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TOPIC PAPER

A CASE STUDY OF THE PA MONG PROJECT(THAILAND): ENVIRONMENTAL ASPECTS

BY

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ABSTRACT

Case study of the Pa Mong Project (Thailand): environmental aspects

The study presents the principal ecosystemic implications of dam and reservoir construction - categorized by physical, biological and human (or socio-economic) effects - and introduces the broad environmental objectives of the Mekong Committee in river basin development.

The construction of the Pa Mong dam will have far-reaching impacts involving human, water (including fish), land, mineral, forestry resources and wildlife. Several investigations have been conducted and estimates made, in order to anticipate the impacts of Pa Mong on these different resources, and evaluate the future socio-economic potential of the area, within its ecosystemic and environmental capacities.

I. INTRODUCTION

Efforts to increase energy and food supplies in many countries have manifested themselves in recent years in the progressive enlargement of the waterscape through the construction of dams and the creation of man-made lakes. This increase in area of standing water on earth has been, obviously, at the expense of land surface area and lineal length of flowing waters. Inherent in this shift from landscape to waterscape are a vast number of inter-related ecological changes. These ecological changes directly or indirectly embrace all of the many impacts of dams and their reservoirs. In many instances, dams around the world have scored highly in the achievement of purposes for which they were constructed and have generated unprecedented benefits. Some have failed in more ways than one, and have created unanticipated costs and woes which have become severe restraints to the realization of the full social and economic potential of those dams. An analysis of causes for successes and failures has shown that usually one or more of the following reasons have been responsible for the failure to realize all the potential planned benefits from dam construction projects: (a) lack of perspective on the part of development agencies; (b) imperfect co-ordination among and within agencies involved; (c) inadequate research on immediate and long-range effects; (d) poor scheduling and implementation of relevant activities; and (e) inadequate supply of technically trained manpower in the country.

Nevertheless, it should be recognized that like mining and the harvest of forest products, water storage involves certain ecological costs that society has to pay. The over-riding factor in the selection and implementation of water management projects must therefore be the minimization of the ecological costs through careful multidisciplinary study, long-range planning, training of needed technical personnel, and thorough, painstaking and chronologically sound execution of the project.

The extensive changes from landscape to waterscape are comparable in many of their short-term and long-term environmental effects to such a sudden natural cataclysm as the eruption of a volcano with its concomitant burial of land surface by lava and ash. A principal difference is that man can choose the site and timing of water storage structures. Also, he has learned, and continues increasingly well to learn how to turn secondary ecological effects into social and economic gains. This learning process has been and continues to be difficult, however, because of the extreme complexity of the ecosystems on which flooding and irreversibly permanent inundation have their effects.

/Historically

Historically the study, planning and logistics which precede, accompany and follow the construction of major dams have never been adequate anywhere in the world. The challenge to the many technical disciplines involved has perhaps never been greater for any other type of economic development scheme. It is the intent to show in the following paragraphs the complexity of the ecosystems involved in change with the construction of a dam and to briefly outline the studies undertaken in the Mekong basin to anticipate the possible environmental side-effects so that the negative effects could be offset and the benefits enhanced. It is hope that it will also be evident from this account that much research and new kinds of planning need yet to be done in order to maximize both the primary and secondary benefits to be derived from the creation of man-made lakes.

II. MACROSYSTEMS VIEW OF ECOLOGY OF A DAM AND RESERVOIR

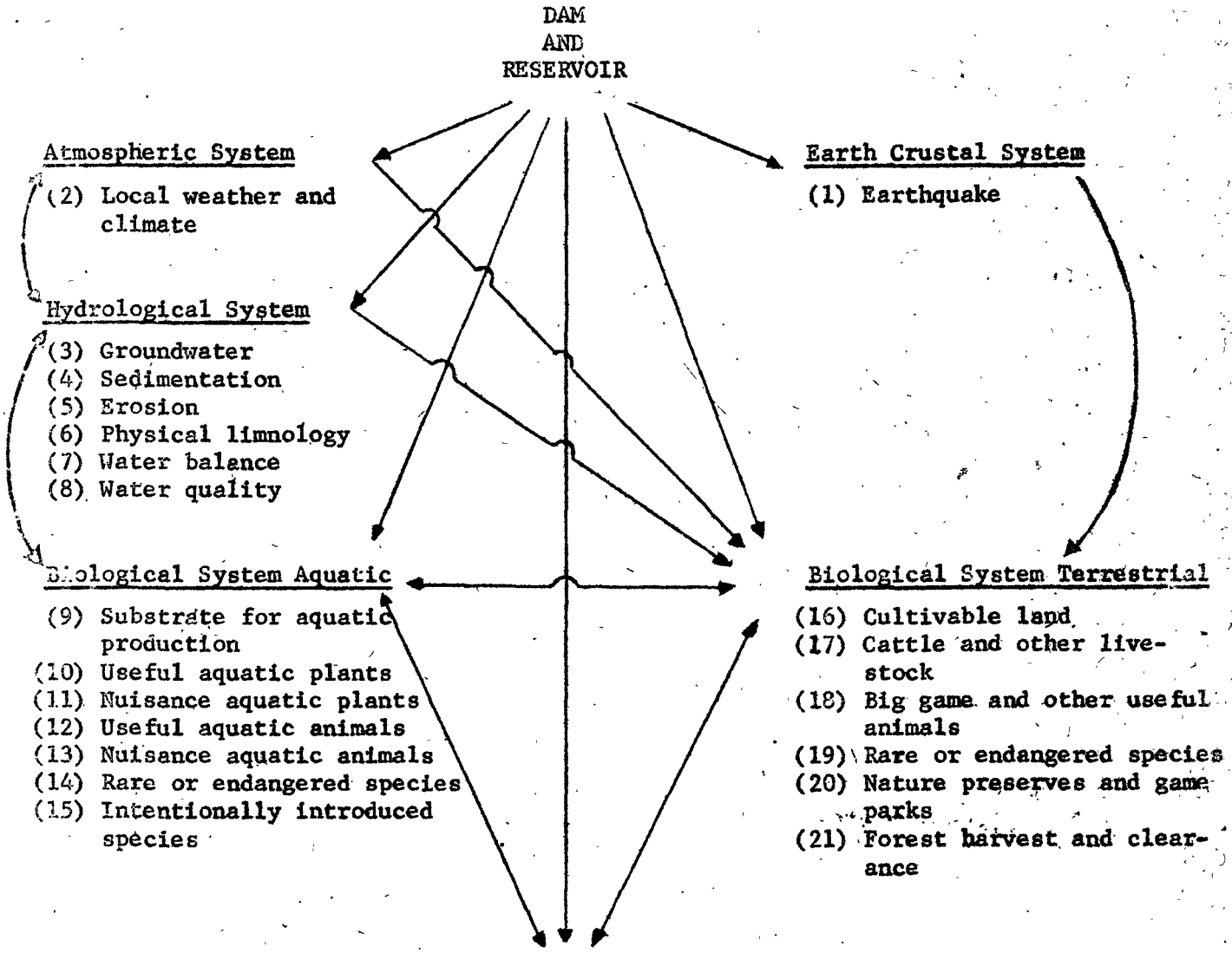
The over-all ecosystem on which a dam and reservoir exert their effects is composed of three principal groups of systems - physical, biological and human or socio-economic (See the figure).

The physical system can be thought of, for present purposes, as being made up of the sun and its energy, the atmosphere, water and the earth's crust. Solar energy is the key to the growth of green plants, the ultimate source of food for all animals. It is also the basis for the hydrologic cycle, evaporating water from the surface of the earth to be redistributed in precipitation. The atmosphere is the transmitter of solar energy, the transport mechanism for water in a large part of its cycle, the retainer of oxygen required by living organisms, and the vehicle for the carbon dioxide used by plants in the manufacture of their tissues through internal interactions of sunlight, chlorophyll, water and chemical elements in solution. Water itself is required by all organisms for their life processes and water and its hydrological cycle are important to man in transport, electric power generation and production through agriculture, aquaculture and manufacturing.

The earth's crust is on its surface the habitation of man and a multitude of other kinds of organisms. It also provides the soil for agriculture, the storage place for ground water, minerals for their many uses and the basins for lakes, ponds, rivers and the oceans. Although the earth's crustal system responds to the environmental shifts inherent in changing it from landscape to waterscape, the response is relatively far less evident to the untrained observer than that of the hydrological and biological systems.

/SOME

SOME POINTS OF IMPACT OF A DAM AND RESERVOIR



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The biological system is the natural factory which, through the life processes of aquatic and terrestrial plants and animals, harnesses solar energy and transfers it to natural resources that are used as food, fibre and industrial raw materials. A key to the perpetuation of this system is the recycling of energy and organic and inorganic materials through physiological processing, death, decay and redistribution. Production by this sybsystem is unusually sensitive to changes in the physical environment - both sudden and long-term. Consequently there are found here many of the secondary effects of reservoirs which in turn directly and indirectly, and so importantly, affect the human part of the ecosystem.

The human system is composed of man's production activities and of his social and cultural institutions, all environmentally dependent and in turn affecting the environment. Principal production activities include hunting, fishing, agriculture along with forestry and livestock production, aquaculture (the aquatic parallel of agriculture, thus importantly aquatic plant and animal production and especially, intensive fish culture), the manufacture of goods and products and the commerce and service industries deriving therefrom. In the human system, social institutions embrace health, education and general welfare services, communication including transportation and cultural and institutional continuity of historical value.

It is within the broad framework of the three preceding parts of the over-all ecosystem and their many components that water management schemes, including the construction of dams have their abundantly interdependent primary and secondary effects. The physical, biological and human components of the over-all ecosystem are affected both at the site of a dam and reservoir and for varying distances off the site - upstream, downstream, in the general vicinity and even far away. On-site impacts include those that are engendered in covering the river channel and valley with water. Down-stream effects centre in those that derive from the basic changes in timing of discharge, alteration of peak discharge volume and differences in chemical and thermal properties of the water as a result of its temporary storage. Upstream effects centre in those that arise from the dam as a physical barrier to fish movement and to stream navigation.

/Since

Since the environmental and social impacts of dams and reservoirs can be so complex and far-reaching, it is of unusual importance that such impacts be most carefully studied and evaluated before final decisions are made on feasibility, and on when and where to start construction. The barest minimum of involvement of supplementary technical expertise during the earliest thinking and planning stages will include a broad-guage and experienced ecologist and a sociologist. Such experts working with the engineers and economists will be able to guarantee that environmental and human considerations receive ever-improving amounts and quality of attention. Together, furthermore, they will be able to evaluate alternatives to constructing a dam. Obviously, decisions to build dams should no longer be made solely on economic or political grounds.

On the basis of existing knowledge it is possible fairly to define in advance the character and scope of many of the impacts of a dam and reservoir. There may be others which have not been studied sufficiently to enable definition and prediction in advance; this is especially true in the tropics where so much new opportunity exists for water resource management. The annex presents a checklist of probable impacts of dam construction. In presenting this list it is not the intention to suggest that all these impacts are attributable to each new or projected river development scheme. Ecologically speaking, each river system is unique and environmental effects of modification/development of aquatic ecosystems cannot be extrapolated from one ecological zone to another; even within the same geographical region water systems can differ greatly in terms of response. Therefore, it is only through properly planned investigations in the particular river system to be developed that it is possible to anticipate problems and arrive at solutions before needless ecological damage, economic loss and human stress are engendered.

III. ENVIRONMENTAL PROBLEMS OF PA MONG

Economic benefits and environmental effects of a dam, as stated earlier, are felt far beyond the location of the dam itself and therefore for incorporation of environmental considerations, planning has to be done in a comprehensive river basin context rather than for individual dams. In view of this the "Mekong Committee" has adopted a comprehensive, integrated development approach for the whole basin in planning for the Pa Mong and other dams. For incorporation of environmental concerns in planning it is

/also

also necessary to establish goals for environmental conservation. The nature of goals would obviously depend on the wishes of policy makers, people and the state of development of the country concerned. The "Mekong Committee's" environmental goal is conservation of productivity of the primary resources, namely water, land and man. Ecological investigations and environment enhancement projects of the Committee have therefore the principal aim of ascertaining the impacts of development on these primary resources and then to implement appropriate measures to maximize beneficial, and offset harmful effects. Brief accounts of some priority environmental problems investigated follow.

1. Human resources

Resettlement. Construction of the Pa Mong dam will necessitate resettlement of between 200,000 and 500,000 people depending upon the size of the dam and the reservoir configuration. Within the reservoir area, 50,000 to 100,000 ha of paddy will be inundated and large areas of upland crops and human habitations will be submerged. While the cost seems high the ultimate benefit to the four riparian nations and to millions of people, is many times higher. Nonetheless, resettlement is perhaps the most difficult socio-economic problem facing the project. Therefore the Committee has sponsored a large number of studies to evaluate the difficulties involved in resetting such a large number of people. The history of other resettlement projects has been reviewed, pilot projects have been established, resettlement alternatives have been examined including the use of reservoir fringe areas, reservoir fisheries, moving to uplands, purchase of private farm lands elsewhere and urban employment. The real costs of resettlement have been comprehensively examined. Thus, step by step, the Mekong Committee's work is evolving what it is hoped would be a competent approach to solving the many difficult socio-economic problems. Possibly the most important factor is the decision taken to set aside an adequate amount of money, at the outset, to cover all real components of resettlement costs.

One method of minimizing the resettlement problem would be by excluding certain areas from the reservoir through construction of exclusion or protection works. The Pa Mong optimization studies examined various reservoir configurations with different dam heights and evaluated the possibility of protecting the populous Loei valley in Thailand and the Vang Vieng valley in the Lao People's Democratic Republic from submersion. Schemes for excluding either or both of the Nam Lik and Nam Mong arms of the reservoir were also examined. After taking

/into

into account all costs and benefits, exclusion of the Nam Lik and Nam Mong drainages, and protection of Vang Vieng and Loei, were found to be economically not justified because exclusion of Nam Lik and Nam Mong drainages from the reservoir would eliminate most of the project's irrigation potential in the Lao People's Democratic Republic and Thailand respectively and protection of Vang Vieng and Loei involve complex engineering solutions to ensure adequate drainage of the areas following construction of the protection measures. The economic studies associated with the Pa Mong optimization have therefore been based on the assumption that no protection or exclusion measures would be taken.

Socio-economics. Construction of Pa Mong dam will have profound impacts on the socio-economic conditions of the rural population downstream. New technologies will have to be applied, attitudes, habits, customs and social institutions will have to be transformed to suit new farming methods, and lifestyles. The "Mekong Committee" is acutely concerned that the quality of life of the affected rural farming population will in fact be improved by the project, as intended. This concern is reflected in the large number of studies executed to understand the existing situation of the population, to forecast the socio-economic impacts expected to result from construction of Pa Mong, and to establish a basis for realistic project planning. Because of the admitted complexity of achieving changes in socio-economic patterns on a massive scale, the "Mekong Committee" recognizes that the transformation must be achieved in progressive stages. An essential basis of the whole programme is the planned system of pioneer agricultural projects, now being implemented. These will involve a series of full-scale farming communities organized to practice and to coexist with the new agricultural methods at selected sites in the lower basin where water is available from either tributary projects or from the Mekong River. They have the objective of ensuring that new concepts will result in higher production and in satisfaction both to the farmers and to the Governments concerned. The accumulated experience should be adequate to permit the Governments to make strategy decisions on such basic questions as educational requirements, community facilities and new institutions (agricultural extension, farming co-operatives, lending institutions etc.). It is also expected to provide the necessary experience for improving planning, and ensuring effective implementation of the proposed large-scale irrigated agriculture to be associated with Pa Mong.

/Urban

Urban development. The inevitable growth of industries, such as those related to construction, agricultural services, food processing, mineral extraction and processing, and agricultural inputs, together with population increase resultant on immigration from resettlement areas, will result in increased urbanization. Following establishment and operation of a large construction settlement associated with the building of the dam it can be expected that a substantial urban community will be established in the vicinity of the dam site. Given the potentials in the region for both the agro-industries and mineral industries, and considering the policy of the Governments towards decentralization of industry, a whole new city can be expected to be established near the dam. This new city could also play an important role in meeting resettlement demands. It may well be opportune to include the planning of such a city in the project from the beginning so that streets, parks, schools, temples, water supply, electricity, entertainment and recreation complexes etc. will be adequate for future requirements.

Recreation and tourism. As one of the world's largest man-made lakes in a region where lakes are scarce, Pa Mong will have considerable tourist potential and much recreational appeal. The new lake will create innumerable choice sites for picnicking and camping as well as for water contact sports. Recreation studies conducted in 1969 and 1976, have indicated that the number of visitors to the reservoir area would increase rapidly over the years. The ultimate importance of this facet of the project will depend on the magnitude of investment made in developing recreational facilities. It is expected that planning for recreation facilities preservation of natural beauty sports, and creation of national parks and fauna reserves, would commence as soon as decision to construct Pa Mong dam is taken.

Public health. Malaria and schistosomiasis are among the major public health disasters that followed dam construction elsewhere in the tropics. Therefore, the Committee has given particular attention to these two hazards.

Malaria investigations sponsored by the Committee were focussed on field observations at existing tributary projects. These studies have covered all facets of malaria propagation from entomological aspects to epidemiological data collections in order to determine the extent to which the creation of new environments might establish favourable habitats for the proliferation of disease vectors. Studies conducted at two reservoirs (Nam Pong and Nam Phrom) in Thailand have produced no evidence of increased malaria hazard as a result of these projects. Another aspect of malaria investigations of the Committee comprised formulation of economical, yet effective, control measures for the disease at dam sites during construction periods.

/Schistosomiasis

Schistosomiasis studies sponsored by the Committee have revealed that the disease is endemic in localized areas of the basin, particularly in the region near the border of the Lao People's Democratic Republic and Democratic Kampuchea. An interesting finding of intensive research in this field is that the intermediate host of the blood fluke (apparently a new strain of Schistosoma japonicum) which causes bilharziasis is the tiny snail, Lithoglyphopsis aperta, which is essentially a rapid-flowing water species. Therefore, it would appear possible that water resource development in this region may not encourage the spread of the disease, unless the snail could adapt to the lacustrine environment of man-made lakes, or to the slow-flowing water environment of irrigation systems. In the meantime, a project to control the disease and the vector where it naturally occurs has been prepared and is awaiting implementation.

Other diseases that might proliferate as a result of water resource development are, for instance, liver flukes and lung flukes in the vicinity of reservoirs, and dengue fever due to increased navigation and resultant increase in breeding places for the vectors in water storage containers in boats. However, such possibilities appear minor when assessed in terms of the present general lack of adequate public health facilities and services in the Mekong basin. Nevertheless studies on these and other diseases are in progress in the Nam Pong region of the basin.

2. Water resources

Ground water. Ground water is very important in the lower Mekong basin as it provides an important source of domestic and community water supply, and because discharge from ground water aquifers comprises most of the dry season base flow of streams. With the construction of Pa Mong the downstream pattern of ground-water flows could change with beneficial consequences by augmenting the total dry season flows. It is estimated that charging of ground-water in irrigation service areas due to seepage from canals, will result in lifting ground-water levels by 1 to 2 m in low lying areas and by as much as 3 to 5 m in uplands. In some areas this level increase might affect hydraulic and salt balance necessitating provision of adequate drainage facilities for successful cropping. Increased charging of ground water in the vicinity of the reservoir should generally improve the availability of water from local wells.

/Water

Water quality. The mineral quality of Mekong river water is excellent with respect both to total salts and individual constituents. It is well suited to all intended uses. Some temporary changes in water quality will take place in the reservoir but the quality of water withdrawn for downstream irrigation is not expected to be changed appreciably. Irrigation return flows however are expected to affect river water quality during the dry season. To ascertain the nature and magnitude of such effects a basinwide water quality study will be conducted in the near future.

The possible pick-up of salt from year-round irrigation of the soils of the Korat plateau in Thailand, which overlies extensive salt formations, was also studied. No problem is anticipated as the salt strata generally lie beneath the zone of ground water affected by irrigation.

The accelerated urban, industrial and agricultural development expected to result from the Pa Mong development will contribute to increased water pollution if proper controls are not exercised. Anticipated population growth will require urban and industrial intensification, with or without Pa Mong, hence the answer will be in establishing a reliable system which puts into effective use the technology by which water pollution can be feasibly controlled. Experience elsewhere has shown that such controls must be implemented as part of the growth process. The 'Mekong Committee" should be in a good position to assist the riparian countries to establish the necessary programme of pollution control in due time.

The most important effect of Pa Mong on water quality relates to estuarine areas in the delta. The present pattern of salinity distribution will be changed by increased fresh-water flows in the dry season which will help in repelling salt-water intrusion. In terms of delta agriculture, the effect of this is favourable; in terms of fisheries the effect is likely to be unfavourable to some salt water species.

Aquatic biology. Downstream of Pa Mong, deterioration in aquatic biological resources is expected to be restricted only to the residual river immediately downstream of the dam. There is some concern that increased dry season flows of fresh water in the delta may affect the extensive mangrove swamps along the coastal area. As much of this extra flow will be extracted for irrigation, it is unlikely that Pa Mong itself will significantly affect the coastline ecology. However, the construction of salinity intrusion barriers, expected to be used as part of the eventual improved agricultural development in the delta, could affect aquatic biological values in the area considerably. Such effects will need to be evaluated and taken into account as part of the evolving delta improvement plan.

/There

There could be explosive growths of aquatic weeds in the project irrigation systems. While experience in existing tributary projects has not yet shown any serious problem the "Mekong Committee's" research programmes include studies to try to develop practical and economical control measures suited to southeast Asian conditions.

Fish reproduction. Because of the economic and cultural significance of fisheries to the people of the basin, the Mekong secretariat has undertaken extensive studies to anticipate the impacts of mainstream regulation. Pa Mong will change present patterns of fish reproduction dramatically, both upstream and downstream. Negative effects would include gross impairment of the existing riverine fishery downstream of Pa Mong for an estimated 20 km because of severe river stage fluctuations which will occur in this reach of the river. Reduced flood flows will reduce the annual harvest of inundation fisheries, particularly in Democratic Kampuchea, and impair the breeding of some species. Losses will also occur where existing aquaculture areas, primarily in Thailand and the Lao People's Democratic Republic, will be converted to cropping. Annual fishery losses would total about 15,000 tons with Pa Mong 230 and up to 20,000 tons with Pa Mong 260.

Losses from changed aquaculture production in Thailand and the Lao People's Democratic Republic will be insignificant compared to the gains from increased reservoir fisheries, increased food production from lands reclaimed as a result of flood control, and increased aquaculture opportunities accompanying irrigation development. It is estimated that in addition to the 820,000 ha of irrigation from the Pa Mong reservoir, more than 100,000 ha could be available for fish farms. To utilize this opportunity for "irrigated aquaculture" the Committee has initiated a programme of establishment of pilot fish farms which will form the nucleii from which development of aquaculture in irrigation service areas will radiate.

In Democratic Kampuchea the losses from the estimated 10 per cent reduction of inundation fisheries will be largely offset by increased food production from larger cropping areas, and by systematic aquaculture programmes to improve varieties and yields of fish through fish farming and cultivation of fish in floating cages.

Some migratory fish species may be endangered by the effects of Pa Mong dam on their vital behavioural patterns. The Mekong Committee's programme will include research and development of facilities for evolving practicable systems for artificial propogation of all migratory species found to be endangered and sufficiently valuable to merit saving.

/Other

Other possible impairments to fisheries which were considered included possible reductions in marine fisheries dependent on nutrients discharged by the Mekong system into the South China Sea. Studies on this aspect have indicated that there will be no significant change in the nutrient discharge. The possible impairment of the very valuable estuarine fisheries, including shellfish as well as finfish, due to changes in salinity patterns (or in patterns of hydrology) was also examined. It was concluded that detrimental effects from increased toxic effects of agricultural chemical residues and pollution from community wastes discharges, would be greater to the fisheries than the effects of hydrological changes. Therefore water quality monitoring and effective water pollution control programmes together with large-scale aquaculture development to offset losses to natural fisheries would be necessary to protect and enhance the environmental and biological values of the river. Such programmes are already afoot.

Reservoir fisheries. The Pa Mong project will convert a large stretch of the Mekong from a flowing river ecosystem to a lacustrine one. Pa Mong 250 will eliminate or reduce currents as far as 344 km upstream from the damsite. Many of the existing riverine species will disappear from the area to be replaced by species that thrive in standing water systems. After a brief depression in fish productivity, stocks will rapidly increase because of proliferation of plankton that usually follows initial inundation. The peak production levels might slowly decline between six or ten years after filling of the reservoir. Afterwards production is expected to stabilize. The "bloom" in fish production around the second and third years will encourage rapid settlement at the reservoir by human fishing communities. Careful reservoir management and improvements in fishing technology will sustain high yields and improve catch efficiency. At present levels of efficiency the reservoir catch from Pa Mong 250 would be about 25,000 tons per year. With improved efficiency this should increase to 55,000 tons per year, or more. The Committee is now implementing pilot projects in reservoir management and development in order to evolve effective measures appropriate for present and future basin reservoirs. It may be noted here that the value of fish now being produced in Mekong tributary reservoirs such as the Nam Pong in Thailand and Nam Ngum in the Lao People's Democratic Republic equals or exceeds the value of power generated by those dams.

/Reservoir

Reservoir ecology. In addition to the effects already noted, impoundment will result in the following ecological changes in the lake itself:

(a) Some changes will occur in water quality, especially in the deeper areas of the reservoir which will become anoxic. These changes are not expected to influence agricultural use of the water though there will be adverse effects on the immediate downstream fishery

(b) Growth of water weeds especially water hyacinth will take place due to nutrient accumulation in the reservoir. It is recognized that this could become a serious factor in project operations. Therefore, a programme of research to develop practical and economic control measures suited to conditions in the basin is planned

(c) Potential disease vector habitats will be created in the lake. Detailed studies thus far on this aspect do not indicate that Pa Mong will produce serious effects in this regard; however, continued monitoring of the vector species involved and checking of epidemiological data in reservoirs already constructed in the basin is continuing which is expected to throw more light on this subject.

3. Land resources

Geology and seismology. Numerous investigations relating to these aspects have been conducted. These studies indicate that geological formations are suited to the proposed dam and powerhouse, and that the proposed area is relatively free of earthquake hazards. However there will be significant landslide hazards along the eastern and southern rims of the Pa Mong reservoir and corrective control measures will have to be taken to reduce these hazards.

Mineral development. An integral part of the Mekong Committee's programme for industrial development in the riparian countries has been exploring and evaluating the extent of mineral resources. The programme has been basin-wide but gives primary attention to the areas of northeast Thailand and northern Lao People's Democratic Republic, which could be readily furnished with power from Pa Mong and the existing tributary projects.

/Very

Very rich deposits of potash have been located in this area. Exploitation of this resource could capture a substantial share of the market for potash throughout southeast Asia. Preliminary indications are that Democratic Kampuchea and southern Viet Nam possess bauxite, though probably not in exportable quantities. Small steel rolling mills could be established in the riparian countries with their needs being met from local iron ore deposits such as those found in the Loei province in Thailand and Xieng Khouang in the Lao People's Democratic Republic. A ferro-alloy industry may be feasible in the basin using local manganese and quartzite ores. Another potential is the use of rock salt mined from northeast Thailand for the manufacture of caustic soda and chlorine. In addition to potash, the rock salts contain large reserves of gypsum and possibly magnesia. Creation of the huge new reservoir and resultant availability of plentiful power and enhanced transportation facilities, should give great impetus to development of the mineral resources of the region, which, without the project, might well remain undeveloped. Mining and ore processing operations will have their characteristic adverse impacts on the environment and therefore proper controls will have to be exercised for preservation of the landscape and prevention of pollution of ground and surface waters.

Sedimentation. With the construction of the Pa Mong dam sediment will be deposited at the head of each valley entering the reservoir. The total annual sediment inflow and depositior in the Mekong arm of the reservoir is estimated at 160 million tons. Over a period of 100 years an estimated 13,300 million m^3 of sediment will be accumulated in the reservoir and the bed level at the dam site will be raised from 165.4 m MSL to 185.7 m MSL. This accumulation is readily absorbed within the inactive storage volume of the Mekong arm (17,776 million m^3) and will not affect the minimum pool level of the active storage (216 m MSL).

Soils. The soil resources and soil fertility in the lower Mekong basin could be expected to be significantly affected by reduced flooding, increased irrigation, increased water tables, salinity changes, and new agricultural methods engendered by Pa Mong. Studies by the Mekong secretariat have shown that with foresight, and reasonable management, it will be possible to protect the soils and enhance their productivity. In the irrigation service areas most of the soils are arable, and the non-arable soils including saline soils, have been excluded from the planned development. With proper use of agricultural

/chemicals

chemicals and water control, including drainage, there should be no deterioration of soil structure and adverse salt balances in the root zones. The principal soils problem will be attaining and maintaining soil fertility. Relatively high fertilizer inputs will be required for most of the project lands to attain the desired high yields.

Silt deposition. The trapping of silt in the Pa Mong reservoir, and the reduction in flooding will reduce the regular deposition of sediments on agricultural land downstream of Pa Mong. This has led to apprehensions that soil fertility may be impaired in the delta soils in southern Viet Nam, and in the back slopes of river levees, the chamkars, in Democratic Kampuchea. Studies were undertaken to examine the mineralogical, chemical and physical analyses of sediments and soils in the Vietnamese delta. It was concluded that the annual deposition of sediment does not measurably increase the fertility of the delta soils, and that water control will be the dominant factor by which large increases in delta agricultural productivity can be realized. In Democratic Kampuchea, studies have determined that areas with an efficient colmatage system receive 20-25 mm per annum of sediment more or less constantly in the present condition. With Pa Mong there will be some reduction in the normal pattern of this silt deposition, but this can be largely overcome by the use of engineered colmatage systems designed to deposit silt at desired places, rather than depending on natural creeks which are only partially effective. Also, with Pa Mong, the effect of the small reduction in silt deposition in the present chamkar areas will be more than offset by the considerable enlargement of the total usable chamkar area.

Channel degradation. Completion and operation of Pa Mong will result in considerable degradation of the stream and banks downstream from the damsite. Clear water released from Pa Mong will have the tendency and potential to pick up its former load of sediment by removing material from the bed and banks of the downstream channel. There has been considerable concern about this degradation, especially in the vicinity of Vientiane and Nong Khai. A number of studies have been undertaken to anticipate the rate and extent of channel degradation. Further studies are necessary to enable suitable protective measures to be devised to suit specific needs.

/It

It is expected that channel degradation will occur over a long period and will extend a considerable distance downstream. Scouring of the channel near the dam will commence immediately the dam is completed, and will occur much more rapidly than in areas further downstream. It is expected that many decades will elapse before the degradation effect reaches its limit, or stable condition is attained. It is estimated that at the stable condition, channel degradation will average about 3 m of bed scouring and 100 m of widening. The most recent studies indicate that 67 per cent of the total volume of degradation will take place in the 200 km downstream stretch immediately below the dam within 133 years.

4. Forests and wildlife

There has been considerable apprehension that the advent of Pa Mong will speed up deterioration of forests and wildlife. On reflection, however, it may be realized that the threat to these ecological values is not from water resource control projects like Pa Mong, but from the unrelenting expansion of population and technology. Together these trends appear to present a dim outlook for the future of the basin unless a positive programme for salvaging the ecological values is instituted. It is believed that the advent of Pa Mong could well contribute to speeding up the needed corrective measures given incorporation of watershed and wildlife protection policies in the management of this project.

With regard to post-impoundment effects of the Pa Mong reservoir on wildlife, studies have indicated that the greatest risk would be from increased hunting made possible by improved access. Rational management of the watershed would enable conservation of the wildlife resources. Watersheds of dams are seen as excellent locations for encouraging rational land use, since in these areas potential control and outside inputs are maximal. A beneficial effect of the project will be that the reservoir may become an important place for sojourn of migrating birds; and a natural waterfowl refuge, supporting as many as 500 game birds per km^2. Here again, effective controls must be exercised to prevent over exploitation of the game birds. The drawdown zone may also provide a habitat for wild pig, deer and elephants, while many species of large game may come to rely on the reservoir for their dry season water supply. Pa Mong 250 reservoir would create more than 1,000 islands,

34 of which (totalling 16,600 ha) would be suitable for development of wildlife. If forest cover is maintained on these islands they will provide a natural habitat for wildlife.

While Pa Mong would certainly inundate a sizable area of forest it would also provide alternative land use and economic opportunities, incentives for watershed management control, and establishment of national parks and reserves, thus affording opportunities for protecting and enhancing both forest and wildlife conservation.

Flood control. An extensive programme of seasonal reservoir regulation studies was conducted, together with those for power regulation, to evaluate flood control potentials of the Pa Mong project alternatives. This was followed by a comprehensive study of flood control benefits including benefits attributable to enhanced utilization of property. Possible potential dis-benefits of reduced silt deposition and reduced fishery potentials were also considered. On the basis of these studies it was concluded that benefits from flood control a outweigh the expected losses.

IV. CONCLUSION

The foregoing account is intended to give some idea of the depth of environmental concern of the Mekong Committee. Many environmental studies have been completed, others are in progress and yet others are planned. Our aim is to ascertain as fully as possible, within the limits of available technology, what the environmental consequences of the Pa Mong would be and to evolve and apply measures to enhance the benefits and ameliorate the adverse effects. This effort of the Committee may not result in completely eliminating environmental hazards, but will certainly reduce ecological costs. It is fortunate that there is still a considerable margin of time left for environmental research before major physical structures are to be built on the mainstream Mekong. That time is being used fully. In the words of Mr. van der Oord, the Executive Agent of the Mekong Committee. "The Mekong Project, which was conceived in the 1950s and which will surely continue into the next century, is in fact an environmental improvement and development programme, one of the largest undertaken in Asia, and perhaps in the world. Everything that the Mekong Project touches has its environmental implications and it is therefore worth recalling, at this time when the international media seem to render such activities deeply suspect, that the purpose of the Mekong Project is to harness the great natural resource of the waters of the Basin for the benefit of its peoples. This will yield benefits not only in terms of electric power, irrigation, and navigation which can be made to serve directly the economic well being of the population, but also in terms of flood protection and control, water supply for all purposes, agricultural diversification and other benefits which will make life safer, healthier, and environmentally richer. In this regard it has been the concern of the Mekong Committee as well as my personal concern that development goals for the Mekong Project should be expressed in terms of human well being, and not simply in outputs of power and irrigation water or even *per capita* income."[1/]

/Annex

1/ Extract from the speech delivered on 18 August 1971 at an ESCAP seminar on environment and development.

Annex

CHECKLIST OF IMPACTS[a/]

Impacts in the area of impoundment

1. Submersion of land areas

Mineral deposits;
Timber and other valuable plants;
Wilderness areas and wildlife habitats;
Cultivated lands, grazing lands and potential agricultural land;
Human settlements;
Public buildings and installations;
Roads, railroads and communication lines;
Sites of historic, archeological or cultural significance;
Sites of recreational interest.

2. Submersion of river stretches and associated flood channels

Fish spawning and breeding habitats;
Breeding and living habitats for disease vectors which require running water, e.g.

Simulium damnosum, vector of *Onchocerca* spp.
Anopheles maculatus maculatus)
Anopheles minimus minimus) vectors of
Anopheles fluviatilis) *Plasmodium* spp.;

River bank and running water habitat for wildlife, including waterfowl, fish-eating mammals and their predators;
Scenic stretches of river with present or potential value for recreation.

3. Formation of a large mass of water

Adds weight locally to the earth's crust with possible tectonic consequences;
Possible modification of local weather (moderation of temperature extremes, increase in humidity locally);
Habitat for waterfowl is created;
Opportunity for water transport to remote areas.

4. Alteration and disturbance of landscape at construction site

Erosion, siltation;
Natural plant and animal communities are altered or destroyed.

5. Creation of a lake ecosystem, hydrobiological events

A. Period of flooding after closure of dam:

River channel and nearby floodplains are submerged.
Large quantities of nutrients are released into the water from soil and vegetation.

/Nutrient-

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a/ Peter H. Freeman, Large Dams and the Environment, (International Institute for Environment and Development, March 1977).

Nutrient-rich water stimulates growth of algae and macrophytes, such as water weeds.

Large quantities of decaying plant material deplete the dissolved oxygen.

Fish requiring higher levels of dissolved oxygen die, especially species found in fast running water.

Algae blooms continue to occur in cycles to cause successive and temporary eutrophication events. Some algae may be toxic (i.e. Microcystis sp). Free-floating water weeds, if present, begin to grow and spread.

B. Rate of flooding slows as lake spreads:

Nutrients continue to enter and enrich the water as additional land is flooded, but at a slowed rate.

Oxygen contribution from tributaries decreases as a function of the increasing volume of water.

Fluctuations between oxygen levels and biological oxygen demand may decrease, as primary productivity declines from initial high level.

Stratefication of water temperature and chemistry begins as water deepens.

Anoxic conditions in deeper water may lead to anaerobic decomposition and generation of hydrogen sulfide.

Free-floating water weeds, such as Salvinia, Pistia stratiotes (water lettuce) and Eichornia spp. (water hyacinth) may spread rapidly.

Adaptable fish, especially planktivorous or facultative feeders may, if present, thrive.

Near or shortly after attainment of projected water level and prior to the establishment of a carnivorous fish population, there may occur a peak in fish production.

C. Projected capacity attained as lake matures:

Drawdown zone becomes defined and is colonized by rooted emergent plants (sedges, grasses, herbs). May become an important habitat for fish spawning and breeding as well as for vectors of diseases, such as mosquitos and snails.

Lacustrine ecology evolves in deeper water of the lake, with well defined stratification of chemicals and nutrients.

/In

In deeper water, iron and manganese may be trapped, and decomposition of submerged trees and other vegetation will slow down in the absence of oxygen.

Lake cycles begin to show seasonal influences of flooding, temperature changes, and winds.

Food webs and trophic chains become defined, and the establishment of a carnivore population and human fishing may lower fish biomass.

The nutrient status of the lake stabilizes as contributions from submerged land and vegetation diminish, and becomes determined by the nutrient content of rain and inflowing water.

Sedimentation begins to form deltas at the mouths of tributary streams.

6. New lake ecosystem, human health events

Increased exposure among lakeside dwellers to endemic diseases transmitted by water; water contaminated by human faeces and urine in immediate vicinity of villages.

amoebiasis
bacillary dysentery
cholera
infectious hepatitis

Increased exposure to diseases through vectors whose habitat may be increased in the lake ecosystem, especially the various snail vectors of schistosomiasis.

People attracted from other regions by dam construction activities or fishing opportunities may be victims or carriers of diseases.

Impacts downstream from the impoundment in river channel and flood plain

1. Modifies downstream hydrograph

Reduces peak flows and floods resulting in decline of seasonal fish spawning and breeding in flooded areas and decline in associated wild life such as water birds and fish-eating mammals.

Reduces peak flow channel scouring.

Groundwater recharge from flood waters ceases.

Flushing of debris and weeds from river channels, oxbows and flood plains ceases.

Reduces capacity for diluting, flushing and transporting wastes.

/Increases

Increases and stabilizes minimum flow with various effects for waste dilution, local ground water recharge, navigation, and water withdrawals for irrigation, homes or industry.

Introduces abnormal and variable flows caused by project operation, such as creation of flood control space, periodic generation of peak power, or exposure of shoreline to control the propagation of insect pests and vectors.

2. Modifies river erosion

Causes shift from an erosion-deposition cycle to one of continual erosion. Channel scouring and degradation take place immediately downstream from the dam.

Reduction of peak discharges halts periodic transport of large quantities of sediment.

Channel stabilizes and vegetation may become established on banks; channel may deepen.

Where not held by vegetation or protected, banks may steadily erode.

Flood plains no longer receive annual increment of silt.

3. Alteration of water quality

Increased salinity may result from evaporation in reservoir.

Temperatures are lowered during usual low-flow period.

Outflow may be turbid due to concentration of silt in density currents.

Water released from deeper portions may be rich in iron and manganese, but initially low in dissolved oxygen.

Water may initially contain H_2S.

Augmented flow during dry period may improve quality by providing more dilution, especially of irrigation return water.

Rapids may be created which produce breeding environments for Simulium damnosum, vector of onchocerciasis or river blindness in places where it occurs.

4. Modification of aquatic productivity and fisheries:

Seasonal peaks in fish production cease as consequence of cessation of flooding and creation of backswamp fisheries.

Productivity may decline as consequence of negative changes in water quality (turbidity, salinity, and fewer nutrients).

Stabilized banks and bank vegetation may increase productivity for some species and for wildlife.

Migrations of some fish are impeded.

/Impacts

Impacts in Delta, Bay or Ocean

1. Reduction of seasonal peak discharge stabilizes the freshwater-saline water boundary and salinity gradient with possible detrimental consequences for shellfish adapted to a changing boundary and for species which have evolved to migrate to or through estuaries during peak runoff.

2. Reduction of total inflow due to irrigation or other consumptive withdrawals results in upstream displacement of the freshwater/salt water boundary.

3. Reduction or cessation of the seasonal flush of organic debris, nutrients and fresh water to the estuary and offshore areas is likely to cause decline in aquatic productivity of these areas.

4. Cessation of annual sediment deposition leads to wave erosion of delta.

5. Increased farming in flood protected areas may result in higher nutrient inflows to estuaries following application and leaching of chemical fertilizers; contamination by pesticides is also possible.

Impacts in Areas of Irrigation Projects

1. Flood control allows development of irrigated farming and establishment of new settlements. Wildlife habitats in reclaimed areas are lost.

2. Application of irrigation water raises water table, possibly resulting in water logging and salination if drainage is not adequate.

3. Agricultural chemicals, molluscicides and salts in return water are discharged into the river downstream from project, with various results.

4. Canals provide stable habitat for weeds and vectors of human disease.

5. Distribution canals and diversion dams may provide recreational uses, and water for domestic consumption, whether intended or not.

6. Atmospheric humidity may increase locally.
