There are four types of culverts categorized from the flood discharge. The size and number of culverts are shown in Table 12.9.

Table 12.9 Type of Culverts

Type		Nos.
Pipe Culvert	ϕ 1.2m	32
Box Culvert	H2B2	16
	H3B4	4
	H3B4 2 cell	1

Source: JICA Study Team

12.4 Tunnel

12.4.1 Design Conditions

Following are the design condition of civil works of the tunnel.

1) Design speed 60km/h

2) Design daily volume (at year 2020)

   5,340 vehicle/day (include motorcycle)
   4,090 vehicle/day (without motorcycle)

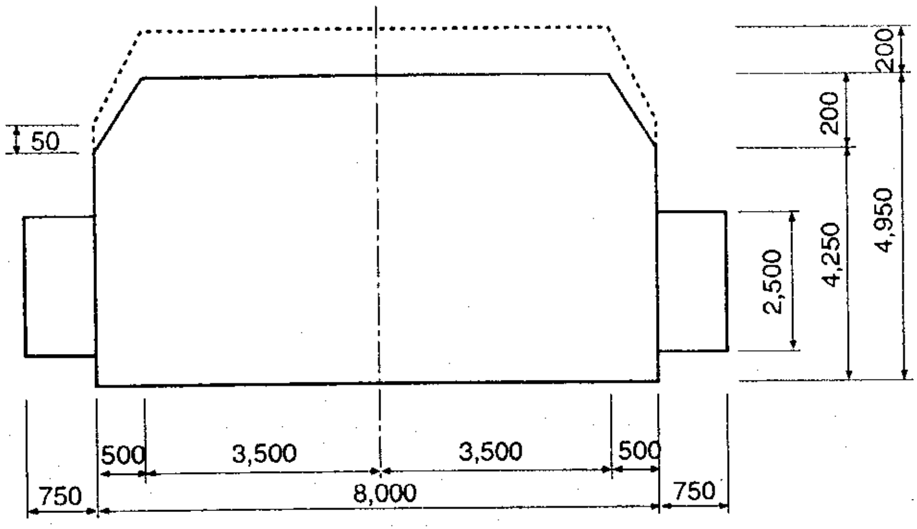
3) Width of road

   Pavement width : 0.5+3.5+3.5+0.5=8.0(m)
   Inspection gallery : 0.75m both sides

4) Vertical clearance 4.750m

5) Additional allowance against future overlay

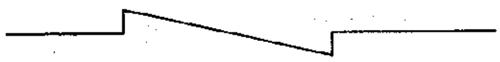
   Carriageway portion : +200mm
   Shoulder portion : +50 mm



6) Alignment of road.

Horizontal alignment: R=∞ (straight)

Vertical alignment: I=3.5%



12.4.2 Inner section

From the economical point of view, inner section of the tunnel should be minimized satisfying the following technical requirements:

- Thickness of concrete pavement	25 cm
- Thickness of roadbed	20 cm
- Vertical distance of road surface and inspection gallery	25 cm
- Side drain ditch	Circle shape ditch
- Space of interior board	Not applied
- For allowance necessary for Construction	5 cm

Several cases assuming various tunnel dimensions were studied. Case-2 in Table 12.10 is selected as it gives minimum inner area of the tunnel.

This dimension can accommodate 2 sets of 600mm diameter jet fans, if necessary.

Table 12.10 Study of Inner Dimension of Tunnel

Item	Radius of upper section	Radius of bottom section	Height of springline	Inner area	Flatness	Distance of space				Judgement
						a	b	c	d	
mark	R1	R2	H	A						
unit	m	m	m	m^2		m	m	m	m	
1	4.850	20.087	1.600	57.165	0.717	0.050	0.064	0.175	0.053	× Radius of bottom section to large
2	4.900	9.800	1.550	57.510	0.709	0.054	0.108	0.199	0.069	○
3	4.950	9.900	1.500	58.017	0.702	0.111	0.151	0.222	0.084	Δ
4	5.000	10.000	1.400	58.040	0.690	0.175	0.186	0.218	0.064	Δ
5	5.050	10.100	1.350	58.534	0.683	0.231	0.227	0.241	0.079	Δ
6	5.100	10.200	1.250	58.531	0.672	0.293	0.259	0.235	0.057	Δ
7	5.150	10.300	1.200	59.012	0.665	0.348	0.299	0.256	0.071	Δ

12.4.3 Type of portal

From the structural point of view, tunnel portal should function as a retaining structure for the slope behind the portal.

In addition, recently from the aesthetic point for view, consideration on harmonization with surrounding environment is also required.

Generally type of tunnel portal can be divided into the following three types.

- Gravity wall type
- Upright wall type
- Protrusion type

Applicability, structural requirements and aesthetic point of these portal type are described in Table 12.11.

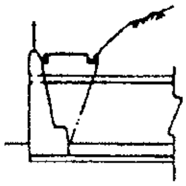
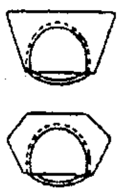
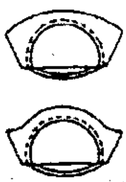
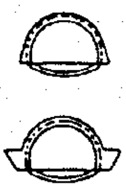
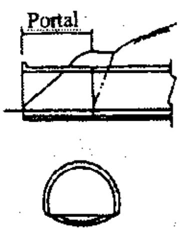
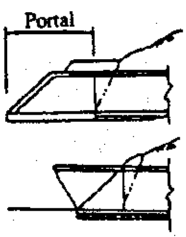
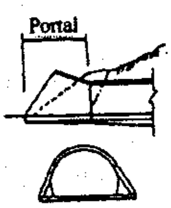
The Project Road has two tunnel portals - east portal and west portal - and upright type portal is selected as the optimum type from economical and construction workability point of view.

- East portal (Kathmandu side)

  The portal will locate in the vicinity of the tip of small ridge that is derived from Bhindhuga saddle.

  In the tunnel approach portion before the portal, longitudinal alignment of the road descends to the tunnel in a gentle terrain. As a result, the tunnel approach portion is constructed by both side cutting with 20m cutting slope.

Table 12.11 Type and Features of Tunnel Portal

Item \ Type		Shape	Applicability in Ground Condition	Structure Requirements	Landscape
Gravity Type	Gravity/Semi-gravity type		·When land feature is rather steep or structure like retaining wall is required. ·When rock fall is expected. ·Backside drainage is easily treated.	·Sufficient slope protection work of backside cut slope is required.	·Wider area of wall requires some means of reducing brightness (fox example, chipping of wall). ·Looks substantial but drivers tend to have an oppressive feeling
Upright Wall Type	Wing type		·When cut works on both sides are required ·When fully expected earth pressure.	As above ·Should be jointed to tunnel	As above
	Arch wing type		·When land feature is relatively gentle. ·When cut works on both sides are relatively minor.	·In some cases, artificial tube is built (particularly in the arch position) ·Some protection earth blanket is necessary.	·Attention should be paid so as to avoid curves in the arch portion causing a sense of in harmony.
Protrusion Type	Half Protraction Type (parapet type)		·When a ridge-like land form or when no structure exists on both sides.	·Several-meter long artificial tube is required and minor retaining walls may be required against back fill.	·As face area of portal is reduced, it well harmonize with surroundings.
	Protruded Type		·When counterweight embankment is used in front of entrance. ·Geological condition of portal area is poor.	·Most economical when land feature and nature of ground are stable. ·If portal area is geologically poor, counter weight embankment and additional R.C. tube is required.	As above
	Split Bamboo Type		·When area adjacent to portal is topographically gentle. ·In the case of inverted split bamboo type, full consideration should be given to the stability of the structure.	·Complex and difficult works such as formwork, re-bar work, as required.	·Harmony with the entrance is attained.
	Bell-mouse Type		·Applicable in places that are topographically and geologically favorable and have open space adjustment to the portal.	As above	·Less influence is induced on the running of vehicles. ·Matches well with land reature adjacent to entrance.

Source: Road Tunnel Standard by JRA

In this case, upright type portal is preferable since it can minimize excavation volume of the backside of the portal.

- West Portal (Dharke side)

  The portal is located on very steep slope. Taking slope failure and rockfall from the backside slope, entrance of tunnel should keep a certain distance from the backside slope.

  In case of protrusion type, big scale of foundation work will be required since the formation of the portal is much higher than base rock.

  On the other hand, upright type requires only concrete foundation and is judged to be economically favorable.

12.4.4 Station of portal

For the determination of the location of east portal, a comparison study was conducted and the result of the study is summarized in Table 12.12.

As described in the table, the location of east portal is determined so that the backside cutting slope height does not exceed 25m and does not reach steep gradient portion.

In case of west portal, since original slope is so steep that there is no advantage to secure a space of the portal by excavation, the location of the portal is determined so that slope excavation is avoided.

As a result, location of the both portals and tunnel length are determined as follows:

East Portal	:	STA 5+515
West Portal	:	STA 6+220
Tunnel Length	:	705 m

12.4.5 Evaluation of geological ground condition

Evaluation of geological ground condition, which is used for the design of supporting work of tunnel excavation, is made according to the seismic velocities obtained by the seismic refraction survey.

In this Study, the evaluation is subject to the rock classification introduced by the Japan Tunnel Technical Standards.

Considering type of rock surrounding the tunnel, geological ground conditions are evaluated as presented in Table 12.13.

Table 12.12 Comparison Table of Potral Locations

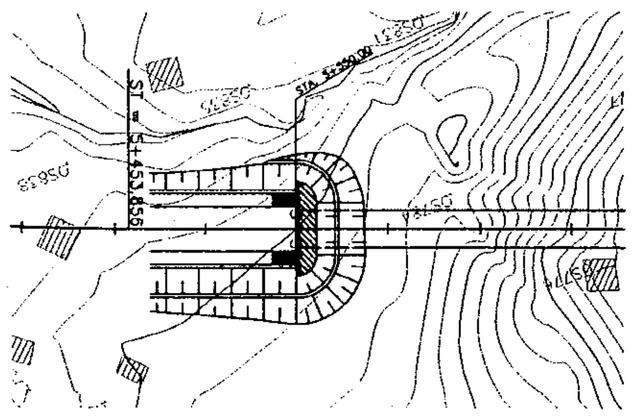
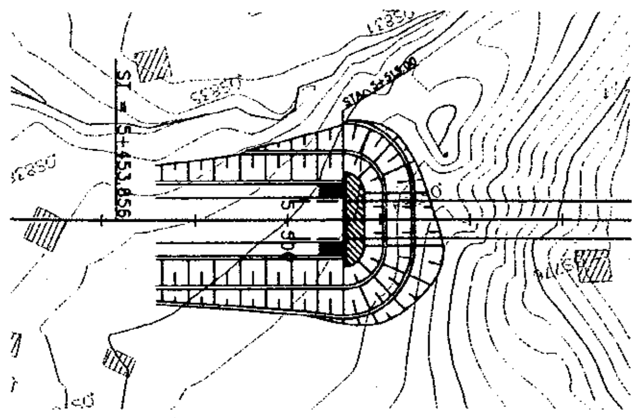
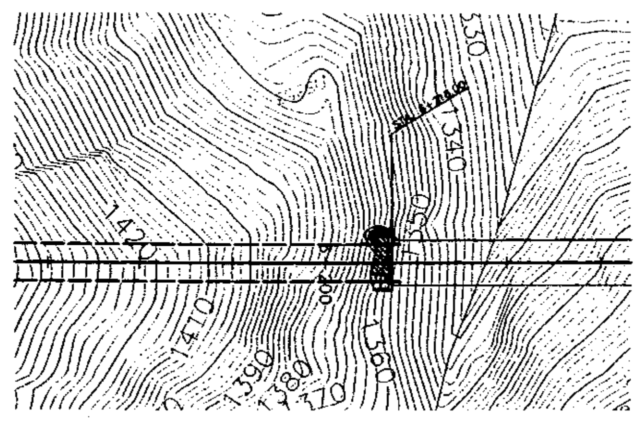
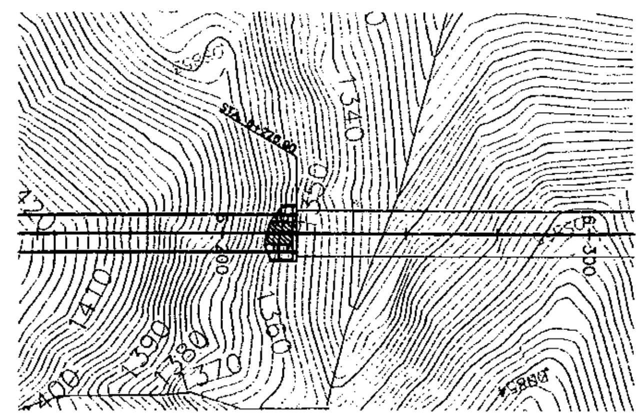
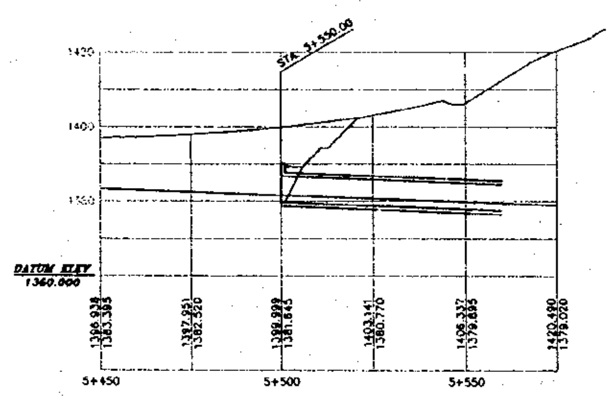
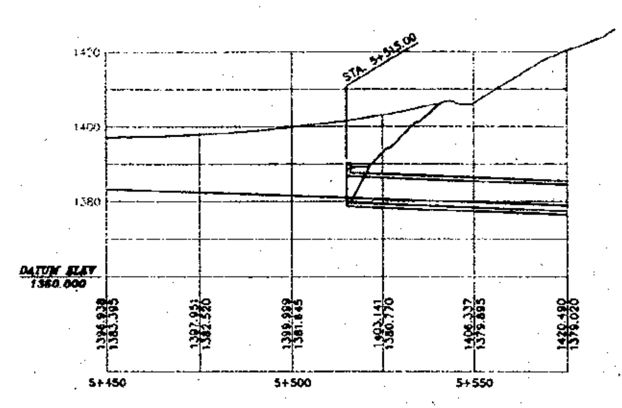
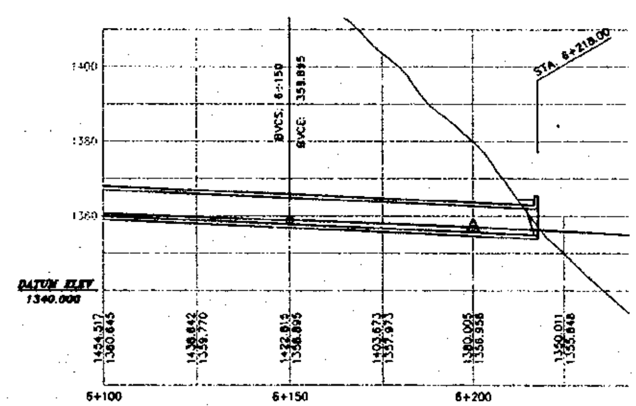
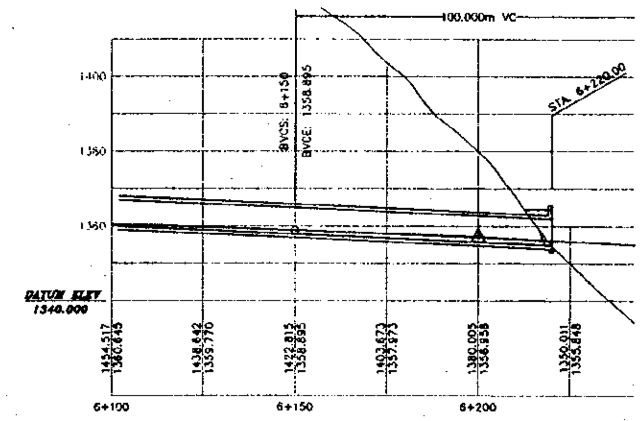
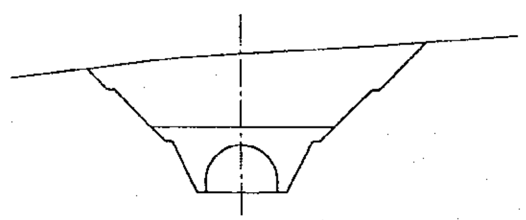
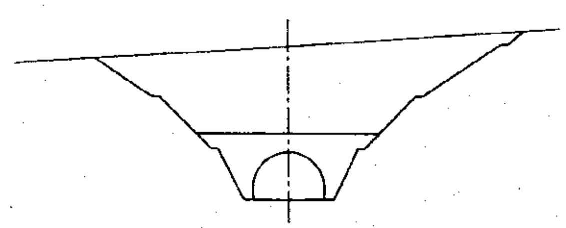
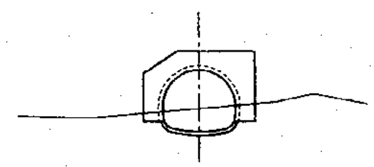
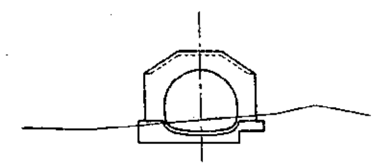
Station	West Portal		East Portal	
	Plan 1 (STA 5+500) (2 steps of cut slopes on back of portal)	Plan 2 (STA 5+515) (3 steps of cut slopes on back of portal)	Plan 1 (STA 6+218) (Bock masonry retaining wall on back of portal)	Plan 2 (STA 6+220) (No cut slope on back of portal)
Plan				
Profile				
Cross Section				
Cost (All Cost in Thousand)	tunnel ;15m*800NRs=12,000NRs Total 12,000NRs	excavation ;9500m3*0.8NRs =7600NRs block masonry ;350m2*3.1NRs =1085NRs slope protection ;1000m2*0.1NRs =100NRs Total 8,785NRs	excavation ;20m3*0.8NRs =7600NRs block masonry ;70m2*3.1NRs =1085NRs Total 1,433NRs	tunnel ;2m*800NRs =1,600NRs base concrete ;10m3*50NRs =50NRs Total 1,650NRs
Note	more uneconomical than Plan 2 15m longer than Plan 2 cutting on both sides along 120m length	more economical than Plan 1 cutting on both sides along 135m length	little difference from Plan 2 unbalanced portal	little difference from Plan 1 needs base concrete
Judgement	△	○	△	○

Table 12.13 Evaluation of Geological Ground Condition along the Tunnel

Grade	Section	Length(m)	Seismic Velocity
DⅢ-a	STA5+515(Portal) ~STA5+555	40	Portal section
DⅡ	STA5+555 ~STA5+620	65	1.9~2.1km/s of elastic wave velocity
DⅠ	STA5+620 ~STA5+750	130	3.0~3.2km/s of elastic wave velocity
DⅡ	STA5+750 ~STA5+825	75	1.9~2.1km/s of elastic wave velocity
DⅠ	STA5+825 ~STA6+175	350	3.0~3.2km/s of elastic wave velocity
DⅡ	STA6+175 ~STA6+195	20	1.2~2.1km/s of elastic wave velocity
DⅢ-a	STA6+195 ~STA6+220(Portal)	25	Portal section

These evaluations should be reviewed during detailed design by detailed geological investigations.

12.4.6 Method of tunnel excavation

"Guideline of Road Construction - Soil Investigation" published by the Japan Road Association introduced relationship between seismic velocity and unconfined compression strength of the rock. In this Study evaluation of unconfined compression strength of the based rock is based on the guideline.

Table 12.14 shows the relationship in case of phyllite rock, which is the type of base rock of the tunnel.

According to this classification, unconfined compression strength of the base rock at tunnel location has unconfined compression strength of 600 kg/cm^2 or more, since it has seismic velocity of 3.2 km/s.

In this case, it will be difficult to use mechanical excavation method, which is applicable to the rock at up to 500kg/cm^2 compression strength, but excavation by blasting method could be employed.

Table 12.14 Seismic Velocity and Unconfined Compression Strength of Phyllite

Rock classification	Seismic wave velocity V (km/sec)	Core of seismic wave velocity Vc (km/sec)	Stress of unconfined compression σc (kg/cm2)	Remark
Weathering rock	1.0 ~ 1.8	2.5 ~ 3.0	120 ~ 240	Soft rock
Soft rock	1.8 ~ 2.8	3.0 ~ 4.3	240 ~ 600	
Middle hard rock	2.8 ~ 4.1	4.3 ~ 5.7	600 ~ 960	Hard rock
Hard rock	4.1>	5.7>	960>	

Source: JH Standard Part I

12.4.7 Construction method of tunnel

Currently, the New Austrian Tunneling Method (NATM) is usually employed for tunnel construction and seems to be the standard tunneling method around the world.

In case of NATM method, excavated surfaces are supported by rock bolts and shot-crete immediately after excavation (initial lining). By this treatment, expansion of loosened zone can be minimized. Movement of tunnel body is always monitored by built-in instruments and if extraordinary condition occurs, necessary countermeasures are provided. Secondary lining, which is thicker concrete lining, is constructed after initial lining.

It is generally considered that by employing NATM method, faster and safer construction can be expected. However, NATM method require special construction machines such as shot-crete machine and large-scale drilling machine (Jumbo). In case of the Project Road, these special construction machines are not available in Nepal and must be procured from outside of Nepal. On the other hand, the conventional tunneling method using H-shaped steel arched support and log should be considered for application of the Project.

The conventional method was broadly used before the NATM method became the prevailing tunneling method. The method does not require big-scale special tunneling machine. This method may be applicable if the tunnel excavation face is rather sound and stable, however, it needs more detail geological information.

Typical cross section of the tunnel when it is constructed by the conventional method is shown in Figure 12.10.

In this Study, the construction plan and cost estimates are prepared based on the NATM method since the method seems to be more reliable at this stage.

Detailed comparison of tunneling methods should be conducted in the detailed design stage based on additional geological investigation.

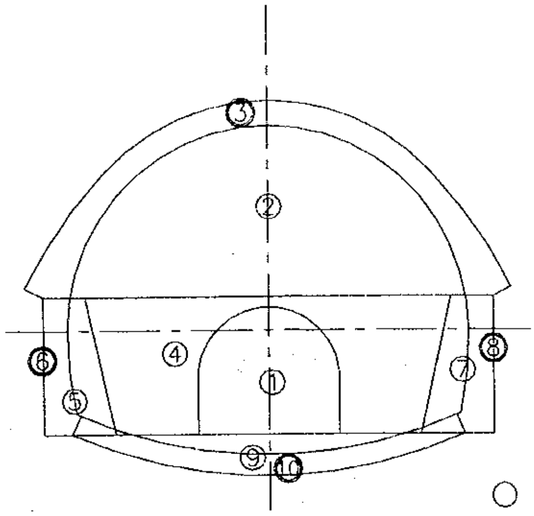


Figure 12.10 Typical Cross Section by Conventional Method

Table 12.15 Standard Supporting Patterns of Tunnel (NATM method)

Classification	Rock bolt			H-shape steel support			Thick of shot-create (cm)	Thick of concrete lining (m)	Thick of inbert (cm)
	Length (m)	Pitch		Upper half	Lower half	Pitch (m)			
		Transverse (m)	Longitudinal (m)						
A	should be designed for each ground condition								
B	3.0	1.5	2.0	-	-	-	5	30	-
C I	3.0	1.5	1.5	-	-	-	10	30	(40)
C II	3.0	1.5	1.5	H-125 U-21	-	1.2	10	30	(40)
D I	4.0	1.2	1.0	H-125 U-21	H-125 U-21	1.0	15	30	45
D II	4.0	1.2	1.0	H-150 U-21	H-150 U-21	1.0	20	30	50
E	should be designed for each ground condition								

Source: Road Tunnel Standard by JRA

12.4.8 Pavement in the tunnel

It is recommended that cement concrete pavement is used in the tunnel as it has the following advantages:

1) Concrete pavement requires less maintenance and is more durable compared to asphalt concrete pavement.

2) If a traffic accident occurs, the concrete pavement is more resistant against heat from fire and less liable to oil penetration compared to asphalt pavement.

3) The surface of the concrete pavement has higher reflectivity and brighter color than asphalt pavement and thus has reduced artificial lighting requirements for required level of illumination.

12.4.9 Ventilation system

Due to following considerations, it is proposed that no mechanical ventilation system is provided for the tunnel.

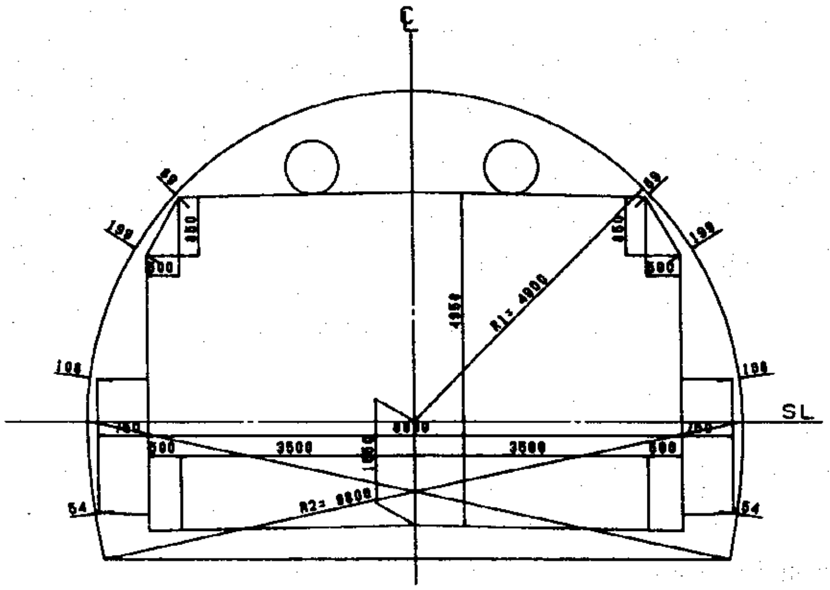
- Both east and west sides of tunnel are the open area and have ravine terrain. Therefore, natural wind ventilation can be expected to a certain extent.

- According to following formula, which used for the judgement of necessity of mechanical ventilation, it is judged that mechanical ventilation is not required.

  $L \times N > 600$

  Where, L is tunnel length in km and N is hourly traffic volume.

In the situation that a mechanical ventilation system is required due to unexpected growth of traffic beyond forecasted, the tunnel can accommodate 2 sets of jet fan ($\phi \doteq$ 600mm).



12.4.10 Lighting system

Tunnel lighting system was studied based on the following design conditions.

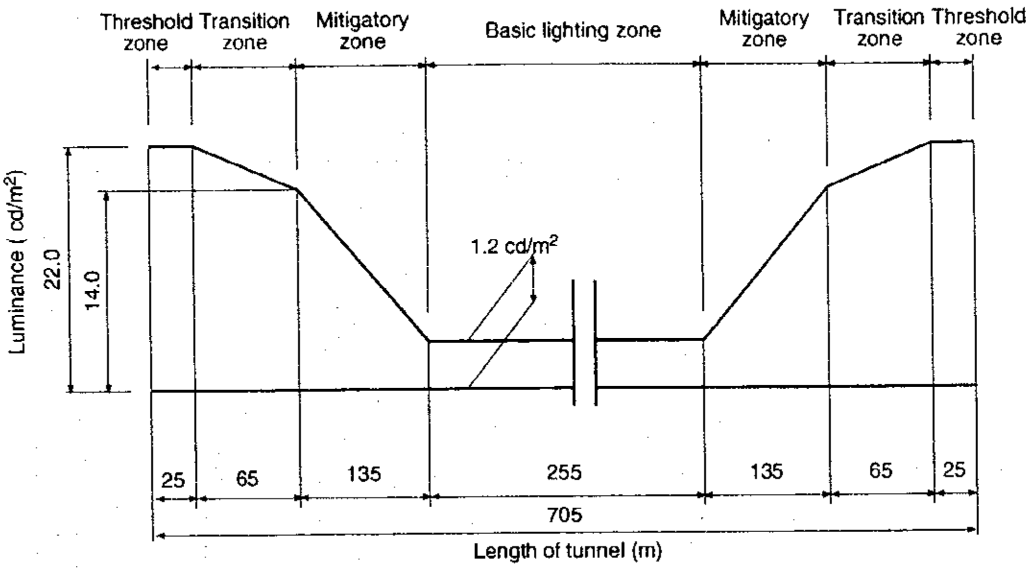
i)	Design speed	60km/h
ii)	Length of tunnel	705m
iii)	Outside luminance	3,000cd/m^2
iv)	Design traffic volume	5,340vehicles/day

The study is conducted according to the Japanese Standard introduced in clause 8.5.3. The results are shown below.

a) Basic lighting

Average luminance 1.2cd/m²

b) Lighting in entrance transition



c) An emergency lighting

In the case of power failure, one-eighth of basic lighting lamps are activated by a storage battery in the lamps for a few minutes during the escape of cars from the tunnel.

12.4.11 Emergency facilities

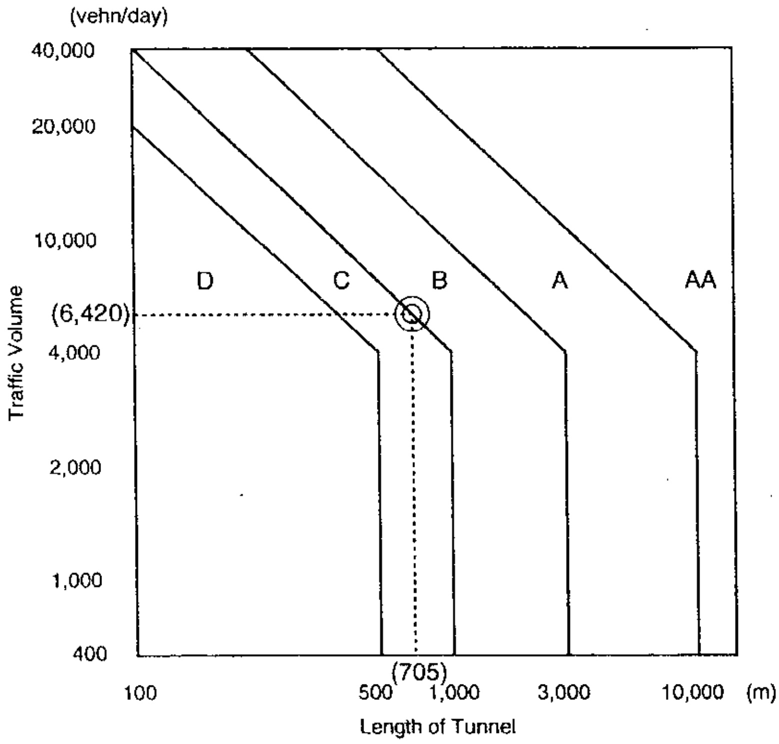
Emergency facilities are provided according to probability of disaster occurrence, which are determined by the length of the tunnel and the traffic volume.

The tunnel is classified into "Class B" by its length (705m) and the traffic volume (5,340vec/day) according to Figure 12.11.

Required facilities are as follows.

	Name of facilities	Installation interval of facilities
1	Emergency telephone	installed at intervals of 200m (one side)
2	Pushbutton type information equipment	installed at intervals of 50m (one sides)
3	Emergency alarm equipment	95m interval from portal
4	Fire extinguisher	installed at intervals of 50m (one side)
5	Guide board	installed at intervals of 200m (both side)

The control office will receive all information from emergency telephone and pushbutton type information equipment. And the information is transferred to the police and fire service.



Source: Emergency Facilities Standard for Road Tunnel by JRA

Figure 12.11 Classification of Tunnel for Emergency Facilities

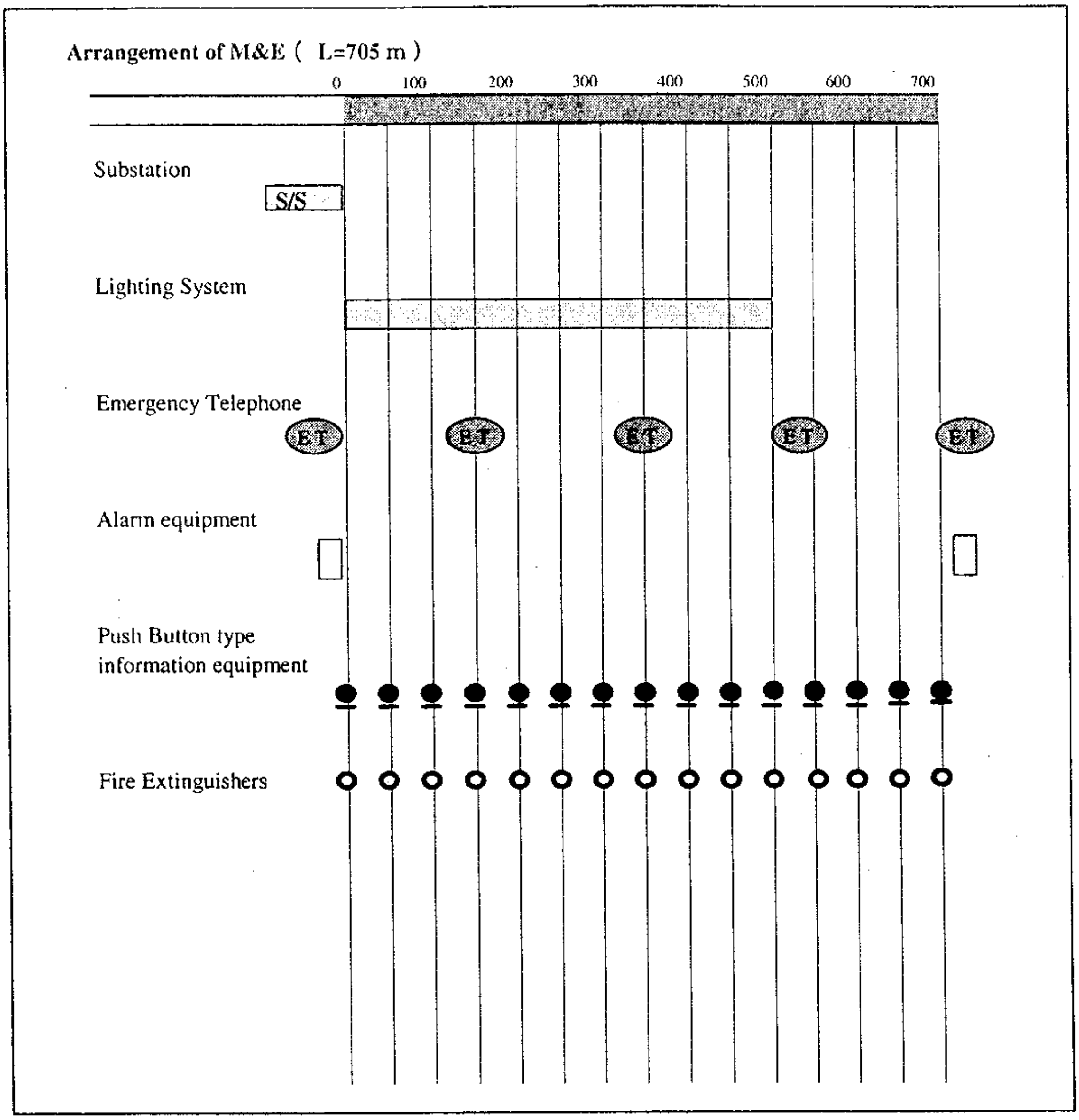


Figure 12.12 Proposed Arrangement of Tunnel Facilities

12.4.12 Other facilities

The tunnel is required to be facilitated with site control office for 24 hours control. The site should have bedrooms and control panel of the tunnel facilities.

For safety reasons, it is recommended to install chatter-bar on pavement of the tunnel along centerline to restrict over taking of running car.

Switch-turn spaces inside of tunnel are also provided against the case that an accident in the tunnel happens.

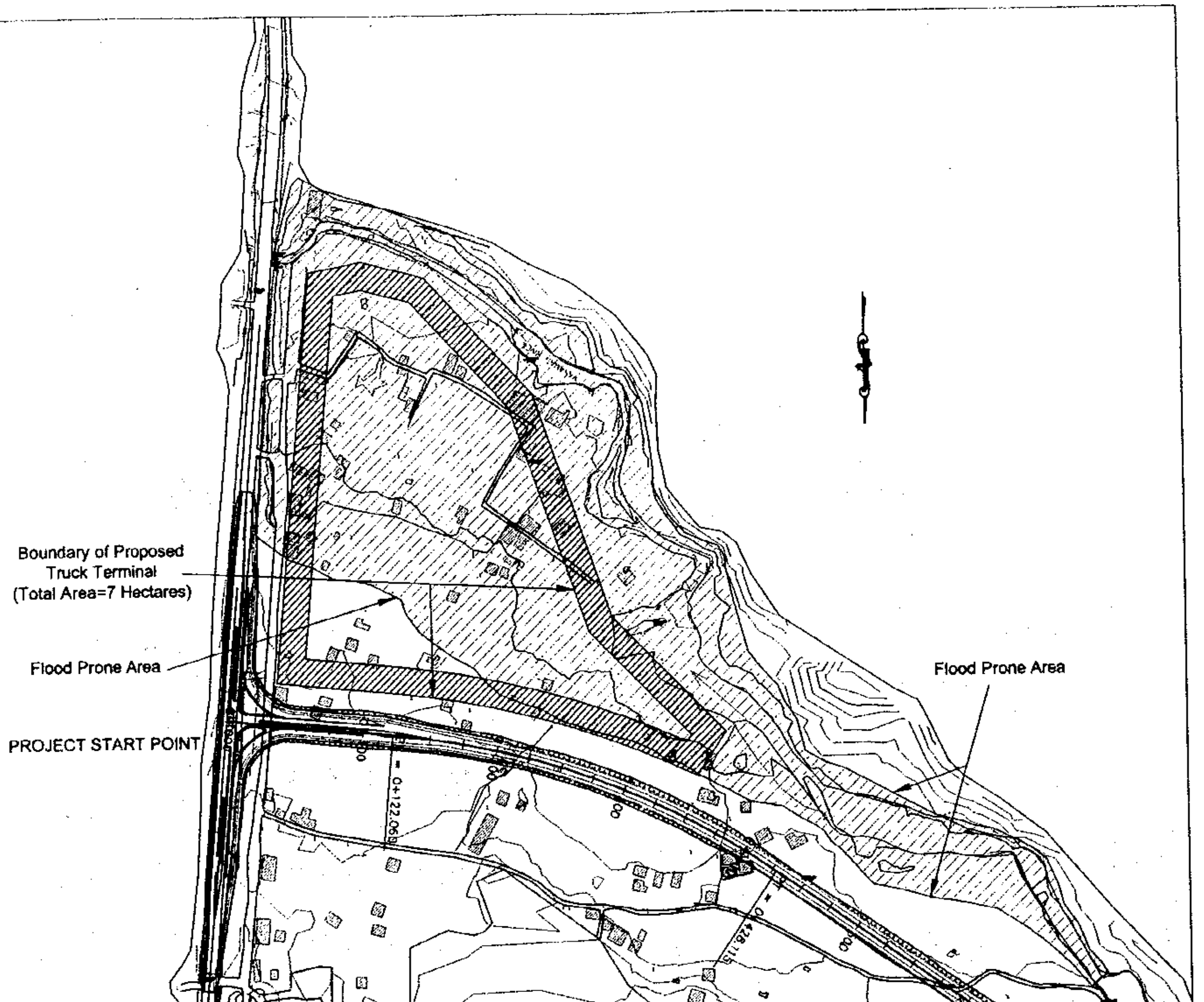


Figure 12.13 Recommended Location for Truck Terminal
Scale 1:5,000

CHAPTER 13 OPERATION AND MAINTENANCE

13.1 General

Highway maintenance is one of the important factors of the highway system. It is a program to preserve and repair the road system with its elements to its designed or accepted configuration. The elements include road surfaces, shoulders, roadsides, drainage facilities, retaining structures, slopes, bridges, tunnels, traffic markings and signs, lighting fixtures etc. The maintenance operations involve the assessment of the conditions of above-mentioned elements, diagnosis of the problem and adopting the most appropriate countermeasures.

The maintenance management should be developed based on the management techniques and, materials and equipment that are available. The planning and scheduling, fiscal work control systems, maintenance criteria and standards should be properly studied.

The Project Road will introduce the first highway tunnel in Nepal that requires special attention of maintenance. The smooth and safe operation of traffic inside the tunnel requires efficient maintenance system and policies.

13.2 Maintenance of Road

Maintenance of road can be broadly divided into following items:

1) Road surfaces
2) Shoulders and approaches
3) Drainage and drainage structures
4) Roadsides
5) Highway appurtenances and traffic control devices

Maintenance policies and procedures for roadway surfaces and shoulders should be designed to offset or minimize the effects of age, wear, loadings and various types of distress. Maintenance programs for pavement surfaces with asphaltic materials can be divided into two categories based on the technical requirements involved in selecting the proper materials and employing the best available methods. The first category includes operations such as patching, crack filling, and use of surface treatments. These operations shall be undertaken annually. The second category includes resurfacing operations that involve precise determinations of pavement characteristics and strength. The pavement design was done for a period of 15 years and the resurfacing is expected to be required around the end of the design life.

The unpaved shoulder should contain a sufficient amount of granular material for stability. The slope should be checked and maintained to provide proper cross slope for drainage. The weakest point of the paved shoulder and the place where most failures start is the joint between the roadway and the shoulder. Maintenance of approach to existing roads (mostly earthen road) should be done so that the Project Road is not affected by dirt and mud carried from these unpaved roads.

Drainage channels should be maintained so as to present the least hazard to vehicles possibly leaving the roadway. Channels should not be dredged to a depth or cross section other than designed. The drainage structures should be maintained to keep water courses free from accumulations of dirt, debris, vegetation and other obstructions. Correcting malfunctioning parts of systems, e.g., erosion and breaks or shifts in structures, waterways, etc., should also be done. In addition to maintaining the structural elements that are part of a highway drainage system, maintenance such as slope protection, contour grading and ditching to divert water on hillsides into courses that will minimize potential damage to roadways should also be considered.

Roadsides are the areas between the outside edges of the shoulders and right-of-way boundaries. As much as any other part of the roadway, the roadside when properly maintained meets the operational needs of the road user, enhances the life of the roadway, enhances safety and keeps better environment. The objectives may include following items:

- Assure good drainage
- Control roadside hazards and obstructions
- Enhance pedestrian and motorist safety
- Reduce animal/vehicle conflict
- Enhance sight distance requirements and,
- Preserve natural features etc.

Maintenance of highway appurtenances include proper maintaining of guardrail, traffic island and curbs at intersections, etc. Maintenance of traffic control devices includes the highway signs, pavement markings, traffic signals and traffic islands. Maintenance of highway signs involves operations such as clearing to improve visibility impaired by growth of vegetation, cleaning to improve legibility impaired by environmentally imposed dirt or vandalism, repairing and repainting, replacing damaged signs etc. Traffic markings should be continuously painted according to the requirements for smooth traffic operation and safety.

13.3 Maintenance of Bridges

R.C. slab bridges and steel bridges are adopted in the Project and anti-corrosion steel is used for the steel bridge. In this case, no major maintenance works will be required for the bridges.

Routine inspection and minor maintenance such as cleaning of drainage, however, should be carried out at the same time of road inspection.

If an extraordinary situation such as earthquake and flood arises, full inspection should be made to check soundness of the structure.

The maintenance program for steel bridges and concrete bridges is summarized as follows:

Item	Period	
Routine Inspection	One year	Exterior of bridge and Bank protection
Repairing	Ten year	Expansion joint, Pavement, Railing and Bank protection etc.

13.4 Operation and Maintenance of Tunnel

13.4.1 Inspection of Tunnel

The inspection of tunnels is broadly divided into two categories: One is the inspection of civil structures such as lining, portals and drainage facilities. The other is checking and maintenance of facilities including ventilation system, machines and equipment, and the communication system. Major items are as follows.

Inspection of Civil Structures

Daily inspection: Inspection of soundness of concrete should be conducted. Exfoliation and detachment of concrete and water leakage should be recognized. This inspection is done by visual inspection from car.

Periodical inspection: Inspection from close range should be conducted. Condition of cracks should be checked and recorded. Inspection of tunnel lining by hammering is also recommended. This inspection is done from the inspection gallery.

Special inspection: to supplement daily and periodical inspection, special inspection shall be made when extraordinary phenomena happen.

Inspection/Maintenance of Facilities

Daily inspection: working condition of machines and equipments should be checked by visual inspection and information from built-in measuring instruments.

Periodical inspection: more detailed checking than daily inspection should be performed periodically on machines and equipments. Cleaning, occasional functioning tests, and detailed measurement using special measuring instruments are carried out.

Extraordinary inspection: this inspection should performed if serious damage of machines or equipment is caused by fire or other accidents or if any problem is foreseen.

13.4.2 Safety Control of Tunnel

Traffic in tunnel has a heavier accident risk than that on open road section. Since the tunnel has limited space and reduced visibility, if once an accident occurs, consequences will easily become more serious. Furthermore, when it is considered that there is no highway tunnel in Nepal to date and this is the first highway tunnel in Nepal, safety control of traffic in tunnel, including countermeasure to reduce accident risk, fire-fighting and rescue system, shall be taken first. Besides the operation of the emergency facility designed in this Study, following administrative countermeasures should be made for this purpose.

i) to restrict vehicle running speed in tunnel up to 40 km/hr.
ii) to prohibit overtaking in tunnel.
iii) to prohibit the vehicles, on which dangerous substance is loaded, to enter the tunnel.
iv) to prohibit low speed vehicles such as Tempo, motorcycle, and bicycle to enter the tunnel.
v) to prohibit pedestrian and livestock to enter the tunnel.
vi) the high emission vehicles, which exhaust thick black smoke shall not be allowed to enter the tunnel.
vi) to facilitate watch houses at both portals and superintend in 24 hours and strictly control the above regulations and charge penalties on the car users who violate the above regulation.
vii) to facilitate site operation office and control operation and maintenance of the tunnel.
vii) to advertise the importance of the traffic safety and the regulations to the people in advance.
viii) to establish an emergency communication system among DOR site operation office, DOR headquarter, police office, hospitals and other agencies concern.
ix) to organize an emergency rescue team and make it practice a fire drills.

13.5 Maintenance of Slope

Slope maintenance means any slope protections against erosion and slope failures to maintain road service after road completion. The importance to be recognized on slope maintenance is the social and economical effect of traffic disturbance caused by slope failures. Such works of a little investment for big returns on the maintenance must be recognized, as a slope maintenance policy. On slope maintenance, precedent countermeasure against slope erosion are especially needed since erosion always leads to slope failures.

Concerning of slope maintenance against erosion can be mainly divided into drainage maintenance and vegetation maintenance.

The former is to maintain smooth surface water flow in the drainage ditch. Trash and/or soil removal in the ditch and ditch repairing are involved. Erosion by overflow water and leaked water in the ditch means the lack of soil mass at the lower portion of slope from the slope stability mechanism. Progressing of these phenomena in the slope can be reached failures in finally. The result of slope stability's inventory survey along the existing road performed by study team supports the series vicious cycle. For this reason, the ditch function must be kept on slope maintenance. Especially efforts of ditch checking and ditch cleaning are required before rainy season.

The latter issue is to prevent slopes from erosion due to rainfall. It is essential for stabilization of slopes to keep sufficient surface drainage. The erosion due to rainfall will directly damage slopes. Beside it, poor slope drainage will increase underground pore water pressure due to infiltration of the surface water and result in slope failures. The vegetation on slope is very effective to prevent slopes from erosion and infiltration of rainfall water. Therefore maintenance work of vegetation is one of crucial work to prevent slope failure.

The maintenance work shall include replanting in bared slope, dewatering cutting grass and removal of sedimentation in slope drainage. These works shall be carried out periodically with monthly interval at least.

13.6 Organization for Operation and Maintenance

The Project Road will introduce new technology, that is highway tunnel in Nepal. Highway tunnel must require sufficient operation and maintenance for the safety of traffic.

To achieve the above objective, the Study Team recommends to establish a Project Operation Unit (POU) particularly for the operation and maintenance of the Project Road. The proposed organization of the POU is introduced in Figure 13.1.

In the organization, the Financial Manager will be responsible for toll collection. The collected toll should be used for all operation and maintenance work including salary of POU staff.

Operation and maintenance section will conduct all operation and maintenance work of highway, bridge and tunnel. Operation and maintenance of highway tunnel is first experience for Nepalese staff, so sufficient level of transfer of knowledge and training must be conducted by the Consultant and supplier of tunnel equipment during construction and beginning of operation stage. Safety control section is responsible for the safety assurance of the tunnel.

This work is also first experience for Nepalese staff so transfer knowledge and training shall be provided during construction and beginning of operation stage. Proposed safety control measures are described in the previous Clause 13.4.

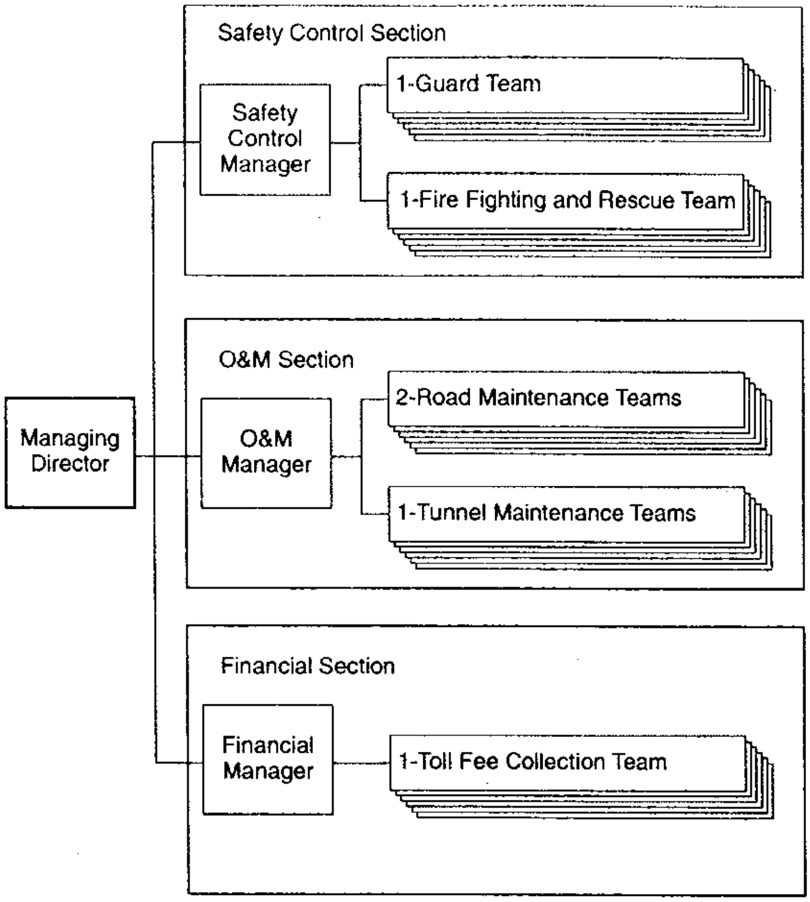
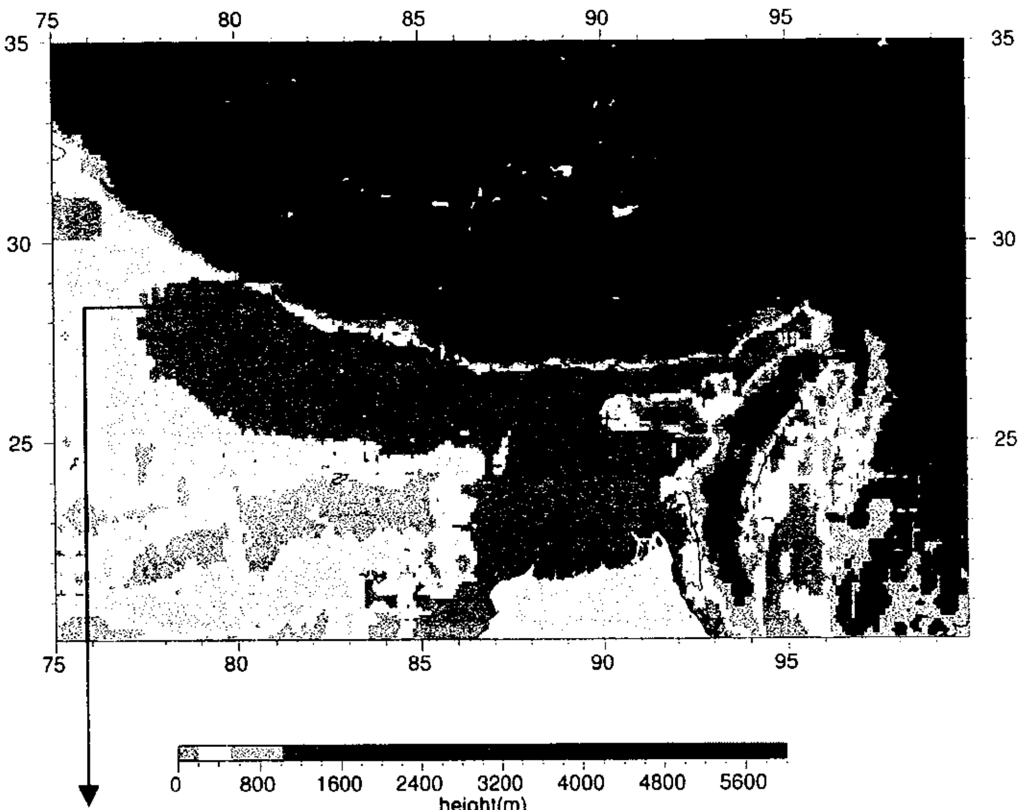


Figure 13.1 Proposed Organization of the Project Operation Unit (POU)

CHAPTER 14 POTENTIAL STUDY ON THE WIND AND SOLAR POWER GENERATION

14.1 Introduction

The aim of this study is to evaluate potential of wind and solar power generation in Nepal, especially around the Project area, by using a numerical weather prediction model. This weather prediction model simulates weather condition in Nepal in each 8km mesh throughout the year 1998. And estimation of the amount of potential electric power generation by wind and solar radiation was carried out using the simulated hourly wind velocity and solar radiation. Finally, facilities of wind power and solar power generation to supply the electric power for maintenance of the tunnel of the Project, was studied. The map of the objective area is shown in Figure14.1.



Information about the Target Area	
Area:	824.0km × 504.0km
Horizontal mesh size:	8.0km × 8.0km
Vertical top:	about 10,000m
Dimension size:	103 × 63 × 25

Figure 14.1 The Map of the Objective Area

14.2 Method

The flow of the analysis is shown in Figure 14.2. At first, some datasets that are needed to calculate the weather were prepared. The datasets are ECMWF (European Centre for Medium Range Weather Forecasts) global atmospheric analysis data (global, 0.5deg grid, 1998 whole year) for initial and boundary weather condition, 8km mesh averaged altitude and land use and snow cover data for surface boundary condition. The weather prediction model is suggested to use these initial data and simulate the 8km mesh weather condition. After the simulation run through the year, distribution map of monthly or annual mean of wind and solar radiation were prepared to estimate the potential for electric power generation.

14.3 Data

14.3.1 ECMWF global analysis data

In this study, the initial boundary weather condition was prepared based on the ECMWF (European Centre for Medium Range Weather Forecasts) global atmospheric analysis data (global, 0.5deg grid, 1998 whole year). The outline of the collected ECMWF data is shown in Table 14.1.

Table 14.1 The outline of collected ECMWF data

Items	Contents
Data kind	ECMWF/TOGA Advanced Operational Analysis Data Sets
Data period	Jan.1998 ~ Dec.1998
Data grid	Equal latitude-longitude grid、0.5degee×0.5degree
Data time	00 06 12 18 UTC (four times daily)
Data region	Global Horizontal 720×361 grids Vertical surface+15 layers (1000 925 850 700 500 400 300 250 200 150 100 70 50 30 10 hPa)

As shown in this table, ECMWF global data have variable analyzed elements from surface to upper 10hPa, 0.5-degree interval in global. This global atmospheric analysis data is collected from the meteorological observed data from all over the world. Therefore, this data can present a reliable global weather condition in large scaled phenomenon. The monthly mean wind distribution maps in south Asia are shown in Figures 14.3 and 14.4. The wind variability cased by Indian monsoon or main wind speed distribution in each month are well presented.

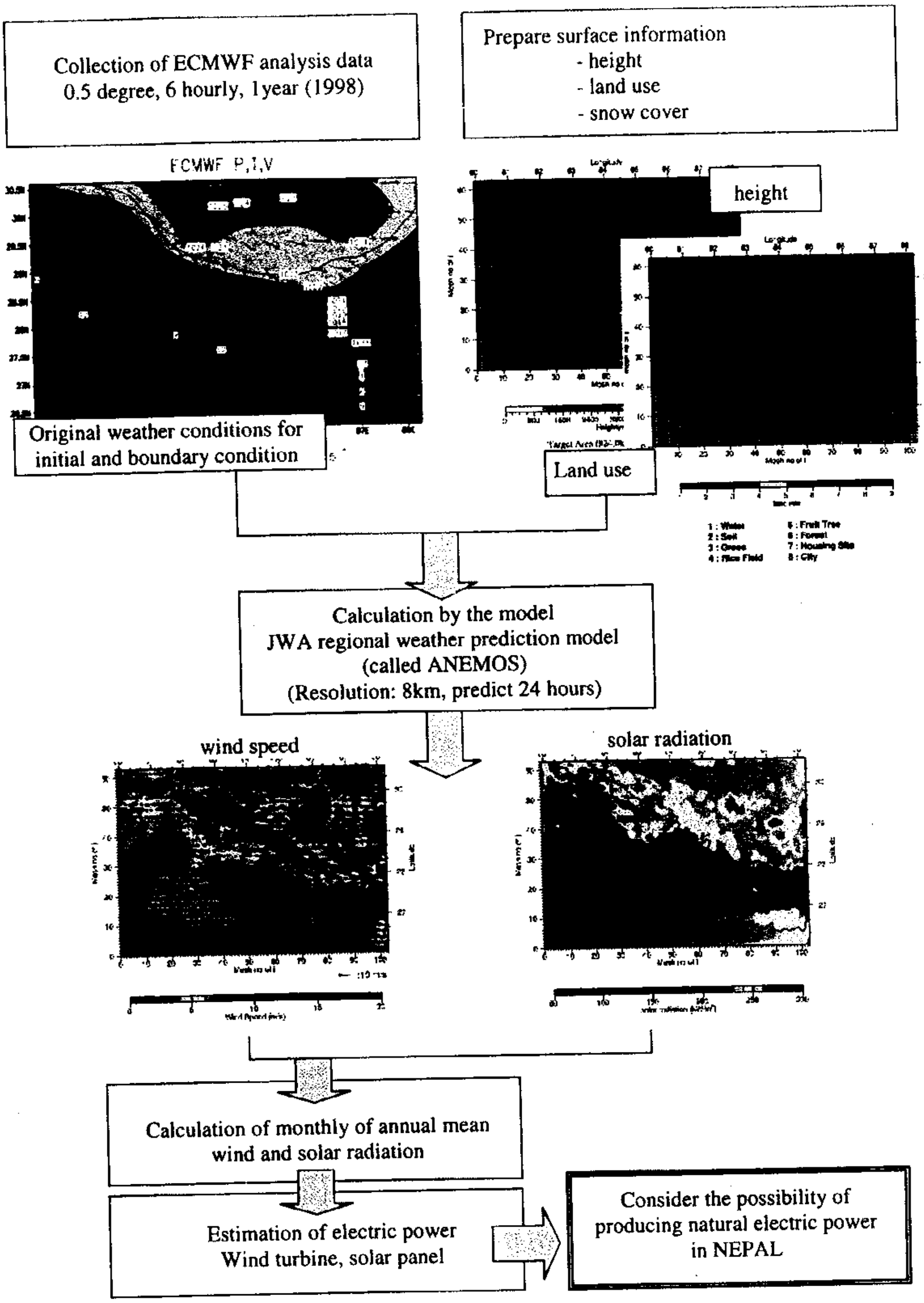


Figure 14.2 Research Flow of the Analysis

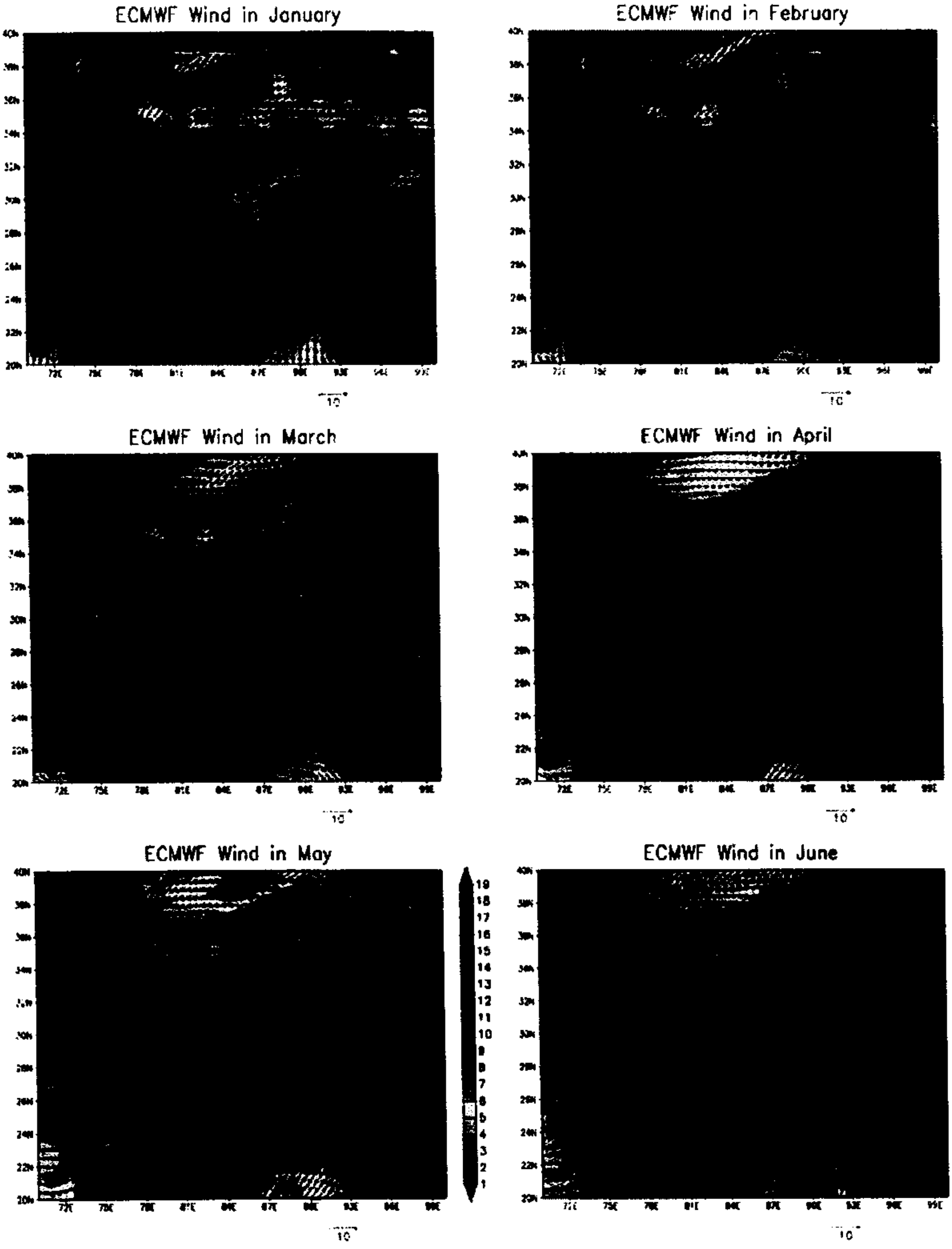


Figure 14.3 Monthly Wind Distribution Map

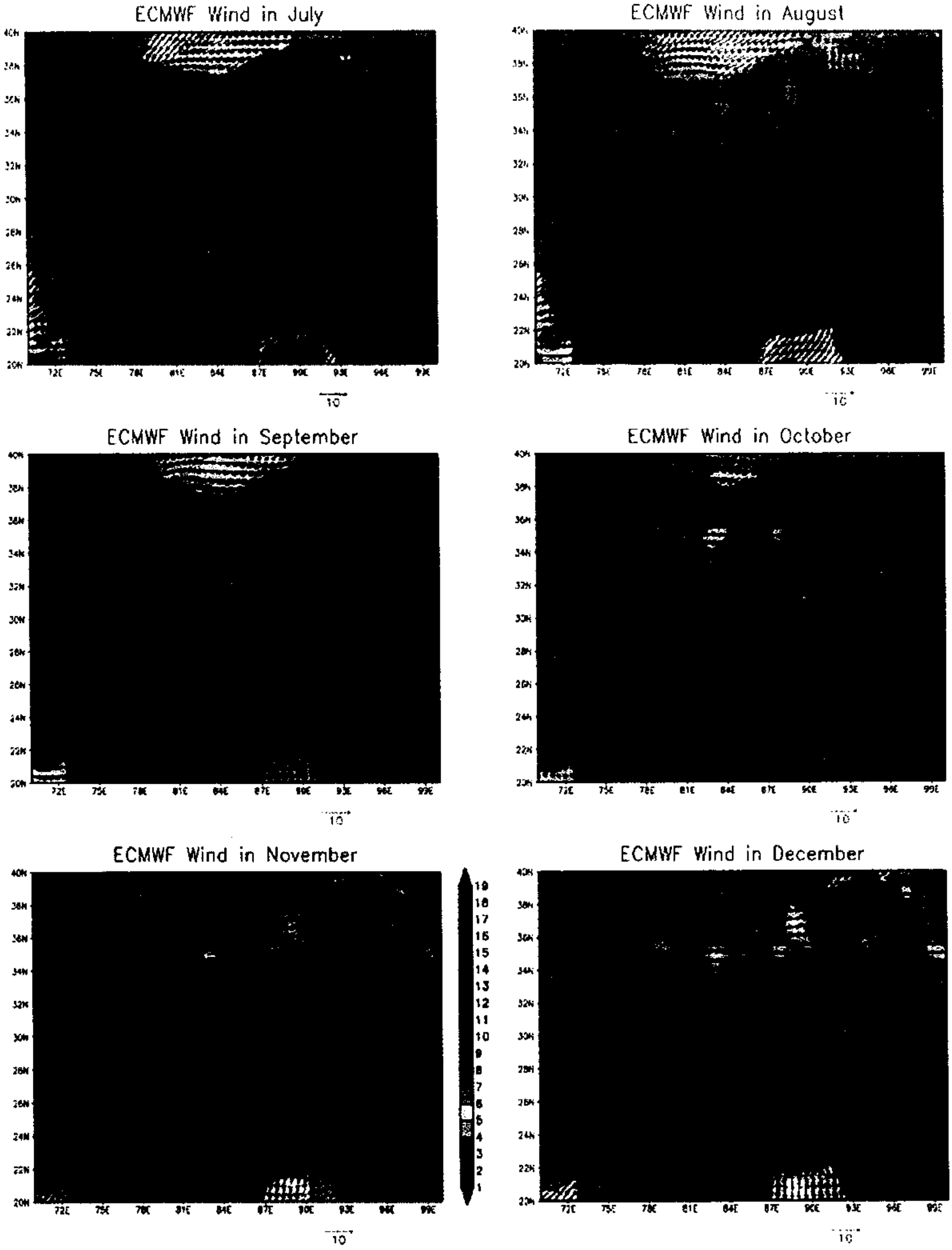
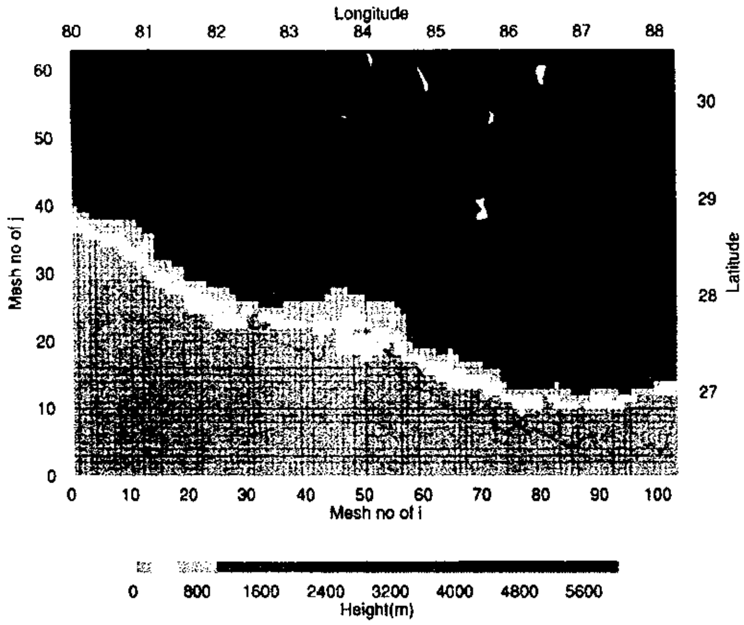


Figure 14.4 Monthly Wind Distribution Map

14.3.2 Height data

ETOPO5 dataset (published by SGS; U.S. Geological Survey) was used as ground height data. The 8km mesh average height data for model input is shown in Figure 14.5.

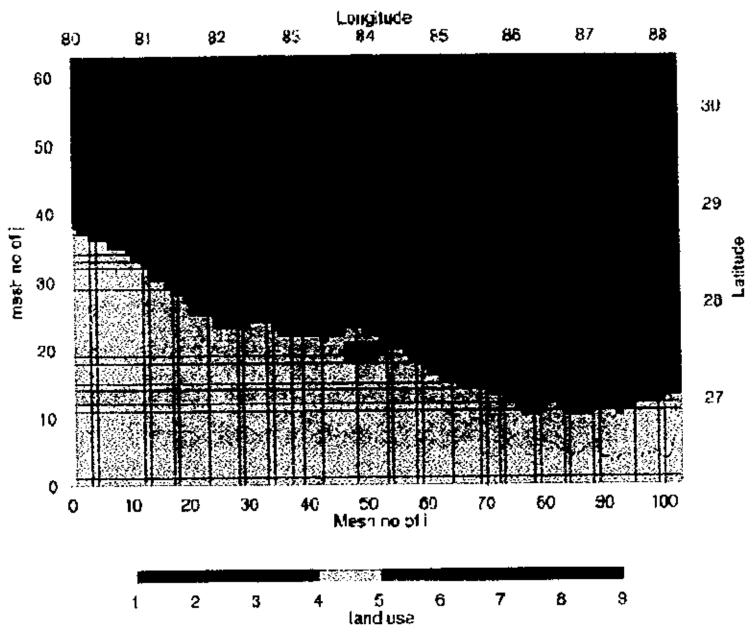


Target Area (824.0km x 504.0km)
Mesh size; dix=8.0km, dy=8.0km

Figure 14.5 The Distribution Average Height by 8km Mesh

14.3.3 Land use data

The 8.0km mesh general land use data in Nepal was prepared to set some surface boundary conditions such as roughness, albedo or wetness. Albedo is defined as ratio of input solar radiation and reflection from ground and it is shown by using a value from 0 to 1. Roughness due to the ground condition or vegetation decides many parameters such as wind profile in the boundary layer in the model. The general land use distribution is shown in Figure 14.6.



1: Water
2: Soil
3: Grass
4: ice Field
5: Fruit Tree
6: Forest
7: Housing Site
8: City

Figure 14.6 The Distribution Average Land Use by 8km Mesh

14.3.4 Snow data

The ground condition of whether ground is covered by snow or not is an important factor for the weather simulation in Nepal. According to some previous meteorological study reports, the snow distribution is classified by altitude as shown in Table 14.2. In the model, if it is judged that there is snow in a mesh, the land use data is replaced by snow.

Table 14.2 Classification of the snow covered area

Height Range	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
5000~	O	O	O	O	O	O	O	O	O	O	O	O
4000~5000	O	O	O	O	O	×	×	×	×	O	O	O
3000~4000	O	O	×	×	×	×	×	×	×	×	×	O
~3000	×	×	×	×	×	×	×	×	×	×	×	×

O: with snow ×: without

14.4 The Weather prediction model

14.4.1 Outline of the model

A numerical weather prediction model called "ANEMOS" is used in this study. ANEMOS is a meso-scale model and was developed by JWA (Japan Weather Association).

ANEMOS has physical system equality similar to the RSM (Regional Spectrum Model) used by JMA (Japan Meteorological Agency). Because the resolution of ECMWF data is 0.5 deg grid (horizontal about 50km mesh) and 6 hourly, it seems that the data do not give enough resolution both spatially and temporally to identify the fine meteorological condition in Nepal. After the initial condition is set and input into ANEMOS with rough ECMWF weather conditions, ANEMOS begins to simulate the weather in all of the fine meshes. Finally, fine mesh meteorological simulated data (horizontal 8km mesh) of Nepal was prepared.

14.4.2 Calculative conditions

The calculative conditions used in the model, for calculation in Nepal are shown in Table 14.3. The calculating region is shown as a red square, enclosing Nepal, 824km ×504km, in Figure 14.1. The calculation in the weather forecast model integrates basic equations shown in Table 14.3 with constant time step (Δt=30S). The model outputs the result in every 1 hour and continues to simulate until after 24 hours with unit of calculation set as 1 day. The initial data for calculation was ECMWF global analysis data of 00UTC and includes 6 hourly boundary conditions. The calculation was done throughout the year 1998.

Table 14.3 The calculative conditions in the model

Items	Calculative condition
Calculation region	824km×504km
Horizontal mesh size	8km×8km
Vertical mesh size	25 layers (dz=20,30,50,80,120,200,200,200,200, 200,200, 200,300,400,800,800,800,800,800,800,800,800,800,800,800m)
Number of Mesh	103×63×25
Time step	Δt=30 second
Initial data	ECMWF global analysis data 0.5degree (about 50km) Daily, 00UTC
Boundary data	ECMWF global analysis data 0.5degree (about 50km) 6 hourly data
Surface condition	Land use analysis data
Height data	USGS/ETOPO5 data http://grid2.cr.usgs.gov/data/etopo5.elev.html
Calculation period	1 year; Jan. 1998 ~ Dec.1998
Calculation results	Hourly, Wind component: u, v, w, turbulence energy, temperature, moisture, cloud water solar radiation...at all mesh

14.5 Results of monthly mean wind and solar radiation

The monthly means for both vector and scalar wind at 30m and average daily cumulative solar radiation on each month were calculated. The vector mean is useful to find out the predominant wind direction during the term. Predominant wind direction means both direction of strong wind speed and high frequency. The solar radiation is calculated in the model as the unit Wh, which was converted later to average daily cumulative solar radiation. The annual mean wind map is shown in Figure 14.7 and the monthly mean wind maps during four seasons: winter (December, January, February), pre monsoon (March, April, May), monsoon, (June, July, August, September), and post monsoon (October, November) are shown in Figure 14.8.

As observed in Figure 14.7, the distribution of the wind speed is affected by the land shapes. The wind speed is large over the mountains, especially over the areas where average height within a mesh is higher than 3000m. Similarly, in areas where the ridge is facing to south (such as around Annapurna Himal or Dhaulagiri Himal), the wind speed exceeds 7m/s. In the plain areas where the mesh average height is lower than 1000m, the wind speed is weaker than 4m/s and it seems difficult to generate efficient electric power. The wind speed around Kathmandu is from 3m/s to 4 m/s.

Based on the data of January, the monthly mean wind speed seems stronger over the high altitude area along the China/Nepal border and weak over the plains. The predominant wind direction is found to be northwest over the mountain and west over the plain.

According to the map of May, the difference of wind speed between the mountains and the plains became smaller as the temperature of mountains started rising. The wind speed was from 1 to 4 m/s over the plains and the predominant wind direction was obscure.

In July, the wind speed in Nepal was formed to be weak even over the mountains. The predominant wind direction was south, from the valleys to the mountains. The wind speed over the plains was about 1 to 2m/s due to continuous Monsoon showers.

In October, the wind speed over the mountains increased together with the ending of the Monsoon season. While, over the plains, the wind speed showed the weakest in the year during this month.

The annual mean daily cumulative solar radiation map is shown in Figure 14.9. The aspect of the solar radiation depends on the effect of monsoon. The plain areas such as Biratnagar and the northern part of the steep slopes such as Jumla or Tibet high land, show larger estimated amount of the solar radiation, exceeding 20MJ/m^2/day. On the high lands such as Tibet, the solar radiation is extremely large due to high altitude and also because of the fact that these areas are not influenced by monsoon shower. Over the slopes, the solar radiation is smaller than 15MJ/m^2/day. Especially around Pokhara where slopes are steep, the solar radiation is only about 10MJ/m^2/day.

The monthly mean daily cumulative solar radiation maps during four seasons are shown in Figure 14.10.

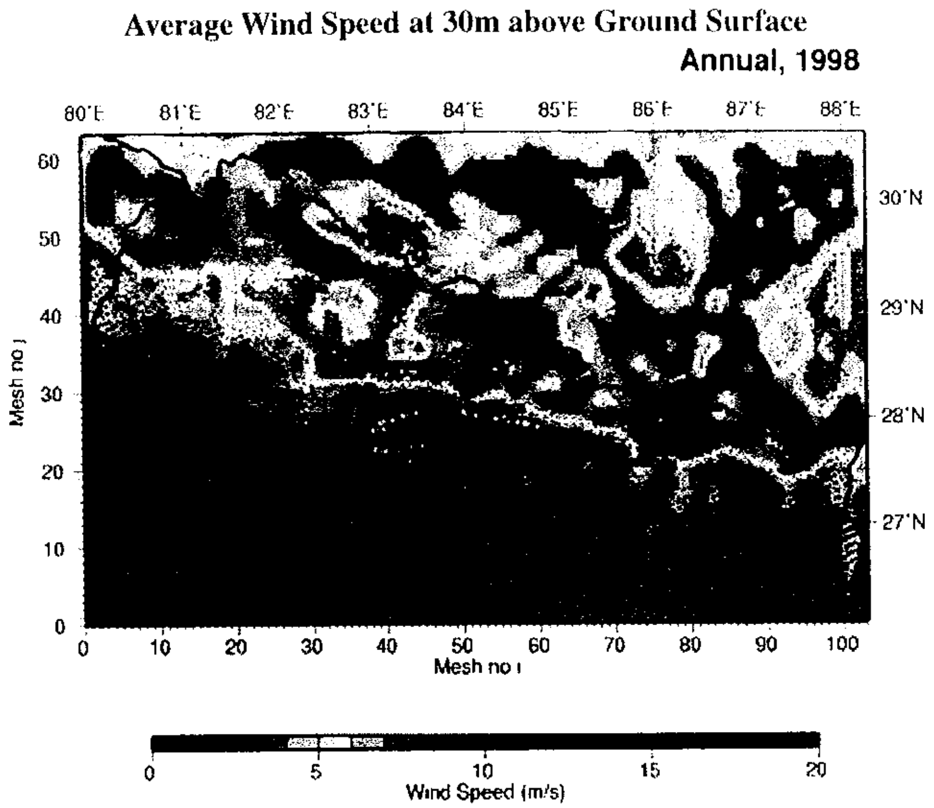
In January, the cumulative solar radiation is about 15MJ/m^2/day and is the least all over Nepal due to short daytime hours in winter.

In May, the cumulative solar radiation is the largest amount in the year. That is about 30MJ/m^2/day in the plains and larger than 30MJ/m^2/day in the mountains , except on the steep slopes because of the occasional monsoon shower.

In July, the cumulative solar radiation is low on the slopes due to the conventional monsoon shower and is about 10MJ/m^2/day. The solar radiation in the northern part of slopes is about 30MJ/m^2/day and in the southeast plain area such as Biratnagar is more than 25MJ/m^2/day. The difference of the solar radiation between northern high lands and slopes is extremely large.

In October, the cumulative solar radiation continues to be low on the steep slopes although a little larger than that in the monsoon season. The daytime gradually becomes shorter and the solar radiation on the mountain shows about 20MJ/m^2/day.

According to the results of the weather forecast model, it was observed that the wind and solar radiation are deeply influenced by monsoon and the distribution of wind speed and solar radiation are different between the dry season and the wet season.



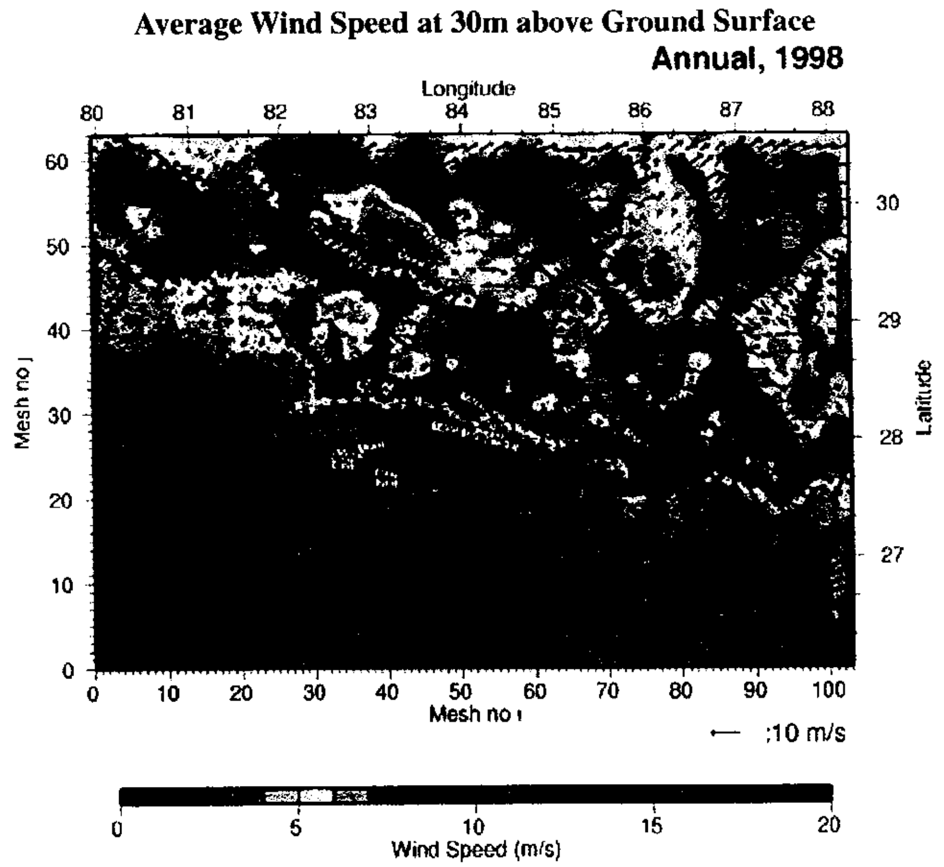
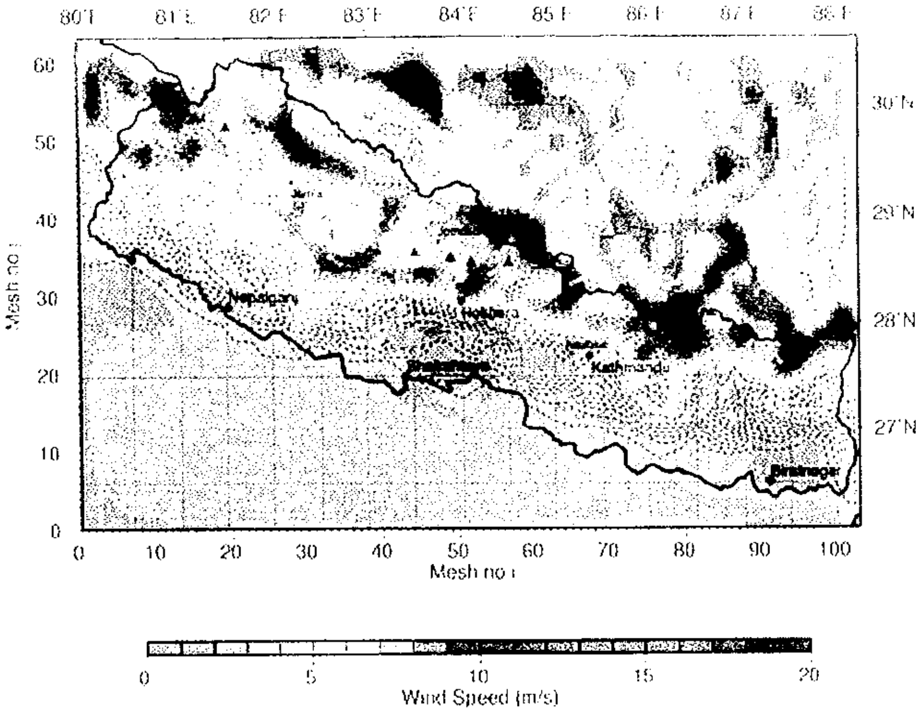


Figure 14.7 Annual Mean Wind Map

Average Wind Speed at 30m above Ground Surface
Annual, 1998



Average Wind Speed at 30m above Ground Surface
Annual, 1998

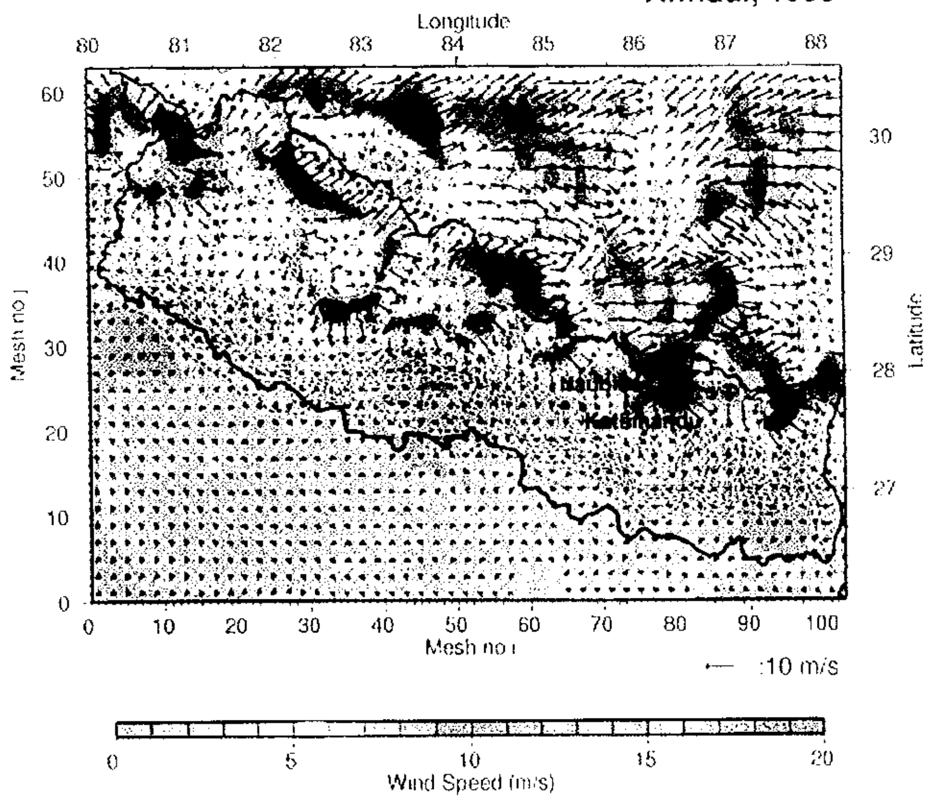


Figure 14.7 Annual Mean Wind Map

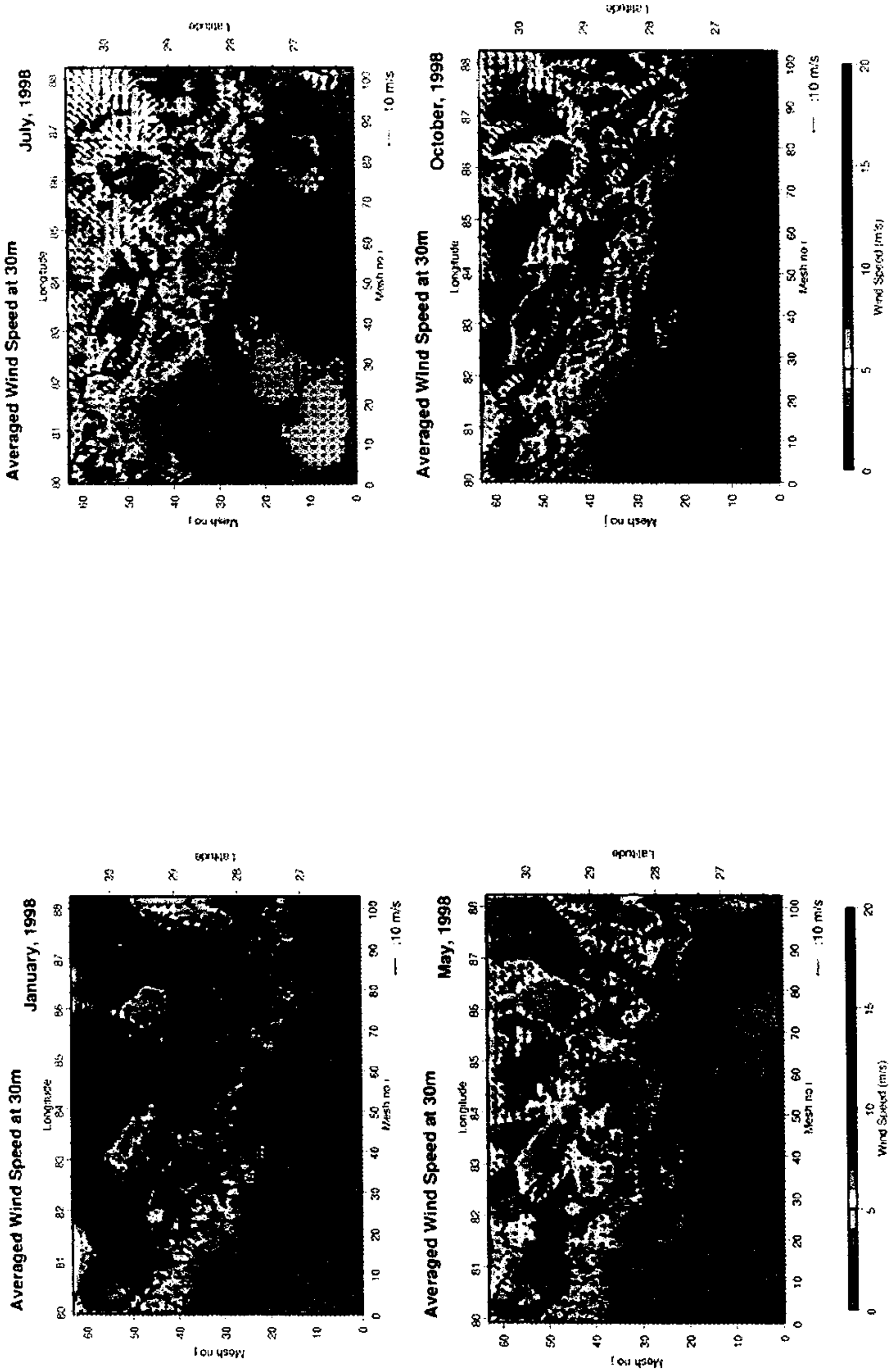


Figure 14.8 Monthly Mean Wind Map

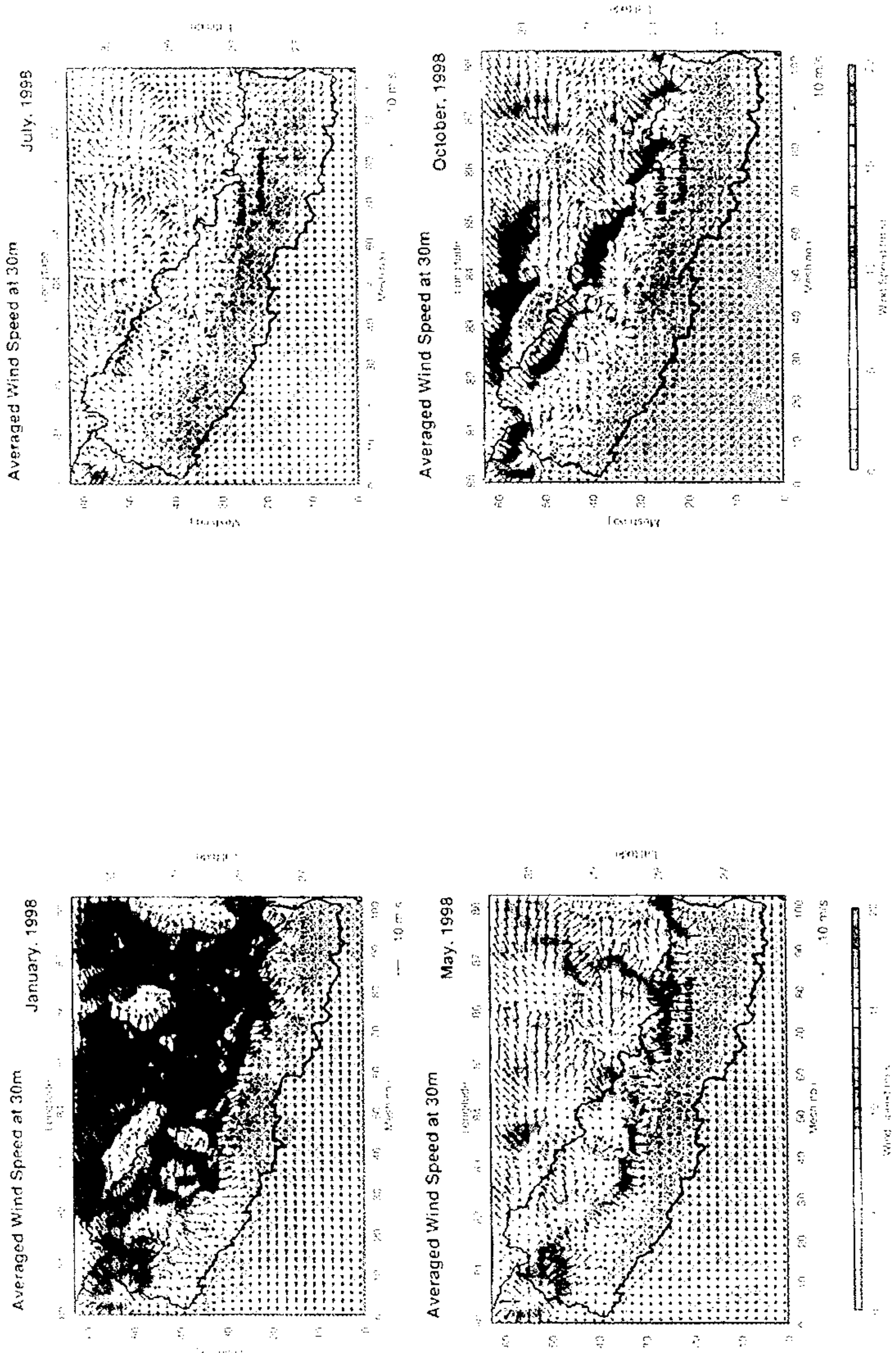


Figure 14.8 Monthly Mean Wind Map

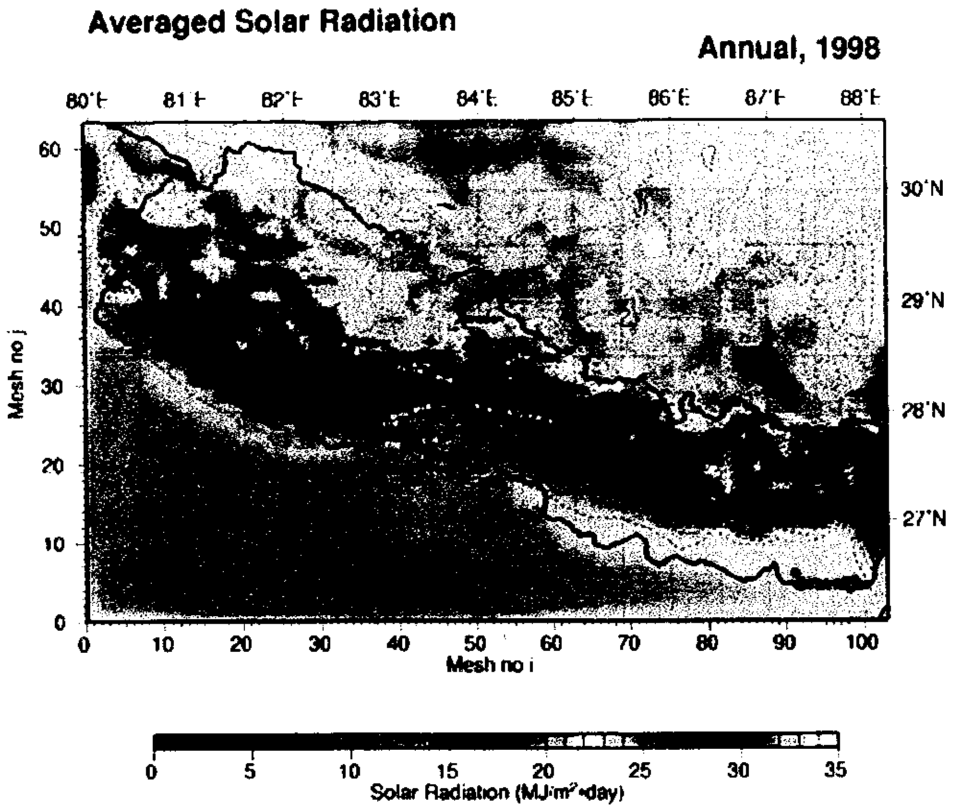


Figure 14.9 Annual Mean Daily Cumulative Solar Radiation

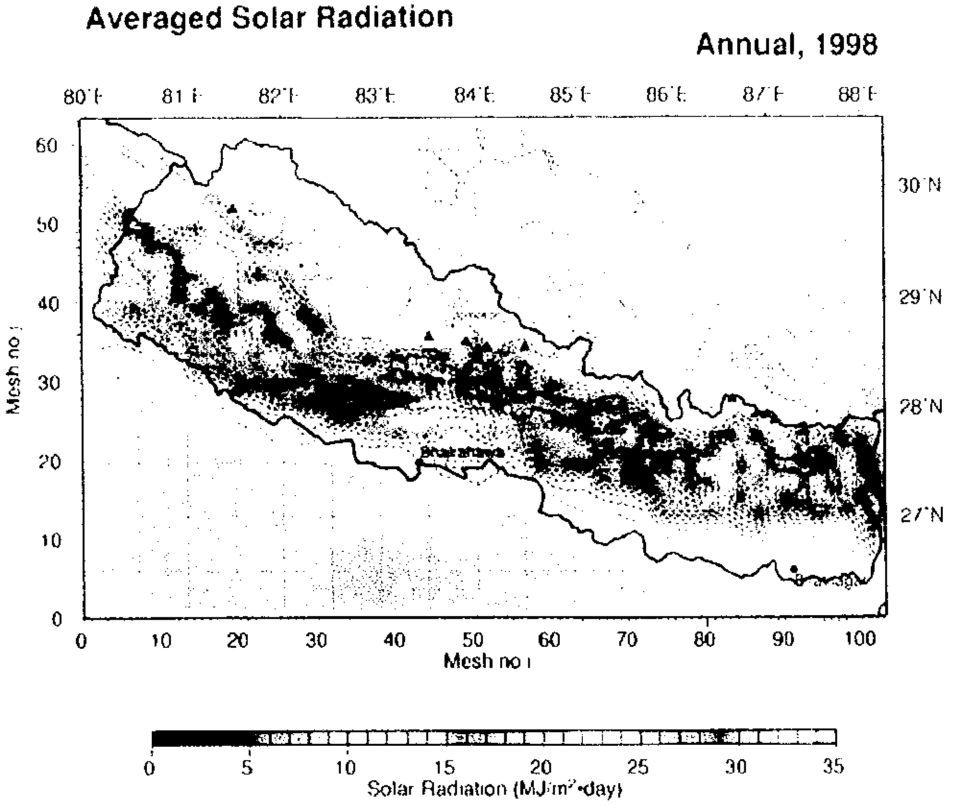


Figure 14.9 Annual Mean Daily Cumulative Solar Radiation

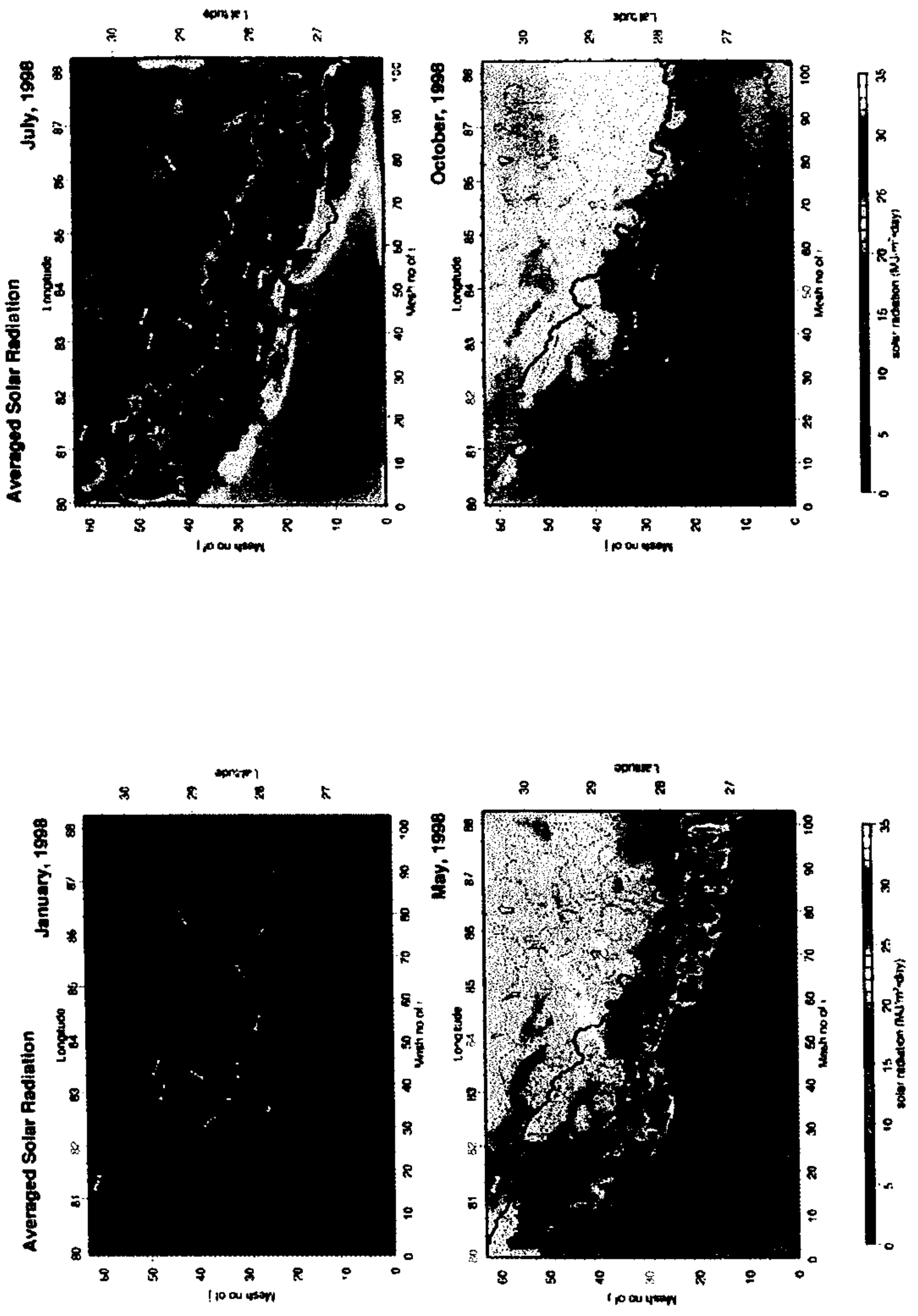


Figure 14.10 Monthly Mean Daily Cumulative Solar Radiation Map

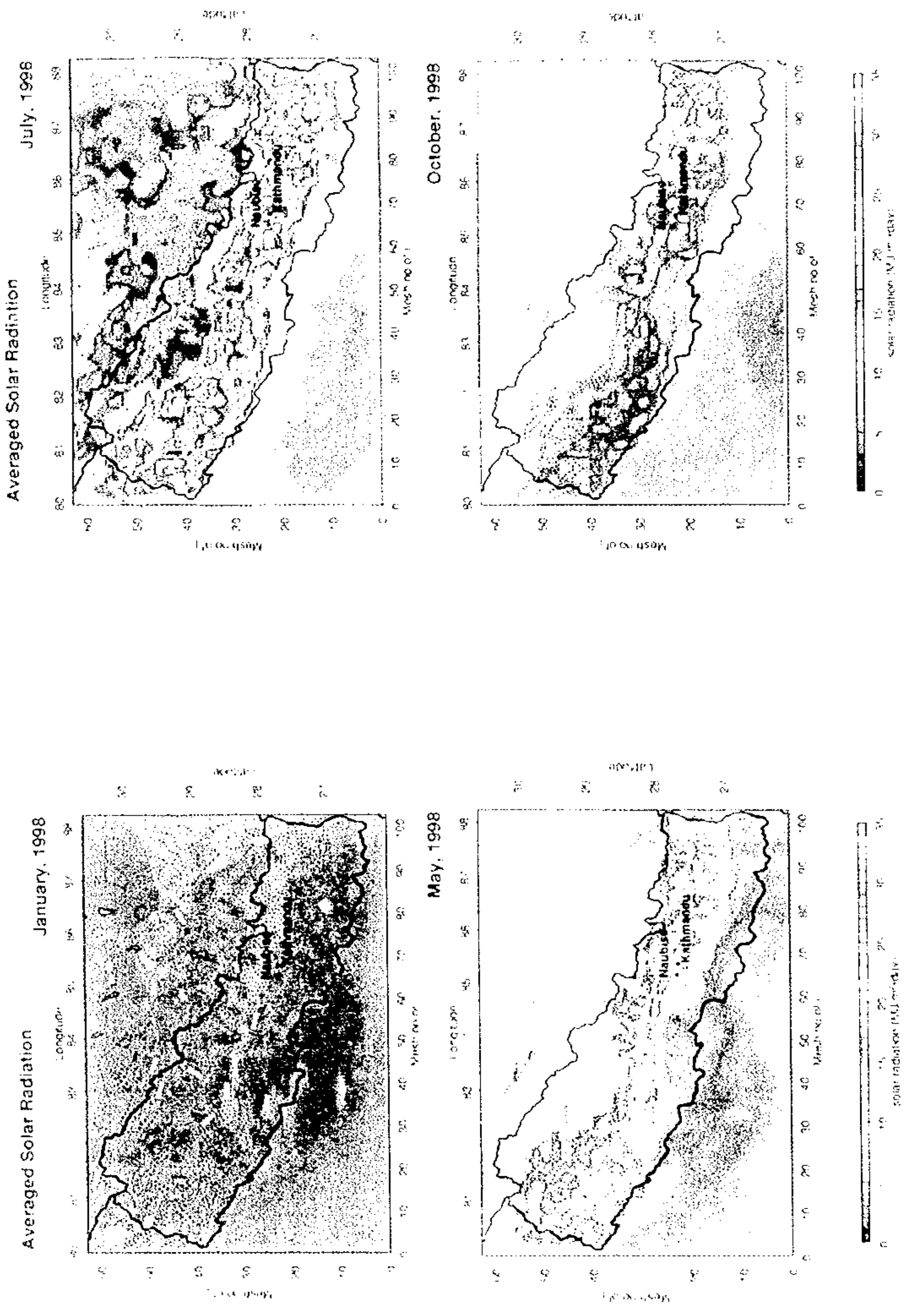


Figure 14.10 Monthly Mean Daily Cumulative Solar Radiation Map

14.6 Precision of the calculated data

After the simulation runs throughout the year, it is clear that the wind speed is strong during the winter and weak during the monsoon season (summer). The seasonal solar radiation in Nepal was less during winter due to short daytime hours and more in the pre-monsoon season. Generally, larger solar radiation is expected, but due to lots of clouds in day time, caused by monsoon showers, lesser radiation resulted. Similarly, less solar radiation was calculated on steep slopes facing south.

To validate the simulated results, wind and sunshine data were collected from the station at Kathmandu airport. Analysis on these data showed similar variation through the year, as resulted from the simulation.

14.7 Estimation of power generation

The quantity of power that can be generated by wind and solar radiation was calculated by the weather forecast model.

14.7.1 Estimation of wind-generated power

A driving characteristic of a wind-generated electricity system by the stall control is shown in Figure 14.11.

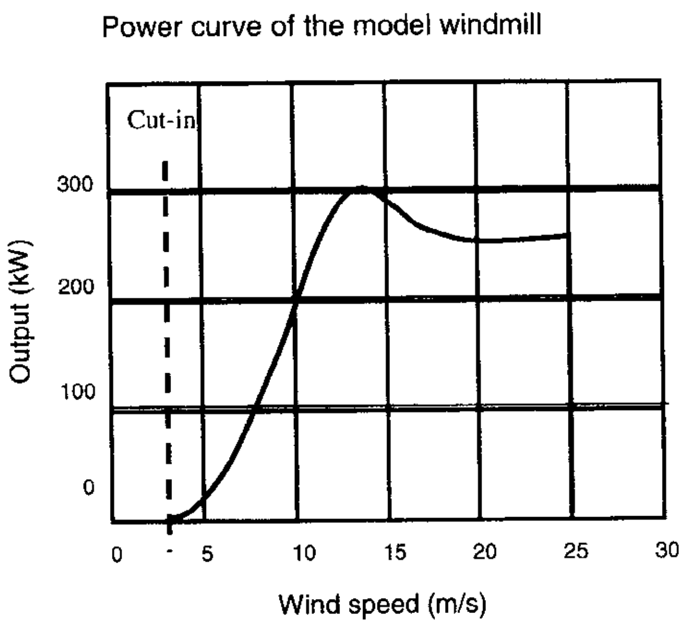


Figure 14.11 The Wind-generated Electricity System (Example for stall control, rated output 300kW machine)

The wind-generated electricity system with the output characteristics as given in Table 14.1 was assumed. The assumed cut in wind velocity and safety cutout wind is 4 m/s and 25 m/s, respectively.

In calculation of generated energy by a wind-generated electricity system, the following expression was used along with the windmill output characteristics of Table 14.4 and wind velocity relative frequency distribution of 30m height by a weather model.

Annual (monthly) mean day multiplication generated energy (kWh/day)

$$= \sum_i V_i \times f_i \times 24h$$

Vi: Electricity output (kW) of wind velocity rank i
Fi : Relative frequency between year (months) of wind velocity rank i

Table 14.4 Output characteristics (amount of 300kW grade, hub 30m) of the wind-generated electricity system

Wind Speed (m/s)	Output (kW)	Wind Speed (m/s)	Output (kW)
0	0.0	15	290.0
1	0.0	16	280.0
2	0.0	17	270.0
3	0.0	18	260.0
4	10.5	19	255.0
5	20.0	20	250.0
6	56.0	21	252.0
7	92.0	22	254.0
8	128.0	23	256.0
9	164.0	24	258.0
10	200.0	25	260.0
11	225.0	26	0.0
12	250.0	27	0.0
13	275.0	28	0.0
14	300.0	29	0.0

The Operation rate is given by the following relationship.

Operation rate (%) = A－B

A: Accumulation relative frequency equal to or more than the cut in wind velocity
B: Accumulation relative frequency equal to or more than the safety cutout wind velocity

14.7.2 Estimation of power from solar energy

Following expression was used to calculated the generated energy from a solar battery panel.

Generated energy (kWh/m2) per unit area in one time I= $Q_i \times \eta_A \times K_T \times 1h$

- Q_i: Global solar radiation in time i (kW/m^2)
- η_A: standard conversion efficiency of solar generation
- K_T: A temperature revision coefficient
  The coefficient K_T is calculated as follows;
  $K_T = 1 - \alpha_{P\max}(T_1 + T_2 - T_s)$
- α_{Pmax}: temperature revision coefficient(1/°C),
  α_{Pmax}=0.0041 in a crystal system
- T_1: Temperature(°C)
- T_2: A quantity of solar battery element temperature rise
- T_s: Cell temperature of normal condition (25°C)

A crystal system solar battery panel of conversion efficiency 10% was assumed in the following parameter set.

η_A=0.1、 α_{Pmax}=0.0041、 T_2=30

The temperature T_1 for every hour was used from the weather forecast model.

14.7.3 The estimate quality

The estimate quality of wind-generator electric system is shown in Figure 14.12, giving the annual mean value of day multiplication generator. The monthly mean in January, May, July, and October are given in Figure 14.13.

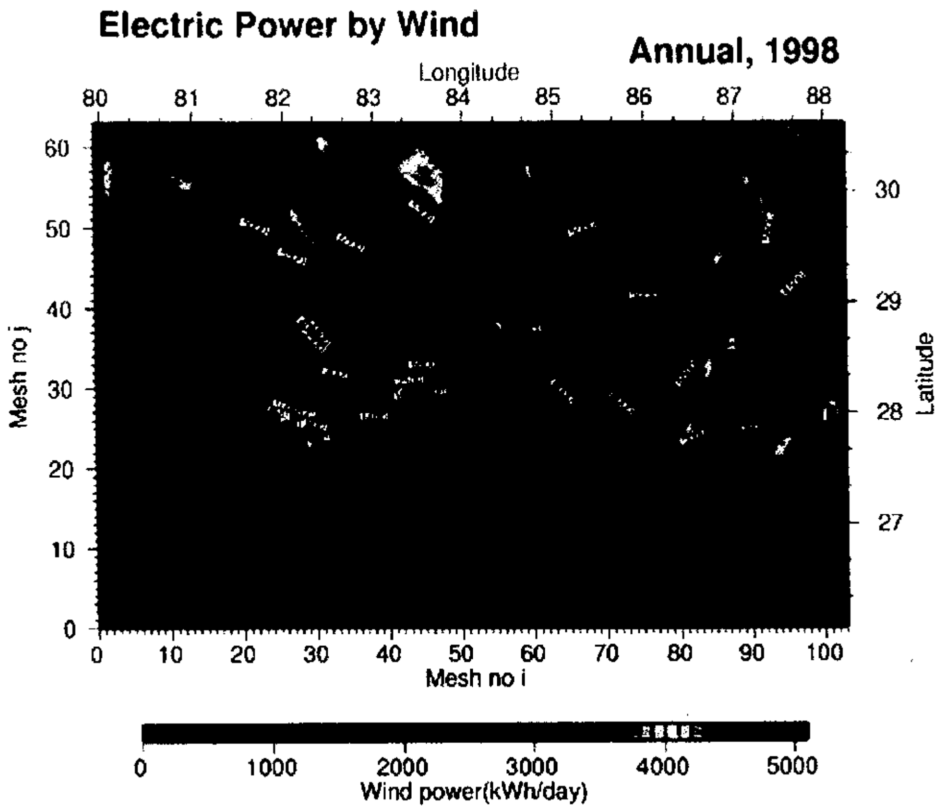


Figure 14.12 Electric Power by Wind (Annual Mean)

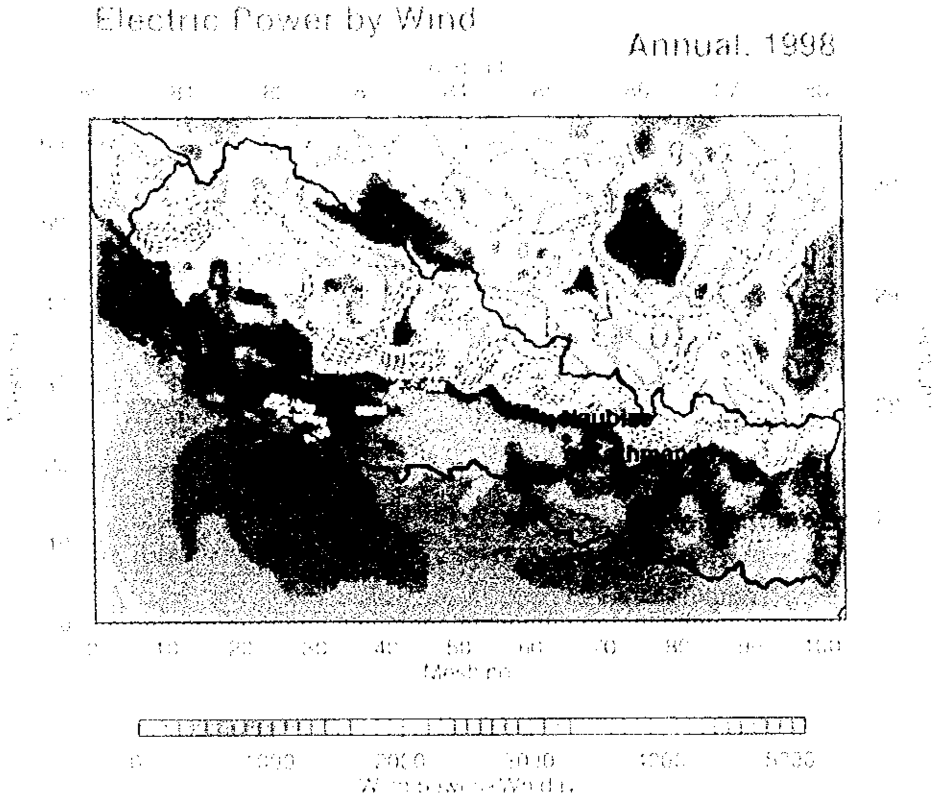


Figure 14.12 Electric Power by Wind (Annual Mean)

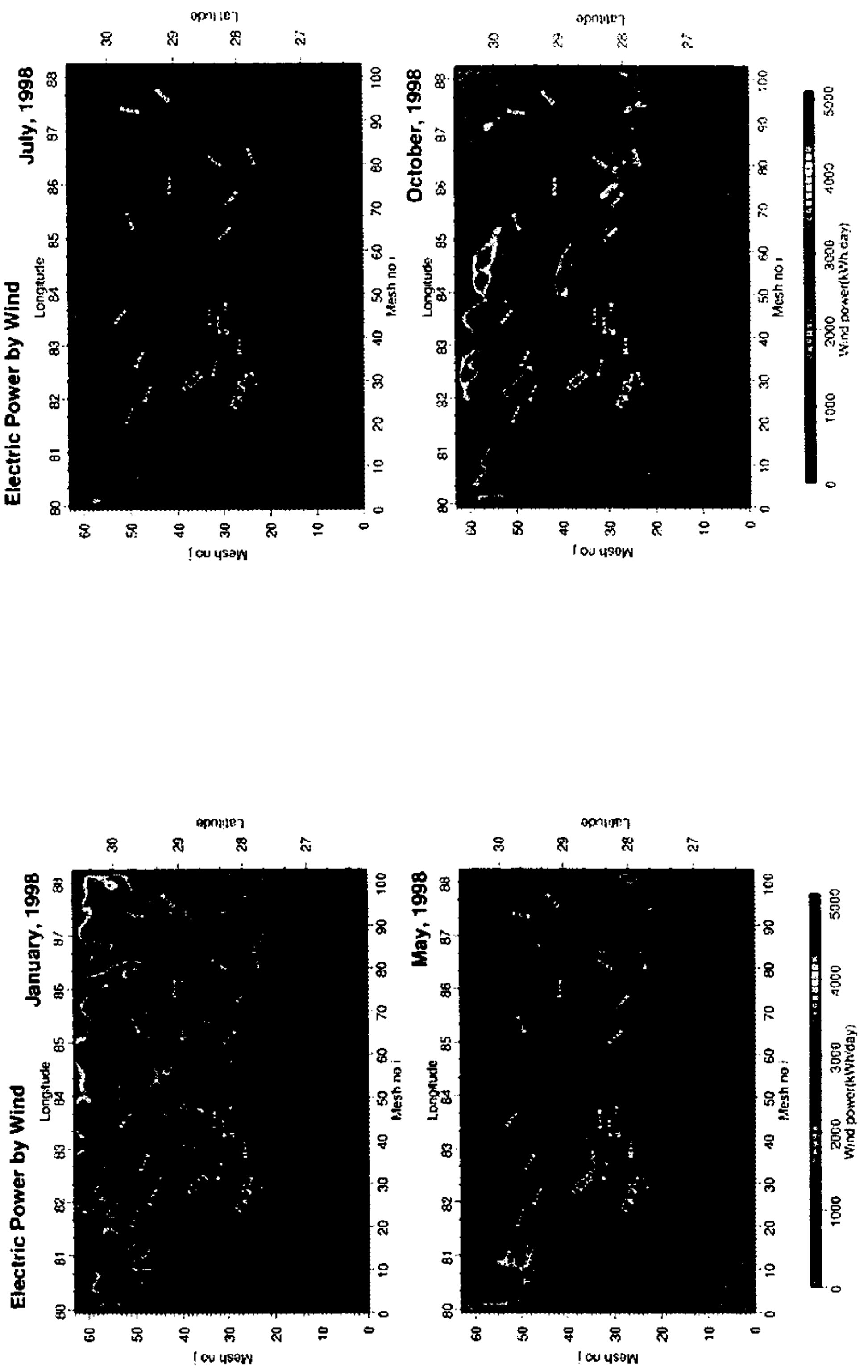


Figure 14.13 Electric Power by Wind (Monthly Mean)

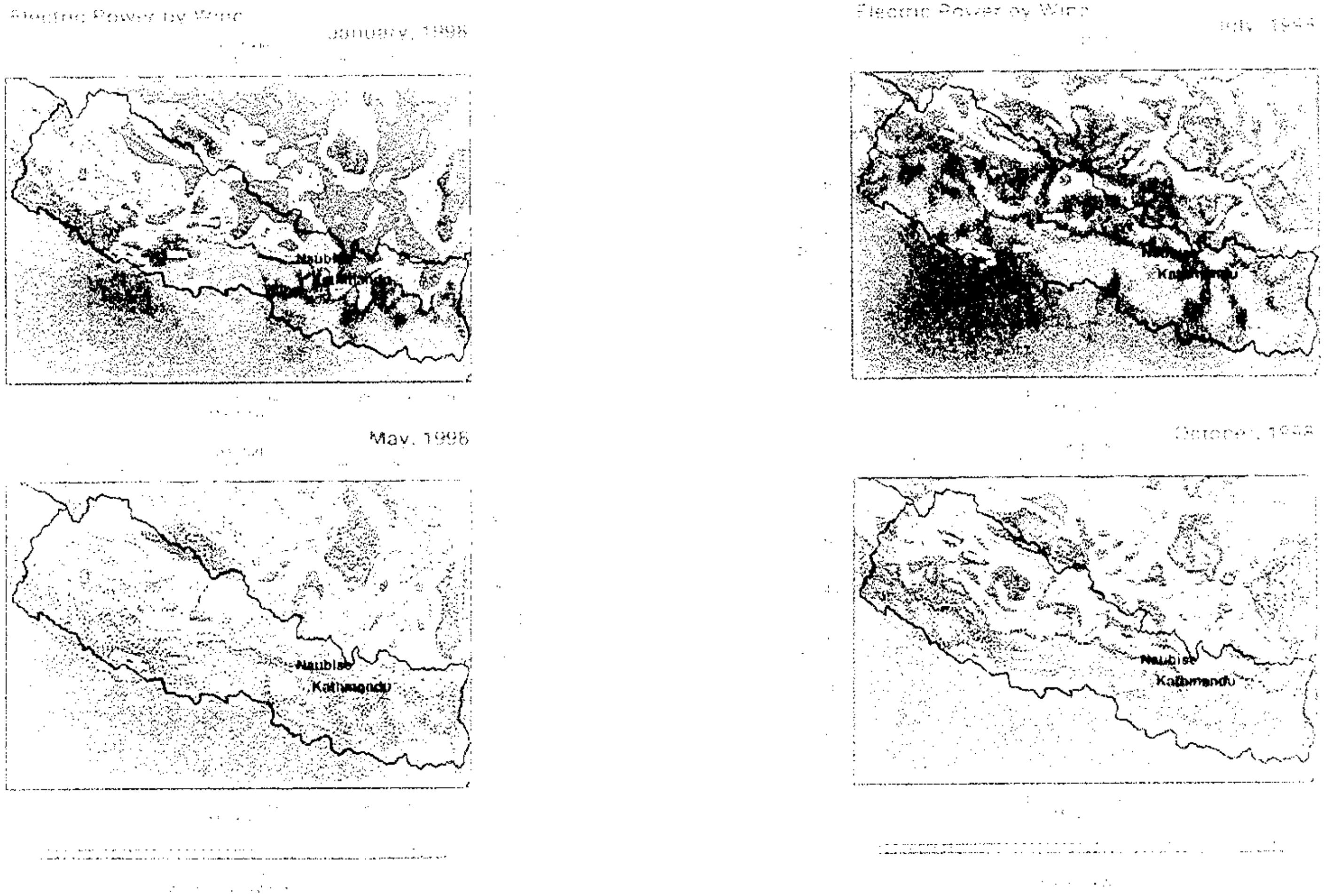


Figure [illegible] Electric Power by Wind (Monthly Mean)

The estimated quantity is as large as 3000kWh/day in mountainous areas, but is only 500kWh/day in plain areas. During the monsoon period, the estimated power generated both in the mountain area and the plains was very small. In other seasons, a large quantity is expected which can be generated from windmills in the mountain areas and slopes, but sufficient amount can not be expected in plain areas.

The estimated quantities of power generate by a solar battery panel are shown in Figure 14.14 and 14.15, for the annual mean of day multiplication generation quantity per unit area and monthly variation, respectively.

In general, a large amount of solar battery generation can be expected throughout Nepal. However, the quantity is affected by bad weather during monsoon season in the steep slopes. The annual mean of power generator is expected to be about 0.5kWh/m^2 per day in plain areas. On the other hand, power generation can not be expected in the slopes during monsoon season, except in the north side of the slopes.

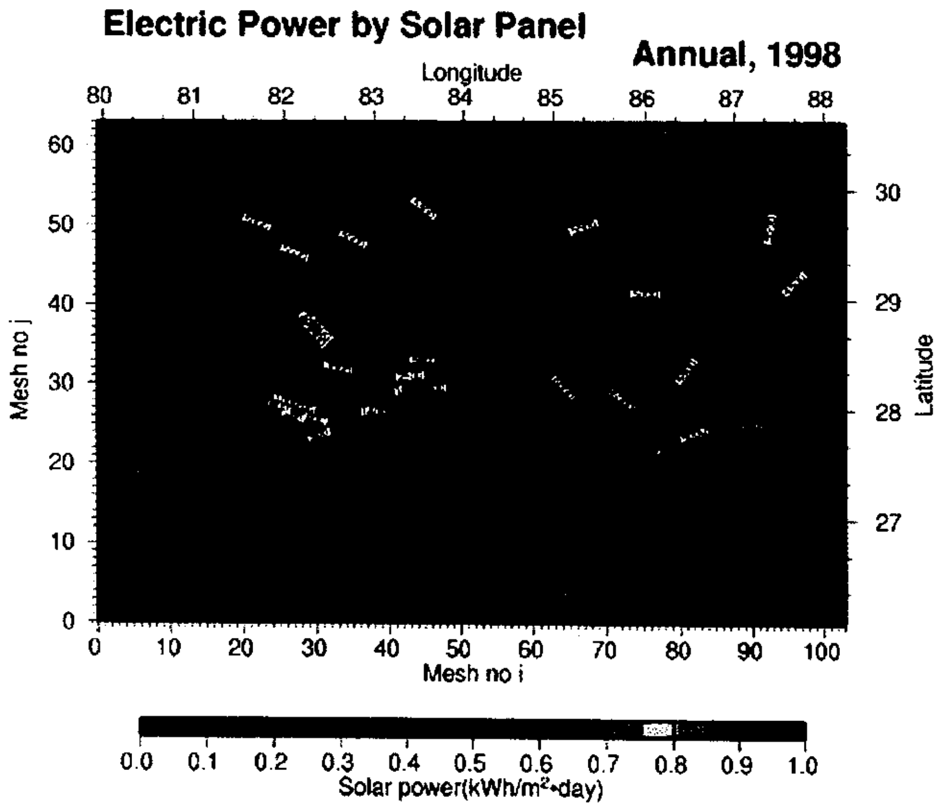


Figure 14.14 Electric Power by Solar Panel, Annual Mean

The estimated quantity is as large as 3000kWh/day in mountainous areas, but is only 500Wh/day in plain areas. During the monsoon period, the estimated power generated both in the mountain area and the plains was very small. In other seasons, a large quantity is expected which can be generated from windmills in the mountain areas and slopes, but sufficient amount can not be expected in plain areas.

The estimated quantities of power generate by a solar battery panel are shown in Figure 14.14 and 14.15, for the annual mean of day multiplication generation quantity per unit area and monthly variation, respectively.

In general, a large amount of solar battery generation can be expected throughout Nepal. However, the quantity is affected by bad weather during monsoon season in the steep slopes. The annual mean of power generator is expected to be about 0.5kWh/m² per day in plain areas. On the other hand, power generation can not be expected in the slopes during monsoon season, except in the north side of the slopes.

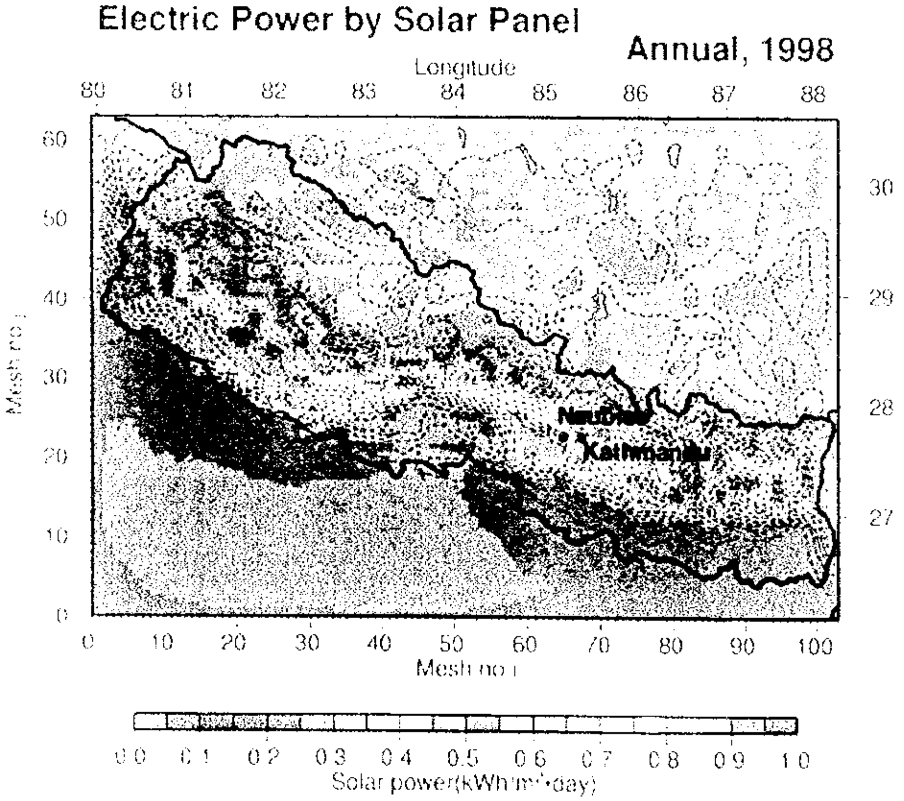


Figure 14.14 Electric Power by Solar Panel, Annual Mean

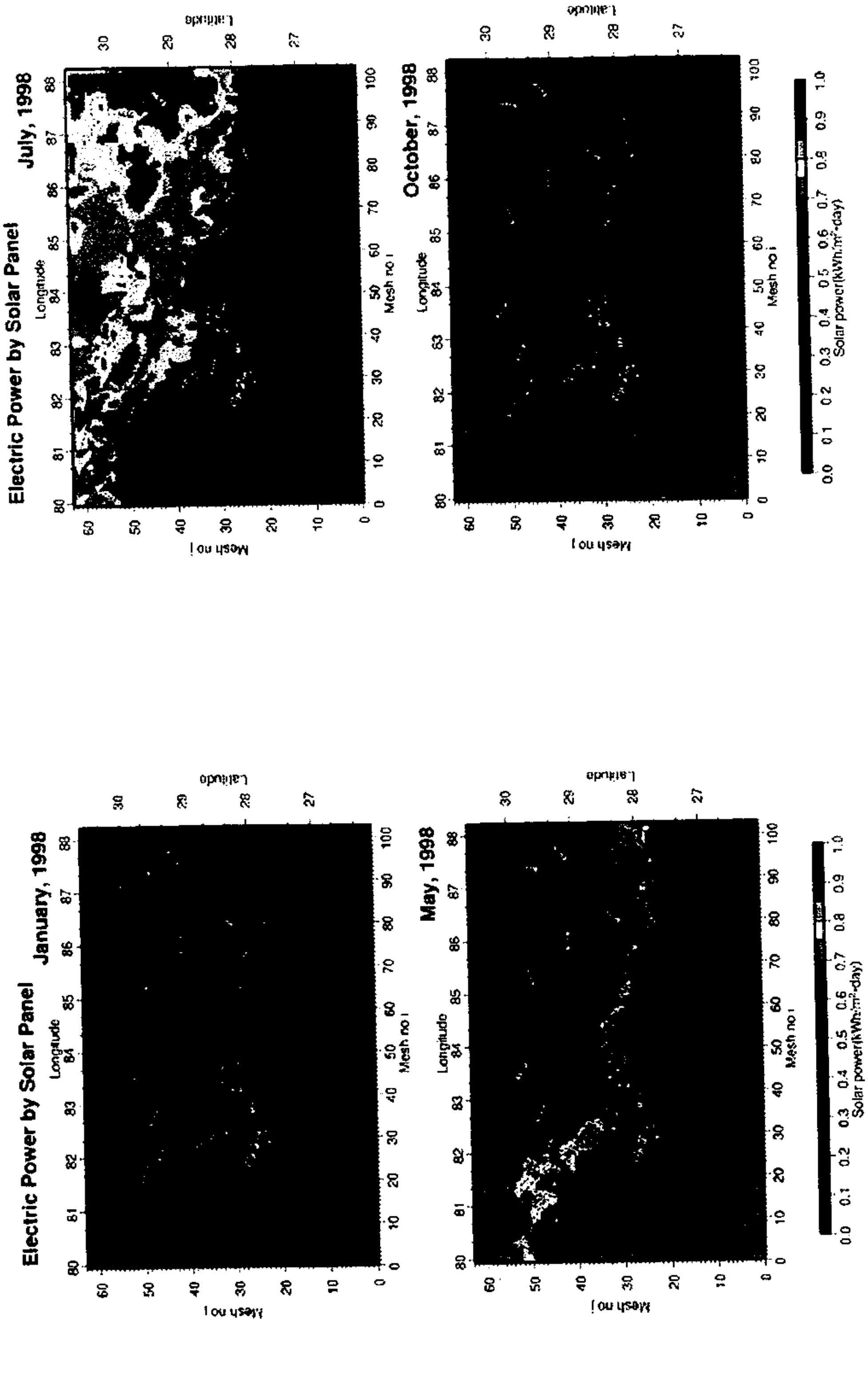


Figure 14.15 Electric Power by Solar Panel, Monthly Average

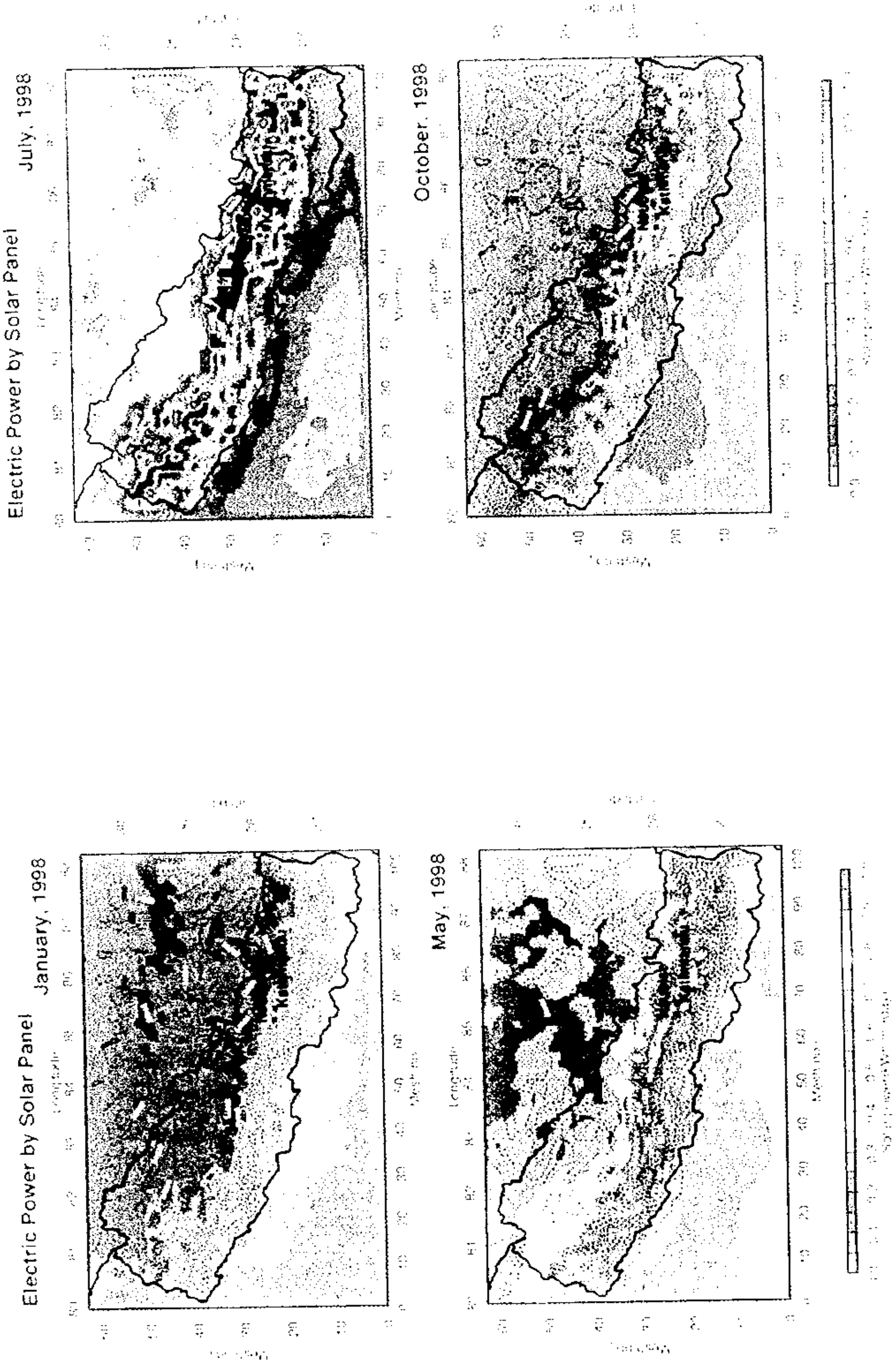


Figure 14.15 Electric Power by Solar Panel, Monthly Average

The monthly and annual mean wind velocity at 30m above the ground surface, solar radiation and the quantity of power generation at the Project area is shown in Table 14.5.

Table 14.5 Monthly and annual mean wind velocity, solar radiation and the quantity of generation at the Project area

(The calculated mesh value including Project area)

Month	WS m/s	WD deg	W-POWER KWh/dy	OR %	SUN kWh/m2dy	S-POWER kWh/m2dy
January	3.2	306.56	109.1	36.2	4.499	0.424
February	3.2	307.09	152.4	43.2	5.168	0.484
March	3.3	292.85	199.3	47.2	5.786	0.538
April	3.2	265.12	186.7	44.3	6.199	0.564
May	2.9	249.39	135.4	34.5	6.426	0.577
June	2.6	239.13	99.7	26.1	6.370	0.567
July	2.6	236.61	73.1	21.4	4.684	0.418
August	2.4	228.95	50.6	14.5	4.400	0.393
September	2.3	235.47	31.4	12.1	4.998	0.447
October	2.5	251.42	51.2	19.2	4.908	0.443
November	3.0	327.62	149.0	34.2	4.631	0.423
December	3.1	323.87	175.7	28.5	4.298	0.399
Annual	2.9	268.65	117.5	30.0	5.194	0.473

WS: monthly mean wind velocity at 30m above the ground surface
WD: monthly mean vector at 30m above the ground surface
W-POWER: estimated cumulative daily wind power
OR: Operation Rate for windmill running
SUN: Solar Radiation
S-POWER: estimated cumulative daily solar power amount

From the above results the potential for wind/solar generation in the Project area was examined.

From Table 14.5, it is clear that the annual mean wind velocity around the Project area is weak (2.9m/s) and that in the monsoon season (June to September) is even weaker. The monthly mean wind velocity is 3.0m/s to 3.3m/s in other months.

On the other hand, possibility of power generation from solar radiation may be expected. In particular, larger quantity of power generation can be expected in pre monsoon season, though there may exist some variation from year to year.

14.7.4 Estimation of power generation for the operation of tunnel

The possibility of using wind or solar generated power in the maintenance of tunnel of the Project was studied further. Following assumptions were made for power requirements in the tunnel (Table 14.6).

Table 14.6 Tunnel facility electric capacity

Tunnel extension: 700m

Facility contents		Base	Daytime	Night	Midnight
For Illumination facility	Basis	37.9kVA	37.9	13.2	11.6
	Relaxation	52kVA	52	0	0
Necessity (kWh)			34.11	11.88	10.44

The quantity of power required for maintenance and the power that can be generated from wind and solar radiation is shown in Figure 14.16 for each hour of the day. From the results it was calculated that two windmills and solar panels of approximately 1,000m^2 area will be required to meet the demand during daytime.

In order to stage the surplus power generated that can be used during less power generation, the required battery level was calculated. Considering the frequency distribution, as given in Figure 14.17 and considering 85% usage of natural energy, battery that has effective capacity of 130 kWh. Indeed, the conversion efficiency of both input and output are estimated as about 70%, so it is necessary to use the battery with capacity of 260 kWh.

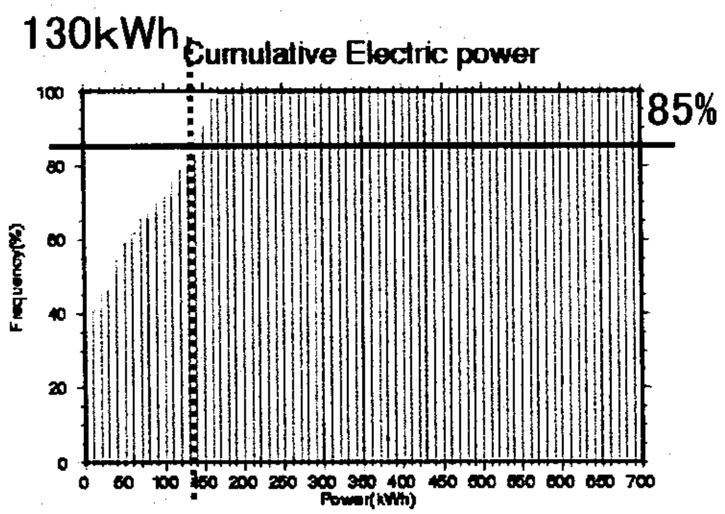


Figure 14.17 Frequency distribution of electricity

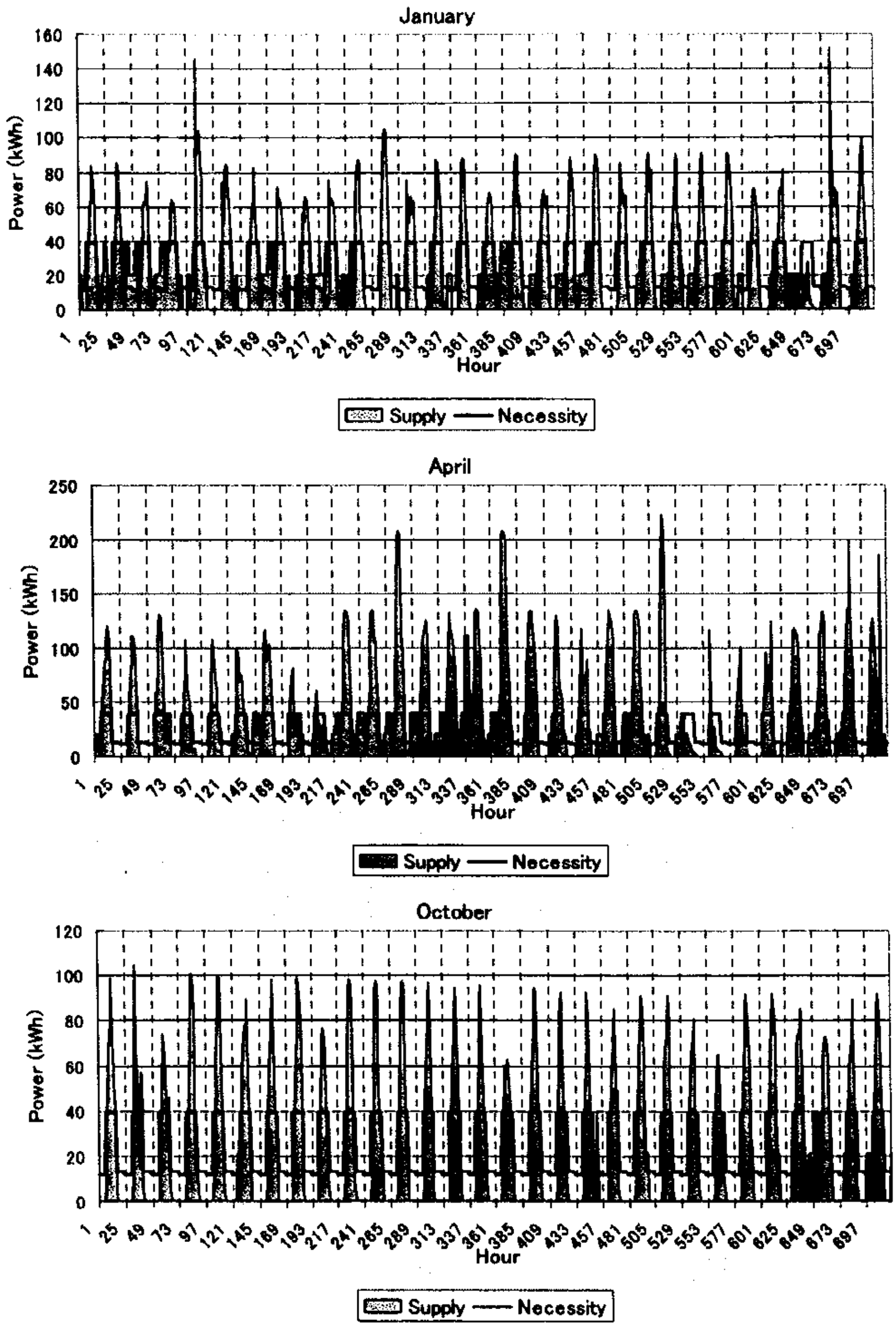


Figure 14.16 Time Sequence of the Hourly Demand and Supply of Power in the Tunnel

14.7.5 Possibility of utilization of wind and solar power

The estimation of the wind and solar power generation shows a result that two sets of 300 kW windmill and 1,000m2 of solar panel can supply power for operation of the tunnel for the period of 85 % of total operation period except monsoon season. This result indicates that the operation of the tunnel can not depend fully on the wind and solar power and needs power supply from existing NEA power system for monsoon season and other period when the wind and solar power can not supply power sufficiently. Therefore the wind and solar power will means to save purchase of electricity from NEA.

The cost for the wind and solar system can be roughly estimated as shown in the table below:

Table 14.7 Rough Cost Estimate for Wind and Solar Power Generation System

ITEM	Requirement	Unit	Unit Price (US$)	Quantity	Amount (US$)
1. Wind Mill Power Generation System	Install Capacity : 600 kW (300 kW @ 2 unit)	kW	*)2,000	600	1.2
2. Solar Power Generation System	Required area of solar panel : 1,000 m2	m2	**)1,000	1,000	1.0
3. Battery System	Storage Capacity : 260 kWh	kWh	*)2,200	260	0.6
4. Total Amount					2.8
Note: *) unit prices base on the current international market price (average price) **) unit price based on the current market price in Japan (average price)					

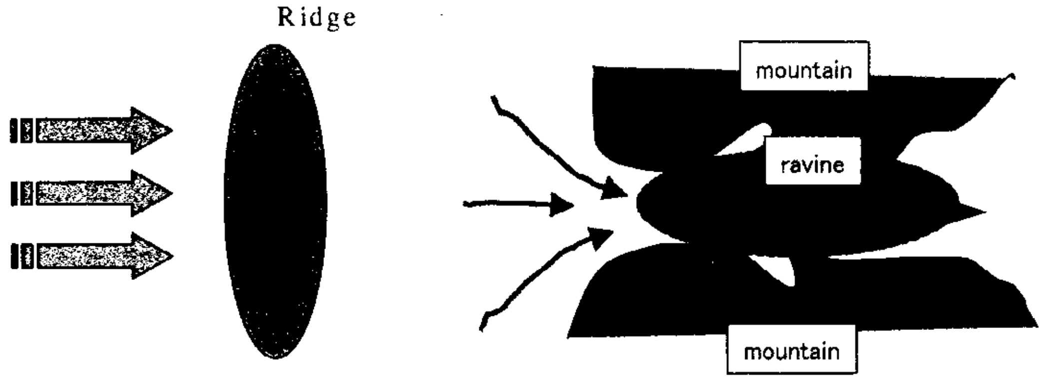
The above cost estimate indicates approx. 2.8 million US$ for the power generation system. On the other hand, total annual consumption of electricity for the tunnel operation is estimated to be 220,000 kWh and will cost about 0.05 million US$, if all electricity is purchased from NEA. Judging from the above result, utilization of the wind and solar power generation for the tunnel operation seems not to be realistic.

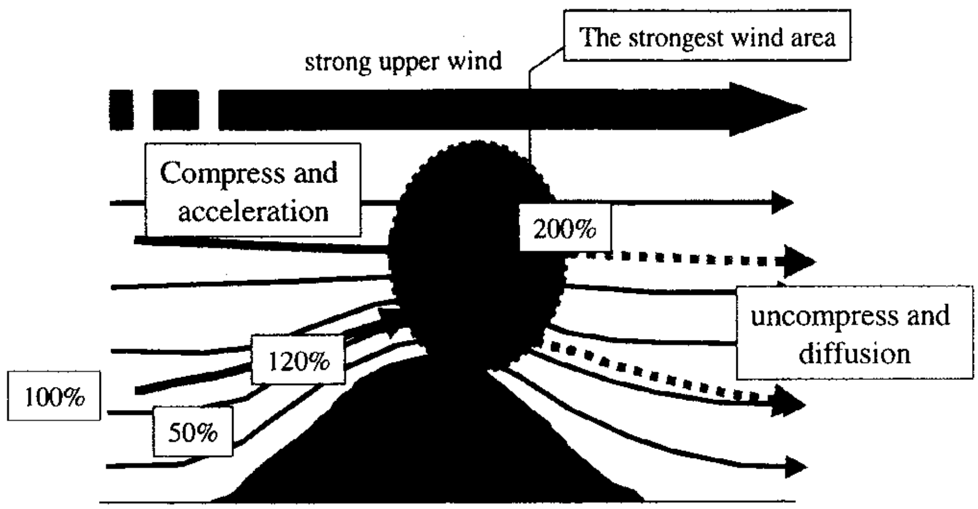
However, considering the following matters, the Study Team concluded that feasibility of utilization of the wind and solar power generation shall be examined more in further detailed study.

a) The above estimation of power generation was based on the data obtained from mesh size of 8km x 8km and does not take local topographical conditions into account. As shown in Figure 14.18, wind velocity is considerably affected by localized change in topography and the project area can be considered to have advantageous topography. Therefore more detailed simulation with mesh size of 250m x 250m will be required to estimate more precise and better results.

b) Due to recent technological innovation and demand increase of the wind and solar power generation system, market prices for facilities of the systems has been descending drastically and may come to the price level where these systems become more feasible.

c) Utilization of the wind and solar power generation systems will contribute to reduction of CO2 by means of saving electricity of NEA. The systems will become more feasible if the CO2 reduction effect is taken into account in economic evaluation.





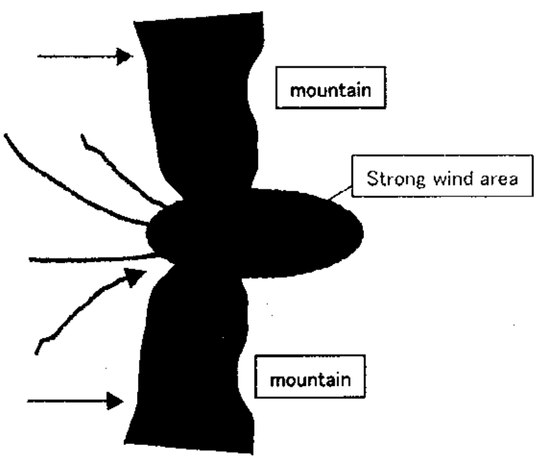


Figure 14.18 The Wind Velocity affected by Topographic Condition

CHAPTER 15 ENVIRONMENTAL STUDY

15.1 General

The Kathmandu – Naubise Alternate Road (the Project Road) will surely contribute a great part to the development of Nepal. However, the road construction will also have various positive and/or negative effects on the physical, biological, socio-economic, and cultural environment in and around the Study area. Assessment of these potential effects is considerably important, as well as the setting up of the mitigation measures against the adverse impacts, and the environmental monitoring plan to realize the environmentally sound and sustainable development.

The objectives of this environmental study are to identify the potential environmental effects at an early stage of the project implementation and include:

- To identify and assess the environmental impacts due to the construction of the Project Road in and around the Study area,
- To set up appropriate mitigation measures on adverse environmental impacts, and
- To set up appropriate plan for environmental monitoring

In this chapter, the following shows the summarized description on EIA procedure in Nepal (Section 15.2), the summary of the field surveys of water quality and household interview (Section 15.3), the results of initial environmental examination (Section 15.4), and EIA study (Section 15.5).

15.2 Official EIA Procedure in Nepal

15.2.1 Legal frame on EIA

The legal frame on the environmental impact assessment (EIA) in Nepal is composed of the Environmental Protection Act 2053, 1996 (EPA 1996) and the Environmental Protection Regulations 2054, 1997 (EPR 1997). The EPR 1997 has been amended in 1999 as the Revised 2055 to shorten the term and simplify the procedure of the EIA process. This legislation is founded upon the National Environmental Impact Assessment Guidelines, 1993, that shows the policy and model to establish the national EIA system in Nepal.

As stipulated under Article 3 of the EPA 1996, the proponent should conduct an EIA study before implementation of the specified proposals listed in Appendix 2 of the EPR 1997. Regarding the road sector, an EIA is required for the construction projects of National Highway or Major Feeder Roads under Regulation 3 and Appendix 2 of the EPR 1997.

15.2.2 EIA procedure

The EIA procedure flow based on the above legislation is shown in Figure 15.1, taking the proponent of the project into consideration.

According to the EPR 1997, the proponent should obtain the approval of the Ministry of Population and Environment (MOPE) regarding the scoping delimitation and the terms of reference (TOR) of EIA before the commencement of the EIA study. The points of the procedure for the TOR approval are summarized as follows:

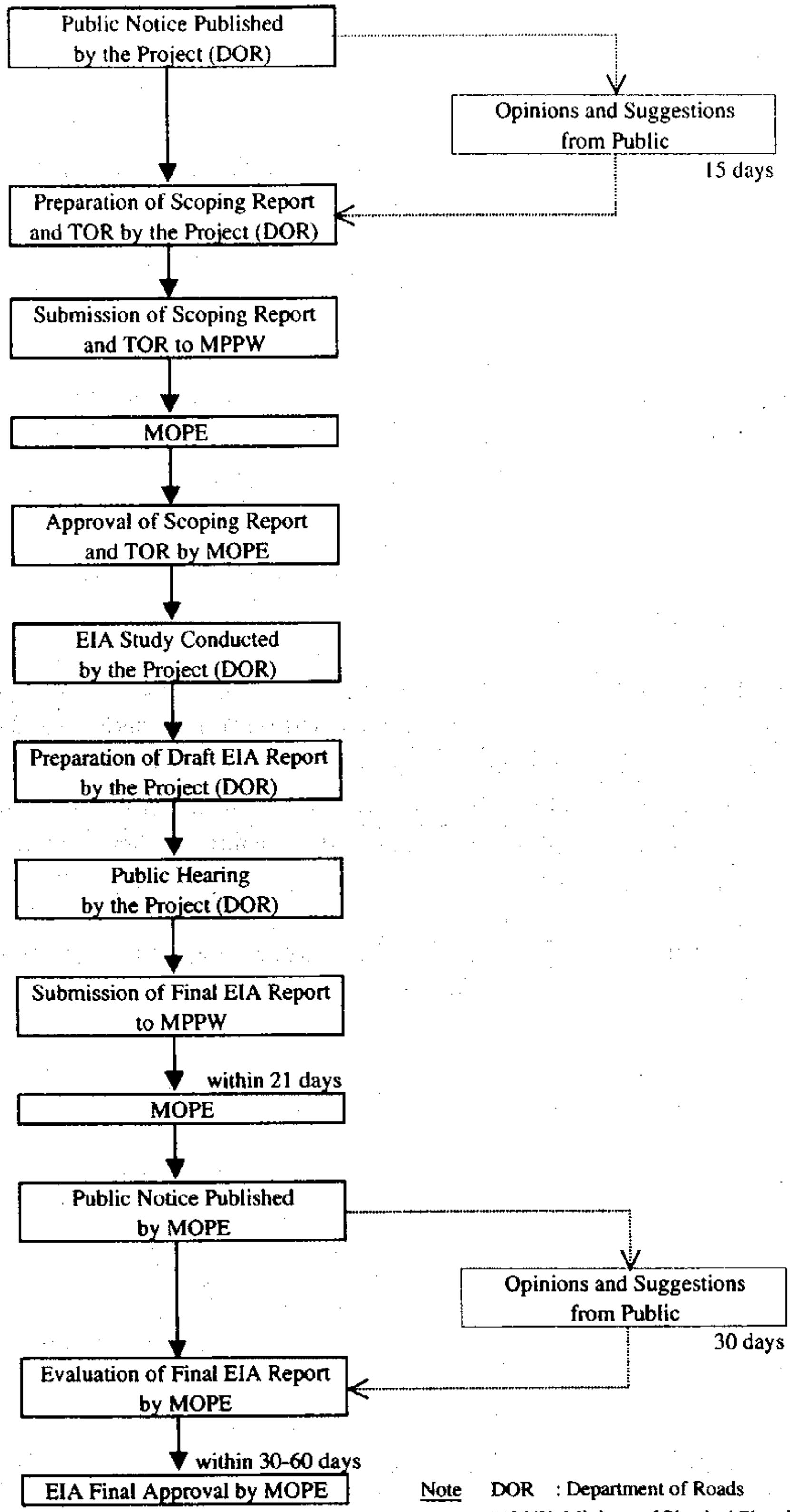
- Public Notice of Proposal by the Proponent
- Opinions and Suggestions from Public (15 days from Public Notice)
- Submission of Scoping Report and TOR to MOPE through the Concerned Agency (MPPW)
- Evaluation and approval on TOR by MOPE

The proponent can start the EIA study after getting the TOR approval by MOPE. As per Regulation 7, 10, and 11 of the EPR 1997, the points of the process for the approval of the EIA report are summarized as follows:

- Conducting the EIA Study and Preparation of Draft EIA Report
- Public Hearing by the Proponent
- Submission of Final EIA Report to MOPE through the Concerned Agency (MPPW)
- Public Notice by MOPE
- Opinions and Suggestions from Public (30 days from Public Notice)
- Evaluation and Approval of EIA Report by MOPE

It is noted that the EPA 1996 and EPR 1997 make the public involvement a prerequisite for the prescribed project implementation. Particularly from the scoping stage up to the approval of EIA report, these legislations provide the stakeholders, such as the local people, with an opportunity to voice their concerns regarding the environmental issues due to the proposal implementation.

Besides, as per EPA 1996, MOPE can constitute a committee that consists of the concerned agency, the related agency including MOPE, and a third party. MOPE generally establish an EIA Report Recommendation Committee for each proposal to review the Scoping Report, TOR, and the EIA report, which are submitted by the proponent.



Note DOR : Department of Roads
MPPW: Ministry of Physical Planning and Works
MOPE : Ministry of Population and Environment

Source: EPA 1996, EPR 1997

Figure 15.1 EIA Procedure Flow

15.2.3 Environmental guidelines of road sector

In 1994, the Ministry of Works and Transport (now MPPW) drafted a separate EIA Guideline particular for this road sector. This guideline was revised in 1996. The Geo-Environmental Unit (GEU) of the Department of Roads (DOR) also prepared the Environmental Management Guidelines in 1997 to specify the environmental mitigation measures in each stage of the surveying, design, construction, and maintenance and operation of the road projects.

In 2000, the Environmental Assessment in the Strategic Road Network (Policy Document) was drafted by GEU of DOR to create understanding in environmental assessment among DOR staff. The purpose of the Policy Document is to explain what procedures are involved in environmental assessment.

15.3 Environmental Survey

15.3.1 Water quality survey

The water quality survey in the Study area was conducted by the JICA Study Team. The sampling and field measurement was carried out on 5th and 6th of May, 2000 as the dry season survey, and on 10th and 11th of June, 2000 as the wet season survey. 16 sampling points, composed of 10 points for wells/springs water sampling and of 6 points for river water sampling, were selected, considering the characteristics of the Study area and the project itself.

The locations of the sampling points and the analytical results are shown in Table 15.1 and 15.2, respectively. Some description of main findings is included in Section 15.4.

Table 15.1 Sampling Points

Source	No.	Sampling Date	Location	Name of VDC
Wells/ Springs	W1	May 5, 2000 June 10, 2000	Baluwadanda, Bhadaure	Naubise
	W2	May 5, 2000 June 10, 2000	Badritar	Jiwanpur
	W3	May 5, 2000 June 10, 2000	Ale ko Pandhero, Amale Bhanjyang	Chhatre Deurali
	W4	May 5, 2000 June 10, 2000	Neupane Kuwa, Bhattarai Gaon	Chhatre Deurali
	W5	May 6, 2000 June 11, 2000	Darshan Khola Mul, Dhansar	Bhimdhunga
	W6	May 6, 2000 June 11, 2000	Darshan Khola, Karki Gaon	Bhimdhunga
	W7	May 6, 2000 June 11, 2000	Namtu Tap	Bhimdhunga
	W8	May 6, 2000 June 11, 2000	Sainleti Tap, Kasarthok	Bhimdhunga
	W9	May 6, 2000 June 11, 2000	Batase ko Kuwa, Puri Gaon	Ramkot
	W10	May 6, 2000 June 11, 2000	(Dug Well)	Sitapaila
Rivers	R1	May 5, 2000 June 10, 2000	Mahesh Khola, Dharke	Naubise
	R2	May 5, 2000 June 10, 2000	Mahesh Khola, Barabise	Naubise
	R3	May 5, 2000 June 10, 2000	Sano Ukali, (Mahesh Khola), Pakhure	Chhatre Deurali
	R4	May 6, 2000 June 11, 2000	Triveni Khola, Shantinagar	Ramkot
	R5	May 6, 2000 June 11, 2000	Masine, (Triveni Khola), Dandapauwa	Ramkot
	R6	May 6, 2000 June 11, 2000	Manamati Khola, Mahadol,	Sitapaila

Source: JICA Study Team

Table 15.2(1/4) Test Results of River Water Samples (dry season)

Parameter	Observed Value						WHO GV
	R1	R2	R3	R4	R5	R6	
Air Temperature (°C)	29.0	27.0	27.0	26.5	27.0	26.5	-
Water Temperature (°C)	21.0	20.0	21.0	21.0	21.5	21.0	-
pH	8.5	8.4	8.1	7.5	7.7	8.1	6.5 – 8.5
EC (μS/cm)	336	345	370	285	305	362	-
Turbidity (NTU)	26	66	42	570	380	56	5
TDS (mg/l)	194	200	214	171	183	217	1000
Alkalinity (mg/l)	120	137	137	99	95	126	500
Phosphate (mg/l)	0.11	0.12	0.13	0.21	0.17	0.18	-
Nitrate (mg/l)	<0.5	<0.5	<0.5	10	4	<0.5	50.0
Iron (mg/l)	0.25	0.52	0.19	2.2	2.4	0.83	0.3
Manganese (mg/l)	0.03	0.03	0.02	0.11	0.12	0.05	0.1
Copper (mg/l)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	2
DO (mg/l)	10.3	9.8	8.5	8.4	8.4	6.5	-
COD(mg/l)	5.5	6	3.5	17	20	9	-
Permanganate Value (mg/l)	0.3	0.2	0.1	1.3	1.3	0.5	-
BOD (mg/l)	1.4	0.9	0.3	2.8	3.4	2.5	-
Total Coliforms (MPN/100 ml)	180+	160	35	180+	180+	180+	0
E-coli (MPN/100 ml)	90	14	5	180+	180+	180+	0
Flow (m^3/sec)	0.484	0.575	0.007	0.045	0.052	0.126	-

Note: N.D. means Not Detected.
Source: JICA Study Team

Table 15.2(2/4) Test Results of Well/Spring Water Samples (dry season)

Parameter	Observed Value										WHO GV
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	
Air Temperature (°C)	29.0	28.0	27.0	27.0	26.0	25.0	24.0	25.0	26.0	25.0	-
Water Temperature (°C)	20.0	21.0	21.0	20.0	20.0	20.0	20.0	20.0	18.0	19.0	-
pH	6.9	6.2	6.5	6.4	7.5	7.5	7.1	7.6	6.4	7.4	6.5 - 8.5
EC (μS/cm)	214	98	196	235	261	187	237	280	159	851	-
Turbidity (NTU)	8	36	6	11	1	12	3	1	1	14	5
TDS (mg/l)	100	58	100	114	110	123	160	137	110	545	1000
Alkalinity (mg/l)	84	34	74	99	103	86	80	111	34	155	500
Phosphate (mg/l)	0.24	0.07	0.40	0.10	0.20	0.20	0.20	0.20	0.14	0.10	-
Nitrate (mg/l)	4	3	2	1	4	<0.5	5	1	2	20	50.0
Iron (mg/l)	0.39	0.22	ND	0.27	0.10	0.44	0.08	0.10	0.13	0.11	0.3
Manganese (mg/l)	0.01	0.02	N.D.	0.2	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.1
Copper (mg/l)	N.D.	N.D.	N.D.	N.D.	0.015	N.D.	N.D.	N.D.	N.D.	N.D.	2.0
DO (mg/l)	5.0	9.2	5.2	3.8	7.3	6.8	6.5	5.2	5.4	2.5	-
COD (mg/l)	2.0	4.5	1.0	3.0	2.5	4.0	2.0	0.5	0.5	3.5	-
Permanganate Value (mg/l)	0.1	0.1	0.1	0.0	0.1	0.2	0.1	0.0	0.1	0.1	-
BOD (mg/l)	0.5	1.7	0.4	1.2	1.1	1.4	1.0	0.4	0.5	0.8	-
Total Coliforms (MPN/100 ml)	2	160	8	180+	50	7	160	3	50	180+	0
E-coli (MPN/100 ml)	Nil	11	1	20	3	Nil	10	Nil	7	35	0
Discharge (liter/min)	4.0	4.5	4.1	3.8	81.5	3.8	2.4	9.5	2.5	- *	-

Note: N.D. means Not Detected.
*: Water table depth was measured instead of discharge volume, and was 5.2m from ground level.
Source: JICA Study Team

Table 15.2(3/4) Test Results of River Water Samples (wet season)

Parameter	Observed Value						WHO GV
	R1	R2	R3	R4	R5	R6	
Air Temperature (°C)	25.0	27.5	26.0	23.0	27.0	22.0	-
Water Temperature (°C)	23.0	25.0	25.0	22.0	26.0	21.0	-
pH	8.3	8.3	8.4	7.4	7.4	7.6	6.5 – 8.5
EC (μS/cm)	440	385	454	415	329	561	-
Turbidity (NTU)	86	140	145	1700	512	115	5
TDS (mg/l)	261	203	259	240	190	331	1000
Alkalinity (mg/l)	134	116	132	65	61	160	500
Phosphate (mg/l)	0.11	0.16	0.18	0.50	0.26	0.22	-
Nitrate (mg/l)	1.0	<0.5	<0.5	15	7	2	50.0
Iron (mg/l)	0.36	0.86	1.4	7.2	1.8	1.6	0.3
Manganese (mg/l)	0.04	0.04	0.04	0.19	0.12	0.17	0.1
Copper (mg/l)	N.D.	N.D.	N.D.	0.01	0.01	N.D.	2
DO (mg/l)	9.6	9.5	7.6	7.3	7.4	6.5	-
COD(mg/l)	8.0	7.0	9.0	46	21	10	-
Permanganate Value (mg/l)	0.3	0.2	0.1	2.6	1.5	0.5	-
BOD (mg/l)	0.5	1.8	1.4	3.6	2.3	1.7	-
Total Coliforms (MPN/100 ml)	180+	180+	180+	180+	180+	180+	0
E-coli (MPN/100 ml)	180+	180+	75	180+	180+	180+	0
Flow (m^3/sec)	1.320	1.301	0.102	0.017	0.012	0.052	-

Note: N.D. means Not Detected.
Source: JICA Study Team

Table 15.2(4/4) Test Results of Well/Spring Water Samples (wet season)

Parameter	Observed Value										WHO GV
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	
Air Temperature (°C)	25.0	22.0	29.0	26.0	21.0	22.0	22.0	24.0	28.0	27.0	-
Water Temperature (°C)	21.0	21.0	21.0	20.0	20.0	20.0	19.5	21.0	20.0	26.0	-
pH	7.1	6.5	6.8	7.5	7.6	7.6	7.4	7.5	6.6	7.1	6.5 – 8.5
EC (μS/cm)	303	128	281	312	348	243	307	354	197	1162	-
Turbidity (NTU)	2	22	24	20	6	4	1	3	4	13	5
TDS (mg/l)	165	77	157	169	182	143	179	205	132	755	1000
Alkalinity (mg/l)	103	32	71	96	97	81	78	109	32	174	500
Phosphate (mg/l)	0.50	0.07	0.70	0.14	0.24	0.20	0.17	0.26	0.22	0.15	-
Nitrate (mg/l)	8	4	4	2	8	<0.5	10	3	4	35	50.0
Iron (mg/l)	0.15	0.12	0.11	0.35	0.17	0.18	0.15	0.11	0.14	0.15	0.3
Manganese (mg/l)	N.D	0.02	0.01	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.1
Copper (mg/l)	N.D.	N.D.	N.D.	N.D.	0.015	N.D.	N.D.	N.D.	N.D.	N.D.	2.0
DO (mg/l)	5.1	6.5	6.1	5.0	7.5	6.6	7.1	5.2	5.1	4.2	-
COD (mg/l)	1.0	2.5	1.5	4.0	2.0	2.5	2.0	2.5	1.0	2.5	-
Permanganate Value (mg/l)	0.1	0.2	0.1	0.2	0.1	0.2	0.1	0.2	0.1	0.1	-
BOD (mg/l)	0.6	2.0	1.0	1.1	0.2	0.2	0.2	1.0	0.5	0.4	-
Total Coliforms (MPN/100 ml)	39	180+	180+	180+	180+	180+	150	180+	180+	180+	0
E-coli (MPN/100 ml)	7	93	150	75	75	150	43	Nil	180+	120	0
Discharge (liter/min)	6.0	5.0	6.1	5.3	91.0	4.3	3.4	14.8	3.3	- *	-

Note: N.D. means Not Detected.
*: Water table depth was measured instead of discharge volume, and was 3.7m from ground level.
Source: JICA Study Team