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# An Integrated Simulation Model for Resource Management in the Nam Pong Basin[1]

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## ABSTRACT

This report summarizes the findings of the final phase of the Nam Pong project. The objective of this project have been (i) for developing quantitative assessment arising from the construction, and operation of the Nam Pong dam in 1964. (ii) for planning and for actual management of resource in the basin. The second objective is the main theme of this report.

This study was composed of three phases. Phase I represented a comprehensive data collection effort comprising an extensive literature review, a reconnaissance survey of the basin, "a post audit" of socio-economic aspects and preparation of an annotated bibiography. Phase II was essentially a fact finding exercise to identify ecological changes mainly through field data collection.

The final phase commenced in 1980 was hybird exercise of transferring an integrate management methodology to a group of Thai scientist and of applying such methodology to the case of Nam Pong basin's resource management.

The most important final products that emerged form this exercise were (i) a management oriented "an integrated simulation model" taken into account four main basic subsystems-land, water, fish and socio-economic and (ii) An identification or institutional structure and the constraints affecting management of basin resources, and resolution recommended.

The model is useful supporting tool for policy formulation and decision making for local through central administrators in connexion with resource management within the Nam Pong basins.

## INTRODUCTION

The Nam Pong River in north-east Thailand is a tributary of the Mun-Chi river system, which joins the Mekong river at Pak Mun on the border with Laos and drains a watershed of approximately 11,500 km$^2$. (Figure 1) The Ubolratana dam on the Nam Pong at Pong Neeb was constructed under the auspices of the Mekong Committee in 1969. Prior to impoundment, much of the Num Pong watershed was forested because there had been no extensive clearance for planting upland crops. Glutinous rice was cultivated in the lowland, and in the wet season there was widespread flooding. The only large town in the river basin was, and still is, Khon Kaen though the population of the basin (1.28 million) was increasing at about five and a half per cent per year, and all good quality agricultural land had been occupied.

People living in the area to be flooded by the reservoir were evacuated by the end of 1965, and received some compensation for land and property lost. About 4,000 families had to move-, and of these about 2,700 went to resettlement projects at Nam Pong (Khon Kaen province) and Non Sang (Udon Thani province). The land allocated at these sites was generally inferior to that lost by flooding and unsuitable for rice cultivation

The dam and power station have been in operation since 1966, generating about 65 GWh of electricity annually. The Nong Wai weir was constructed down-stream in 1966 to divert water released from the power house into canals for dry season cultivation and supplementary irrigation. The incomes of farmers benefiting from this irrigation project are new considerably higher than average rural incomes in the Nam Pong basin, and an unanticipated benefit from the project has been fish production from the reservior of up to 2,000 tones per year.

However, other less beneficial effects were believed to be occurring as a direct or indirect result of the Nam Pong projects, which have already,

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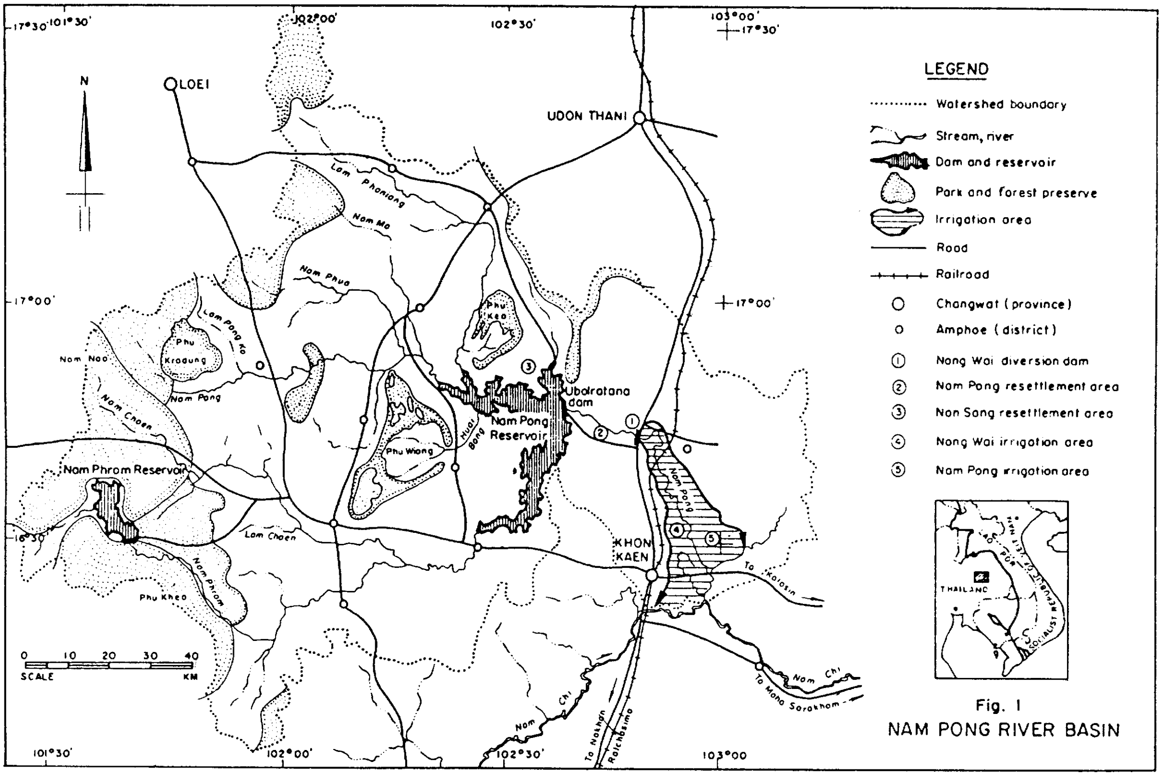


Fig. 1
NAM PONG RIVER BASIN

or could in the future, affect the physical and biological resources of the basin and the quality of life of its people. With a view to taking stock of the changes that had occurred and were still occurring, and to assess the overall performance of the development, the Mekong Committee in 1977 launched the Nam Pong Environmental Management Research Project.

The ultimate objective of this project, which was executed in three phases, was to provide a comprehensive assessment of the effects of a typical dam and reservoir on the environment of the region, including at-site, upstream, and downstream effects. It was anticipated that the process and result would help in "the development and testing of a methodology for planning and management of resources at the river basin level (Mekong Committee, 1979).

The frist phase of the Nam Pong Project, completed in January 1978, comprised a reconnaissance survey of the area, a post audit of economic and social impacts, and a review of relevant literature for the preparation of an annotated bibliography.

The second phase, completed in November 1979, was an ecological study of the entire Nam Pong basin, covering thirteen discrete research tasks on subjects such as hydrology, limnology, fisheries, socio-economics, pests, human and animal health, water quality, and water and land use.

The third phase, to be described in this report, began in September 1980. Its goal was the integration of all the data available about the biological/physical socio-economic aspects of the Nam Pong basin, and the development of a synthesis that would be usable and relevant to the managers and institutions responsible for the development of the basin. An Adaptive Environmental Assessment methodology was employed, and the major product of this effort was a management oriented computer simulation model. It is this model, its results, and the resulting discussion management actions that will be elaborated hereunder.

## ORGANIZATION, METHODOLOGY AND ACTIVITY

The Nam Pong model was built over a seven-month period, beginning with a four-week

**Table 1** Actions discussed and implemented in the Nam Pong simulation model

| *Submodel* | *Actions considered relevant* | *Actions implemented in the model* |
|---|---|---|
| WATER | Set operating rule curve<br>Set flood control rule curve | Set rule curve |
| FISHERY | Enhance stock<br>Aquaculture (fish farming)<br>Regulate fisheries<br>Specify fishing season | Stock reservoir<br>Fish culture<br>Restrict number of fishermen<br>Restrict fishing season |
| LAND USE | Zone land<br>Regulate land tenure<br>Regulate deforestation<br>Regulate legal forestry<br>Regulate forest planting<br>Promote fertilizer use<br>Accelerate dry season cropping<br>Promote crop diversification | Regulate deforestation rate<br>Regulate reforestation<br>Accelerate dry season cropping |
| SOCIO-ECONOMIC | Resettle population<br>Control migration by incentives<br>Establish new industries<br>Increase efficiency of labour<br>Supply services : power<br>roads<br>health<br>education | Increase effectiveness of family planning<br>Establish new industries (sugar refinery) |

workshop The workshop served the dual purpose of model conceptualization and the training of a core group of Thai scientists who would continue to refine and make the model operational for a six-month period after the initial workshop. Model conceptualization will be covered here.

The first step in the workshop procedure was to define and bound the problem clearly. In particular, management actions (inputs) and resultant indicators (output) were identified-indicators being those quantities which can be used to evaluate the preformance or well-being of a system. A list of relevant actions and indicators was compiled and edited (Tables 1 and 2)

The next step was to define the spatial extent and resolution required to represent the system adequately. The spatial units of the Nam Pong watershed eventually agree upon include six functionally distinct areas : (I) a watershed, including forests and upland agriculture; (II) a reservoir including the drawdown zone fisheries; (III) a resettlement area; (IV) and urban area around Khon Kaen; (V) irrigation areas downstream of the diversion dam; and (VI) further potentially irrigable area (Figure 2)

Similarly, the temporal extent or time horizon for the assessment project had to be specified. Because appropriate time horizons varied with the particular concerns of the various agencies represented among the workshop participants, the model was designed to simulate one year at a time for any number of years specified with 20

**Table 2 Indicators discussed and implemented for the Nam Pong simulation model**

| *Submodel* | *Indicators considered relevant* | *Indicators selected for model* |
|---|---|---|
| WATER | Quantity of water for irrigation<br>Power generated<br>Area damaged by flood<br>Water quality<br>Sedimentation in reservoir | Reservoir inflow<br>Reservoir level<br>Reservoir outflow<br>Reservoir storage<br>Power generated<br>Area flooded<br>Water demand<br>Water shortage |
| FISHERY | Fish harvest<br>Catch per effort<br>Biomass of fish<br>Species composition of fish<br>Successional stage of fish | Number of fishermen<br>Fishing income<br>Fish harvest<br>Catch per effort<br>Biomass of each generic group |
| LAND USE | Forest area<br>Yield per area subsistence crop<br>Yield per area market crop<br>Dry season growing area<br>Irrigated area | Sedimentation rate<br>Area of each land-use type<br>Yield of each land-use type<br>Erosion and sedimention |
| SOCIO-ECONOMIC | Population<br>Average per capita income<br>Income distribution<br>Quantity and quality of domestic water<br>Health<br>Education<br>Mortality rate | Net income<br>Income by profession<br>Income per capita<br>Population distribution (spatially and temporally) |

years as the basic temporal resolution if none other was specified. As different environmental processes clearly have different time dynamics, each subsystem could subdivide its time steps finer than one year, but linkages with other subsystem had to be specified on an annual basis (Figure 3).

Once the system was spatially and temporally bounded, the next step was to disaggregate the total system into subsystems. An overview of the process considered in the model (Figure 4) show the submodels that were developed. A number of working subgroups within the modelling team was then asked to identify explicitly the information it would need to make predictions about how particular subsystems would change over time. In particular, needs for information transfer between submodels had to be specified. When the information needed was expressed in unambiguous form (units, time of year, etc.), the result was a summary table of information needs, or a "looking outward matrix" (Table 3). This table also provided an interaction quide for the working subgroups in the process of model refinement.

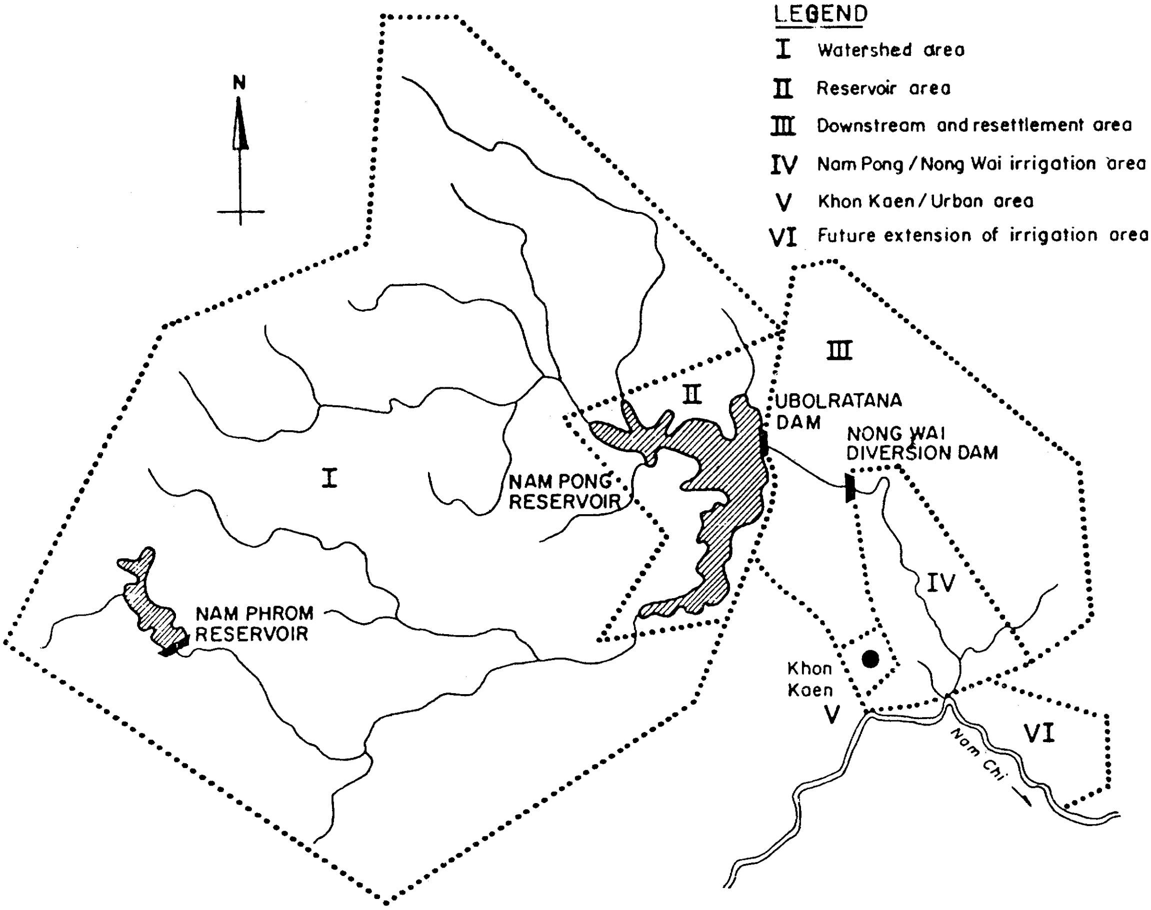


**Fig. 2 Spatial extent and subdivisions for the Nam Pong model.**

A series of interviews with potential users of the results of the project was conducted just prior to developing the various submodels, in order to make them feel part of the process, to make the model more sensitive to their concerns, and to introduce them to the project methodology. Users were asked to clarify their goals, and to specify relevant indicators and actions for the assessment-all information that could be used directly in the development and refinement of the submodels. (Table 4)

As an example of submodel development, the conceptual structure of socio-economic submodel and its linkage with other submodel is illustrated in figure 5.

An analysis was conducted at the same time to identify the institutional structure and the constraints affecting management of resource in the Nam Pong basin. The major components of this analysis were :

(a) A review of the institutions currently involved in the Nam Pong basin and the implications of their involvement;

(b) Identification of the institutional constraints on the four subsystems collectively making up the Nam Pong model;

(c) An exploration of policy alternatives and manatement options that explicitly account for the institutional constraints.

## RESULTS AND DISCUSSION

The integrated simulation model consists of four interacting subsystems encompassing the dynamics of water management, land-use patterns, socio-economics and reservoir fisheries. The dynamics of each subsystem are represented by a submodel, each of which provides information required by other submodels. The integrated model is responsive to wide range of management actions and presents its 20-year projection as graphical

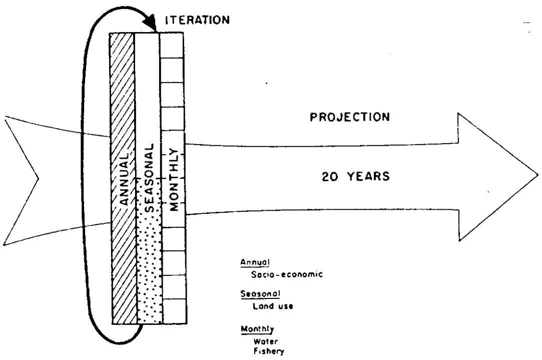


**Fig. 3 Temporal horizon and length of iteration intervals for the Nam Pong model.**

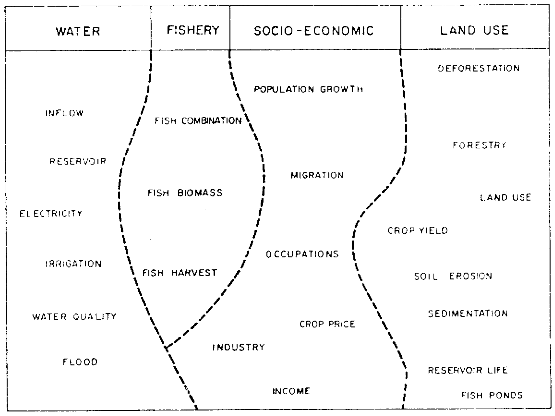


**Fig. 4 Allocation of modelling concerns to sub models.**

**Table 3 The final looking outward matrix**

| FROM \ TO | WATER SUBMODEL | FISHER SUBMODEL | LAND USE SUBMODEL | SOCIO–ECONOMIC SUBMODEL |
|---|---|---|---|---|
| WATER | | Reservoir water level (m MSL)<br>Reservoir surface area ($km^2$)<br>Turbidity<br>Inflow ($10^6 m^3$) | Flooded area ($km^2$)<br>Water shortage ($10^6 m^3$)<br>Inflow ($10^6 m^3$) | |
| FISHERY | | | Drawdown area ($km^2$) | Fish harvest (ton)<br>Number of commercial fishermen |
| LAND USE | Water demand for irrigation ($10^6 m^3$) | | | Crop production (ton)<br>Cultivated area ($km^2$) |
| SOCIO-ECONOMIC | Water demand for industry and domestic uses ($10^6 m^3$) | | Population change | |

displays of the system indicators (i.e., variables) over time.

All the selected simulation results presented here are from the integrated model. All the submodels are run together on an Apple II Plus microcomputer. All basic scenarios are a 20-year projection of current resource management (the hypothetical year 1 relates to 1979).

## 1. Water Subsystem

The resultant pattern represents relatively high inflow in year 1, 3 and 4, followed by low inflow in years 5, 6 and 7 and thereafter fluctuation from year to year to the end of the predictive period. Water release follws the same patterns as inflow, an in low and average inflow period water release is regulated according to the demand downstream. The peak monthly release is approximately 2850 million $m^3$. At this time extensive flooding occur in the downstream area (Figures 6 and 7).

Relationship between water release and water shortage is shown in Figure 8. A severe monthly water shortage occurs during years 6 to 9 and the maximum monthly amount of water shortage in a month is 158 million $m^3$. Flooding occurs five time in the 20 year simulation during periods of high water release (Figure 9). The maximum flooded area which occurs once in the 20-year period is about 18,000 ha, whereas the average area flooded in each of the five flood years is about 10,000 ha.

The monthly enery pattern is closely follows

**Table 4 Summary of interviews-goals, indicators, actions**

| *Interview* | *Goals* | *Indicators* | *Actions* |
|---|---|---|---|
| 1. The Governor of Khon Kaen Province | Increase standard of living<br>Maintain law and order<br>Prevent insurgency<br>Protect the environment | Per capita income<br>Crime rate<br>Safty of people<br>Number of insurgents<br>Degree of public co-operation with Government | Provide services to farmers<br>Guarantee prices of products<br>Introduce incentives<br>Control insurgents<br>Regulate deforestation<br>Promote reforestation |
| 2. EGAT Regional Office | Meet power targets<br>Provide for irrigation<br>Control flooding<br>Co-operate with fisheries | Power generated<br>Adherence to rule curve | Building dykes for flood protection<br>Building dams on Nam Chi<br>Control releases from Ubolratana dam<br>Raise dam<br>Avoid spillage |
| 3. Departmnt of Fisheries | Increase yield from reservoir<br>Protect spawning grounds<br>Educate people in fish conservation<br>Serve as case study for other reservoir | Catch<br>CUE<br>Biomass<br>Income to community | Increase stocking capability<br>Encourage use of fish cages<br>Regulate fishing gears<br>Regulate access to spawning area<br>Introduce fishermen co-operatives<br>Streamline market process |
| 4. Ubolratana Resettlement | Issue land ownership documents to settlers<br>Increase per capita income of settlers | Number of households settled<br>Number of ownership documents issued<br>Crop yields<br>Net immigration into area | Establish co-operatives<br>Obtain loans for farmers<br>Provide training and education<br>Provide water supply for irrigation |
| 5. RID Nong Wai Project | Irrigate 42,000 ha<br>Improve irrigation<br>Increase dry season cultivation<br>Increase yield | Cultivated area (wet and dry season)<br>Crop yield/ha<br>Irrigation efficiency<br>Farmers' participation | Establish water-user groups<br>Provide training for farmers<br>Increase number of RID personnel<br>Improve water distribution system |
| 6. Khon Kaen Agricultural Office | Increase crop yields<br>Set up demonstration plots in each village | Number of demonstration plots<br>Crop yields | Organize farmers' groups<br>Introduce new crop varieties<br>Train farmers<br>Control pests<br>Supervise farmers |
| 7. Regional Forestry Office | Maintain existing forest<br>Regulate legal harvest<br>Increase forested area through reforestation | Area of good forest<br>Rate of deforestation<br>Rate of reforestation | Establish forest protection units<br>Implement agro-forestry<br>Reforest<br>Regulate legal forestry |
| 8. Provincial Health Office | Increase family planning<br>Improve child health, and nutrition<br>Improve rural sanitation<br>Increase medical care<br>Motivate private sector to invest in health care | Number of people practising family planning<br>Rate of population growth<br>People-doctor ratio<br>Number of people receiving medical services | Increase government spending for health care<br>Educate village doctors<br>Train volunteers for simple medical care<br>Set up mobile medical team<br>Improve vaccination service |

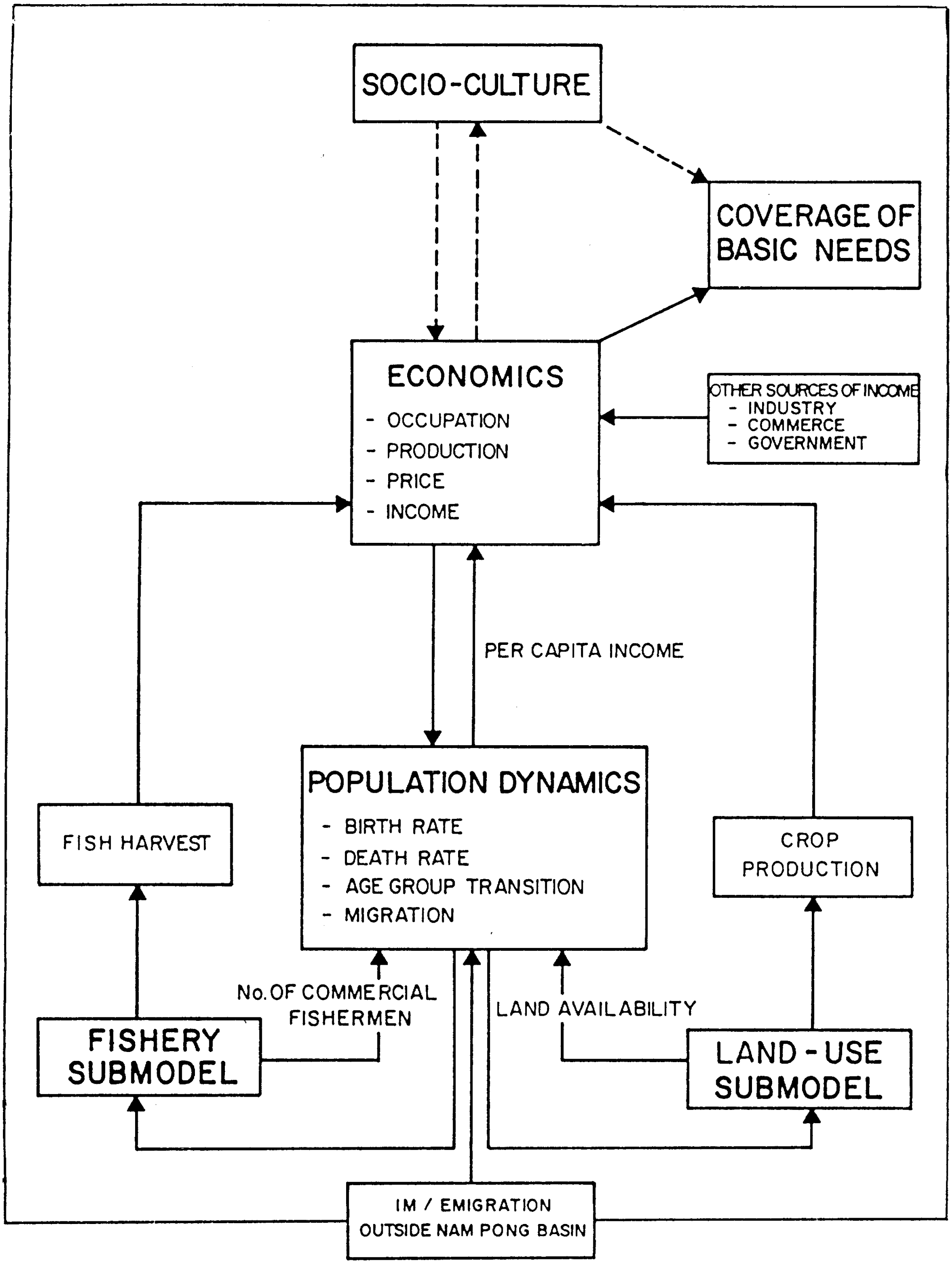


**Fig. 5 Conceptual structure of socio-economic submodel**
**Dashed lines show linkages to socio-cultural factors which are not explicitly expressed in the socio-economic submodel**

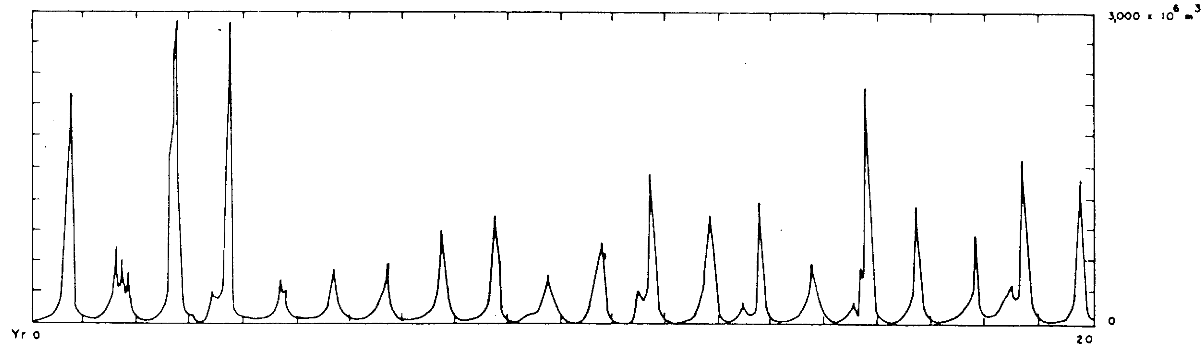


Fig. 6 Monthly inflow to Nam Pong reservoir - basic scenario.

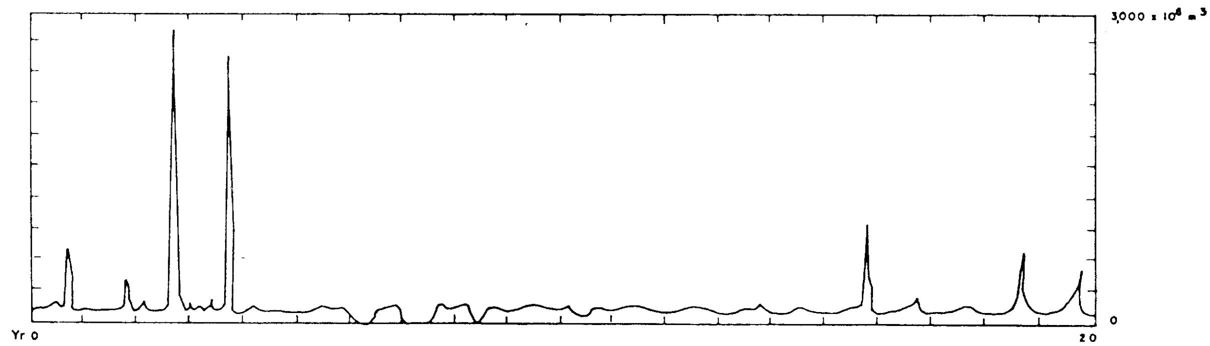


Fig. 7 Water release from the resevoir - basic scenario.

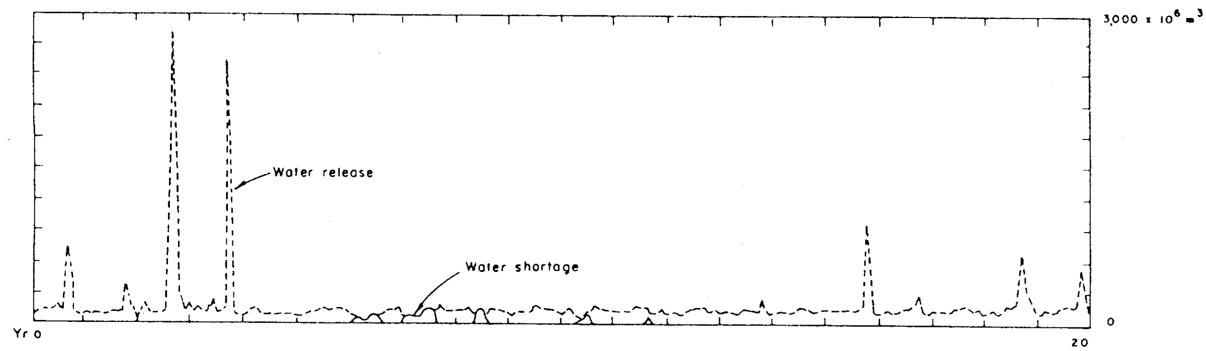


Fig. 8 Relationship of water release and water shortage - basic scenario

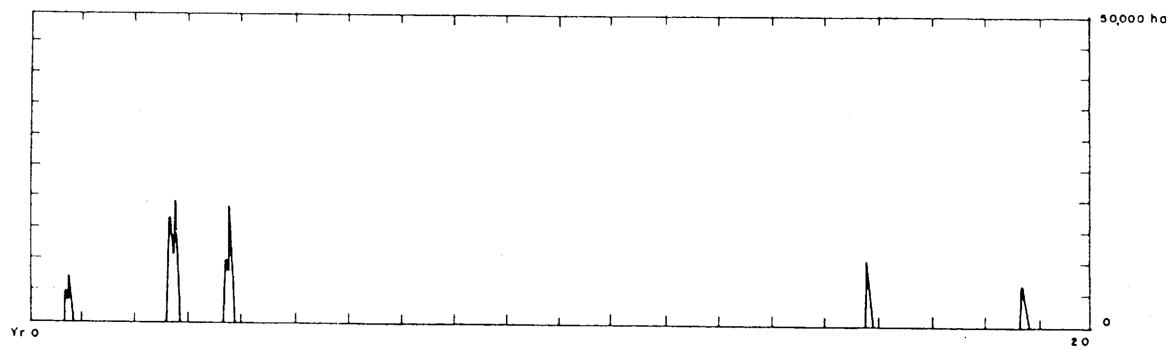


Fig. 9 Area flooded as a result of the water release pattern shown in Fig. 8

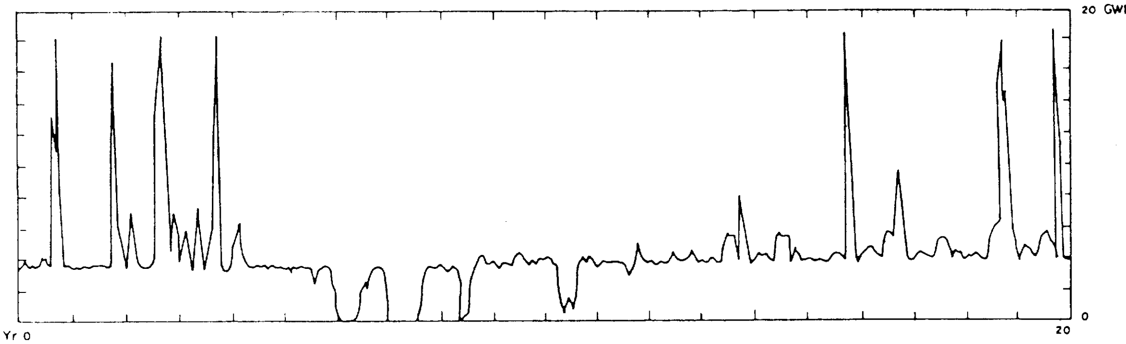


Fig. 10 : Energy generated - basic scenario.

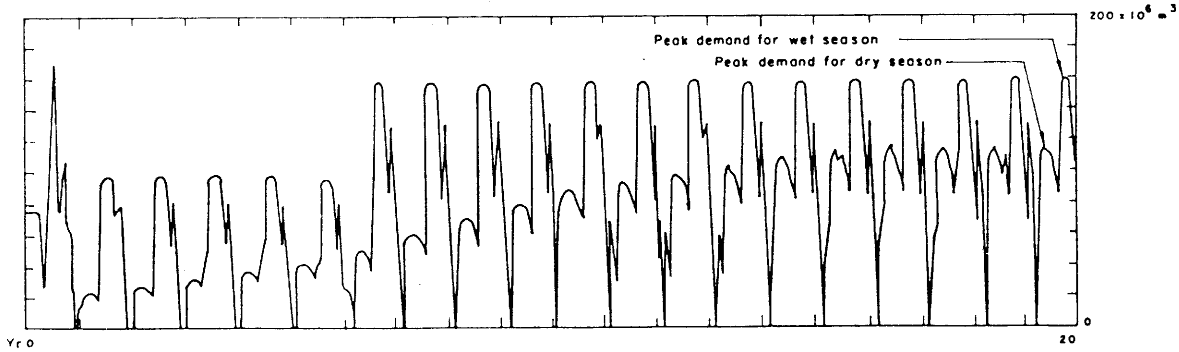


Fig. 11 Water demand pattern - basic scenario.

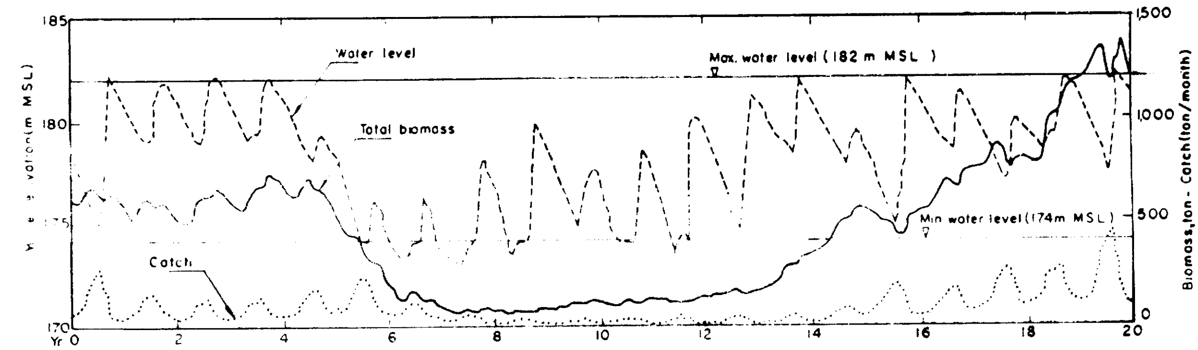


Fig. 12 Total biomass and catch profiles - basic scenario

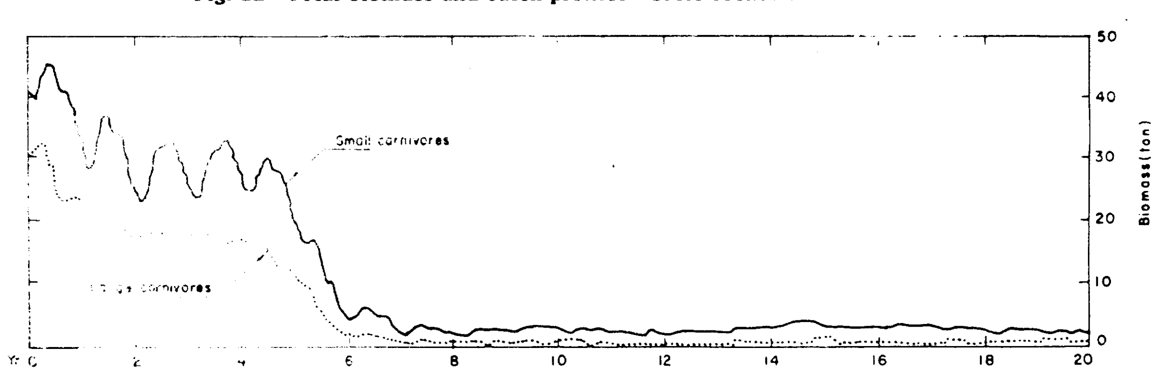


Fig. 13 : Carnivore biomass profiles - basic scenario

the water release patterns. Its produces 18 GWh, the full energy capacity, when water release in any one-month period is more than 500 million $m^3$, and drop to zero when the water shortage is severe. (Figure 10)

The water demand pattern is illustrated in Figure 11. In dry season water demand increases with the increase response of farmers to the opportunity for dry season cultivation. The wet season demand is constant for five years, and then increases when the irrigation project extends to spatial unit VI.

## 2. Fishery Subsystem

The fluctuation in the projected fish biomass depends primarily upon the sprawning season of the fish while the predicted catch is inversely proportional to the water level as depicted in Figure 12. The figure also shows the significant influence of water level on the fish biomass. This reflects the fact that when the water level is low the fish population cluster together and are easier to catch.

Rapid decline in the carnivore groups (High economic value) depicted in Figure 13 is due mainly to selective catch.

## 3. Land-Use Subsystem

Analysis of land-use change and crop production during 20-year prediction period was performed for each of the six spatial unit. However, it is intended to elaborate and illustrate as an example the result from spatial unit I which is the watershed which cover two-third of the basin area, the only unit with forest of 4,670 $Km^2$ (in 1979).

In spatial unit I the forest area decrease rapidly unitl in reaches the lower limit of 2,000 $Km^2$. This is the approximate total area of national park and wildilife reserve and steeply sloping land unsuitable for agriculture the decrease in forest area is certainly a result of rapid population growth which increases the demand for agricultural land, and also of increasing production of sugarcane and kenaf as raw materials for the newly established factories in the basin. As a result, within the 20-year projection period, the area of sugar-cane and kenaf increase slightly, while the area of rice and cassava almost double (Figure 14).

Main crop production shows increasing trend for the period under simulation. Significant increases are sugar-cane and kenaf whereas rice production increases steadily. (Figure 15).

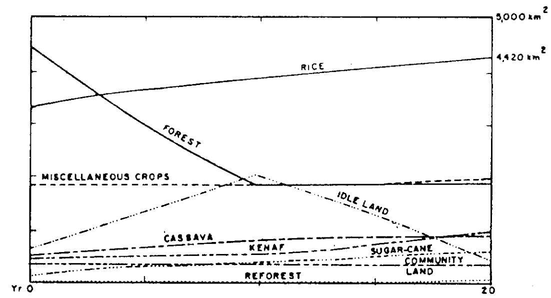


**Fig. 14 Land use for spatial unit I - basic scenario**

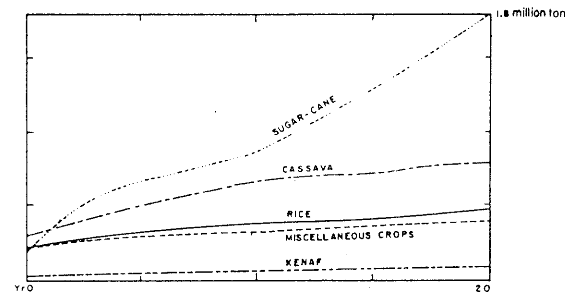


**Fig. 15 Crop production in spatial unit I - basic scenario**

Soil erosion in the watershed area is illustrated in Figure 16. Total soil erosion increases in year 1 to reach its maximum of 11.83 million tons per annum in year 9, corresponding to the decrease in forest area in the same unit. By that time the only forest land remaining is the 2,000 $km^2$ area reserve, and the agricultural land is almost fully occupied. After year 9 soil erosion will decrease slightly due to changes in crop cultivated.

Sedimentation in the reservoir will follow the same trend as soil erosion, and reaches it maximum (2.36 million tons per annum) around year 9 and then tapers off. If the Government can maintain the forest area of the Nam Pong watershed at 2,000 $Km^2$, as hypothesized in the model, the amount of sedimentation predicted should not greatly affect the functional life span of the reservoir which was planned to be 200 years.

## BUT WHAT WILL HAPPEN IF THE GOVERNMENT FAIL TO MAINTAIN THE 2,000 KM² FOREST AREA AS PLANNED?

Under the present conditions of high population growth rate, and low opportunities for alternative employment in the area and with limited staff to

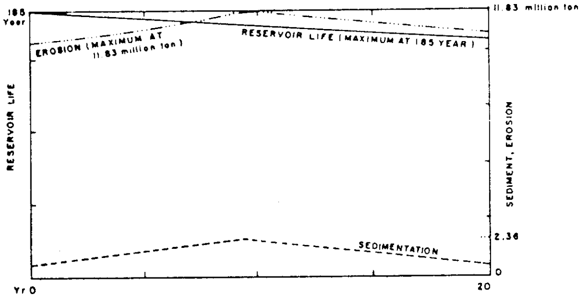


**Fig. 16 Sedimentation and reservoir life-basic scenario**

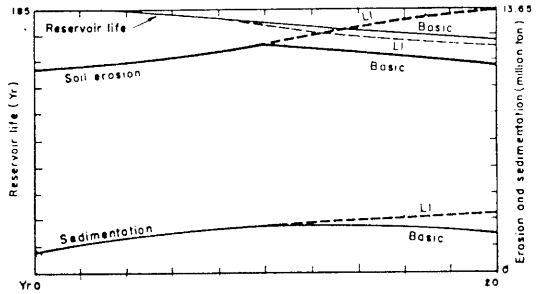


**Fig. 18 Comparison of changes in soil erosion, sedi mentation and reservoir life between basic and LI scenarios**

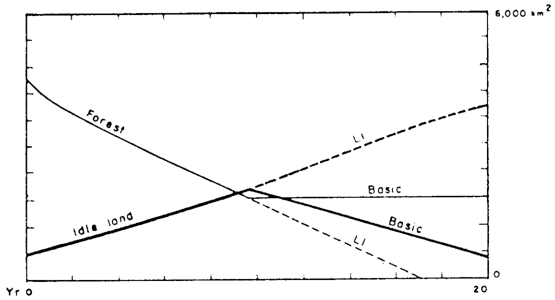


**Fig. 17 Comparison of major land use changes in spatial unit I between basic and LI scena rios**

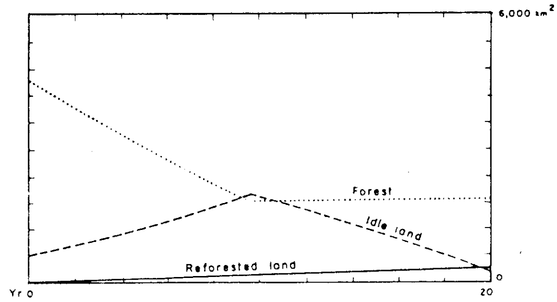


**Fig. 19 Land-use changes after reforestation-L2 scenario**

enforce protection, it is possible that deforestation will continue. Scenario L1 is intended to simulate the land-use changes and its impacts to other sectors.

The results as given in Figure 17 show clearly that under such condition all forest area are completely exploited by year 17 resulting in a rapid increase in idle land and a slight increase in agricultural land.

The cost of complete deforestation of the watershed area to other resources in the reiver basin is evident. As an example, in Figure 18, soil erosion and sedimentation in the reservoir are considerably increased (from 11.83 million tons to 13.65 million tons per annum and from 2.26 million tons to 2.73 million tons per annum respectively). Reservoir capacity will decline at a higher rate, and the functional life-span of the reservoir is reduced around 3%.

## COULD REFORESTATION CHECK THE DEFORESTATION RATE?

The rate of reforestation normally depends on the budget allocated by the government. Currently Khon Kaen Forest Division obtains an average annual budget sufficient to reforest 20 $Km^2$ but only a portion, perhaps sufficient for 2 $Km^2$ per year, will be available for the Nam Pong basin. However, in view of the initial capital cost and present value of the Nam Pong water resource development, additional expenditure on reforestation to protect the watershed and ensure environmentally sound and efficient management of the water resource would be fully justified.

Scenario L2 simulates the land-use subsystem under a strong and continuing reforestation programme i.e., if annual planting increase to the possible maximum of 20 $Km^2$ per annum.

The scenario (Figure 19) shows clearly that even at the maximum rate of reforestation, the forest area only recover slightly as deforestation continues at a much higher rate. It indicates obviously that even a strong, continuing and effective government reforestation programme (as hypothesized here) cannot counter balance the deforestation. This happens everywhere in Thailand. The government

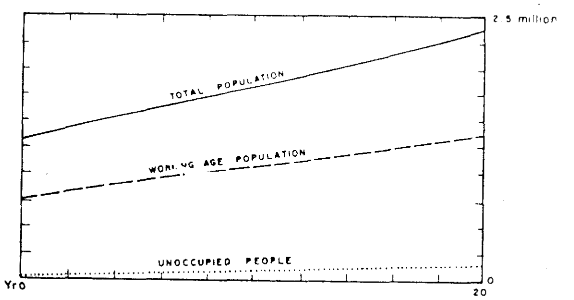


**Fig. 20 Population dynamics in the Nam Pong basin -basic scenario.**

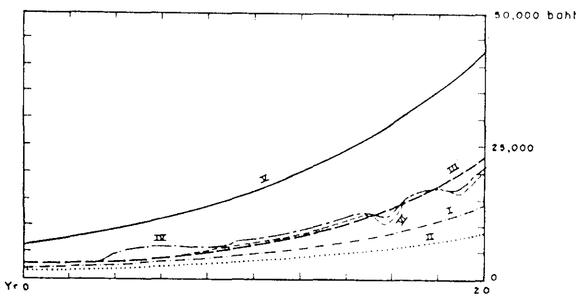


**Fig. 21 Trends of per capita income, all spatial units -basic scenario.**

should manage to provide more alternative employment opportunities, which would indirectly relieve the population pressure on forest land and reduce deforestation. Cooperation with private sector in implementing private tree farm project must be put in action soonest. Other-wise the policy enhancing private sector to invest in creating tree-farm would be merely nice words in the fifth national economic and social development plan (1982-1986).

## 4. Socio-Economic Subsystem

4.1 *Population change* : the basin population is projected to increase, in a uniform trend, from 1,279,000 to 2,398,796 over the 20-year period. (Figure 20) The working age population in year 20 is approximately 58% of the total population with the ercentage of unemployment increaseing from 3% in year 1 to 11% in year 20. This increasing proportion of unemployment warrants serious government consideration since it implies that the number of new job opportunities created in the economy are not sufficient to absorb increments to the labour force. Given the limited supply of agricultural land, unless it can be farmed more intensively, for example, by double-cropping as in Unit IV and VI, productive activities will have to be found outside the basin thus obiously enhance current paramount urban problems. Population estimates for year 1 and year 20 for all spatial units is given below in Table 5.

**Table 5 Population in year 1 and year 20-all spatial units**

| Spatial Unit | Year 1 | Year 20 | Percentage increase |
|---|---|---|---|
| I | 758.000 | 1.561.153 | 98.9 |
| II | 80.000 | 147.995 | 85.0 |
| III | 240.000 | 355.759 | 48.2 |
| IV | 54.000 | 90.395 | 67.4 |
| V | 84.000 | 185.404 | 120.7 |
| VI | 36.000 | 85.090 | 61.4 |
| Total | 1.279.000 | 2.398.796 | 87.5 |

4.2 *Economic indicatiors* : The basin economic structure changes gradually during the 20 year simulation but agriculture remain the predominant sector. It should be noted that economic treand were simulated from market price and estimate future inflation rates at 10% per annum which contribute greatly to the exponential growth of the unit incomes in the later years.

Per capita income is used as an indicator of the welfare of the people in each unit. Average income per capita for the whole basin over 20 years from approximately Baht 1,800 in year 1 to Baht 17,600 in year 20. The results (Figure 21) show that under the conditions simulated the developmental potential varies considerably among spatial units. The gap in income in Khon Kaen town and rural areas grows progressively. Yet in opposite direction to the stated government policy in reducing income gap between urban and rural area.

Income per capita continues to be lowest in spatial unit I and II which are dependent and must remain dependent on rainfed cultivation and grow only one crop per year. Though agricultural conditions are similar in unit III, income rise much more rapidly, and by year 18 become the highest in the rural area of the basin. This prosperity results from extensive cash cropping of sugar-cane and kenaf to supply the sugar mill and pulp mill in the unit. This is unexpected pleasing surprise.

Incomes in the irrigated spatial units (IV and VI) are initially higher than unit III, because agricultural yields are higher in the rainy season and an increasing proportion of the land that grows two crops per year. However, extreme variation of precipitation (see inflow trend) cause fluctuation in income which is clearly shown in Figure 21.

## 5. The Institutional Context

As the Nam Pong model evolved, interviews and meeting with various govenment representation provideed insight and understanding related to an integrated view of the Nam Pong system. The result is a suggested institutional model from the point of veiw of the "roles" that each of the agency can best perform. This is the first step towards defining institutional setting that could work to promote a more integrated approach to basin management.

5.1 *Water subsystem* : Responsibility for reservoir operation should remain with EGAT (the Electricity Generating Authority of Thailand) but as the reservoir water management will affect other subsystems, closer links between EGAT, RID (Royal Irrigation Department) and DoF (Department of Fisheries) and the DoAE (Department of Agricultural Extension) all at provincial level would be valuable. This co-operation could easily be initiated and promoted throught the assistance of the existing Provincial Development Committee (PDC).

5.2 *Fishery subsystem* : Management of fishery resources must mainly be responsible of DoF, especially in respect of fish stocking, increasing the yield of fish and other technical investigation. However, other activitics related to conservation and protection of fishery resources must be performed in close co-operation with the local administration and law enforcement agencies.

5.3 *Land-use subsystem* : The protection of forest resources and'the extension of reforestation programme in the watershed area in now under the responsibility of RFD (Royal Forest Department) and this should continue. To increase the efficiency of forest resource protection, and to resolve problems of illegal landholding in forest areas (which is the major constraint to the reforestation programme) assistance from the local administration and law enforcement agencies is essential to extend the control network sufficiently to cover the whole watershed area. This may even require assistance of the army.

One of the major goals of the Nam Pong project is to increase agricultural production within the irrigated area. This is currently the responsibility of RID. However, such development requires a multi-displinary approach, utilizing the knowledge of engineers, agricultural extension officials, community development workers and administrative personnel.

5.4 *Socio-economic subsystem* : The national policy ot reduce the high population growth rate must be implemented. What is needed is an increase in technical manpower and budget available to the current family planning programme. If provided, the Provincial Public Health Office will be able to accelerate its effective family planning activities in the basin area which ultimately will relieve pressure on resources exploitation.

The division of responsibilities described above could be made differently and other agencies might be included (such as the army, Khon Kaen University etc.) as the resource management programme progresses. The final dicision on which roles are to be performed by which agency and further revision of the administrative strategy must be left to the process of discussion which can be initiated and carried on by the existing PROVINCIAL DEVELOPMENT COMMITTEE.

## CONCLUSION

The Nam Pong simulation model represents an intergration of ideas and information that explicitly accounts for the linkages between the biophysical-socio-economic components. Although not a complete representation of the real world in detail in captures moslt of the important dynamics and facilitates exploration of a wide range of management options.

In utilizing models for resource management it is important to de-emphasize the quantitative nature of the model output and concentrate more on the predictive trends. Point of more interest is how the basin system responds given the various perterbation imposed (i.e., drought, flood, over-population etc.).

The Nam Pong model is serving in :

(1) Develop good understanding of the basin system, its dynamic nature and its response to stress.

(2) Identify management actions that can partially or completely mitigate adverse impacts (e.g. family planning, institutional setting)

(3) Recommend institutional seeting.

The context of this paper, its methodology and its application were repeatedly extended to various instutions, for example

(1) Office of Governor, Khon Kaen on 25 March 1981.

(2) Khon Kaen University during 19-22 March 1981. (Transferring methodology to Office of Water Resource Development)

(3) Chulalongkorn University on 21 December 1981.

(4) Kasetsart University on 20th Annual Conference 5 February 1981.

It certainly received considerable interest.

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