## 9.3 Environmental Monitoring Plan

### 9.3.1 Monitoring

There will be no disturbance of the riverbed during bridge construction. However, from an environmental point of view, it is necessary to confirm that silty water will not be discharged into the river, especially in winter. This monitoring should be carried out by photographic survey during the period in which there is the greatest likelihood of silty water discharge from construction. The construction supervisor will be charged with the responsibility of this monitoring. Environmental monitoring plans for other environmental factors are not specifically necessary, as the construction plan already includes careful consideration of environmental problems.

### 9.3.2 Maintenance

There will be no environmental problems of the construction of the bridge, because maintenance of the bridge (repainting and cleaning around bearings, etc.) will be performed by the PWD in accordance with the proposed items and schedule.

## 9.4 Mitigation of Environmental Impact

Electric generators should be placed as far as possible from settlements. As described in section 9.2.2, "Environmental Impact Assessment", construction noise will not be a severe problem. However, reaction to noise pollution depends on local attitudes toward the construction. Thorough explanation of the construction schedule is thus vital to gain the cooperation of villagers. The construction supervisor will be charged with this responsibility. Environmental mitigation plans for other environmental factor are not specifically necessary, as the construction plan already includes careful consideration of environmental problems.

# CHAPTER 10
# IMPLEMENTATION PLAN

# CHAPTER 10 IMPLEMENTATION PLAN

## 10.1 General

The Public Works Division (PWD) of the Ministry of Communications is the only body responsible for roads and oversees all aspects of the Bhutanese roads network (Planning, construction, operating, maintenance, safety works, etc.).
The administrative structure of the PWD is described in detail in Chapter 3.
The order of implementation plan by international tendering is as follows:

(1) Selection of consultants for detailed design
(2) Completion of detailed design
Following contract of consulting services, the detailed design will be performed in which design drawings and tender documents are prepared by the consultants.
(3) Selection of supervisory consultants
Supervisory consultants will be selected to assist the tender procedure and supervise the construction works.
(4) Tendering stage by PWD with consultants
(5) Tender evaluation
(6) Selection of contractor
(7) Construction

## 10.2 Implementation Plan

Implementation plan for construction stage by international tendering is shown in Figure 10.1.
The schedule of main stage of implementation is as follows:

- Selection of consultants for detailed design
- Completion of detailed design : 8 months after selection of consultants
- Selection of consultants for supervision : 3 months after completion of detailed design
- Selection of contractor : 9 months after Completion of detailed design
- Completion of land acquisition : 9 months after completion of detailed design
- Commencement of construction : 9 months after completion of detailed design
- Completion of construction : 28 months after commencement of construction

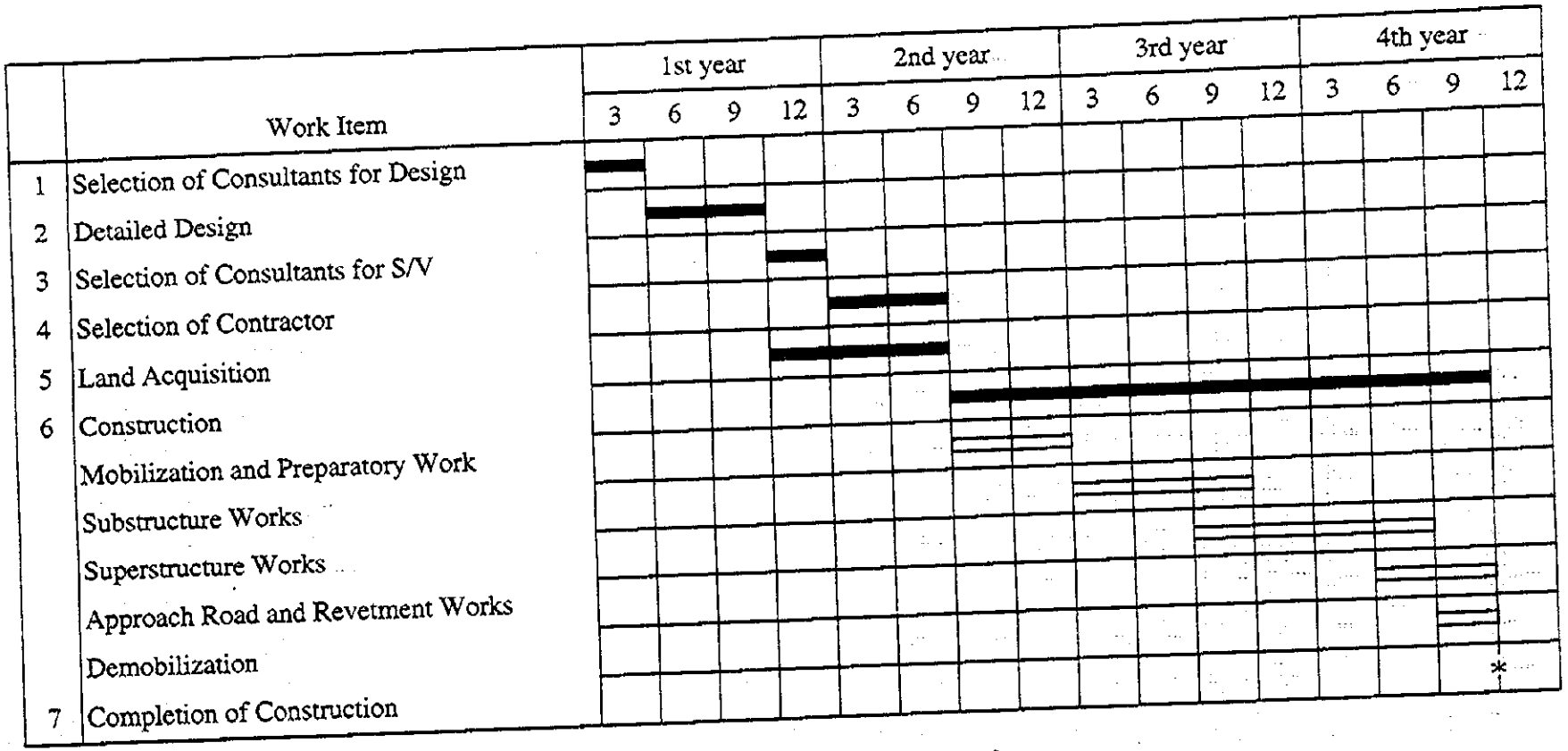


Figure 10.1 Implementation Schedule
(International Competitive Bid Procedure)

Construction work can be roughly divided into preparation work and construction of each bridge. Preparation work following the construction contract consists of procurement and transport of materials and equipment, and construction of the temporary structures at the sites. Each bridge construction work consists of the preparation work, removal of existing bridge, foundation work, substructure work, superstructure work, approach road and revetment work.

The rainy season in the sites extend from June to September. Heavy rainfalls in July and August. Therefore, a work arrangement considering accessibility to the sites and efficiency of the site works should be required during these periods.

# CHAPTER 11
# ECONOMIC AND SOCIAL EVALUATION

# CHAPTER 11 ECONOMIC AND SOCIAL EVALUATION

## 11.1 Economic Evaluation

### 11.1.1 Basic Concept

In this section, the cost of the Project Bridge, expressed in terms of economic cost, is evaluated by the benefit which accrues from the Project, which is also expressed in economic cost.

Cost of the Project Bridge here is obtained through some modification of cost estimated in Chapter 8.

In general, benefit estimates for road users is studied based on the savings of vehicle operating cost (VOC) and travel time. Time saving benefit is generally defined that it is income increase which can earn income from another job opportunities by using the saved travel time. However, the industrial structure in Bhutan is mainly agriculture at present, and the existing economic situations are not as bringing about many job opportunities. Accordingly, the benefits based on the travel time saving would be difficult to be estimated in Bhutan. Taking account of the above situations, the benefit estimate in this Study will be taken only savings in VOC into account.

The work flow of the economic evaluation is illustrated in Figure 11.1.

In general, three types of indicators are used for the economic evaluation of bridge construction project; Internal Rate of Return (IRR), Net Present Value (NPV), Cost Benefit Ratio (CBR). Each indicator is explained as below.

IRR is calculated through the solution of the following equation:

$$B(r) - C(r) = 0$$

$$B(r) = \sum_{t=1}^{n} \frac{Bt}{(1+R)^t}$$

$$C(r) = \sum_{t=1}^{n} \frac{Ct}{(1+R)^t}$$

This indicator shows the discount rate which gives the break even point between the present value of benefit and that of cost in the stream of these values during the period of project life.

NPV indicates the balance between the discounted benefit and cost under the assumed discount rate. Consequently, a positive value of this indicator means the project is economically feasible. NPV is calculated through the solution of the following equation:

$$NPV = B(r) - C(r) = \sum_{t=1}^{n} \frac{Bt}{(1+r)^t} - \sum_{t=1}^{n} \frac{Ct}{(1+r)^t}$$

Moreover, CBR is an indicator obtained by dividing the present value of benefit by that of cost:

$$CBR = B / C$$

$$B = \sum_{t=1}^{n} \frac{Bt}{(1+r)^t}$$

$$C = \sum_{t=1}^{n} \frac{Ct}{(1+r)^t}$$

where, R : Internal Rate of Return
Bt : Benefit in the year(t)
Ct : Cost in the year (t)
n : Project life in year
r : Discount Rate

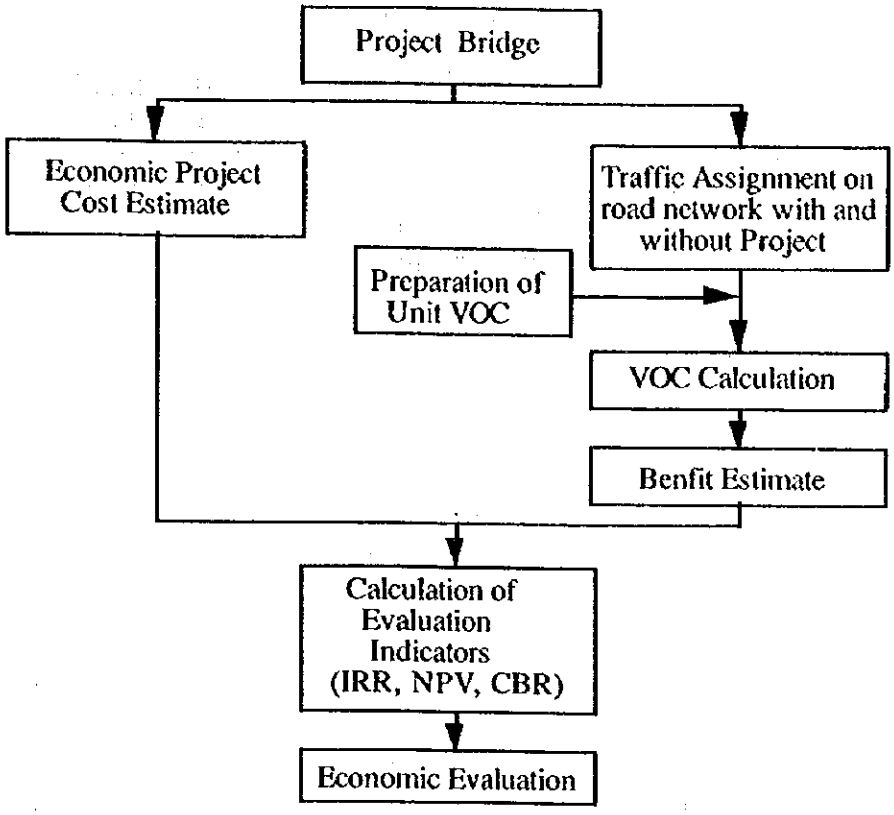


Figure 11.1 Work Flow of Economic Evaluation

### 11.1.2 Estimates of Economic Project Cost

In general, the economic cost is adopted as the project cost for study on economic evaluation. The economic cost is cost which taxes and duties are deducted, and land acquisition cost is deducted from the project cost, and portion of price escalation is deleted.

(1) Implementation Schedule and Cost Disbursement

Cost disbursement schedule is one of the greatest factors which affect the results of economic evaluation.

The implementation schedules and cost disbursements based on the project costs and construction schedule estimated in Chapter 8 and Chapter 10 are listed in Table 11.1.

Table Cost Disbursement

(1000 Nu.)

| | | 1999 | 2000 | 2001 | 2002 | Total |
|---|---|---|---|---|---|---|
| No. 1 Kurizampa | Construction | 0 | 54,885 | 36,590 | 0 | 91,475 |
| | D/D | 3,132 | 0 | 0 | 0 | 3,132 |
| | S/V | 0 | 4,293 | 4,293 | 954 | 9,540 |
| | Sub-total | 3,132 | 59,178 | 40,883 | 954 | 104,147 |
| No. 2 Chamkar Zam | Construction | 0 | 50,217 | 27,040 | 0 | 77,257 |
| | D/D | 3,132 | 0 | 0 | 0 | 3,132 |
| | S/V | 0 | 4,293 | 4,293 | 954 | 9,540 |
| | Sub-total | 3,132 | 54,510 | 31,333 | 954 | 89,929 |
| No. 3 Bjee | Construction | 0 | 0 | 52,670 | 22,573 | 75,243 |
| | D/D | 3,132 | 0 | 0 | 0 | 3,132 |
| | S/V | 0 | 4,293 | 4,293 | 954 | 9,540 |
| | Sub-total | 3,132 | 4,293 | 66,963 | 23,527 | 87,915 |
| No. 4 Wachy Zam | Construction | 0 | 0 | 29,743 | 44,615 | 74,358 |
| | D/D | 3,132 | 0 | 0 | 0 | 3,132 |
| | S/V | 0 | 4,293 | 4,293 | 954 | 9,540 |
| | Sub-total | 3,132 | 4,293 | 34,036 | 45,569 | 87,030 |
| No.5 Mangdichu | Construction | 0 | 75,430 | 113,145 | 0 | 188,575 |
| | D/D | 8,353 | 0 | 0 | 0 | 8,353 |
| | S/V | 0 | 4,293 | 4,293 | 954 | 9,540 |
| | Sub-total | 8,353 | 79,723 | 117,438 | 954 | 206,468 |
| Total | Construction | 0 | 180,532 | 259,188 | 67,188 | 506,908 |
| | D/D | 20,883 | 0 | 0 | 0 | 20,883 |
| | S/V | 0 | 21,464 | 21,464 | 4,770 | 47,698 |
| | Sub-total | 20,883 | 201,996 | 280,652 | 71,958 | 575,489 |

Note 1: Construction --- Construction Cost, D/D --- Detailed Design Cost, S/V --- Supervision Cost
Note 2: The construction cost of No. 4 Wachy Zam Bridge includes the land acquisition cost for paddy field.

(2) Maintenance Cost

The maintenance costs after the opening of the Project Bridges are as follows based on section 12.4 in Chapter 12:

Table 11.2 Maintenance and Operation Costs

(unit: Nu.)

| | Inspection (Every Year | Periodical Maintenance (Every Year | Repainting (Once/7 years) | Repaving (Once/5 years) |
|---|---|---|---|---|
| No. 1 Kurizampa | 10,000 | 60,000 | 1,044,000 | 211,000 |
| No. 2 Chamkar Zam | 10,000 | 60,000 | 965,000 | 472,000 |
| No. 3 Bjee | 10,000 | 60,000 | 944,000 | 196,000 |
| No. 4 Wachy Zam | 10,000 | 60,000 | 900,000 | 232,000 |
| No. 5 Mangdichu | 25,000 | 150,000 | 2,858,000 | 587,000 |
| Total | 65,000 | 390,000 | 6,711,000 | 1,698,000 |

### 11.1.3 Estimates of Vehicle Operating Cost (VOC)

(1) Characteristics of VOC

Vehicle operating costs consist of the costs in proportion to running distance and running time. The costs in proportion to running distance (vehicle running cost) are composed of fuel consumption, lubricating oil consumption, tire and tube consumption and repair/maintenance cost (parts and labor cost). The costs in proportion to running time (fixed cost) are composed of depreciation and capital cost, crew cost and overhead. The level of VOC tends to differ by vehicle type, model of vehicle, driving speed and many other factors relative to driving conditions.

In the Study, only vehicle running cost as VOC will be taken into consideration, as it will be easy to understand practically for road users.

(2) Unit VOC

Unit VOC in terms of economic cost is estimated by vehicle type on the information gathered by the Study Team for each item of cost. Unit VOC under the actual driving conditions in Bhutan is estimated as shown in Table 11.3 based on the information listed in Table 11.4.

Table 11.3 Unit Vehicle Operating Cost

( Unit : Nu. / Km )

| | Fuel | Lubricant | Tire | Repair | Total |
|---|---|---|---|---|---|
| Scooter | 0.800 | - | 0.068 | 0.225 | 1.093 |
| Light Vehicle | 0.896 | 0.008 | 0.493 | 0.993 | 2.390 |
| Bus | 1.344 | 0.119 | 4.590 | 2.961 | 9.014 |
| Truck | 1.536 | 0.329 | 4.533 | 1.535 | 7.933 |

Source : Study Team

Note: Unit VOC of "Light Vehicle" was calculated based on Land Cruiser and Hilux (pick-u type).
Unit VOC of "Bus" was calculated based on Tata Bus (42 seats).
Unit VOC of "Truck" was calculated based on Tata Truck (10t).

## Table 11.4 Basic Information for Calculation of Unit VOC

(Prices)

| | | Selling Price | Bhutan Sales Tax (BST: %) |
|---|---|---|---|
| Vehicle Cost (Nu.) | | | |
| | Scooter | 26,530 | 15 |
| | Marti Van | 217,347 | 20 |
| | Omni Van | 191,329 | 20 |
| | Land Cruiser | 1,050,000 | 20 |
| | Pick-up | 527,000 | 20 |
| | Tata Bus (42 seats) | 871,000 | 15 |
| | Tata Truck (10t) | 650,000 | 15 |
| Tire Cost (Nu.) | | | |
| | Scooter | 400 | 15 |
| | Marti Van | 1,434 | 15 |
| | Omni Van | 1,434 | 15 |
| | Land Cruiser | 4,357 | 15 |
| | Pick-up | 4,357 | 15 |
| | Tata Bus | 9,000 | 15 |
| | Tata Truck | 8,000 | 15 |
| Fuel Cost (Nu./l)---average | | | |
| | Petrol | 23.34 | 5 |
| | Diesel | 11.08 | 3 |
| Lubricants Cost (Nu./l) | | | |
| | Gear Oil | 60 | 5 |
| | Grease | 80 | 5 |

(Fuel Consumption )

| | Plain section (Km/l) | Mountainous section (Km/l) | Using Fuel |
|---|---|---|---|
| Scooter | 32 | 25 - 30 | petrol |
| Car (various Toyota models) | 13 - 18 | 9 - 14 | diesel |
| Taxi (Marti Van) | 12 - 17 | 10 - 16 | petrol |
| Land Cruiser | 14 - 16 | 12 - 14 | diesel |
| Pick-up (Hi-lux) | 14 - 16 | 9 - 14 | diesel |
| Bus | 8 - 15 | 6 - 9 | diesel |
| Light Truck | 8 - 14 | 6 - 8 | diesel |
| Heavy Truck | 8 - 14 | 6 - 8 | diesel |

(Repair & Maintenance Cost)

- 5% of vehicle cost for scooter, light vehicle and truck
- 20% of vehicle cost for bus ( long distance operation )

(Utilization)

| | Km per year |
|---|---|
| Scooter | 5,000 |
| Light Vehicle | 20,000 |
| Bus | 50,000 |
| Truck | 18,000 |

(Life of New Tire)

| | Km per tire |
|---|---|
| Scooter | 10,000 |
| Light Vehicle | 20,000 |
| Bus | 10,000 |
| Truck | 9,000 |

Source : Study Team

### 11.1.4 Benefit Estimates

The density of existing trunk road network in Bhutan is very low. Accordingly, when a section of the network is closed temporarily by disaster or traffic accidents, the road users are compelled to make a long detour. In case of the collapse of any of existing bridges, the same situations will be generated, and road users will suffer many inconveniences. Moreover, since the passage of heavy vehicles on the old bridges outliving their design life along the national highway network is regulated at present, the smooth freight movements are obstructed and the economic activities in Bhutan are restricted.

Taking the above mentioned conditions in consideration, benefit calculation is carried out as the comparison of vehicle operating cost under the trunk road network "with" the Project Bridges and that of under the trunk road network "without" the Project Bridges. That is to say, the benefit calculations in this Study are estimated as the comparison between the case "with" the traffic regulation for heavy vehicles as same conditions at present (heavy vehicles will be compelled to make a long detour.) and the case "without" the traffic regulation for heavy vehicles as a result of construction of the selected five (5) bridges.

The actual method of benefit calculation is as follows:

- The basic road network for the benefit calculation is the network including a section of Indian national highway which is the alternative route of the east-west national highway in Bhutan (see Figure 4.4 in Chapter 4).

- Taking account of the locations of five (5) Priority bridges Bridges for replacement between central towns in each district, the vehicle operating costs for each case of "with" and "without" Project Bridges are calculated. In short, the cases for benefit estimates are as follows:

  Case 1 "with" and "without" No. 1 Kurizampa Bridge and No. 2 Chamkar Zam Bridge between Jakar (Bumthang) and Gangola (Mongar), provided that the other Project Bridges are constructed.

  Case 2 "with" and "without" No. 3 Bjee Bridge and No. 4 Wachy Zam Bridge between Wangdue Phodrang and Trongsa, provided that the other Project Bridges are constructed.

Case 3 "with" and "without" No. 5 Mangdichu Bridge between Zhemgang and Gelephu (Sarpang), provided that the other Project Bridges are constructed.

- Benefit estimates are calculated based on the difference of two vehicle operating costs between "with" and "without" Project.

Based on the above mentioned method, the results of benefit estimates by case and year are listed in Table 11.5.

Table 11.5 Estimated Benefit

( Unit : Million Nu. / Year )

| | 2000 | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|
| Case 1 (Kurizampa & Chamkar Zam) | 18.91 | 21.98 | 28.37 | 35.67 | 38.74 |
| Case 2 (Bjee & Wachy Zam) | 46.84 | 55.59 | 70.26 | 84.69 | 95.25 |
| Case 3 (Mangdichu) | 11.03 | 13.25 | 16.20 | 19.10 | 20.61 |

11.1.5 Economic Analysis

In this section, the relatively economic priority of the Priority bridges is analyzed by the indicators explained in 11.1.1.

Premises for economic analysis are assumed as follows:

- Implementation schedule and cost disbursement
  The implementation schedules and cost disbursements are as shown in Table 11.1.
  The Maintenance costs are as shown in Table 11.2.
- Project life for economic analysis
  Project life of 30 years, after the opening of the Project Bridges, is assumed.
- Annual increasing rate of benefits
  Annual benefits after the opening of the Project Bridges are assumed as follows:
  until 2020 --- applied annual average growth rate of every five years
  after 2020 --- applied annual average growth rate from 2015 to 2020
- Discount rate
  Discount Rate 15% are assumed corresponding to the present long term interest rate in Bhutan.

The results of three indicators for economic evaluation (IRR, NPV, CBR) based on the economic cash flows (see Appendix-K) are shown in Table 11.6.

From results of economic analysis, the economic indicators for Case 2 (including No. 3 Bjee and No. 4 Wachy Zam Bridges) become relatively high, and it is judged that Case 2 is feasible. The economic indicators for Case 1 (including No. 1 Kurizampa and No. 2 Chamkar Zam Bridges) and Case 3 (including No. 5 Mangdichu Bridge) are low, due to the relatively low traffic demand and high cost of No. 5 Mangdichu Bridge.

Table 11.6 Results of Economic Analysis

| | IRR (%) | NPV (in Million Nu.) | CBR |
|---|---|---|---|
| Case 1 (Kurizampa & Chamkar Zam) | 11.6 | - 46.1 | 0.72 |
| Case 2 (Bjee & Wachy Zam) | 28.2 | 161.9 | 2.25 |
| Case 3 (Mangdichu) | 6.2 | - 102.4 | 0.40 |

Note : NPV and CBR under discount rate 15%

### 11.1.6 Sensitivity Analysis

Sensitivity analysis is to confirm the stability on feasibility of the project through the fluctuations of results based on calculations by using the corresponding values to the uncertainty of some factors for economic analysis. In general, the fluctuation factors in sensitivity analysis on highway/bridge development projects are as traffic demand, construction costs, maintenance costs and so on. The analysis in this Study was conducted for the conceptual cases in which different levels of benefit and cost were assumed as follows.

(1) Project cost + 10%
(2) Project cost - 10%
(3) Two years delay of timing of the project implementation

The results are shown in Table 11.7. From the results of sensitivity analysis, the fluctuations of IRR indicators through the calculations based on the above assumptions are 10.7 - 12.6% in Case 1, 26.3 - 30.5% in Case 2 and 5.5 - 7.0% in Case 3.

Table 11.7 Results of Sensitivity Analysis

| | | IRR (%) | NPV (in million Nu.) | CBR |
|---|---|---|---|---|
| Case 1 | Original | 11.6 | - 46.1 | 0.72 |
| | Cost - 10% | 12.6 | - 29.9 | 0.80 |
| | Cost + 10% | 10.7 | - 62.2 | 0.65 |
| | Two years delay | 12.3 | - 27.9 | 0.77 |
| Case 2 | Original | 28.2 | 161.9 | 2.25 |
| | Cost - 10% | 30.5 | 174.7 | 2.50 |
| | Cost + 10% | 26.3 | 149.1 | 2.05 |
| | Two years delay | 28.5 | 127.2 | 2.27 |
| Case 3 | Original | 6.2 | - 102.4 | 0.40 |
| | Cost - 10% | 7.0 | - 85.7 | 0.44 |
| | Cost + 10% | 5.5 | - 119.1 | 0.36 |
| | Two years delay | 6.6 | - 74.1 | 0.42 |

Note : "Original" is the results of economic analysis.

### 11.1.7 Economic Analysis on Combinations of Project Bridge Construction

In this section, the economic analysis on the combinations of the Priority bridges construction is carried out, and the results are referred to a decision of the combination of Project implementations.

The studied combinations are as follows:

Combination 1 --- All Priority bridges (No. 1 ~ No. 5)
Combination 2 --- No.1 Kurizampa Bridge, No.2 Chamkar Zam Bridge, No.3 Bjee Bridge and No.4 Wachy Zam Bridge on the National Highway Route No. 1
Combination 3 --- No.1 Kurizampa Bridge, No.2 Chamkar Zam Bridge and No.5 Mangdichu Bridge
Combination 4 --- No.3 Bjee Bridge, No.4 Wachy Zam Bridge and No.5 Mangdichu Bridge

Premises for economic analysis in this section are assumed as follows:

(a) Cost disbursement

The same as the above mentioned.

(b) Benefit estimates

In case of "without" all project bridges, the above mentioned premise for benefit estimates can not apply, because the detours for the heavy vehicle O-D pairs of zone C (Bumthang), H (Trongsa) and I ( Zhemgang) concerned do not exist. Accordingly, the benefit estimates are based on the following premise:

"In the case "with" priority bridges, the passage of heavily laden vehicles is not regulated. On the other hand, in the case "without" priority bridges, the loads are divided and transported by two (2) heavy vehicles, because fully loaded heavy vehicles with a load capacity of eight (8) tons, which are generally used in Bhutan, cannot pass on account of the limitation of load capacity on the existing bridges. In this case, the required heavy vehicles for freight transportation are estimated by applying 48.6% (excluding the observation values at the survey stations in highway sections including the Project Bridges) as percentage of heavy laden vehicle traffic volumes on the results of roadside O-D survey. That is to say, in the case "without", the heavy vehicle traffic volumes increase with the result that heavy vehicle operating costs increase." (see Appendix-K)

Based on the above premise, the results of benefit estimates by combination and year are listed in Table 11.8.

Table 11.8 Estimated Benefit by Combination and Year

(Unit : Million Nu./Year)

| | 2000 | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|
| Combination 1 | 38.78 | 45.95 | 58.05 | 69.75 | 77.28 |
| Combination 2 | 24.07 | 28.65 | 36.11 | 43.58 | 48.65 |
| Combination 3 | 10.90 | 12.70 | 16.25 | 19.47 | 21.06 |
| Combination 4 | 22.14 | 25.87 | 33.11 | 39.48 | 43.49 |

(c) The other premises are same as the above mentioned.

The results of three indicators for economic evaluation (IRR, NPV and CBR) based on the economic cash flows (see Appendix-K) are shown in Table 11.9.

Table 11.9 Results of Economic Analysis by Combination

| | IRR (%) | NPV (in million Nu.) | CBR |
|---|---|---|---|
| Combination 1 | 8.4 | - 222.5 | 0.52 |
| Combination 2 | 8.3 | - 143.1 | 0.51 |
| Combination 3 | 1.7 | - 265.8 | 0.20 |
| Combination 4 | 7.0 | - 171.1 | 0.44 |

Note : NPV and CBR under discount rate 15%

From the results of economic analysis by combination, the indicator IRR and CBR of Combination 1 (implementation of all priority bridges) and Combination 2 (implementation of No.1 ~ No.4 bridges) are relatively high. That is to say, from the viewpoint of national economy, the implementation of project bridge construction is very positive.

## 11.2 Impacts on Economic and Social Development

The socioeconomic importance of road construction projects including bridge development is largely attributed to multiplier effects to the economic and social activities. The positive effects estimated in the previous section are only part of them, called "direct effects". There are many other "indirect effects". Indirect effects are quite important in a sense, that not only road improvement, but also safe and reliable bridge development give an impetus to regional development in many aspects of economic and social activities.

In this respect, the indirect effects which would be brought about by the projects should be carefully fostered and utilized so as to direct them for the further development of the nation.

The safe and reliable national highway network will be strengthened by implementation of Project for national highway bridge construction in this Study. The expected indirect effects which will be brought about by this are as follows:

(Transport Service)
Road transport in Bhutan remains the only mode of travelling and freight movement within the country and to the neighboring Indian states. Accordingly, the implementation of the Project will provide adequate and efficient passenger transport service, and ensure the safety, convenience and comfort of passengers. At the same time, it will contribute to speedy and smooth freight movement.
Especially, since the National Highway Route No. 1 is only East-West highway which connects western and eastern regions in Bhutan, this route development which ensures the safety and reliability of the road transportation will greatly influence socioeconomic activities. Moreover, the improvement of reliability on the only four North-South highways which connect the East-West highway to India, during roughly 300 Km east to west, will bring about more benefit for the Bhutanese economy, which keeps close relations with the Indian economy.

In accordance with the above viewpoint, it is expected that the replacements (new constructions) of selected five bridges having the strict load capacity limitation need to be implemented immediately.

(Education)

The implementation of the Project will contribute to provide the residents for the safe and reliable accessibility to educational facilities in and around the project bridges. Especially, the constructions of new Kurizampa, Chamkar Zam and Mangdichu Bridges near which primary and junior high schools exist will provide the residents for many benefits.

(Health Service)

The ability of health service teams to provide timely service will be improved by the availability of reliable transport. This would be more so when a team must respond to an emergency such as road traffic accidents or when a critically ill patient must be moved to a higher level care center.

The replacements of selected five (5) bridges near the district hospitals which are the first level referral institutions and are equipped to provide curative, promotive, preventive and emergency services will be required without delay.

(Postal Service)

The Project will contribute to prompt, efficient and economical postal services to all parts of the country through a more effective mail transport network.

(National Development)

Infrastructure is viewed as a prerequisite for starting any development in the country. A well spread and good infrastructure would enhance development by increasing efficiency of economic activities and the delivery of services.

Development of infrastructure is particularly difficult in Bhutan due to scattered and sparse pattern of human settlement brought about by mountainous and rugged terrain. Moreover, as there are constraints on freight movement and access to markets on account of load capacity limitation of the existing bridges, the economic activities and industrial developments in the whole country are restricted, especially in the central region including Bumthang, Trongsa and Zhemgang Districts. Continued emphasis has been placed on the central region since the launching of planned development in Bhutan.

Accordingly, it is greatly expected that the implementation of the Projects in this Study will mitigate these constraints.

(Improving Quality of Life for the Residents)

In the objectives of the national development plan, measures to improve the quality of life in Bhutan are directed not only to raise the income-earning capacity of the majority of the population, but also to improve access to basic services such as education, health and religion as Buddhism has a significant influence on the values of the Bhutanese and has shaped the institutions, organizations and social structure, and facilities such as clean drinking water, sanitation and communications. It is clear that the implementation of the Projects will contribute to providing the residents with safe and reliable access to basic services and facilities. Figure 11.2 shows a example of the situation of No. 2 Chamkar Zam Bridge and public facilities distribution.

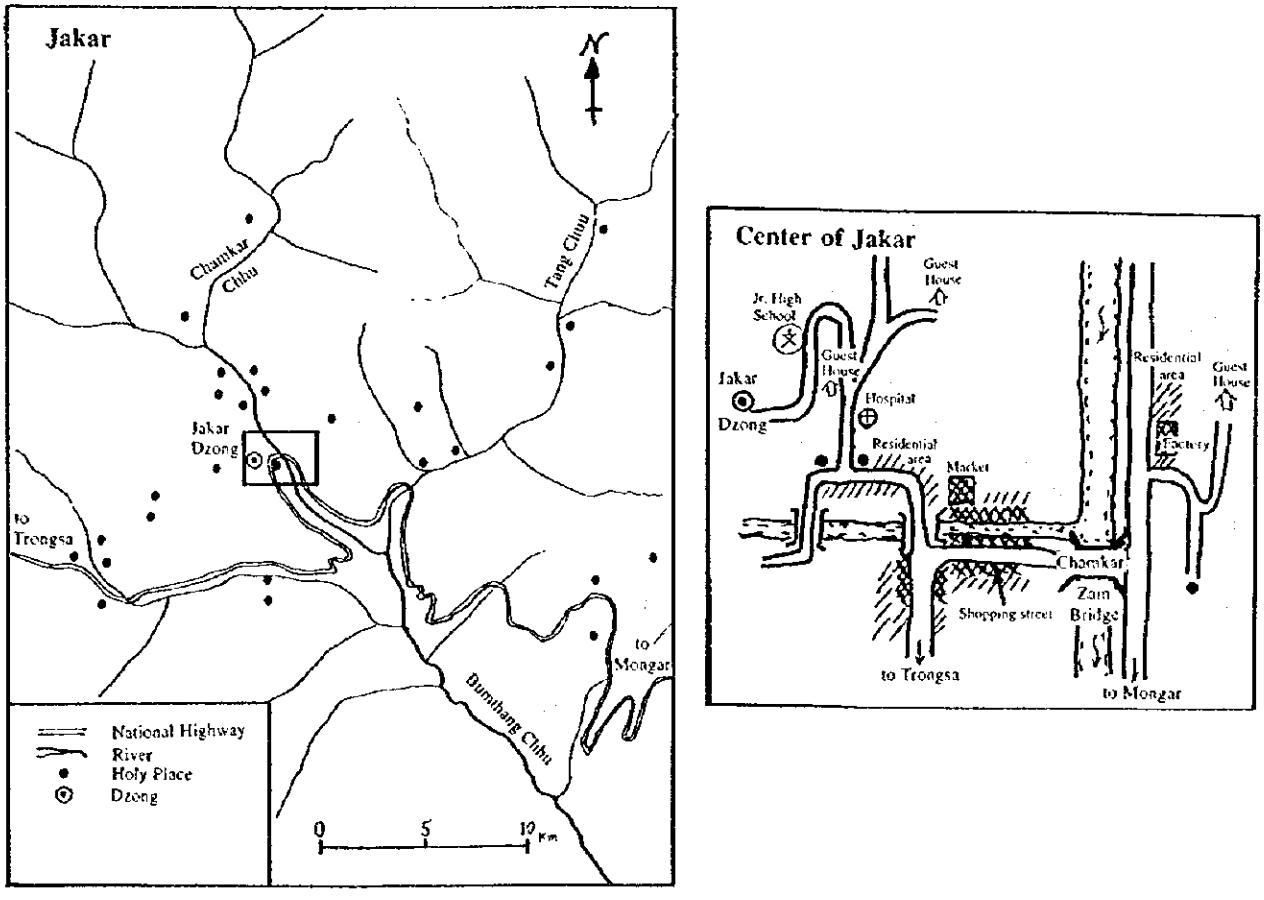


Figure 11.2 Chamkar Zam Bridge and Public Facilities Distribution

# CHAPTER 12
# MAINTENANCE AND OPERATION PLANNING

# CHAPTER 12 MAINTENANCE AND OPERATION PLANNING

## 12.1 Existing System of Maintenance and Operation

Lengths of highways and roads, and also numbers of bridges, administrated by PWD, and existing organization for maintenance and operation of PWD at present are described below.

### 12.1.1 Roads under PWD

| | | |
|---|---|---|
| i) | National Highways | 1,052 km |
| ii) | District Roads | 400 km |
| iii) | Feeder Roads | 441 km |
| iv) | Urban Roads | 86 km |
| | Total | 1,980 km |

The above total includes the following roads which are proposed to be taken over from Project DANTAK.

| | | |
|---|---|---|
| i) | Tashigang - Kurizampa Highway | 113 km |
| ii) | Deothong - Bhangtar Road | 50 km |
| iii) | Sibsoo - Tendu Road | 24 km |

### 12.1.2 Bridges under PWD

In accordance with the Bridge Inventory, August 1997, there are 103 bridges along National Highways, Route Nos.1 to 5, including 30 bridges under DANTAK. Therefore 73 bridges along National Highways are under PWD.

### 12.1.3 PWD Organization related to Bridge Maintenance and Operation

Organization chart is shown in Figure 3.5 of Chapter 3.
Maintenance and operation are undertaken by eight Road Maintenance Divisions.

(1) Technical staff of eight Road Maintenance Divisions

| | | |
|---|---|---|
| i) | Executive Engineer | 8 |
| ii) | Assistant Engineer | 30 |
| iii) | Section Officer | 66 |
| | Total | 104 |

(2) Workers

At present 2,840 persons are employed; however, the number is proposed to be reduced to 1,627 persons.

(3) Capacity

At present eight (8) divisions are capable of constructing 10 km of new road per year and maintaining over 200 km per year.

(4) Inspection

Frequency of Inspection

by Superintending Engineer, once in 2 months
by Executive Engineer, 4 times in a month
by Assistant Engineer, 10 times in a month
by Section Officer, daily

(5) Repair and rehabilitation

Routine maintenance daily
Periodical maintenance at a interval of 4 to 5 years

(6) Budget

For the years 1994 to 1998, the following budget was allocated for maintenance and operation of roads and bridges under PWD.

Unit: Million Nu.

| Fiscal Year | 1994~95 | 1995~96 | 1996~97 | 1997~98 |
|---|---|---|---|---|
| Budget | 75.6 | 100.4 | 113.9 | 98.0 |

Source: PWD,

## 12.2 Maintenance and Operation Plan

Maintenance and operation plan for the priority projects is recommended as follows:

### 12.2.1 Maintenance and Operation System

Maintenance and operation works will be performed by the Road Maintenance Division, which administrates each priority project (bridge).

### 12.2.2 Maintenance and Operation Method

Maintenance and operation work consists of periodical inspection, maintenance and repair, and specific repair (re-painting of steel structure and re-paving of road surface):

(1) Periodical Inspection

Periodical inspection will be made by one engineer from Bridge Cell of PWD headquarters for the five (5) priority bridges, every three months. It takes five days for periodical inspection of 5 bridge per time.

(2) Maintenance and Repair

Maintenance and repair will be performed by Road maintenance Division.
Items to be performed are shown in Table 12.1.

Table 12.1 Maintenance and Operation Schedule

| | Item | Maintenance and Repair | Period |
|---|---|---|---|
| Bridge | Drain Pipe | Cleaning of sediments | 3 months |
| | Expansion Joint | Repairing of metal and sealant | 3 months |
| | Railing | Repairing damages from traffic | 3 months |
| | Bearing | Removal of soil deposit | 6 months |
| | Substructure | Removal of flood deposit | 1 year |
| Approach Road | Pavement | Repairing of cracks and potholes | 3 months |
| | Shoulder | Planting, reinforcement | 3 months |
| | Embankment | Planting, toe reinforcement | 3 months |
| | Slope Protection | Draining | 3 months |
| | Safety Facilities | Repair of safety facilities | 3 months |

Large scale rehabilitation will not be necessary for 20 to 30 years after the completion of bridges. However, it is important to record the results of periodical inspection and conditions of damages to establish the repair schedule and its scale.

(3) Specific Repair

The steel structure is to be repainted once every seven years, and re-paving of bridge surface and approach road surface once every five years.

## 12.3 Maintenance and Operation Cost

Maintenance and operation cost for priority projects (five bridges) will be as follows:

(1) Periodical Inspection

| | |
|---|---|
| Bridge No.1 to No.4: | 10,000 Nu. per year per bridge |
| Bridge No.5 | 25,000 Nu. per year |
| Total | 65,000 Nu. per year |

(2) Maintenance and Repair

| | |
|---|---|
| Bridge No. 1 to No.4 | 60,000 Nu. per year per bridge |
| Bridge No.5 | 150,000 Nu. per year |
| Total | 390,000 Nu. per year |

(3) Repainting (Every seven years)

| | |
|---|---|
| Bridge No.1 to No.4 | 900,0000 to 1,044,000 Nu. per bridge, every seven years |
| Bridge No.5 | 2,858,000 Nu, every seven years |
| Total | 6,711,000 Nu. every seven years |

(4) Re - paving (Every five years)

| | |
|---|---|
| Bridge No,1 to No.4 | 196,000 to 472,000 Nu. per bridge, every five years |
| Bridge No.5 | 587,000 Nu., every five years |
| Total | 1,698,000 Nu. every five years |

Maintenance and operation cost for each bridge is summarized in Table 12.2.

Table 12.2 Maintenance and Operation Cost

| Br. No. | Br. Name | Area of steel (m2) | Area of pavement (m2) | Cost (Nu.) | | | |
|---|---|---|---|---|---|---|---|
| | | | | Inspection | Periodical maintenance | Re-painting | Re-paving |
| 1 | Kurizampa | 2,610 | 703 | 10,000 | 60,000 | 1,044,000 | 211,000 |
| 2 | Chamkar Zam | 2,412 | 1,571 | 10,000 | 60,000 | 965,000 | 472,000 |
| 3 | Bjee | 2,358 | 653 | 10,000 | 60,000 | 944,000 | 196,000 |
| 4 | Wachy Zam | 2,250 | 772 | 10,000 | 60,000 | 900,000 | 232,000 |
| 5 | Mangdichu | 7,146 | 1954 | 25,000 | 150,000 | 2,858,000 | 587,000 |
| Total | | 16,776 | 5,653 | 65,000 | 390,000 | 6,711,000 | 1,698,000 |
| | | | | Every year | Every year | Once/7 years | Once/5years |

For the five priority projects, the cost per annum is as follows:

| | |
|---|---|
| Inspection: | 65,000 Nu. |
| Periodical Maintenance | 390,000 Nu. |
| Re-painting | 959,000 Nu. (6,711,000/7) |
| Re-paving | 340,000 Nu. (1,698,000/5) |
| Total | 1,754,000 Nu. |

PWD's budget for road maintenance for the fiscal year 1997~1998 is 98 Million Nu. Maintenance and operation cost for priority projects (five bridges), 1,754,000 Nu. is 2 per cent of PWD's budget.

# CHAPTER 13
# CONCLUSIONS AND RECOMMENDATION

# CHAPTER 13 CONCLUSIONS AND RECOMMENDATION

## 13.1 Conclusions

All of the bridges constructed along the major national highways within the Project area are temporary structures already having passed their intended life span. Due to this fact, the loads which these bridges are able to bear decreases each year and tighter load restrictions must be enforced. In particular, four (4) bridges along National Highway Route No. 1, which is the only east-west route connecting the nation's cities and towns; and one (1) bridge along National Highway Route No. 4, which is a major connecting route to India, are more than 25 years old and their function as bridges has considerably diminished. Initially built with a design load of 18 tons, there is now a mere 4-ton load restriction being enforced on these bridges. Each year, despite efforts in maintenance, it becomes more and more difficult to deal with problems such as deformation and sagging, elements which lead to serious damage. In light of this situation, this project is in urgent need of administration, the effects of which are indicated in the following:

1) The present road network is of low density and alternative routes are few. Thus, large vehicles are required to make quite long detours due to load restrictions. By mitigating these detours and time incurred therein, the direct beneficial effects on the national economy alone make it evident that this is a project with high potential.

2) Although it is difficult to calculate the exact economic loss incurred in a situation in which a deteriorated bridge collapses, it is assumed to out-balance the economic gain incurred by the new traffic generated along the detour route.

3) By constructing permanent bridges along National Highway Route No. 1, which connects Thimphu with the second largest city Trashigang, besides alleviating restrictions on transportation and contributing to the efforts of the National Development Plan, the improved route will become a symbol of the balanced national development for which the country is striving, as well as being a safe means of linking the east and the west.

4) Through the mitigation of bridge load restrictions, an enlarged market for agricultural products may be merely one result of the improved quality in transportation. In other words, better access will encourage growth of industries

along the routes, with ripple effects on the overall national economy. In particular, the replacement of Mangdichu Bridge on National Highway Route No. 4 and the mitigation of load restrictions will have considerable impact on the development of industries along the route in the central Bhutan Dzongkhags of Trongsa and Zhemgang.

5) Major social impacts resulting from the construction of permanent bridges include access to educational and medical facilities, which will contribute to the social security of the local residents.

13.2 Recommendation

This Project poses no particular technical problems, the positive effects are great, and the concerned agencies are fully capable of administering the Project. Considering the rate of deterioration of the bridges, the Project should be carried urgently.