CHAPTER VI

RESULTS AND DISCUSSION OF RESULTS

This chapter describes how the analysis results were evaluated. The evaluation consisted of an economic analysis of the quantifiable costs and benefits attributable to any improvement atternative and also a comparison between the analysis result of any analysed alternative. A final step in this evaluation was a series of sensitivity tests to determine the effect on the economic analysis results of variation in major input factors.

6.1 Criteria and Condition

The following criteria and conditions were applied in this analysis.

a) The analysis is made under the concept "any alternative must be taken different improvement type and maintenance standard".

b) The alternative costs are comprised of construction cost and maintenance cost.

c) The alternative benefit are comprised of road users' benefit and agricultural benefit (or value added benefit).

d) The period of quantification of costs and benefits is taken for 16 years from commencing of road construction.

e) Valuation of costs and benefits is made at both of financial and economic component of prices.

f) Evaluation is made under the criterion of Net Present Value, Internal Rate of Return and First Year Benefit (hereinafter called NPV, IRR and FYB respectively).

g) Present values of costs and benefits are calculated with a discount rate of 12 percent per annum to the present values in 1981, the year when the construction of the road will commence.

h) The alternative is judged most economically justifiable, if it has a highest positive net present value.

6.2 Alternative Costs Calculation

Five types of cost are used by the HDM model in the economic analysis. The derivation of these costs are described respectively as follow:

6.2.1 Construction Cost

Both financial and economic construction costs were estimated and applied to the model in lump sum cost because the model cannot calculated by itself. The economic construction cost was estimated by deducting tax elements from financial cost. Construction was assumed to start in the begining of 1981 for a period of one year after completly detailed engineering and land acquisition in 1980. Total construction cost

would be expensed completly in 1981.

6.2.2 Road Maintenance Cost

For each year in the analysis period the model estimates the quantities of labor, equipment and material required to maintain a road. These quantities are then converted to monetary costs based on the applicable unit prices. The quantities of labor, equipment and meterial are estimated according to maintenance policy and maintenance standard and condition of a road in that year. (In this study the costs of maintenance are not separately calculated as labor, equipment and material but they are calculated according to total unit cost of maintenance activities such as grading, patching, overlaying, resurfacing). The costs predicted by the model are for actual maintenance activities.

Roadway surface condtions are also computed by the model. They are described in terms of roughness, rut depth, looseness (for unpaved road only) and patching (for paved road only). The model also provided the modified structural numbers of the road and the year since major maintenance activity was last performed. The surface condition parameters are computed for two subdivisions or seasons of each year, the length of the season was input by the models' user. The two season are dry season (when earth and gravel roads are dusty) and wet season (when earth and gravel roads are not dusty). These parameters are used to compute roads' user costs.

6.2.3 Vehicle Operating Costs

Vehicle Operating Costs were calculated by the model for each representative vehicle on each type of road surface improvement under well-maintained conditions. The model calculated the vehicle operating costs as a function of road geometry, environment, surface type and condition and the characteristics of vehicles using the road. the surface conditions used in the vehicle operating cost relationships represent the average conditions for each season (unpaved road) or year (paved road). Operating cots are those costs incurred through owning and operating the vehicle, and including fuel, oil, tyres, maintenance parts and labor, depreciation, interest, overhead, and crew costs. These costs are summarized for used in this study in Table 5.3 for the six vehicle classifications studied.

6.2.4 Passenger Travel Time Costs

Travel time costs are related to the time value of passengers and cargo holding. These costs are estimated as the same functions that effect vehicle operating cost.

Because no data available for cargo holding cost, therefore in this analysis cargo holding costs are not included. The saving in time cost in this analysis is the road users' benefit due to passenger only.

6.2.5 Other Costs and Benefits

These items are different from previous mentioned but they are the base costs and base benefit those taken to and from improvement activity. Application of these items to the model for the analysis propose are very difficult because some of them are non-quantitiable costs or benefits and some are not available. Another reason is the model cannot calculate these items by itself but it provides a facility for the user to feed these item in for analysis.

In this study, only benefit from agricultural activity that is resulted from the development and improvement of a road is applied to the model.

6.3 Economic Analysis for Alternatives Within Links

All costs that are described in section 6.2 are separately calculated for each link. Since the road studied was divided into two links, therefore two sets of these costs are calculated. After complete the calculation, the model then combined the results of two links together and showed in term of one group alternative.

These costs are, then, discounted back to get a discrounted financial term and a discounted economic term in the first year of analysis period by using discount rates (8.0%, 10.0%, 12.0%, 14.0% and 16.0%). For each run the model can calculate those costs using five discount rate at the same time. The model includes some provisions to input separate variables (maintenance standard, construction option, traffic set, discount rate)

for each link. These input variables can be varied and thus, in each link, alternative solutions can be obtained.

Among alternative solutions within each link, the economic evaluation is made by the model. For comparison between each link alternative or group alternative the model calculates NPV, IRR and FYB by using ralationships as previously described in Chapter II.

From economic comparison, the user could search for the best group alternative and some details to explain why it is the best.

6.4 Economic Analysis Results

Four group alternatives were defferently formulated for this study based on the construction option, maintenance policy and maintenance standard. These group alternatives are comprised of Group Alternative I (ALT-I), Group Alternative II (ALT-II), Group Alternative III (ALT-III) and Group Alternative IV (ALT-IV). The characteristics of these group alternatives were declared as shown in Appendix A.

6.4.1 Results for Group Alternative I

The results obtained from the HDM model calculation are shown in Table 6.1, for both financial and economic values and for five discount rates.

TABLE 6.1

Discounted Economic and Financial Values for

Group Alternative I (In Million Bahts)

Discounted Value to 1981 Present Value	Discount rate (%)				
	8.0	10.0	12.0	14.0	16.0
Economic Construction Cost	31.279	31.519	31.694	31.824	31.920
Economic Road Maintenance Cost	11.696	10.319	9.180	8.231	7.433
Economic Vehicle Operating Cost	100.987	89.237	79.598	71.622	64.965
Economic Travel Time Cost	47.38	41.936	37.466	33.764	30.670
Economic Value Added Benefit	80.289	68.890	59.660	52.128	45.930
Financial Construction Cost	34.755	35.021	35.216	35.360	35.467
Financial Road Maintenance Cost	12.940	11.416	10.157	9.107	8.224
Financial Vehicle Operating Cost	124.491	110.019	98.148	88.323	80.121
Financial Travel Time Cost	47.886	42.386	37.869	34.127	31.001
Financial Value Added Benefit	80.289	68.890	59.660	52.128	45.93

6.4.2 Results for Group Alternative II

The results of group alternative II obtained from the HDM model calculation are shown in Table 6.2, for both financial and economic values and for five descount rates.

TABLE 6.2

Discounted Economic and Financial Values for Group Alternative II (In Million Bahts)

Discounted Value to 1981 Present Value	Discount rate (%)				
	8.0	10.0	12.0	14.0	16.0
Economic Construction Cost	50.969	51.359	51.645	51.856	52.013
Economic Road Maintenance Cost	4.356	3.853	3.438	3.091	2.799
Economic Vehicle Operating Cost	122.505	107.757	95.667	85.670	77.335
Economic Travel Time Cost	44.687	39.554	35.341	31.851	28.935
Economic Value added	80.289	68.890	59.660	52.128	45.930
Financial Construction Cost	55.657	56.082	56.395	56.625	56.797
Financial Road Maintenance Cost	4.788	4.236	3.779	3.398	3.077
Financial Vehicle Operating Cost	151.219	133.034	118.124	105.795	95.513
Financial Travel Time Cost	45.377	40.162	35.881	32.334	29.372
Financial Value Added Benefit	80.289	68.890	59.660	52.128	45.930

6.4.3 Results for Group Alternative III

The results of group alternative III obtained from the HDM model calculation are shown in Table 6.3, for both financial and economic values and for five discount rates.

TABLE 6.3

Discounted Economic and Financial Values for Group Alternative III (In Million Bahts)

Discounted Value to 1981 Present Value	Discount rate (%)				
	8.0	10.0	12.0	14.0	16.0
Economic Construction Cost	50.969	51.359	51.645	51.856	52.013
Economic Road Maintenance Cost	14.939	12.939	11.271	9.872	8.692
Economic Vehicle Operating Cost	106.587	94.719	84.929	76.781	69.939
Economic Travel Time Cost	43.189	38.328	34.331	31.015	28.239
Economic Value Added Benefit	80.289	68.890	59.660	52.128	45.930
Financial Construction Cost	55.657	56.082	56.395	56.625	56.797
Financial Road Meintenance Cost	16.010	13.868	12.083	10.586	9.323
Financial Vehicle Operating Cost	131.946	117.247	105.124	95.033	86.559
Financial Travel Time Cost	43.761	38.839	34.791	31.432	28.622
Financial Value Added Benefit	80.289	68.890	59.660	52.128	45.930

6.4.4 Results for Group Alternative IV

The results of group alternative IV obtained from the HDM model HDM model calculation are shown in Table 6.4, for both financial and economic values, for five discount rates.

TABLE 6.4

Discounted Economic and Financial Values for Group Alternative IV (In Million Bahts)

Discounted Value to 1981 Present Value	Discount rate (%)				
	8.0	10.0	12.0	14.0	16.0
Economic Construction Cost	50.969	51.359	51.645	51.856	52.013
Economic Road Maintenance Cost	54.540	48.534	43.533	39.334	35.779
Economic Vehicle Operating Cost	83.125	74.118	66.709	60.558	55.408
Economic Travel Time Cost	40.972	36.378	32.602	29.473	26.857
Economic Value Added Benefit	80.289	68.890	59.660	52.128	45.930
Financial Construction Cost	55.657	56.082	56.395	56.625	56.797
Financial Road Maintenance Cost	57.901	51.524	46.214	41.756	37.981
Financial Vehicle Operating Cost	103.581	92.339	83.090	75.413	68.984
Financial Travel Time Cost	41.371	36.736	32.928	29.771	27.131
Financial Value Added Benefit	80.289	68.890	59.660	52.128	45.930

6.5 Comparison of Group Alternatives Results

The group alternative IV (ALT-IV) was selected as a base alternative for the comparison propose. According to the concept, as stated in section 6.1, which was formulated to eliminate some problems those resulted from value added benefit estimation that cannot calculate by the model, the comparison is carried out based on the relation of "active" or "with project" alternatives. The comparison between an "active" and an "inactive" alternative was executed and shown in the final report on feasibility study for Phetchabun - Chai Badan highway project, 1979, done by Japan International Cooperation Agency.

6.5.1 Results from Comparison Between Group Alternative I (ALT-I) and Base Group Alternative (ALT-IV)

The results of the comparison are summarized below. The detailed calculation for the following results is shown in Appendix B.

a) Net Present Value: (discounted to 1981)

Discount rate	Net Present Value (NPV)
8.0 %	38.264 Million Bahts
10.0 %	37.378 "
12.0 %	36.551 "
14.0 %	35.782 "
16.0 %	35.069 "

b) Internal Rate of Return (IRR) : 17.50 %

C) First Year Benefits (FYB) : 6.41 %

6.5.2 Results from Comparison Between Group Alternative II (ALT-II) and Base Group Alternative (ALT-IV)

The detailed calculation for the following results is results is shown in Appendix B.

a) Net Present Value : (discounted to 1981)

Discount rate	Net Present Value (NPV)
8.0 %	7.089 Million Bahts
10.0 %	7.866 "
12.0 %	8.398 "
14.0 %	8.753 "
16.0 %	8.975 "

b) Internal Rate of Return (IRR) : 0.40 %

c) First Year Benefits (FYB) : 0.00 %

6.5.3 Results from Comparison Between Group Alternative III (ALT-III) and Base Group Alternative (ALT-IV)

The detailed calculation for the following results is shown in Appendix B.

a) Net Present Value : (discounted to 1981)

Discount rate	Net Present Value (NPV)
8.0 %	13. 922 Million Bahts
10.0 %	13.044 "
12.0 %	12.313 "
14.0 %	11.697 "
16.0 %	11.174 "

b) Internal Rate of Return (IRR) : 34.10 %

c) First Year Benefits (FYB) : 0.00 %

6.6 Sensitivity Testing

Sensitivity testing was carried out to test the effect on the sensitivity of the analysis results of the variation of major variables such as construction costs, vehicle operating costs and benefits. The results of sensitivity analysis are summarized in Table 6.5, 6.6, 6.7 and 6.8.

TABLE 6.5

Sensitivity analysis results for Case 1

(Costs at 15 percent increase)

(In Million Baht)

Net Present Value for	Discount rate (%)				
	8.0	10.0	12.0	14.0	16.0
ALT - I V.S ALT - IV	41.218	40.355	39.544	38.786	38.082
ALT - II V.S ALT - IV	7.090	7.865	8.399	9.753	8.975
ALT - III V.A ALT - IV	13.923	13.044	12.313	11.697	11.173

TABLE 6.6

Sensitivity analysis results for Case 2

(Costs at 15 percent decrease)

(In Million Baht)

Net Present Value for	Discount rate (%)				
	8.0	10.0	12.0	14.0	16.0
ALT - I V.S ALT - IV	33.511	34.403	33.558	32.777	32.054
ALT - II V.S ALT - IV	7.090	7.865	8.399	8.753	8.975
ALT - III V.S. ALT - IV	13.923	13.044	12.313	11.697	11.173

TABLE 6.7

Sensitivity analysis results for Case 3

(Costs at 15 percent decrease and benefits at 20 percent increas: the optimistic condition)

(In Million Baht)

Net Present Value for	Discount rate (%)				
	8.0	10.0	12.0	14.0	16.0
ALT - I V.S. ALT - IV	35.311	34.403	33.558	32.777	32.054
ALT - II V.S. ALT - IV	7.090	7.865	8.399	8.753	8.975
ALT - III V.S. ALT - IV	13.923	13.044	12.313	11.697	11.173

TABLE 6.8

Sensitivity analysis results for Case 4

(Costs at 15 percent increase and benefits at 20 percent decrease: the pessimistic condition)

(In Million Baht)

Net Present Value for	Discount rate (%)				
	8.0	10.0	12.0	14.0	16.0
ALT - I V.S. ALT - IV	41.218	40.355	39.544	38.786	38.082
ALT - II V.S. ALT - IV	7.090	7.865	8.399	8.753	8.975
ALT - III V.S. ALT - IV	13.923	13.044	12.313	11.697	11.173

6.7 Conclusion of Analysis Results

According to the criterion and conditions in section 6.1, the Group alternative I is the most theoretical suitable road surface improvement type, because it gives higher positive net present value than the others. From the sensitivity testing, the results are also indicated the same hierachy.

Although the basic data for this study are brought from the data those used in the feasibility study of Japan International Cooperation Agency (JICA), the results obtained from this study show different values from those of JICA. The study also indicates different most appropriate road surface improvement type. The differences of analysis results are caused by following reasons.

a) The JICA feasibility study selected a road surface improvement type from "Miminum Design Standards for Provincial Roads" of Department of Highways as shown in Table 4.2. Because of the road surface improvement type was not selected by feasibility study to determine most economical improvement type, this selection may cause an over or under design and also an over or under estimated construction cost that used in economic analysis.

b) Maintenance policy and maintenance standard that applied in the feasibity study by JICA has only one standard which taken from Department of Highways, therefore it may cause an over or under estimated vehicle operating costs and an over or under estimated travel time cost.

c) Comparison of analysis results in this study is done by compare one "active" alternative related to another "active" alternative. However, JICA feasibility study was done by comparing one "active" alternative related to an "inactive" or "do nothing" alternative.

d) Some non-quantifiable benefits those caused from national policy such as equity of public services, national security, and other policies are not applied in this study; therefore theoretical result.

6.8 Summary of Analysis Results

From previous analysis results, comparison shows that the most economical road surface improvement type for the Tha Maduk - Sri Thep provincial road is to be reconstructed to laterite gravel road with widening of roadway section from existing condition to 9.00 meter. If the Tha Maduk - Sri Thep provincial road was decided to reconstruct to paved road, the analysis result shows that the most theoretical suitable maintenance standard that applied for the road is the periodic maintenance that is recommended by Louis Berger International Incorporation as shown in section 5.4.

For the comparison of paved road only, the most economical alternative is considered based on the maximum benefit. The benefit is maximized by lower road maintenance costs and higher in saving of vehicle operating costs and travel time costs.