Site Selection by Using Scoring Matrix in Mae Kuang Udomdhara Reservoir Inflow Augmentation Project

Thanar Suwattana
Office of Project Management, Royal Irrigation Department, Bangkok 10300, Thailand

ABSTRACT: Mae Kuang River Basin is located in the northern part of Thailand. The water demand for various activities in this river basin e.g. domestic use, agriculture, industry and downstream ecology preservation is currently high and is anticipated to be much higher in the future. Based on analytical data, the inflow to Mae Kuang Reservoir during pre-construction and after-construction period (6 years) shows much variation and is lower than the average record for 4 years. It affects the irrigation water use in the project area where the present water shortage amounts to 140 million cubic meters and will increase to 200 million cubic meters in the future. The study of reservoir inflow augmentation has been outlined by considering water management improvement, river basin management and water diversion from external water resources. In the beginning, 6 diversion routes are identified. Then, the most appropriate diversion route is selected by applying scoring matrix (weighted and unweighted factors) together with engineering, environmental, social and economic criteria. The gained inflow will sufficiently support a production in agricultural sector and other water use sectors in the long term.

1 INTRODUCTION

Due to heavy rain during August and September 1994, the Ping River overflowed its banks and an inundation took place in Chiang Mai City, Hang Dong, San Patong and Chom Thong Districts. As a result, the people were in trouble especially houses near the Ping River were greatly damaged. Moreover, there was a water shortage in Mae Kuang river basin area in 1995. The Royal Irrigation Department (RID) studied the Flood and Water Shortage Alleviation Project in the Upper Ping River Basin including many sub-basins like Mae Taeng, Mae Ngad and Mae Kuang sub-basins etc. The study, in which different methods were integrated, was completed in 1997. One efficient method both for flood and water shortage is to divert the water from Mae Ngad Dam to Mae Kuang Reservoir by a diversion tunnel, 4 meter in diameter and 23 kilometer in length. Thus, the Mae Kuang inflow augmentation amounts to 49 million cubic meters per annum. However, this volume is not sufficient for water shortage. Therefore, more plans to solve this problem are made by augmenting the water in the Mae Kuang Reservoir from nearby sub-river basins. The RID has studied how to augment Mae Kuang inflow by emphasizing water management improvement, Mae Kuang river basin management and water diversion from external water resources in order to solve water problems for long term.

2 MAE KUANG RIVER BASIN CONDITION

Mae Kuang River Basin is a tributary of Ping River Basin. It lies in 2 provinces, namely Chiang Mai and Lamphun Provinces. The origin comes from mountainous terrain in Doi Saket District east of Chiang Mai Province connecting to Chiang Rai Province covering a drainage or catchment area of 2,699 square kilometers. Mae Kuang River Basin flows through Doi Saket, San Sai and San Kamphaeng Districts in Chiang Mai Province and Lamphun's Muang District into Mae Ping River in Ban Sob Tha, Pa Sang District, Lamphun Province. At present, the lower Mae Kuang area is invaded by farmers and housing area; therefore, the river basin condition has changed i.e. the decreasing of river size and capacity. In addition, there is always a water shortage in the dry season and flooding in the wet season.

Mae Kuang River Basin consists of one large scale irrigation project: Mae Kuang Udomdhara Dam in Doi Saket District, Chiang Mai Province. The catchment area is 569 km^2. Its function is to store water and benefit mostly from annual inflow. Its storage capacity is 263 million cubic meters (MCM) and effective capacity is 249 MCM. In addition, it consists of 74 medium and large irrigation projects and more than 100 peoples' irrigation projects. The agricultural area is 59,520 hectare (ha.). According to the assessment from 1964 to 1998, the average annual inflow was 201.70 MCM, the maximum inflow was 483 MCM and the minimum inflow was 82 MCM. However, the inflow statistics in six-year period from 1994 to 1999 showed that the average annual inflow was 187.70 MCM, the maximum inflow was 265.20 MCM in 1994 and the minimum inflow was 96.80 MCM in 1998. The inflow records show high variations of monthly and annual flow.

3 WATER DEMAND AND WATER SHORTAGE

Crop cultivation for the Mae Kuang Irrigation Project is planned and studied in order to supply water to a total irrigation area of 28,000 ha in the wet season and 11,930 ha in the dry season. Owing to an increase in community and dwelling people, land use has changed. At present, the irrigation area for Mae Kuang Operation and Maintenance Project is only 22,770 ha in the wet season and 2,730 ha in the dry season and the total water demand is 244.78 MCM. Concerning water use in the future, land use will also be considered and it is found that the agricultural area is 23,152 ha with 140% crop intensity of land use requiring water demand of 328 MCM. Besides, water is required for domestic use, industry and ecological system preservation. In the future, water demand will be 390 MCM that is 130 MCM higher than the present demand. The water shortage is currently 70 MCM and is expected to be 190 MCM in the future.

4 STRATEGIES FOR SOLVING WATER SHORTAGE PROBLEM

In formulating the guidelines for solving water shortage problem and flood problem, several water use organization sectors such as public sector, industrial sector and agricultural sector are considered as affected groups. Therefore river basin management is especially emphasized by letting and persuading river basin organizations participate in planning and formulating guidelines in order to avoid conflicts of interest on resources management.

4.1 Water management improvement

To improve the river basin management, environmental resources are taken into consideration. The water-source forest in upstream catchment area will be improved in order to strengthen and stabilize the river flow condition. The potential of groundwater use from the lower Chiang Mai aquifer area is 40 MCM. Increasing of irrigation efficiency, farm system development and cultivation system improvement is able to decrease the volume of water use in the Mae Kuang Project area for the dry season by 42.24 MCM per year on average. However, the water shortage still amounts to 156.93 MCM per year on average.

4.2 Mae Ngad and Mae Kuang Reservoirs Management by tunnel linking

A tunnel of 4-meter in diameter will be constructed to link both reservoirs and 2 sub-river basins will be properly managed. By this way, water shortage problem can be solved at a certain level that is the average volume of 49.34 MCM per year is stored. However, more alternatives should be determined for long term demand.

4.3 Mae Kuang Udomtara Reservoir Inflow Augmentation by diversion

Mae Kuang Udomdhara Reservoir Inflow Augmentation can be done by diverting river flow from nearby sub river basins of the Ping River Basin or from remote sub river basins where it is sounded in terms of engineering, social, economics and minimum environmental impacts. As a result, efficient volume will be obtained to meet the reservoir storage capacity and water demand. Basically, the following diversion routes are considered as shown below:

Diversion route 1 : Mae Lao River - Mae Ngad Reservoir - Mae Kuang Udomtara Reservoir
Diversion route 2 : Mae Kok River - Mae Ngad Reservoir - Mae Kuang Udomtara Reservoir
Diversion route 3 : Ping River - Mae Ngad Reservoir - Mae Kuang Udomtara Reservoir
Diversion route 4 : Mae Lao River - Mae Kuang Udomtara Reservoir
Diversion route 5 : Fang River - Mae Ngad Reservoir - Mae Kuang Udomtara Reservoir
Diversion route 6 : Mae Taeng River - Mae Ngad Reservoir -Mae Kuang Udomtara Reservoir

Six diversion routes are shown in Figure 1. 6-alternative diversion routes

5 SELECTION OF APPROPRIATE DIVERSION ROUTE

Three of six diversion routes were initially selected by considering of preliminary engineering issue, cost estimation of each diversion route, analyzing of water cost per cubic meter, monitoring of environmental issues etc. This first screening of 6 alternative diversion routes to 3 diversion routes was the way of saving time for finding more in-depth information of the 3 remained. It can be concluded as follows:

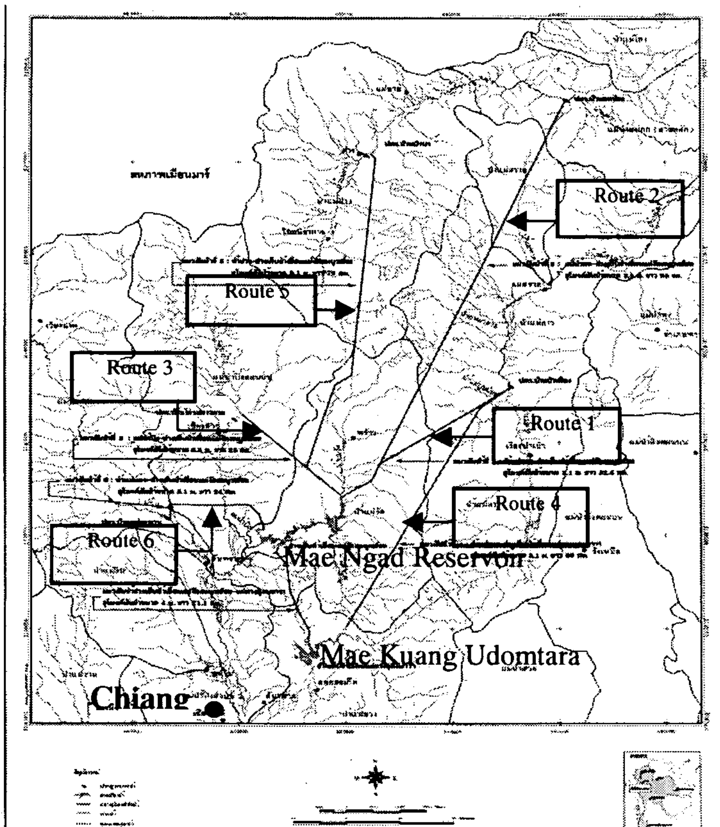

Figure 1. 6 -

Table 1. Preliminary selection of 6 - alternative diversion routes by screening criteria

Diversion Route	Engineering and Economic		Social	Environmental	
	Cost of water per cubic meter (Bath)	Water volume to meet water demand in Basin (MCM/year)	Inflow augmentation from Same river basin	Location of Regulator and appurtenance structure	Diversion tunnel Alignment
Route 1	*2.68*	177.83 (128.49)	X	Watershed Class 4	19.02 km. Through watershed class 1 A
Route 2	8.12	163.74 (114.40)	X	Watershed Class 4	57.16 km. through watershed class 1 A
Route 3	*3.49*	138.98 (89.63)	✓	Watershed Class 5	11.49 km. through watershed class 1 A
Route 4	4.11	128.49	X	Watershed Class 4	45.01 km. through watershed class 1 A
Route 5	5.35	158.26 (108.92)	X	Watershed Class 5	46.19 km. through watershed class 1 A
Route 6	*2.69*	150.49 (101.14)	✓	Watershed Class 1B	13.07 km. through watershed class 1 A

Remark : (xxx.xx) excluding water volume diverted from Mae Ngad Reservoir

The most appropriate diversion route is selected from three diversion routes by giving priority to engineering, environment, social and economics on the same database and scoring matrix (weighted and unweighted) as shown in the table below. Various factors and activities include diversion water volume, tunneling system length, geological and geotechnical condition and quality along tunnel alignment, agricultural households, social acceptance, water cost per unit, physical environmental resources and ecological environmental resources etc.

Table 2. Weighted scores of Case 1-5 for considerable aspects

Aspect	Weighted scores				
	Case 1	Case 2	Case 3	Case 4	Case 5
Engineering	30	30	40	20	25
Social	10	20	10	30	25
Economics	30	20	10	20	25
Environment	30	30	40	30	25
Total	100	100	100	100	100

The 6th Diversion route: Mae Taeng River - Mae Ngad Reservoir - Mae Kuang Udomtara Reservoir was found to be the most appropriate route. The following scores were tabulated:

Table 3. Result of Case 1-5 of 3 - selected diversion route

Diversion route	Scores				
	Case 1	Case 2	Case 3	Case 4	Case 5
Diversion route 1	66.96	64.73	56.68	67.41	70.18
Diversion route 3	62.15	59.38	56.02	60.03	62.91
Diversion route 6	82.82	81.71	77.47	82.17	84.72

However, an additional factor was also considered in the selection of diversion route 6 by releasing the water from Mae Ngad Dam in the dry season to the Mae Faek Irrigation headwork and by low head pump next to Mae Taeng irrigation main canal which would deliver raw water for domestic water work of Chiang Mai Province. At present raw water shortage is still the problem to water work system since there are no reservoir development projects in the Mae Taeng River Basin for water resources and flood alleviation.

Table 4. Scoring Matrix of engineering, social and economics factors for diversion route selection.

No.	Factors	Weight of Factors	Grading criteria	Scores according to priority	Total scores
Engineering					
1	Irrigation water volume compared to water demand volume	9	> 0.5 0.3 – 0.5 < 0.3	3 2 1	27 18 9
2	Irrigation water volume compared to average annual inflow	7	> 20% 20 - 40% < 40%	3 2 1	21 14 7
3	Geotechnical condition along tunnel alignment	9	Very suitable Moderately suitable Slightly suitable	3 2 1	27 18 9
4	Length of tunneling system	9	> 20.0 km. 20.0 – 30.0 Km. < 100 – 120 Km.	3 2 1	27 18 9
			Total	Engineering scores	30
Social					
1	Number of benefited agricultural households	9	> 10,000 households > 8,000 - 10,000 Households < 8,000 households	3 2 1	27 18 9

Table 4. Scoring Matrix of engineering, social and economics factors for diversion route selection. (cont.)

No.	Factors	Weight of factors	Grading criteria	Scores according to priority	Total Scores
2	Acceptance of concerned people	9	High Medium Low	3 2 1	27 18 9
3	Host & donor basin management	9	High Medium Low	3 2 1	27 18 9
				Total Social scores	10
Economic					
1	Net Present Value (based on 12% discount rate)	9	> 1,000 million baht >1000 - 10,000 million baht < 100 million baht	3 2 1	27 18 9
2	Economic Internal Rate of Return	9	> 12% > 10 – 12% < 10%	3 2 1	27 18 9
				Total Economic scores	30

Remark - Weight factor : Rating scale 1 (least important) – 9 (most important)
- Importance level 1 (low) – 3 (high)

Table 5. Scoring Matrix of environmental factors for diversion route selection

Major environmental factors	Weight of Scores	Level of impacts -3	-2	-1	0	+1	+2	+3	Suitable Scores
Physical resources 1) Runoff water - Direction and water flow rate is affected. - Changing in river basin volume. - Physical change in catchment area. As a result, river basin may be improved or enlarged.	7								
2) Surface water quality - Water quality is changed.	7								
3) Geological condition and earthquake - Building security or structures may be affected.	7								
4) Mineral resources - Lost of mineral resources in the construction area or in the flooded area - Mineral resources are contaminated.	5								
5) Management of tunnel materials	7								
6) Soil erosion - Banks may be eroded or degraded.	7								
Ecological resources 7) Aquatic ecology - Dangerous aquatic animals are spread.	7								
8) Forest - Forest areas are lost.	9								
9) Watershed area - There is a change in river basin condition.	9								
10) Wildlife -Wild animals are affected by construction activities.	9								

Table 5. Scoring Matrix of environmental factors for diversion route selection (cont.)

Major environmental factors	Weight of Scores	Level of impacts							Suitable Scores
		-3	-2	-1	0	+1	+2	+3	
Human use value 11) Transportation - Project component construction obstructs local transportation.	3								
12) Water use and water resources management - Negative effects on downstream water use of the intake structure may arise especially when the inflow is low.	5								
13) Mining - Mining activities are directly affected. Some plans may be adjusted.	5								
14) Flood - The bank of water resources area may be getting more flooded.	5								
15) Fisheries and aquaculture - Project development may lead to indirect effect (more fishery activities).	3								
16) Agriculture - There are indirect positive effects in the areas where more water can be used.	5								
Quality of file 17) Socio-economic aspect - People in the construction area/reservoir may lose their lands and properties and/or dwellings permanently.	9								
18) Asset compensation - Asset compensation must be paid before construction.	7								
19) Archeology & history - Archeological or historical places may be directly affected.	3								
20) Aesthetic values and tourism - Tourist activities on the river may be affected as building construction obstructs the river basin. This will continuously affect the concerned people.	5								

7 CONCLUSION

Using of Scoring Matrix could be applied several criteria such as technical, socio-economic, comparative cost, environmental criteria etc. to some kinds of project which would be fitted to project data, information or analyzed data. Decision can be made on total scores by desirable rating scale of many factors. In the Mae Kuang Reservoir Inflow Augmentation Study, various strategies are planned namely water management improvement, environmental management, increase in water use efficiency, cropping system improvement, Mae Ngad Reservoir and Mae Kuang Reservoir mutual river basin management etc. The derived inflow can lessen the water shortage problem at a certain level. The study of Mae Kuang Reservoir Inflow Augmentation is done by diverting water according to the appropriate diversion route to the available reservoirs without constructing new reservoirs. At the same time, hydraulic structures, one factor for irrigation, have low impacts but are beneficial to water shortage and flood problem solution in the long term especially the inflow can support the production in the agricultural sector.

8. REFERENCE

Royal Irrigation Department (1997). *Feasibility Study and Environmental Impact Assessment of Flood and Water Shortage Alleviation Project in the Upper Ping River Basin.* Bangkok.