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INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT
INTERNATIONAL DEVELOPMENT ASSOCIATION

A REVIEW
OF
LAND AND WATER RESOURCE DEVELOPMENT
IN
THE LOWER MEKONG BASIN

February 28, 1972

Special Projects Department

CURRENCY EQUIVALENTS

This report follows the practice of the Mekong Committee and Secretariat in using the United States dollar as the unit of currency.

WEIGHTS AND MEASURES EQUIVALENTS

The metric system is used throughout this report.

One meter	=	3.28 feet
One kilometer (km)	=	0.62 miles
One hectare (ha)	=	10,000 square meters 1.47 acres
One million cubic meters (mcm)	=	810.7 acre feet
One milliard	=	1,000 mcm
One cubic meter per second (cms)	=	35.31 cubic feet per second
One metric ton	=	1,000 kilograms 2,204.6 lbs 0.984 long tons
One kilovolt (kv)	=	1,000 volts
One megawatt (MW)	=	1,000 kilowatts
One gigawatt hour (GWh)	=	1,000,000 kilowatt hours

ABBREVIATIONS

ECAFE	-	United Nations Economic Commission for Asia and the Far East
UNDP	-	United Nations Development Programme
ADB	-	Asian Development Bank
FAO	-	Food and Agriculture Organization
USAID	-	United States Agency for International Development
OTCA	-	Overseas Technical Cooperation Agency (Japan)
USBR	-	United States Bureau of Reclamation

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DEVELOPMENT IN THE LOWER MEKONG BASIN

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I. BACKGROUND

A. The Mekong Committee

1.01 Since the early 1950's the United Nations has supported the four riparian governments in investigating the resources of the Lower Mekong Basin. A formal basis for international cooperation in water resource development was established in 1957 when the Committee for Coordination of Investigations of the Lower Mekong Basin (the "Mekong Committee") was created as a result of a recommendation by the United Nations Economic Commission for Asia and the Far East (ECAFE).

1.02 Each of the four governments appoint a member with plenipotentiary authority to serve on the Committee. According to its statute the functions of the Committee are to promote, coordinate, supervise and control the planning and investigation of water resources development. To these ends the Committee is authorized to:

(a) Prepare and submit to participating governments plans for carrying out coordinated research, study and investigations;

(b) Make requests on behalf of the participating governments for special financial and technical assistance and receive and administer separately such financial and technical assistance, as may be offered under the technical assistance program for the United Nations, the specialized agencies and friendly governments;

(c) Draw up and recommend to participating government criteria for the use of the water of the main river for the purpose of water resources development.

1.03 Operational assistance to the Committee is provided by an Executive Agent and a Secretariat, which are supported by the four member countries, ECAFE, and the United Nations Development Programme. On important matters the Committee is assisted by an Advisory Board of international experts.

1.04 The immense water resources of the Lower Mekong Basin are as yet virtually unexploited. Only recently have the first steps been taken to conserve and regulate the runoff of the Mekong's tributaries for irrigation and hydro-electric power. However, over the past decade, the Committee has been active in sponsoring investigation and studies to measure the Basin's potential for hydropower, irrigation and flood control, in identifying projects to exploit these potentials, and in supporting the riparian governments in project preparation and implementation. The Committee's work has attracted the support, both technical and financial, of other governments and international agencies interested in promoting regional development.

B. The Indicative Basin Plan

1.05 A notable event in the history of Mekong development was the publication in July 1970, of a draft report on an Indicative Basin Plan, which had been prepared by the Secretariat at the request of the Committee. The report presents the first comprehensive study of the Mekong's potential for power generation, irrigation and flood control. While the report indicates the possible timing and sequence for six major projects, it does not purport to be a definitive plan. Rather it is intended as a framework for further investigation and planning of the Basin's water resources.

C. The Bank's Review of Mekong Development

1.06 While the Indicative Basin Plan report was being brought to completion, the Bank began its review of Basin development in response to a letter of April 1969 from the Secretary-General of the United Nations to the President of the World Bank. U Thant's letter written in consultation with the Mekong Committee observed that decisions would soon be needed on major investments in Basin development, and therefore it would be in the interests of all concerned for the World Bank to be more closely associated with the cooperative effort for Mekong development.

1.07 In his reply, Mr. McNamara welcomed U Thant's suggestion and said that he had discussed possible Bank^{1/} involvement with the President of the Asian Development Bank and with member countries of the World Bank, and all had agreed that he should make an affirmative response to the Secretary-General's proposal.

1.08 As foreshadowed in Mr. McNamara's reply, Mr. Mohamed Shoaib, a Vice President of the Bank, was designated as the Bank's Special Representative for Mekong Affairs. Also, a division was established in the Bank's Special Projects Department to review the current status of Basin planning and development and prepare a report which would form a basis for discussion of the Bank's future participation in Mekong affairs.

1.09 Early in 1970, members of the Bank visited the Mekong Basin to become familiar with the various efforts being made toward Basin development. It was found that a large volume of data and reports were already available and that two important studies -- the Mekong Secretariat's Indicative Basin Plan and a feasibility report on the Pa Mong Project -- would be available in draft form by mid-1970.

1.10 For assistance in assembling and evaluating data and reports, the Bank secured the services of Sir Alexander Gibb and Partners of the United Kingdom.^{2/} Also, in view of the importance attached to the Pa Mong

^{1/} References to "World Bank" or "Bank" should be understood to refer to the World Bank Group.

^{2/} Gibb obtained the assistance of International Land and Agriculture, Consultants, Netherlands, for agriculture studies; the Institute of Hydrology (UK) for hydrology studies; and Merz and McLellan (UK) for power studies.

project, the Bank commissioned Acres International (Overseas) Ltd., Canada, to undertake an analysis of the project's power benefits. The Bank also commissioned a staff group of Resources for the Future, Inc. of Washington, D.C., to prepare a report on agricultural development.

1.11 At an early stage of review, it became apparent from field observations that problems were being encountered in the implementation of irrigation projects. Discussions with the Secretariat and the development agencies of the riparian governments revealed that all concerned realized the need for these problems to be given early attention. Thus, while the consultants proceeded with their review of major project proposals and development potentials, the Bank Review Group focussed its attention on means for overcoming the readily observable development constraints. Accordingly, the Bank cooperated with the Mekong Secretariat, the UNDP, FAO and ADB in formulating a Pioneer Projects Program. The pioneer projects, which would be identified and prepared under the program, would test, on a scale large enough to have wider applications, various techniques for agricultural management and water control.

1.12 With completion of the consultants' studies in December 1970, it was possible to prepare a background paper summarizing the principal findings of the Bank's review and submit this to the Committee and Secretariat in February for their review and comments. In July 1971, working papers on agriculture and on developments in the tributary basins and the mainstem formed a basis for further technical discussions with the Mekong Secretariat. These and other exchanges of views with the Committee, the Secretariat and the riparian government agencies, have been taken into account in completing the Bank's review of Mekong development presented in subsequent chapters of this report.

1.13 A paper entitled "A Review of Lower Mekong Basin Development -- Problems and Policies", which summarizes key conclusions of the Bank's review and discusses the institutional framework for the Basin's development and possible Bank involvement, was submitted to the Secretary-General of the United Nations on February 16, 1972 and circulated to other agencies and organizations. Parts of this summary paper form Chapter II of this report.

II. SUMMARY AND CONCLUSIONS

2.01 The Khmer Republic, Laos, Northeast Thailand and the Vietnamese Delta, which together comprise the Lower Mekong Basin, have a combined population of about 30 million in an area slightly larger than France.^{1/} Some 90% of this population is rural and the Basin's economy as a whole is almost completely dependent on agriculture. Rice-growing predominates to an exceptional degree over all other activities, with ricelands accounting for as much as 85% of the 10 million hectares of cultivated land. Controlled irrigation and double cropping are minimal.

2.02 Population pressure is not yet severe and extension of the cultivated area has enabled the population increase to be accommodated. Although some improvements are noted for the last two or three years, rice yields have been generally stagnant at relatively low levels -- ranging from less than 1 ton of paddy per hectare in parts of Northeast Thailand and Laos to 2.5 tons of paddy per hectare in some delta provinces. These yields have nevertheless permitted self-sufficiency in rice in Northeast Thailand, a substantial though dwindling surplus for export in the Khmer Republic, and a surplus in the Vietnam Delta which, with the recent improvement, is just sufficient to meet the rice deficit of other areas of the country. Only in Laos, and probably attributable in large measure to direct and indirect effects of prolonged hostilities, is there a rice deficit, of the order of 10-15% of consumption.

2.03 Prospects for the future indicate serious problems. Population growth has risen to over 2½% per annum and may be approaching 3%. By contrast, currently available data indicate further availability of land suitable for rice at no more than about 20% of the existing rice area in Northeast Thailand and 10% in the Khmer Republic and Vietnamese Delta -- and such land is generally of appreciably lower quality than existing rice land. Diversification into other crops than rice is expanding and these crops constitute major exports for Northeast Thailand and the Khmer Republic. However, a major part of such diversification is taking place on upland soils which require high standards of soil and water management to sustain present levels of production. Largely because of poor soil structure of presently uncultivated areas, the prospect for increased production using traditional techniques is quite limited.

^{1/} Some relatively small, sparsely populated areas of Laos and the Khmer Republic lying outside the Basin are excluded; the Chiang Rai province of Northern Thailand and the larger but less populated Central Highland provinces of Vietnam lying within the Basin are included.

2.04 Land and water are the chief physical assets of the Basin countries and their development clearly will play a major role in overall economic development. However, resource development alone cannot be relied upon solely as a means for improving the material well-being of the predominantly rural population of the Basin. Complementary efforts in rural development will also be needed such as an expanded network of farm to market roads, improvement and expansion of health services with emphasis upon the dissemination of family planning information, and the provision of educational services which are relevant to the needs of farming communities. To support agricultural development and to diversify the economic structure of the Basin it would also appear desirable to introduce a measure of industrial development into some of the major sub-basins. Promising opportunities are agricultural processing and the establishment of manufacturing and light industries to supply consumer goods for some of the sizeable regional markets within the Basin. Apart from land and water, the Basin has on present knowledge few natural resources. Forests, fisheries, and perhaps some minerals can contribute to the development of the Basin. In these conditions, it is evident that for some time to come development in a meaningful sense for the great majority of the population must be centered on improvements in agricultural productivity. The Bank's review has accordingly concentrated primarily on the agricultural sector and related hydropower development. The following paragraphs summarize some of the key findings.

A. Agriculture

2.05 The information available on soils leads to the conclusion, critical for development planning, that the major part of present rice lands is not suited to other higher value crops. Exceptions occur in respect of narrow belts of alluvial soils along the banks of the river system above the delta and in some larger areas in the delta -- if water availability in the dry season can be improved. Much more limited exceptions should be found in parts of the command areas of projected irrigation schemes based on reservoir storage.

2.06 A second finding of basic importance is that, because of both low returns and high costs, the prospects for viable year-round irrigation schemes based on storage dams are poor. The low returns derive from the character of the command areas of projected irrigation schemes, which are predominantly rice lands generally unsuited on account of soil types and poor drainage for other crops, and from the low unit value of rice. Even an increase of four tons of paddy per hectare -- far above levels yet attained in the region -- would yield only about \$200 per hectare in gross income. The incremental benefit attributable to irrigation would be significantly smaller.

2.07 Recently constructed irrigation works and feasibility studies for new projects in the area indicate that irrigation costs generally exceed the limits for viable projects based on such returns. For the two banks of the river above the delta, irrigable land and favorable water resources generally do not coincide. Nearly 90% of the runoff of the Basin above the delta is concentrated on the eastern side of the Mekong where the monsoon strikes the Annam range. Here the topography is mountainous, areas suitable for irrigation few and the population sparse. On the west bank, rainfall is considerably lower and the tributaries carry very little water once the wet season ends. Costs of adequate storage dams on these tributaries are correspondingly high and power potential -- and hence the costs that can be allocated to power -- very limited. Moreover, in the larger potential irrigation areas of the west bank, the undulating nature of the terrain and existing parcelization would necessitate substantial expenditure on levelling and consolidation. So far as the mainstem irrigation potential is concerned, two of the proposed multi-purpose projects would provide large volumes of storage for direct gravity irrigation. However, if the cost of such irrigation development -- excluding the cost of the storage dam -- approaches the order of \$1,700 per hectare as indicated in recent studies of Pa Mong project, the economic feasibility of these developments must be considered doubtful, and until experience with ongoing irrigation projects provides more favorable benefit and cost data, it would seem prudent to place a fairly low economic value on the potential for direct irrigation from mainstem projects.

2.08 In the case of tributary projects where dams and main canals have already been constructed, the incremental costs of building field distribution systems could be justified by potential benefits. A major constraint is implementation capacity, but a phased development of perhaps 250,000 hectares over the next two or three decades can be envisaged. In selected areas the well drained alluvial soils forming the natural levees of the Mekong are suitable for diversified year-round cropping under pump irrigation. In the Vietnam Delta the extensive network of navigation and drainage canals form a source of water which is already being exploited by low-lift pumps. The potential is good for further development of low-lift pumping, but the impact of such development on saline water intrusion requires early attention. In the upper reaches of the delta the canals contain fresh water throughout the year, but in the lower delta saline water enters the canals during the dry season. The minimum dry season flow entering the delta is very large compared to likely irrigation needs, but any depletion of the flow by irrigation diversions would tend to worsen the salinity intrusion problem. Therefore, upstream storage on the mainstem to provide low-flow augmentation will become an important factor in Delta development.

2.09 The limitations on extension of the rice area and on viable irrigation from storage dams make it the more important that attention be focussed on other ways of increasing agricultural production. It is also evident that both an increase in rice yields and diversification into other crops need to be considered. An increase in rice yields appears necessary to feed the growing population of the Basin, and in the case of the delta, the rest of Vietnam. In many areas of the Basin where subsistence rice farming predominates, an improvement in rice yields also appears as a prerequisite for diversification into higher value crops. Without greater assurance of adequate supplies of rice in poor as well as good seasons, farmers are understandably unwilling to venture into other types of farming. In the longer run, self-sufficiency in rice needs to be accompanied by increased diversification into other crops -- whether by dry season crops on such rice land as is suitable, by non-rice farming of upland soils or by subsidiary crops and animal husbandry on individual farms -- if the agricultural economy of the Basin is to escape the limitations imposed by the low unit value of rice.

2.10 Review of existing information on the potential of the Basin for increasing rice yields and for crops other than rice indicates that a very large measure of conjecture still exists. Lack of practical experience even more than the insufficient soil and hydrological information makes overall assessment particularly hazardous. There are some encouraging signs. High-yielding varieties of rice appear to have had considerable success in some parts of the delta over the last three or four years under conditions of less strict water control than usually considered necessary. Where water availability has been adequate, alluvial soils in the rice areas of the delta and along the banks of the river system above the delta have grown a variety of dry season crops successfully.

2.11 The greatest uncertainty, however, concerns the large areas of upland soils above the delta. A study of land capability maps indicates that as much as 3 million hectares in Northeast Thailand may be suitable for dry foot crops only a fraction of which is at present cultivated in any year. A similar situation prevails in the Khmer Republic. Export crops of maize have been successfully grown for years around Korat in Northeast Thailand and in the Khmer Republic, but comparable soils and hydrology elsewhere, at least in Northeast Thailand, appear scarce; the same is true for areas suited for rubber in the Khmer Republic. In more recent years, kenaf and cassava crops have expanded to become important exports from Northeast Thailand. They are grown by shifting cultivation, under which about 70% of land is fallow in any year, on the predominant podzolic soils of low inherent fertility of this area. Here, the twin dangers of a reduction of fertility and soil erosion as a result of over-cropping are already becoming apparent and are likely to increase under the influence of rising population pressure.

2.12 In brief, there are a number of encouraging indications for further diversification in areas of alluvial rice lands for dry season crops if water can be provided, and for rainfed upland soils if proper soil and water management can be introduced. To these should be added some small areas of better soils such as the Bolovens plateau and the Battambang area at the western end of the Great Lake in the Khmer Republic which have higher intrinsic, but so far largely untested, potential.

2.13 It is against this background that the Bank's review has considered the possibilities for raising agricultural productivity apart from conventional storage irrigation. The first finding is that much greater attention should be paid to lower cost ways of providing improved water control. Above the delta, variations in the timing of the monsoon and the frequent occurrence of dry spells during the growing season present serious hazards resulting in wide variations in rice production from year to year. Some modest run of the river schemes for supplying additional water at the crucial early growing stage could well prove viable. Based on very limited information, the area which could be so serviced is, however, likely to be quite small. More important could be expansion in use of low-lift pumps along rivers and the existing network of canals in the delta. The rate of expansion in the use of pumps in the delta indicates considerable possibilities and should permit some diversification into higher value dry season crops on stretches of alluvial soils. Improved drainage and better control of flood runoff can provide additional possibilities in some other areas. Groundwater availability does not, on existing evidence, appear encouraging, but more needs to be learnt. In the lower delta, a high priority must be rehabilitation and reconstruction of canal and other structures controlling salinity intrusion. Further possibilities appear to exist for extending this system which will allow greater use of low-lift pumps. Finally, less costly methods of delivering water from the storage dams of multipurpose projects such as Pa Mong may prove feasible, including diversion into existing tributary river systems, to supplement water availability in dry spells of the wet season as well as in the dry season. Though not a short-term possibility, the extent of the area that could physically be serviced from such storage is so large, perhaps over $1\frac{1}{2}$ million hectares in the case of Pa Mong, that such possibilities deserve careful study.

2.14 No less important, and indeed to a large extent complementary, is the improvement of seeds. The apparent success of high-yielding varieties of rice in some parts of the delta over the last three or four years has already been referred to. No evidence was found of any careful monitoring of this experience, including levels of fertilizer and other inputs, with a view to determining the limits of more general applicability. Yet such an assessment would appear of the highest priority. It is, however, not only in the new high-yielding varieties that a potential exists. Selection, upgrading and large-scale production of traditional varieties

to substitute for seed rice kept over from the previous crop may well have even larger potential. The speed of adoption of high-yielding variety rice in the delta -- from a negligible area to over 300,000 ha in three years -- portends well for the readiness of farmers to change when success is demonstrable.

2.15 A third direction of great importance to which more attention is needed is the promotion of rainfed crops, including trial of new crops in different areas on a sufficiently extensive scale for results to have applicability for normal farming conditions. As already noted, the proportion of rice lands likely to be irrigated is small and for the longer term diversification into higher value crops appears indispensable for a significant raising of living standards. That the process will be long, given the time inevitably needed to introduce new types of farming and supporting services, makes it the more urgent for action to be initiated quickly. In this connection the use of crop rotations for proper management of upland soils deserves particular attention.

2.16 Supporting activities in such fields as transport, storage, credit and education appear vital to the success of other measures. Conditions in these respects vary considerably over the Basin. Over large parts of the Basin, however, the rural transport system is inadequate to provide farmers with quick and economical access either to inputs or to markets for their produce. More generally, growth in agricultural production is constrained by inadequacies in storage and processing. Shortage of people with mechanical, technical, or managerial skills, makes remedying this situation particularly difficult and points to the need for a thorough analysis of the constraints, and action in several inter-related fields. The report by Resources for the Future recommends immediate attention to providing vocational education relevant to the experience of rural children, expansion of storage and processing facilities, and the designing of credit systems to provide short-term credit on reasonable terms to farmers for investment in fertilizer and for capital goods for farm improvement.

2.17 To sum up the prospects in the absence of greater experience of changing the predominantly traditional rice-farming pattern of agriculture in the area is obviously difficult. However, so far as the next five years or so are concerned, it would appear that, taking account of the possibilities for a greater degree of cropping in relation to cultivated area as population expands and existing development policies, the rice balance should be maintained. For Northeast Thailand and Laos this would imply self-sufficiency, for the Khmer Republic some margin for export once the dislocations due to hostilities are ended, and for the Vietnam Delta a sufficient transfer to other provinces to enable the country as a whole to maintain self-sufficiency. Some further diversification into other crops is foreseeable but, with the possible exception of the Vietnam Delta, not on a very significant scale.

2.18 Beyond the next five years or so the outlook becomes much more problematic. There is, however, reason for optimism that income can be raised for a large part of the population if action focussed in the directions outlined above is pursued energetically on a broad front. The potential for rice is indicated by the fact that rice paddy yields in Central and Northern Thailand are roughly twice those in areas of the Khmer Republic comparable in terms of soils and water regime, yields in Korea around 50% above those of comparable areas in the Vietnam Delta. While export markets for rice may be limited by the "green revolution" in previously importing countries, the domestic market should expand steadily both as a result of population growth and the potential for cattle, pig and poultry raising. The rapidity of growth of secondary crops in various areas both of alluvial and upland soils when incentives have been favorable likewise provides grounds for optimism in regard to diversification and here the prospect for export markets appears generally more favorable than for rice. The costs involved in developing these potentials, moreover, appear less demanding than the effort of organization and administrative reform involved. Without such an effort, on the other hand, a decline in living standards for a considerable part of the Basin population may well result from the population pressure. In the longer term, the mainstem projects which the Mekong Committee have under consideration, and to which attention is now turned, could provide a further impetus. But this prospect should in no way detract from the urgency of stepping up measures for a more general improvement in agricultural productivity both under irrigated and rainfed conditions.

B. Electric Power and Multipurpose Projects

2.19 A considerable part of the activities of the Mekong Committee has been devoted to the examination of the large hydro-electric power potential of the Mekong and its tributaries. The power requirements of the Basin itself appear likely to remain small in relation to this hydro potential which could exceed 25,000 MW. Major benefits from Mekong power seem, therefore, likely to accrue to population outside the Basin and primarily in the main load centers of Bangkok and Saigon situated at more than 600 km from the main dam sites identified. However, in the case of Laos and the Khmer Republic, power exports could contribute directly to the Basin's development by augmenting scarce foreign exchange receipts and development resources, while some part of any power economies achieved in Thailand and Vietnam would presumably redound to their Basin territories.

2.20 Of particular relevance to Basin development planning is the conclusion that none of the mainstem projects would, on the basis of existing information, provide power at a significantly lower cost than alternative conventional or nuclear fuel plants. Partly for this reason, partly because technological advances of the last two decades as related to neighbouring countries such as Japan have reduced the importance of

moderately low cost energy among the factors relevant to the location of electricity-intensive industry, and partly due to the sparse raw material resources, Mekong power appears unlikely to prove a major determinant in the siting of industries such as bauxite refining within the Mekong Basin. The value of enclave processing type industries not based on local materials for the economy of the Basin would, if experience elsewhere in the world is a guide, be likely to be marginal in any case.

2.21 Given that the economic advantage for power of the mainstem projects will probably not prove large, additional considerations are likely to play heavily in decisions on their building and timing. These considerations include on the one hand the extent to which national power systems are willing to rely on remote sources of energy, large in relation to the total system, particularly when situated outside national territory. On the other hand, and of particular relevance to the development of the Basin for its inhabitants, lie considerations of additional benefits which may be obtained from the multipurpose nature of some of these projects.

2.22 The Indicative Basin Plan proposed the construction of six major projects in the following sequence: Sambor (1981), Nam Theun (1981), Pa Mong (1983), Stung Treng (1992), Ban Koum (1997), and High Luang Prabang (1999). Except for Nam Theun, a project on a Mekong tributary in Laos, the projects are all on the mainstem of the Mekong. The plan was conceived in accordance with the principle that power requirements of the four riparian countries for the period 1980-2000 would be met by exploiting the hydro-electric potential of the Mekong Basin.

2.23 All of the mainstem projects would derive their primary benefits from power generation, but two of the projects -- Pa Mong and Stung Treng -- because of their large reservoirs, would have other attributes in terms of Basin development. Pa Mong would open up possibilities for irrigation in both Northeast Thailand and Laos and considerably reduce flooding in the upper and middle reaches of the Mekong. Stung Treng would offer possibilities for irrigation in the Khmer Republic and eliminate flooding of large areas in the Delta which are now subject to inundation every year. Also the projects would substantially increase dry-season flows in the Mekong Delta. In fact, either of the projects alone would provide dry-season flows in excess of any foreseeable requirements for Delta irrigation and salinity control.

2.24 In their review of mainstem development, the Bank and its consultants concentrated on three of the six projects -- Pa Mong, Stung Treng and Sambor. The first two obviously merit attention because they are the only projects with sufficient storage to even out the wide seasonal variations in river flows. Also, they are not only the largest projects but also the only true multipurpose projects. Pa Mong has been studied in considerably more detail than any other project on the mainstem. Work on Stung Treng has been confined to mapping and geophysical investigations, and a desk study by the Mekong Secretariat. Further desk studies of the

project were made by the Bank's consultants. The Sambor Project was selected for review because it has been the subject of a feasibility grade study and it was assigned priority in the Indicative Basin Plan. The Tonle Sap Barrage, which had been investigated under the auspices of the Mekong Committee, was also reviewed. This is a scheme for a barrage across the Tonle Sap designed to utilize the Great Lake in the Khmer Republic as a storage reservoir.

2.25 Revised and updated estimates of Pa Mong, prepared by the Bank's consultants, indicate a mid-1970 cost of US\$1,133 million for the dam and high tension transmission lines for integration into the Thai power system. As presently planned, the project would have an installed capacity of 4,800 MW and generate about 27,000 GWh annually. Although the energy from Pa Mong could be absorbed progressively into the Thai power system, it would account for about 60% of Thailand's total power demand in the early 1990's ^{1/} -- the earliest date when all of the Pa Mong units could be installed. Thailand, therefore, has to make an important policy decision on whether it would be willing to depend for a large percentage of its national power on a single source located about 600 km away from the main load center of Bangkok. Since the project lies on the border between Thailand and Laos, prior agreement between the two countries would be necessary on the legal, financial, construction and operational aspects of the project.

2.26 As a means of assessing the relative economic merit of alternative modes of power development and to provide a comparison between mainstem projects, the Bank's consultants used the "equalizing discount rate (EDR). This is the discount rate which equalizes the present value of costs -- capital costs and operating costs -- of alternative power systems developments designed to meet identical load growth. Non-power benefits of mainstem projects were considered as cost off-sets in these analyses. The EDR for Pa Mong is about 10% for power benefits alone, 9% with fuel costs for the thermal plants at 30 cents per million Btu and 10.1% at 40 cents. If commissioned in the latter part of the eighties, permitting faster installation of the power units, the EDR would be increased by about 1%. Average annual foreign exchange savings of the order of \$70 million would also be significant. The costs of year-round gravity

^{1/} Forecasts of power "needs" for periods of several decades are difficult in any country. They are the more so when rates of growth are very high from a small base, heavily dependent on assumptions of rates of overall economic growth and on backlogs due to hostilities; and also on decisions on the priority of electricity as against, say, education in conditions of strained overall development resources. In accepting estimates that appear reasonable, it is recognized that they will need to be frequently reviewed. The broad conclusions presented here may be affected somewhat as regards timing, but are unlikely to be so in other respects.

irrigation from the Pa Mong storage on present estimates appear too great to warrant any significant attribution of net benefits in the overall evaluation. Flood control benefits in the delta would also be of marginal significance due to the fact that the major part of the Basin runoff occurs below Pa Mong. Some important flood control benefits would, however, accrue along the upper reaches of the river and are estimated on the basis of present designs to add 0.7% to the EDR, or somewhat lower if a part is preempted by prior dyke protection of the Vientiane area. Pa Mong would also, if the first major project built, contribute significantly to the augmentation of dry-season flows in the delta and thereby substantially reduce salinity problems. Until more is known on the delta water regime and agricultural potential, it is difficult to assess the benefits that Pa Mong -- or other major projects -- could provide in this regard. A rough and possible conservative estimate indicates a 1.5% addition to the EDR.

2.27 Although Pa Mong project has been the subject of detailed technical studies, one major uncertainty remains; this is the resettlement of the reservoir population which presently numbers about 280,000 and would have grown to 450,000 by the mid-1980's. Lands suitable for resettling the reservoir population have not so far been located in either Laos or Thailand. An adequate resettlement program for the population, which by the time of project completion will be several times larger than that relocated under such projects as Aswan, Kariba, Volta or Mangla, would be much more costly than figures used in the project cost estimates. Thus, the economic benefits of the project would also have to be weighed against the economic costs and the social and political risks of such a massive relocation and compensation program. Map studies indicate that reduction of the dam elevation by 20 m combined with modifications of associated structures could reduce the population affected by more than two-thirds. The Bank, therefore, recommends that serious consideration be given to an alternative project formulation with a lower reservoir level, in order to reduce the resettlement problem to more manageable proportions. Until such alternatives have been considered and an adequate resettlement program has been formulated and costed, the agricultural benefits have been studied in greater detail and information on the project's ecological impact has been assessed, an adequate evaluation of Pa Mong project is hardly possible.

2.28 Investigations of Stung Treng are much less advanced. The project differs from Pa Mong in certain essential features. The main part of the power produced would be apportioned to Vietnam as well as Thai load centers. The reservoir, lying below the confluence of the Mekong and the main east bank tributaries, would provide major flood control for the delta as well as augment dry season flow and thus permit a change in the upper delta from floating rice to varieties of perhaps 50% higher yield. Consultants estimate indirect benefits from reduction of delta flooding of the order of \$30 million annually -- against \$6 million for Pa Mong. Population displaced would be less, though still of the order of 250,000 by 1985, and land appears to be more readily available for relocation.

2.29 Estimates based on desk studies indicate that Stung Treng would cost some 50% more than Pa Mong while energy generation would be about 30% higher. Although, therefore, the equalizing discount rate based on power alone can be expected to fall below that of Pa Mong -- 8% to 9% on the rough estimates -- its rating on total net benefits may prove comparable. Foreign exchange savings would be somewhat higher than for Pa Mong.

2.30 Stung Treng, lying completely outside the territory of either of the main power consumers, poses in even more acute form than Pa Mong the problem of site location in relation to national boundaries. Moreover, whereas Thailand has negligible hydropower potential to develop apart from Mekong mainstem possibilities, Vietnam has perhaps 2,500 MW of potential, outside the Basin and on Basin tributaries, sufficiently attractive to warrant technical studies. On the other hand, Stung Treng is the only mainstem project which could provide Vietnam with a substantial measure of flood protection for the delta. It would appear that a careful weighing of these factors by the riparian countries concerned and a determination of policy is required before very extensive and expensive feasibility grade investigations of Stung Treng would be justified.

2.31 The Sambor project was studied by the Overseas Technical Cooperation Agency (OTCA) of Japan. Desk studies were also made by the Bank's consultants. As formulated by OTCA, Sambor is essentially a power project -- the active storage in the reservoir available for augmentation of dry-season flow in the delta is quite small. The Bank's review has indicated that a revision in the project's mode of operation to increase active storage and to maximize the project's multipurpose benefits merits further study. The aim of such a revision would be to formulate a viable hydropower project which would also make a significant contribution to dry-season water needs in the delta.

2.32 The Tonle Sap project in the Khmer Republic was designed primarily to augment the flood control effects of the Great Lake which acts as a huge natural reservoir for the rising Mekong flow during the monsoon period. By erecting gates across the connecting channel, flood storage capacity could be reserved for peak flow periods and the waters released at a later period. The project cost is modest relative to Stung Treng or Pa Mong -- of the order of \$140 million. Unfortunately, studies of the potential flood control effects have proved disappointing. Further difficulties arise from constraints on operation to reduce interference with the important though declining Great Lake fish catch. An alternative design which would involve a lower structure and control only the outflow from the lake merits consideration. As well as augmenting the dry-season flow in the delta, the project might also help to improve fish production. The former function would duplicate the major mainstem projects; but if the fish potential proves large and/or the project is commissioned sufficiently in advance of Pa Mong or Stung Treng, the project at a lower level may prove viable.

2.33 Long-range planning for the Mekong Delta has also received attention. Two conceptual plans have been prepared; one by Development and Resources Corporation (D&R) in cooperation with a planning group of the Vietnam Government, and one outlined in the Indicative Basin Plan. The two proposals have much in common but differ in scope and timing.

2.34 The D&R proposed a massive investment in water control works in the Vietnamese Delta over an area of 1.6 million ha. The physical works envisaged comprise a system of levees extending on both sides of the Mekong and Bassac stopping short of the Khmer border. These levees would be primarily for flood control down to Can Tho and would continue thereafter for the purpose of salinity control. Within the protected area existing canals would be used and, where necessary, extended to provide a complete system of irrigation and drainage channels, with a series of pumps and control structure to regulate the flow of water. The estimated capital cost of the program was US\$1.25 billion. The program was phased in four stages over a period of 20 years from 1971-1990 with the major works substantially complete by 1986. Increased agricultural production would result from lateral expansion, reclamation, improved agricultural practices, flood control and irrigation. The major component of this increase, about three-quarters, is projected to result from dry-season irrigation.

2.35 Included as one of the major projects in the Indicative Basin Plan is a conceptual plan referred to as Delta Development. The major flood control and irrigation works are designed to include the Delta in the Khmer Republic as well as Vietnam. Development is phased in two stages timed to coincide with the implementation of the two major upstream storage projects, Pa Mong and Stung Treng. This stage would also include the completion of coastal embankments. The estimated expenditure during the plan period of 1980-2000 would be of the order of one billion US dollars. By making allowance for the effect of upstream storage projects, the scope of the works would be less than the D&R proposals.

2.36 Further elaboration of these plans will require a much more detailed knowledge of delta hydrology and agronomy than presently exists. Also, irrigation on the scale proposed would only be possible following construction of the Tonle Sap project or one of the major upstream storage projects. In the formulation of long-range plans, a clearer assessment of the potential for more productive agriculture in the absence of large investments in water control appears to be required. The investigations of delta hydrology and agriculture which are currently being undertaken under the auspices of the Mekong Committee with the help of the Netherlands Government, should, in conjunction with other recommendations made in the Bank's review, help to fill vital gaps in the information.

2.37 In summary, the Bank's review concludes that the justification and timing of mainstem project development must be viewed in the context of the increasing demand for power within the riparian countries, the feasibility of reservoir resettlement, the need for flood control in specific areas of the Basin and the advantages of improved irrigation along the river itself. However, development of an international river involves considerably more technical, legal, political and administrative problems than that of a national river. Moreover, it requires the full commitment and the active participation of all the countries which are affected, directly or indirectly, by such development, and in some cases the chief beneficiary may not be the country in which the projects are located.

2.38 Power needs will obviously be an important determinant of the timing and sequence of mainstem developments. Although long-term projections must be treated with caution, before 1990 the power demand of the riparian countries will have probably reached a sufficient level to absorb at least one hydro-electric scheme on the scale contemplated in the mainstem projects. This demand can, of course, be met by conventional oil-fired or nuclear installations but in view of the lack of indigenous fuels such a mode of development involves a permanent commitment by the riparian countries to using energy with a high foreign exchange cost. However, some of the major hydropower projects lie outside of the countries with the largest demands. Even countries in areas with a history of political stability have shown reluctance to depend on plants outside of their borders for a large part of their power capacity. Thus the creation of a regional power system will call for a high degree of cooperation and a mutual confidence between the countries concerned.

2.39 Irrigation demands as a determinant of mainstem development are subject to an even greater degree of uncertainty than power demands. There are three areas of the Basin in which mainstem development would provide opportunities for large-scale irrigation -- Northeast Thailand, the area north of the Great Lake in the Khmer Republic and the Mekong Delta. In Northeast Thailand, a first priority is to make effective use of water stored in existing storage reservoirs; only when this has been accomplished will there be a basis for judgments on the economics and timing of direct irrigation from Pa Mong. In the Khmer Republic, the areas which could be commanded from Stung Treng have yet to be studied in any detail. In the Vietnam Delta there is considerable scope for development of low-lift pump irrigation from existing canals. However, irrigation diversions during the dry season would tend to worsen the salinity intrusion problem in the lower Delta. Thus, the need for a modest volume of upstream storage to increase dry-season flows in the Delta during a period of two to three months will become an important factor in mainstem development. A more detailed understanding than presently exists of the potential for agricultural development in the absence of irrigation will also be needed to assess future irrigation

needs. Outside of the Vietnam Delta, there have been virtually no attempts to adopt new technologies in the production of rice, the Basin's principal agricultural product. Intensive efforts directed to accumulating experience in the development of the water resources of the tributary basins and the delta and in promoting the development of rainfed agriculture appear, therefore, as an essential prerequisite to decisions on irrigation from mainstem projects.

2.40 Considerable emphasis has been placed to date on the need to overcome the problem of flooding. In addition to specific reaches upstream, particularly the area around Vientiane, about five million ha are subject to annual flooding in the area of the Delta and around the Great Lake. The pattern of agricultural cultivation has evolved around this natural phenomenon, and varieties of rice are adapted to the particular flood conditions that prevail; however, flooding does result in a depression of yields in some areas. Also, flood-dependent varieties possibly have less potential for yield increases than varieties cultivated under rainfed conditions. To some extent, however, the adverse effects of floods can be circumvented by using short maturation varieties of rice in conjunction with low-lift pumping which will enable a higher yielding crop to be harvested before the onset of the flood. Also, the introduction of sorghum as an "after-flood" crop in Vietnam has indicated the feasibility of more productive land use without large investments in flood control. Thus, the flood problem as far as agriculture is concerned may now assume a lower priority than it has previously been given.

2.41 In this context it is worth noting that Stung Treng is the only project capable of providing a high degree of flood control in the lower reaches of the river and in the Delta. While flood control is generally regarded as beneficial it will result in profound changes in the water regime. These changes could initially be damaging if they are introduced too abruptly and without careful advance planning. Agreements on the mode of operation of Stung Treng would be necessary to protect the interests of Vietnam and the Khmer Republic, the riparians who would be affected by the project.

2.42 The Bank's review has confirmed the findings of the Mekong Committee that multipurpose development of the Mekong River is technically feasible and in the long-term holds considerable promise for regional economic development. However, before such plans can be translated into firm decisions on the timing and sequence of major investments, numerous problems attendant to the assessment of project costs and benefits and to the joint development of an international river will have to be resolved.

C. National and Basin Approaches

2.43 Consideration of the development of the Mekong Basin is rendered more complex by the fact that territories of four countries are involved and that for two of them, Thailand and Vietnam, the territories within the Basin constitute only a part of their total national territory. Even if the Basin lay entirely within one country, problems of priority and allocation of resources, of local interests, and of political balance would arise. The history of major river storage schemes bears ample testimony to the difficulty of securing an acceptable allocation of costs. Such difficulties are particularly evident when, as is often the case, the costs and disturbance of construction is concentrated upstream where the most advantageous sites for storage and power potential are found, while the major benefits lie downstream or in urban centers outside the Basin. Within a single country, adjustments in national financial assistance can help in finding a solution. Between two or more countries, the finding of an acceptable solution is inevitably more difficult, though it is possible that international financial assistance, where available, can play a catalyst role. It is nonetheless of even greater importance than in the case of a single country that the benefits as well as the costs of the proposed projects should be fully recognized by all concerned; without such a common basis, the possibilities of cooperative action must inevitably be reduced. Much light must be shed on the problems before enlightened self-interest can play its part.

2.44 The benefits of cooperation between the riparian countries in the development of the Mekong Basin have to date been discussed largely in terms of total estimated costs and benefits of the proposed mainstem projects in an integrated development of the river system and with reference to agreement on mainstem low-flow water use. These certainly constitute a most important aspect and the desirability of regarding the river and its tributaries as a total system from the beginning can be fully endorsed. Only in this way can benefits be maximized in relation to costs and the international difficulties often caused in other river systems by isolated, independent action be averted.

2.45 It is not infrequently suggested, on the other hand, that because the four national territories of the Basin are so dissimilar and because priorities for their development must be determined in the context of national planning involving non-Basin territories and their problems in the case of Thailand and Vietnam, the major emphasis should be on national approaches to development of the respective Basin territories. The four component territories differ substantially in physical conditions, in ethnic groups, in population density, in degree of integration into commerce, in transport facilities and in education levels to mention only a few of the important considerations for policy. It is indeed for this reason and because of the need for a national perspective in determining priorities, that the Bank's review stresses the desirability of considering separately the potential of each of the four component territories of the Basin.

2.46 The national and Basin-wide approaches are not, however, regarded as being in antithesis but as strongly complementary. Apart from the mainstem projects, which directly affect more than one riparian country, joint riparian efforts can be of great assistance to the sub-basin's development by economizing Basin studies and expertise, in communicating relevant experience, in preparation of agricultural projects and in organizing financing and technical assistance. In current conditions in the Basin, shortage of expertise and requirements for training appear at least as important as shortage of finance. The pioneer project program is illustrative. Fourteen pioneer project areas are being selected throughout the Basin to test, on a scale large enough to have wider practical application, various techniques for agricultural management and water control. They are being chosen and designed so that the experience gained will have relevance for other parts of the Basin irrespective of national boundaries. At the same time, a system of multi-lateral financing and riparian involvement has been created which facilitates the provision of international financial and technical assistance support.

2.47 Moreover, it is only by close interaction between the national and Basin approaches, that the experience in the development of sub-basins can contribute to the evaluation and design of the major projects. A close working relationship between the program makers at national and Basin level is, in addition, essential to widen the appreciation at national level of the benefits and limitations of the major projects proposed.

2.48 None of the mainstem projects with the possible exception of Tonle Sap, seems likely to be appropriate for completion for perhaps 15 years or more. Far from regarding this as a long period, it should be considered as uncomfortably short for the formulation of a detailed approach to the development of Mekong Basin and Mekong River. Time will also be required to gain the additional experience required for detailed project formulation and realistic assessment of agricultural benefits. Riparian agreement, detailed design, arrangements for finance and operation, and actual construction may require a dozen years or more for such major projects as Pa Mong or Stung Treng even when, as for Pa Mong, much of the data and site testing have already been accomplished to feasibility grade. Accordingly, although the need for basic decisions on the mainstem projects is not regarded as imminent -- and in any case appears impractical in present conditions -- the interaction and, where necessary, coordination of national and Basin approaches is not a matter of only future concern. It is rather of immediate urgency.

2.49 In the longer run, such activities could have more far-reaching effects. The economies of the four riparian countries are at present largely isolated from each other. Trade between them (excluding entrepot trade in the case of Laos) represents only a few percent of their total foreign trade; their exports, almost exclusively agricultural products, are competitive. Yet in the longer term, benefits may be derived from greater integration of their relatively small domestic markets. The Mekong effort could provide a basis for greater cooperation in other fields, perhaps extending to neighbouring countries.

2.50 In this context of the complementarity of the Basin and national approaches, some brief observations on national planning appear appropriate. None of the four riparian countries have long-term perspective type plans for development. In Thailand, however, a five-year development plan for 1972-1976 is being drafted, including a five-year plan for development of Northeast Thailand. Here, at the invitation of the Thai Government, a Bank team has been able to review more closely the problems of overall development, relative priorities of water resource projects and relationships to national programs. Conditions in the other territories of the Basin have precluded similar studies. It is understandable that in Laos, the Khmer Republic and Vietnam immediate problems dominate to such an extent as to give long-term planning relatively low priority. While attention is in fact being given in all four countries to the adoption of broad policies towards future development, it is probably unrealistic to anticipate close attention by the four countries to detailed long-term planning on a Basin-wide basis at this time except as an adjunct to pressing shorter term programs.

2.51 There is an evident danger in these circumstances of planning at national and Basin levels getting so out of step as to render their integration difficult, with a resulting isolation of the Basin planning. It is the more important that the Basin-wide effort take into account the constraints under which the national development efforts must necessarily operate over the years immediately ahead. For the reasons indicated, it was not possible to undertake an assessment of general development priorities in each of the riparian countries in relation to the Basin territories.

D. A Priority Program

2.52 The Bank's review confirms the priority of agriculture in Basin development and emphasizes the merit of regional cooperation in the development of the Basin's land and water resources. However, the review also concludes that most, if not all, of the promising opportunities for land and water development in the Lower Mekong Basin require substantial further preparation before they could be considered ready for implementation.

Recognizing the urgent need for project preparation, the Bank's review has identified a "Priority Program" of pre-investment studies to promote investments in the period immediately ahead and to lead logically into a longer term basin development program.

2.53 The program includes studies and investigations with implications for the Basin as a whole, including the preparation of a Basin-wide program of pioneer agricultural projects which is already funded, selected pre-investment studies in each of the national components of the Basin, and the most urgent follow-up action in the preparation of multipurpose projects on the Mekong River. A preliminary estimate indicates a funding requirement of US\$12.0 million which might lead eventually to follow-up investments on the order of US\$250 million.

2.54 It is recommended that this program, many elements of which have already been adopted by the Committee, should be contained in the work program of the Committee. In addition to the pioneer project program which is expected to lead to roughly \$50 million of projects, the priority program places emphasis on investigations that could be speedily concluded and form the basis for further investment in field distribution systems for existing reservoirs in Northeast Thailand and the Khmer Republic. Investigations of the potential in the Khmer Republic for improving the productivity of river-bank farms by crop diversification and of the Great Lake fisheries, and in Northeast Thailand of flood protection in the lower reaches of the Nam Mun are also included. In the Vietnam Delta, emphasis is on evaluating the further potential for low-lift pumping and expanded use of high-yielding rice varieties, on carrying forward investigations in relating to three salinity control cum irrigation projects, and on hydrologic data collection required as a basis for more comprehensive planning of Delta development. In Laos, investigations required for extension of the Nam Ngum project and for determining the further potential of the Nam Ngum Valley below the dam are included along with studies to enable final decisions to be taken on flood protection of the Vientiane Plain.

2.55 Investigations of Basin-wide significance include further studies of Pa Mong, particularly relating to reduction in dam elevation, studies of a basic redesign for the Tonle Sap project, a consolidation of the work so far carried out on Stung Treng, further studies of the Sambor project, and a continuation of the delta studies undertaken by the Netherlands team. Particular importance is attached to a Basin-wide program of research and field trials of techniques for improving agricultural productivity under rainfed conditions.

III. THE LOWER MEKONG BASIN

A. Physical Characteristics

3.01 The Mekong, one of the world's great rivers and tenth largest in terms of annual flow, begins its 4,200-kilometer journey to the sea in the mountains of Tibet. The Lower Mekong Basin begins where the river leaves China and becomes the border between Laos and Burma. It covers an area of 620,000 square kilometers, some 77% of the total drainage area of the Mekong, and includes virtually all of the land area of Laos and the Khmer Republic, the Northeastern provinces of Thailand, and the Delta provinces and part of the Central Highlands of the Republic of Vietnam. The following brief account of the salient features of the Basin is supplemented by the maps included at the end of this report.

3.02 The Basin is bounded to the east and north by the Annamite Range, which extends from the Central Highlands of Vietnam through the entire length of Laos. The range is subject to high annual rainfall and contributes nearly 90% of the incremental discharge of the Mekong in its lower basin. Most of Laos is mountainous and forest-covered; areas of level land suitable for permanent cultivation are found along the river valleys, the banks of the Mekong and in plateau areas such as the Bolovens Plateau and the Plain of Jars.

3.03 Except for low mountain ranges on its western and southern borders, Northeast Thailand is an undulating plain between 100 and 200 meters in elevation. The two largest rivers are the Nam Mun and Nam Chi; their combined drainage area, commonly known as the Mun-Chi Basin, occupies two-thirds of the land area of Northeast Thailand. The remaining one-third of the region is a broad strip of land along the right bank of the Mekong. The broad valley lands are primarily devoted to paddy cultivation. In recent years there has been a considerable increase in the use of upland areas for such crops as kenaf, maize and cassava. Some of the lowest rainfall areas in the Basin are in the western provinces of Northeast Thailand.

3.04 There is a marked imbalance in resource endowment between the left and right banks of the Mekong in its upper reaches. Land is more plentiful in Northeast Thailand but the water resource is limited, whereas Laos has ample water but limited areas of cultivable land.

3.05 The Mekong plain, lying at an elevation of less than 100 meters encompasses most of the Khmer Republic. A notable feature is the Great Lake, a unique natural reservoir linked to the mainstem of the Mekong by the Tonle Sap. Water enters the Lake from the Mekong in the flood season, and flows from the Lake to the Mekong as the flood recedes. The area surrounding the Great Lake is similar in topography and climate to Northeast Thailand. Numerous tributary streams of the Great Lake rise in the hills forming the northern and south-western boundaries of the Khmer Republic. The Plains surrounding the Great Lake and Tonle Sap are largely devoted to rice cultivation. Some upland areas have long-established rubber plantations.

3.06 The Mekong Delta, extending from Kompong Cham in the Khmer Republic to the South China Sea, consists of the vast alluvium built up by the river. Except for coastal mangrove swamps and the acid sulphate soils of the Plain of Reeds the delta alluvium constitutes the most fertile land in the Basin. Every year from September to November, when the Mekong is in spate, flood water overflows the river banks inundating large areas of the delta lands in the Khmer Republic and Vietnam. Rice cultivation practices are adapted to both the timing and depth of flooding, and about one-half of the rice grown in the Delta is flood dependent. A prominent feature of the Vietnam Delta is the long-established network of navigation and drainage canals.

B. Rainfall and Hydrology

3.07 The Lower Mekong Basin is situated in the center of the monsoonal region of Asia and is affected by the annual regime of monsoon winds and precipitation. Sheltered from the northeast monsoon by the Annamite mountains to the east, the Basin has a pronounced dry period from November to March. The southwest monsoon, carrying with it moist air, covers the entire lower basin giving rise to a rainy period varying from May to September in the north and west, and from May to November in the south. The highest rainfall areas are the central and southern parts of Laos and the western coastal areas of the Delta (2,000 - 2,400 mm). Large areas in Northeast Thailand and the regions surrounding the Great Lake are shielded by the coastal ranges and receive less rainfall, ranging between 1,000 and 1,400 mm. The main crop-growing seasons correspond closely to the seasonal rainfall patterns.

3.08 Entering the Lower Basin above Chiang Saen in Northern Thailand the Mekong has an average annual flow just under 100 billion cubic meters. By the time the river discharges into the South China Sea over 2,500 km downstream, the average annual flow has increased to nearly 500 billion cubic meters. By far the major portion of this increase in flow comes from the Laotian left bank of the Mekong. With an average unit run-off of 1,100 mm, rising to over 2,000 mm in the case of some tributaries, the area on the left bank contributes nearly 90% of the increase in flow from less than 60% of the drainage area. In contrast, the Nam Mun, the major tributary on the right bank, which drains a large area of Northeast Thailand, has a run-off of about 200 mm or only one-tenth of the run-off of the left bank tributaries.

3.09 The flow in the Mekong is derived largely from rainfall so that the hydrograph reflects the pattern of rainfall distribution during the year. The river starts to rise following the onset of the southwest monsoon in May or June and attains its maximum level in September or October. It falls quite rapidly until December and recedes more slowly during the dry period of the year. At Kratie, in the Khmer Republic, just above the delta reaches of the river, the lowest recorded monthly mean flow is about 1,360 cubic meters per second compared with a maximum of 73,600 cubic meters per second.

3.10 Below Phnom Penh, the river divides into two arms before continuing its course through the delta -- the Mekong on the east and the Bassac on the west. Further downstream the Mekong divides into five branches before it enters the sea. Although the storage effect of the Great Lake reduces peak flows into the Mekong Delta, overbank flow from the six delta branches causes flooding of over 3,000 sq. km each year in the monsoon season. During the dry-season as the flows in the Mekong and Bassac recede, the effect of salinity intrusion is felt over large areas of the Lower Delta.

C. Soils and Land Use

3.11 At present about 10 million ha of the Basin's total area of 64.5 million ha is cultivated. About 85% of the cultivated area is used for rice. The major rice producing areas are the tributary flood plains of Northeast Thailand, areas surrounding the Great Lake, and the Mekong Delta. Most of the land suited to rice cultivation by virtue of topography and water regime is under cultivation; for the Basin as a whole the scope for lateral expansion is probably between 10 and 15%. Apart from some of the fertile alluviums in the Delta, the ricelands offer limited prospects for crops other than rice.

3.12 In the uplands the soils are generally of low inherent fertility and where they are in use it is primarily in the form of shifting cultivation. Permanent cultivation of these soils would require more advanced techniques of farm management and soil conservation than are followed at present. The limited areas of fertile upland soils which can support permanent cultivation are mostly already in use for crops such as rubber (Khmer Republic) and maize (Northeast Thailand).

D. Population

3.13 Current statistics place the 1970 population of the Basin at 30 million, and the growth rate in the past ten years at about 3% per year. Over 90% of the Basin population is classified as rural and most of these are dependent for their livelihood on agriculture. Population of the urban centers has been growing much faster than the population generally -- from 5 to 10% annually -- reflecting a gradual movement away from the land. Phnom Penh (500,000) and Vientiane (150,000) are the largest urban centers in the Basin. In Thailand and Vietnam the largest towns and cities lie outside the Basin. Bangkok, the capital of Thailand, has a population of over three million. Saigon, the capital of the Republic of Vietnam, has a population of more than two million. These cities as well as being the major ports of their respective countries are also their chief centers of commerce and industry.

IV. THE INDICATIVE BASIN PLAN

4.01 In 1962 the Mekong Committee noted the desirability of a comprehensive water resources development plan for the Lower Mekong Basin and requested the Secretariat to prepare an Amplified Basin Plan (so called because it was intended as an amplification of a 1957 ECAFE study). To meet this requirement, it was necessary to embark on a major program of data collection and analysis; to undertake project reconnaissance and feasibility studies; and to analyze and compare numerous alternatives for water resource development. In many fields, such as economic analysis, hydrology, hydrography, mapping, geology, project reconnaissance and feasibility studies, the Committee and Secretariat received considerable assistance from cooperating countries and United Nations specialized agencies.

4.02 The Secretariat worked closely with ECAFE Division of Water Resource Development and a draft report was completed in June 1970. This report was reviewed with each of the National Mekong Committees and was the subject of a seminar in Bangkok in November 1970, attended by more than 150 representatives of riparian governments, cooperating countries, international agencies, the Secretariat, and interested foundations, universities and other organizations. In late 1970 the Advisory Board recommended, and the Mekong Committee approved, changing the title to Indicative Basin Plan. The draft report has now been revised to take into consideration the comments of the Advisory Board, the Mekong Committee, and the participants in the seminar; the report is to be published in early 1972.

4.03 The Indicative Basin Plan report outlines a development program involving a capital expenditure of more than US\$8,000 million over a period of 30 years. In terms of project content, it includes a Short-Range Plan (1970-1980) and a Long-Range Plan (1980-2000); Annex 2 to this report contains tabular summaries of the two plans and a map showing the location of the projects is included at the end of this report.

4.04 The Short-Range Plan comprises a number of on-going projects and some new multipurpose and irrigation projects in the tributary basins and the Delta, with a total investment outlay of \$795 million. The Long-Range Plan includes five major projects on the mainstem of the Mekong, one large hydro-electric development on a tributary, and a plan for providing a high degree of flood protection in the Delta coupled with irrigation and salinity control. Three of the mainstem projects are primarily for power (Sambor, Ban Koum, and High Luang Prabang), the other two projects (Pa Mong and Stung Treng) with their large reservoirs would provide a high degree of flow regulation, flood control and irrigation, and would also be the two largest power and energy producers.

4.05 All of the major hydro-electric powerplants and the main load centers in the riparian countries, principally Bangkok and Saigon, would be interconnected by high-voltage transmission lines. The Plan envisions the output of the mainstem hydro-electric plants being purchased by the public electricity supply agencies in the riparian countries, so that Mekong power would be combined with other sources of power to meet requirements in their respective service areas.

4.06 The projected demands for power and energy for the four Basin countries, used as a basis for the Plan, are summarized below. The Plan is designed to meet virtually all of the growth in demand after 1980 by hydro-electric generation, primarily from mainstem projects.

Indicative Basin Plan

Power and Energy Demands

	<u>1970</u>	<u>1980</u>	<u>1990</u>	<u>2000</u>
Power (MW)	1,180	5,040	11,800	24,000
Energy (GWh)	5,470	26,200	64,100	129,000
Average annual growth in energy demand (%)	17	9.2	7.3	

4.07 Because of the large storage reservoirs required for optimum development of the power potential at Pa Mong and Stung Treng, a vast potential for irrigation would be created. It would be possible to divert water to large areas of land in Northeast Thailand from Pa Mong, and to the northern part of the Khmer Republic from Stung Treng. Also, because of the change in the seasonal pattern of run-off, year-round irrigation in the Mekong Delta would no longer be constrained by lack of water, and the problem of salinity intrusion in the lower reaches would be alleviated. In addition, the attenuation of Mekong floods by the Stung Treng reservoir would relieve annual flooding in large areas of the Delta and improve the technical and economic feasibility of flood protection dikes in the upper and middle Delta.

4.08 The Plan aims to provide irrigation to about 1,450,000 ha by the year 2000. This would be made up as follows:

Indicative Basin Plan

Area Irrigated by Year 2000 (thousand ha.)

	<u>Direct Irrigation</u>			
	<u>Tributary</u>	<u>Mainstem</u>	<u>Irrigation</u>	<u>Total</u>
	<u>Projects</u>	<u>Projects</u>	<u>in the</u>	<u>Irrigated</u>
			<u>Delta</u>	<u>Area</u>
Laos	35	61	-	86
N.E. Thailand	232	651	-	883
Khmer Republic	103	35	121	259
Vietnam	<u>46</u>	<u>-</u>	<u>169</u>	<u>215</u>
Totals	<u>416</u>	<u>747</u>	<u>290</u>	<u>1,443</u>

4.09 According to the Plan report, the provision of irrigation on this scale would make it possible to produce a large volume of agricultural products for export, as shown in the following table. Some 60% of the incremental rice production attributable to irrigation (about 3 million tons of milled rice) and all of the incremental production of other crops, is designated for export.

Indicative Basin Plan

Crop Production and Demands by Year 2000

	<u>Rice (Paddy)</u>	<u>Other Crops</u>
	<u>(million tons)</u>	<u>(million tons of</u>
		<u>Paddy equivalent)</u>
Total Production with irrigation	30.7	6.3
Domestic Demand	25.0	3.8
Surplus for export	<u>5.7</u>	<u>2.5</u>
Estimated Production without irrigation	21.4	4.8

4.10 As the first comprehensive study of the Mekong's potential for power generation, irrigation and flood control, the Indicative Basin Plan is to be regarded as a document of major importance. Its exhaustive analysis and comparison of a wide array of possible developments has led to the identification of a number of projects which clearly merit priority for further planning and investigation. Also, an important by-product of the preparation of the Indicative Basin Plan has been the stimulus it provided for project investigation and the collection and analysis of basic data.

4.11 There are certainly formidable problems to be overcome before international development of the Basin's water resources could become a reality - in fact, nowhere are these problems more clearly perceived than in the Mekong Committee and Secretariat - but this should not be allowed to detract from the value of the Plan as a demonstration of the way in which the Mekong could be developed for the mutual benefit of the four riparian countries.

4.12 In the review of the Mekong development effort, the Bank found the Indicative Basin Plan to be one of the chief sources of information. However, a detailed review of the timing and sequence of project implementation was not undertaken since it was realized that the Plan is to be regarded more as framework for future development (as in fact it is described in the sub-title of the report) than as a definite proposal for project implementation.

V. DEVELOPMENT PERSPECTIVES

A. Agricultural Development

The Present Situation

5.01 The Mekong Basin has a total land area of about 64.5 million ha of which approximately 10.1 million ha is presently cultivated. Land used for cultivation of rice, the main crop and staple food of the Basin's inhabitants, occupies about 8.6 million ha, or 85% of the cultivated land. Crops other than rice, occupying about 1.5 million ha, are grown on the upland areas, the levee soils along the rivers, and on some areas of higher ground in the valleys. Crop production is largely confined to the wet season (May through October). Dry season crops are grown only where there is easy access to a perennial source of water.

5.02 The dominance of rice in terms of land use should not be allowed to obscure the importance of other crops in terms of total production, export earnings, farmer income and, not least, dietary supplements. With the exception of plantation crops such as rubber and some specialized fruits, most of the diversified crop production takes place on individual farms. Livestock breeding, fishing, and the raising of poultry are other activities of farm families which are by no means insignificant in terms of household food supplies and cash income.

5.03 Annual paddy production in the Basin averaged about 10 million metric tons in the 1960's period. The average planted area was 7.3 million ha which represents a cropping intensity of 85% on the 8.6 million ha estimated to have been developed for paddy production. The average Basin yield is about 1.3 tons per planted ha. The highest yields are recorded in the Vietnam Delta and the lowest in parts of Northeast Thailand and Laos.

5.04 Crops other than rice which have significance in terms of exports are rubber (Khmer Republic), kenaf and cassava (Northeast Thailand), and maize (Khmer Republic and Northeast Thailand). In 1968, about 50,000 tons of rubber was exported from the Khmer Republic representing 30% of the value of exports. Kenaf and cassava were both grown on a large scale in Northeast Thailand for the first time in the 1960's. Kenaf production reached 650,000 tons of fiber on 520,000 ha in 1966, although the production has since declined due to uncertain market conditions. Cassava production reached a peak of 160,000 tons of roots in 1965 and has since stabilized somewhat below that level. Maize production in Northeast Thailand and the Khmer Republic ranges between 100,000 and 150,000 tons, most of which is exported. Fruit and vegetables are grown throughout the Basin and average annual production in the 1963-68 period was on the order of 1.6 million tons.

5.05 With a present population of close to 30 million, the Basin is not overpopulated in comparison with many other parts of Asia. Farm families account for nearly 90% of the total population. Farms are generally larger than in other parts of Southeast Asia. The average farm holding is about 3.5 ha in Northeast Thailand and about 3.0 ha in the Vientiane Plain (the only area in Laos for which information is available). Smaller holdings of about one ha are common in the more densely populated provinces of the Khmer Republic and the Vietnam Delta, but in the less densely populated provinces average farm sizes are on the order of 3.0 ha. Outside of the Delta, the majority of the farms have traditionally been owned by the farmers. As a result of recent land reform measures, owner-operated farms may now be more common in the Delta. However, more information about land tenure in the various parts of the Basin is needed as a basis for the formulation of sound agricultural projects and programs.

5.06 There are no projects in the Basin providing a dependable year-round supply of irrigation water to the farmer's field. In Northeast Thailand and the Khmer Republic, there are some run-of-river schemes -- diversion dams diverting natural river flows for use in canal systems. Some large dams and numerous smaller reservoirs, or "tanks", have been constructed in recent years in Northeast Thailand, but the water delivery systems are still under construction. A major reservoir project is under construction in the Khmer Republic and a number of projects are at various stages of investigation and planning.

5.07 In the Vietnam Delta there is a long established system of navigation and drainage canals. The construction of sea-defense dikes along the coast to protect farmland from tidal inundation also dates back many years. Lately, work has been in progress to restore control structures on the canals and also to complete some new structures: the chief purpose of the structures is to prevent salt water from entering the canals during the low-flow season. Another recent development has been the introduction of low-lift power driven pumps for irrigating lands bordering the canals.

Prospects for Rice Production

5.08 In regard to rice production, the picture is broadly as follows: Laos imports about 15% of its needs from Thailand; Northeast Thailand is on the average self-sufficient but with fairly wide swings in annual production; the Khmer Republic exported about 15% of its production during the 1960's; and the Vietnam Delta with 40% of the country's population accounts for about 70% of the national production.

5.09 Yields for rainfed transplanted paddy, the type most commonly grown, range between 2.6 tons/ha in some of the Vietnam Delta provinces to less than 1.0 ton/ha in parts of Northeast Thailand and Laos. Flood-adapted varieties grown in the Delta and around the Great Lake have yields between 1.0 and 1.5 tons/ha. High yielding varieties have been introduced in Vietnam

over the past three years. It is reported that over 300,000 ha were planted in 1970, most of which was in the Delta. Statistics for the 1970/71 harvest show a sharp increase in the Delta's paddy production, but the data do not differentiate between local and improved varieties. The High Yielding Varieties Program in the Delta also involved widespread distribution of fertilizers at prices attractive to farmers. This is the only instance in the Basin where fertilizer has been used on a large scale for paddy production. For other areas of the Basin, the use of fertilizers and other chemical controls is negligible.

5.10 For the future a policy directed towards self-sufficiency in rice production would appear appropriate for Laos and Northeast Thailand. Geographically, these two areas are not well placed to compete in the world export market. Nor do the ricelands offer the possibilities for conversion to other high value crops on a large enough scale to justify imports of rice. For similar reasons, continued self-sufficiency should be a minimum target for the Khmer Republic but, with a return to more peaceful conditions, efforts should be made to regain its former export markets. The Delta provinces of Vietnam will have to continue to serve as a major source of rice for the remainder of the country, and efforts should be made to resume exports now that Vietnam has again reached a position of self-sufficiency. The prospects for rice exports are not, however, encouraging at the present time. In recent years, both prices and the volume of world trade in rice have declined as a result of production increases in countries which formerly were major importers.

5.11 The gradual upward trend in rice production over the years has been achieved by bringing more land into production. With the possible exception of the Vietnam Delta in recent years, there has been hardly any discernible upward trend in yields. Data on land capability and present land use are not available in sufficient detail to form any firm conclusions as to the scope for further lateral expansion. The best approximations at the present time are that the ricelands could be expanded by about 20% in Northeast Thailand, and at the most 10% in the Khmer Republic and the Vietnam Delta. The scope for lateral expansion in Laos is unknown but, with only 3% of the land area presently cultivated, there is probably some potential for further expansion. However, in all areas it may be safely assumed that new land brought into production will be increasingly of marginal suitability for rice production because of less favorable soils or topography, greater exposure to flooding, etc. Thus, incremental rice production through lateral expansion of ricelands is likely to encounter rising production costs.

5.12 In any case, beyond the next four to five years, the prospects for further gains in production by increasing the cropped area are by no means certain for most of the Basin. Therefore, programs designed to raise the general level of rice productivity in the Basin should have a high priority. Particular emphasis should be placed on measures to raise productivity in the absence of water control, that is under rainfed and

flood dependent conditions. Even under the most ambitious development program, it would be many years before more than a small percentage of the nine million hectares of ricelands could be served by irrigation and drainage systems. There are, of course, possibilities for providing supplementary water at critical periods of the growing season by low-cost diversions from streams and ponds. While the number of farmers with access to a reliable water source is small compared to the total number engaged in rice cultivation, every effort should be made to improve the utilization of localized sources of supplementary irrigation so as to reduce the risks of rainfed cropping and facilitate the use of modern inputs.

5.13 Lack of water control is certainly one of the constraints on the attainment of higher levels of rice productivity; it is also the most costly constraint to eliminate. Moreover, there is no clear correlation between rainfall and yields. For example, some of the relatively dry western provinces of Northeast Thailand produce higher rice yields than some of the eastern provinces which experience high rainfall.

5.14 Most of the research so far devoted to rice cultivation has been irrigation-oriented. While such efforts should continue, there is a need for more intensive efforts to find out what can be accomplished under rainfed conditions. A constraint which has not received sufficient attention is the poor quality of seeds used by the farmers. It is the normal practice to use seeds held back from the previous year's harvest. Improved seeds, including both local varieties and the new short-stem varieties, multiplied under commercial conditions with proper quality control, are not available to many of the Basin's farmers. A program of improved seed multiplication and distribution could be a major factor in increased productivity. Most of the new varieties of rice have been developed to produce high yields under ideal conditions with precise water control and other inputs. But it is of interest to note that in the Vietnam Delta such varieties have reportedly out-performed local varieties under rainfed conditions with only moderate fertilizer applications. The introduction of such improvements will no doubt be assisted by the fact that, with a rapidly increasing population, there will also be more intensive use of the already developed rice land, and decrease in farm size in some parts of the Basin will lead to higher labor inputs and more careful farming practices.

Prospects for Crop Diversification

5.15 Most of the progress to date in crop diversification has taken place in the uplands. Rainfed crop cultivation in these areas is confined to the wet season. Also, the areas where soils are suitable for permanent cropping are limited in extent and, with few exceptions, are already in use. Examples of continuous cultivation are the rubber plantations in the Kampong Cham Province of the Khmer Republic, and the maize-growing areas in the Korat Province of Northeast Thailand.

5.16 Kenaf and cassava, which have come to be major exports for Northeast Thailand in recent years, are primarily grown under shifting cultivation on podzolic soils of low inherent fertility. After several crops have been grown the soil loses its fertility. If the soil is then left fallow for a period of ten to fifteen years, the natural regeneration of vegetative cover will restore its fertility. Shifting cultivation is an inefficient use of the land resource since less than 20% of the land is occupied by a crop in any one year. It is also potentially destructive when erosion control is neglected and when attempts are made to cultivate the land continuously. The rapid degradation of the physical characteristics of the podzolic soils is such as to militate against the use of chemical fertilizers as the sole device for maintaining soil fertility. The solution to the problem of shifting cultivation lies in making more productive use of the regeneration phase. This will require a crop rotation system involving grass crops and legumes, which will restore rather than deplete the soil fertility. The inclusion of pasture in the rotation would be more profitable if combined with livestock raising.

5.17 There are large areas of podzolic soils in the Basin, but it is only in Northeast Thailand where they have been exploited on a large scale. Trials of various techniques for maintaining soil fertility on fixed farm holdings on the less fertile soils should therefore have a high priority both for Northeast Thailand and the Basin as a whole.

5.18 Throughout the Mekong Delta, in Vietnam and the Khmer Republic, there are large areas of fertile alluvial soils which offer good possibilities for diversification in the dry season. There is room for further expansion of the practice of planting crops on the receding flood in the more deeply flooded areas, and in the Vietnam Delta the existing canals are a source of water for supplementary irrigation by low-lift pumps. Recently, encouraging results have been obtained with sorghum as an "after-flood" crop in Vietnam. In the lower reaches of the Delta, salinity control in the dry season would permit expansion of vegetable and fruit cultivation along the canal banks.

5.19 The levee soils along the Mekong and its tributaries could be cultivated more intensively for a wide range of crops, particularly with irrigation in the dry season. Particularly good possibilities exist in the riverain areas of the Mekong in the Khmer Republic. The lowland rice paddies of Northeast Thailand and the Khmer Republic offer few opportunities for diversified dry-foot crops because of their poor drainage characteristics. There is, however, some scope for diversification on the higher fringe of the ricelands where rice productivity is in any case low.

Prospects for Irrigation

5.20 Within the Basin there is considerable diversity in rainfall, hydrology, topography and soils. Hence, there is a similar diversity in the modes of irrigation to be considered for development. The following broad review of potentialities and problems is intended as a background for the more detailed review of development priorities discussed in Chapter VI.

5.21 Large-scale, year-round irrigation from the rivers of Northeast Thailand and the tributaries of the Great Lake in the Khmer Republic requires large reservoirs to conserve and regulate the highly seasonal pattern of runoff, and extensive canal system to distribute the stored water over the irrigable lands. This represents the most costly form of irrigation development in the Basin, and can be economically justified only where there is an assurance of intensive year-round cultivation of high value crops. However, over much of the area topographically suited to irrigation in Northeast Thailand and the Khmer Republic, the poor drainage characteristics of the soils preclude cultivation of crops other than rice, without substantial investment in drainage facilities. Since these areas already support a wet-season rice crop, the incremental benefits of year-round irrigation do not justify high cost irrigation facilities.

5.22 A number of projects involving large storage reservoirs and canal systems are under construction in Northeast Thailand, and a start has been made on the first large reservoir project in the Khmer Republic. As originally formulated, the projects had the objective of providing year-round irrigation for intensive double-cropping with a high degree of diversification. It is now apparent that the transition from rainfed paddy cultivation to year-round agriculture will take much longer than originally anticipated. While considerable progress has been made in construction of the dams and main canals, progress has been very slow in providing effective systems for delivering water to the farmers' fields. It is evident that there are formidable social problems in superimposing sophisticated water control systems on existing patterns of land use and land tenure, and also in operating and maintaining such systems. These problems are now widely acknowledged and a more gradual approach aiming initially at supplementary wet-season irrigation is being considered.

5.23 The future policy for the western tributaries of the Mekong should be concentrated on making more effective use of the dams and canals already constructed or under construction, and for the time being to limit project investigations to areas where the soils are suitable for diversified cropping. Experience with on-going projects will be an invaluable guide to the planning and economic evaluation of direct gravity-irrigation from Pa Mong and Stung Treng. Until such experience becomes available, it would seem prudent to place a fairly low economic value on the potential for direct irrigation from mainstem projects.

5.24 The eastern provinces of the Khmer Republic are thinly populated and soils and topography over much of the area are not favorable from the standpoint of irrigation. Investments in water control in these areas should have a low priority.

5.25 The well drained alluvial soils forming the natural levees of the Mekong are suitable for diversified year-round cropping under irrigation, and the first steps have been taken to develop pump-irrigation in Northeast Thailand and in Laos. In the Khmer Republic a form of flood irrigation is practised along the banks of the Mekong where the levee soils are suitable for a wide range of crops. Prospects for further development are good, particularly in conjunction with pump irrigation in the dry season.

5.26 The extensive network of navigation and drainage canals in the Vietnam Delta form a source of water which is already being exploited by low-lift pumps. In the upper reaches of the Delta, these canals contain fresh water throughout the year, but in the lower Delta saline water enters the canals during the dry season. The potentials are good for further development of low-lift pumping. The minimum dry season flow entering the Delta is very large compared to likely irrigation needs, but any depletion of the flow by upstream diversions tends to worsen the salinity intrusion problem. Therefore, upstream storage on the mainstem to provide low-flow augmentation, becomes an important factor in Delta development.

Agricultural Data Collection

5.27 In reviewing the present situation and in assessing potentials for future development, the Bank and its consultants found that there is a need for more detailed, accurate and up-to-date information on agricultural production, and land use. Each of the riparian countries publishes annual statistics on agricultural production. Normally, these include planted areas, yields and production for the major crops, and in some cases harvested areas are given. Except for Laos, the data are broken down by province. The chief source of error lies in the estimates of planted and harvested areas which are obtained by compiling a vast number of field reports of variable quality -- clearly a formidable task when millions of hectares have to be covered. Also, because of personnel and budgetary constraints, crop-cutting programs to establish yields are on too small a scale to cover adequately the large areas and wide diversity of conditions. The problem of delineating and measuring areas devoted to major crops is reflected in the lack of up-to-date information on land use. As a consequence, only the broadest correlation is possible between the present land use and the different soil types (mapping of agricultural soils to a small scale are available for Northeast Thailand, the Khmer Republic and the Vietnam Delta).

5.28 The existing soils maps have formed a basis for various studies of land capability, notably the EARI Atlas, the work of Development & Resources, Inc. in Vietnam, and a UNDP supported program in Northeast Thailand. However, an urgent need exists to obtain sufficient land use information to superimpose present land use patterns on the land capability maps. If this were to be accomplished, the scope for lateral expansion of cultivated areas could be more accurately assessed. Also, much has yet to be learned regarding actual field experience with individual crops and cultural practices under various conditions of soils and water regime.

5.29 In a large measure, the critical gaps in land resource data is a result of the various agencies engaged in data collection having to rely largely on field inspections supplemented by out-of-date aerial photography. Major advances in the quality and detail of land resource data could be achieved if these agencies had at their disposal more modern techniques of photography and remote-sensing from aircraft and earth satellites. The economic and technical feasibility of land resources survey from aircraft is well established, and the first earth satellite specifically designed for earth resource surveys is planned for launching in the near future.^{1/} One important advantage of an earth resource satellite is that it provides coverage at frequent intervals -- about once every 15 days in the case of the Mekong Basin. It is to be noted that the Mekong Committee has endorsed a proposal for participation in the ERTS program submitted to NASA by the Engineer Agency for Resource Inventories, U.S. Army Corp of Engineers. This proposal calls for acquisition of satellite survey data for the Mekong Basin.

B. Power Development

Power Demands

5.30 In 1970 the combined power consumption of the riparian countries was about 1,000 MW and energy generated was approximately 5,000 GWh. Thailand and Vietnam, the two largest countries, accounted for about 75% and 20% respectively of the power and energy generated. Annual growth rates in power consumption in both Thailand and Vietnam are presently above 20% and, in the past, have been higher -- during the 1960's Thailand's growth for several years reached 30%. In the Khmer Republic and Laos, the chief constraint to energy consumption is lack of distribution facilities, but as this constraint is removed these two countries could also have high growth rates in demand.

^{1/} The first Earth Resource Technology Sattelite "ERTS A" is to be launched on April 1, 1972, by the National Aeronautics and Space Administration of the United States Government. The Priority Program outlined in Chapter VIII includes a recommendation for instituting a program to take advantage of the ERTS program and other techniques of data acquisition and analysis.

5.31 According to the load forecasts used by the Mekong Secretariat in preparing the Indicative Basin Plan, the generation requirements of the four riparian countries by the year 2000 would reach 129,000 Gwh and 24,000 MW - or twenty-four times the present requirements. Thailand (64%) and Vietnam (29%) would between them still account for most of the demand. The major load centers, which lie outside the Basin, are Bangkok and the Central Provinces of Thailand, and the Saigon-Cholon area of Vietnam.

5.32 The demands for Thailand adopted by the Secretariat were close to the highest of three "Moulton" forecasts prepared in 1966.^{1/} The power authorities in Thailand are now using the "Moulton B" forecast which was also used by USBR in their evaluation of the Pa Mong Project. For Laos, the Secretariat adopted the forecast prepared by Electricite du Laos; this was also adopted by USBR. The Secretariat's forecast for the Khmer Republic included a large block of power for an aluminum complex, to be constructed in 1980 in conjunction with the Sambor Project. For Vietnam, the Secretariat's projection postulates a three-fold increase in generation between 1970 and 1975 (average annual growth rate of 25%) in recognition of the pent-up demand which presently exists. Thereafter, growth rates decline from 16% (1975-80) to 8.5% (1990-2000); in the early years this is similar to the pattern of growth experienced in Thailand.

5.33 If the "Moulton B" forecast for Thailand is substituted for the figures used by the Secretariat, and the special industrial load for the Khmer Republic is deleted (so that the projections do not reflect pre-determined assumptions as to future development), the projections for the four riparian countries would be as tabulated below.

Total Generation Requirements
Thailand, Vietnam, Laos, Khmer Republic

	<u>Energy (Gwh)</u>	<u>Power (MW)</u>	<u>Average Annual Growth in Energy Demand</u>
1970	5,000	1,000	
1980	21,050	4,240	15.5%
1990	51,100	9,780	8.6%
2000	112,250	21,240	8.1%

^{1/} "Thailand Electric Power Study" 1966, prepared by a team headed by J.S. Moulton under contract to USAID.

5.34 In rapidly expanding systems there are inevitably considerable uncertainties in any long-range projections of power and energy demands. However, as a background for considering alternative forms of power system expansion, the projections listed above are not unreasonable when compared with experience in other developing countries. Annual growth rates are projected to decline from the present high levels exceeding 20% to about 10% in the early 1980's and then level off at about 8%. It is to be noted, however, that a steeper decline in year-to-year growth rates in the next five years could result in much lower long-term demands.

Sources of Power

5.35 In the Indicative Basin Plan, a proposal is put forward for meeting virtually all of the growth in the power demands of the riparian countries in the period 1980-2000.

5.36 The five mainstem projects in the Indicative Basin Plan, with an installed capacity of 21,700 MW and an annual energy generation of 116,000 GWh, would develop over 90% of the hydro-electric potential of the mainstem of the Mekong.

5.37 The other major project in the Plan, the Nam Theun Project (2,500 MW and 8,000 GWh), is the largest block of power which could be developed at a single site in Laos. This represents about 20% of the potential of the Laotian tributaries assessed in a recent desk study by the Secretariat. The power potentials of 58 possible damsites on 14 river basins were estimated; but, except for Nam Theun, none of the projects has a capacity of 1,000 MW and nearly half have capacities less than 100 MW.

5.38 In Vietnam, hydro-electric projects which appear sufficiently attractive to warrant technical studies have a potential of about 2,500 MW, of which about 1,000 MW is in the Mekong Basin. By the end of the 1970's virtually all of the hydro-electric potential of Thailand will have been developed. The hydropower resources of the tributaries in the Khmer Republic are as yet unexploited, but the total potential is only 300 to 400 MW.

5.39 Sources of fossil fuel within the Basin countries are small in relation to anticipated requirements for power generation, but exploration in off-shore areas may yet lead to discovery of oil and natural gas. Thailand has a major program under way for construction of large oil-fired steam plants using imported fuel in the vicinity of Bangkok. Units of 300 MW have been installed and larger units are being planned. Vietnam also is planning to construct oil-fired thermal plants in Saigon and the Mekong Delta. Throughout the Basin many communities are dependent on small diesel-powered generators.

5.40 Experience in the USA and Europe has shown that, with unit sizes between 900 and 1,100 MW, nuclear power becomes competitive with thermal power. Some technical studies of nuclear power have been made in Thailand, the only national system likely to be large enough to permit integration of large nuclear power plants before the 1990's.

Basic Considerations in Power Development

5.41 Comparative analyses of hydro-electric power from mainstem projects on the Mekong and thermal power generated close to the main load centers have been made by the Secretariat and also by the Bank's consultants (see Chapter VII). These analyses show that Mekong hydropower is competitive with thermal generation and has the advantage of long-term savings in foreign exchange. But, on the basis of present information, the early hopes of Mekong planners that hydro-electric energy would have a marked economic advantage compared to thermal energy would not appear justified. However, a definitive assessment of the comparative merit of alternative sources of energy will have to await a more comprehensive assessment of project costs and benefits including an assessment of the ecological impact of the proposed major storage dams.

5.42 Exploitation of the Mekong's hydro-power potential would require a high degree of regional cooperation in power system planning and development. With two exceptions, the major possibilities for hydro-electric development lie outside of the two countries -- Thailand and Vietnam -- which will be the main markets for power and energy. The two exceptions are the hydro-electric potential of the Central Highlands in Vietnam and the Pa Mong Project which lies on the border of Thailand and Laos. An approach to development which would permit the four riparian countries to share the hydro-electric resources of the Basin could have considerable merit in view of the scarcity of indigenous fuels. Furthermore, in the case of Laos and the Khmer Republic, power development for export to the other riparians could make a significant contribution to the countries' foreign exchange receipts. However, major investment decisions must necessarily be consistent with national policies for power development, and dependence of a national power system on power and energy from plants located beyond the national boundaries is widely acknowledged as one of the major issues to be faced. Until recently, the international aspects of Mekong hydro-electric development could be considered only in general terms. But now that more information is gradually becoming available about the potential of the major projects and their costs and benefits, a basis will soon exist for the governments and agencies involved to establish more definite views as to the policies governing development of the Basin's power resources.

5.43 So far, this discussion has been primarily concerned with the long-term prospects of hydro-power development from mainstem projects. There follows a brief review of the near- to medium-term outlook for power development in each of the riparian countries, with particular reference to areas within the Basin.

5.44 The growing demands for power and energy in Thailand will be met by the construction of oil-fired steam plants near Bangkok. Northeast Thailand was recently connected to the Thai power grid which serves all of the country except for some isolated areas in the south. Formerly dependent on a gas-turbine, several hydro-plants subject to wide seasonal variations in output, and numerous small diesel plants, the Northeast can now be assured of a more reliable and adequate power supply. The Nam Ngum project in Laos is also connected to the Thai power system, and Thailand has agreed to purchase energy in excess of requirements in Laos.

5.45 In Vietnam, attention will be given to realizing the country's large hydro-power potential, to providing additional thermal generating capacity in the Saigon area, and to progressive integration of the numerous independent systems. Plans are well advanced for the first thermal power to be installed in the Delta, and future plans call for interconnection with the Saigon system.

5.46 Recently, one major hydro-power project on the Nam Ngum, and two smaller hydro schemes have been placed in operation in Laos. There is considerable potential for further development of small hydro-power projects near the chief population centers. The magnitude of the demand in Laos and the distance between load centers are such that no advantage would be gained by interconnection. Hydro-power development to meet local needs should have a high priority in Laos because of the high freight costs incurred in transporting fuel from Bangkok, the chief port of entry.

5.47 A number of multipurpose projects on the tributaries of the Great Lake have been investigated in the Khmer Republic. The plants generally have low annual plant factors, are subject to seasonal variations in peaking capability (because of changes in reservoir levels), and would be subject to certain constraints on operation imposed by the need to meet irrigation requirements. Also, the projects are in need of further investigation following collection of more hydrologic and topographic data. Because of the long lead-time needed to establish the economic viability of the multipurpose developments, a strategy of increasing the thermal capacity of the system appears to be indicated for the near-term. Although this would involve higher fuel costs, the capital investments would be much lower. With further investigation some of the hydro-electric projects might be found to have a useful place in a larger system.

VI. NATIONAL DEVELOPMENT OF LAND AND WATER RESOURCES

A. General Considerations

6.01 Consideration of the development of the Mekong Basin is rendered more complex by the fact that territories of four countries are involved and that for two of them, Thailand and Vietnam, the territories within the Basin constitute only a part of their total national territory. Even if the Basin lay entirely within one country, problems of priority and allocation of resources, of local interests and of political balance would arise. The history of major river storage schemes bears ample testimony to the difficulty of securing an acceptable allocation of costs. Such difficulties are particularly evident when, as is often the case, the costs and disturbances of construction are concentrated upstream where the most advantageous sites for storage and power potential are found, while the major benefits lie downstream or in urban centers outside the Basin. Within a single country, adjustments in national financial assistance can help in finding a solution. Between two or more countries, the finding of an acceptable solution is inevitably more difficult, though it is possible that international financial assistance, where available, can play a catalyst role.

6.02 The benefits of cooperation between the riparian countries in the development of the Mekong Basin have to date been discussed largely in terms of total estimated costs and benefits of the proposed mainstem projects in an integrated development of the river system and with reference to agreement on mainstem low-flow water use. These certainly constitute a most important aspect and the desirability of regarding the river and its tributaries as a total system from the beginning can be fully endorsed. Only in this way can benefits be maximized in relation to costs and the international difficulties often caused in other river systems by isolated, independent action be averted.

6.03 It is not infrequently suggested, on the other hand, that because the four national territories of the Basin are so dissimilar and because priorities for their development must be determined in the context of national planning involving non-Basin territories and their problems in the case of Thailand and Vietnam, the major emphasis should be on national approaches to development of the respective Basin territories. The four component territories differ substantially in physical conditions, in ethnic groups, in population density, in degree of integration into commerce, in transport facilities and in education levels to mention only a few of the important considerations for policy. It is indeed for this reason and because of the need for a national perspective in determining priorities, that the Bank's review stresses the desirability of considering separately the potential of each of the four component territories of the Basin.

6.04 However, the national and Basin-wide approaches can be regarded as strongly complementary. Apart from the mainstem projects, which directly affect more than one riparian country, joint riparian efforts can be of great assistance to the sub-basin's development by economizing Basin studies and expertise, in communicating relevant experience, in preparation of agricultural projects and in organizing financing and technical assistance. In current conditions in the Basin, shortage of expertise and requirements for training appear at least as important as shortage of finance.

6.05 Moreover, it is only by close interaction between the national and Basin approaches, that the experience in the development of sub-basins can contribute to the evaluation and design of the major projects. At this point in time and under the prevailing political conditions in the region, it appears that the four riparian governments are still striving to gain a clear understanding of how the joint multipurpose development of the Mekong River would compare with alternative development on national territory and when it would become essential to increase the support for regional cooperation in order to further their respective national development goals. It is therefore essential that both project-oriented basin and national planning fill in some of the major information gaps and lead to a clearer perception of the cost and benefits of regional development by the riparian governments. It is in this context that the following chapter considers separately the land and water development potentialities of each of the major component territories of the Basin.

B. Laos

6.06 With the exception of the much-studied Vientiane Plain, there is a lack of reliable information on land resources and agricultural production in Laos. From the limited data available, it appears that the land cultivated in any one year is about 700,000 ha of a total land area of 23.2 million ha. Annual production is on the order of 500,000 tons of paddy rice, 100,000 tons of upland rice, and 180,000 tons of other crops (chiefly corn, fruit and vegetables).

6.07 Distance and topography, as well as the disturbed political situation, are barriers to the movement of agricultural commodities in Laos. For many of the river towns, it is easier to trade across the Mekong with Thailand than with other areas in Laos. The balance of trade in agricultural produce is presently in favor of Thailand, and it is estimated that Laos imports about 50,000 tons of milled rice annually.

6.08 In part, the need for imports may stem from local deficit areas being created by an influx of population to the security of the river towns (Vientiane alone accounts for half of the rice imports). A contributory factor, however, could be the close ethnic ties between merchants on both sides of the upper reaches of the Mekong and the incentives

created by consumer goods being available at lower prices in Laos than in Thailand. Thus, Laos' trade deficit in agricultural produce could conceivably be due, at least in part, to the marketing medium rather than low productivity.

6.09 Laos is unlikely to be able to export rice because its neighbours are likely to be self-sufficient and the country is far removed from the chief ports of the region. Therefore, the policy for rice production should be aimed at reducing imports and achieving a sustained growth in production sufficient to keep pace with a growing population. With a present population of less than 3 million, and less than 3% of the total land area under cultivation, and with ample rainfall over most of the country, the goal of self-sufficiency should be well within reach if there is a return to more peaceful conditions.

6.10 The potential for diversified crops is good, but again the export prospects are distinctly limited, except perhaps for crops particularly suited to conditions in Laos. Fertile levee soils are found along the Mekong near some of the major river towns, and upland soils of high fertility are found in the high rainfall area of the Bolovens Plateau. The levee soils and the Bolovens Plateau could be cultivated more intensively during the wet season than they are at the present time.

6.11 Considerable attention has been given to possibilities for irrigation development in the Vientiane Plain. Planning studies have led to the identification of eight irrigation projects with a combined area of 33,000 ha. The water supply for these projects would be obtained from central pumping plants on the Mekong and Nam Ngum. Flood protection dikes along the Mekong and Nam Ngum are included in the proposed plans. Construction of one of the eight projects will begin shortly. This is the Tha Ngon Project (800 ha) which is being supported by the Asian Development Bank, and the Overseas Technical Cooperation Agency of Japan. Two projects, the Hat Doc Keo Project (6,000 ha) -- also known as Casier Sud -- and the Tha Deu Project (1,900 ha) are included in the Mekong Committee's Pioneer Project Program. Some of these projects may prove to be economically feasible because of their proximity to markets and the generally good soils. Their construction and operation should provide an opportunity for personnel in various government agencies to gain experience in all phases of irrigated agriculture.

6.12 Outside of the Vientiane Plain there are reported to be numerous small dams and pumping schemes, but the only large project is the Nam Tan Project in Northern Laos being constructed by the Royal Lao Government with the assistance of the United States Agency for International Development. The project comprises a diversion dam and a canal system designed to serve about 6,000 ha of land. This project should provide experience in design and operation and serve as a forerunner of further gravity irrigation projects.

6.13 Land and water resource investigations in Laos have in the past been oriented toward irrigation development. More emphasis should now be placed on agricultural surveys of areas which could be sources of supply for the main population centers. Such surveys should include crop inventories, land use studies and soil surveys. Priority should be given to identifying production possibilities under rainfed conditions. This does not mean that possibilities for irrigation should be ignored, but they should not be pursued at the expense of other forms of development.

6.14 Construction of the first stage of the Nam Ngum hydro-electric project, 70 km north of Vientiane, has recently been completed. The initial stage comprises a concrete dam and spillway, and a powerhouse containing two 15-MW units. The project is designed to permit the future installation of spillway gates and the extension of the powerhouse for three additional 35-MW units. First power is expected to be generated early in 1972. An agreement for the sale of energy to Thailand has been negotiated. An important feature of the Nam Ngum is its potential for increasing the dry season flow in the Mekong once the spillway gates are installed. This low-flow augmentation could be significant in relation to downstream uses in the Khmer Republic and the Vietnam Delta.

C. Northeast Thailand

6.15 Out of a total land area of approximately 17.0 million ha in Northeast Thailand, between 3.2 and 3.7 million ha are cropped to paddy and dry-foot crops in any one year. Rice is the main crop, but there are fairly wide year to year fluctuations in cropped area and production which appear to be due to climatic conditions, particularly in the amount of rainfall at the beginning and end of the growing season. In the period 1960-1968, the average area planted to rice was 2.6 million ha, the average production was 3.1 million tons, and the average yield per planted ha was 1.2 tons/ha. Thailand is one of the world's largest exporters of rice, but the Northeast region is believed to be mainly self-sufficient neither contributing to exports nor importing from the rest of the country. About 75% of the Northeast's production is glutinous rice for which there is limited export potential.

6.16 Other important crops are kenaf, cassava and maize. The world market for kenaf is closely related to the fluctuations of the world jute crop. As a result of shortfalls in the jute crop in 1966, exports of kenaf from the Northeast reached a peak of 650,000 tons. Production has declined since then and in 1969 was about 319,000 tons; however, a large area is understood to have been planted in 1971. Cassava, another export crop has shown rapid growth in the 1960's with less fluctuations than kenaf. Production of roots range between 110,000 and 150,000 tons,

but the Northeast accounts for only about 6% of Thailand's production. Most of the maize production takes place in an area of fertile soils lying to the west of Korat. Production varies between 100,000 and 150,000 tons, and represents about 10% of Thailand's exports.

6.17 Given the limited export possibilities for rice, especially the glutinous variety, the policy for Northeast Thailand should be to diversify agricultural production while maintaining self-sufficiency in rice. The available information on land capabilities indicates that 3.3 million ha which is presently in use for rice (on the average about 80% is planted in any year) could be expanded to about 4.0 million ha. Thus, over the next few years, rice production could be increased, as it has in the past, by bringing more land into production. But in the long run, higher levels of productivity will be needed to keep pace with population growth. Therefore, a start should now be made on programs designed to bring about a general increase in productivity, particularly under rainfed conditions. Another source of increased production is the 200,000 ha of land which could be served from existing reservoirs.

6.18 Average paddy yields for the fifteen provinces of the Northeast range from 2.6 tons/ha to 0.7 tons/ha. An essential element in formulating a program to assist the farmers in improving productivity should be a thorough investigation into the reasons for the wide variations in yields between provinces. These variations cannot be explained in terms of rainfall. For example, the province of Ubon which is the largest rice producer has ample rainfall but a low average yield of about 0.8 tons/ha.

6.19 A study of land capability maps for Northeast Thailand shows that about 3 million ha of land in the upland areas can be considered as suitable for dry-foot crops. It is in these areas where the rapid growth in kenaf and cassava cultivation has taken place. The problem in these areas is the decline in soil fertility which follows continued annual cultivation of the same crop. The land can be cropped for two to three years. If natural regeneration of forest cover is depended on to restore soils fertility, a fallow period of about ten years is required. Under a strict rotation of three years cultivation and ten years fallow, it would be possible for about 0.5 million ha to be cropped annually. However, there is already at least 0.5 million ha under crops at present and the cropped area has increased every year -- a trend likely to continue with a growing population. If the trend continues unchecked, the agricultural potential of the upland soils could be exhausted. Controls on forest clearing are almost impossible to enforce, therefore the solution lies in encouraging the farmers to adopt farming practices which, in their own interests, will stabilize cultivation of the uplands. Such practices would involve rotation with pasture or other grass crops in combination with improved soil and water conservation.

6.20 Six large reservoirs with the primary purpose of irrigation were constructed toward the end of the 1960's. Work has been concentrated on construction of the dams and main canals. Progress has been slow in developing the distribution systems. Where systems have been provided, they have served to demonstrate that the problems of implementing year-round irrigation for multiple cropping are more formidable and more costly to solve than was originally assumed. The Bank's review of the situation leads to the conclusion, which now is generally accepted, that a step-by-step approach should be adopted. The first priority is to construct systems to provide a reliable supply of supplementary water for the wet-season rice crop. As experience is gained by the operators and the farmers, opportunities will develop for dry-season irrigation. The projects as originally formulated would serve about 200,000 ha. Development in the next few years should be concentrated on about 40,000 ha where the main canals have already been constructed. In some areas these canals are in need of repair and modification. Immediate attention should also be given to the formulation of detailed plans for irrigation of the remaining 160,000 ha commanded by already existing storage dams.

D. The Khmer Republic

6.21 For many years the Khmer Republic has derived most of its foreign exchange from the export of agricultural commodities. Until 1969, rice products (milled rice and rice flour) were running at levels exceeding 250,000 tons and at times reaching 500,000 tons. Rubber and to a lesser extent maize have also been important export crops. Although recent data are not available, it is probable that communications have been disrupted by hostilities and this has caused a sharp decline in exports.

6.22 Of the total land area within the Basin of 18.1 million ha, some 3.4 million ha are in use for agriculture. Ricelands occupy about 3.0 million ha but on the average only 85% is planted to rice in any year. The patterns of rice cultivation follow closely the varying hydrologic conditions that prevail throughout the region. Of the total rice crop, some 70% is planted to various forms of rainfed paddy and the remaining 30% is cultivated as flood-dependent varieties. Annual production of paddy averaged 2.6 million tons in the 1960's, with a mean overall yield of 1.1 tons per ha. The total area under crops other than rice is about 400,000 ha. Rubber is the most important perennial crop occupying 60,000 ha. Production of fruit and vegetables on a similar area approaches 600,000 tons. Maize, grown on 125,000 ha is the most important field crop.

6.23 Looking to the future, the Khmer Republic should have no difficulty in meeting domestic demands for rice in view of the large surpluses that have been achieved in recent years. However, if the external markets are regained with a return to more peaceful conditions, the challenge will be to service these markets at the same time as increasing production to meet the needs of a growing population. This challenge could be met by a modest overall increase in the yields of paddy grown under rainfed and flood-dependent conditions, and it is to this end that the main effort should be directed. Except for completion of the on-going Prek Thnot project and rehabilitation of the Bovel project, further large investments in civil works with the primary purpose of rice production does not appear justified.

6.24 A number of multipurpose projects on the tributaries of the Great Lake have been investigated in varying degrees of detail. The Battambang Project and the Stung Chinit project have been studied in some detail, whereas studies of other development possibilities have not advanced beyond reconnaissance grade. The Battambang Project seems to deserve priority in further studies because it is located in an area where soils are suitable for diversified cropping and flood control benefits may prove to be significant. In its present formulation as a multipurpose project including a dam, power plant and downstream diversion dam, the project has a low rate of return. Alternative project formulations need to be examined including the possibilities of constructing initially only the diversion dam to serve a limited area. In the case of the Stung Chinit Project there are also a number of economic and technical aspects of the project, as currently proposed, which require further study and analysis.

6.25 There are good prospects for expansion of diversified agriculture in riverain areas of the Mekong where a form of flood irrigation is practised for many years. Narrow channels -- known locally as "preks" -- are cut through the natural levees to admit flood waters to the river-bank farms. With low-lift pumps to provide supplementary water, more intensive and varied dry-season cropping would be possible.

6.26 Possibilities for low-lift pumping exist in the upper reaches of the Mekong Delta, particularly the Prey Veng province on the left bank of the Mekong. A large number of shallow depressions or "bengs" are found in this area which retain water on the receding flood. Studies should be made to determine the possibilities for replenishing the water in the "bengs" during the dry season. This area has a reasonably predictable water regime -- the area is flooded each year but depths are low enough to permit cultivation of single transplant paddy. As a result, the farmers in the area have shown some interest in the use of fertilizers.

The area on the left bank of the Mekong, between the border with Laos and the Delta, is relatively undeveloped and soils and topography are generally unsuited to cultivation. There are, however, soils with good potentials for diversified farming in the Ratanakiri province, which are relatively undeveloped because of their remote location.

E. The Vietnam Delta

6.27 The sixteen Delta provinces of Vietnam cover an area of some 3.8 million ha. With a population of approximately 6.8 million, or 40% of the national population, the Delta accounts for 70% of Vietnam's rice production. About 1.9 million ha of soils has been identified as cultivable. The area planted to rice each year averages about 1.6 million ha, and about 150,000 ha is planted annually to non-rice crops (chiefly fruits, vegetables and coconuts). Thus, an additional area of about 150,000 ha of cultivable land remains to be brought into production. About one million ha of land is unsuitable for cultivation; this includes the acid-sulphate soils of the Plan of Reeds, the peat soils of the U Minh forest, and the saline soils along the coast. These soils would be difficult and costly to reclaim.

6.28 Three systems of rice cultivation have developed in the Delta which are adapted to the seasonal water regime. Floating rice is grown on about 500,000 ha in the more deeply flooded areas in the upper part of the Delta. In the less deeply flooded middle Delta, a system in which the rice is transplanted twice (apparently as a form of weed control) is practised on about 200,000 ha. Single transplant rice is planted to about 900,000 ha in the areas which generally are free from flooding. Average yields are on the order of 2.6 tons/ha for single transplant rice, 2.0 tons/ha for double transplant rice, and 1.5 tons/ha for floating rice. Average paddy production over the period 1959-1968 was 3.3 million tons, but sharp increases in production have been reported for the 1969/70 harvest (3.93 million tons) and the 1970/71 harvest (4.39 million tons). This increase is attributable to the widespread introduction of high-yielding varieties. In 1970, about 320,000 ha were planted to new varieties in the Delta, mostly grown under rainfed conditions in the lower Delta but some dry-season cropping using low-lift pumps took place in the middle and upper Delta. Government officials in Vietnam are of the view that the country returned to a condition of self-sufficiency with the 1970/71 harvest, and are optimistic of further gains in production.

6.29 The Vietnam Delta has some important physical aspects: large tracts of developed paddy lands intersected by a long-established network of navigation and drainage canals; flooding which is predictable and only infrequently damaging; a supply of water for dry-season cropping in the upper and middle reaches of the Delta; and an established water

transport system connecting the area to a large domestic market as well as outlets for export. Thus, despite some constraints such as salinity intrusion during the dry season in the lower reaches of the Delta, inadequate surface drainage in the high rainfall areas, and in the longer-term a limit to the availability of dry season water, there is a considerable potential for development.

6.30 Aside from agricultural development programs, of which the most notable is the introduction of high-yielding varieties, there has been a renewal of efforts over the past few years to upgrade and extend the existing water control infrastructure. Coastal embankments and salinity control structures on the canals have been repaired, some new control structures are now under construction, and a start has been made on the large backlog of canal dredging. At the same time, farmers in some areas have begun to use small low-lift pumps for irrigation.

6.31 A number of development projects are under consideration. Studies have been made of two projects for irrigation and salinity control in the Go Cong and Kien Hoa provinces. Parts of the Tiep Nhut salinity control projects have been constructed and designs have been prepared for a large control structure designed to protect over 50,000 ha from salinity intrusion. In the deeply flooded upper Delta, the Caisan project -- a scheme to provide flood protection and irrigation of 60,000 ha -- has been identified. In varying degrees, however, all of these projects need to be prepared in more detail before they could be considered ready for implementation.

6.32 There are good possibilities for diversified cropping on the fertile alluvial soils of the Delta, particularly on lands bordering the main canals in the upper and middle Delta where fresh water is available for pumping during the dry season. In the lower Delta, salinity intrusion is a constraint on dry season irrigation. However, if control structures are provided to prevent salinity intrusion, the fresh water retained in the canals has considerable value for irrigation of higher value crops along the canal banks, and also for domestic water supply.

6.33 A recent development has been the introduction of sorghum as a dry-season crop in the floating rice zone, which has been successful without irrigation; depletion of residual soil moisture is prevented by leaving the rice straw on the ground until the sorghum crop is harvested.

6.34 Long-range planning has also received attention. Two conceptual plans have been prepared; one by Development and Resources Corporation (D&R) in cooperation with a government planning group, and one outlined in the Indicative Basin Plan. The two proposals have much in common but differ in scope and timing.

6.35 The D&R report proposed a massive investment in water control works in the Vietnamese Delta over an area of 1.6 million ha. The physical works envisaged comprise a system of levees extending on both sides of the Mekong and Bassac stopping short of the Khmer border. These levees would be primarily for flood control down to Can Tho and would continue thereafter for the purpose of salinity control. Within the protected area existing canals would be used and, where necessary, extended to provide a complete system of irrigation and drainage channels, with a series of pumps and control structures to regulate the flow of water. Navigation locks would be incorporated at certain points to permit the movement of low draught boats. The estimated capital cost of the program was US\$1.25 billion. The program was phased in four stages over a period of 20 years from 1971-1990 with the major works substantially complete by 1986. Increased production would result from lateral expansion, improved agricultural practices, flood control and irrigation, leading to agricultural production of 5.44 million tons of paddy equivalent in 1980 and 11.73 million tons in 1990. The major component of this increase, about three-quarters, arises from dry-season irrigation on the 1.6 million ha.

6.36 Included as one of the major projects in the Indicative Basin Plan was a conceptual plan referred to as Delta Development. The major flood control and irrigation works were designed to include the Delta in the Khmer Republic as well as Vietnam. The development was phased in two stages timed to coincide with the implementation of the two major upstream storage projects, Pa Mong and Stung Treng. Stage I (1983-1991) would consist of a flood embankment along the west bank of the Bassac from Can Tho to Phnom Penh, followed by irrigation of 250,000 ha, 121,000 in the Khmer Republic and 190,000 in Vietnam. Salinity dikes would also be constructed in the lower reaches of the Mekong and Bassac to combat saline intrusion. Stage II (1992-2049) would complete the flood embankments along the Bassac and Mekong Rivers from Kompong Cham to the lower limit of the flooded area in Vietnam. Irrigation and drainage would be extended over a further 466,000 ha in the Khmer Republic and 2,030,000 ha in Vietnam. This stage would also include the completion of coastal embankments. The estimated expenditure during the plan period 1980-2000 would be of the order of one billion US dollars. By making allowance for the effect of upstream storage projects, the scope of the works would be less than the D&R proposals.

6.37 Further elaboration of these plans will require a much more detailed knowledge of Delta hydrology than presently exists. Also, irrigation on the scale proposed would only be possible following construction of a major upstream storage project. Another important factor in the formulation of long-range plans will be a clearer assessment of the potential for more productive agriculture in the absence of large investments in water control.

6.38 One of the more important determinants of the potential for agricultural development in the Delta is the amount of water which can be diverted during the dry season and the effects of such diversions on salinity intrusion. A much more detailed knowledge of the relationship between dry-season flows and salinity intrusion is needed for the planning of major developments. This need is fully recognized by the Government of Vietnam who are being assisted in the training of personnel and the procurement of equipment by the Mekong Secretariat and USAID. A program of hydrologic observations in the Delta should have the highest priority. The results of such a program will be essential to determine the timing and magnitude of benefits from low-flow augmentation provided by upstream storage projects.

VII. A REVIEW OF MAINSTEM PROJECTS

A. Introduction

7.01 The Indicative Basin Plan proposed the construction of six major projects in the following sequence: Sambor (1981), Nam Theun (1981), Pa Mong (1983), Stung Treng (1992), Ban Koum (1997), and High Luang Prabang (1999). Except for Nam Theun, a project on a Mekong tributary in Laos, the projects are all on the mainstem of the Mekong. The plan was conceived in accordance with the principle that power requirements of the four riparian countries for the period 1980-2000 would be met by exploiting the hydro-electric potential of the Mekong Basin.

7.02 All of the mainstem projects would derive their primary benefits from power generation, but two of the projects - Pa Mong and Stung Treng - because of their large reservoirs, would have other attributes in terms of Basin development. Pa Mong would open up possibilities for irrigation in Northeast Thailand and considerably reduce flooding in the upper and middle reaches of the Mekong. Stung Treng would offer possibilities for irrigation in the Khmer Republic, and eliminate flooding of large areas in the Delta which are now subject to inundation every year. Also the projects would substantially increase dry season flows in the Mekong Delta. In fact, either of the projects alone would provide dry-season flows in excess of any foreseeable requirements for Delta irrigation and salinity control. With proper preparation the large reservoirs would also offer opportunities for substantial fisheries development.

7.03 In their review of mainstem development, the Bank and its consultants concentrated on three of the six projects - Pa Mong, Stung Treng and Sambor. The first two obviously merit attention because they are the only projects with sufficient storage to even out the wide seasonal variations in river flows. Also, they are not only the largest projects but also the only true multipurpose projects. Pa Mong has been studied in considerably more detail than any other project on the mainstem. Work on Stung Treng has been confined to mapping and geophysical investigations, and a desk study by the Mekong Secretariat. Further desk studies of the project were made by the Bank's consultants. The Sambor Project was selected for review because it has been the subject of a feasibility grade study and it was assigned priority in the Indicative Basin Plan.

7.04 The Tonle Sap Barrage, which had been investigated under the auspices of the Mekong Committee, was also reviewed. This is a scheme for a barrage across the Tonle Sap designed to utilize the Great Lake in the Khmer Republic as a storage reservoir.

7.05 The Ban Koum and High Luang Prabang Projects have a low priority for development and do not merit consideration at this time. Furthermore, little information is available for these projects. As in the case of Sambor, the Ban Koum reservoir is small and development would depend on prior construction of Pa Mong. The High Luang Prabang Project has less storage and power potential than Pa Mong and requires much longer transmission lines. Lack of data also precluded a review of the Nam Theun Project.

B. Project Evaluation

Methodology

7.06 As a means of assessing the relative economic merits of alternative modes of power development and to provide a comparison between mainstem projects the Bank's consultants used the "equalizing discount rate" (EDR). This is the discount rate which equalizes the present value of costs (capital costs and operation, maintenance and replacement costs) of alternative power systems developments designed to meet an identical load growth. Multipurpose benefits of storage dams were considered as offsets to the cost of hydro-power development. In the case of Pa Mong and Stung Treng each project was evaluated as though it would be the first project constructed on the mainstem. The intention was to determine whether either project had so marked an economic advantage that it could be a factor in deciding the sequence of implementation (other factors would also have considerable weight, not least the more advanced state of investigations at Pa Mong). The earliest date at which it was considered feasible for the projects to become operational as a "first-in" project was taken as 1983 for Pa Mong and 1985 for Stung Treng.

7.07 In the case of Sambor, the project formulation would depend on the status of upstream development. With upstream storage a larger power-plant capacity is justified and the annual energy generation is increased. Three alternatives were therefore considered:

- (1) as an isolated project with an installed capacity of 1,500 MW, operational in 1983
- (2) as a project in conjunction with Pa Mong with an installed capacity of 3,000 MW, operational in 1983
- (3) as a project constructed after Stung Treng with an installed capacity of 4,500 MW, operational in 1991.

7.08 The comparative analyses of the three mainstem projects were conducted by Sir Alexander Gibb and Partners in association with Merz and McLellan. These analyses used similar alternative thermal-power developments and took into account irrigation and flood control benefits. Secondary benefits from improved navigation, fisheries, domestic water supply, etc., could not be quantified with any degree of precision and they were therefore excluded from the analysis.

7.09 Studies of Pa Mong with special reference to its economics as a power project were conducted by Acres International (Overseas) Ltd.

7.10 The basic source of data for project cost estimates was the report of the United States Bureau of Reclamation on the Pa Mong Project, which were based on 1969 price levels. Gibb and Acres jointly conducted a general review of the USBR cost estimates and up-dated them to mid-1970 levels. Some changes were made in individual items, in particular to reflect international rather than USA costs for generating equipment and transmission lines. The basic cost parameters were then used in preparing estimates for the Stung Treng and Sambor projects.

Hydro Versus Thermal Power Comparisons

7.11 In the assessment of the relative economic merits of hydro-power development the conventional method of comparison with an alternative thermal power system development was used. The load forecasts given by the Mekong Secretariat in the Indicative Basin Plan were adopted as a basis for the analyses as it was the only forecast available for all four riparian countries.^{1/} Calculations were made for various prices of fuel oil ranging from 20 cents to 40 cents per million Btu.^{2/}

7.12 The technique employed can be illustrated by the procedures followed for Pa Mong. Two alternative plans were prepared for power systems development to meet projected demands in Thailand and Laos. The system for the "Thermal Alternative" comprised existing and planned power plants in Thailand and Laos followed by a series of thermal plants added as required to meet projected demands. The system for the "Pa Mong Alternative" differed only in that the Pa Mong units replaced an approximately equivalent thermal capacity. Annual costs, both capital costs and operation, maintenance and replacement (O, M & R) costs, were computed for a 60-year period for each of the two alternatives. The "equalizing discount rate" is the rate at which the present values of the two cost streams become equal to each other.

7.13 The analysis was carried out for a 60-year period. It was assumed that, after the completion of Pa Mong, further capacity additions would be identical for both alternatives. Therefore, it was necessary to develop installation schedules and load forecast only up to a point in time three years following the completion of Pa Mong. Beyond this point,

^{1/} In the case of Pa Mong, studies were also made using several different forecasts for Thailand.

^{2/} Recent developments in the world oil markets have brought about substantial increases in the price of fuel oil and the range of sensitivity tests is now being extended to 60 cents per million Btu (exclusive of taxes and duties).

the excess of O, M & R costs for the Thermal Alternative over the Pa Mong Alternative were included in the cost stream of the Thermal Alternative for the remainder of the 60-year period. Provision was made in both cost streams for replacement of thermal generating capacity every 33 years. The foreign exchange components of the cost streams were also computed to determine foreign exchange savings over the 60-year period of analysis.

Irrigation and Flood Control Benefits

7.14 To estimate irrigation benefits attributable to the multipurpose projects, a simplified approach was adopted by the consultants. Three categories of irrigation were postulated:

- (i) High cost irrigation, either by direct gravity or medium lift pump schemes, for which a complete conveyance system would have to be developed at an estimated average cost of US\$1,000 per ha. (Refer to discussion in paras. 5.20 to 5.23).
- (ii) Medium cost irrigation where an existing canal infrastructure could be further developed at an average cost of US\$400 per ha to permit widespread use of low-lift pumps.
- (iii) Low cost irrigation where the existing infrastructure could be used without modification for low-lift pumping.

The medium and low cost irrigation areas, each of about 500,000 ha in extent, lie in the Vietnamese Delta, and would be developed as a result of increasing dry season flow. In practice it was considered that all the low cost irrigation would have been developed from existing river flows and could not be attributed to mainstem development. Medium cost irrigation was assumed implemented at a rate of 20,000 ha per year. The high cost irrigation areas would be located further upstream in the Khmer Republic and Northeast Thailand. It was assumed that 300,000 in each area would be developed at a rate of 10,000 ha per year initially rising to 20,000 ha per year after 10 years. Benefits were calculated as the net increase in value of agricultural production resulting from the irrigation works.^{1/}

7.15 The consultants used the estimates given in the USBR Pa Mong Report for flood benefits in the upper and middle reaches of the Mekong. An independent technique for assessing flood benefits in the Delta was evolved which could be used for both Pa Mong and Stung Treng. It was assumed that the major source of flood benefits in the Delta would arise

^{1/} Rice output was valued at \$55 and \$60 per metric ton of paddy at farm-gate depending on location.

from enhanced use of land through changes in cultivation techniques permitted by the improved hydraulic regime. The method used to estimate benefits was an elaboration of a technique developed initially by Development and Resources Corporation and subsequently by the Secretariat. The Delta was divided into four cultivation zones, high yielding varieties, single transplant, double transplant, and floating rice, according to the maximum flood depth which normally occurs in each zone. If the flood depth is reduced by upstream storage it is assumed that the mode of cultivation will change with a consequent increase in yields. Changes in flood depths due to individual upstream projects were made by reference to the results of the Delta Model.^{1/}

C. Pa Mong

7.16 The Pa Mong multipurpose project sited 20 kilometers upstream of Vientiane where the Mekong forms the international boundary between Thailand and Laos has long been recognized as one of the major potential developments on the mainstem of the Mekong. A feasibility study was started in 1963 by the United States Bureau of Reclamation and a Stage I report was completed in 1970. A Stage II report is now nearing completion. The Stage I report presented designs and supporting studies for the storage and power facilities, and for a 43,000 ha irrigation development (11,000 ha in Laos, and 32,000 ha in Northeast Thailand). It is understood that the Stage II report will present plans for irrigation of about 650,000 ha in Northeast Thailand. Allowing four years for the pre-construction phase, including further site studies, detailed design and tendering, followed by eight years to complete the main civil works, it is estimated that the scheme could become operational at the earliest by 1983.

7.17 The main structure at Pa Mong would be a concrete gravity dam 100 m high and 1,360 m long. This structure would incorporate a 375 m spillway, capable of discharging 36,000 cms, flanked by a powerhouse on each side. Each of the two powerhouses would contain four 600-MW generating units, to give a total installed capacity of 4,800 MW. Average annual energy generation would be 27,000 GWh. Virtually all of the output would be used in Thailand. Four 500-kv transmission lines with an intermediate substation would connect the plant to the main load centers at Bangkok. Loads in Northeast Thailand would be served by 115-kv transmission lines from the plant and by 230-kv lines from the Chaiyaphum substation. The output of Pa Mong would represent about 60% of Thailand's power demand in the early 1990's - the earliest date by which all of the Pa Mong units could be installed.

^{1/} A mathematical model developed for the Mekong Committee with UNDP assistance by the French firm SOGREAH for investigation of hydraulic problems in the Mekong Delta.

7.18 To seal off two tributaries, the Nam Mong and the Nam Lik, which pass through the reservoir area, a 70 m high and 2,000 m long earthfill dam would be constructed across the Nam Mong and a 90 m high arch dam across the Nam Lik. Together with over 20 km of dikes the three dams would create a reservoir of 98.3 milliiards gross storage volume up to the normal maximum retention level at El 250 m and inundate an area of nearly 4,000 sq. km. The average annual flow of the river at the project site is about 145 milliiards with a lowest recorded flow of 90 milliiards. The proposed mode of operation would use about 42 milliiards of storage, within the normal operating range of El 250 - El 236.5 m, for the joint purposes of power, irrigation and flood control.

7.19 The total cost of the project, excluding irrigation works, is estimated by USBR at US\$1,079 million (mid-1969 prices). A revised estimate, up-dated to mid-1970, of US\$1,133 million was derived by the Bank's consultants. This included one or two modifications to the project as well as an increase in the costs allowed for resettlement of the population displaced by the reservoir (see paragraph 7.25 below).

7.20 Economic analyses based on the consultants cost estimates indicate the following equalizing discount rates:

Pa Mong - Equalizing Discount Rates

	<u>Fuel Cost</u> (cents per million Btu)	
	<u>30</u>	<u>40</u>
Power only:	9.0	10.1
Power and direct irrigation:	9.3	10.4
Power, direct irrigation, and Delta irrigation:	10.8	11.9
Power, direct and Delta irrigation, and flood control:	11.5	12.6

7.21 Power benefits are predominant since they accrue much earlier and more rapidly than irrigation benefits. Irrigation benefits in the Delta, as a result of low-flow augmentation, are more significant than benefits from direct irrigation in Northeast Thailand. In fact, the results raise some doubts regarding the economic viability of direct irrigation if development costs approach \$1,700/ha as indicated in the USBR Report (the consultants adopted a figure of \$1,000/ha).

7.22 The foregoing analyses were conducted by Sir Alexander Gibb and Partners in association with Merz and McLellan, and were designed to provide a basis of comparison with Stung Treng and Sambor. Studies by Acres International (Overseas) Ltd. were primarily devoted to testing the sensitivity of the equalizing discount rate to changes in timing of the project.

7.23 The dam and reservoir costs, representing almost half of the total project cost would be expended before any power is produced. Therefore, the highest return to the project occurs when the generating units are installed as quickly as possible and the load growth is such that all of the output of the units can be absorbed in the system. Acres' studies showed that with the Moulton load forecast for Thailand, the equalizing discount rate increased, by about 1% if the commissioning date changes from 1983 to 1988. This is not in itself an argument for deferring this project, but it demonstrates that, in terms of power benefits, the equalizing discount rate is not adversely affected by a delay in implementation. A further sensitivity analysis was conducted by Acres which showed that with a fuel price of 50 cents per million Btu, the equalizing discount rate for power alone increases by about 1.2%.

7.24 The dam structures have been designed with a normal retention level of the reservoir at El 250 m. At this level the power capacity of the project would be greatly enhanced compared with lower elevations, but it would result in the inundation of an area of over 4,000 sq. km containing a present population of about 280,000. By the mid-eighties, the total from normal population growth is likely to be approaching 450,000. While the project might be considered as technically feasible, it may be questioned whether an undertaking involving relocation on this scale, by far the largest ever attempted, is feasible on social grounds. It has proved difficult to identify land of similar quality to that farmed in the reservoir area for relocation of even a fraction of the displaced population. Furthermore, the costs allowed for resettlement at about \$40 per head (excluding administrative costs) appear to be very low. In comparable projects in other parts of the world costs of up to \$500 per head have been encountered.^{1/}

7.25 In view of the high costs associated with resettlement even if suitable areas for relocation can be found, and the social and political difficulties likely to be encountered in such a massive operation, it is recommended that further consideration should be given to a scheme with a lower reservoir level.

^{1/} Studies are in progress to prepare an up-dated evaluation of Pa Mong Project which would consider among the various sensitivity tests the impact of alternative levels of resettlement costs on the equalizing discount rate.

7.26 In the course of their studies, USBR examined a number of alternatives over a range of reservoir levels. The lowest end of the range was a project with a normal retention level at El 230 m, but with the design flood passing through the spillway the reservoir would rise to a maximum level of El 234 m.

7.27 The USBR scheme retained the Nam Lik and Nam Mong Dams. As explained below the resettlement problem could be greatly reduced if the reservoirs formed by these dams could be eliminated. Map studies indicate that the provincial town of Loei in Thailand, one of the largest population centers in the reservoir, would be unaffected provided the maximum pool could be kept below El 230 m. However, even at this level, relatively densely populated areas in the Vang Valley in Laos, would be inundated. But this area could be spared if it were feasible to construct a dike along the Pa Mong-Nam Lik saddle (approximately at El 220 m) and thereby eliminate the Nam Lik Dam and reservoir. Similarly, flooding of a large number of villages and cultivated land in Udorn provinces in Thailand could be prevented by eliminating the Nam Mong Dam and reservoir - the Nam Mong-Pa Mong saddle is in fact above El 230 m. Therefore, it appears desirable to consider an alternative scheme in which (a) the maximum flood level would not exceed El 230 m, (b) a dike at the Pa Mong-Nam Lik saddle would replace the Nam Lik Dam and reservoir, and (c) the Nam Mong Dam and reservoir would be eliminated. According to the USBR study a project with a normal retention level of El 230 m would have an installed capacity of 3,200 MW and annual energy generation of 17,700 GWh. The effective storage between pool levels of El 230 m and El 216 m (excluding the Nam Lik and Nam Mong reservoirs) would be about 20 milliards - still a very large volume of storage; for example, almost twice the storage capacity of the Tarbela reservoir on the Indus. Flood benefits would be reduced as a result of the low storage capacity, but these are a small component of total benefits and the flood benefits in the Vientiane Plain may in any case be largely pre-empted by prior construction of levees.

7.28 In view of the above considerations, the Bank recommends that serious consideration be given to an alternative project formulation with a lower reservoir level in order to reduce the resettlement problem to more manageable proportions. Until such alternatives have been considered, an adequate resettlement program has been formulated and costed, timing and magnitude of agricultural benefits have been firmed up, and the project's ecological impact has been assessed, an adequate evaluation of Pa Mong Project is hardly possible.

D. Stung Treng

7.29 Investigations of the Stung Treng Project are much less advanced than those for Pa Mong or Sambor and have been confined to topographic mapping, geophysical surveys, and desk studies performed by the Mekong Secretariat. The Bank's consultants also conducted desk studies and arrived at a somewhat different formulation for the project than the Secretariat.

7.30 The site presently proposed for the Stung Treng dam lies on the Mekong River in Cambodia just downstream of the confluence with the Se San tributary. The scheme as formulated by the Bank's consultants would consist of a concrete gravity dam 70 m high, a 450 m spillway section, a powerhouse with an installed capacity of 6,000 MW, and earth embankments with a total length of 26 km. Although the area inundated by the reservoir would amount to nearly 9,000 sq. km the area of cultivable land submerged would probably be less than in the case of Pa Mong. Preliminary studies by the Mekong Secretariat indicate a 1985 population in the reservoir area of about 270,000. The possibilities for resettlement might possibly be more favorable than in the case of Pa Mong, since there are areas, particularly in the Khmer Republic, which are sparsely populated.

7.31 The reservoir with a normal retention level at EL 88 m would have a gross storage capacity of 110 milliards. The proposed mode of operation would utilize about 72 milliards for the purposes of power generation, flood control and irrigation. The total cost of the main structure and transmission lines, but excluding any irrigation works, is estimated at US\$1.87 billion.

7.32 The major part of project benefits would arise from electric power generation, which would amount to an average annual production of 35,000 GWh. Sited at a distance of 600 km from Bangkok and 300 km from Saigon, the project could provide power to the major load centers in Thailand, Vietnam and Cambodia. Attenuation of the Mekong summer flows by about 30% would partially or totally relieve about 1.75 million ha of cultivable land in the Khmer and Vietnamese Delta areas from annual flooding, leading eventually to a more stable and profitable form of agricultural development. A more immediate impact on agricultural production would arise from the augmentation of dry season flows, which would be more than sufficient to meet the irrigation requirements of the Mekong Delta, and would at the same time reduce the effects of saline intrusion. Other benefits would include improved navigation, and possible growth of a fishery industry in the reservoir.

7.33 An indicative economic evaluation of Stung Treng, assumed to be operational in 1985, was carried out on the same basis as for Pa Mong; the results are as follows:

Stung Treng - Equalizing Discount Rate

	<u>Fuel Cost</u> (cents per million Btu)	
	<u>30</u>	<u>40</u>
Power only:	7.8	8.7
Power and direct irrigation:	8.5	9.4
Power, direct irrigation, and Delta irrigation:	9.6	10.5
Power, direct and Delta irrigation, and flood control:	10.6	11.5

7.34 Allowing for all benefits the equalizing discount rate (for 40 cents fuel) is 11.5% compared with 12.6% for Pa Mong. It is to be emphasized that each project has been considered for purposes of comparison as the first project on the mainstem. Irrigation benefits in the Delta, due to low-flow augmentation, could only be attributed to the first project constructed. Thus, as a second project, the equalizing discount rate indicating cost offsets for agricultural and flood control benefits for either Pa Mong or Stung Treng would be about 1% less than indicated.

7.35 In recent discussions with the Mekong Secretariat it has been learned that soils and topography in the areas that could be commanded from Stung Treng appear less favorable from the standpoint of irrigation development than so far assumed. If this is confirmed by further studies the equalizing discount rate for Stung Treng would be further reduced by about 0.7%.

7.36 Indicative estimates based on desk studies indicate that Stung Treng would cost some 50% more than Pa Mong while energy generation would be about 30% higher. Although, therefore, the equalizing discount rate based on power alone can be expected to fall below that of Pa Mong - 8% to 9% on the rough estimates - its rating on total net benefits may prove comparable. Foreign exchange savings would be somewhat higher than for Pa Mong. On the other hand, Stung Treng, lying completely outside the territory of either of the main power consumers, poses in even more acute form than Pa Mong the problem of site location in relation to national boundaries. Moreover, whereas Thailand has negligible hydro-power potential to develop apart from Mekong mainstem possibilities, Vietnam has perhaps 2,500 MW of potential, outside the Basin and on Basin tributaries, sufficiently attractive to warrant technical studies and which might suffice for power needs into the 'nineties. On the other hand, Stung Treng is the only mainstem project which could provide Vietnam with a substantial measure of flood protection for the delta. It would appear that a careful weighing of these factors by the riparian countries concerned and a determination of policy is required before very extensive and expensive feasibility grade investigations of Stung Treng would be justified.

E. Sambor

7.37 The Sambor Project on the Mekong near Kratie in the Khmer Republic was given early priority for detailed investigation by the Mekong Committee, together with Pa Mong and Tonle Sap, and a feasibility study was carried out by the Overseas Technical Cooperation Agency of Japan (OTCA) between 1963 and 1969. Although not as big as Pa Mong or Stung Treng, Sambor is nevertheless a major scheme in terms of capital outlay and the size of the civil engineering works. The project consists of a low dam and spillway section of about 45 m maximum height, and just over 1 km in length, incorporating a long centrally located power plant.

7.38 About the same distance from Bangkok and 50 km closer to Saigon, Sambor would serve the same power market as Stung Treng, except where the project would be constructed prior to upstream storage, in which case Sambor was assumed to serve only Vietnam and the Khmer Republic. To meet the Mekong Secretariat load forecast, OTCA proposed an installed capacity of 875 MW for the project operating in isolation, increased to 2,100 MW when operated in conjunction with Pa Mong. The Mekong Secretariat in its Indicative Basin Plan adopted an installed capacity of 3,000 MW when operating with Pa Mong and 3,250 MW when operating as part of an integrated river system which would also include Stung Treng. There is no unique answer to the choice of installed capacity as it is clearly dependent on the phasing of Sambor with other mainstem developments. It could be as high as 4,500 MW. For this reason, the Bank's consultants examined three alternatives with installed capacities of 1,500 MW, 3,000 MW and 4,500 MW to cover the various stages of mainstem development. Costs were estimated by the consultants on the same basis as for other projects. Annual energy production for these alternatives are given below:

Sambor Project Alternatives

	<u>Average Annual Energy (GWh)</u>	<u>Cost (mid-1970) (US\$ million)</u>
(1) Without upstream storage Operational 1983 (1,500 MW)	10,500	527
(2) With Pa Mong Operational 1983 (3,000 MW)	19,000	869
(3) With Stung Treng Operational 1991 (4,500 MW)	25,000	1,205

7.39 The economic evaluation carried out by OTCA showed a rather low equalizing discount rate for the project; about 5% for an 875 MW installation and 7% for a 2,100 MW capacity. For a 1,500 MW scheme the Bank's consultants derived an equalizing discount rate of 9%, and slightly higher values for the larger installations with upstream storage. This corresponds closely to the analysis of the Mekong Secretariat.

7.40 As formulated by OTCA, Sambor is essentially a power project. The proposed operating range for the reservoir would be between El 40 and El 38, which represents an active storage of 2 milliards. Flood storage space of 2.5 milliards would be provided between El 40 and El 42. OTCA identified about 34,000 ha which could be irrigated directly from the Sambor project. The Bank's consultants adopted the basic project proposed by OTCA but, as mentioned above, they investigated alternative power-plant capacities. The consultants also estimated benefits from direct irrigation and from low-flow augmentation in the Delta, and found that these benefits would have the effect of increasing the EDR to about 10%.

7.41 Sambor would be more attractive as a possible "first-in" project on the Mekong if it provided a larger volume of storage to meet dry-season water needs in the Delta. A change in the proposed mode of reservoir operation would appear to meet this requirement. For example, if the reservoir were operated between El 42 in the flood season and El 36 in the dry-season, the active storage available for low-flow augmentation would be about 6.2 milliards. This would be enough to increase the average flow at Kratie in March and April from 2,000 cms to over 3,000 cms. This mode of operation would also have the effect of evening out the monthly variations in energy generation. Further studies of the Sambor project to investigate alternative modes of reservoir operation to maximize multipurpose benefits deserve priority. Finally it is to be noted that resettlement would be less of a problem than at Pa Mong and Stung Treng. The reservoir would inundate between 4,000 and 5,000 ha of cultivated land which at present is occupied by a population of about 15,000.

F. Tonle Sap Barrage

7.42 The Great Lake in the Khmer Republic, situated to the west of the Mekong River, is connected to it at Phnom Penh by the Tonle Sap River. The natural direction of flow in the Tonle Sap River is from the Great Lake into the Mekong, but during the monsoon season the water level in the Mekong rises above that in the Lake causing the flow to reverse. The Lake then acts as a temporary storage reservoir holding up to 60 milliards of water. As the flood level of the Mekong begins to drop, the flow in the Tonle Sap reverts to its normal direction and the water stored in the Great Lake discharges into the main stem.

7.43 A report on designs and cost estimates for the Tonle Sap Barrage was prepared by the Government of India's Central Water and Power Commission (CWPC) in 1964. The report proposed that a barrage, sited at the exit of the Great Lake into the Tonle Sap would be closed in the early part of the flood season, thus preventing flows from the Tonle Sap entering the Great Lake. A large volume of the Lake's storage capacity

would thus be retained to absorb the later peak flood in the main river following the re-opening of the gates. This water would then be held back in the La'e and released slowly during the dry season to augment irrigation supplies and combat the problem of saline intrusion in the Lower Mekong Delta. Other benefits envisaged include a revival of the fishing industry, improved navigation, and limited hydro-electric power generation.

7.44 Opinions as to the merits of the project have been somewhat modified since its original formulation. The Delta Model was used to study the effects of the barrage on flood levels in the Delta, and to derive criteria for operation. As a result of these studies, it was concluded that the flood attenuation potential of the project would be small and consequently the Mekong Secretariat rejected the scheme for early implementation in the development of the mainstem. Among the factors tending to limit the flood control effect of the barrage were (a) the need to keep the barrage open until mid-July to permit migration of fish into the Lake, (b) the large inflow to the Lake from surrounding tributaries, and (c) the limited conveyance capacity of the Tonle Sap River.

7.45 Although the project would not provide any appreciable flood control, some benefits would arise from irrigation in the Delta and from the beneficial effect on fisheries in the Lake. The project as formulated would have the effect of almost doubling the flow entering the Delta during the lowest months of the dry-season. The Lake is the chief center for the fishing industry in the Khmer Republic, but the present yield of about 30,000 tons is less than half the yields achieved 25 years ago. The French Fisheries Mission concluded that when the Lake reaches its lowest level there is a migration of fish from the Lake. The Mission concluded that prevention of this dry-season depletion in stocks (by holding the Lake one or two meters above its lowest level) could lead to an improvement in production.

7.46 There would be little justification for a project on the Tonle Sap if there was a strong possibility of Pa Mong coming into service in the 1980's. Nevertheless, in view of the uncertainties surrounding the implementation of massive developments on the mainstem, and the possibility that there may be some urgency in providing dry-season water in the Khmer and Vietnamese portions of the Delta, the concept of providing low-flow augmentation by controlling the Great Lake should not be rejected without further consideration. An alternative which merits further study is a design which would provide control only over the outflow from the Lake between surface levels of +4 and +2 meters. This is in contrast to the scheme as presently formulated which is designed to control both outflow and inflow over a range of Lake levels between +10 and +1 meters.

7.47 The storage between +4 and +2 meters is about 7.5 milliards and if released during the two or three low-flow months the additional water supply would be sufficient for irrigating possibly 500,000 ha. Limiting the drawdown of the Lake to +2 meters could possibly have a beneficial effect on fisheries in the Lake. However, even in its modified form the project would still constitute an interference with one of the world's most complicated ecosystems and attention would have to be given to the ecological impact of civil works designed to change the regime of the Great Lake.

G. General Considerations in Mainstem Development

7.48 The justification and timing of mainstem project development must be viewed in the context of the increasing demand for power and irrigation within the riparian countries, the need for flood control in specific areas of the basin and the advantages of improved irrigation along the river itself. However, the development of an international river involves considerably more technical, legal, political and administrative problems than that of a national river. Moreover, it requires the full commitment and the active participation of all the countries which are affected, directly or indirectly, by such development, and in some cases, the chief beneficiary may not be the country in which the projects are located.

Power Development

7.49 Power needs will be an important determinant of the timing and sequence of mainstem developments. Although long-term projections must be treated with caution, there will undoubtedly be rapidly increasing demand for power in the next 30 years. Before 1990 the power demand of the riparian countries will have probably reached a sufficient level to absorb at least one hydro-electric scheme on the scale contemplated in the mainstem projects. This demand can, of course, be met by conventional oil-fired or nuclear installations but in view of the lack of indigenous fuels such a mode of development involves a permanent commitment by the riparian countries to using energy with a high foreign exchange cost. However, some of the major hydropower projects lie outside of the countries with the largest demands. Even countries in areas with a history of political stability have shown reluctance to depend on plants outside of their borders for a large part of their power capacity. Thus, the creation of a regional power system will call for a high degree of cooperation and mutual confidence between the countries concerned.

Irrigation

7.50 Irrigation demands as a determinant of mainstem development are subject to an even greater degree of uncertainty than power demands. There are three areas of the Basin in which mainstem development would provide opportunities for large-scale irrigation - Northeast Thailand, the area north of the Great Lake in the Khmer Republic and the Mekong Delta. In Northeast Thailand, a first priority is to make effective use

of water stored in existing storage reservoirs; only when this has been accomplished will there be a basis for judgments on the economics and timing of direct irrigation from Pa Mong. In the Khmer Republic, the areas which could be commanded from Stung Treng have yet to be studied in any detail. In the Vietnam Delta there is considerable scope for development of low-lift pump irrigation from existing canals. However, irrigation diversions during the dry season would tend to worsen the salinity intrusion problem in the lower Delta. Thus, the need for a modest volume of upstream storage to increase dry-season flows in the Delta during a period of two to three months will become an important factor in mainstem development. A more detailed understanding than presently exists of the potential for agricultural development in the absence of irrigation will also be needed to assess future irrigation needs. Outside of the Vietnam Delta, there have been virtually no attempts to adopt new technologies in the production of rice, the Basin's principal agricultural product. Intensive efforts directed to accumulating experience in the development of the water resources of the tributary basins and the delta and in promoting the development of rain-fed agriculture appear, therefore, as an essential prerequisite to decisions on irrigation from mainstem projects.

7.51 In contrast with many of the river basins of the world, the Mekong Basin offers relatively few technical obstacles to agreements on joint development for purposes of irrigation. At present, the use of dry-season flows of the Mekong by the upper riparians - the prime source of disputes in most other basins - is negligible. For many years to come pumping in the upper reaches will be small in comparison with the dry-season flow at Pa Mong which seldom falls below 1,000 cubic meters per second. Large-scale gravity diversions on the mainstem can only be achieved by elevating the water surface in the river - in other words by construction of storage reservoirs. In the case of Pa Mong and Stung Treng the storage would be more than sufficient to meet potential diversion requirements, as well as to greatly increase dry-season flows in lower reaches of the river. An added safeguard to the lower riparians is that Pa Mong and Stung Treng would be primarily operated as power projects and hence reservoir releases would be continuous.

Flood Control

7.52 Considerable emphasis has been placed to date on the need to overcome the problem of flooding. In addition to specific reaches upstream, particularly the area around Vientiane, about five million ha is subject to annual flooding in the area of the Delta and around the Great Lake. The pattern of agricultural cultivation has evolved around this natural phenomenon, and varieties of rice are adapted to the particular flood conditions that prevail; however, flooding does result in a depression of yields in some areas. Also, flood dependent varieties possibly have less potential for yield increases than varieties cultivated under rainfed conditions. To some extent, however, the adverse effects

of floods can be circumvented by using short maturation varieties of rice in conjunction with low-lift pumping which will enable a higher-yielding crop to be harvested before the onset of the flood. Also, the introduction of sorghum as an "after-flood" crop in Vietnam has promise as a means of more productive land use without large investments in flood control. Thus, the flood problem as far as agriculture is concerned may now assume a lower priority than it has previously been given.

7.53 Stung Treng is the only project capable of providing a high degree of flood control in the lower reaches of the river and in the Delta. While flood control is generally regarded as beneficial it will result in profound changes in the water regime. These changes could initially be damaging if they are introduced too abruptly and without careful advance planning. Agreements on the mode of operation of Stung Treng would be necessary to protect the interests of Vietnam and the Khmer Republic, the riparians who would be affected by the project.

Navigation

7.54 The need for improved navigation is generally accepted and mainstem projects would have a beneficial effect on specific river reaches. However, no systematic attempt has yet been made to quantify navigational benefits in financial terms. Until this is done, they must be regarded as an important but intangible benefit arising from river control, and any additional cost arising from navigation works will need to be properly justified.

Environmental Considerations

7.55 A primary objective of resource development should be to improve on the natural environment - irrigation compensates for deficiencies in climate, flood control modifies river flows which otherwise are damaging, the generation of hydro-electric power and energy is a means of providing a more comfortable and productive environment. However, unless great care is exercised in project planning and management there is a risk of the beneficial effects of development being outweighed in whole, or in part, by adverse environmental consequences. This is particularly true in a tropical environment, and even more so when development involves impounding the waters of one of the world's largest rivers, which with its present regime has been an important determinant of the socio-cultural development of the riparian peoples.

7.56 The Mekong Committee is fully aware of the environmental and ecological risks of mainstem development and the need for analysis and evaluation. Studies so far conducted under the auspices of the Committee have served to indicate the dimensions of some of the problems that might be encountered; such as the possible spread of waterborne diseases and

parasites, the growth of algae and aquatic weeds, and the effects of reservoirs (both adverse and beneficial) on fisheries. However, much remains to be done before the adverse consequences of development can be predicted and solutions can be found so that the benefits of development can be realized with minimal adverse effects on both the human and non-human ecology.

The Resettlement Problem

7.57 Large-scale resettlement of population from the proposed reservoirs is one of the most difficult problems to be faced and one that may have a far-reaching effect on the formulation not only of mainstem projects, but also major reservoir developments on the tributaries. In the case of Pa Mong, the magnitude of the resettlement problem is such that serious consideration should be given to an alternative formulation of the project, as suggested earlier in this chapter. When investigations of the Stung Treng Project are resumed a first priority should be given to estimating resettlement and relocation requirements at different reservoir levels.

Project Readiness

7.58 The Bank's review has confirmed the findings of the Mekong Committee that multipurpose development of the Mekong River is technically feasible and in the long-term holds considerable promise for regional economic development. However, numerous problems attendant both to the assessment of project costs and benefits and to the joint development of an international river will have to be resolved before decisions can be reached on the timing and sequence of these major investments. A number of important follow-up actions in the further preparation of these projects have been identified in the recommended Priority Program. Furthermore, it is hoped that other project-oriented basin and national planning activities identified in the Priority Program and in the Mekong Committee's Work Program will lead to a clearer perception of the costs and benefits of joint multipurpose development of the Mekong River by the riparian governments.

VIII. A PRIORITY PROGRAM FOR BASIN DEVELOPMENT

8.01 The Bank's recommendations for development activities to be undertaken in the near-term are presented in the following Priority Program. This program specifies the actions required to bring to the stage of financing and implementation the more promising projects for irrigated and rainfed agriculture, and also indicates priorities for further investigation of mainstem projects. The recommended program of planning and development activities is by no means intended to cover all activities to be carried out under the auspices of the Mekong Committee, but rather represents the Bank's judgment as to activities which deserve a priority claim on available finance and on the implementation of both Mekong Secretariat and riparian agencies.

8.02 Most of the promising opportunities for irrigation development in the tributary basins and the Delta require further preparation before they could be considered ready for implementation. This need for further preparation stems from the somewhat disappointing results of irrigation projects to date, and the now unanimous recognition that further capital investments should be preceded by careful and realistic planning. However, with prompt and effective action, there are projects in each of the national components of the Basin which could be brought to the implementation stage toward the end of 1973.

8.03 The Priority Program also provides for further studies to provide a deeper understanding than presently exists of the present status of rainfed agriculture and potentials for future development. The Program includes the formulation of a central data bank, the application of space-borne remote sensing techniques in land resource surveys, a rainfed crop improvement program, and a survey of the high-yielding variety program in the Vietnam Delta. The Mekong Committee and its recently formed Agricultural Sub-Committee could have an important role in implementing these elements of the Program. The Agricultural Sub-Committee has been created to "promote cooperation between the Mekong Committee and the Ministries of Agriculture in the four Mekong countries, to harmonize agricultural aspects of Basin planning with national agricultural development plans and to formulate and coordinate research and experimental works in agriculture".

8.04 Recognizing the need for project preparation, the Mekong Committee in cooperation with UNDP and the Bank has formulated a Pioneer Projects Program which would concentrate on the identification and detailed formulation of projects for irrigated and rainfed agriculture. The pioneer projects would be prototypes in which practical trials of the most promising approaches will lead, by successive modification, to

to the selection of methods for application in full-scale development projects. Where appropriate, the feasibility studies of the full-scale development projects will be carried out as an integral part of the pioneer project implementation. The Pioneer Projects Program is therefore an important feature of the Priority Program.

8.05 Priorities for further studies of mainstem projects include investigations of a "low" Pa Mong, investigations of alternative modes of reservoir operation for Sambor, and a design study for a structure on the Tonle Sap for controlling the outflow from the Great Lake.

8.06 The principal features of the Priority Program are briefly described below and summarized in Annex 1.

A. Basinwide Studies

1. Pioneer Project Program: Identification and preparation of a program of pioneer agricultural projects. The program will include irrigation developments dependent upon dams and reservoirs under construction or already completed; irrigation developments dependent upon pumping schemes from the Mekong and its tributaries; projects for irrigation, drainage and salinity control in the Mekong Delta; and improvements in rainfed crop production.

All projects will give special attention to the requirements for comprehensive rural development. The program of pre-investment studies is projected to require total expenditures of US\$2.0 million. While the cost of implementation of such a program is still highly conjectural the figure of US\$50.0 million has been used in discussions with potential donors to indicate a rough order of magnitude for total program costs.

2. Pa Mong Project: (a) Technical and economic studies of a project with maximum pool at about El 230 (Estimated Cost: US\$0.5 million); (b) A review of environmental studies so far executed, identification of further studies and preparation of terms of reference for the execution of further studies (Estimated Cost: US\$0.05 million); and (c) Execution of studies identified and formulated under (b) (Estimated Cost: US\$0.5 million).

3. Tonle Sap: Design studies and cost estimates for a structure to control outflow from Great Lake between Lake levels of +4 and +2 meters above MSL. Present project plans would involve civil works costing US\$140 million. It is expected that the proposed redesign of the project will bring substantial savings in costs (Estimated Cost: US\$0.2 million).

4. Sambor Project: Studies to investigate alternative modes of reservoir operation to maximize multipurpose benefits.

5. Stung Treng: (a) A comprehensive desk study bringing together work of the Secretariat and the Bank's consultants leading to the preparation of detailed terms of reference for further project investigations (Estimated Cost: US\$0.1 million); (b) Site investigations and feasibility study subject to firm expression of interest by riparians in project (Estimated Cost: US\$12.0 million).

6. Delta Studies: Study in both Khmer and Vietnam portions of Delta to establish guidelines for future development, and identify priority projects (study by Netherlands Team in progress, estimated cost of follow-up: US\$0.6 million).

7. Central Data Bank: Establish a central data bank to store in computerized form all types of data pertaining to Basin development in conjunction with a comprehensive inventory and evaluation of the existing data base for basin planning (Estimated Cost: US\$0.3 million).

8. Rainfed Crop Improvements: A basinwide program for research and field trials of techniques for improving agricultural productivity under rainfed conditions (Estimated Cost: US\$3.0 million).

9. Agricultural Data: A program for applying new techniques of remote sensing and data processing to the acquisition and analysis of data on land use, land capability, crops and crop production for the entire Basin. Arrangements have been made with NASA for coverage of the Mekong Basin by the Earth Resource Technology Satellite (ERTS) Program. Funds are required for ground controls and data interpretations (Estimated Cost: US\$0.4 million).

B. Laos

1. Nam Ngum: (a) Operation studies to develop rules for reservoir operation following installation of spillway gates -- taking into account flood reduction in Nam Ngum Valley and low-flow augmentation in the Delta; (b) Technical and economic studies for installation of additional power generating units (Estimated Cost: US\$0.05 million). These studies may lead to follow-up investments for the installation of spillway gates (US\$0.6 million) and additional generating units (US\$20 million).

2. Flood Protections, Vientiane Plain: Review and summarize existing proposals with a view to arriving at final decision on diking and bank protection (Estimated Cost: US\$0.1 million).

3. Nam Ngum Valley: Survey of potential for agricultural development in the area between the Vientiane Plain and the Nam Ngum dam site (Estimated Cost: US\$0.2 million).

4. Resource Surveys: Security situation permitting, reconnaissance surveys of land use, soils, crops and crop production in areas which are potential sources of agricultural products for major population centers in Laos (Estimated Cost: US\$0.3 million).

C. Northeast Thailand

1. Irrigation from existing reservoirs: Surveys of the current status of construction of canal systems served by existing reservoirs and preparation of plans for their completion. Stage I would cover selected priority areas totalling about 40,000 ha, and Stage II would cover about 100,000 ha of the remaining area. (Estimated Cost: US\$0.6 million). Follow-up investments may total about US\$35 million.

2. Flood protection study: There are large areas in the lower reaches of Nam Mun where annual flooding imposes a severe constraint on crop production. Studies are needed to establish the nature of the problem and to indicate possible remedies. (Estimated Cost: US\$0.15 million). Follow-up investments may require outlays in the order of magnitude of US\$5.0 million.

3. Development studies on Nam Chi: Two areas on Nam Chi (Bantoom Bantiew and Sang Badang) are presently protected from flooding. The possibility of irrigation in these areas using releases from upstream reservoirs merits consideration. (Estimated Cost: US\$0.2 million). A very first estimate of follow-up investments US\$5.0 million.

4. Rainfed Crop Improvement: Identify possibilities for production increases and quality improvement for dry-foot crops such as kenaf, cassava, cotton, oilseeds, and corn (Estimated Cost: US\$0.2 million).

D. Khmer Republic

1. Prek Thnot Project: Completion of irrigation system designed for Stage I (5,000 ha) to be served from storage and diversion works presently under construction. Planning studies for ultimate expansion of service area to 70,000 ha. (Estimate subject to further review, a notional cost of US\$1.0 may be appropriate). These works are ongoing, but additional funds may be required.

2. Stung Battambang: Several planning reports have been prepared for a multipurpose project on Stung Battambang. Further technical and economic studies are needed, especially consideration of staged development (Estimated Cost: US\$0.4 million). Existing studies propose a project costing US\$20.0 million.

3. Stung Chinit: Review feasibility report on this project which has recently been completed by OTCA (Estimated Cost: US\$0.1 million). The recently completed feasibility study pertains to a project costing US\$26.0 million.

4. Riverbank Farms: Review possibilities for further development of diversified agriculture on levee soils along Mekong (Estimated Cost: US\$0.2 million).

5. Fisheries: Identify measures required to arrest the decline in yields of the Great Lake (Estimated Cost: US\$0.3 million).

E. Vietnam Delta

1. Project Planning: Project identification and formulation for the following areas:

(a) Go Cong (50,000 hectares), Kien Hoa (100,000 hectares), Tiep Nhut (50,000 hectares) - primarily salinity control and irrigation;

(b) Coisan (60,000 hectares), An Truong (10,000 hectares) - primarily flood protection, irrigation and drainage. To the extent that pioneer projects are being formulated in each of these project areas, feasibility studies of the larger developments may be carried out as an integral part of pioneer project implementation. However, to retain flexibility in project preparation, additional funds for pre-investment studies will be required. (Estimated Cost: US\$1.0 million).

2. Low-lift Pumping: Survey of extent of low-lift pumping in the Delta, crops grown and impact on production, pumping practices and equipment, and forecasts of future growth (Estimated Cost: US\$0.4 million).

3. High Yielding Varieties (HYV) Program: Preparation of a report describing history, present status and future prospects for the cultivation of high yielding rice varieties (Estimated Cost: US\$0.1 million).

4. Hydrologic Data Collection: Implement a program designed to provide an understanding of the occurrence and effects of salinity intrusion and the possible consequences of increasing diversion during periods of low flow (Estimated Cost: US\$0.5 million).

5. Inventory of Water Control Infrastructure: A survey to obtain up-to-date information on the present condition and performance of canals, canal structures, and salinity control works (Estimated Cost: US\$0.3 million).

8.07 The above-listed studies and investigations are designed to promote investments in the period immediately ahead and to lead logically into a longer term basin development program. The Priority Program would require a commitment of about US\$12 million to meet the highest priority needs for expeditious preparation of land and water development projects in the Basin. Within this total, provision has also been made to fund the most urgent follow-up to past and ongoing studies of the most promising mainstem projects. Provided that these pre-investment funds are committed during the course of 1972 and 1973, and assuming further that security conditions will allow the necessary field work, the Priority Program can be expected to result in the preparation of a "pipeline" of priority projects requiring, over the course of the period from 1972 to 1978, commitments of US\$250 million to cover total project costs. Given the present state of pre-investment studies this estimate is of necessity highly conjectural, and the uncertainties about future security conditions, and policies and priorities of the riparian governments further reduce this projection to a mere order-of-magnitude guess. Finally, the Basin development program includes mainstem projects which would require unusually large, indivisible investments and even the best prepared of the mainstem projects are still undergoing close scrutiny, the outcome of which cannot be pre-judged. The above projections have, therefore, been confined to tributary projects and other land and water development activities on the basis of reasonable assumptions about project preparation requirements and likely improvements in the implementation capacity of the riparian governments. With these qualifications, the estimate of an investment program of \$250 million is advanced as a first indication of the likely short-term outcome of the proposed \$12 million program of pre-investment studies.

LOWER MEKONG BASIN

PRIORITY PROGRAM

Description	Estimated Cost of Pre-Investment Studies (\$ million)	Estimated Cost of Likely Follow-up Investment (\$ million)	Description	Estimated Cost of Pre-Investment Studies (\$ million)	Estimated Cost of Likely Follow-up Investment (\$ million)
A. BASINWIDE STUDIES			C. NORTHEAST THAILAND		
1. Pioneer Project Program	1/	50.0	1. Irrigation from Existing Reservoirs		
2. Pa Mong Project			(a) Stage I (40,000 ha)	0.20	
(a) Study of Low Pa Mong	0.50		(b) Stage II	0.40	
(b) Review & Formulation of Ecological Studies	0.05		2. Nam Mun Flood Protection	0.20	
(c) Ecological Studies	0.50		3. Nam Chi Development	0.20	
3. Tonle Sap Project	0.20		4. Rainfed Crop Improvement	0.20	
4. Sambor Project	0.20		Sub-Total	1.20	45.0
5. Stung Treng Project Desk Study	0.10 ^{2/}				
6. Delta Study (follow-up)	0.60		D. KHMER REPUBLIC		
7. Central Data Bank	0.30		1. Prek Thnot Project - Phase II	1.00	
8. Rainfed Crop Improvement Research and Field Experiments	3.00		2. Battambang Project	0.40	
9. Improvement of Agricultural Data Base	0.40		3. Stung Chinit Project	0.10	
Sub-Total	5.85	50.0	4. Riverbank Farms	0.20	
			5. Fisheries Studies	0.30	
B. LAOS			Sub-Total	2.00	50.0 ^{4/}
1. Nam Ngum Project (Re: Spillway Gates and Phase II)	0.05		E. VIETNAM DELTA		
2. Flood Protection for Vientiane Plain	0.10		1. Project Planning	1.00	
3. Reconnaissance Studies for Nam Ngum Valley	0.20		2. Review of Low-lift Pump Development	0.40	
4. Resource Surveys	0.30		3. Review of High Yielding Variety Program	0.10	
Sub-Total	0.65	25.0 ^{3/}	4. Hydrologic Data Collection	0.50	
			5. Inventory of Water Control Infrastructure	0.30	
			Sub-Total	2.30	80.0 ^{5/}
			T O T A L	12.00	250.0

1/ Estimated cost of US\$ 2.0 million already funded.

2/ Site investigations and feasibility study estimated at US\$ 12 million should be deferred pending review of desk studies by riparian Governments.

3/ To cover the cost of the following possible investments: Nam Ngum Power Plant Phase II; Nam Ngum Spillway Gates; and Flood and Bank Protection Works for Vientiane.

4/ To cover the cost of the following possible investments: two major tributary projects; and one program of minor irrigation works.

5/ To cover the cost of the following possible investments: one major salinity control and irrigation project including rehabilitation of existing sea defenses; one flood protection, irrigation and drainage project including rehabilitation of existing water control works; and one program for low-lift pump development.

LAND AREA AND POPULATION

<u>Geographical Area</u>	<u>Area</u> (km ²)	<u>Estimated 1970 Population</u>			
		<u>Total</u> (000)	<u>Density</u> (per km ²)	<u>Rural</u> (000)	<u>Urban</u> (000)
Khmer Republic	181,035	6,938	38.3	6,154	784
Laos	236,800	2,962	12.5	2,634	328
Thailand	514,000	35,814	69.7	30,614	5,200
Rep. of Vietnam	173,263	18,128	104.6	14,525	3,603
Totals	<u>1,105,098</u>	<u>63,842</u>	<u>57.8</u>	<u>53,927</u>	<u>9,915</u>
Lower Mekong Basin:					
Khmer Republic	163,797	6,459	39.4	5,719	740
Laos	220,500	2,769	12.6	2,448	321
Northeast Thailand	170,226	12,608	74.1	12,148	460
Northern Thailand	18,803	1,139	60.6	1,098	41
Delta Provinces (Vietnam)	37,911	6,714	177.1	6,100	614
Central Highlands (Vietnam)	34,118	646	18.9	585	61
Total (Basin)	<u>645,355</u>	<u>30,335</u>	<u>47.0</u>	<u>28,098</u>	<u>2,237</u>
Percentage in Basin	58.4	47.5	81.3	52.1	22.6

Indicative Basin Plan
Short-Range Plan (1970-1980)

	<u>Irrigated Area (hectares)</u>	<u>Installed Capacity (MW)</u>	<u>Estimated Cost (\$ million)</u>
<u>Khmer Republic:</u>			
Prek Thnot Project ^{1/}	35,000	18	54
Battambang Project	68,000	37	91
Thermal Power Station	-	45	8
Transmission Lines	-	-	5
Sub-total	<u>103,000</u>	<u>100</u>	<u>158</u>
<u>Laos:</u>			
Nam Ngum Project ^{1/}	35,000	130	80
Nam Dong and Se Done ^{2/}	-	3	4
Sub-total	<u>35,000</u>	<u>133</u>	<u>84</u>
<u>Northern Thailand:</u>			
Completion of seven multi- purpose projects ^{1/}	232,000	36	169
Nam Phrom Hydroelectric Project ^{1/}	-	60	22
Pak Mun Hydroelectric Project	-	100	32
Sub-total	<u>232,000</u>	<u>196</u>	<u>223</u>
<u>Vietnam:</u>			
Danhim Hydro (Rehabilitate and Extend)	-	332	68
Upper Se San Project	21,700	260	92
Upper Se Prok Project	24,500	26	35
"Polder" Development in the Delta	40,000	-	40
Thermal Power Stations	-	600	81
Transmission Lines	-	-	14
Sub-total	<u>86,200</u>	<u>1,218</u>	<u>330</u>
<u>Basin Summary:</u>			
<u>Totals</u>	<u>456,200</u>	<u>1,647</u>	<u>795</u>

^{1/} Under construction

^{2/} Completed 1971

Indicative Basin Plan
Projects in the Long-Range Plan (1980-2000)

Project ^{2/}	Installed Capacity (MW)	Annual Energy (GWh)	Active Storage (billion m ³)	Estimated Cost ^{2/} (\$ million)
Nam Theun (1981)	2,500	8,000	6	243
Sambor (1981)	3,250	22,000	2	584
Pa Mong (1983)	4,800	24,000	42	844
Stung Treng (1992)	7,200	35,000	46	1,440
Ban Koum (1997)	3,300	20,000	-	637
High Luang Prabang (1999)	2,750	15,000	10	412
Delta Development (1983) ^{1/}	-	-	-	-
	<u>23,800</u>	<u>124,000</u>	<u>106</u>	<u>4,160</u>

^{1/} A plan for flood protection, irrigation, and salinity control in the Khmer and Vietnam parts of the Delta.

^{2/} Costs shown are for dams and power plants only, the capital costs of the Long-Range Plan as estimated in the Indicative Basin Plan Report are:

	<u>US\$ million</u>
Dams and power plants	4,160
Power transmission facilities	951
Direct Irrigation	1,274
Delta Development	<u>1,055</u>
	<u>7,440</u>

LOWER MEKONG BASIN INDICATIVE BASIN PLAN

- Limits of the Lower Mekong Basin
- Rivers
- ▭ Reservoirs and lakes
- Gauge and discharge-observation stations
- SHORT RANGE PLAN (1971-1980)
- ▭ Dams completed
- ▭ Dams under construction
- ▭ Dams proposed
- ▭ Future reservoirs
- LONG RANGE PLAN (1981-2000)
- ▭ Dams and reservoirs
- Bridges
- International boundaries
- National capitals
- Important towns

This boundaries shown on this map do not necessarily represent the boundaries of the World Bank and its staff.



