : वायो इन्जिनियरिंगको काम

कार्यको विवरण	एकई	श्रोत साधन						कैफियत		
		श्रमिक		निर्माण सामग्री		यांत्रिक उपकरण				
		तह	एकई	परिमाण	किसिम	एकई	परिमाण		किसिम	एकई
(ग) ३० देखि ४० मि मि साइजको वर्गाकार कोठा भएकै जुटको जालीलाई नौगो स्लोपमा राखन र लाइम पेग वा बाँसको पेग राख्ने काम सहित	ब.मि	सिपालु	संख्या	०.१५	जुटको जाली	ब.मि	१.००	५० से मि लामो एम एस रड (कठको हैम्पर)	-	श्रमिक खर्चको ३ %
(घ) १५० मि.मि. ५०० मि.मि मेस साइजको जुटको जालीलाई नौगो स्लोपमा मल्ल अड्याउने कामको लागि राख्ने, मल्ल राख्ने र लाइम पेग वा बाँसको पेग राख्ने काम सहित ।	ब.मि	सिपालु	संख्या	०.१०	मल्ल जुटजाली	ब.मि	०.०५	५० से मि लामो एम एस रड (कठको हैम्पर)	-	श्रमिक खर्चको ३ %
(१२) ग्यावियन सिलिण्डर बोल्टर बनाउने काम	मि	ज्यामी	संख्या	०.०८५				मैचि बेल्ला	-	श्रमिक खर्चको ३ %
(क) ३० से.मि व्यासको बोल्टरको लागि ठाउँ तयार गर्ने: देखमा माटो खन्ने काम ।	मि	सिपालु	संख्या	०.०५				मैचि बेल्ला	-	श्रमिक खर्चको ३ %
(ख) ६० से.मि व्यासको बोल्टरको लागि ठाउँ तयार गर्ने: देखमा माटो खन्ने काम ।	मि	ज्यामी	संख्या	०.३६				मैचि बेल्ला	-	श्रमिक खर्चको ३ %
(ग) बोल्टर पानेल बनाउने काम: ७० मि मि _x १०० मिमि साइजको षटकोणिय मेस बनाउने (बोर्डको लागि १० एस डब्लु जि र जाली को लागि १२ एस डब्लु जि को ग्यावियन तार)	ब.मि	ज्यामी	संख्या	०.१०	जिआइ तार	के.जी	२.००	मेवियन फ्रेम र टुल	-	श्रमिक खर्चको ३ %

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समुह २७ : वायो इन्जिनियरिंगको काम

	कार्यको विवरण	एकई	श्रोत साधन								कैफियत	
			श्रमिक		निर्माण सामग्री		यांत्रिक उपकरण					
			तह	एकई	परिमाण	किसिम	एकई	परिमाण	किसिम	एकई		परिमाण
	(घ) ३० से.मि व्यासको बोल्टर सिलिण्डर निर्माण गर्ने ठाउँमा राख्ने, तन्काउने, ढुंगाले पर्ने, बन्द गर्ने र व्याक फिल गर्ने काम	मि	ज्यामी	संख्या	०.३७५	ढुंगा	घ.मि	०.०९	मेकियनटुल्स डोको	-	श्रमिक खर्चको ३ %	
	(ङ) ६० से.मि व्यासको बोल्टर सिलिण्डर निर्माण गर्ने ठाउँमा राख्ने, तन्काउने, ढुंगाले पर्ने, बन्द गर्ने र व्याक फिल गर्ने काम	मि	ज्यामी	संख्या	०.७५	ढुंगा	घ.मि	०.३६	मेकियनटुल्स डोको	-	श्रमिक खर्चको ३ %	
	(च) ३० से.मि व्यासको बोल्टर सिलिण्डर निर्माण गर्ने ठाउँमा राख्ने २० गेजको कालो पोलिथिन सिट राखि तन्काउने, ढुंगाले पर्ने, बन्द गर्ने र व्याक फिल गर्ने काम	मि	ज्यामी	संख्या	०.३७५	कालो पोलिथिन गिट्टी	ब.मि घ.मि	०.४० ०.०९	मेकियनटुल्स डोको	-	श्रमिक खर्चको ३ %	
	(छ) ६० से.मि व्यासको बोल्टर सिलिण्डर निर्माण गर्ने ठाउँमा राख्ने २० गेजको कालो पोलिथिन सिट राखि तन्काउने, ढुंगाले पर्ने, बन्द गर्ने र व्याक फिल गर्ने काम	मि	ज्यामी	संख्या	०.७५	कालो पोलिथिन गिट्टी	ब.मि घ.मि	०.८० ०.३६	मेकियनटुल्स डोको	-	श्रमिक खर्चको ३ %	
	(ज) बोल्टरलाई अड्याउने काम: १२ मि मि व्यासको फालासे डण्डी २ मि लम्बाई टुक्रामा कट्टी ११ मिटर फरकमा पर्ने गरी बोल्टर लाई अड्याउने	संख्या	ज्यामी	संख्या	०.५	एम एस रड	मि	२.००	स्लेज हेमर	-	श्रमिक खर्चको ३ %	
	(झ) जियो टेक्सटाइल सिट राख्ने काम ।	ब.मि	ज्यामी	संख्या	०.०५	टेरमोपेपर	ब.मि	१.१५	खुकुरी	-	श्रमिक खर्चको ३ %	

समुह २७ : वायो इन्जिनियरिंगको काम

	कार्यको विवरण	एकई	श्रोत साधन										कैफियत
			श्रमिक		निर्माण सामग्री		यांत्रिक उपकरण						
			तह	एकई	परिमाण	किसिम	एकई	परिमाण	किसिम	एकई	परिमाण		
२७	(१३) बाँसद्वारा दि गाई बनाउने (क) बाँसको ठण्डी ठाडो पारी बाँसको जाली बनाउने काम: उचाई: १.६० मि बाँसलाई चिरी जाली बुन्ने काम । यसरी जाली बुन्दा जालीलाई बाँसको ठाडो ठण्डी (पोष्ट) मा राम्ररी कसिने गरी बुन्नु पर्ने । दि गाईको साइज: ६० से.मि व्यास र उचाई १.३० मी ।	संख्या	ज्यामी	संख्या	०.२५	बाँस	संख्या	२.२०	बुकुरी	-	श्रमिक खर्चको ३ %		

STANDARD SPECIFICATIONS FOR BIO-ENGINEERING WORKS (INTERIM)

- 2800 PROVISION OF SEED**
 - 2801 GRASS SEED COLLECTION
 - 2802 TREE AND SHRUB SEED COLLECTION
- 2810 PROVISION OF PLANT CUTTINGS**
 - 2811 PROVISION OF GRASS CUTTINGS
 - 2812 PROVISION OF HARDWOOD CUTTINGS
- 2820 NURSERY CONSTRUCTION**
 - 2821 NURSERY ESTABLISHMENT
 - 2822 CONSTRUCTION OF NURSERY BEDS
- 2830 NURSERY OPERATION AND MANAGEMENT**
 - 2831 NURSERY PRODUCTION OF GRASS
 - 2832 NURSERY PRODUCTION OF TREES AND SHRUBS IN POLYPOTS
 - 2833 NURSERY PRODUCTION OF HARDWOOD PLANTS BY VEGETATIVE METHODS
 - 2834 EXTRACTION OF PLANTS FROM THE NURSERY
 - 2835 COMPOST AND MULCH PRODUCTION
- 2840 FINAL SLOPE PREPARATION FOR BIO-ENGINEERING**
 - 2841 CUT SLOPE PREPARATION FOR GRASS PLANTING
 - 2842 FINAL PREPARATION OF FILL SLOPES FOR BIO-ENGINEERING
- 2850 SITE PLANTING AND SOWING**
 - 2851 SOWING OF GRASSES ON SITE
 - 2852 DIRECT SEED SOWING OF SHRUBS AND TREES ON SITE
 - 2853 SITE PLANTING OF GRASS SLIPS AND CUTTINGS
 - 2854 SITE PLANTING OF SHRUBS AND TREES RAISED IN POLYTHENE POTS
 - 2855 SITE PLANTING OF HARDWOOD CUTTINGS
 - 2856 BRUSH LAYERING, PALISADES AND FASCINES
 - 2857 USE OF FERTILISER
- 2860 JUTE NETTING WORKS**
 - 2861 SUPPLY OF JUTE NETTING
 - 2862 PLACEMENT OF NETTING
- 2870 GABION WIRE BOLSTERS**
 - 2871 FABRICATION OF BOLSTER PANELS
 - 2872 PLACEMENT OF CONTOUR BOLSTERS
 - 2873 PLACEMENT OF HERRINGBONE BOLSTERS
- 2880 SITE PROTECTION**
 - 2881 PROVISION AND ROLE OF SITE WATCHMEN
 - 2882 FABRICATION OF BAMBOO TREE GUARDS
 - 2883 PLACEMENT OF BAMBOO TREE GUARDS
- 2890 SITE AFTERCARE AND MAINTENANCE**

2800 PROVISION OF SEED

1. The Contractor shall provide or collect seeds of the required species in accordance with the requirements described hereafter, of the species and quantities required, as and when required. He shall supply all necessary expertise, resources and facilities to ensure that these requirements are met in full. It is essential that the seed is of a high quality as it forms the basis to the success of any bio-engineering programme.
2. The Engineer will give indications as to the expected amounts of seeds required and the time of availability. But it is the Contractor's responsibility to ensure that adequate quantities of seeds are obtained in a timely fashion.
3. The weights to be specified are for sun-dried seeds separated completely from fruiting bodies and other unwanted parts, and ready for storage and subsequent sowing. There is usually a large discrepancy between this weight and that of the freshly collected, untreated fruits.
4. Should the Contractor be unable to supply the specified seeds, the advice of the Engineer should be sought. It may be possible to substitute other species. Some commercial seed sources in Nepal and India are known to supply old or badly treated seeds. For this reason, seed should not be obtained commercially without the Engineer's written authority.

2801 GRASS SEED COLLECTION

1. The species of grass seeds to be collected will be determined by the Engineer. The Contractor will be responsible for determining seed sources, though these may be specified by the Engineer's instructions. Seeds should normally be collected in or very close to Division of use or the project area.
2. If the Engineer does not specify the species, then the current approved list of bio-engineering plants, as determined by the Geo-Environmental Unit of the Department of Roads should be referred to.
3. Seeds must be collected from as many individual plants as possible. With grasses, it is difficult to determine the best genetic material from the appearance of form; but it is generally sound practice to select from the largest and most vigorous plants.
4. The Contractor may under no circumstances damage or remove the roots of grass plants while collecting seed. The Contractor is responsible for safety measures and for making all necessary arrangements with landowners, farmers and the local District Forest Office, as applicable, before the collection of seeds.
5. Seeds may only be collected when fully ripe. Seeds collected early are not viable when planted and will cause a failure of the planting programme. The Contractor will be held liable if the germination rate of seeds is seriously lower than the normally expected percentage (as defined in publications issued by the Geo-Environmental Unit).
6. Immediately after collection, seeds must be separated from flower heads by the method normally used by farmers for other grasses. Once separated, the seeds must be sun-dried before storage.
7. Seeds must be stored in a cool, dry, ventilated building with adequate precautions taken against pests. Containers should be raised above the floor. They should not be kept in the same building as cement, or any chemicals, fuels or lubricants. Grass is best stored in bags made of hessian (jute) sheet. Seeds should be carefully inspected on a weekly basis to ensure that there is no deterioration or mould formation, or pest attack. Seeds can only be stored successfully if they have been properly dried in the sun beforehand.

2802 TREE AND SHRUB SEED COLLECTION

1. The species of tree and shrub seeds to be collected will be determined by the Engineer. The Contractor will be responsible for determining seed sources, though these may be specified by the Engineer's instructions. Seeds should normally be collected in or very close to the working area.
2. If the Engineer does not specify the species, then the current approved list of bio-engineering plants, as determined by the Geo-Environmental Unit of the Department of Roads should be referred to.
3. Seeds must be collected from as many healthy individual plants as possible. In any event, they must be collected from at least ten individual plants. The plants from which the seeds are collected must show vigorous growth and good form. Mis-shaven and stunted plants should not be considered.
4. The Contractor must under no circumstances damage plants while collecting seed. The Contractor is responsible for making all necessary arrangements with landowners, farmers and the local District Forest Office, as applicable, before the collection of seeds.
5. The collection of seeds from trees can be a dangerous business, placing the collectors at considerable personal risk. Specialist equipment and training is available in Nepal for this purpose. It is the Contractor's responsibility to ensure safe working conditions for his employees or subcontractors.
6. Seeds may only be collected when fully ripe. Seeds collected early are not viable when planted and will cause a failure of the planting programme. The Contractor will be held liable if the germination rate of seeds is seriously lower than the normally expected percentage.
7. Immediately after collection, seeds must be separated from fruit by the method normally used by farmers and foresters for this purpose; this depends on the individual species but may be a time-consuming process for certain fruits. Once separated, the seeds must be sun-dried before storage.
8. Seeds must be stored in a cool, dry, ventilated building with adequate precautions taken against pests. Containers should be raised above the floor. They should not be kept in the same building as cement, or any chemicals, fuels or lubricants. If kept in sealed containers, the seeds should be carefully inspected on a weekly basis to ensure that there is no deterioration or mould formation. Seeds can only be stored successfully if they have been properly dried in the sun beforehand.

2810 PROVISION OF PLANT CUTTINGS

1. The species of plants to be collected for vegetative propagation will be determined by the Engineer. The Contractor will be responsible for determining plant material sources, though these may be specified by the Engineer's instructions. Plants should normally be collected in or very close to the working area.
2. If the Engineer does not specify the species, then the current approved list of bio-engineering plants, as determined by the Geo-Environmental Unit of the Department of Roads should be referred to.

2811 PROVISION OF GRASS CUTTINGS

1. Cuttings of various types must be taken from grass species which are known to propagate easily by vegetative means.
2. Cuttings must be made from as many healthy individual plants as possible. The plants from which the cuttings are taken must show vigorous growth and good form. Grass clumps showing stunted growth should not be considered as sources.
3. Apart from the clumps which are dug up to make cuttings, the Contractor must under no circumstances damage other plants. The Contractor is responsible for making all necessary arrangements with landowners, farmers and the local District Forest Office, as applicable, before the making of hardwood cuttings.
4. The type of cuttings to be made depends on the species and should be as shown in the table below. If the species used is not listed here, then the latest technical information provided by the Geo-Environmental Unit should be consulted. If the species is still not covered, then stem and root slip cuttings should be used.

Local name	Botanical name	Best propagation	Details
Amliso	<i>Thysanolaena maxima</i>	Rhizome cuttings	Stem: 100 - 150 mm; rhizome: 50 - 80 mm
Babiyo	<i>Eulaliopsis binata</i>	Slip cuttings	Stem: 100 - 150 mm; root: 30 - 60 mm
Dhonde	<i>Neyraudia reynaudiana</i>	Stem/slip cuttings	Stem cuttings: 2 nodes plus 50 mm each side Slips: stem: 100 - 150 mm; root: 30 - 60 mm
Kans	<i>Saccharum spontaneum</i>	Slip cuttings	Stem: 100 - 150 mm; root: 30 - 60 mm
Khar	<i>Cymbopogon microtheca</i>	Slip cuttings	Stem: 100 - 150 mm; root: 30 - 60 mm
Khus	<i>Vetiver zizanioides</i>	Slip cuttings	Stem: 100 - 150 mm; root: 30 - 60 mm
Napier	<i>Pennisetum purpureum</i>	Stem cuttings	Two nodes plus 50 mm each side
Narkat	<i>Arundo clonax</i>	Stem/slip cuttings	Stem cuttings: 2 nodes plus 50 mm each side Slips: stem: 100 - 150 mm; root: 30 - 60 mm
Padang bans	<i>Himalayacalamus hookerianus</i>	Large slip cuttings	Stem: 750 - 1200 mm; root: 100 - 200 mm
Phurke	<i>Arundiuella nepalensis</i>	Slip cuttings	Stem: 100 - 150 mm; root: 30 - 60 mm
Sito	<i>Neyraudia arundinacea</i>	Slip cuttings	Stem: 100 - 150 mm; root: 30 - 60 mm
Tite nigalo	<i>Drepanostachyum intermedium</i>	Large slip cuttings	Stem: 750 - 1200 mm; root: 100 - 200 mm

5. Where roots are required for the cuttings, grass clumps should carefully dug up. They must not be pulled hard, as this can damage the material. They must be separated carefully by hand, using a sharp khukuri or razor blade when necessary. There must be no tearing of the plant fabric.
6. Stem cuttings must be made using sharp secateurs. The top cut should be made at rightangles to the stem and the bottom cut should be made at 45° to the stem: this is to show the orientation of planting.

7. Once cuttings have been made, they must be wrapped in wet hessian jute immediately. At all times, cuttings are to be kept moist and as cool as possible, and should be wrapped in wet hessian between all operations such as digging out of the ground, splitting out, trimming and planting. Under any circumstances, all cuttings must be planted the same day that they are made.

2812 PROVISION OF HARDWOOD CUTTINGS

1. Hardwood cuttings must be taken from shrubs and trees of species which are known to propagate easily by vegetative means.
2. Cuttings must be made from as many healthy individual plants as possible. The plants from which the cuttings are taken must show vigorous growth and good form. Mis-shaven and stunted plants should not be considered as sources.
3. Apart from the branches from which cuttings are taken, the Contractor must under no circumstances damage plants while taking cuttings. The Contractor is responsible for taking safety precautions and for making all necessary arrangements with landowners, farmers and the local District Forest Office, as applicable, before the making of hardwood cuttings.
4. Hardwood cuttings must be made from stems which are between 6 and 18 months old. Materials outside this range are not normally vigorous or strong enough to survive as cuttings. The Contractor may be held liable if the success rate of cuttings is seriously lower than the normally expected percentage.
5. Hardwood cuttings must be made using sharp secateurs or a sharp saw. The top cut should be made at rightangles to the stem and the bottom cut should be made at 45° to the stem: this is to show the orientation of planting. Under no circumstances must there be any damage to the bark of the cutting.
6. Hardwood cuttings are normally 300 to 500 mm in length and 20 to 40 mm in diameter. This size should not be exceeded for the majority of species unless specified by the Engineer.
7. A number of species can be propagated using large truncheon cuttings. In this category fall chuletro (*Brassaiopsis hainla*), dabdabe (*Garuga pinnata*), kavro (*Ficus lacor*), phaledo (*Erythrina* species) and *Gliricidia sepium*. Hardwood cuttings for these species should be in the range of 1500 to 2500 mm in length and 30 to 80 mm in diameter unless otherwise specified.
8. Once cuttings have been made, they must be wrapped in wet hessian jute immediately. At all times, cuttings are to be kept moist and as cool as possible, and should be wrapped in wet hessian between all operations such as taking from the parent plant, trimming and planting. Under any circumstances, all cuttings must be planted the same day that they are made.

2820 NURSERY CONSTRUCTION

1. The Contractor shall provide nurseries to contribute stocks of grasses, shrubs and trees for planting operations as required by the Engineer. This shall be done according to the specifications described hereunder, as and when required by the Engineer. The Contractor shall supply all necessary expertise, resources and facilities to ensure that these requirements are met.
2. The establishment and effective operation of plant nurseries is a skilled business requiring experienced and trained staff. These specifications alone do not provide all the information needed to set up and run nurseries. The Contractor should seek the advice of specialist agencies and should refer to the large number of reference books available on the subject.
3. The purpose of a nursery is to supply good quality, healthy plants of the correct type and species, at the precise time they are required, and at a reasonable cost.

2821 NURSERY ESTABLISHMENT

1. The Contractor shall provide nursery facilities adequate to supply all of the stock required for planting operations. Alternatively, he may procure planting stock from elsewhere at the time of site planting, providing it is of a standard acceptable to the Engineer and as described hereunder.
2. In selecting a site for a nursery, the Contractor must fulfil the following requirements.
 - (i) Nurseries must be as close as possible to all sites to be planted. They must be at the same altitude as, and in an identical climatic area to, the sites to be planted.
 - (ii) Wherever possible, nurseries must be established on land owned by the Department of Roads if it is available and biophysically suitable. If it is not, other land of His Majesty's Government should be used if it is available.
 - (iii) Nurseries should have a reliable and adequate supply of water which remains constant throughout the later part of the dry season.
 - (iv) Nurseries should have all weather vehicular access.
 - (v) Nurseries should have a perimeter of stock proof fencing, effective against all domestic animals.
 - (vi) Nurseries should have a weather- and pest-proof office cum seed store and proper storage facilities for seed. Seed must be kept cool, dry and in sealed containers, as specified in clauses 2801 and 2802.
 - (vii) All nurseries should be provided with at least two above-ground compost bays, built of stone, brick or timber. These will be used on an alternate basis to ensure a continual supply of compost.
 - (viii) Where a nursery is established on a slope exceeding 2°, the ground must be levelled by terracing before beds are constructed.
 - (ix) A constant staff of qualified and experienced people must be provided.
 - (x) There must be adequate space in each nursery location for all operations to be performed in the cycle of work. In particular, all plants need to be spaced out periodically as they grow and there must be adequate bed area to accommodate them.

2822 CONSTRUCTION OF NURSERY BEDS

1. Nursery beds must be made in a different way according to their purpose. The Contractor must ensure that there are adequate beds available for all the operations to be undertaken in the nursery.
2. There must be paths around all beds to ensure the best possible access for operations such as weeding and watering.
3. The table below summarises the construction details of the four main bed types, which are described in full in paragraphs 4 to 7.

Bed type	Beds for grass seeds, grass slips and tree stool cuttings	Seed beds for tree seedlings	Stand out beds for polypots seedling	Beds for the propagation of bamboo culm cuttings
Bed size	1000 mm wide × 250 mm high	1000 mm wide × 170 mm high	1000 mm wide × 150 mm high	1000 mm wide × 300 mm high
Details of construction	50 mm of washed gravel placed above the ground; then 50 mm of 1:1 mix of sieved soil and compost; and topped with 150 mm of 3:1 mix of sieved forest topsoil and washed sand.	50 mm of washed gravel placed above the ground; then 50 mm of unsieved forest soil; 50 mm of 1:3 mix of sieved forest soil and washed sand; and topped with 20 mm of washed, sieved and sterilised sand.	50 mm layer of gravel placed above compacted ground. A flat stone or brick surround.	Ground below the bed is dug to a depth of 300 mm. Bed is made with 100 mm of unsieved soil (lower) and 200 mm of sieved soil (upper). A bund 100 mm high is formed around the edge.

4. Soil beds should be constructed to hold grass seeds, grasses being propagated by vegetative means and tree stool cuttings. These can be of any practical length but must be flat and of one metre in width. They should rise to a height of 250 mm above the surrounding ground. They are made up as follows: 50 mm of washed gravel is placed above the ground; then 50 mm of 1:1 mix of sieved soil and compost; and the bed is topped with 150 mm of 3:1 mix of sieved fertile, loamy forest topsoil and washed sand. All sieving should be done with a mesh size of 2 mm or smaller. One square metre of such a bed will contain 100 grass slips spaced at 100 mm centres within rows at 100 mm centres and will produce at least 300 slips for planting out, depending on the particular species, and the soil and climate of the nursery.

5. Seed beds must be made very carefully for germinating small seeds of shrubs and trees. These can be of any practical length but must be flat and of one metre in width. They should rise to a height of 170 mm above the surrounding ground. They are made up as follows: 50 mm of washed gravel is placed above the ground; then 50 mm of unsieved forest soil; 50 mm of 1:3 mix of sieved forest soil and washed sand; and the bed is topped with 20 mm of washed, sieved and sterilised sand. All sieving should be done with a mesh size of 1 mm or smaller.

6. Standout beds should be constructed to hold seedlings in polythene pots. These can be of any practical length but must be flat and of one metre width. Bed floors should be above surrounding ground level and they should have a 50 mm layer of gravel placed above compacted ground. They should have a surround, preferably made from flat stones or bricks. One square metre of standout bed will contain an average of 115 filled pots of the size specified (100 × 180 mm) when spaced out.

7. Beds for the propagation of bamboo culm cuttings should be made specially. These can be of any practical length but must be flat and of one metre width. They should rise to a height of 300 mm

above the surrounding ground. They are made up as follows: the ground below the bed is dug to a depth of 300 mm; the bed itself is then made with 100 mm of unsieved soil on the original surface, and 200 mm of sieved soil above this. All soil sieving should be done with a mesh size of 2 mm or smaller. Finally, a bund 100 mm high is formed around the edge.

8. Shades must be constructed over the beds and kept in position over delicate seedlings during hours of intense sunlight, according to need. Shades should be 750 to 1000 mm above the soil or the top of filled pots, and angled so as to be effective for as much of the day as possible (*ie* with the lower side to the south). Bamboo strips laced together with coir (coconut fibre) string are particularly suitable in most cases; but over tree and shrub seed beds, thatched shades with a polythene lining must be used.

2830 NURSERY OPERATION AND MANAGEMENT

1. The contractor must operate the nursery according to a high standard. The nursery is to be staffed well tended at all times. It must be maintained in a clean, tidy and efficient manner at all times. Plants must always be healthy and vigorous.
2. Due to the nature of bio-engineering works, nurseries will normally be operated and managed by small local contractors with a range of agricultural skills. Nurseries may also be operated and managed by direct employees of the Division Road Office.
3. Plants must be kept properly weeded at all times.
4. Watering, as required for good plant growth, must be carried out regularly in the cool of the evening between sunset and dusk. The Contractor must ensure that the soil in all beds is kept moist but not saturated at all times. Beds must be kept moist even when empty, so that the soil is kept in good condition.
5. The timing of many nursery operations is of the utmost importance. Activities such as seed sowing and the taking of cuttings must be carried out within the critical few weeks when they will yield the desired results. Most other operations, such as spacing out, root pruning and watering, must also be carried out in a timely manner. The contractor is responsible to keep works to the strict schedule required and under no circumstances to permit delays.

2831 NURSERY PRODUCTION OF GRASS

1. Grass will be propagated in nurseries either by seeding in carefully prepared beds or by vegetative propagation.
2. Where grass seeding is required in the nursery, finely sieved fertile soil mixed with clean sand to a texture of sandy loam must be placed in beds before the seeds are sown. Seeds will be covered with a sheet of hessian jute until they have germinated, when it will be carefully removed. Watering of fresh seedlings will be by a fine spray and not by the rose of a watering can.
3. Grasses to be propagated by vegetative methods will be of the species instructed. The Contractor should obtain adequate quantities of the plant material required, but under no circumstances is he to cause serious depletion of grass stocks in any steep or erosion-prone area.
4. Vegetative propagation will normally be by rhizome cuttings. With this method, the grass is treated in exactly the same way as a bamboo being propagated by the traditional Nepalese farmer's technique. A clump is carefully dug up and brought to the nursery, being kept cool and damp at all times. Stems are cut above the first or second node above the ground: this usually gives a length of 100 to 200 mm. The clump is separated carefully, with the minimum of damage to the rhizomes and fine roots. Slips should be separated out which keep a length of stem and about 50 mm of the rhizome. Each slip should have some buds on the rhizome, but in some grasses these can be difficult to see. The slips should be planted with the soil surface at the same level as it was originally, in rows at 200 mm centres; slips should be at 200 mm centres within the rows. A sheet of hessian jute should be placed over the tops of the cuttings. When the new shoots are about 50 mm long, it can be removed.
5. Every two to three months, all grasses should be lifted from the beds, split carefully and replanted. It is normal that, once split out, three times the previous bed area is required. This is a standard practice to bulk up the supply of planting stock without having to degrade the natural vegetation cover in the region of the nursery.

2832 NURSERY PRODUCTION OF TREES AND SHRUBS IN POLYPOTS

1. Trees and shrubs will be seeded either in seed beds or directly in polythene pots ("polypots"). Finely sieved fertile soil mixed with clean sand to a texture of sandy loam must be placed in well shaded beds for seeding. Watering of fresh seedlings will be by a fine spray, and not by the rose of a watering can.
2. All plants must be grown on in pots of dimensions 100 × 180 mm (4 × 7 inches) or greater when laid flat. The pots should be of black, 200 gauge polythene. They must have adequate drainage holes at the bottom and be filled with fertile forest topsoil mixed with clean sand to a texture of sandy loam.
3. Roots protruding from the bottom of pots must be pruned with a razor blade on a regular basis which will not exceed weekly and may need to be more frequent. Protruding roots should never be allowed to become more than 25 mm in length.
4. When polypot seedlings begin to compete with each other for light, they should be respaced as required. This would typically mean doubling the bed space occupied by the plants.
5. To be acceptable for planting on site, trees and shrubs must be healthy, vigorous and showing no signs of damage, wilt, irregular growth, fungal or pest attack, or nutrient disorders. They must be at least 300 mm in height above soil surface level and of good form. The roots must be in good condition and there should be no signs of disturbance to the soil in the polythene pot, even after transport to site.

2833 NURSERY PRODUCTION OF HARDWOOD PLANTS BY VEGETATIVE METHODS

1. Trees and shrubs which can be propagated by vegetative methods may be specified by the Engineer. The Contractor should produce these by the appropriate method, as required.
2. All cuttings and stools must be made as specified in clause 2812 and planted in fertile soil beds of the type specified in clause 2822.
3. Cuttings must be planted 300 mm apart in holes slightly larger than their diameter. They must be placed at such a depth that only one bud remains above the soil surface (*ie* about 30 mm of the cutting).
4. When plants compete with each other for light, they should be cut back as necessary.
5. To be acceptable for planting on site, trees and shrubs produced in this way must be healthy, vigorous and showing no signs of damage, wilt, irregular growth, fungal or pest attack, or nutrient disorders. They must be at least 500 mm in height above soil surface level and of good form.

2834 EXTRACTION OF PLANTS FROM THE NURSERY

1. The Contractor is responsible for extracting plants from nursery beds and preparing them ready for transport. They should be extracted from the beds only on the morning that they are required for planting on site.
2. Plants must be hardened off, starting at least two weeks before they are to be taken out of the nursery. This process requires a gradual reduction in the amount of watering and shading. The aim is to prepare them for transfer to a much more hostile location.
3. The night before the plants are to be lifted, they should be thoroughly watered. This is to make the soil softer and ease the business of extracting the roots.

4. Plants growing in soil beds should be carefully lifted from the soil. There must be no pulling of stems or roots, but they must be dug out and extracted with no strain on any part of the plant.
5. Plants from soil beds must be wrapped in wet hessian jute. Hardwood plants should have a ball of soil around the roots. Grass clumps can have most of the soil shaken or washed off.
6. Polypot seedlings should be lifted and stacked neatly in metal or wooden trays. They must always be lifted by the pot and never by the stem or leaves.
7. All plants are to be kept moist, in a cool, shady place, until they are loaded for transport to site. In the vehicle, they must not be stacked high. For transport on rough roads, they must be packed in carefully so that they do not fall over or roll around. The vehicle must be shaded.

2835 COMPOST AND MULCH PRODUCTION

1. The Contractor is to produce compost and mulch for nursery or site operations. It is to be produced in a timely manner, in the quantities required. Compost is normally required to sustain the long term fertility of nursery beds. Mulch may also be used in the nursery, but is normally produced to enhance site planting works, particularly the direct seeding of grass.
2. Compost and mulch should be made from annual and perennial weeds of poor rooting characteristics, such as ban mara (*Eupatorium adenopherum*) and tite pate (*Artemesia vulgans*). The greenery should be collected when there is most material available but before it forms seeds. This is most often in Shrawan and Bhadra.
3. Collected material should be chopped finely and stored in a mound, compost bay or pit. The maximum size for chopped compost is 50 mm; the maximum size for chopped mulch is 150 mm.
4. Both compost and mulch should be kept moist but not waterlogged and in an aerated condition. They should be completely turned once a month on a regular schedule. Compost can have cow manure mixed in to assist the process of decomposition.
5. Neither compost nor mulch should be applied until they are fully rotted. By this time they should be black and the parts of individual plants should be indistinguishable. Early application can lead to a nutrient loss in the soil if microbes extract nitrogen to decompose the added organic material.

2840 FINAL SLOPE PREPARATION FOR BIO-ENGINEERING

1. The Contractor shall prepare slopes for planting operations as required by the Engineer. This shall be done according to the specifications described hereunder, as and when required. The Contractor shall supply all necessary expertise, resources and facilities to ensure that these requirements are met.
2. In the course of all slope preparation works, it is essential that no damage is done to existing vegetation unless the Engineer's instruction specifically requires certain plants to be removed.
3. The timing of many bio-engineering operations is of the utmost importance. Activities such as planting and seed sowing must be carried out within the critical few weeks when they will yield the desired results. All other operations must be carried out in a timely manner to permit this to happen. The contractor is responsible to keep works to the strict schedule required and under no circumstances to permit delays.

2841 CUT SLOPE PREPARATION FOR GRASS PLANTING

1. The objective of final cut slope preparation is to produce a surface adequately prepared for grass planting. Grass lines are used to provide a strong surface cover but need a well prepared surface in which to be planted; if grass is to be an effective form of slope protection, it must be allowed to establish properly on a slope which does not subject it to undue stress from erosion and mass movement in its initial stages.
2. The Contractor must ensure that the slope under instruction is trimmed to a straight angle, according to the Engineer's specification. Cut slopes to be planted with grass will normally be instructed as 3 vertical:2 horizontal, but this may be varied at the Engineer's discretion. In any event, a straight profile must be obtained. Concavities must be filled with well compacted material or, in some cases, with dry stone dentition. Convexities must be removed and it is essential that the general profile does not have a shape giving over-steep segments.
3. All loose material must be removed from the slope and tipped elsewhere in an approved location.

2842 FINAL PREPARATION OF FILL SLOPES FOR BIO-ENGINEERING

1. The objective of the final preparation of fill slopes is to produce a surface adequately prepared for shrub or tree planting or grass sowing, or a combination of these. Vegetation is used to provide a strong surface cover but needs a well prepared surface in which to be planted: if it is to be an effective form of slope protection, it must be allowed to establish properly on a slope which does not subject it to undue stress in its initial stages.
2. The Contractor must ensure that the slope under instruction is trimmed to a straight angle, according to the specification. In any event, a straight profile must be obtained. All masses of loose debris, especially where it has previously been tipped at the head of the slope, must be removed. Concavities must be filled with well compacted material or, in some cases, with dry stone dentition. Convexities must also be removed and it is essential that the general profile does not have a shape giving over-steep segments.

2850 SITE PLANTING AND SOWING

1. The Contractor shall plant or sow grasses, shrubs and trees as required by the Engineer. This shall be done according to the specifications described hereunder, as and when required. The Contractor shall supply all necessary expertise, resources and facilities to ensure that these requirements are met.
2. Due to the nature of bio-engineering works, they will normally be undertaken by small local contractors with a range of agricultural skills. Any bio-engineering site activity may also be managed by direct employees of the Division Road Office.
3. It is the Contractor's responsibility to ensure that all planting stock, whether provided from a nursery under a separate contract or through a separate instruction, is of high quality and is vigorous enough to grow on the site to be planted.
4. All seeds and other planting stock must be of species indigenous to Nepal unless otherwise specified. All species must be covered in the current approved lists of species produced from time to time by the Geo-Environmental Unit of the Department of Roads. They must be appropriate for the precise site conditions in which they are to be planted and the Contractor must ensure that they apply to the specific altitude and other environmental characteristics of the site in question.
5. The timing of many bio-engineering operations is of the utmost importance. Activities such as planting and seed sowing must be carried out within the critical few weeks when they will yield the desired results. All other operations must be carried out in a timely manner to permit this to happen. The contractor is responsible to keep works to the strict schedule required and under no circumstances to permit delays.

2851 SOWING OF GRASSES ON SITE

1. The sowing of grasses is intended to create a strengthened slope surface which is resistant to erosion. The Contractor is required to carry out the sowing of grass seeds according to the Engineer's specific instructions.
2. It is assumed that the site will already have been prepared for seed sowing, under a separate instruction; but it is nevertheless the responsibility of the Contractor to ensure that the condition of the site is good enough for the successful establishment of grasses.
3. The Contractor is required to supervise all field operations very closely. The sowing of grass seeds is a delicate business and should be approached in the same way as for agricultural crops. The Contractor should employ experienced agricultural labourers for this work.
4. Seed will have been collected and stored under a separate instruction well before the time of sowing. However, it is the Contractor's responsibility to check that it has been carefully stored and remains fully viable.
5. Immediately before sowing, the ground surface should be lightly scarified to ease early root penetration. Seeds should then be laid thinly over the surface. Under no circumstances should they be broadcast, because the lightness of perennial grass seeds and the steepness of the slopes to be treated give a poor cover using such a technique. The Contractor is responsible for ensuring that the correct quantities of seeds are used, while giving a good, even cover.
6. A cover of 25 grammes of grass seed per square metre of surface should be achieved unless otherwise specified.

7. After sowing, a mulch of prepared and dried cut herbs should be laid over the whole seeded area in a thin layer. If the mulch is too thick it will prevent light from getting to the seed and will inhibit germination. Herbs suitable for this and locally available in large quantities are:

tite pate (*Artemisia vulgans*);

tapre (*Cassia* species);

ban mara (*Eupatorium adenophorum*).

However, freshly cut herbs should not be used because of the danger of resprouting and weeding.

8. If specified, the mulch should be secured with jute netting of mesh size 300 × 500 mm and the netting fixed in place using suitable live pegs or hardwood cuttings (*eg simali, Vitex negundo*) at one metre centres.

2852 DIRECT SEED SOWING OF SHRUBS AND TREES ON SITE

1. The direct sowing of shrubs and trees is intended to create a strengthened slope surface which is resistant to erosion, and anchorage of unstable surface layers. The technique is particularly effective where very stony materials preclude the use of other planting techniques or where the site will be badly affected by disturbance during the planting of polypot seedlings, or where the site is still unstable and does not warrant the costs involved in planting but would benefit from relatively cheap seeding. The Contractor is required to carry out the sowing of shrub and tree seeds according to the Engineer's specific instructions.

2. It is assumed that the site will already have been prepared for seed sowing, under a separate instruction; but it is nevertheless the responsibility of the Contractor to ensure that the condition of the site is good enough for the successful establishment of shrubs and trees.

3. The Contractor is required to supervise all field operations very closely. The sowing of any seeds is a delicate business and should be approached in the same way as for agricultural crops. The Contractor should employ experienced agricultural labourers for this work.

4. Seed will have been collected and stored under a separate instruction well before the time of sowing. However, it is the Contractor's responsibility to check that it has been carefully stored and remains fully viable.

5. Sowing should start at the top of the slope and the labourers should work downwards. Care must be taken not to disturb areas already seeded.

6. To sow the seeds, a small hole should be made in the slope. The tool used to do this depends on the size of the seed. For some seeds, a piece of gabion wire is adequate; for others, a piece of mild steel with a flattened end is required. The hole should be in the best soil available but if there is little real soil, then a crevice between two stones is acceptable. Two seeds should be placed in each hole and a covering of soil or whatever fines are available should be placed over them. This covering should never exceed 10 mm and should preferably be about 5 mm; it should never be less than this. Seeds should be placed at 50 to 100 mm centres, as ground conditions dictate.

7. In some cases the seed can be broadcast starting at the top of the site and working down slope as evenly as possible so that the whole site is lightly covered. This is used where the site is still active and only warrants minimum expenditure, or where the site is naturally rough, providing plenty of niches in which the seed can catch. Quantities of seed depend on the type of seed involved but are generally half that of the quantities used in the nursery. With utis (*Alnus nepalensis*) seed it should be at a rate of 1 gramme of seed per square metre.

2853 SITE PLANTING OF GRASS SLIPS AND CUTTINGS

1. The planting of grass slips and cuttings is intended to create a strengthened slope surface which is resistant to erosion. The Contractor is required to carry out the planting of grass seedlings or rooted cuttings, according to the Engineer's specific instructions. The configuration of planting will be determined according to individual site conditions. It will be either random, contoured or downslope.
2. It is assumed that the site will already have been prepared for planting, under a separate instruction; but it is nevertheless the responsibility of the Contractor to ensure that the condition of the site is good enough for the successful establishment of grasses, and accords with the specifications given in clauses 2840, and 2841 or 2842.
3. Using appropriate tools (such as tape measures and spirit levels), planting lines must be marked out with string as required. Unless specified differently, the row spacing to be marked out is as shown in the table below.
4. The Contractor is required to supervise all field operations very closely. The planting of grass slips is a delicate business and should be approached in the same way as the transplanting of millet seedlings. The Contractor should employ experienced agricultural labourers for this work.

Planting configuration	Slope steepness	Row spacing
Random lines	Slope less than 30 degrees	1000 mm centres
	Slope 30 to 45 degrees	500 mm centres
	Slope more than 45 degrees	250 mm centres
Contour lines	Slope less than 30 degrees	1000 mm centres
	Slope 30 to 45 degrees	500 mm centres
	Slope more than 45 degrees	250 mm centres
Diagonal lines	All slopes	500 mm centres
Downslope lines	All slopes	500 mm centres

5. The plants supplied to the Contractor should be prepared for planting by the Contractor as given below. The Contractor is to transport them from the nursery wrapped in hessian jute. At all times, plants are to be kept moist and as cool as possible, and should be wrapped in wet hessian between all operations such as extraction from the bed, pruning and planting. Under any circumstances, all plants supplied must be planted the same day that they are lifted from the nursery.
6. Grass slips or cuttings should be carefully separated from the clumps to give the maximum viable planting material. Any roots in excess of 25 mm should be cut off using a sharp khukuri or razor blade. Shoots and stems should be lopped off 100 mm above ground level.
7. Planting should be started at the top of the slope and under no circumstances should new plants be walked on or otherwise disturbed. Using a small bar (usually made of mild steel and with a flattened end), a hole should be made that is just big enough for the roots. The slip or cutting is inserted; care must be taken that the roots are not tangled or bent back to the surface. Soil is then replaced around the roots and firmed with the fingers. The spacing of plants within rows should be 100 mm unless otherwise specified.

8. If the soil is dry and there is no rain within 16 to 24 hours of planting, the site should be watered carefully with a fine spray. The Contractor will be required to water for the first two weeks after planting in the event of inadequate rainfall.

9. In certain circumstances it may not be possible to provide grass plants from a nursery. In this case the Engineer will specify the species and expected source of grass plants. It is important to minimise disruption to neighbouring land, in the event that species are collected from areas surrounding the road. It is the Contractor's responsibility to collect the stock required from a wide area and not to give rise to any soil erosion through the excessive removal of plants in one locality.

2854 SITE PLANTING OF SHRUBS AND TREES RAISED IN POLYTHENE POTS

1. The planting of trees and shrubs is intended to replace or restore something of the natural vegetation on the slope to be treated. The Contractor is required to carry out the planting of seedlings to the Engineer's specific instructions.

2. It is assumed that the site will already have been prepared for planting, under a separate instruction; but it is nevertheless the responsibility of the Contractor to ensure that the condition of the site is good enough for the successful establishment of delicate young plants.

3. The spacing of plants will be determined according to individual site conditions. However, it will normally be at one metre centres unless otherwise specified.

4. The Contractor is required to supervise all field operations very closely. The planting of trees and shrubs is a delicate business and should be approached in the same way as the planting of horticultural seedlings. The Contractor should employ experienced agricultural or forestry labourers for this work.

5. The plants supplied to the Contractor will normally be from a nursery as arranged by separate instructions, and will be ready for planting. They should be at least 300 mm in height above the soil surface and hardened off in the normal way. The Contractor is to collect the plants from the nursery and transport them to site with all due care. The plants will normally be supplied in polythene pots, which should not be removed until the moment of planting. Plants are to be lifted by the pots, never by the stem or leaves. At all times they are to be kept as cool as possible. The Contractor is responsible for ensuring that the soil around the roots does not dry out. Under any circumstances, all plants supplied must be planted within three days of removal from the nursery.

6. Planting should be started at the top of the slope and under no circumstances should new plants be walked on or otherwise disturbed.

7. A planting pit wide and deep enough for the main root to be buried in without bending it and wide enough for all the roots and surrounding soil ball should be made at the time of planting. Some compost if available should be mixed with the soil from the slit prior to backfilling around the roots. The polythene pot must be removed from the seedling by cutting it away with a razor blade. The plant should then be carefully placed into the hole, the compost and soil packed in, and all surrounding soil firmed up, taking care not to cause any damage to the plant or its roots. The surface over and around the pit should then be mulched using any appropriate, locally available material, such as manure, compost, dead leaves or cut herbage. The use of freshly cut ban mara (*Eupatorium adenophorum*) and tite pate (*Artemisia vulgaris*) should be avoided, since it can resprout from the buds after being cut.

8. The Engineer may specify bigger seedlings for specific areas, such as those to be used intensively for amenity purposes. These will normally have been growing in a nursery for at least a year and should have well developed roots as well as aerial parts. They will be provided either as bare root

stock with a substantial root ball, or in pots of a minimum of 100 × 180 mm laid flat dimensions. When these larger seedlings are planted, the pits will be of 300 mm diameter and 300 mm depth. In addition, well-rotted compost will be mixed with the soil backfill in a ratio of at least one part compost to ten parts soil.

2855 SITE PLANTING OF HARDWOOD CUTTINGS

1. Certain trees and shrubs can be planted on site by means of hardwood cuttings. Where these are specified, the Contractor is required to carry out the planting of cuttings as required in the Engineer's instructions.
2. It is assumed that the site will already have been prepared for planting, under a separate instruction; but it is nevertheless the responsibility of the Contractor to ensure that the condition of the site is good enough for the successful establishment of delicate young plants.
3. The spacing of hardwood cuttings will be determined according to individual site conditions. However, it will normally be at 500 mm centres unless otherwise specified.
4. The Contractor is required to supervise all field operations very closely. The planting of tree and shrub cuttings is a delicate business and should be approached in the same way as the planting of horticultural cuttings (eg those of tea). The Contractor should employ experienced agricultural or forestry labourers for this work.
5. The cuttings supplied to the Contractor will normally be from a nursery as arranged by separate instructions, and will be ready for planting. They should be at least 300 mm in length. The Contractor is to collect the cuttings from the nursery and transport them from the nursery wrapped in hessian jute. At all times, cuttings are to be kept moist and as cool as possible, and should be wrapped in wet hessian between all operations such as cutting from the parent plant, trimming and planting. Under any circumstances, all plants supplied must be planted the same day that they are lifted from the nursery.
6. Planting should be started at the top of the slope and under no circumstances should new plants be walked on or otherwise disturbed. Using a small bar (usually made of mild steel and with a flattened end), a hole should be made that is just big enough for the cutting. The cutting is inserted and the soil is replaced around it and firmed with the fingers. The cutting should be inserted to a depth such that two-thirds to three-quarters of it is buried.
7. If the soil is dry and there is no rain within 16 to 24 hours of planting, the site should be watered carefully with a fine spray. The Contractor will be required to water for the first two weeks after planting in the event of inadequate rainfall.
8. In certain circumstances it may not be possible to provide cuttings from a nursery. In this case the Engineer will specify the species and expected sources. The Contractor should then obtain the cuttings required in the manner described in clause 2812.
9. The Engineer may specify bigger cuttings for specific areas, using large truncheon cuttings. In this category fall chuletro (*Brassaiopsis hainla*), dabdabe (*Garuga pinnata*), kavro (*Ficus lacor*), phaledo (*Erythrina* species) and *Gliricidia sepium*. Cuttings of these species should be planted at 1000 mm centres. A large crowbar should be used to make the planting hole, but otherwise the technique is as described above for smaller cuttings. Under no circumstances should these cuttings be hammered into the ground.

2856 BRUSH LAYERING, PALISADES AND FASCINES

1. Under certain conditions, the Contractor will be required to construct vegetation structures using hardwood cuttings. Where these are specified, the Contractor is required to carry out the necessary preparation and planting works as required in the Engineer's instructions.
2. It is assumed that the site will already have been prepared for planting, under a separate instruction; but it is nevertheless the responsibility of the Contractor to ensure that the condition of the site is good enough for the successful establishment of delicate young plants.
3. The cuttings supplied to the Contractor may be from a nursery as arranged by separate instructions, and will be ready for planting. They should be at least 400 mm long for brush layering, 600 mm long for palisades and 1000 mm in length for fascines. The Contractor is to collect the cuttings from the nursery and transport them from the nursery wrapped in hessian jute. At all times, cuttings are to be kept moist and as cool as possible, and should be wrapped in wet hessian between all operations such as cutting from the parent plant, trimming and planting. Under any circumstances, all plants supplied must be planted the same day that they are lifted from the nursery.
4. If the instruction to the Contractor includes the provision of cuttings, then the Engineer will specify the species and expected sources, and the Contractor must then obtain the cuttings required. This will be done in the manner described in clause 2812 except that the size of cuttings will be of a minimum length of 600 mm for brush layering on landslide debris, 450 mm for brush layering on road embankments, 600 mm for palisades and 1000 mm for fascines, and minimum diameters of 30 mm for brush layering, 40 mm for palisades and 50 mm for fascines.
5. Cuttings of the following species, if specified, should be a minimum of 2000 mm in length: chuletro (*Brassaiopsis hainla*), dabdabe (*Garuga pinnata*), kavro (*Ficus lacor*), phaledo (*Erythrina* species) and *Gliricidia sepium*.
6. The Contractor is required to supervise all field operations very closely. The planting of tree and shrub cuttings is a delicate business and should be approached in the same way as the planting of horticultural cuttings (eg those of tea). The Contractor should employ experienced agricultural or forestry labourers for this work.
7. Planting should always be started at the top of the slope and under no circumstances should new plants be walked on or otherwise disturbed.
8. Brush layering should be constructed as given below, unless specified differently.
 - (i) Starting at the bottom of the area to be treated, and using appropriate measuring equipment, exact lines should be marked out. From 1 metre above the bottom of the slope, a precise contour line should be marked out every 1 metre up the slope.
 - (ii) Starting at the bottom, trenches of depths approximately 450 mm on landslide debris or 350 mm on road embankments should be excavated along the lines.
 - (iii) Cuttings should then be placed into each trench at 50 mm centres, the correct way up and angled so that they are at rightangles to the maximum slope angle. All cuttings should be inserted to a depth such that two-thirds to three-quarters of their length is buried
 - (iv) The trench should then be partially backfilled and another line of cuttings placed along the trench at 50 mm centres and 100 mm behind the first line, and with the individual cuttings offset to coincide with the gaps between the cuttings in the first line. This results in cuttings at 25 mm centres in

each brush layer (*ie* 40 cuttings per running metre). The trench is then completely backfilled and gently compacted. Any loose or excess material is cleared down the slope before the next line is planted.

(v) In some cases it will be specified that cuttings should be placed in a criss-cross fashion. Where this is to be done, one layer of cuttings is laid in the trench at 30° to one side of the line of maximum fall of slope. A second layer of cuttings is laid on top of this, at 30° to the other side of the line of maximum fall of slope. Backfilling and compaction are then completed.

9. Palisades should be constructed as given below, unless specified differently.

(i) Starting at the top of the area to be treated, and using appropriate measuring equipment, exact lines should be marked out. From 1 metre below the top of the slope, a precise contour line should be marked out every 1 metre down the slope.

(ii) Starting at one end and using a small bar (usually made of mild steel and with a flattened end), a hole should be made that is just big enough for the first cutting. The cutting is inserted and the soil is replaced around it and firmed with the fingers. The cutting must be the correct way up and angled so that it is vertical. The cutting should be inserted to a depth such that two-thirds to three-quarters of it is buried.

(iii) This process should be repeated along the entire line, with a series of cuttings placed at 50 mm centres.

(iv) If a double line is specified, then a second line of cuttings must be placed in the same way, 100 mm behind the first and with the individual cuttings offset to coincide with the gaps between the cuttings in the first line.

(v) The soil around the single or double line is then completely backfilled into any remaining gaps and gently compacted. Any loose or excess material is cleared down the slope before the next line is planted.

10. Fascines are bundles of hardwood cuttings laid horizontally in trenches, and parallel to the line of the trench. The bundles are thereby completely buried. Fascines should be constructed as given below, unless specified differently.

(i) Starting at the bottom of the area to be treated, and using appropriate measuring equipment, exact lines should be marked out. From 1 metre above the bottom of the slope, a precise contour line should be marked out every 1 metre up the slope.

(ii) Starting at the bottom, trenches approximately 200 mm in depth should be excavated along the lines.

(iii) Cuttings should then be laid along each trench, so that they lie horizontally along the trench. There should normally be eight cuttings together, although where material is short a minimum of four cuttings is permissible. They must be overlapped so that no two ends coincide. The cuttings must then be tied using jute or coir (coconut fibre) string at 500 mm intervals to form a bundle. As the fascine is created, it thereby forms a continuous bundle right across the slope.

(iv) The trench should then be backfilled and gently compacted. The top of the fascine should be 50 to 100 mm below the surface. Any loose or excess material is cleared down the slope before the next line is planted.

11. The Engineer may specify that orientations other than along the contour of the slope are used. In this event, the Contractor must alter the laying out of lines accordingly and meet the precise angle required.

12. If the soil is dry and there is no rain within 16 to 24 hours of planting, the site should be watered carefully with a fine spray. The Contractor will be required to water for the first two weeks after planting in the event of inadequate rainfall.

2857 USE OF FERTILISER

1. Under certain circumstances, the use of chemical fertilisers may be specified in place of farmyard manure or mulching. Unless otherwise specified, the rates given below should be used.

2. Levels of fertiliser application vary according to soil type and nutritional content. However, if nutritional data are not available, the following figures can be used as a rough guide:

Nitrogen: 10 g/m²;

Phosphorus: 5 g/m²;

Potassium: 4 g/m².

The table below lists the chemical composition and percentage of the major plant nutrient elements in the chemical fertilisers commonly available in Nepal.

Commercial name	Chemical formula	Percentage N P K
Sulphate of ammonia	(NH ₄) ₂ SO ₄	21 0 0
Urea	CO(NH ₄) ₂	46 0 0
Triple superphosphate	CaH(PO ₄)	0 21 0
Muriate of potash	KCl	0 0 49
Complexol	Unknown	20 9 0
Diammonium phosphate	(NH ₄) ₂ HPO ₄	18 20 0

2860 JUTE NETTING WORKS

1. The Contractor shall provide and install jute netting as required by the Engineer. This shall be done according to the specifications described hereunder, as and when required. The Contractor shall supply all necessary expertise, resources and facilities to ensure that these requirements are met.

2. The Engineer may instruct that jute netting applications be used in conjunction with other techniques, particularly the sowing or planting of grasses. In this event, the netting should be applied before the plants are introduced. When planting, the labourers must take care only to hold or stand on the pegs and not to disturb the netting except when carefully placing grass seed underneath on the soil surface.

2861 SUPPLY OF JUTE NETTING

1. The Contractor will manufacture or obtain a supply of jute netting to the Engineer's specification.

2. 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 tosa (special grained), 100% 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.

3. The detailed specifications for wide mesh jute netting are as follows. "Wide mesh" jute netting is used for holding mulch on to slopes which have been sown with grass seed. [Note: warp ends are the length-ways threads and weft strands are the cross-ways threads]

- (i) Material: High quality tosa (special grained), 100% 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: 3 strands per 1000 mm.

- (vi) Mesh size: 150 × 500 mm rectangular mesh.
- (vii) Weight: 0.2 kg per square metre.

2862 PLACEMENT OF NETTING

1. The Engineer will normally instruct the placement of standard jute netting on slopes in excess of 40 degrees. It is therefore a difficult task to place the netting in an effective manner which fulfils the Engineer's purpose. Carelessly placed netting is often useless and can actually be detrimental to the slope surface.
2. It is assumed that the site will already have been prepared for the application of jute netting, under a separate instruction; but it is nevertheless the responsibility of the Contractor to ensure that the condition of the site is good enough for the optimum effect to be attained. In any event, a smooth profile must be obtained. All loose debris must be removed. Concavities must be filled with well compacted material or, in some cases, with dry stone dentition. Convexities must also be removed and it is essential that the general profile does not have a shape giving over-steep segments.
3. Starting at one end of the site to be treated, a roll of netting should be pegged 300 mm above the slope to be covered.
4. The netting should be rolled slowly down the slope. Hardwood cuttings, ideally of simali (*Vitex negundo*) or pegs (usually made from split bamboo culms) should be hammered through the netting at centres of 500 to 1000 mm; they should protrude about 80 mm. Labourers must stand on these cuttings or pegs and not hang on to the netting.
5. This process should be repeated until the entire slope surface is covered. The strips are then laced together with lengths of the same jute yarn, to form a continuous net. The lacing must form joins every 250 mm or less.
6. The tension of the netting must now be reduced so that it hugs the slope surface precisely. This is done by pulling up about 200 mm at the bottom of the netting and hooking it on to the pegs a little higher up. This process is repeated up and across the slope until the netting rests snugly against the surface and is nowhere tight or pulled away from the surface in minor concavities.
7. The netting should then be pegged at 1000 mm centres with staples of 10 mm reinforcing bar at least 100 mm wide and 300 mm long, firmly hammered into the slope face. Additional staples should be used to hold netting closely against the face of concave slope segments.
8. Finally, the bottom of the netting is trimmed to give a tidy finish.
9. In the case of wide mesh jute netting, it will only be specified for use on slopes which have already been treated with grass seed and mulch. These will usually be less than 45° and are therefore easier to work on. However, the process of placing the netting is similar to that for standard netting.
10. Wide mesh netting should be pegged securely at the top and rolled slowly down the slope. Hardwood cuttings, ideally of simali (*Vitex negundo*) or pegs (usually made from split bamboo culms) should be hammered through the netting at centres of 1000 mm; they should protrude about 80 mm. Labourers must stand on these cuttings or pegs and not hang on to the netting. This process should be repeated until the entire slope surface is covered. The strips are then laced together with lengths of the same jute yarn, to form a continuous net. The lacing must form joins every 500 mm or less.

11. The tension of the netting must now be reduced so that it hugs the slope surface precisely and holds the mulch firmly against the surface throughout the area covered. The netting should then be pegged at 1000 mm centres with staples of 10 mm reinforcing bar at least 100 mm wide and 300 mm long, firmly hammered into the slope face. Additional staples should be used to hold netting closely against the face of concave slope segments. Finally, the bottom of the netting is trimmed to give a tidy finish.

2870 GABION WIRE BOLSTERS

1. The Contractor shall provide and install wire bolsters as required by the Engineer. This shall be done according to the specifications described hereunder, as and when required. The Contractor shall supply all necessary expertise, resources and facilities to ensure that these requirements are met.

2871 FABRICATION OF BOLSTER PANELS

1. Bolster panels will be either 5×1 metres or 5×2 metres in size, according to the type of bolster to be used. They will be woven with an hexagonal mesh in the same way as normal gabion panels. For the panel frame, 10 swg galvanised wire should be used; for the mesh, 12 swg is adequate. Wire should preferably have a high grade zinc coating. Failing this, a medium grade zinc coating is acceptable.
2. Weaving should start from one of the long sides. A total of 83 coils of wire should be spaced evenly along the 5 metre length. This gives a mesh width of about 60 mm. Each weave should have three twists, as for normal hexagonal mesh. If done reasonably tightly, this gives a length of about 80 mm to each mesh link. In any event, the mesh length should not exceed 90 mm. The mesh should be turned on to the larger frame wire at least one and a half turns and made fully secure.

2872 PLACEMENT OF CONTOUR BOLSTERS

1. A contour bolster treatment gives a series of stone-filled wire tubes of 300 mm diameter, laid in trenches cut across the slope. The tops of all the tubes should be flush with the surface of the slope in which they are placed. The purpose is to check scour of the slope surface by preventing the development of rills and gullies.
2. The site to be treated should be given final preparation immediately before bolster installation. All small protrusions and depressions must be obliterated by cutting, or by infilling and compaction.
3. Starting at the base of the area to be treated, and using appropriate measuring equipment, exact lines should be marked out. From 2 metres above the base of the slope, a precise contour line should be marked out every 2 metres up the slope.
4. Starting at the bottom, trenches with circular base should be dug along the lines, adequate to take the final 300 mm diameter tubes.
5. Bolster panels should then be laid along the trenches and shaped to fit neatly into the base of the trenches, as well as into any curves formed as a result of the slope contours; each panel should be securely joined to the next panel, to form a continuous bolster tube.
6. The panels should be packed with stones, closed over and the edges wired together. All stones must be bigger than the mesh size. The same care should be taken as when filling a conventional gabion basket, and stones must be carefully placed to give good structural integrity.
7. The ends of the bolsters should be closed over and wired together. The trenches around all the bolsters should then be filled and compacted with material left from the excavations.
8. Once all of the lines are in place, all surplus debris should be cleaned off the slope. Mild steel bars of at least 10 mm diameter should then be driven into the slope through the lower sides of the contour bolsters. These should be at least every 2 metres along the lines. Bars should be 2 metres in length on slopes composed of soft materials, but at the Engineer's discretion, on slopes comprising hard rocky materials, bars of 1 metre length will be adequate. All bars must be driven home until the tops protrude no more than 25 mm above the slope surface.

2873 PLACEMENT OF HERRINGBONE BOLSTERS

1. A herringbone bolster network is in essence a system of wire tubes of between 300 mm to 1200 mm in diameter depending on the amount of water flowing through the site, laid in trenches cut into the slope. A main bolster runs straight down the slope (the spine) with others running into it at an angle of 30 to 50 degrees to the fall of the slope (the herringbones or branches) depending on slope angle and terrain morphology. The tops of all the tubes should be flush with the surface of the slope in which they are placed or inlaid to allow boulder pitching to be laid over the top. The purpose is both to check scour of the slope surface by preventing the development of rills and gullies, and to drain the surface material in a similar way to a French drain. The diagonal components should be at 2 to 5 metre centres if measured straight down the slope.
2. The site to be treated should be given final preparation immediately before bolster installation. All small protrusions and depressions must be obliterated by cutting, or by infilling and compaction.
3. Starting at the base of the area to be treated, and using appropriate measuring equipment, exact lines should be marked out: every 7.1 metres across the slope, a line should run straight up to the top of the slope (these form the main bolster spines). From the base of the line, and every 3 metres above this, other lines of 5 metres length should be marked at 45 degrees to the main line (these will form the herringbones).
4. Starting at the bottom, trenches with circular base should be dug along the lines, adequate to take the final 300 mm diameter tubes, or 600 mm diameter tubes if larger (5 × 2 metre) panels are specified.
5. If it is specified that an impermeable lining should be used, then 20 gauge black polythene sheeting must be laid along the bottoms of the trenches and the bolsters constructed on top of this.
6. Bolster panels should then be laid along the trenches and shaped to fit neatly into the base of the trenches, as well as into any curves formed as a result of the slope contours; the panels of the herringbones should be securely joined to the panels of the main bolster.
7. The panels should be gradually closed together and secured, working up from the bottom of the slope, while stones are passed in from above to fill them. The stones should be randomly packed so as to allow free drainage, and all stones must be bigger than the mesh size. The same care should be taken as when filling a conventional gabion basket, and stones must be carefully placed to give good structural integrity.
8. The upper ends of the herringbones should be closed over and wired together; they should touch the ends of the next herringbones but should not be secured to each other. The trenches around all the bolsters should then be filled and compacted with material left from the excavations.
9. Once all of the lines are in place, all surplus debris should be cleaned off the slope. Mild steel bars of at least 10 mm diameter should then be driven into the slope through the sides of the main spine bolsters and the lower sides of the herringbone bolsters. These should be at least every 2 metres along the lines. Bars should be 2 metres in length on slopes composed of soft materials, but at the Engineer's discretion, on slopes comprising hard rocky materials, bars of 1 metre length will be adequate. All bars must be driven home until the tops protrude no more than 25 mm above the slope surface.

2880 SITE PROTECTION

1. The Contractor is to protect a planted site for the period specified. Protection is to include the prevention of damage to all manner of site works and plants by local people and domestic or wild animals. It also includes an active role in tending the plants and improving their growth, as specified below.
2. Because of the long time required for plants to become robust, the period of maintenance by the contractor will normally be for twelve months. However, in the case of small contracts, a period of only six months may be specified.

2881 PROVISION AND ROLE OF SITE WARDENS

1. The Contractor is required to provide an adequate number of site wardens to fulfil the specified requirements. The function of a warden is broader than that of a watchman, chowkidar or heralu. It involves a number of routine maintenance operations.
2. Wardens must be mature and reliable characters who need little supervision for the adequate fulfilment of their duties. They must be active and physically fit. Old people who are losing their strength should not normally be employed. They must be experienced agricultural workers familiar with caring for plants. They must be prepared to remain on site through all hours of daylight and through all adverse weather conditions. They must eat their meals on site and at no time leave the site untended for any reason whatsoever.
3. The role of the warden is primarily to tend the plants. He or she must take the initiative in weeding, mulching, replanting failed plants, pruning and protecting plants against all pests. This is an active role requiring individuals with considerable energy and initiative. The warden must work constantly to maintain and improve the site and its bio-engineering plants.
4. The warden is also required to protect plants on the site from damage by local people, domestic and wild animals. In doing this he or she should use a friendly approach to the people as far as possible. The Contractor must educate the warden fully in the reasons for the job, so that he or she can explain to others the importance of safeguarding plants on the site. Wardens should be effective communicators with others since they also fulfill an inevitable function as the ambassador between the Department of Roads and local road neighbours.

2882 FABRICATION OF BAMBOO TREE GUARDS

1. The Contractor shall provide bamboo tree guards as required by the Engineer. This shall be done according to the specifications described hereunder, as and when required. The Contractor shall supply all necessary supervision, resources and facilities to ensure that these requirements are met.
2. The bamboo strips used to make bamboo tree guards are to be made from mal bans (*Bambusa nutans* subsp *cupulata*) whilst the uprights are to be made from tharu or dhanu bans (*Bambusa nutans* subsp *nutans* or *Bambusa balcooa*). Bamboo tree guards shall be a minimum of 450 mm in diameter by 1300 mm in height so that they are able to provide sufficient protection from grazing and from the elements for the first 18 months after planting the seedling.
3. The guard is made by cutting 5 bamboo posts which are a minimum of 50 mm wide by 10 mm thick and at least 1600 mm long. The posts should be cut so that they have a strong spear-like point at the bottom that can be driven into the ground when placing out on site. The bamboo poles used to make the uprights should be a minimum of 3 years old.

4. Bamboo strips, a minimum of 5 mm thick and 50 mm wide are cut from poles that are at least 2 years old. The bamboo used must be split so that the outer wall remains intact. Only lengths with the outer wall intact are to be used. The split bamboo should be the length of the whole bamboo pole that it is cut from, or as long as possible. The split bamboo must be woven in and out of the bamboo uprights and pulled tight, so that it is firm and strong. The end of each of the strips must be woven back into the basket and tied with binding wire to keep it in place. End pieces must not be left sticking out and unbound, because they quickly get broken and the basket starts to unravel from this point. The split bamboo should be woven round the poles so that when they are tightly pressed down there are no gaps in the guard.

2883 PLACEMENT OF BAMBOO TREE GUARDS

1. Tree guards are to be installed on site at the time of planting, no later than the second week of July, and must be placed carefully around the planted seedlings.
2. The tree guards should be placed over the seedling immediately after planting. The upright posts must be firmly driven at least 200 mm into the ground so that the guard is able to resist bashing and rubbing from cows, buffalo, goats and people. The woven slats should be pushed down firmly from the bottom upwards so that they touch one another and are free from large gaps.
3. Tree guards alone are not adequate protection for small plants. The Contractor must provide a site watchman in addition, for the time specified, to maintain the tree guards and ensure that local people respect them, and generally fulfil all the requirements of clause 2881.

2890 SITE AFTERCARE AND MAINTENANCE

1. The Contractor shall maintain planted bio-engineering sites as required by the Engineer. This shall be done according to the specifications described hereunder, as and when required. The Contractor shall supply all necessary expertise and resources to ensure that these requirements are met.
2. The Contractor shall carry out weeding as required throughout the site. All annual weeds and other unwanted plants shall be cut just above the ground and the aerial parts will be used to make compost or mulch. Weeds must not be pulled out by the roots since this disturbs the ground surface.
3. Weeding should be carried out throughout the growing season. It must be undertaken with particular diligence at the end of the monsoon, so that there is the minimum amount of competition during the subsequent dry season.
4. The Contractor shall carry out mulching as required throughout the site. All plants required under the bio-engineering specifications will be mulched using material prepared as specified in clause 2835, or the aerial parts of weeds cut on the site or brought from elsewhere for the purpose. The desired plants should be kept mulched at all times but especial care must be taken in the spring, when the soil moisture deficit is at its greatest.
5. The Contractor shall replace failed, damaged, diseased and very weak plants, using fresh, healthy plants of the same species, at the correct time of year for planting. This replanting operation will normally be carried out during the monsoon in the year following the first planting works. Vegetation structures will be enriched by the planting of additional cuttings or seedlings, as instructed by the Engineer. Failed seeding areas will be reseeded at the appropriate time of year.
6. In replanting and enrichment works, the Engineer may specify the use of different species. This will be done where failures or poor performance of plants may be attributed to poor stock or an incorrect initial choice of species.
7. All bio-engineering sites must be maintained so that there are at least the following two storeys of vegetation. In certain locations, however, there may be a number of additional vegetation storeys.
 - (i) A dense ground cover of healthy grass plants, in the configuration specified at the time of planting.
 - (ii) An open canopy of shrubs or trees with a deeper rooting network.
8. In general it is necessary to keep the upper canopy thinned in order to maintain the lower ground cover. Most grasses require high light intensities and become degraded if subjected to excessive shade from the overstorey. It is therefore the Contractor's responsibility to thin the canopy as necessary to permit adequate levels of light to penetrate for the optimum growth of the grass understorey.
9. All thinning and pruning operations are to be undertaken in accordance with the guidelines issued by the Geo-Environmental Unit. Since these are skilled silvicultural operations, the Contractor must take appropriate professional advice and employ suitably skilled personnel.
10. All products from thinning and pruning operations are to be disposed of in accordance with the regulations of His Majesty's Government. The Contractor should follow the instructions of the Engineer in this regard.
11. Other maintenance operations are to be undertaken by the Contractor according to the instructions of the Engineer.

GRASSES FOR BIO-ENGINEERING IN THE ROAD SECTOR (includes small legumes)
(Species used or recommended for bio-engineering throughout Nepal)

Local name	Botanical name	Rec	Character	Altitude	Sites	Best propagation	Comments
Amliso	<i>Thysanolaena maxima</i>	✓	Large clumping	Terai-2000m	Varied	Slip cuttings	Best in damper areas
Babiyo	<i>Eulalopsis binata</i>	✓	Medium-sized clumping	Terai-1500m	Hot and dry	Slip cuttings/seeds	
Banso ghans	<i>Eragrostis tenella</i>		Large spreading	500-1800 m	Varied	Slip cuttings/seeds	
Blue panic grass	<i>Panicum antidotale</i>		Medium-sized spreading	500-1800 m	Varied and dry	Slip cuttings	High grazing risk
Buffalo grass	<i>Cenchrus ciliaris</i>		Medium-sized spreading (exotic)	500-1800 m	Varied and dry	Slip cuttings	High grazing risk
Clover	<i>Trifolium</i> species		Small spreading legume (exotic)	Terai-2000 m	Varied; moist	Stem cuttings/seeds	High grazing risk
Dangre khar	<i>Cymbopogon pendulus</i>		Large clumping	Terai-1200 m	Varied	Seeds	Best in damper areas
Desmodium	<i>Desmodium distortum</i>		Spreading legume (exotic)	Terai-1800 m	Varied	Stem/slip cuttings	High grazing risk
Desmodium greenleaf	<i>Desmodium intortum</i>		Spreading legume (exotic)	Terai-2000 m	Varied and dry	Stem/slip cuttings	High grazing risk
Dhonde	<i>Neyraudia reynaudiana</i>	✓	Large clumping	Terai-1500m	Hot and dry	Stem/slip cuttings/seeds	15,520,000 seeds/kg
Dubo	<i>Cynodon dactylon</i>		Small creeping	Terai-1800 m	Varied	Stem cuttings	
Dhungre	Unknown		Large clumping	1500-2500 m	Damp or shady	Large slip cuttings	
Dhus	Unknown		Large clumping	1500-2500 m	Varied, dry to moist	Slip/stem cuttings	
Jaughans	Unknown		Medium-large spreading	1600-3000 m	Varied	Slip cuttings/seeds	
Kagati ghans	<i>Cymbopogon citratus</i>		Medium-large clumping	Terai-1500 m	Varied	Slip cuttings/seeds	
Kans	<i>Saccharum spontaneum</i>	✓	Large clumping and spreading	Terai-2000m	Hot and dry to moist	Slip cuttings	Very tough on all sites
Katara khar	<i>Themeda</i> species	✓	Large clumping	Terai-2000m	Varied	Slip cuttings/seeds	

GRASSES FOR BIO-ENGINEERING (continued)

Local name	Botanical name	Rec	Character	Altitude	Sites	Best propagation	Comments
Khar	<i>Cymbopogon microtheca</i>	✓	Medium-large clumping	500-2000m	Hot and dry; varied	Slip cuttings/seeds	1,681,000 seeds/kg
Khus	<i>Vetiver zizanioides</i>	✓	Medium-large clumping	Terai-1500m	Varied	Slip cuttings	Fill slopes only; 1,712,000 seeds/kg
Kikiyu, thulo dhobo	<i>Pennisetum clandestinum</i>		Small creeping (exotic)	Terai-1800 m	Varied	Stem/slip cuttings	High grazing risk
Kudzu	<i>Pueraria lobata</i>		Spreading legume (exotic)	500-1500 m	Varied	Stem/slip cuttings	High grazing risk
Molasses	<i>Melinis minutiflora</i>		Medium-large spreading (exotic)	Terai-1800 m	Varied to dry	Slip cuttings/seeds	High grazing risk
Musekharuki	<i>Pogonatherum paniceum</i> (?)		Small spreading	Terai-2500 m	Varied	Slip cuttings	
Napier	<i>Pennisetum purpureum</i>		Large semi clumping (exotic)	Terai-1750 m	Varied; needs fertile soil	Stem cuttings	High grazing risk
Narkat	<i>Arundo donax</i>	✓	Large clumping and spreading	Terai-1500m	Hot and dry; varied	Stem/slip cuttings	
NB21	<i>P. Purpureum</i> × <i>typhoides</i>		Spreading (exotic)	Terai-1750 m	Varied	Stem cuttings	High grazing risk
Padang bans	<i>Himalayacalamus hookerianus</i>	✓	Large clumping (small stature bamboo)	1500-2500 m	Moist	Large slip cuttings	High grazing risk
Phurke	<i>Arundinella nepalensis</i>	✓	Medium-sized clumping	700-2000 m	Varied; stony	Slip cuttings/seeds	1,809,000 seeds/kg
Rato kans	<i>Friantus rufipilus</i>		Medium-sized clumping	900-2200 m	Varied	Slip cuttings/seeds	
Salimo khar	<i>Chrysopogon gryllus</i>		Medium-large clumping	800-2000 m	Varied	Slip cuttings/seeds	
Setaria	<i>Setaria anceps</i>		Medium-large spreading (exotic)	500-2500 m	Varied to dry	Slip cuttings/seeds	High grazing risk
Sito	<i>Neyraudia arundinacea</i>	✓	Large clumping	Terai-1500m	Varied	Slip cuttings/seeds	Higher rainfall areas; 16,390,000 seeds/kg
Stylo	<i>Stylosanthes guianensis</i>		Spreading legume (exotic)	500-1500 m	Varied	Stem/slip cuttings	High grazing risk
Thulo kharuki	<i>Capipedium assimile</i> (?)		Medium-large clumping	600-2000 m	Varied	Slip cuttings/seeds	Higher rainfall areas
Tite nigalo bans	<i>Drepanostachyum intermedium</i>	✓	Large clumping (small stature bamboo)	1000-2500 m	Varied	Large slip cuttings	Drier sites than padang

Geo-Environmental Unit

Rec: ✓ = particularly recommended for roadside areas.

Department of Roads

SHRUBS/SMALL TREES FOR BIO-ENGINEERING IN THE ROAD SECTOR
(Species used or recommended for bio-engineering throughout Nepal)

Local name	Botanical name	Rec	Character	Altitude	Sites	Best propagation	Comments
Aak	<i>Calatropa giganteum</i>		Small shrub, large fleshy leaves	Terai-1000 m	Hot and dry; harsh	Seeds/polypots	
Ainseu	<i>Rubus ellipticus</i>		Thorny shrub up to 2 m high	1000-2500 m	Varied	Seeds/root cuttings	
Alainchi	<i>Elettaria cardomomum</i>		Herb up to 2 m high	1000-2000 m	Moist	Seeds/polypots	Bears heavy shade
Amala	<i>Phyllanthus emblica</i>		Small tree	Terai-1500 m	Hot and dry; harsh	Seeds/polypots	Coppices well
Amba/ambak	<i>Psidium guajava</i>		Small tree, up to 5 m	Terai-2000 m	Varied and dry	Seeds/polypots	
Aparajita	<i>Clitoria ternatea</i>		Climbing shrub (exotic)	Terai-1500 m	Varied	Seeds	Legume; high grazing risk
Areri	<i>Acacia pennata</i>	✓	Small thorny tree, up to 5 m	500-1500 m	Hot and dry; harsh	Seeds/polypots	36,000 seeds/kg
Argali	Unknown		Shrub up to 3 m high	1500-2500 m	Varied, dry to moist	Hardwood cuttings	Not used as a fodder
Arile kanda	<i>Caesalpinia decapetala</i>		Thorny climber (exotic)	Terai-1500 m	Varied	Seeds/stem cuttings	
Arnalito, seabuckthorn	<i>Hippophae salicifolia</i>		Small thorny tree	1000-2500 m	Varied and dry	Seeds/polypots	Strongly promoted for bio-engineering in China
Assuro	<i>Adhatoda vasica</i>	✓	Shrub up to 3 m high	Terai-1000m	Varied	Hardwood cuttings	
Bainsh	<i>Salix tetrasperma</i>	✓	Tree up to 15 m high	Terai-2700m	Moist	Hardwood cuttings	High grazing risk; coppices well
Bains	Unknown; <u>not</u> <i>Salix</i>		Shrub up to 5 m high	1300-2000 m	Varied to moist; bears shade	Hardwood cuttings	
Bagankali/ baramase phul	<i>Bougainvillea spectabilis</i>		Thorny climber (exotic)	Terai-1500 m	Varied and dry	Stem cuttings	
Ban chutro	<i>Berberis aristata</i>		Thorny shrub up to 2 m high	1500-3000 m	Varied and dry	Seeds/polypots	
Ban silam	<i>Elsholtzia blanda</i>		Shrub	Terai-1500 m	Varied	?	
Bayer	<i>Zizyphus mauritiana</i>		Thorny shrub up to 4 m high	Terai-1200 m	Hot and dry; harsh	Seeds/polypots	

Rec: ✓ = particularly recommended for roadside areas.

Geo-Environmental Unit

Department of Roads

SHRUBS/SMALL TREES FOR BIO-ENGINEERING (continued)

Local name	Botanical name	Rec	Character	Altitude	Sites	Best propagation	Comments
Bhimsenpati	<i>Buddleja asiatica</i>		Shrub up to 4 m high	600-1800 m	Hot and dry; harsh	Seeds/hardwood cuttings	
Bhui katahar	<i>Ananas comosus</i>		Thorny herb up to 1 m high	Terai-1600 m	Hot and dry; harsh	Stem cuttings	
Bhujetro	<i>Butea minor</i>	✓	Shrub up to 4 m high	500-1500 m	Hot and dry; harsh	Direct seeding	450 seeds/kg, including separated pod segments
Bilaune	<i>Maesa chisia</i>		Shrub	Terai-2000 m	Varied	?	
Bokshi ghans	<i>Mimosa rubicaulis</i>		Shrub up to 3 m high	500-1700 m	Varied	Hardwood cuttings/seeds	
Chiya	<i>Camellia sinensis</i> (and other species)		Shrub up to 4 m high	Terai-2000 m	Varied and moist	Hardwood cuttings	
Chutro	<i>Berberis asiatica</i>		Thorny shrub up to 2 m high	1000-2500 m	Varied and dry	Seeds/polypots	
Coffee	<i>Coffea arabica</i>		Shrub up to 2 m high	Terai-2000 m	Varied	Seeds/polypots	
Dhanyero	<i>Woodfordia fruticosa</i>	✓	Shrub up to 3 m high	Terai-1500m	Hot and dry; harsh	Seeds/polypots	
Dhusun	<i>Colebrookea oppositifolia</i>	✓	Shrub up to 3 m high	Terai-1000m	Hot and dry; harsh	Seeds/polypots	
Gahate	<i>Desmodium species</i>		Shrub up to 4 m high	400-1500 m	Varied	Seeds/polypots	Eastern Nepal; different from gahate in Far West
Ghangaru	<i>Pyracantha crenulata</i>		Shrub up to 2 m high	1500-2500 m	Varied	Hardwood cuttings (?)	
Ghurmis	<i>Leucosceptrum canum</i>		Tree up to 8 m high	1000-2500 m	Varied	Hardwood cuttings/seeds	Coppices well
Hasna/hasua	<i>Cestrum nocturnum</i>		Shrub	Terai-1500 m	Varied	?	
Imili	<i>Rumex hastatus</i>		Herb up to 1 m high	600-2000 m	Hot and dry; harsh	Seeds	
Kanda phul	<i>Lantana camara</i>	✓	Shrub up to 2 m high	Terai-1750m	Hot and dry	Hardwood cuttings	Not hard cut slopes
Kera	<i>Musa paradisiaca</i>		Tree up to 5 m high	Terai-1300 m	Varied and dry	Root suckers	

Geo-Environmental Unit

Rec: ✓ = particularly recommended for roadside areas.

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SHRUBS/SMALL TREES FOR BIO-ENGINEERING (continued)

Local name	Botanical name	Rec	Character	Altitude	Sites	Best propagation	Comments
Kettuke	<i>Agave americana</i>	✓	Large cactus; sub-species with and without thorns	Terai-2400m	Hot and dry	Root suckers	Grows well on south-facing slopes
Keraukose	<i>Indigofera atroturpurea</i>	✓	Tree up to 8 m high	Terai-2000m	Hot and dry; harsh	Seeds/polypots	94,000 seeds/kg
Khiro	<i>Sesum inegne</i>		Small tree	800-1500 m	Varied and dry	Hardwood cuttings/seeds	
Kimbu	<i>Morus alba</i>		Small tree	Terai-2000 m	Varied and dry	Hardwood cuttings/seeds	High grazing risk
Kunyelo	<i>Trema orientalis</i>		Small tree, up to 6 m high	Terai-1500 m	Stony and dry	Hardwood cuttings/seeds	Best on dry sites in higher rainfall areas
Lalupate	<i>Poinsettia pulcherrima</i>		Shrub up to 5 m high	Terai-1500 m	Varied	Hardwood cuttings/seeds	
Mesquite	<i>Prosopis juliflora</i>		Small thorny tree (exotic)	Terai-1000 m	Hot and dry; harsh	Seeds/polypots	Tolerates calcareous soils
Namdi phul	<i>Colquhounia coccinea</i>	✓	Shrub up to 3 m high	1000-2000 m	Varied	Hardwood cuttings	
Nil kanda	<i>Duranta repens</i>		Thorny shrub	Terai-1500 m	Varied and dry	Hardwood cuttings/seeds	
Pate siuli	<i>Opuntia ficus indica</i>		Large thorny cactus, up to 4 m high	Terai-1800 m	Varied and dry	Stem cuttings	
Rahar	<i>Cajanus cajan</i>		Shrub up to 4 m high (exotic)	Terai-1500 m	Varied and dry	Seeds	Fast growing legume; high risk of grazing
Rato chulsi	<i>Osbeckia stellata</i>		Shrub	Terai-1500 m	Varied	?	
Saruwa/bihaya	<i>Ipomoea fistulosa</i>	✓	Recumbent shrub	Terai-1500m	Varied; sunny sites; stands waterlogging	Hardwood cuttings	Fill slopes only
Sajiwan (kadam in the terai)	<i>Jatropha curcas</i>		Shrub up to 4 m high	Terai-1000 m	Varied	Hardwood cuttings	
Simali	<i>Vitex negundo</i>	✓	Small tree, up to 6 m high	Terai-1750m	Hot and dry; varied	Hardwood cuttings	Very versatile; pollards well
Sisal	<i>Agave sisalana</i>		Cactus	Terai-1000 m	Hot and dry; varied	Root cuttings (?)	
Siuli/sihundi	<i>Euphorbia royleana</i>		Shrub	900-1800 m	Varied	?	

Geo-Environmental Unit

Rec: ✓ = particularly recommended for roadside areas.

Department of Roads

SHRUBS/SMALL TREES FOR BIO-ENGINEERING (continued)

Local name	Botanical name	Rec	Character	Altitude	Sites	Best propagation	Comments
Tara phul/kochu	<i>Helianthus tuberosus</i>		Spreading herb	800-1500 m	Varied	Root cuttings	
Thakal	<i>Phoenix humilis</i>		Small stature palm tree	Terai-1000 m	Hot and dry; needs shade	Direct seeding on site	Often slow growing; not a pioneer
Tilka	<i>Wendlandia puberula</i>	✓	Tree up to 10 m high	Terai-1500m	Hot and dry; harsh	Seeds/polypots	Pollards well
Udalo	<i>Hypericum cordifolium</i> (?)		Shrub up to 1.5 metres high	1200-2500 m		Seeds/polypots	

LARGE CLUMPING BAMBOOS FOR BIO-ENGINEERING IN THE ROAD SECTOR

Local name	Botanical name	Character	Altitude	Sites	Best propagation	Comments
Choya/tarna bans	<i>Dendrocalamus hamiltonii</i>	Thin culm, heavy branching	300-2000 m	Moist	Culm cuttings	
Dhanu bans	<i>Bambusa balcooa</i>	Thick culm, heavy branching	Terai-1600 m	Varied	Culm cuttings	
Kalo bans	<i>Dendrocalamus hookeri</i>	Heavy branching, brown hairs	1200-2500 m	Varied	Culm cuttings	
Mal bans	<i>Bambusa nutans</i>	Strong, straight culms	Terai-1500 m	Dry/varied	Traditional method	Subspecies <i>cupulata</i>
Nibha/ghopi/lyas bans	<i>Ampelocalamus patellaris</i>	Smaller, blueish culms	1200-2000 m	Varied	Traditional method	
Tharu bans	<i>Bambusa nutans</i>	Strong, straight culms	Terai-1500 m	Varied	Traditional method	Subspecies <i>nutans</i>

Notes. Bamboos were re-classified in 1994, so these names do not all correspond with the 1991 *Vegetation Structures* . . . manual or some other documents. The authority for these names is: Stapleton, C. 1994. *Bamboos of Nepal: an Illustrated Guide*. Royal Botanic Gardens, Kew: London.

Tite nigalo and padang bans are included in the list of grass species.

Geo-Environmental Unit

Rec: ✓ = particularly recommended for roadside areas.

Department of Roads

LARGE TREES FOR BIO-ENGINEERING IN THE ROAD SECTOR
(Species used or recommended for bio-engineering throughout Nepal)

Local name	Botanical name	Rec	Character	Altitude	Sites	Light	Coppicing	Best propagation	Seeds/kg	Comments
Acacia	<i>Acacia auriculiformis</i>		Small non-thorny tree (exotic)	Terai-1000 m	Hot and dry; harsh	Full light	Pollards well	Seeds/polypots	40,000	Best of all introduced acacias
Amp/aap	<i>Mangifera indica</i>		Medium-sized fruit tree	Terai-1200 m	Hot and dry but not stony	Full light	Can be lopped	Seeds/polypots	-	
Ashare phul	<i>Lagerstroemia parviflora</i>		Medium to large tree	Terai-1200 m	Varied to dry	?	?	Seeds/polypots	30,000	
Babul/kikar	<i>Acacia nilotica</i>		Medium-sized thorny tree (exotic)	Terai-1000 m	Hot and dry; harsh	Full light	Coppices poorly	Seeds/polypots	9,000	Very successful in drier parts of India
Badahar	<i>Artocarpus lakoocha</i>		Medium to large deciduous tree	Terai-1300 m	Varied and moist	Bears shade	Can be lopped	Seeds/polypots	2,000	Difficult to establish
Bakeno	<i>Melia azedarach</i>	✓	Medium to large deciduous tree	Terai-1800m	Hot and dry; harsh	Demands light	Coppices well	Seeds/polypots	1,200	Needs deep soil for really fast growth
Bange kath	<i>Populus ciliata</i>		Large deciduous tree	2000-3000 m	Dry to moist	Full light	Pollards well	Hardwood cuttings	-	Grows down to 1200 m in the Far West
Banghi	<i>Anogeissus latifolia</i>		Large deciduous tree with drooping branches	Terai-1700 m	Hot and dry	Full light	Coppices well	Seeds/polypots	100,000	
Birendra phul	<i>Jacaranda mimosifolia</i>		Medium size deciduous ornamental (exotic)	Terai-1600 m	Varied to dry	Light	Does not coppice	Seeds/polypots	50,000	
Champ	<i>Michelia champaca</i>		Large evergreen tree	500-1500 m	Varied to moist	Light or shade	Coppices well	Seeds/polypots	14,000	
Chilaune	<i>Schima wallichii</i>	✓	Large evergreen tree	900-2000 m	Varied; dry to moist	Bears shade	Can be lopped	Seeds/polypots	160,000	Can colonise existing plantations
Chiuri	<i>Alexandra butyracea</i>		Large tree	Terai-1700 m	Varied and poor	Demands light	Withstands lopping	Seeds/polypots	450	Slow initial growth on poor, stony soils
Chuletto	<i>Brassaiopsis hainla</i>		Small prickly evergreen tree	800-2000 m	Varied	?	Can be lopped	Seed/hardwood cuttings up to 2 m	25,000	
Dabdabe	<i>Garuga pinnata</i>	✓	Large deciduous tree	Terai-1300m	Varied and dry	Full light	Coppices well	Seed/hardwood cuttings up to 2m	4,000	Grows in most sites suitable for sal
Dar/githi	<i>Boehmeria rugulosa</i>		Small to medium tree	300-1700 m	Varied	Light or shade	Stands heavy lopping	Seeds/hardwood cuttings	2,000	Natural coloniser, often found with utis
Deshi katus	<i>Castanea sativa</i>		Large tree (exotic)	1000-2000 m	Varied	Light or shade	Coppices well	Seeds/polypots	250	
Dhale katus	<i>Castanopsis indica</i>		Large tree	900-2900 m	Varied	Light or shade	Coppices	Seeds/polypots	1,300	Grows best in higher rainfall areas

Geo-Environmental Unit

Rec: ✓ = particularly recommended for roadside areas.

Department of Roads

LARGE TREES FOR BIO-ENGINEERING (continued)

Local name	Botanical name	Rec.	Character	Altitude	Sites	Light	Coppicing	Best propagation	Seeds/kg	Comments
Dhupi salla	<i>Cryptomeria japonica</i>		Large evergreen tree (exotic)	1200-2500 m	Varied but not hot or dry	Bears shade	?	Seeds/polypots	250,000	
Dudhilo	<i>Ficus nerifolia</i>		Small deciduous fodder tree	900-2200 m	Varied and dry	Bears shade	Can be lopped	Seeds/polypots	1,600,000	High grazing risk
Gobre salla	<i>Pinus walllichiana</i>	✓	Large coniferous tree	1800-3000 m	Dry; varied	Full light	Can be lopped	Seeds/polypots	22,500	Not on moist sites; use only exceptionally
Gliricidia	<i>Gliricidia sepium</i>		Small leguminous tree (exotic)	Terai-500 m	Hot, not too dry; free draining	Full light	Coppices and pollards well	Seeds/hardwood cuttings up to 2 m	8,500	Has not performed well in Nepal so far
Gogan	<i>Saurauia nepaulensis</i>		Medium-sized fodder tree	750-2100 m	Varied	Bears shade	Can be lopped	Seeds/polypots	4,000,000	
Golainchi/goila	<i>Plumeria acuminata</i>		Ornamental tree	500-1500 m	Varied and dry	Bears shade	?	Seeds/polypots	-	
Gulmohar	<i>Delonix regia</i>		Medium-sized ornamental tree	Terai-1000 m	Varied and dry	Full light	Can be lopped	Seeds/polypots	-	
Ipil ipil	<i>Leucaena species</i>		Several species of small fodder trees	Terai-1500 m	Varied and dry	Full light	Coppices and pollards well	Seeds/polypots	20,000	Not recommended due to pest problems
Jamun	<i>Syzygium cumini</i>		Medium-sized evergreen tree	Terai-1600 m	Moist	Bears shade	Coppices well	Seeds/polypots	1,000	
Kadam	<i>Anthocephalus chinensis</i>		Large deciduous tree; horizontal branches	Terai-1000 m	Varied and moist	Bears shade	Coppices well	Seeds/polypots	900,000	High grazing risk
Kagati	<i>Citrus aurantifolia</i>		Small fruit tree	500-1500 m	Varied	?	?	Hardwood cuttings	-	
Kaju	<i>Anacardium occidentale</i>		Small nut tree	Terai-1600 m	Varied and poor	?	?	Grows in steep, rocky sites	-	
Kalki phul/bottlebrush	<i>Callistemon citrinus</i>		Small ornamental tree (exotic)	Terai-1800 m	Varied; tolerates swampy sites	Full light	Can be lopped	Seeds/hardwood cuttings	850,000	Common ornamental
Kalo siris	<i>Albizia lebeck</i>	✓	Medium-sized deciduous tree	Terai-1200m	Hot and dry; harsh	Full light	Coppices well	Seeds/polypots	5,000	High grazing risk
Kangiyo	<i>Grevillea robusta</i>		Large, straight-stemmed ornamental tree (exotic)	Terai-1600 m	Varied; avoid windy sites	Full light	Can be pollarded	Seeds/polypots	100,000	
Kapur	<i>Cinnamomum camphora</i>		Evergreen tree (exotic)	Terai-2000 m	Prefers moist sites	?	Coppices well	Seeds/polypots	3,500	
Kavro	<i>Ficus lacor</i>		Small, nearly evergreen fodder tree	Terai-1600 m	Varied	Full light	Can be lopped	Hardwood cuttings up to 2 m	-	High grazing risk

LARGE TREES FOR BIO-ENGINEERING (continued)

Local name	Botanical name	Rec	Character	Altitude	Sites	Light	Coppicing	Best propagation	Seeds/kg	Comments
Khanyu (khosro)	<i>Ficus semicordata</i>	✓	Small stature, heavy branching	Terai-2000m	Hot and dry; varied	Full light	Coppices well	Seeds/polypots	1,500,000	
Khari	<i>Celtis australis</i>		Medium-sized deciduous tree	700-2400 m	Varied	Bears shade	Coppices and pollards well	Seeds/polypots	4,500	
Khasru	<i>Quercus semecarpifolia</i>		Large forest tree	1700-3800 m	Varied	Full light	Coppices and pollards well	Seeds/polypots	150	
Khayer	<i>Acacia catechu</i>	✓	Large, thorny tree	Terai-1000m	Hot and dry; harsh	Full light	Coppices well	Seeds/polypots	30,000	
Koiralo	<i>Bauhinia variegata</i>		Medium-sized fodder tree	Terai-1900 m	Varied and dry	Full light	Coppices well	Seeds/polypots	2,500	
Kutmero	<i>Litsea monopetala</i>		Medium-sized evergreen fodder tree	Terai-1600 m	Varied to stony and dry	Light or shade	Can be lopped	Seeds/polypots	5,300	
Lahare pipal	<i>Populus x euramerica</i>		Large deciduous varieties (exotics)	Terai-1700 m	Moist	Full light	Coppices and pollards well	Hardwood cuttings	-	
Lankuri	<i>Fraxinus floribunda</i>	✓	Large deciduous tree	1200-2700 m	Varied; best in moist sites	Prefers light	Coppices well	Seeds/polypots	60,000	
Lapsi	<i>Choerospondias axillaris</i>		Medium to large deciduous tree	950-1900 m	Varied and dry	Strong light	Can be lopped	Seeds/polypots	300	
Makadamia	<i>Macadamia tetraphylla</i>		Exotic nut tree	Terai-1600 m	Hot and dry; harsh	?	?	Seeds/polypots	-	
Mashala	<i>Eucalyptus camaldulensis</i>		Large tree with a thin crown	Terai-1800 m	Hot and dry; harsh	Full light	Coppices well	Seeds/polypots	770,000	Best eucalypt in Nepal; stifles nearby plants
Mayal/mel	<i>Pyrus pashia</i>		Small tree, often spiny	1500-2500 m	Varied	?	?	Seeds/hardwood cuttings	70,000	Spreading superficial roots; root suckers
Musure katus	<i>Castanopsis tribuloides</i>		Large deciduous tree	500-2300 m	Varied and dry	Light or shade	Coppices well	Seeds/polypots	400	Most widespread of all katus species
Nebharo	<i>Ficus auriculata</i>		Medium-sized fodder tree	Terai-2000 m	Varied and dry	Full light	Coppices and pollards well	Seeds/hardwood cuttings	3,000,000	High grazing risk
Nim	<i>Azadirachta indica</i>		Large evergreen tree	Terai-900 m	Hot and dry	Full light	Coppices well	Seeds/polypots	3,000	
Okhar	<i>Juglans regia</i>		Medium-sized nut tree	1200-2800 m	Varied and moist	Full light	Coppices well	Seeds/grafting	35	
Painyu	<i>Prunus cerasoides</i>	✓	Medium-sized flowering tree	500-2400 m	Varied and dry; stony	Bears shade	Coppices	Seeds/polypots	2,500	

Rec: ✓ = particularly recommended for roadside areas.

LARGE TREES FOR BIO-ENGINEERING (continued)

Local name	Botanical name	Rec	Character	Altitude	Sites	Light	Coppicing	Best propagation	Seeds/kg	Comments
Patle katus	<i>Castanopsis hystrix</i>		Large evergreen tree	1000-2500 m	Varied	Bears shade	Coppices well	Seeds/polypots	600	
Phalant	<i>Quercus lamellosa</i>		Large forest tree	1600-2800 m	Moist sites preferred	Bears shade	Coppices well	Seeds/polypots	25	Best in areas of higher rainfall
Phaledo	<i>Erythrina</i> species	✓	Three fodder species	900-3000 m	Varied	Light	Can be lopped	Seeds/hardwood cuttings up to 2m	2,000	Long cuttings are very successful
Rajbriksha/ amaltas	<i>Cassia fistula</i>		Medium-sized ornamental tree	Terai-1400 m	Varied and dry	Light or shade	?	Seeds/polypots	6,300	Popular ornamental
Rani (khote) salla	<i>Pinus roxburghii</i>	✓	Large coniferous tree	500-1950 m	Hot and dry; varied	Full light	Can be lopped	Seeds/polypots	8,000	Not on moist sites; use only exceptionally
Rato siris	<i>Albizia julibrissin</i>	✓	Medium-sized deciduous tree	800-3000 m	Varied and moist	Light or shade	Coppices well	Seeds/polypots	24,000	Fast growing in damp sites
Ritha	<i>Sapindus mukorossi</i>		Large tree	700-2000 m	Varied	?	?	Seeds/polypots	600	
Sahijan/ shobhanjan	<i>Moringa oleifera</i>		Small ornamental tree	Terai-1000 m	Hot and dry; varied	Light or shade	Coppices and pollards well	Hardwood cuttings up to 2 m	3,000	
Sal	<i>Shorea robusta</i>		Large forest tree	Terai-1000 m	Varied; dry to moist	Light or shade	Coppices well	Seeds/polypots	450	
Saur	<i>Betula alnoides</i>		Small tree	1200-3000 m	Varied to moist	Full light	?	Seeds/polypots	5,000,000	Natural coloniser
Seto siris	<i>Albizia procera</i>	✓	Medium-sized deciduous tree	Terai-1350m	Moist	Full light	Can be lopped	Seeds/polypots	18,000	Sensitive to grass competition
Sisau	<i>Dalbergia sissoo</i>	✓	Large broadleaved tree	Terai-1400m	Varied	Full light	Coppices and pollards well	Seeds/polypots / stump cuttings	33,000	Needs reasonable soil
Suntala	<i>Citrus chyracarpa</i>		Small fruit tree	500-1500 m	Varied	Full light	?	Hardwood cuttings	-	
Tanki	<i>Bauhinia purpurea</i>		Medium-sized deciduous fodder tree	Terai-1600 m	Varied and dry	Needs light	Can be lopped	Seeds/polypots	4,000	High grazing risk
Tendu	<i>Diospyros malabarica</i>		Medium-sized evergreen tree	Tera-1500 m	Moist sites and good soils	Bears shade	Can be lopped	Seeds/polypots	800	High grazing risk
Tooni	<i>Toona ciliata</i>		Large deciduous tree	Terai-1700 m	Moist sites and good soils	Light or shade	?	Seeds/polypots	125,000	
Utis	<i>Alnus nepalensis</i>	✓	Large broadleaved tree	900-2700 m	Varied and moist	Full light	Probably does not coppice	Seeds/polypots	500,000	

Geo-Environmental Unit

Rec: ✓ = particularly recommended for roadside areas.

Department of Roads

PLANTS WHICH SHOULD NOT BE USED FOR BIO-ENGINEERING

Local name	Botanical name	Reason for not using as a bio-engineering species
Smaller plants		
Ban mara	<i>Eupatorium adenopherum</i>	Very shallow rooting; stifles other plants; has become a damaging weed
Tite pate	<i>Artemesia vulgans</i>	Very shallow rooting; stifles other plants; has become a damaging weed
Annual grasses	Various	Too short lived
Trees		
Cassia (exotic)	<i>Cassia siamea</i>	Suffers from grass competition; creates heavy shade when canopy closes; competes heavily with other species
Ipil ipil	<i>Leucaena leucocephala</i>	Growth has been severely hampered by attacks of the insect Psyllid
Patula salla	<i>Pinus patula</i>	Frequently suffers from either drought or nutritional problems in Nepal hill plantations
Sagawan (teak)	<i>Tectona grandis</i>	This tree tends to suppress all undergrowth and is known to give rise to conditions allowing extensive erosion below its canopy.

Note. Species such as salla (pines) and mashala (eucalypts) should only be used in mixtures with other plants, where they constitute no more than 50% of the plants. In this capacity they have distinct advantages but in single stands tend to stifle surface plant cover. A mixture of rani salla and chilaune, for example, can be particularly effective in a number of ways.

GLOSSARY OF BIO-ENGINEERING TERMS

Annual	Of plants which complete their life cycle from seed to reproduction, to death in one year.
Bamboo	A perennial grass with woody culms from rhizomes. The term is used loosely to cover a number of genera other than just <i>Bambusa</i> .
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, <i>Alnus nepalensis</i> is the Species <i>nepalensis</i> of the <i>Alnus</i> Genus (which contains all alders): hence <i>Alnus nepalensis</i> .
Breast wall	A wall provided to protect a soil slope without considering retaining properties
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 <i>a layering</i> (see below).
Checkdam	A physical obstruction provided in water courses to control gully erosion.
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.
Colonise	The establishment of the first plants on bare ground
Compost	Decomposed plant matter used as an organic fertiliser.
Coppice	Where the trunk of a tree is cut off about 30 cm above the ground to allow new shoots to come from the stump.
Culm	The stem of a grass.
Cutting	Any part of a plant (stem, rhizome or root) that is used for vegetative propagation. See also <i>Grass slip</i> and <i>Slip cutting</i> .
Dentition	The filling of cavities, usually on steep cut slopes.
Drill	See under <i>Planting drill</i> .
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.
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 <i>Slip cutting</i> .
Hardwood cutting	A woody stem from a shrub or tree, inserted in the ground for vegetative propagation.
Layering	A plant which forms from the stem, stolon or rhizome of another plant. This can be used as a means of propagation. This is different from <i>brush layering</i> (see above).
Leat	An irrigation channel (kulo in Nepali).
Lop	Where the branches of trees are cut to provide fodder or small firewood.
Mulch	A layer of material placed on the soil surface to conserve moisture.
Naike	(Nepali) A nursery foreman.

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.
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.
Pioneer species	The first plants to colonise bare ground.
Planting drill	When grasses are propagated using vegetative parts, the planting drill consists of one or more grass slips or cuttings.
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.
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.
Recalcitrant	Seeds which must not be dried but have to be kept moist during storage.
Rhizome	An underground stem which 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.
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.
Slip cutting	A cutting made from a grass which has fibrous roots but no rhizome system. See also <i>Grass slip</i> .
Stem	The part of a plant with nodes, buds and leaves; usually above ground, but some (such as rhizomes) are underground.
Stolon	A stem which grows along the ground, producing at its nodes new plants with roots and upright stems.
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.
Toe wall	A wall of low height provided to protect the toe of a soil mass.
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.
Weft	In weaving, the cross threads woven into the warp by passing the shuttle across the loom.

CALCULATION OF NURSERY SIZE

The amount of land required depends largely upon the number of plants to be produced, the time they will spend in the nursery and the density at which they will stand in the beds, as well as on the slope and quality of the site.

Before starting the calculation of area needed, it is useful to list the various components of the nursery that are required, as follows:

- seedbeds (for roadline bio-engineering nurseries usually a total bed area of 5 m²);
- grass beds (main grass plant growing area);
- polypot standout beds (main shrub/tree growing area);
- paths, roads, irrigation leats;
- working area, soil storage (including thatched shelter), compost making area;
- chowkidar's hut/tool and seed store;
- area for any future expansion.

The calculation for nursery size is based on the main plant growing area required. For example: a nursery is needed for the following average annual production.

500,000 grass slips; and

18,000 shrub/tree plants in 4" × 7" (10 × 17.5 cm when folded flat) polypots.

In this hypothetical example, the grasses and half of the shrubs/trees need less than one year but the other half of the shrubs/trees in polypots require between one and two years in the nursery.

- (i) 500,000 grass slips.

Bed space is required for $(500,000 / 5) = 100,000$ slips to grow into clumps which will give a multiplication by five times when the plants are taken to site. They stand at 100 per m²:

$$100,000 / 100 = 1,000 \text{ m}^2.$$

- (ii) 18,000 polypots of 4" × 7" (10 × 17.5 cm) size.

Space is required for 22,500 (*ie* 18,000 pots + 25%) to allow for losses and culling. They stand at 128 per m² when spaced out (see note below):

$$22,500 / 128 = 176 \text{ m}^2.$$

But half of these plants require twice as much space because they will be in the nursery for more than 12 months:

$$88 + (88 \times 2) = 264 \text{ m}^2.$$

Grand total of beds = 1,264 m².

This must be multiplied by 1.5 for an unterraced nursery, or by 3 for a terraced nursery, to allow space for the paths between beds and for terrace risers. An unterraced nursery would therefore need 1,896 m² for the main plant growing area, and a terraced nursery 3,792 m². In addition space will be needed for seed beds for shrubs/trees (total bed area required 5 m²), the chowkidar's hut, vehicle access road, irrigation leat or water tank, and areas for working, soil storage, and compost making. So the total area required is likely to be 2,000 m² (about 4 ropanis) on a level site or almost twice as much on a steep site.

Spacing out: once polypot seedlings reach a height of 20 to 30 cm, they have to be given additional space. This is done by separating the rows of plants across the bed, usually by about 5 cm.

CALCULATION OF GRASS SLIP MULTIPLICATION

The nursery multiplication of grasses by slips produces a three to seven times increase in the number of plants each time the grass clumps are split out, depending on the species, altitude and time of planting in the nursery. At altitudes below 1200 metres, slips of grasses except amliso can be multiplied by seven times; amliso can usually only be multiplied by three times. At higher altitudes, usually above about 1200 metres, a three times multiplication is usually only possible. However, the timing of planting in the nursery bed also regulates the productivity. The table below summarises this information.

Nursery altitude	Species	Slips first planted	Number to plant
Terai-1200 m	Amliso	February	Final site number / 3
	Any other grass	February	Final site number / 7
		April/May	Final site number / 3
Above 1200 m	Any grass	February/March	Final site number / 3

For example, if a nursery at Bharatpur has to produce 100,000 grass slips for site planting in July, this should be the programme:

- either:** January: prepare 143 m² of grass beds;
 February: plant 14,300 grass slips at 100 mm spacing;
 July: lift all grass clumps, split into 100,000 slips and plant on site;
- or:** early April: prepare 334 m² of grass beds;
 April/May: plant 33,400 grass slips at 100 mm spacing;
 July: lift all grass clumps, split into 100,000 slips and plant on site.

The multiplications by three or seven when the clumps are lifted and divided are, of course, only broad estimates. Usually there is adequate extra to cover losses.

Number of grass slips per planting drill. The planting drill described in the rate analysis norms consists of a different number of slips, depending on the type of grass, the nature of its rooting and the parts used for vegetative propagation.

The table below summarises the requirement of grass slips per planting drill by different means of vegetative propagation. An important implication of this is that grasses with fibrous roots which are propagated by means of rooted slip cuttings need two slips per planting drill and so nursery planning has to take this into account.

Propagation method	No. of slips per drill	Examples of species
Rooted cuttings of grasses with rhizome root systems	1	Amliso, padang, tite nigalo
Rooted cuttings of grasses with fibrous root systems	2	Babiyo, kans, khar, phurke
Single or double node stem cuttings	1	Dhonde, napier, narkat
Single or double node stolon cuttings	1 or 2	Dhubo, kikiyu

CALCULATION OF TREE SEED REQUIREMENTS

Because of natural uncertainties, it is necessary to obtain and sow many more seeds than the actual number of seedlings required. It is normal practice to grow 25% extra seedlings and discard the poorer plants when they leave the nursery. It is also normal to allow four times the amount of seed for the total number of seedlings to be grown. Therefore, for every 10 seedlings to be used on site, 50 seeds should be obtained and sown.

The table below shows as an example the quantity of seeds required to grow 5,000 each of utis and khote salla trees.

S No	Detail	Utis	Khote salla
1	Number of plants needed	5,000	5,000
2	Number of plants to be produced: $[1] \times 5 / 4$	6,250	6,250
3	Number of seeds needed: $[2] \times 4$	25,000	25,000
4	Seeds/kg	1,350,000	10,000
5	Seeds/g	1,350	10
6	Grammes of seed required: $[3] / [5]$	18.5	2,500
7	Seed order	Say 20 g	2.5 kg

VEGETATIVE PROPAGATION: TYPES AND AGES OF CUTTINGS

The species lists in this document give details of the types of cuttings by which different plants can be propagated. The table below lists the types and gives the source and necessary age of the material.

Type of plant	Cutting type	Source of material	Age of parent part
Grasses	Stem (culm) cuttings	Upright stem	6 to 18 months
	Rhizome cuttings	Clump	2 to 3 years
	Slip cuttings	Clump	2 to 3 years
	Stolon cuttings	Horizontal stem	6 to 18 months
Bamboos	Rhizome cuttings	Clump	≥ 2 or 3 years
	Stem (culm) cuttings	Upright stem	1 to 2 years
Trees and shrubs (woody plants)	Stem cuttings	Single plant stem	1 to 3 years
	Stump cuttings	Single plant stem	1 to 3 years

SEED COLLECTION TIMES FOR GRASSES

Local name	Botanical name	Seed collection
Amliso	<i>Thysanolaena maxima</i>	Mar-Apr
Babiyo	<i>Eulaliopsis binata</i>	Jan-Feb
Banso ghans	<i>Eragrostis tenella</i>	Dec-Jan
Blue panic grass	<i>Panicum antidotale</i>	Use cuttings
Buffalo grass	<i>Cenchrus ciliaria</i>	Use cuttings
Clover	<i>Trifolium species</i>	Use cuttings
Dangre khar	<i>Cymbopogon pendulus</i>	Dec-Jan
Desmodium	<i>Desmodium distortum</i>	Use cuttings
Desmodium greenleaf	<i>Desmodium intortum</i>	Use cuttings
Dhonde	<i>Neyraudia reynaudiana</i>	Dec-Jan
Dhubo	<i>Cynodon dactylon</i>	Use cuttings
Dhungre	Unknown	Dec-Jan
Dhus	Unknown	Dec-Jan
Jaughans	Unknown	May-Jun
Kagati ghans	<i>Cymbopogon citratus</i>	Nov-Dec
Kans	<i>Saccharum spontaneum</i>	Nov-Dec
Katara khar	<i>Themeda species</i>	Oct-Nov
Khar	<i>Cymbopogon microtheca</i>	Dec-Jan

Local name	Botanical name	Seed collection
Khus	<i>Vetiver zizanioides</i>	Sep-Nov
Kikiyu, thulo dhubo	<i>Pennisetum clandestinum</i>	Use cuttings
Kudzu	<i>Pueraria lobata</i>	Use cuttings
Molasses	<i>Melinis minutiflora</i>	Use cuttings
Musekharuki	<i>Pogonatherum paniceum</i> (?)	Use cuttings
Napier	<i>Pennisetum purpureum</i>	Use cuttings
Narkat	<i>Arundo donax</i>	Nov-Jan
NB21	<i>P. purpureum</i> × <i>typhoides</i>	Use cuttings
Padang bans	<i>Himalayacalamus hookerianus</i>	Use cuttings
Phurke	<i>Arundinella nepalensis</i>	Dec-Jan
Rato kans	<i>Friarthus rufipilus</i>	Dec-Jan
Salimo khar	<i>Chrysopogon gryllus</i>	Dec-Jan
Setaria	<i>Setaria anceps</i>	Jul-Aug
Sito	<i>Neyraudia arundinacea</i>	Dec-Jan
Stylo	<i>Stylosanthes guianensis</i>	Use cuttings
Thulo kharuki	<i>Capipedium assimile</i> (?)	Dec-Jan
Tite nigalo bans	<i>Drepanostachyum intermedium</i>	Use cuttings

SEED INFORMATION FOR SHRUBS/SMALL TREES

Local name	Botanical name	Seed collection time	Seeds/kg	Viability (months)
Aak	<i>Calatropa giganteum</i>	Feb-Mar	About 500,000	6
Ainselu	<i>Rubus ellipticus</i>	Nov-Dec	About 50,000	6
Alainchi	<i>Elettaria cardomomum</i>	?	-	-
Amala	<i>Phyllanthus emblica</i>	Sep-Jan	-	-
Amba/ambak	<i>Psidium guajava</i>	Aug-Oct	About 10,000	12
Aparajita	<i>Clitoria ternatea</i>	?	-	-
Areri	<i>Acacia pennata</i>	Nov-Dec	36,000	12
Argali	Unknown	Use cuttings	-	-
Arile kanda	<i>Caesalpinia decapetala</i>	?	-	-
Armalito, seabuckthorn	<i>Hippophae salicifolia</i>	Aug-Nov	130,000	12
Assuro	<i>Adhatoda vasica</i>	Use cuttings	-	-
Bainsh	<i>Salix tetrasperma</i>	Use cuttings	-	-
Bains	Unknown; <u>not</u> <i>Salix</i>	Use cuttings	-	-
Bagamkali/ baramase phul	<i>Bougainvillea spectabilis</i>	Use cuttings	-	-
Ban chutro	<i>Berberis aristata</i>	?	-	-
Ban silam	<i>Elsholtzia blanda</i>	?	-	-
Bayer	<i>Zizyphus mauritiana</i>	Dec-Mar	1,000	24
Bhimsenpati	<i>Buddleja asiatica</i>	Use cuttings	-	-
Bhui katahar	<i>Ananas comosus</i>	Use cuttings	-	-
Bhujetro	<i>Butea minor</i>	Nov-Jan	450	18
Bilaune	<i>Maesa chisia</i>	?	-	-
Bokshi ghans	<i>Mimosa rubicaulis</i>	Use cuttings	-	-
Chiya	<i>Camellia sinensis (et al)</i>	Use cuttings	-	-
Chutro	<i>Berberis asiatica</i>	Mar-Apr	-	-
Coffee	<i>Coffea arabica</i>	Aug	About 500	3
Dhanyero	<i>Woodfordia fruticosa</i>	Mar-Apr	About 1,000,000	12
Dhusun	<i>Colebrookea oppositifolia</i>	Mar	About 1,000,000	12
Gahate	<i>Desmodium species</i>	?	-	-
Ghangaru	<i>Pyracantha crenulata</i>	Use cuttings	-	-
Ghurmiso	<i>Leucosceptrum canum</i>	Use cuttings	-	-
Hasna/hasua	<i>Cestrum nocturnum</i>	?	-	-
Imili	<i>Rumex hastatus</i>	Mar-Apr	About 250,000	6
Kanda phul	<i>Lantana camara</i>	Use cuttings	-	-
Kera	<i>Musa paradisiaca</i>	Use root suckers	-	-

SEED INFORMATION FOR SHRUBS/SMALL TREES (continued)

Local name	Botanical name	Seed collection time	Seeds/kg	Viability (months)
Kettuke	<i>Agave americana</i>	Use cuttings	-	-
Keraukose	<i>Indigofera atropurpurea</i>	Nov-Jan	94,000	12
Khirro	<i>Sesuvium portulacastrum</i>	Use cuttings	-	-
Kimbu	<i>Morus alba</i>	Use cuttings	-	-
Kunyelo	<i>Trema orientalis</i>	Use cuttings	-	-
Lalupate	<i>Poinsettia pulcherrima</i>	Use cuttings	-	-
Mesquite	<i>Prosopis juliflora</i>	May-Jun	-	-
Namdi phul	<i>Colquhounia coccinea</i>	Use cuttings	-	-
Nil kanda	<i>Duranta repens</i>	Use cuttings	-	-
Pate siuli	<i>Opuntia ficus indica</i>	?	-	-
Rahar	<i>Cajanus cajan</i>	?	-	-
Rato chulsi	<i>Osbeckia stellata</i>	?	-	-
Saruwa/ bihaya	<i>Ipomoea fistulosa</i>	Use cuttings	-	-
Sajiwan	<i>Jatropha curcas</i>	Use cuttings	-	-
Simali	<i>Vitex negundo</i>	Use cuttings	-	-
Sisal	<i>Agave sisalana</i>	Use cuttings	-	-
Siuli/sihundi	<i>Euphorbia royleana</i>	?	-	-
Tara phul/kochu	<i>Helianthus tuberosus</i>	Use cuttings	-	-
Thakal	<i>Phoenix humilis</i>	Feb	About 1,000	6
Tilka	<i>Wendlandia puberula</i>	Feb-Mar	About 1,000,000	12
Udalo	<i>Hypericum cordifolium</i> (?)	May-Jun	-	-

SEED INFORMATION FOR LARGE TREES

Local name	Botanical name	Seed collection time	Seeds/kg	Viability (months)
Acacia	<i>Acacia auriculiformis</i>	Mar-Apr	40,000	12
Amp/aap	<i>Mangifera indica</i>	May-Jul	-	Sow immediately
Ashare phul	<i>Lagerstroemia parviflora</i>	Jan-Feb	30,000	36
Babul/kikar	<i>Acacia nilotica</i>	Dec-Feb (?)	9,000	12
Badahar	<i>Artocarpus lakoocha</i>	Jun-Jul	2,000	Sow immediately
Bakeno	<i>Melia azedarach</i>	Nov-Mar	1,200	12
Bange kath	<i>Populus ciliata</i>	Use cuttings	-	-
Banghi	<i>Anogeissus latifolius</i>	Dec-Mar	100,000	15
Birendra phul	<i>Jacaranda mimosifolia</i>	Feb-Mar	50,000	24
Champ	<i>Michelia champaca</i>	Aug-Nov	14,000	1
Chilaune	<i>Schima wallichii</i>	Jan-Apr	160,000	6
Chiuri	<i>Aesandra butyracea</i>	Jun-Aug	450	Sow immediately
Chuletro	<i>Brassaiopsis hainla</i>	May-Jun	25,000	Sow immediately
Dabdabe	<i>Garuga pinnata</i>	Jun-Sep	4,000	12
Dar/githi	<i>Boehmeria rugulosa</i>	Oct-Jan	2,000	3
Deshi katus	<i>Castanea sativa</i>	Oct-Nov	250	Recalcitrant
Dhale katus	<i>Castanopsis indica</i>	Oct-Nov	1,300	Recalcitrant
Dhupi salla	<i>Cryptomeria japonica</i>	Oct-Nov	250,000	24
Dudhilo	<i>Ficus neriifolia</i>	Jun-Aug	1,600,000	12
Gobre salla	<i>Pinus wallichiana</i>	Oct-Nov	22,500	12
Gliricidia	<i>Gliricidia sepium</i>	?	8,500	12
Gogan	<i>Saurauia nepaulensis</i>	Mar-Apr	4,000,000	12
Golainchi/ goila	<i>Plumeria acuminata</i>	?	-	-
Gulmohar	<i>Delonix regia</i>	Mar-May	-	-
Ipil ipil	<i>Leucaena species</i>	Nov-Jan	20,000	> 60
Jamun	<i>Syzygium cumini</i>	Jun-Jul	1,000	2
Kadam	<i>Anthocephalus chinensis</i>	Oct-Jan	900,000	12
Kagati	<i>Citrus aurantifolia</i>	Sep-Nov	-	-
Kaju	<i>Anacardium occidentale</i>	?	-	-
Kalki phul/ bottlebrush	<i>Callistemon citrinus</i>	Oct-Feb	850,000	-
Kalo siris	<i>Albizia lebbek</i>	Nov-Jan	5,000	>60
Kangiyo	<i>Grevillea robusta</i>	Jun-Sep	100,000	12
Kapur	<i>Cinnamomum camphora</i>	Sep-Nov	3,500	3
Kavro	<i>Ficus lacor</i>	Mar-May	-	-

SEED INFORMATION FOR LARGE TREES (continued)

Local name	Botanical name	Seed collection time	Seeds/kg	Viability (months)
Khanyu (khosro)	<i>Ficus semicordata</i>	Jul-Oct	1,500,000	6
Khari	<i>Celtis australis</i>	Oct-Dec	4,500	12
Khasru	<i>Quercus semecarpifolia</i>	Jun-Aug	150	Sow immediately
Khayer	<i>Acacia catechu</i>	Jan-Feb	30,000	24
Koiralo	<i>Bauhinia variegata</i>	Mar-May	2,500	12
Kutmero	<i>Litsea monopetala</i>	Jun-Aug	5,300	Sow immediately
Lahare pipal	<i>Populus × euramerica</i>	Use cuttings	-	-
Lankuri	<i>Fraxinus floribunda</i>	Sep-Jan	60,000	Sow immediately
Lapsi	<i>Choerospondias axillaris</i>	Oct-Jan	300	12
Makadamia	<i>Macadamia tetraphylla</i>	?	-	-
Mashala	<i>Eucalyptus camaldulensis</i>	Jul-Sep	770,000	24
Mayal/mel	<i>Pyrus pashia</i>	Nov-Jan	70,000	Sow immediately
Musure katus	<i>Castanopsis tribuloides</i>	Oct-Nov	400	Recalcitrant
Nebharo	<i>Ficus auriculata</i>	Mar-May	3,000,000	12
Nim	<i>Azadirachta indica</i>	Jun-Jul	3,000	0.5
Okhar	<i>Juglans regia</i>	Sep-Dec	35	Recalcitrant
Painyu	<i>Prunus cerasoides</i>	Oct-Nov	2,500	9
Patle katus	<i>Castanopsis hystrix</i>	Oct-Nov	600	Recalcitrant
Phalant	<i>Quercus lamellosa</i>	Oct-Dec	25	6
Phaledo	<i>Erythrina species</i>	Nov-Mar	2,000	60
Rajbriksha/ amaltas	<i>Cassia fistula</i>	?	6,300	> 60
Rani (khote) salla	<i>Pinus roxburghii</i>	Jan-Mar	8,000	12
Rato siris	<i>Albizia julibrissin</i>	Sep-Feb	24,000	> 60
Ritha	<i>Sapindus mukorossi</i>	Sep-Feb	600	12
Sahijan/ shobhanjan	<i>Moringa oleifera</i>	Mar-Jun	3,000	1
Sal	<i>Shorea robusta</i>	Jun-Jul	450	Sow immediately
Saur	<i>Betula alnoides</i>	Oct-Feb	5,000,000	12
Seto siris	<i>Albizia procera</i>	Dec-Jun	18,000	> 60
Sisau	<i>Dalbergia sissoo</i>	Feb-May	33,000	12
Suntala	<i>Citrus chyracarpa</i>	Dec-Jan	-	-
Tanki	<i>Bauhinia purpurea</i>	Nov-Apr	4,000	12
Tendu	<i>Diospyros malabarica</i>	Apr-Jun	800	2
Tooni	<i>Toona ciliata</i>	May-Jun	125,000	3
Utis	<i>Alnus nepalensis</i>	Nov-Mar	500,000	18

GUIDELINES FOR APPLYING BIO-ENGINEERING TECHNIQUES, ALL SLOPES

Slope angle	Slope length	Material drainage	Site moisture	Optimal technique
START	→	→	→	→
> 50°	> 15 metres	Good	Damp	Diagonal grass lines
			Dry	Contour grass lines
		Poor	Damp	1 Downslope grass lines and stone-pitched rills or 2 Chevron grass lines and stone-pitched rills
			Dry	Diagonal grass lines
	< 15 metres	Good	Any	Jute netting and planted grass
			Damp	1 Downslope grass lines or 2 Diagonal grass lines
		Poor	Dry	1 Jute netting and planted grass or 2 Contour grass lines or 3 Diagonal grass lines
35 - 50°	> 15 metres	Good	Any	1 Horizontal bolster cylinders and shrub/tree planting or 2 Downslope grass lines and stone-pitched rills or 3 Grass seeding, mulch and wide mesh jute netting
		Poor	Any	1 Herringbone bolster cylinders and shrub/tree planting or 2 Another drainage system and shrub/tree planting
	< 15 metres	Good	Any	1 Brush layers of woody cuttings or 2 Contour grass lines or 3 Contour fascines or 4 Palisades of woody cuttings or 5 Grass seeding, mulch and wide mesh jute netting
		Poor	Any	1 Diagonal grass lines or 2 Herringbone fascines and shrub/tree planting or 3 Herringbone bolster cylinders and shrub/tree planting or 4 Another drainage system and shrub/tree planting
<35°	Any	Good	Any	1 Contour strips of grass and shrubs/trees or 2 Shrub/tree planting
		Poor	Any	1 Diagonal lines of grass and shrubs/trees or 2 Shrub/tree planting
	< 15 metres	Any		Turfing
	Base of any slope			Large bamboo planting
Any	Any	Any rocky material		Direct seeding of shrubs or shrubs/small trees
Gullies ≤ 45°	Any gully			1 Large bamboo planting or 2 Live check dams

Notes. 'Any rocky material' is defined as material into which rooted plants cannot be planted but seeds can be inserted in holes made with a steel bar.

Chevron pattern: <<<<<<

Herringbone pattern: <<<<<< (like the bones of a fish).

ASSESSING THE QUALITY OF BIO-ENGINEERING SITE WORKS

The following are some simple rules for assessing the quality of bio-engineering works. They are not fully comprehensive, but give some indicators to look for.

Individual plants should be:

- a bright, healthy colour;
- showing no signs of wilting;
- well proportioned (*ie* not stunted or very tall and thin);
- growing fast, with a number of long new shoots;
- without signs of discoloration on the leaves;
- without signs of insect attack on the leaves or shoots (*eg* holes eaten in the leaves);
- without any obvious signs of disease;
- undamaged;
- not yellowed, except in the later part of the dry season.

Grass lines should be:

- complete, with plants at the spacing specified within the rows;
- the right distance between the rows, according to specification;
- even, with no gaps or poor plants in them;
- straight, according to specification.

Brush layers should be:

- complete, with the right number of cuttings per running metre;
- the right distance between the lines, according to specification;
- even, with no gaps or dead cuttings;
- straight, according to specification.

Fascines, which will need some minor excavations to check, should be:

- complete, with the right number of cuttings per running metre;
- the right distance between lines, according to specification;
- straight, according to specification.

Whole sites should be:

- completely treated, with no gaps or areas missed out;
- evenly covered;
- fully tidied up, with no loose debris on the slope;
- showing no signs of instability;
- stable enough to survive the early rains while plants get established
- generally looking good, complete and healthy throughout.

ASSESSING THE QUALITY OF BIO-ENGINEERING NURSERIES

This following are some simple rules for assessing the quality of bio-engineering nurseries. They are not fully comprehensive, but give some indicators to look for.

Grass beds (slip and rhizome cuttings, and grass seeds) and **hardwood cutting beds** should be:

- composed of good, fertile, well aerated soil;
- kept moist at all times;
- showing even growth;
- well weeded;
- kept with a porous, uncapped soil surface.

Grass plants should be:

- a healthy green colour;
- growing vigorously, with a number of long new shoots;
- showing no signs of wilting;
- without signs of discoloration on the leaves;
- without any obvious signs of disease or insect attack.

Shrub and tree seed beds should be:

- composed of good, fertile, well aerated soil and fine, clean sand;
- kept moist at all times;
- well shaded;
- showing even growth;
- well weeded.

Polypot seedlings should be:

- a bright, healthy colour;
- showing no signs of wilting;
- growing fast, with long new shoots;
- kept with roots pruned;
- kept moist throughout the soil cylinder;
- well weeded;
- without signs of discoloration on the leaves;
- without signs of insect attack on the leaves or shoots (*eg* holes eaten in the leaves);
- without any obvious signs of disease;
- undamaged.

Whole nurseries should be:

- kept tidy and clean;
- weeded throughout;
- well maintained;
- protected properly at all times.

SURVIVAL RATES OF PLANTS

Grasses propagated by slip should give a survival rate of almost 100% in the nursery and about 95% on site. If there are significantly more failures than this, then you should investigate the possible reasons. The most common reasons are that the slips were allowed to dry out at some stage during the transplanting process.

Grasses propagated by rhizome cuttings have a slightly lower survival rate. However, this should still exceed 95% in the nursery and 90% on site. Failures greater than these should be investigated.

Where grasses are grown from seed, it is almost impossible to estimate the survival rate. However, if the standard application rates are used, there should be a thick, even cover of grasses resulting. If this does not occur, the usual causes are from sowing too early or from seeds being washed off the surface.

Shrubs and trees have to be considered separately. In nurseries it is normal to plant more cuttings or to sow more seeds than are required because, however good the nursery staff, there will inevitably be significant losses. The processes of taking from cuttings or germinating, transplanting and growing on, all take a toll on the young plants.

It is normal practice to allow four times the amount of seed for the final number of seedlings required.

It is normal practice to grow up 25% more seedlings than will be required, and to discard the poorer plants when they leave the nursery.

Therefore, for every 100 seedlings used on site, 400 seeds will have been sown and 125 seedlings will have been grown up.

On site, the survival rates for shrubs and trees can vary considerably depending on the biophysical harshness of the site, the quality of the plants and the quality of the planting works. In forestry plantations in Nepal, the survival of only 80% is considered acceptable, although it should be much more. The same rate should be used for bio-engineering works. If less than 80% survive, then a thorough investigation should be made. The usual causes of casualties are from careless handling and planting on site, and subsequent grazing damage.

SAFETY CODE OF PRACTICE FOR WORKING ON SLOPES (TENTATIVE)

1. This code is designed to promote the safety of all Department and Contract personnel while working on slopes at sites where persons are at risk of falling a distance of more than 2 metres.
2. No-one may gain access to the site unless they are authorised by the Engineer or the Contractor.
3. No person may work unaccompanied unless they are on a very gentle slope (less than 30° slope). All personnel must leave the slope to take refreshments, meals *etc.*
4. During site works, all fragile slopes shall be clearly marked off and personnel informed of the dangers.
5. All access equipment, ropes and tackle must be regularly inspected and adequately maintained in a sound condition.
6. Where persons could fall over the edge of a slope, temporary guard rails or ropes should be installed where practicable. All persons exposed to a risk of falling must be provided with a secure and well anchored safety line. Such a rope must be of sufficient strength to provide them with safe arrest in the event of a fall.
7. Care must be taken to prevent tools and loose objects falling from the slope. Loose articles should be raised or lowered in a safe manner. They should not be carried up or down ladders, unless in the case of small items, which may be carried in a suitable shoulder bag.
8. Extreme care must be exercised on slopes during adverse weather conditions (wind, rain, fog and darkness create their own hazards in addition to the hazards inherent in slope work) and supervision must assess the conditions with great care before allowing access to the slope. Only where absolutely necessary may persons go on to slopes in heavy rain or during the hours of darkness. In such cases, no person shall go on to the slope unaccompanied.
9. Any scaffolding that is used must be composed of good quality materials. Bamboos should be freshly cut, of strong and flexible nature. Scaffolding must be correctly erected by competent persons and of appropriate capacity.
10. Ladders must be in good condition and adequate for the job. Ladders should extend one metre beyond the landing point and must be on a firm base, correctly pitched and lashed as soon as is possible. Unlashed ladders must be "footed".
11. If there is any potential hazard to personnel below where the slope work is taking place, adequate temporary warning notices, barriers and a "look out" person shall be employed. Where appropriate, standard traffic warning and control measures must be taken.
12. Appropriate protective clothing shall be issued, including, where necessary, protective helmets and boots with steel toe caps and slip resistant soles.

ANNUAL CALENDAR OF BIO-ENGINEERING WORKS

Month	Main activities	Comments/other works
Shrawan Jul-Aug	- Site plantation works: all grass slips and seedlings; all shrub and tree seedlings and hardwood cuttings; all remaining direct seeding - Observation of newly planted sites and maintenance as required	Site plantation starts this month in the Mid and Far Western Regions
Bhadra Aug-Sep	Observation of newly planted sites and maintenance as required	Budget release expected now: start detailed programming
Aswin Sep-Oct	- Observation of newly planted sites and maintenance as required - Conduct post-monsoon survey of roadside slopes, prioritise problem areas and begin planning for remedial works - Make initial assessment and order for jute netting (jute harvesting season) - Coppicing and pollarding of trees	Jute net weaving takes place all year round but timely ordering ensures the best quality fibres and lowest prices
Kartik Oct-Nov	- Preparation for seed collection: final establishment of quantities required and planning of seed sources - Compost and mulch making	
Mangsir Nov-Dec	- Seed collection, treatment and storage - Preparation for physical site works: planning, programming, contracting, <i>etc</i> - Compost and mulch making	This is the main seed collection period for grasses and some shrubs and trees, but seeds of some plants ripen at other times
Poush Dec-Jan	- Seed collection, treatment and storage - Begin to prepare nurseries for operations in the spring - Preparation for physical site works: planning, programming, contracting, <i>etc</i>	Existing nurseries should be in good order all year round but beds still need to be cultivated, polypots need to be filled, <i>etc</i>
Magh Jan-Feb	- Preparation of nurseries for operations in the spring - Low altitude nurseries start seed sowing - Site works: slope trimming, start of construction of civil works, <i>etc</i> - Seed collection, treatment and storage - Pruning and thinning of trees	
Falgun Feb-Mar	- Main period for starting nursery production - Sowing of seeds - Site works: slope trimming, construction of civil works, <i>etc</i> - Pruning and thinning of trees	
Chaitra Mar-Apr	- Nursery operations in full swing - Site works: slope trimming, construction of civil works, <i>etc</i>	
Baishak Apr-May	- Nursery operations in full swing - Site works: slope trimming, construction of civil works, <i>etc</i> - Application of jute netting on site	
Jestha May-Jun	- Nursery operations in full swing - Final physical site works - Final preparation of materials for site planting - Direct sowing of shrub and tree seeds on site - Direct sowing of grass seeds on gentle slopes or under mulch	
Ashad Jun-Jul	- Nursery operations continue - Site plantation works: all grass slips and seedlings; all shrub and tree seedlings and hardwood cuttings; all remaining direct seeding	Site plantation works start this month in most parts of the Eastern, Central and Western Regions

NURSERY ACTIVITY CALENDAR: LOW ALTITUDE NURSERIES

For nurseries below about 1200 to 1500 metres above sea level.

Activity	Shrawan	Bhadra	Aswin	Kartik	Mangsir	Poush	Magh	Falgun	Chaitra	Baisakh	Jestha	Ashad
Nursery construction	Complete by end of Mangsir											
Seed preparation, all plants												
Check seed sources												
Seed collection				*	*	*	*					
Seed treatment				*	*	*	*					
Annual preparation												
Soil and sand collection												
Order new supplies												
Bed preparation												
Grass slip production												
Check material sources												
Plant material collection												
Transplanting												
Respacing									As required			
Restocking grass beds												
Transplanting grass slips												
Shrub and tree seedling production												
Prepare potting mixes												
Filling polypots												
Seed sowing												
Pricking out									As required			
Root pruning										As required		
Spacing out										As required		
Sowing for large plants												
Extraction of plants from the nursery												
Uplifting and preparing											As required	
Transporting to site											As required	
Site planting works	Depends on rain										Depends on rain	
Routine activities												
Weeding												
Maintain water supply												
Watering			As required									
Shading of young plants									As required			
Record keeping												
General maintenance	Regular checks and repairs made											
Pest and disease control	Daily checks and action taken when necessary											
Protection of the nursery												
Compost production												
Making compost												
Turning compost				As required								

* Main seed collection period only; some seeds are collected at other times of the year, according to when they ripen.

NURSERY ACTIVITY CALENDAR: HIGH ALTITUDE NURSERIES

For nurseries above about 1200 to 1500 metres above sea level.

Activity	Shr	Bha	Asw	Kar	Man	Pou	Mag	Fal	Cha	Bai	Jes	Ash	Shr	Bha	Asw	Kar	Man	Pou	Mag	Fal	Cha	Bai	Jes	Ash					
Nursery construction	Finish by end Man																												
Seed preparation, all plants																													
Check seed sources																													
Seed collection				*	*	*	*									*	*	*	*										
Seed treatment				*	*	*	*									*	*	*	*										
Annual preparation																													
Soil and sand collection																													
Order new supplies																													
Bed preparation																													
Grass slip production																													
Check material sources																													
Plant material collection																													
Planting into beds																													
Restocking grass beds																													
Shrub and tree seedling production																													
Prepare potting mixes																													
Filling polypots																													
Seed sowing																													
Pricking out			As required											As required															
Root pruning					As required										As required														
Spacing out						As required												As required											
Extraction of plants from the nursery																													
Uplifting and preparing																													
Transporting to site																													
Site planting works																													
Routine activities																													
Weeding																													
Maintain water supply																													
Watering			As required												As required														
Shading of young plants							As required											As required											
Record keeping																													
General maintenance	Regular checks and repairs made												Regular checks and repairs made																
Pest and disease control	Daily checks and action taken when necessary												Daily checks and action taken when necessary																
Protection of the nursery																													
Compost production																													
Making compost																													
Turning compost				As required												As required													

* Main seed collection period only; some seeds are collected at other times of the year, according to when they ripen.