ENVIRONMENTAL IMPACT ASSESSMENT

DAKPAI – BULI ROAD

ISDP – ZHEMGANG, BHUTAN

EIA TEAM

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3. P.D.Wangdi (P.E. Dakpai - Buli Road) Member
4. Lhakpa Sherpa (Survey Head, Dakpai – Buli Road) Member
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6. Dechen Dorji (Gup, Nangkor Geog, Zhemgang) Member

February 1998
**EXECUTIVE OR NON-TECHNICAL SUMMARY**

1. **TITLE:** Dakpai – Buli Road Construction
2. **PROJECT LOCATION:** 15 km from Zhemgang towards Gelephu, Nangkor Geog, Zhemgang
3. **PROPOONENT:** Zhemgang Dzongkhag
4. **IMPLEMENTING AGENCY:** Public Works Division (PWD)
5. **FUNDING AGENCY:** RGOB and the Government of the Netherlands
6. **RATIONALE FOR THE ROAD**
   - Approximately 36.5 km of new road construction connecting Dakpai-Buli was approved in the 8th Five Year Plan budget of Zhemgang Dzongkhag.
   - Having finalized the formulation of ISDP, Phase II in March 1997, the Dutch Government has shown interest in funding Nu. 37.5 million as a part of the project budget.
   - Before the project is started it is the policy of the RGOB and donor’s wish to become aware of the environmental impacts of the project.
   - The assessed impacts are followed with remedial measures that will help to design the implementation of the project.
7. **MAJOR FINDINGS:**
   - Three houses can be saved from damage through breast wall erection; one house worst affected was dismantled; and house below the road would be affected by falling road debris (all houses are located at Dakpai road take-off point).
   - One irrigation canal would be affected as road cuts through the chainage of the canal and by falling debris as canal runs parallel to the road for about 100m.
   - Two micro hydroelectric stations (one below Kikhar and at Tingtibi) may be affected if mitigation measures are not attended.
   - About 153 numbers of orange trees are likely to get damaged and damage can be reduced if proper construction method is adopted as suggested in this report.
   - About 1.2 acres of paddy field will be lost as road passes through it and the lost can be minimized if suggested measures here in the report are adopted.
   - About 6.6 acres of Dryland (kamzhing) will be lost as road traverses through it and damage can be reduced by proper construction methods suggested here.
   - Some areas are sensitive to soil erosion given the steep terrain and rugged topography of the area; proper care in construction and application of bioengineering techniques can help the situation.
   - The project does not encroach into any of the declared protected areas.
   - The road cuts through the habitat of Golden Languor but not much impact is predicted while the habitat is large enough to sustain the impact from blasting and road construction.
   - Tigers and elephants are reported to have inhabited some years ago but EIA team could not trace of theirs existence any longer in the site; other faunal species habitat will not be endangered by the project.
   - The rolling debris can damage the vegetation below the road that can possibly distort the micro-ecosystem of the area; damage can however be minimized if proper suggested construction method here is adopted; the vegetation listed in the report is not endemic to the project site.
   - Project can benefit three geogs of the district that has population of about 6272 for example: by cutting journey time from 8 hour to 1hour (Buli to Dakpai); the underutilized tsherii land can be converted into cash crop cultivation; making accessible of farm products to nearby towns.
   - The income of the locals can also be improved through tourism as the area has important wildlife, religious significance in Buli and a beautiful lake still largely intact.

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Can provide access for other social services to get into the geog and in particular the future hydro-projects at Burgang Chhu flowing by the side of Buli, which has power potential of 30 Mega Watt.

It can also encourage industries in the area such as paper making factories as Daphne plant is existing in abundance.

The pressure on natural resources of the locality can be reduced as people can seek for other alternatives such as tin sheet for roofing.

It is anticipated that project can bring appreciable positive health impacts such as cleanliness awareness among locals, improvement of health services, opening options for nutrient food, etc.

Other findings are as in the table below.

### SUMMARY OF OTHER FINDINGS

<table>
<thead>
<tr>
<th>ROAD CHAINAGE (KM)</th>
<th>AVERAGE SLOPE GRADIENT (%)</th>
<th>AV. ROAD GRADIENT (%)</th>
<th>GEOLOGY</th>
<th>SOCIO-CULTURAL INDICATORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0+000 to 0+840 (Takeoff point Dalpa)</td>
<td>≥ 85</td>
<td>&lt; 5</td>
<td>Phylites, Mica Schist, colluvium soil</td>
<td>Passes through Orange orchard and 5 houses were affected. Rocks exposed are highly fractured, and uneven vegetation growth which indicate landslide.</td>
</tr>
<tr>
<td>0+840 to 4+000</td>
<td>≥ 40</td>
<td>&lt; 5</td>
<td>Garetiferrous mica Schist</td>
<td>Agricultural land above and below road</td>
</tr>
<tr>
<td>4+000 to 6+000</td>
<td>≥ 80</td>
<td>≥ 9</td>
<td>Garetiferrous mica Schist</td>
<td>Can damage irrigation cannel</td>
</tr>
<tr>
<td>6+000 to 10+600</td>
<td>≥ 60</td>
<td>&lt; 6</td>
<td>Mica Schist</td>
<td>Kikhar power station is within blasting by rocks</td>
</tr>
<tr>
<td>10+600 to 11+000</td>
<td>&lt; 40</td>
<td>&lt; 5</td>
<td>Residual soil</td>
<td>Road passes through agricultural land, settlement above</td>
</tr>
<tr>
<td>11+000 to 16+000</td>
<td>≥ 80</td>
<td>&lt; 5</td>
<td>Garetiferrous Mica Schist, residual soil</td>
<td>Passes through Paddy field, Kamzhing and Tsheri</td>
</tr>
<tr>
<td>16+000 to 24+000</td>
<td>≥ 90</td>
<td>&lt; 5</td>
<td>Gneiss</td>
<td></td>
</tr>
<tr>
<td>24+000 to 27+000</td>
<td>≥ 90</td>
<td>&lt; 5</td>
<td>Gneiss, and weathered gneiss, sandy silt</td>
<td>One chorten located above the road alignment</td>
</tr>
<tr>
<td>27+000 to Burgang Chhu</td>
<td>&lt; 35</td>
<td>&lt; 4</td>
<td>Residual soil</td>
<td>Passes through paddy field</td>
</tr>
<tr>
<td>Burgang Chhu to Buli village</td>
<td>&lt; 40</td>
<td>≥ 9</td>
<td>Residual soil</td>
<td>Can affect chorten, Paddy land, Dryland and tsheri.</td>
</tr>
</tbody>
</table>

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8. RECOMMENDATIONS FOR MITIGATION/COMPENSATION

- In the steep terrain the cut material should be transported to the extent possible using excavators. Where no depressions are available to be filled nearby, the cut earth and materials should be transported and dumped at an appropriate identified site. Bulldozers can be deployed in the mild terrain to achieve progress.
- Controlled method (not overcharging the explosives) should be adopted. Power Gel 801 explosives is recommended and simultaneous initiation technique should be strictly adhered to.
- Provide restoration structures such as breast and retaining walls as may be necessary to protect the existing structures.
- Bioengineering techniques such as Brush Layer, Live Stacking, Wattle Fence, Grass Seeding, and surface and subsurface drains to be employed for stabilizing soil, and for reclamation of both quarry and dump/disposal sites.
- Lined concrete longitudinal V-shape drains should be provided with at least 5 cross drains in one kilometer and discharge should be drained into natural gully nearby.
- Exercise good coordination among relevant institutions such as Division of Geology and Mines, Forestry Services Division, Project Dakpai – Buli Road, Mangde Chhu Division (PWD), and Zhemgang Dzongkhag administration for solving the conflict impacts like resource use competition, allocation of quarry sites, in the event of involving locals, and logging road corridor trees.
- Conduct Public consultations to manage freely let irrigation water from the locals’ paddy field and random stone quarrying along the road.

9. PROPOSED MONITORING

- Twice a year during the construction period (i.e. in June and December of the Year). The monitoring program should be for land use change including soil erosion/landslide, animal habitat distortion, frequency of sediment flushing of two hydropower stations, width of road corridor opening, vegetation damage, mode of construction, socio-economic impact, conflict impact, health impact and etc.
- Once a year during post project period (i.e. in June of the year). The monitoring program in here will basically be for land use change including landslides, impairing other support services, resource use conflicts and others.
## GLOSSARY

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Course</td>
<td>Super Structure of road</td>
</tr>
<tr>
<td>Chhu</td>
<td>River</td>
</tr>
<tr>
<td>Chorten</td>
<td>Religious Monuments</td>
</tr>
<tr>
<td>Chuzhing</td>
<td>Irrigated paddy field (wetland)</td>
</tr>
<tr>
<td>DGM</td>
<td>Division of Geology and Mines</td>
</tr>
<tr>
<td>Dungkhag</td>
<td>Sub-District</td>
</tr>
<tr>
<td>Dzongkhag</td>
<td>District</td>
</tr>
<tr>
<td>Dzogkhag Yargye Tshogchung (DYT)</td>
<td>District Development Committee</td>
</tr>
<tr>
<td>EDD</td>
<td>Electric Delay Detonators</td>
</tr>
<tr>
<td>EIA</td>
<td>Environmental Impact Assessment</td>
</tr>
<tr>
<td>Geog</td>
<td>Block (Sub-division of a district)</td>
</tr>
<tr>
<td>Gup</td>
<td>Elected head of a block</td>
</tr>
<tr>
<td>IEE</td>
<td>Initial Environmental Examination</td>
</tr>
<tr>
<td>ISDP</td>
<td>Integrated Sustainable Development project</td>
</tr>
<tr>
<td>Kamzhing</td>
<td>Dry agricultural land (Dryland)</td>
</tr>
<tr>
<td>LUPP</td>
<td>Land Use Planning Project</td>
</tr>
<tr>
<td>MSL</td>
<td>Mean Sea Level</td>
</tr>
<tr>
<td>NEC</td>
<td>National Environment Commission</td>
</tr>
<tr>
<td>Pangzhing</td>
<td>Agricultural fallow land</td>
</tr>
<tr>
<td>PWD</td>
<td>Public Works Division</td>
</tr>
<tr>
<td>RGOb</td>
<td>Royal Government of Bhutan</td>
</tr>
<tr>
<td>SNV</td>
<td>Netherlands development Organization</td>
</tr>
<tr>
<td>TOR</td>
<td>Terms of Reference</td>
</tr>
<tr>
<td>Tsamdo</td>
<td>Pasture land</td>
</tr>
<tr>
<td>Tshogpa</td>
<td>Elected Representative of a village</td>
</tr>
</tbody>
</table>

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1 INTRODUCTION

1.1 PROJECT RATIONALE

Bhutan with an area of approximately 46,000 sq. km, roughly 150 km north-south and 300 km east-west has a road network totaling some 3,284 km (1997) of which about 2,000 km are blacked topped, 1,100 km are built with base course only, and 184 km are earth roads. Motor road construction began only in 1959 with the assistance of the government of India. The lack of an elaborate motorable road network is a major constraint for the socio-economic development through out the kingdom of Bhutan.

The national highway passes through the district for a distance of about 106km. However, it touches few villages along the way and fails to provide efficient links for the regions scattered communities and settlements. The only other road presently in use branches off from the highway measuring 40km, joining Tingtibi to Gomphu. Together, these two roads serve less than 25 percent of the district population. It was therefore, found that the road network to be a major shortcoming for the socio-economic development of the District.

As needs identified high degree of importance was therefore attached to the roads network in Zhemgang Dzongkhag during the 43rd session of the Dzongkhag Yargye Tshogchung (DYT) on 13 – 14 July 1995 and supplemented by the strong acknowledgement given by the study commissioned by the ISDP/Zhemgang in relation to economic development opportunities in Zhemgang district provided adequate justification for the proposal of a new road of approximately 36.5 km length, connecting Dakpai – Buli in the 8th Five Year Plan of the Zhemgang Dzongkhag. Having finalized the formulation of the ISDP, Phase II, in March 1997, the Dutch Government has shown interest in funding part of the project which is a component of the ISDP overall project. The ISDP is a co-financed venture comprising Royal Government of Bhutan, Save the Children Federation – USA/Bhutan Programme, and SNV-Netherlands Development Organization/Bhutan Programme. However, before a final decision on financing is reached, it is the policy of the Royal Government of Bhutan (RGoB) and the donor’s desire, that a study be conducted to apprise them of the environmental impacts of the proposed project. The Public Works Division (PWD), responsible for nationwide road construction and maintenance, will be an executing agency for the project.

The National Environment Commission (NEC) in consultation with the Zhemgang Dzongkhag drew up terms of Reference (TOR) for the EIA (refer Annex 12). The primary objective of this EIA is to keep development socially, economically and environmentally viable, and to ensure that the development is taking place within the country’s framework of sustainable development philosophy.

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1 Bhutanese Environmental Assessment Sectoral Guidelines, Highways and Roads, NEC, Thimphu, Bhutan, 1997
2 Environmental profile of Bhutan’s Central District of Zhemgang, ISDP, 1997
EIA, Dakpai-Buli Road, February 1998
Environmental Impact Assessment Context

The EIA focuses on the identification of all foreseeable impacts on existing infrastructure and support services, health, the economy, the local society, ecology, and the resulting conflicts of interest.

An impact mitigation plan then assists in minimizing the negative effects that have been identified, and makes it possible to achieve the development that is acceptable to all.

1.2 CONTEXT FOR THE EIA

National Environment Commission (NEC) was created in late 1980s as a body to address national environmental issues. In 1993 the commission was able to formalize its first EIA guidelines. This guideline didn’t materialize in implementation owing to shortcomings in the draft itself, and due to other constraining factors in the country. The most current EIA framework, the Revised Environmental Guidelines of 1997 is composed of two documents:

a) Institutionalizing and strengthening of the Environmental assessment Process in Bhutan, NEC Thimphu, Bhutan – October 1997; and

b) Bhutanese Environmental Assessment Sectoral Guidelines, NEC Thimphu, Bhutan – October 1997.

The two guidelines are supplemented by the draft legal document “Environmental Act of Bhutan, 1997 (draft)”.

Our EIA for the road project closely follows ‘HIGHWAYS AND ROADS’ section of the Bhutanese Environmental Assessment Sectoral Guidelines, 1997. The Bhutanese environmental process is illustrated in Figure 1.1 and the idealized way of reviewing the project is given in Figure 1.2.

As Zhemgang Dzongkhag has been identified as a pilot site for the implementation of sustainable development strategies, it has been both the desire of the donor as well as the policy of the Government of Bhutan that an environmental appraisal be carried out before the project is initiated. Moreover, the EIA mechanism has been recognized as a tool for the achievement of sustainable development, making a project environmentally, socially, and economically viable.

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5 The institutionalizing and strengthening of the environmental assessment process in Bhutan, National Environment commission Thimphu, Bhutan-October 1997.


7 Environmental Act of Bhutan (draft), National Environment Commission, Thimphu, Bhutan - August 1997
Figure 1.1: The Environmental Assessment Process

Figure 1.2: Idealized Project Assessment Process

Government Decisions

<table>
<thead>
<tr>
<th>Approvals</th>
<th>Permits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approval to Proceed</td>
<td>Conditional Site Permit</td>
</tr>
<tr>
<td>Site Permit</td>
<td>Activity Permit</td>
</tr>
<tr>
<td>Investment Approval</td>
<td>Final Approval</td>
</tr>
<tr>
<td>Environmental Permit</td>
<td></td>
</tr>
</tbody>
</table>

Reference: EIA Guidelines in Bhutan, NEC, Thimphu-1997

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1.3 **OBJECTIVES OF EIA**

There are three main aims, which can be fulfilled by carrying out an environmental assessment before the initiation of a project:

i. It assists the proponent in planning the project better: for instance, the impacts such as project impairing the existing infrastructures in the area can result lot of complications and confrontations with the users of the infrastructure later during implementation period often impinging the work progress and provoking other complications as well. If the impacts are identified earlier before the project is initiated and key stakeholders are consulted and then subsequently mitigation plan put into place can avoid such unwanted thought provoking matters later during implementation.

ii. It enables the decision-makers to make informed, reasoned choices by making the information available to the decision-makers about the pros and cons of the project; and

iii. It helps the people to better understand the full ramifications of the project. For instance, EIA can make people understand about the implementation of the project; the coordination that the local people must attend to the project staff for achieving the project target; the resources available in the locality and its possibilities to make optimal use can be informed; some people getting badly negative impacted can be identified and solution can be suggested; and etc.
The methods closely followed for carrying out this EIA were as described below (refer Figure 2.1):

i. Wrote-up the EIA proposal based on the TOR and presented the proposal. An EIA team was also formed during this period. The work schedule was also presented and agreed among members. The significant stakeholders were invited to attend the presentation.

ii. Completion of the official protocols and reminders to the team members about the work schedule and its changes. This also meant team mobilization for the field work.

iii. Collection and review of secondary information pertaining to the project and information, which included: relevant environmental guidelines both national and international, existing literatures on Zhemgang Dzongkhag viz. ISDP Phase II project document, socio-economy, the Dzongkhag 8th Five Year Plan, the land use map, topographic map, the protected area system and studies done on flora and fauna of the area, hydrological and meteorological data, and information related to the catchment area of the project. A review was also carried out of alternative explosive technologies, the bioengineering methods of controlling environmental degradation, the PWD specification of works and the design manual, and the existing land compensation policies.

iv. Arrangement of logistics for field work. Concurrently during this time the people of the locality was also informed about the EIA team’s work plan and the timing for the necessary meetings and or consultations.

v. The actual field appraisal began with initial briefing to the team members on the methods and procedures of assessing the impacts. Walked through the proposed alignment and alternative alignments referring the latest land use map and carrying out physical assessments. The suitability of the alignment from all the survey angles was discussed among the team members. The gradient of the side slopes and longitudinal gradient of the road was also measured and a suitable alignment was proposed to the surveyor. Soil and rock types, floral and faunal findings were discussed and noted. The assessments also included studying whether or not the project could possibly damage or impair other existing infrastructures such as irrigation canals, hydropower stations, religious monuments, and the dwellings of the locals. Wherever the road infringed private properties, concerned people were consulted and alternatives proposed. A consultation was also made with the locals on the conflicts that the project might cause, such as the resource use conflicts. The means to solve the conflicts were discussed with the people. Meanwhile, the findings of the each day were discussed among the team members at the end of the day and solutions to mitigate the problems were brainstormed.

vi. Noting the deficiency of the team’s expertise, an engineering geologist was referred and fielded to the site. The findings were incorporated to enable the engineers’ to design the project accordingly. Details refer Annex 9.

vii. The analyses of the data and report writing.

viii. Presentation of the results through three levels of workshop: one at the geog level, dzongkhag level and national level.
Figure 2.1: The methods followed to carry out EIA

- **EIA Terms of Reference**
- **EIA Proposal**
- **Proposal Presentation and EIA Team Formation**
- **Protocols & Preparation of field Logistics**
- **IMPACT IDENTIFICATION & ASSESSMENT**

1. **Ecological Impact**
   - Methods: Literature review, site observation, interviewing locals, surveying, etc.
2. **Social Impact**
   - Methods: Physical assessment, public consultation, review literatures, etc.
3. **Economic Impact**
   - Methods: Physical assessment, public consultation, cost-benefit analysis, etc.
4. **Impact on Infrastructure**
   - Methods: Physical assessment, public consultation, referring land use map.
5. **Health Impact**
   - Methods: Physical assessment, public consultation, etc.
6. **Conflict Impact**
   - Methods: Physical assessment, public consultation, review literatures, etc.

**ANALYSES OF THE INFORMATION**

**EIA REPORT WRITE-UP**
- (Includes: Identified impacts, mitigation plan, monitoring plan)

Review

Are all significant impacts addressed?

- **No**
- **Yes**

**Final EIA REPORT**

**Workshops**

*EIA, Dakpai-Buli Road, February 1998*
3 BASELINE STATEMENT OF THE PROJECT AREA ENVIRONMENT

3.1 THE HUMAN ENVIRONMENT

Zhemgang Dzongkhag is located in central Bhutan and the project area is located between the longitude 90°44'3.48"E and 90°49'34.68"E, and latitude 27°10'6.6"N to 27°11'52.8"N (refer map in page 9). For the reasons of administration Dzongkhag is divided into 7 geogs, of which 3 southern geogs collectively form the Panbang Dungkhag (sub-Dzongkhag). About 44 percent of the total Dzongkhag area falls in the existing or proposed national parks (Manas, Black Mountain and Thrumshingla). The Dzongkhag area is about 2,125.9 sq. km (LUPP, 1995) of which 11 percent is arable land, 85 percent forest, 1 percent settlement and shrubs, and 2 percent others.

As per the Baseline survey of Zhemgang Dzongkhag (1994/95), the resident population numbers about 16,700 (spread across 90 villages) while an additional 4,700 people are registered in Zhemgang but live elsewhere. 90% of total households consists of subsistence farmers and the non-farmer households are mainly of government employees, shopkeepers and loggers. The Dzongkhag details are illustrated in the figures below.

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8 Land Use Planning Project, LUPP Dzongkhag and Geog data sheets for Zhemgang Dzongkhag, Ministry of Agriculture, Thimphu, Bhutan, April 1995.

9 Integrated socio-economic scenario (February 1996) prepared by the Zhemgang Dzongkhag Administration, and ISDP's baseline survey of Zhemgang Dzongkhag (1994/95). EIA, Dakpai-Buli Road, February 1998
Baseline Statement of the Project Area

The road proposed by the project (Dakpai – Buli) connects three major villages: Kikhar, Tali and Buli, all in Nangkor Geog. Kikhar has 35 households, Tali 19 households and Buli with 77 households. The direct beneficiaries of the project will be from three goegs: Nangkor, Shingkhar and Bardo and the estimated total population benefiting directly from the project is about 6272. (refer map in page 11)

3.2 DESCRIPTION OF THE ROAD ALIGNMENT

The project falls basically in two watersheds, those of the Pramdogang chhu and Burgang Chhu. General topography of the area is mostly rugged, broken and steep exceeding over 100% gradient at some places. The summary of the topography through which the proposed road alignment runs is as the following:

- From the take-off point at Dakpai until km0+840 chainage, the side slope of the terrain is little over 85% and road longitudinal gradient with less than 5 percent; rocks are exposed and uneven vegetation growth exists; it also hits through the settlement (dwellings) and orange orchard.

- From chainage km0+840 to km4+000 mild terrain with average side slope grade of 40%; the road longitudinal grade little less than 5%; paddy field is located above this chainage.

- From km4+000 to km6+000 the alignment hits through irrigation canal; rocky stretch follows up to the valley cut by Pramdogang Chhu with side slope grade over 80%; road’s longitudinal grade is slightly less than 9%.

- From km6+000 to km10+600 the average side slope grade is about 60% and road longitudinal gradient is slightly less than 6%; the road bends into six hairpin zigs; Kikhar hydropower station is located about 150m away below this bends.

- Then road cuts through cultivation land starting from approx. km10+600 to km11+000. The terrain is quite mild and road gradient is less than 5%.

- From km11+000 to km16+000 paddy fields are located above the road; it also hits tsheri and kamzhing (dryland); side slope grade after crossing agricultural in average is about 80% and road gradient about 5% or less.

- Km16+000 to km24+000 (after Tali) a dense broad-forest leaf forest runs through, encountering steep side slopes exceeding over 90%; the alignment also hits through screes for the length of about 400m; just after Tali village the trees exist at a tilt.

- Km24+000 to km27+000 the alignment runs just little below a chorten; the side slope gradient exceeds over 90% and road gradient less than 5%.

- Km27+000 to Burgang Chhu the road traverses at the base of the mountain hitting through the paddy field; the terrain is mild and road grade is less than 4%.

- Between Burgang Chhu and Buli village the road climbs at an average gradient of 9% or slightly less hitting through agricultural land; a chorten newly built exists near the influence of road.
Dzongkhag Overview and Project beneficiaries

Legend:

\[\text{Dzongkhag boundary}\]
\[\text{Geog boundary}\]
\[\text{National Highway}\]
\[\text{Proposed Road}\]

November 1997

Scale = 1:500,000
3.3 LAND USE

As the project is located in Nangkor Geog the discussions will be confined within this geog only. The total land area of Nangkor Geog is about 493.8 sq.km. of which total arable land is about 4187 ha while forest is the major dominating land use of the geog. The details of the land use is given in the following table.

**TABLE 3.1: LAND USE OF THE NANGKOR GEOG (PROJECT AREA)**

<table>
<thead>
<tr>
<th>LAND USE</th>
<th>AREA IN HECTARE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Agricultural Land</strong></td>
<td></td>
</tr>
<tr>
<td>1. Wetland (irrigated)</td>
<td>300</td>
</tr>
<tr>
<td>2. Dryland terraced</td>
<td>423</td>
</tr>
<tr>
<td>3. Dryland unterraced</td>
<td>452</td>
</tr>
<tr>
<td>4. Tsheri</td>
<td>1646</td>
</tr>
<tr>
<td>5. Orchard</td>
<td>1364</td>
</tr>
<tr>
<td><strong>Total arable land</strong></td>
<td>4185</td>
</tr>
<tr>
<td><strong>Forest Land</strong></td>
<td></td>
</tr>
<tr>
<td>1. Fir forest</td>
<td>4592</td>
</tr>
<tr>
<td>2. Chir Pine forest</td>
<td>2095</td>
</tr>
<tr>
<td>3. Mixed forest</td>
<td>6333</td>
</tr>
<tr>
<td>4. Broadleaf forest (&gt;80%)</td>
<td>22352</td>
</tr>
<tr>
<td>5. Broadleaf and conifers mixed</td>
<td>5992</td>
</tr>
<tr>
<td>6. Scrub forest</td>
<td>2127</td>
</tr>
<tr>
<td><strong>Pasture Land (natural)</strong></td>
<td>347</td>
</tr>
<tr>
<td><strong>Settlements</strong></td>
<td>30</td>
</tr>
<tr>
<td>Others (snow glaciers, rocks, water spreads)</td>
<td>1287</td>
</tr>
</tbody>
</table>

*Courtesy: LUPP, Thimpu, 1995*

Of the types of agriculture wetland cultivation is the most productive requiring a great deal of water and in this project area because of good irrigation facilities it is more prominent. *Tsheri*, shifting cultivation is also major land use in the area practiced by every household. The main crops cultivated in the project area are maize, paddy, millet, potatoes and chilies, mandarin orange is the major cash crop with little cardamom plantation. Trends can however, be observed of *tsheri* converting into more permanent cultivation such as mandarin orange orchard. Pasture land, locally called as *Tsamdo* is also an important land use as domestic livestock is reared by almost all households for multi-purposes such as dairy products, draft power to plough the field, manure, and etc. The other land uses are basically dominated by montane broadleaf forest. The forest resources are used by locals for grazing, fuelwood, food products, house construction and leaf litter. Refer land use map in page 12.
3.4 ECOLOGICAL CONDITIONS

The project area is located at an average elevation of about 1600 m (m.s.l) and the broad leaf-forest is the dominant vegetation type in the area with patches of chirpine forest. In wet valleys herbaceous vegetation with wild banana plants are found. The area has some precious commercial timber species which include *quercus semecarpifolia*, *castanopsis*, *terminalia* species, *chilauny*, *schima wallichii*, *alangium*, *alnus nepalensis*, *alingia*, *betula alnoides*, *dendrocalamus*, *euodia*, *lithocarpus*, *chir pine* (*Pinus roxburghii*), and *walnut*. Besides, the area also has good resources of daphne and bamboo species. The vegetation mentioned above are however not endemic to the project area exclusively but goes beyond the surrounding and also found in southern belt of Bhutan.

The area is also a habitat for Golden Langaar, endemic animal species for Bhutan. The other animal species found are: hornbill (*buceros bicornis*), bear, barking deer, wild goat, monkey, leopard, wild cock, squirrel, and wild boar. The golden Langur exits in three groups: one group about 3 km away from Zhemgang town towards eastside. The habitat is somewhere below the national highway and going right down hill (field assessment on December 1997). The other group’s habitat is right below Dakpai zig going down the valley towards Tingtibi. The third group stays along the Pramdogang valley. It was noted that each group has its own habitat boundary and does not encroach into other group’s habitat. Another species worth discussing is the *Buceros bicornis* (hornbill) whose habitat is after crossing Tali village going up to Tali saddle. Field assessment during October 1997 the team was able to trace quite few but going back in December 1997 we couldn’t trace any. On inquiry to the locals it was reported that this birds migrate to the hotter region down to Pangbang during winter and return to Tali side as hot resumes.

In the settlements of Kikhar, Dakpai, Tali and Buli wild boars and monkeys had already became a great nuisance. Farmers complaint of Golden Langur at the moment is very little limited to the people of Dakpai destroying cornfield. This illustrates that some degree of perturbation has already occurred in the ecosystem of the project area.

Two main rivers viz. Pramdogang chhu and Burgang Chhu drain the project area. The estimated catchment area of Burgang Chhu is about 178 sq.km. The Project area receives an annual average rainfall of 1610mm with mean annual discharge of rivers as 6.236 m³/sec. The maximum rainfall

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10 Field assessment in December 1997 and cross examining with the residents.

11 Interview with the residents and field assessment in September 1997.

*EIA, Dakpai-Buli Road, February 1998*
recorded in a day was 81.3mm with maximum temperature of 33°C while minimum temperature recorded was 0.5°C (Hydrology Unit, DoP, Thimphu 1997). The maximum rainfall recorded in a day in the year and humidity record for the project area in time series is illustrated in Figures below (data for Buli has been recorded only until 1991 and since which time the meteorological has been out of order).

3.5 GEOLOGY

The general geology of the road stretch falls mainly in Chekha formation which comprises of garnetiferrous mica schist, porohyroblastic sandstone, phyllites, schists, quartzite, marble, calc-silicate and conglomerates. The geology of the project area is mainly phyllites, garnetiferrous mica schist and gneiss of Thimphu formation. Phyllites in Dakpai are highly fractured having at least four sets of joints, which are 70°/64°, 40°/237°, 85°/345° and a foliation of 37°/256°.

Garnetiferrous mica schist is intercepted between orange orchard at Yurmaling and Chhudugang Chhu. This is massive with persistent bedding joints. Gneiss, which is fine grained in nature is found between Chhugang Chhu and Buli. The gneiss found along the foot trail are mostly sound except for 50m the gneiss is under weathering influence.

3.6 CURRENT STATUS OF THE ROAD PROJECT

The roadwork was begun sometime in October 1996 by the Planning and Design cell, PWD with a reconnaissance survey. Detailed design began in February 1997. The works completed as on 20th October 1997 are as under:

- Preliminary line (P-Line) laid out until Buli, end of proposed road stretch.
- Approximately 2m width of trace cutting and alignment fixation completed up to 24 km.
- Detailed survey completed for 4.5km and engineering design up to 0.9 km to guide the construction which begun on 14th October 1997.
- The actual construction of the road began on 14th October 1997 coinciding with an auspicious day in the Bhutanese calendar. However, at the moment, the construction has been suspended temporarily, awaiting an EIA report and other project preparations.
4 ASSESSMENT OF IMPACTS

In this section the impacts will only be identified and solutions to manage the impacts will be dealt in chapter 5 under the mitigation section. The identified problem area is illustrated by map in page 17.

4.1 ECOLOGICAL IMPACTS

The ecological impacts are usually considered negative given a simple reason that nature does not need human interventions to maintain its ecosystem in balance. However, impacts are assessed from the negative aspects that are associated with the project as well as positive impacts that the project could bring to the local environment. The negative impacts are those that have the tendency to alter the ecosystem that is currently existing in the harmony.

4.1.1 Effect on flora and fauna

The project does not fall in any of the declared protected areas; however, the area remains a habitat of golden Langaur, a highly protected and endemic species of Bhutan. Tigers and elephants are reported to have inhabited the locality some years ago, but currently their existence in the area is not known and neither was the EIA team able to trace their presence during the field assessment. The other animal species available found in the area are hornbill (buceros bicorns), bear, barking deer, wild goat, monkey, leopard, wild cock, squirrel and wild boar.

The alignment passes through some virgin forest particularly from the start of Tali until the crossing of Burgang Chhu. The area also retains some important commercial tree species such as Michelia species (champ), a rare and expensive species in the country. Other commercial trees include quercus semecarpifolia, castanopsis, terminalia species, chilauny, schima wallich, alangium, alnus nepalensis, altingia, betula alnoides, dendrocalamus, euodia, lithocarpus, chir pine (Pinus roxburghii), and walnut. The region also has a good stock of cane and daphne forest, and cane is one of the main sources of income for the locals. The species listed above are however not limited to this particular project extending well beyond project boundaries.

Given the steep and sensitive topography of the area it is foreseen that the environmental degradation viz.: vegetation destruction could be fairly major compared to destruction elsewhere in the kingdom as a consequence of bulldozer construction and uncontrolled (explosive) blasting. Most if not all the vegetation downhill of the road head could be damaged because of falling debris and fly rocks. An attempt to illustrate the damage comparison is as given below and assumptions are based on the construction experienced of first 200m carried out at Dakpai in late October 1998.

12 Interview with Forest Range Officer, Zhemgang Range Office, October 1997.
13 Interview with the people of Kikhar, Tali, and Buli in October 1997.
EIA, Dakpai-Buli Road, February 1998
Assessment of Impacts

Predicted magnitude of vegetation damage through conventional construction

- Average road corridor clearance uphill the centerline of the road to be 13m. The corridor clearance above the C-line of the road for 36,000m (road length) x 13m (corridor width) = 4,68,000 sq.m.

- Average damage to the road downhill vegetation keeping Pramdogang and Burgang Chhu as the limit and main receptor of the debris. The area of damage can thus be calculated as 36,000m (road length) x 90m (the downhill damage that would be created by rolling debris) = 32,40,000 sq.m.\(^\text{14}\)

- The total area for 36km road that could come under damage is therefore 37,08,000 sq.m or 370.8 hectare. And given that the area has standing tree potential of 391 cu.m per hectare, the volume of standing tree that may be damaged = 1,44,982 cubic meter.\(^\text{15}\)

Tree volume that may be harvested through road corridor opening

Assuming that 15m of corridor needs to be clearly felled for road construction, the average estimated tree volume that would come in 1km of road would be 1.5ha x 391 cu.m per ha = 586 cu.m. Say approximately 600 cu.m per km.

As normally happens, there is also a danger that larger area scarification may reduce the size of the habitat for the animal population in the region, which could cause some species to move away from region. This may cause an ecosystem imbalance. For instance, it could further compound the problem of farmland encroachment by boars and monkeys. In addition, the clearance of land in the area may also lead to the loss of some of the area’s scenic beauty.

From the above discussion it can be concluded that the animal habitat could be reduced by approx. 370ha and broader road corridor width can hinder the movement of wild animals particular golden langur. Furthermore, the broadleaf forests generally exhibit a higher resistance to perturbation. But once disturbed, the resilience capability is considerably weakened and can take decades to recover. For floral and faunal well being there is rarely any that project can have a positive impact on the site. Besides some commercial tree plantation replacing shrubs there is no much scope for the improvement of the ecological conditions of the forested area.

4.2 SOCIAL IMPACT

The social impacts can be discussed under three main heading i.e. demographic impact, cultural resource impact, and socio-cultural impact. The impacts can either be positive or negative.

\(^\text{14}\) The average damage of 90m that would be caused to vegetation downhill of road is based on observation carried out by the EIA team in the newly started road construction of Dakpai – Buli in October 1997.

Assessment of Impacts

Positive impacts are those effects from the project, which benefit the population of the region either explicitly or implicitly, while negative impacts are associated with unwanted elements.

4.2.1 Demographic Impact

Nangkor Geog, the most direct beneficiary of the project has only 2 basic health units (BHUs) serving a population of 2344; one located at Buli and another at Tshedang\(^6\). In summer typhoid is the most prevalent disease in the village of Kikhar, and Buli has high rate of respiratory tract infection with 742 reported cases in 1996 for the estimated population of 616\(^7\). The birth rate for the Nangkor Geog is 15 per 1000 while the death rate is 6 per thousand (1996 record).

It is reported that many people in the Geog die fairly young because the two BHUs do not have the adequate infrastructure to deal with medical emergencies, and the bigger medical centers are long distances away. The nearest hospital with adequate medical facilities is at Yebilapcha, approximately 35km away from Dakpai.

It is hoped that the project will help solve this problem by directly facilitating transportation. It can also help to bring in other social services to the Geog. Basing on the birth rate of 15 per 1000 the estimated population of Nangkor Geog by 1998 would be approximately 2488 (linear projection) from 2344 in 1994. It is anticipated that further the rural population would increase by a significant proportion. Some 50 workers from the project can add 250 people more to the rural population assuming the average family size of each worker to be 5 can cause an upswing in the population trend of the Geog. The total population in the geog will therefore be 2738, which will impinge on the limited resources of the locals. The project staff may limit the access of the local residents to existing services by exerting additional demands and pressures on services such as BHUs and schools. Since much of the farmland still remains under-utilized in the form of tseri, it is likely that increasing human migration into the area may cause resulting population pressures in the region.

The schooling impact can also spread into geogs of Bardo and Shingkhar as population concentrates in Nangkor.

4.2.2 Cultural Resource Impact

On the whole, the project does not hold major adverse implications for much of the archaeological, historical and cultural artefacts, structures and environmental features that are of religious or ritual significance. However, there are two chortens (religious monuments) which are likely to get disturbed to some degree; one located approximately 1.5km after the saddle crossing Tali village and the other some distance short of the Buli village, recently built.

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\(^6\) ISDP, Phase II proposal 20\(^{th}\) March 1997.

\(^7\) BHU III Buli, November 1997.

EIA, Dakpai-Buli Road, February 1998
Assessment of Impacts

4.2.3 Socio-Cultural Impact

The language, social organization, social relationship, religious beliefs and rituals in the region is still largely intact. There are few literate among the residents, and the Tshogpa, who is appointed by the Gup, or village headman, largely leads the communities. Visitors are always extended a warm welcome and it is a part of the culture of the communities to render innumerable hospitalities.

As the project implementation begins, it could create differences in the level of earnings that, in turn, could create imbalances in the currently harmonious social structure. If mass laborers for the project are imported from foreign countries, there is also a danger that their religious beliefs and rituals may clash with local practices, causing tensions.

4.2.4 Economic Impact

A look at the socio-economic baseline survey carried out in 1994 by the ISDP/Zhemgang Dzongkhag reveals that the average export of grain by Nangkor Geog per year per household is Nu.343 while the import is Nu. 561, making the net import of Nu.218\(^{18}\). This illustrates the poverty of the people. The people are basically subsistence farmers. As road traverses through agricultural land at various points a sample assessment was conclusively carried out in Buli to find out the landholdings of the people and its related impacts on their livelihoods. The finding details are as provided in table 1.1 below.

**TABLE 1.1: Buli Households that will be negatively impacted by the project either directly or indirectly**

<table>
<thead>
<tr>
<th>S.No</th>
<th>Place name</th>
<th>Holder Name</th>
<th>Type of landholdings (acre)</th>
<th>Total in acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wetland</td>
<td>Dryland</td>
</tr>
<tr>
<td>1</td>
<td>Langbi</td>
<td>Rimola</td>
<td>1.55</td>
<td>0.62</td>
</tr>
<tr>
<td>2</td>
<td>Gangbi</td>
<td>Dechen Wangmo</td>
<td>1.00</td>
<td>Nil</td>
</tr>
<tr>
<td>3</td>
<td>Baryong</td>
<td>Kinley Wangchuk</td>
<td>2.42</td>
<td>1.58</td>
</tr>
<tr>
<td>4</td>
<td>Trongtey</td>
<td>Tenzin Chozom</td>
<td>1.40</td>
<td>0.97</td>
</tr>
<tr>
<td>5</td>
<td>Langbi</td>
<td>Lakeymo</td>
<td>0.62</td>
<td>0.56</td>
</tr>
<tr>
<td>6</td>
<td>Langbi</td>
<td>Dolma Yangzom</td>
<td>1.72</td>
<td>0.60</td>
</tr>
<tr>
<td>7</td>
<td>Trongmath</td>
<td>Chewang Buthri</td>
<td>1.72</td>
<td>0.11</td>
</tr>
</tbody>
</table>

*Source: Tshogpa Buli, October 1997*

The above landholding figure by the household clearly illustrates that some have only an acre of land to survive. Out of about 144 households in the road stretch approximately 25 households are negatively impacted as road traverses through their agricultural field. The other negative impacts such as income opportunities by pottering can be lost but impact spreads across on negligible households i.e. few households in Buli.


_EIA, Dakpai-Buli Road, February 1998_ 20
Assessment of Impacts

The positive economic impacts spread across three geogs, making estimated total population of 7044. It is assumed that project can help lift the economy of the locals in following ways:

- By making subsidiary contracts available through the project;
- Employing people in the project;
- Encouraging cash crop cultivation on tseri land;
- Giving farmers convenient access (through the road) to markets for their produce in nearby towns;
- Through tourism as area has important wildlife species and Buli with religious significance has also a beautiful lake that is still largely intact;
- Potential site for paper factories given the abundance of daphne plant; and
- The project can also help to establish future hydropower station at Burgang Chhu as the river has 30MW capacity potential.

The project could also help to reduce the impact on the local resources by opening options for using foreign materials such as corrugated galvanized iron (CGI) roofing instead of the timber used presently.

4.2.5 Human Settlement impact

The impacts on human settlement can be discussed under two categories:

- Damage to dwellings/houses
- Agricultural land damage

a) Damage to dwellings/houses

At the take off point Dakpai, five houses are likely to be affected. Four houses are located up-hill of the road and one below the road. Two houses are built of timber with mud wall while rests are huts with bamboo as the main construction material. All are one storey dwellings and can be categorized as semi-permanent structures. All the households have land ownership.

Of five, the one worst affected was dismantled and it now houses a shop belonging to the same landholder, Nima. The plot measuring 400 sq.m was purchased by Nima in 1976 for an amount of Nu.15,000 (fifteen thousand) for which she has the District Court verdict as supporting evidence. The affected landlady was desperately looking for an empty plot near by that would enable to maintain her subsistence livelihood.

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19 Hydrology Unit, Division of Power, Thimphu, 1998.

EIA, Dakpai-Buli Road, February 1998
Assessment of Impacts

The immediate danger for the house below the road comes from cut earth and material, which may have to be rolled down after being excavated. The three other houses above the road can be saved without relocation if proper restoration measures are applied.

b) Agricultural land damage

Orange Orchard: At Dakpai it was appraised that about 15 trees of three year old would be affected. The orchard damage in area would be about 236 sq.m. The orchard is registered under the name of a women called Dechen Doma.

From chainage 840m to 950m the road runs through the middle of two orange orchards belonging to Nima and Minjurla. The damage in getting a road width and fly rocks from blasting is estimated to be about 138 trees and in land area it’s about 1100 sq.m. The land area that would be damaged from the fly rocks is not considered as it can always be reclaimed later. The orange trees here in Yurmaling are about 15 year old.

In total it is estimated that about 153 tree would be damaged.

Cultivated Land: The cultivated land that would be affected can be categorized as: dryland, wetland, and tsheri. The road cuttings through cultivated land are mostly below Kikhar and between Kikhar and Tali. In the whole stretch of 36km approximately 26,400 sq.m (6.6 acre) of dryland would likely be affected by the project. Tsheri about 14,400 sq.m (3.6 acre). The road preliminary line (P-line) before reaching proposed Burgang Chhu Bridge passes through wetland/paddy-land at Gangbi and approximate damage that would occur was estimated about 3,000 sq.m (0.75 acre). And just immediately before Buli village about 1,800 sq.m (0.45 acre) wetland would be damaged as per the P-line drawn. The total wetland that would be affected was estimated to be about 1.2 acre.

4.3 IMPACT ON INFRASTRUCTURE AND SUPPORT SERVICES

The major existing infrastructures that would be affected by the project are: two hydro-power stations one located below Kikhar (Kikhar power station) and another located up-stream of Mangde-Chhu PWD Division office (Tingtibi power station); and an irrigation canal at road chainage 4km 370m from Dakpai. The power station below Kikhar supplies electricity to about 40 households. While the other power station feeds to Yebilapcha school and hospital, residents at Tingtibi, Mangde-Chhu PWD office, and Zhemgang Dzongkhag town. The Pramdogang Chhu runs Tingtibi station, where as Kikhar station is by a tributary of Pramdogang Chhu (Chhudogang Chhu).

An irrigation canal feeds paddy field belonging to more than 34 households and it is a drinking water source for four houses. The cement Hume pipe canal is about 1.5 km in length. It is the main lifeline of the people of Kikhar and Dakpai.

\[20\]Disclaimer: Some dryland were left fallow and it is presently in Tsheri form, however, it is registered as dryland in their landholdings.

EIA, Dakpai-Buli Road, February 1998
Assessment of Impacts

Since the road alignment hits right at the source of the irrigation canal the water supply is endangered from being completely cut off. Further, the road runs just little above the canal running parallel to it for a distance. Any boulder inadvertently rolled down from the road could break the chainage of the canal.

Kikhar power station can be affected if the road blasting is done in an uncontrolled fashion, causing the river to be backed up with falling debris. While the Tingtibi power station is not within the range of fly rocks from road blasting, the debris loading into Pramdogang Chhu could over silt the river body, eventually endangering the power station.

4.4 CONFLICT IMPACT

This can be discussed into two categories: resource use conflict and cultural conflict.

Resource use conflict: As the road creeps in it is likely that the accessibility to the resources are enhanced, which would create a situation of resource use competition. The case is more prominent with stone quarrying. The project might reduce the abundance of the local resources. Stone quarrying by locals for their construction on any stretch of road (as usually happens along the existing road) may pose create nuisance for the project. Such excessive stone quarrying by locals may also result in landslides. This could happen both during the implementation of the project as well as the post project period.

Cultural conflict: Since paddy-fields are situated both above and below the road, people might leave the water to drain freely in the traditional fashion they have been accustomed to. This would cause problems and damage the road. The spillover from above irrigated paddy was evident and erosions have occurred. Similarly, for those paddy fields below road there is also a danger that slides might occur because of irrigation being casually drawn along any stretch of road.

4.5 HEALTH IMPACT

Concerning health appreciable positive impacts are foreseen from the project. There are however, certain negative impacts associated with it. As the literacy rate is quite low in the communities of Dakpai, Kikhar, Tali, and Buli there is likelihood that any foreign disease can easily be transferred to the communities. If the project imports mass foreign laborers the chances of transferring the diseases are particularly high as the laborers themselves usually come from the illiterate groups of neighboring Indian states.

Other than the above, there are hardly any negative health impacts that are worth discussing attributable to the project.

4.6 IMPACT ON GEOLOGY OF THE AREA

The stretch between 0 to 250 km taking-off at Dakpai zig have been found slightly unstable as rocks are highly fractured. The slippage of the overhead material down to the road is of main
Assessment of Impacts

concern. Beyond 250 m chainage until Orange orchard at Yurmaling there is thick vegetation cover and the site is found stable as area trees do not show bending.

The zone after the orchard is made up of colluvial materials, which are relatively stable at the moment. However, since the slope is well over 45° it is anticipated that it would be problematic during excavation and bench cutting could help to maintain the slope stable.

The garnetiferous mica schist goes up to Pramdogang Chhu. The bridge across Pramdogang Chhu has its abutment on the schist and other bank dip slope. If unstable rocks are observed rock bolts should be provided.

After Kikhar a marshy area was identified, the results of an abandoned irrigation channel. There are evidences that erosion has occurred there quite recently. The area could prove unstable if the above spill is not tackled at the source.

Steep gorges are observed beyond Tali with shallow material on the top of the rock layer. Competent rock excavation through controlled blasting should ease the problem. In the same stretch approximately 400m away from Tali towards Bulila, a slide prone area has been observed. Previous erosions' are visible keeping vegetation of the area at a tilt. Given the high side slopes of the area exceeding 100% there is every chance of landslides. The landslide zone is confined in the gully with seasonal water in it. It is also in this same stretch that alignment encounters Scree what is called Garee Garee in local term. As these are found in layers the disturbance at the toe of scree could easily stimulate the boulder on top to roll down making area unstable. The vibration of the blasting could also accelerate the rolling of the scree.

The area crossing Tali saddle is made up of sandy silt which are highly permeable, however the terrain being very steep exceeding in some areas over 115% the area could face serious erosion problems.

4.7 IMPACT OF TRAFFIC

Vehicle frequencies in feeder roads of Bhutan are usually low as experienced by the Eastern Feeder Roads Project, Trashigang (September 1997). However, since the project area is rich in forest resources fuelwood and timber extraction activity from the neighborhood of Nangkor Geog could induce some traffic. Further, as usually happens new shops cropping up along the roadside can also infuse some more traffic for transporting the shop material.

However, outside the project vehicles it is anticipated that the average daily traffic volume would be approximately 5-6, which the negative traffic impact will therefore be negligible vis-a-vis positive impacts.

4.8 ENVIRONMENTAL TRAINING

Usually, engineers have the tendency to treat the environment as running counter to their work. There is little awareness and understanding of its significance among the staff of PWD. Therefore, environmental training is found to be a priority for effectively incorporating the
principles of institutionalizing EIA in the road construction. The groups identified for training at the priority are:

- Project Engineers and Surveyors; and
- Machine operators.

In the current way of surveying appreciable opening has occurred which has in the process loss of much vegetation. Further, proper surveying technique can help to lay out different route alternatives considering social, economical and environmental aspects equally. This will allow the decision-makers with options to choose the best suitable route alignment.

Project engineers needs some exposure to environmental friendly construction and short training at a supervisor level as they are responsible for smooth implementation of the project and giving lead for the operators.

The operators level training can be had in the field in the process of construction. This can make a great impact on the implementation of sustainable road construction.

### 4.9 COMPARISON OF ALTERNATIVES

Based on impact assessments, the environmental ranking for different construction alternatives can be summarized as below:

<table>
<thead>
<tr>
<th>New Method Construction</th>
<th>Old Method Construction</th>
<th>Do-nothing alternative</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RANK I</strong></td>
<td><strong>RANK II</strong></td>
<td><strong>RANK III</strong></td>
</tr>
<tr>
<td><strong>Negative Impacts</strong></td>
<td><strong>Negative Impacts</strong></td>
<td>The region will remain economically backward and compound the environmental problem as population increases the locals resources may get threatened.</td>
</tr>
<tr>
<td>1. Faunal habitat disturbance approx. 54 ha.</td>
<td>1. Faunal habitat disturbance approximately 370 ha.</td>
<td></td>
</tr>
<tr>
<td>2. Loss of vegetation about 0.216 lakh m$^3$</td>
<td>2. Loss of vegetation about 1.45 lakh m$^3$</td>
<td></td>
</tr>
<tr>
<td>3. Little landslide and erosion</td>
<td>3. More Landslides and erosion</td>
<td></td>
</tr>
<tr>
<td>4. High initial cost of construction</td>
<td>4. Impact on Communities and individuals</td>
<td></td>
</tr>
<tr>
<td><strong>Positive Impacts</strong></td>
<td><strong>Positive Impacts</strong></td>
<td></td>
</tr>
<tr>
<td>1. Improvement of socio-economy of the region</td>
<td>1. Improvement socio-economy of the region</td>
<td></td>
</tr>
<tr>
<td>2. Low maintenance cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Impact on communities and individual</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5 IMPACT MANAGEMENT PLAN

The impact management can be discussed into two distinct heading i.e. impact mitigation plan and impact monitoring plan.

5.1 IMPACT MITIGATION PLAN

The purpose of mitigation in the EIA process is to:

- Look for better ways of doing things so that negative impacts of a proposal are eliminated or minimized, and the benefits are enhanced; and
- Ensure that the public or individuals do not bear costs, which are greater than the benefits that accrue to them.

The following are the mitigating measures for each of the identified problems:

5.1.1 Construction code and appropriate technology

5.1.1.1 Construction Technology

Since the project area in general is quite steep with an average gradient of side slope ±70% it is important that appropriate technology is sought. Cut and fill method is the construction technique that was found appropriate for the site. A combination of excavator and small bulldozer has proved ideal in such condition (Road Construction training using excavator at Kharungla for supervisors, Forestry 3rd Project February 1998). Excavator is the main construction equipment while bulldozer helps in leveling the road surface thus achieving work progress. However, during project formulation (PF) period other possible alternatives can be explored. In the depressions or gullies, retaining walls with suitable Hume pipe culverts should be laid before being filled with excavated material. This ensures that the culverts gain a thick padding on the top, which can act as a resistance to load, and protect the structures from damage.

Where there are no depressions found nearby to dump the cut material it should be transported despite longer lead. A site should be identified during PF period for dumping the cut material. By not allowing the material to slide downhill, the stone resources are saved which can be used for other road works. In this way vegetation damage downhill is also minimized, reducing erosion problems. The major disadvantages of conventional construction are wastage of resources from slide downhill, and which has the secondary effect of causing environmental degradation. In the suggested road construction technology excavator machines have to be always accompanied by at least three dump trucks.
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The road can also be constructed in several phases: first a track of 2m width and after one monsoon extension of width to 3.5m and a year later to the design width. In this way heavy disturbances can be avoided occurring in one time and allowing the slope to gain stability. For to arrive at a suitable construction method it is recommended that the project formulation carry out km-wise description and measures required.

A heavy over burden of excavated material will be encountered where the road cuts through the middle of the slope, making the area prone to landslides. In this case it is suggested that the high cuts be kept at a minimum to the extent possible. For vegetating the bare plains refer the bioengineering methods discussed later under the heading of bioengineering slopes.

As the road type is feeder road it is recommended that civil works closely follow specifications of class -C road, PWD. The design of civil engineering structures other than suggested, should follow the Road Design Manual of PWD prepared by Snowy Mountains Engineering Corporation.

Assuming that feeder roads are not black topped it is recommended that at least two stretches of road exceeding 8 percent grade should be tarred. This would reduce the maintenance cost in the long run.

5.1.1.2 Drainage

From studies of hill roads in Bhutan and elsewhere in the region it has been revealed that the durability of the road depends entirely upon good drainage systems. For the proposed road being feeder road class the longitudinal drains recommended are the V-shape drain. It is intended that in an emergency, vehicles could even use the additional space afforded by the drains to pass each other in a manner that is safe. As the maximum rainfall intensity for a day for the area is 128mm it recommended that 50cm * 50cm V-shape drain for the earth section and 30cm * 30cm for rocky section would be adequate to discharge the runoff smoothly. It should be line drain with plain concrete. In the rocky sections explosives should be used to make enough space for the required ditch dimensions. Holes of 30cm depth should be bored in series keeping regular space intervals. Delay detonators and detonating cord or cordex should be used for blasting needed to obtain suitably sized drains in the rocky sections.

In 1km of longitudinal drain it is recommended that approximately 5 Hume pipe culverts to be laid down so that accumulated runoff does not spill over on to the road. 45 – 60 cm diameter Hume pipes would be adequate for the cross drains. Importance should also be attached to draining the runoff from the cross drains into a natural gully nearby.

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22 Road Design Manual, Public Works Department, Ministry of Social Services, Royal Government of Bhutan, prepared by Snowy Mountains Engineering Corporation under ADB -TA.

23 Record at Meteorology station Buli, 1991
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5.1.1.3 Recommended Construction Equipment

The suggested road construction equipments are as listed below, which is only an indication and PWD should therefore explore other suitable/appropriate equipment during PF period as the site may demand.

1. Excavator – 2 no.
2. Dump Trucks – 4no.
3. Bulldozer (small size – 1no.
4. Pay Loader – 1no.
5. Air Compressor – 2no.

5.1.2 Blasting technology

Given the steep terrain and difficult topography of the area it is likely that mass explosives would have to be used in the construction process. For the blasting to be effective, it is important that the area of responsibility of personnel engaged in planning and carrying out blasting work cover all the recommendations. The following are the mitigation measures for effective, safe and environmental friendly blasting:

1. Qualification and appointment of shotfirers and assistant personnel.
   - The shotfirer should be preferably at least 21 years old and be of stable temperament and have a practical experience working with a shotfirer for at least one year.
   - The shotfirer should have attended a recognized course of training covering the theoretical, practical and legal aspects for the use of explosives for all types of blasting work.
   - To qualify for the shotfirer assistant, a person should be at least 18 years old and be of stable temperament.
   - The assistant should have attended a short course dealing with the main hazards in the handling and use of explosives.
   - Where the blasting operation is so extensive that several shotfirers are required, one should be appointed as having an overall control.

2. Choice of explosives and initiating systems.
   - Explosives recommended are Power Gel 801 and Special Gelatine SG80, however Power Gel 801 is preferable over the later.
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- Electric Delay Detonators (EDD) of the same electrical sensitivity and produced by the same manufacturer should be used. Detonating cord or *cordex* should be the connecting wire between holes.

- The series of holes are intended to detonate instantaneously and subsequent series after few milliseconds.

3. Environmental factors

- Engineers generally aim for a speedy progress of work. The usual tendency, therefore, is to overcharged the explosives, which create undesirable fly rocks and vibration pollution.

- **CONTROLLED BLASTING** is a method that is cost-effective, practical and economical that is therefore recommended to adhere to. Depending upon site conditions and circumstances other alternatives could also be explored viz.: silent blasting, costly and time consuming can be deployed if timing is rightly planned; heating and cooling rapidly could be adopted; burying isolated rock blocks by digging holes in the ground; forcing rock splitting iron bars on drilled holes. The plan of drilling blast holes and charges calculations should be recorded on daily basis and documented for production on inquiry.

- Experience has shown that most people react negatively if an operation is begun, without their knowledge, and reactions could take the form of complaints. For this reason, it is advisable that every effort be made to pre-empt potentially annoying complaints with good public relations efforts before blasting even starts.\(^{24}\)

4. Site storage, transport of explosives, charging of boreholes, blasting equipment and other safety guidelines

- Refer **BLASTING MANUAL**, Public Works Department, Ministry of Social Services, Royal Government of Bhutan.\(^{25}\)

5.1.3 Bioengineering methods

Landslides can be common in the region because of its steep and precipitous slopes. In a landslide great masses of soil and rocks suddenly move down leaving behind large wounds in the landscape, which could be widen by subsequent slides. The debris would pile up at the base of the slopes ultimately loading the two major water bodies, Pramdogang Chhu and Burgang Chhu. This may also cause obstruction of waterways that might deprive the support services downstream.

The possible bioengineering measures suitable for the area is: Brush Layer, Live Stacking, Wattle Fence, Grass Seeding, and surface and sub-surface drains to prevent water from entering

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\(^{24}\) Applied explosives technology for construction and mining by Stig O Olofsson, Nitro Nobel, Dyno Explosives Group.

\(^{25}\) Note: the other points discussed in the explosive section are those shortcomings of the PWD blasting manual.

EIA, Dakpai-Buli Road, February 1998
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the sliding area. The bioengineering should be carried out as soon as the road formation width is obtained not waiting until whole 36km is finished. This will ensure the vegetation used in bioengineering to grow fast as the surface is even and soil wet. Each method is discussed below and elaboration provided in annexes.

1. **Brush Layer:**

Recommended for wet slopes or steep and rocky slopes because of its deep stabilization action. The branches of rooting plants/trees such as *erythina* and *salix* species (willows) could be used. The construction should be carried out during dormant season. For details refer Annex 1. Construction steps are:

1. Small terraces 0.5-1 m at an angle of 10° – 30° inclination, beginning at the toe of the slope;
2. Lay the brush layer crosswise, one fourth of each branch should extend over the edge of the terrace;
3. The lower ditch is filled with material from the ditch above; and
4. Continue next layer and onwards.

ii. **Live Stacking**

Recommended for shallow zone soil stabilization where increase in vegetative cover is needed. Long, straight stems of trees and brushes that root easily are excellent materials. To be constructed during dormant season. Details provided in Annex 2. The construction steps are:

1. Prepare hole with crow bar;
2. Plant cutting right side up as deep as possible keeping one third of length exposed;
3. Tamp the soil around to secure firmly in the ground so that it cannot be easily moved or pulled out;
4. It can be planted in random or in line as desired.

iii. **Wattle Fence**

Recommended for small, shallow slides where instantaneous back holding of material is needed. In combination with other methods it could be excellent for bank protection. This could reduce the maintenance cost of longitudinal drains. The pegs can be wooden or steel of 3 – 10 cm diameter. Cuttings should be of pliable woods sapling, branch or other material. For details please refer Annex 3. The construction steps are:

1. Excavate small terrace;

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ITECO, FAO Bhutan, Stabilization handbook.

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2. Long pegs with spacing 100 cm;

3. Small pegs with spacing 30 cm between long pegs; and

4. Cuttings are woven in pegs.

iv. Grass Seeding

Recommended for surface protection of bare slopes. It helps to provide a good microclimate and looks more pleasing to the eye. It also helps to speed natural reestablishment of vegetation. Highly suitable for good soil and gentle slopes particularly road cuttings through agricultural land of Kikhar. 10 – 50gm seeds per sq.m would be appropriate. Details refer Annex 4. The construction steps are:

1. To prevent seeds from rolling down the slope, make small grooves inclining at 3-5% towards horizontal;

2. Space the grooves at 10 cm interval; and

3. Start broadcasting the seeds from bottom to top.

Landscape and environmental Aesthetics

For the road to fit into its landscape the road corridor width in the mild slope should not exceed 12m however in the steeper slopes little more than 12m may be required. To make it more pleasing to the eye, it is also advisable that all the tree stumps in and around road bank be removed and vegetated. This will make the completed road look neat. The finished road’s side slope should be:

- 0.1:1 (H:V) in hard rocky section
- 0.3:1 for ordinary rock
- 0.5:1 if natural side slope has hard soil
- 1:1 for ordinary soil

Similarly, suitable side slope gradient for downhill of the finished road has to be maintained. Sketch of typical road section is given in Annex 5.

The quarry sites should be fenced with tin sheet (C.G.I) to prevent debris falling/downhill. The quarry and disposal sites should be reclaimed by way of bioengineering techniques suggested in the above section.

5.1.4 Existing infrastructure and support services

The infrastructures that would be effected are: an irrigation canal and two micro hydropower stations. The effect on irrigation canal would be more serious than for the later two. Two alternatives are suggested for mitigating damage to the canal:
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Alternative 1: Substitute the existing open drain by laying series of 60 cm diameter Hume pipe for about 100m and cover the pipes with a thick padding of earth. Provide inspection chambers at about 30m interval. Cover the structure with soil until adequate thickness of cushion is obtained. The formation cutting can now proceed. This is a solution that can be implemented at one go, and that will take care of the problem more permanently.

Alternative 2: Lay the Hume pipes without providing inspection chambers for the required stretch and lay enough cushion (earth material) on top. Dig out the pipes after acquiring the formation width and having built retaining walls. Provide rectangular plain, concrete open drain at the base of the road retaining wall. Construction details are illustrated by sketch in Annex 6.

Since the earth cushion over the existing canal is very thin and the road runs parallel to it for a distance it could also be damaged as a result of falling boulders. For this reason, it is advisable to conduct the blasting operations in accordance with controlled techniques. CUT AND TRANSPORTED METHOD of construction should be employed.

The hydropower station below Kikhar would suffer less impact if controlled blasting operations are strictly followed, and by keeping the loading of the Chhudugang Chhu at the minimum. Tingtibi power station is not within the reach of the blasting fly rocks but great care should be taken not to overload the Pramdogang chhu with debris as it is the main receptor of the pollution in the catchment area.

5.1.5 Land compensation, restoration and resettlement of human settlement

At Dakpai road takeoff point 5 houses were affected in the construction of first 200m. 2 houses need relocation i.e. belonging to Nima, above road, and Dechen Dema, below. The compensations recommended for the two are based on legal documents produced by the affected parties and the initial cost involved for the construction:

Compensation to Nima

Alternative 1:

- Cost of 10decimal (400sq.m) plot as per purchase agreement of Zhemgang Court in 1976 is Nu.15,000.00

- Interest for 21 year at the rate of Nu.1050 per annum is Nu.22,050.00

- Rebuilding the house at a cost of Nu.10,000.00

- Total Sum to be compensated is Nu.47,050.00 (forty seven thousand fifty).

Alternative 2:

- Provide land substitute nearby the same location as she owns a shop license. She had already identified the plot. The cost of construction about Nu. 10,000 (ten thousand) should be provided.

EIA, Dakpai-Buli Road, February 1998
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Compensation to Dechen Dema

- As the dwelling is a hut type it is recommended that Nu.8000.00 compensation would suffice for reconstruction.

- Cost of land (Kamzhing) for 225 sq.m is Nu.1,112.00.27

- Total Compensation Nu.9,112.00

**Note:** Land substitution is not required as she has enough land nearby Dakpai area.

Other agricultural land damage should be compensated based on actual measurements during construction. The Land compensation rate is given below in Table 5.1.28

**TABLE 5.1: LAND COMPENSATION RATE**

<table>
<thead>
<tr>
<th>S.NO.</th>
<th>LAND TYPE</th>
<th>RATE (IN NU.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Chuzhing (Wetland)</td>
<td>35,000 per acre i.e. 8.65 per sq.m</td>
</tr>
<tr>
<td>2.</td>
<td>Kamzhing (dryland)</td>
<td>20,000 per acre i.e. 4.9 per sq.m</td>
</tr>
<tr>
<td>3.</td>
<td>Tseri/Pangzhing (shifting cultivated Land)</td>
<td>5,000 per acre i.e. 1.24 per sq.m</td>
</tr>
<tr>
<td>4.</td>
<td>Tsamdo (pasture land)</td>
<td>200 per acre i.e. 0.05 per sq.m</td>
</tr>
</tbody>
</table>

The damage to the orange trees can be minimized if blasting operations are conducted using controlled techniques. The compensation is recommended on per tree damage basis. The land compensation is not required in this case. Following are the compensation rates per tree damage according to age:29

**TABLE 5.2: ORANGE TREE COMPENSATION RATE PER TREE**

<table>
<thead>
<tr>
<th>CROP</th>
<th>AGE IN YEAR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Orange</td>
<td>233</td>
</tr>
</tbody>
</table>

**Restoration at Dakpai (road takeoff point)**

To save the other houses from sliding material it is important to provide breast walls of suitable height. Gabion walls would be appropriate, as structure need to be in several layers. The top of the structure should be vegetated to help stabilize the soil faster.

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27 As per item 1(b) page 4 of Land Compensation rate 1996, Ministry of Home Affairs, Thimphu, Bhutan

28 Land Compensation Rate 1996, Ministry of Home affairs, Thimphu, Bhutan

29 Annexure “C” page 14 of Land Compensation Rate 1996.

EIA, Dakpai-Buli Road, February 1998
5.1.6 Conflicts and coordination

Since the road passes through many agricultural fields it is anticipated that the project might encounter conflict with locals. The conflicts and their possible amelioration suggested below:

Conflict:

1. Road used as a channel for drawing water to the paddy field
2. Random stone quarrying along the road by the locals

Ameliorating measures for conflict 1:

- The project implementing agency should conduct public meetings involving the project staff and locals likely to raise conflicts. The coordination should be done through Zhemgang Dzongkhag administration which would involve District Irrigation Engineer (D.I.E), Gup and Tshogpa. The conflict should be prevented as the road passes through the settlement and agricultural land.

- The parties responsible for the project should provide a briefing on the planned activities of the project and seek the cooperation required from the locals. Site visits should be conducted to locate the exact position of the culverts that would mutually satisfy all parties’ purpose.

- Draw the minutes of meeting and document it in the event that people do not comply with the arrangements agreed.

- Surface and Sub-surface drain:

Surface drains above the road are recommended for draining the spillover of water from the paddy fields located above the road and other watercourses from entering into the area. The surface drains could be stone pitched or just earthen depending on the nature of seriousness. Sub-surface drains are recommended for marshy areas where excessive leaching/seepage is anticipated. It could be French drain or polythene pipes with pore holes on all sides. The polythene pipes should be driven into the problem area maintaining regular spacing between pipes. The construction steps of French Drain are:

1. Excavate rectangular drain across the road;
2. Lay gunny bags on all sides of the drain;
3. Fill with stone chips; and
4. Lay the road material over it.

Ameliorating measures for conflict 2:

- Currently, there are two institutions in the Kingdom permitting stone quarrying: the Division of Geology and Mines (DGM) under the Ministry of Trade and Industry, and the Forestry Services Division under the Ministry of Agriculture. The shared authority has created
problems elsewhere in the country and would likely create problems here too. It is important that this duplication of authority be clarified at the earliest.

- The quarry site allocations should take place in close consultation with the DGM personnel.
- The quarry sites for PWD and locals should be zoned and it is advisable that locals be involved through Dzongkhag administration before decisions are finalized.

5.1.7 Health and safety of workers

Since the project staff would put additional pressures on the limited medical facilities in the communities, it is advisable that the project employ/hire its own health worker. First Aid Kits should be provided at all work sites. Workers should be provided with safety facilities as follows:

- Helmets
- Mouth respirator for the drillers
- Handgloves
- Gumboots
- Goggles for the drillers
- Ear protector
- Red Sugar (Molasses) for the driller

As the camps keep on moving, three alternatives of shelter are suggested. Details of shelter are provided in Annex 7. The location of camps should consider water availability, school, latrines etc. For 250 people it is recommended that about two water tankers be provided for water supply.

In the event of foreign labor import it is VERY important that compulsory disease check-up is carried out right at the Bhutan entry point. This would prevent the mass spread of disease in the rural communities with whom they come into contact.

5.1.8 Environmental training

Since the actual implementation of project will be carried out by surveyors, engineers and operators it is very important that some sort of training or exposure is imparted on the identified personnel. This will make a great impact on the successful implementation of the project. The training that would be more suitable for each level of personnel are:

**Project Engineers and surveyor:**

Classroom training on the possibilities of route alternative alignment on the contour map. The different considerations that should be attended to when aligning the road can be included. Identifying control points on the map. Then the paper work should be confirmed with field situation as maps are sometimes very inaccurate. Introduction of different surveying equipments
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and its application possibilities phase-wise. The techniques of laying different route alternatives giving equal consideration to all parameters of the environment that will also enhance the decision-maker with options to choose the best alternative.

Furthermore, for the engineers to instill awareness exposures are essential and that can be done through short training workshop and excursions.

Operators level:

The excavator machine can built excellent roads at a slight higher cost that is acceptable to all parties involved provided Hands-On-Machine training is imparted to the operators. The training arrangements can be replicated from what the Forestry Development Corporation under Forestry Services Division is doing and has carried out. For instance, in early February 1998 the Forestry Development Corporation under technical assistance of FAO not only imparted training for the operators’ level in road construction by excavators but also provided 10day training for the road supervisors’ level. Such arrangements can be cost effective and practical.

If the capability to train the excavator operators does not exists in the country then the foreign trainer should be hired.

5.1.9 Estimated costs Scenario

The following is an attempt at weighing the costs and savings between conventional and environmentally sensitive techniques of road construction.30

5.1: Feeder Road Cost for Old Method per KM

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>EXPLANATION</th>
<th>AVERAGE COST (NU.) IN MILLION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Construction of feeder road up to base course per kilometer including permanent works</td>
<td>1.621</td>
</tr>
<tr>
<td>2.</td>
<td>Maintenance cost per km for Zhemgang in 10 year @ Nu.67,000/km/year</td>
<td>0.67</td>
</tr>
<tr>
<td>3.</td>
<td>External cost through loss of vegetation downhill/uphill considering 1,42,122 cubic feet per km would be damaged (Nu.40.86/cft). Note: since geology and slopes are more difficult than other parts of Bhutan this will incur more formation cutting cost and similarly B/R walls which is not considered for the calculation here.</td>
<td>5.81</td>
</tr>
</tbody>
</table>

TOTAL COST PER KM IN 10 YEAR IF ALL LOSSES ARE CONSIDERED 8.101 million Ngultrum

Source: 8th Five Year Plan Programs and 7th Five Year Plan Review, PWD, September 1997.

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30 Disclaimer: Since the literature on output of excavator is not available the estimation could not be carried out effectively. It is likely that considerable difference might occur in the process.

EIA, Dakpai-Buli Road, February 1998
### 5.2: COST FOR NEW CONSTRUCTION PER KM

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>EXPLANATION</th>
<th>AVERAGE COST (NU.) IN MILLION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>From the experience of Forestry Development Corporation, excavator 320B can construct 25m per day in rocky terrain. Therefore the rental cost of 1km will be 40day x Nu.11,500</td>
<td>0.460</td>
</tr>
<tr>
<td>2.</td>
<td>Bulldozer will take 6 day to level following excavator. The rental cost for 6day per km will therefore be 6 day x Nu. 8,500</td>
<td>0.051</td>
</tr>
<tr>
<td>3.</td>
<td>Power chainsaw, labor and blasting cost</td>
<td>0.200</td>
</tr>
<tr>
<td>4.</td>
<td>Breast wall required in one km for Zhemgang situation is about 15number in average (from existing road). Keeping average cost of Breast wall about Nu.60,000. The breast wall cost per km will be 105 x Nu.85,000</td>
<td>0.60</td>
</tr>
<tr>
<td>5.</td>
<td>In average about 10 retaining Wall will be required per km. Keeping average cost per wall as Nu.75,000. The cost of retaining wall per km will be 10 x 75000.</td>
<td>0.75</td>
</tr>
<tr>
<td>6.</td>
<td>5 culverts required per km and average cost per culvert to be about Nu. 35,000. The cost per km will be 5 x 35,000</td>
<td>0.175</td>
</tr>
<tr>
<td>7.</td>
<td>Cement concrete line drain 50cm x 50cm will cost per km</td>
<td>0.200</td>
</tr>
<tr>
<td>8.</td>
<td>Base course cost remaining same as conventional method</td>
<td>0.354</td>
</tr>
<tr>
<td>9.</td>
<td>Bioengineering per km</td>
<td>0.100</td>
</tr>
<tr>
<td>10.</td>
<td>Other mitigation measures (lumpsum)</td>
<td>0.050</td>
</tr>
<tr>
<td>11.</td>
<td>Considering that maintenance cost per km will occur only 1/3 of Nu.67,000 in this method. The cost per km for Zhemgang in 10 years will be 10 x 22333</td>
<td>0.223</td>
</tr>
<tr>
<td>12.</td>
<td>External cost through vegetation damage per km considering 21174 cubic feet would be damaged. The cost therefore would be 21174 x 40.86</td>
<td>0.865</td>
</tr>
</tbody>
</table>

**TOTAL COST IN 10 YEAR PER KM**

|              | 4.028 |

Note: The above exercise is carried out for illustration purposes only project formulation should deal this in detail.
5.2 IMPACT MONITORING PLAN

Monitoring is used to study: what impacts occurred; to ensure that the anticipated impacts are maintained within the levels predicted; to ensure that conditions of approval are adhered to; that mitigation measures are effectively applied and the benefits expected from the EIA are achieved as the project proceeds. The regulation or control of such changes are not part of effective monitoring, but rather are activities that depend upon the results of monitoring. The monitoring plan for roads can be differentiated into two distinct phases: construction period monitoring and operation period monitoring or post project monitoring.

5.2.1 Construction phase monitoring

The monitoring in the construction phase can be carried out in three different forms:

- Internal monitoring and reporting, according to donor demands and assessment by SNV;
- External monitoring by the Team, consultant to be assigned by SNV;
- Monitoring by donor: mid term review and end evaluation of ISDP with assessment of progress/impact in relation to the project formulation.

5.2.1.1 Internal monitoring

It should be carried out by PWD, the project implementing agency and reported to PWD headquarters and SNV - Thimphu. It should be a continuous process until the completion of the project. The monitoring can and comprehensive including physical work achievement and environmental parameters. The budget for monitoring should be in-built in the project.

5.2.1.2 External Monitoring

5.2.1.2.1 Team for Monitoring

1. One Engineer, PWD, Thimphu
2. EIA Officer, NEC, Thimphu
3. Gup, Nangkor Geog, Zhemgang
4. District Engineer, Zhemgang
5. Environmental consultant (to be deputed by SNV, Thimphu)
6. Forest Officer, Forestry Services Division
Impact Management Plan

5.2.1.2.2 Roles and Responsibilities

ISDP Zhemgang

The ISDP can initiate the monitoring and mobilize the team. Compile monitored data and advise PWD to implement that highlights action. Also advise PWD to formulate the project.

National Environment Commission (NEC)

To be in the monitoring team and issue letter of instruction for matters that provokes action.

PWD (Dakpai – Buli project)

Implement mitigation measures and comply with periodic and timely comments provided by monitoring team and or NEC.

5.2.1.2.3 Budget for monitoring

The budget for monitoring should be in-built in the project itself.

5.2.1.2.4 Frequency of Monitoring

Biannual monitoring is recommended to be conducted during the construction phase. The first during the monsoon season around June, and other during the lean season around December of the year. *Ad hoc* monitoring may be called for if any agency finds it necessary or if adverse complaints are received pertaining to the project.

5.2.1.2.5 Monitoring Format

The monitoring takes three different forms:

1. **Baseline Monitoring**: This should be done during the pre-project period. It is basically the collection of baseline data. The data gathered will serve as the basis for effects monitoring. Certain baseline data can be obtained from EIA report such as Land Use Map and site photographs. Data like silt load in the river bodies and other parameters in the river system is not assessed in this EIA exercise. Data can be collected during project formulation period.

2. **Effects Monitoring**: It happens during the construction period to detect changes in the environmental parameters that can be attributed to the project. It is a continuous process the Dakpai-Buli Project will carry out.

3. **Compliance monitoring**: Unlike the other two this is a periodic inspection (which is set twice a year in this case) to ensure that mitigation measures are observed and standards met. External team listed above will carry this out.

The approach to monitoring is:

1. Review document commencing baseline conditions;

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2. Monitor compliance with agreed conditions;

3. Review the accuracy of impact prediction;

4. Identify trends in impacts;

5. Review activities and/or mitigation measures;

6. Verify the accuracy of past predictions and effectiveness of mitigation; and

7. Review effectiveness of the environmental management plan.

The table that follows is an indicated checklist for environmental monitoring.

### TABLE 5.3: FORMAT FOR COLLECTING ENVIRONMENTAL MONITORED DATA

1. Name of team members:

2. Start date:

3. Finished date:

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>PARAMETERS TO BE MEASURED</th>
<th>QUANTITY</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>List construction machines by type</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i. Excavator</td>
<td>FILL AS</td>
<td>FILL AS</td>
</tr>
<tr>
<td></td>
<td>ii. Bulldozer</td>
<td>APPROPRIATE</td>
<td>APPROPRIATE</td>
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<tr>
<td></td>
<td>iii. Pay loader</td>
<td></td>
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<td></td>
<td>iv. Dump Truck</td>
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<td></td>
<td>v. Road roller</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>vi. Etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Explosives by type</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i. Special gelatine</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ii. Superdyne</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>iii. Detonating cord</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>iv. Cordex</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>v. Delay Electric detonators</td>
<td></td>
<td></td>
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<tr>
<td>3.</td>
<td>Blasting technique</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i. Controlled method</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ii. Are drill holes planned?</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>iii. Charge calculation carried</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>iv. Are personnel handling explosives adequately qualified?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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### Impact Management Plan

<p>| | | | | |</p>
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<tr>
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</thead>
<tbody>
<tr>
<td>v.</td>
<td>Are safety measures observed?</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>vi.</td>
<td>Are records maintained up to date?</td>
<td></td>
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<tr>
<td>4.</td>
<td>Is cut and fill method of construction adopted?</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>5.</td>
<td>Are benching carried out for steeper slopes?</td>
<td></td>
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<tr>
<td>6.</td>
<td>Assess vegetation likely to be affected by fly rocks, downhill falling/sliding debris, etc…</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>7.</td>
<td>Are sites restored as recommended?</td>
<td></td>
<td></td>
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<tr>
<td>8.</td>
<td>Are appropriate compensations paid?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>Are suggested measures carried out to save existing structures?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>Assess faunal habitat disturbance particularly Golden Langur</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>Are existing hydropower stations not impaired?</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>12.</td>
<td>Assess silt load in Pramdogang chhu and Burgang chhu</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>13.</td>
<td>Are public coordination activities carried out?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td>Was DGM consulted in quarry site identification and allocation?</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>15.</td>
<td>Are logging activities coordinated?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16.</td>
<td>Are drains provided and appropriate?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17.</td>
<td>Are adequate cross drains provided?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18.</td>
<td>Are mitigation measures provided appropriate?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19.</td>
<td><strong>Bioengineering methods</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i.</td>
<td>Brush layer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ii.</td>
<td>Live stacking</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>iii.</td>
<td>Wattle fence</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>iv.</td>
<td>Grass seeding</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>v.</td>
<td>Surface /and or subsurface drain provided</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20.</td>
<td>Is longitudinal road gradient appropriate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21.</td>
<td>Are route alternatives suggested followed?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22.</td>
<td>Is black-top provided for steeper grade road?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>23.</td>
<td>Are chortens’ damage saved through mitigating measures?</td>
</tr>
<tr>
<td>24.</td>
<td>Did project laborers cause medical concern to the locals?</td>
</tr>
<tr>
<td>25.</td>
<td>Are there any instances of new diseases after the project came in?</td>
</tr>
<tr>
<td>26.</td>
<td>Are there any cultural conflicts? What are they?</td>
</tr>
<tr>
<td>27.</td>
<td>Are there any economic impacts on the locals?</td>
</tr>
<tr>
<td>28.</td>
<td>Did health facilities and other social services improve?</td>
</tr>
<tr>
<td>29.</td>
<td>Are laborers provided with reasonable shelter?</td>
</tr>
<tr>
<td>30.</td>
<td>Are the laborers provided with safety facilities?</td>
</tr>
<tr>
<td>31.</td>
<td>Etc. and so on</td>
</tr>
</tbody>
</table>

*Note: The list can be tailored as may be felt necessary by the monitoring team.*

### 5.2.2 Post project or operation phase monitoring

As the road will always remain usable it is also important that adequate attention be given to operation period monitoring.

#### 5.2.2.1 Team for Monitoring

1. EIA Officer, NEC, Thimphu
2. District Engineer, Zhemgang Dzongkhag
3. Gup, Nangkor Geog, Zhemgang Dzongkhag
4. Engineer, PWD headquarters, Thimphu.

#### 5.2.2.2 Roles and responsibilities

**National Environment Commission (NEC)**

Document the monitored data and take appropriate actions as is suitable.

**Mangde Chhu Division, PWD**

On completion, it is assumed that the project will be handed over to the Mangde Chhu Division, PWD, for maintenance work. The maintenance code should be carried out as presently practiced.

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(refer maintenance manual, PWD). Bioengineering methods should be a recourse wherever necessary. Provide monitoring budget by incorporating into the annual maintenance budget of Dakpai-Buli road.

5.2.2.3 Frequency for Monitoring

The monitoring should be carried out once a year. Monitoring is recommended in the monsoon season, preferably during June.

5.2.2.4 Monitoring Format

Unlike the construction monitoring, the monitoring in this case could be simpler. Assuming that major problems are solved during the project period, the monitoring here will look into the following parameters as provided in Table 6.2 below.

**TABLE 6.2: FORMAT FOR COLLECTING ENVIRONMENTAL MONITORED DATA**

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>EXPLANATION</th>
<th>QUANTITY</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Are drains O.K.?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>About landslides in the area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Are other support services not impaired by road?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Are bioengineering methods suitable? Mention progress and further requirements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Were transportation problems solved?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Did social services available to the locals improved?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Did the economy improve?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Are there problems arising from the influx of people related to the project?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>Are there resource use conflicts?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>Etc and so on</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
BRUSH LAYER

Function: Instantaneous and effective stabilisation of steep rocky slopes

Road Width

Min 30 cm

COMPACTED SOIL

SECTIONAL PLAN

Branches of rooting trees

Min 20 cm

30 cm COMPACTED SOIL

RECOMMENDATIONS

- After monsoon during dormant season
- Ideal for wet slopes, rocky and steep slopes
- For deep stabilisation
- Rest same as wattle fence

ISDP ZHEMGANG
DECEMBER 1997
LIVE STACKING

FUNCTION: A fastest and effective measure to secure a vegetative cover

RECOMMENDATIONS

- For marshy area
- Crowbars can be used to bore holes
- Willows and erythina trees are excellent

ISDP ZHEMGANG
DECEMBER 1997
WATTLE FENCE

FUNCTION: For small and shallow slides

- 100 M
- 30 M
- 30 M

Fencing poles
Ground level
Long pegs

LONGITUDINAL CROSS-SECTION

RECOMMENDATIONS
- Construct after monsoons during dormant season
- For finished road side slopes of batter 1:1 to 1:5 (H:V)

ISDP ZHEMGANG
DECEMBER 1997
GRASS SEEDING

FUNCTION: Used for surface protection of bare slopes and helps to provide good micro-climate.

RECOMMENDATIONS
- For gentle slope
- The seeds are sown
  broadcast
- Space of grooves about
  20 cm

ISDP ZHEMGANG
DECEMBER 1997
TYPICAL CROSS SECTION OF FEEDER ROAD SHOWING CUT AND FILL BATTER

The slopes are horizontal: vertical

ISDP ZHENGANG
DECEMBER 1997
SECTION OF IRRIGATION CHANNEL AT KHIKHAR PAM

Notes:
1. Provide water access during const. by providing Hume pipe preferably 45-60 cm dia
2. carry out formation cutting
3. Construct appropriate structures at the inlet of canal
4. Construct rectangular/open box course rubble masonry irrigation canal
5. construct breast wall to hill side of canal with proper toe wall and stone pitching works at the valley side

ISDP ZHEMGANG
DECEMBER 1997
TEMPORARY DWELLING OF WORK FORCE AT THE ROAD CONSTRUCTION PROJECT
TYPE I (UPTO SIX MONTH)

Bed room (10'X12')

SECTION X-X

Tarpaulin roofing

LEGEND
W = 3'
W1 = 2.5'
D = 3'
D1 = 2.5'

ALL WALLS ARE TO BE OF BAMBOO EKRA
ONE LATRINE FOR TWO FAMILIES TO BE CONSTRUCTED SEPARATELY

ISDP ZHEMGANG
DECEMBER 1997
TEMPORARY DWELLING OF WORK FORCE AT THE ROAD CONSTRUCTION PROJECT
TYPE III (ONE TO THREE YEARS)

LEGEND
V1 = 2.5'
D = 3'

. ALL WALLS ARE TO BE OF BAMBOO EKRA
. SEPARATE LATRINE TO BE CONSTRUCTED

ISDP ZHEMGANG
DECEMBER 1997
TEMPORARY DWELLING OF WORK FORCE AT THE ROAD CONSTRUCTION PROJECT
TYPE II (FOR ONE YEAR TO THREE YEARS)

STONE PITCHING

BED ROOM
(B'X10')

ROOM
(6'TX10')

PLANKS OR CHITRA FLOORING

PLANKS OR CHITRA

TARPALIN ROOFING

BAMBOO MAT ONE LAYER FOLLOWED BY TARPALIN

CHITRA OR PLANKS

SECTION X-X

SHELF

KITCHEN
(6'X 8')

KITCHEN
(6'X 8')

Cement Conc. SINK

LEGEND

W = 2.5'
W1 = 3'
D = 3'
D1 = 2.5'

ALL WALLS ARE TO BE OF BAMBOO EKRA

ONE LATRINE FOR TWO FAMILIES TO BE CONSTRUCTED SEPARATELY

ISDP ZHEMGANG
DECEMBER 1997
Terms of Reference:
EIA for the Dakpai - Buli Road in Zhemgang Dzongkhag

1 Background

Construction of approximately 36 km of road connecting Dakpai with Buli is proposed in the 8th Five Year Plan of Zhemgang Dzongkhag. Division of Roads (DoR), under the Public Works Division (PWD), has the responsibility for road construction and maintenance in Bhutan and will also be the executing agency for the Dakpai - Buli Road. In March 1997, the formulation of the Integrated Sustainable Development Programme (ISDP), Phase II, will be finalised. It is proposed that the donor (the Dutch Government) will fund part of the road construction. Before being able to decide on financing, the donor wants to know the environmental impacts of such road construction.

The Royal Government of Bhutan (RGOB) has given the mandate to the National Environment Commission (NEC) to review and assess the need for environmental impact assessment (EIA) in relation to development projects and to scope the EIA. Bhutan’s fragile mountainous environment with its rich biological diversity and its unique culture and religious background makes it imperative to carry out EIAs for any major development projects in order to make it possible to mitigate adverse environmental impacts, such as soil erosion and landslides. Therefore, general Environmental Impact Assessment Guidelines for Bhutan were issued by the NEC in 1993, and according to these, EIA is required prior to any binding decision in relation to major development projects.

The main purposes of the EIA are to reveal positive and negative environmental consequences of the project to decision-makers and other interested parties, and to provide environmental background information that makes it possible to design, construct and operate the road in an environmentally sound way. The EIA takes place concurrently with technical and economic feasibility studies of the project, and in an iterative interaction with these studies in order to make it possible to incorporate environmental considerations equally with technical and economic aspects. Thus, EIA is considered a flexible and transparent tool for ensuring environmentally sound development.

Zhemgang Dzongkhag will be responsible for the execution of the EIA, whereas the EIA will be financed through the ISDP budget.

The EIA should address the proposed road project as well as potential alternatives. The alternatives could include alternative transport modes, alternative alignments and alternative designs.

A mission from the National Environment Commission (NEC) visited the project area 19 - 22 November 1996 and held meetings with the Dzongkhag officials, the ISDP officials and the DoR survey team. An initial environmental examination (IEE) was made on the basis hereof. The main findings from the IEE are summarised below:
• Depending on the alignment chosen for the Dakpai - Buli road, the socio-economic benefits will vary - both for the villages immediately alongside the proposed road and for the villages that are located in Shingkhar and Bardho Gewogs east and south-east of Buli.
• The top-soil in the project area are mainly clay sand/sandy clay, and in some places bed-rocks are exposed. Details on the geology will have to be obtained from the DoR survey team.
• The project area consists mainly of mixed broadleaf forests with both temperate and subtropical species. The mammal wildlife includes species as deer, wild boar, leopard, monkey, bear, and there are some indications of occurrence of tiger exists. Besides that, there are a wide variety of bird species.
• Apparently, no protected areas are affected by the proposed road project. This has to be clarified with the Nature Conservation Section (NCS).
• Only minor areas of paddy fields seems to be affected by the proposed road project.
• No information was obtained about the possible conflicts between the proposed road and religious or cultural sites.

These Terms of Reference (ToR) for the Dakpai - Buli road project are based on the findings from the IEE.

2 Project Objectives

The goal of the proposed road project is formulated by Zhemgang Dzongkhag as to improve the socio-economic status of the rural population of Nangkar, Shingkhar and Bardho Gewogs consisting of a population of approximately 9500, by providing direct and indirect benefit after road construction from the existing road in Dakpai up to Buli. For Shingkhar and Bardho Gewogs the road up to Buli will shorten the journey to Zhemgang and the main road with two days.

3 Project Description

The construction of the Dakpai - Buli road will be taken up by the DoR. The alignment of the road starts from Dakpai highway and goes towards Kikhar village. Between Dakpai and Kikhar there are two possible alignments: One going to the bottom of the Dakpai Chu valley and passing through approximately 3 km of bedrocks, and another one going zig-zag up the hill from the small hydel plant to Kikhar. The length of the two alternatives will be approximately the same. After Kikhar there are two alternatives for the alignment: One road going through Kikhar directly to Buli crossing Kikhar top without touching other villages on the way. The distance of this road might be the shortest, and it will pass through dense forest. The other alternative will be via Tali village to Buli. Again from Tali there are two alternatives; one going through Tali directly to Buli, crossing the mountain top in the forest area without reaching other villages. The other alternative will be from Tali to Goling village top, passing near the Sobling village, through Tali-Gomphu to Buli. This alternative will give the longest distance concerned, but reaches nearby all the villages in the project area. If Burgangchu Hydro Power Project will be realised in the future, this alternative will directly reach to the site, whereby additional road construction would not be required.
4  Project Benefits

The project benefits are identified by Zhemgang Dzongkhag as follows:

The road from Dakpai to Buli will improve the communication between the three gewogs' population. It will reduce the transportation costs of imported goods for rural people. It will furthermore facilitate the transportation of all kinds of materials for development activities like construction, seed, seedling, medicine, food stuff etc. It will encourage the people to produce more cash crops, vegetables, and even surplus food, which could be marketed outside their gewogs. It will reduce the post harvest losses, middle men business activities, and improve the quality of ash crops.

In brief, the overall benefit after construction of the Dakpai - Buli road will be uplift of the rural population for educational status, medical facilities, improvement of the living standard, and outlet facilities etc. The foremost importance of development activities lie on the extension of the road and its proper maintenance.

5  Scope of Work

The ToR for the Dakpai - Buli road have been prepared to meet the needs for an EIA and mitigation plan which are in agreement with the Environmental Impact Assessment Guidelines for Bhutan, 1993.

The impact assessment should identify, describe and assess potentially significant adverse and beneficial environmental impacts of the road project and accessory activities imposed by the project, such as extraction of construction materials, disposal of excess material and establishment of labours' camps. The impact assessment should cover the construction period as well as the operation period. The impacts of various alternatives should be compared and assessed against the situation of not implementing the project, that is the do-nothing alternative.

The mitigation plan should identify a set of responses to potentially adverse environmental impacts; determine requirements for ensuring that those responses are made in an effective and timely manner; and describe the means of meeting those requirements. Emphasis should be given to roles and responsibilities of agencies charged with implementing, mitigation and monitoring, that is who is going to do the work and pay for it?

5.1  Identification and Assessment of Impacts

Identification, description and assessment of environmental impacts should be based on observations from field investigations covering land use, topography, geology, flora and fauna in the study area that may contain environmental issues relating to the project. The field observations should be supplemented with various baseline data (maps, aerial photos, reports, scientific literature etc.) for example from the Land Use Planning Project (LUPP) under the Ministry of Agriculture. The assessment should cover both the proposed project and alternatives that have been considered, including the do-nothing alternative. It should include, but not necessarily be limited to, the following aspects:
- Land use with particular emphasis on critical watershed areas, loss of agricultural land, replacement of settlements, and loss of ecologically valuable areas.
- Topography.
- Landscape and environmental aesthetics.
- Geology, hydrogeology and hydrology with special regard to soil erosion and landslides. Possible sites of landslides due to loose soil and landslide prone areas should be mapped. Planned earth movements should be described. Will downstream water bodies be impaired by siltation or by polluted run-off water from the road?
- Existing land and water rights should be included, as well as existing irrigation canals and their command areas.
- Ecology, flora and fauna, including a description of biotopes with relevant lists of flora and fauna. Number of trees required to be logged along with species, and, if possible, the approximate quantity in cubic meters/feet.
- Protected areas. Will the road project affect protected areas, nature reserves or sanctuaries?
- Historical, cultural and religious areas and monuments.
- Occupational health and safety during construction and maintenance.
- Construction camps and work sites.
- Socio-economy. What are the expected intentional and unintentional induced development resulting from the road? Does the road provide for reasonably equitable service to rural residents? With respect to possible displacement of people, are provisions for property compensation and rehabilitation reasonably fair?
- Consequences for existing development projects, such as possible siltation that may affect the existing micro-hydel plant.
- Resource demands.
- Impacts of traffic, based on an estimate of vehicle frequency.
- Vibrations from blasting

5.2 Comparison on Alternatives

Based on an assessment of impacts, the environmental advantages and disadvantages of project alternatives should be compared, and alternatives should be ranked environmentally. Comparisons should relate to the do-nothing alternative, and to the greatest possible extent, the impacts should be presented in quantitative terms. Permanent effects should generally be considered more critical than temporary, and impacts that cannot easily be mitigated should similarly be considered more critical than impacts that can easily and for economical costs be mitigated.

5.3 Mitigation Plan

Based on the findings of the above evaluation, a mitigation plan should be prepared. The mitigation plan should describe in detail mitigation actions needed, estimate their costs, staffing needs, and timing for corrective measures and actions. Roles and responsibilities in relation to the actions needed should be specified in detail.
a) **Technical Mitigation Measures.** Technical measures that are, or could be, incorporated into project design and construction phases to eliminate or reduce adverse environmental impacts should be identified and described in general terms. Description and technical details should be presented for each suggested mitigation measure, including cost estimates, staffing needs, and timing for corrective measures and actions. The level of detail of the technical description should be approximately that of a preliminary design. The following aspects should be specifically addressed:

- Construction technology,
- Need for blasting,
- Drainage system alongside the road,
- Types of retaining walls in major landslide prone areas, or any other alternatives for stabilising slopes.
- Provision for culverts or larger drainage systems for the monsoon season.
- Temporary disposal of fertile top-soil to be reserved for reclamation.
- Establishment of native shrubs/trees for further prevention of landslides above and below the road.
- Land tenure, land use rights and land values.
- Raw material extraction, handling, storage and transportation.
- Disposal of excess material from construction works.
- Reclamation plan for the roadside, left quarries and disposal sites.

b) **Environmental Management Plan for the Construction Phase.** A draft environmental management plan for construction activities should be prepared with the purpose of incorporation of environmental terms and conditions into the road construction Tender Documents. The management plan should cover all aspects of road construction, and responsibilities should be assigned, including responsibilities for mitigation operations, emergency response procedures, supervision, financing, monitoring and reporting. Institutional capacity for implementing the plan should be reviewed and training needs assessed. Special attention should be paid to the following issues:

- Implementation of technical mitigation measured.
- Occupational health and safety issues, including labours' camps and work sites.
- Waste management, water supply, traffic, housing and services for labours.
- Possible spills or accidents resulting from use of hazardous materials such as in blasting.
- Response actions in case of accidents or unforeseen events.

c) **Operation and Maintenance Plan.** A draft operation and maintenance plan - or a code of maintenance practice - should be prepared. The plan/code of practice should describe maintenance procedures and assign responsibilities in relation to regular maintenance, emergency response actions, supervision, financing, monitoring and reporting. Institutional capacity for implementing the plan should be reviewed and training needs assessed.

d) **Environmental Monitoring.** A monitoring programme covering the construction phase as well as the operation phase of the road should be prepared, including assignment of responsibilities and an implementation schedule. The monitoring programme should make sure that the proposed mitigation plan are
implemented by the agencies or companies that are in charge of road construction and road maintenance.

e) Environmental Training. An implementation plan for environmental training of planners, designers and road workers should be prepared in accordance with the findings of the training needs assessment.

f) Estimated Costs. The costs and/or savings from the proposed mitigation plan should be estimated. (In a number of instances, the maintenance costs of not constructing proper retention walls and road drainage systems will exceed the investment costs of these constructions. Hence, in a long term prospect, such mitigation measures result in net savings.)

6 Report Format

The EIA report should include a non-technical executive summary and a technical part supplemented with relevant annexes.

6.1 Executive Summary

The EIA report should include a precise, non-technical description of significant findings and recommendations, including (reference to) relevant maps, photos and figures.

6.2 Technical EIA Report

The technical component of the EIA report should include the following sections:

a) Project Description. The project description should cover both the proposed project and alternatives considered. The description should be at a level of detail that provides adequate background information for comparison and ranking of project alternatives. At a minimum, the project description should include the following information:
   - Location of the road.
   - Length and width of the road.
   - Brief summary of topography (slope gradient), geology and land use along the proposed route.
   - Technical design of the road. Special attention should be paid to road drainage and to supporting structures to safeguard against soil erosion and landslides.
   - Accessory constructions and activities (quarries, disposal of excess material, temporary roads, workers' camps etc.).
   - Resource demands.
   - Construction Plan, including construction technology.

b) Review of Policy and Legislative Framework. This section should review the policy and legislative framework relating to the project.
c) **Baseline Information.** This section should contain a description of the existing environment situation based on field investigations complemented with available literature, maps, etc. Quantification should be made whenever possible. Documentation from the field investigations should be presented here or be put into an annex of the report.

d) **Assessment of Impacts.** This section should describe and assess significant potential environmental impacts of the proposed project and project alternatives.

e) **Comparison of Alternatives.** This section should compare and rank project alternatives.

f) **Mitigation Plan.** This section should present a mitigation plan with findings and recommendations based on the impact assessment.

### 7 Reporting and Timing

A draft report should be prepared by the proponent and reviewed by the Zhemgang Dzongkhag/ISDP, the NEC, the GYT, the DYT and possibly other relevant institutions to be selected by the NEC.

Six copies of the draft final report should be submitted to the NEC for comments and approval by the NEC not later than two weeks after the completion of the review of the draft report. Similarly four copies should be submitted to Zhemgang Dzongkhag/ISDP for comments.

The NEC will submit its comments to the Zhemgang Dzongkhag/ISDP within two weeks after receipt of the draft final report.

Ten copies of the final report should be submitted to the NEC not later than three weeks after receipt of comments from the NEC on the draft final report. Similarly, ten copies should be submitted to Zhemgang Dzongkhag/ISDP

### 8 Background Information

**Background Information from Zhemgang Dzongkhag:**

- Integrated Socio-economic Scenario, 8th FYP
- Socio-economic Baseline Survey, 1994
- Natural Resources Inventory, July 1995
- Grain, Money and Labour, April 1996
- Slowly Getting Strong (Economic Development), January 1996
- Energy Study, December 1995

**Background Information from the NEC:**

- Environmental Impact Assessment Guidelines for Bhutan, National Environment Commission, 1993
REPORT ON THE STABILITY OF THE SLOPES ALONG DAKPAI- BULI FEEDER ROAD

By

Yeshi Dorji, Sr. Geologist

Abstract:

The study along the Feeder Road has been carried out in connection with the EIA on a qualitative basis from 26th November,97 to 28th November,97. During the study a traverse was made along the alignment up to Tali and then the rest of the traverse was done along the track due to the limited time. The rock types encountered along the alignment of Dakpai-Buli Road are Phyllites, garnetiferous mica schist and the granite geniuses. The rocks in the Dakpai area are Phyllites, which are highly fractured and would make the slope unstable. The same types of rocks continue till Chhudugang Chu. On crossing the Pramdogang Chuo garnetiferous mica schist have been encountered. This looks to be massive and competent. Beyond Chhudugang Chuo gneiss is encountered which seem to be massive. The vegetation from Dakpai to Buli is dense mixed forest and the trees show no instability.

The remedial measures proposed are to provide breast walls at Dakpai and re-grade the slope, cut and fill to be adopted where ever the slopes are steep and biostabilisation measures be carried out in the areas where benching, re-grading of slopes are taken up.

Introduction:

As per the intimation from Karma Jimba, EIA consultant a preliminary study on the stability of Dakpai-Buli Road has been carried out from 24th to 29th November 1997. The actual fieldwork was done from 26th to 28th November 1997. The methodology adopted during the study was a qualitative one, i.e. I) study of the outcrops along the alignment up to 18km and along the track thereafter; ii) study of the vegetation; iii) any old slide zones. A traverse was made along the alignment till Tali and then the traverse was made from along the track. The study was a qualitative one as there was a time constraint.

Geology:

The regional Geology of the stretch of the road mainly falls in the Chekha formation which comprises of garnetiferous mica schist, porphyroblastic sandstone, phyllites, schists, quartzite, marble, calc-silicate and conglomerates. Thimphu Group of rocks, which are gneiss, garnetiferous mica schist, and quartzite, underlying the Chekha formation.
The local geology of the area is mainly phyllites and garnetiferrous mica schist of Chekha formation till Chhudugang Chu and gneiss of Thimphu Group Rocks from Chudugang Chu to Buli. The phyllites in Dakpai area are highly fractured and there are at least four sets of joints, which are 70°/64°, 40°/237°, 85°/345° and a foliation of 37°/256°. Garnetiferrous mica schist is intercepted between orange orchard and Chuduigang Chu. This is massive in nature with persistent bedding joints. They are fine grained in nature. The gneiss has been encountered between Chuduigang Chu and Buli. The gneiss seems to be very sound along the track. There was a stretch of about 50m of weathered gneiss along the track, which is basically sandy silt. The gneiss is medium grained to coarse grained.

Observations:

During the study it has been observed that the stretch between 0 to 250m have been found to be unstable and requires retaining structures and regrading as the rocks exposed are highly fractured. The stretch after that had a thick vegetation cover and seems to be stable as the trees do not show much of bending and also they are well nourished.

The zone after the orange orchard has been observed to make of colluvial materials which seems to be stable at the moment. The foot track does not show any failure in the zone. However since the slope is well over 45° it would be problematic during the excavation and care should be taken to cut benches so that the slope remains stable.

After this stretch garnetiferrous mica schist has been observed to be massive and less problems have been foreseen. The bridge over Pramdogang Chuo has its abutments on the schist which looks sound but the left bank forms the dip slope. It should be noted that no joints should window in the excavated face. If the joints windows in the cut face then it should be observed and if unstable rock bolts should be provided.

The stretch beyond Tali run through a steep gorge and the foot track runs just below the crown of the slide. However the material deposited on top of it does not to be much and the rock is competent rock excavation with controlled blasting will not create any problem.

There is a zone of talus, which is around 250m. The slope could be unstable and using minimum blasting should carefully do excavation in such an area. However the angle of repose for such a zone is around 45° and has a very good permeability thereby creating less problem of instability.

The road section after Bulila seems to be running through gneiss and a weathered zone of gneiss. Presently the area seems to be stable but during the construction or trace cutting if the Roads Department foresees any problem they should intimate the undersigned to do a study along the stretch. There are few slides observed but they seem to be small or medium slide, which could be stabilized by providing retaining, structures.

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**Recommendations:**

The remedial measures and construction practices to be carried out are

- A breast wall be provided in Dakpai area and re-grade the slope to 45°.
- Between the orange orchard and around 200m towards Kikhar benches are constructed.
- Rock bolts if required be provided on the left bank of Pramdogang Chu. The blasting be done in two stages with a pre-split face and then the main blasting so that no fractures will be propagated in the main rock body.
- Cut and fill techniques are be adopted for stretches where the slope is pretty steep.
- In the gullies proper catchment be calculated and culverts be designed.
- Bio-stabilization be carried out in the areas where benching and re-grading of slopes have been taken up.