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EMPHASIS ON DISTRIBUTION: STRATEGIES FOR SMALL SCALE WATER RESOURCES DEVELOPMENT IN THAILAND[1]

Anat Arbhabhirama, Shlomo Angel, and Marcia R. Brewster[2]

ABSTRACT: This paper discusses strategies for the development of water resources, emphasizing the delivery of reliable water supplies, for both domestic and production purposes, to every village and to every farmer. This necessitates a shift of emphasis from the construction of large storage reservoirs to the construction, operation, and maintenance of water distribution systems capable of reaching the largest number of farms, and a shift from projects that benefit the few, to projects that benefit the many. Water distribution in this context takes on three interrelated meanings: a geographical meaning, a technical meaning, and an economic meaning. The geographical meaning focuses on the spatial distribution of the recipient population as a key to identifying the proper distribution of water projects in physical space. The technical meaning relates to the physical distribution of water through canal systems to the farmers' fields. The economic meaning refers to the equitable distribution of benefits from water projects. The paper provides an illustration of the need for an emphasis on distribution, using the state of development of water resources in northeast Thailand as an example, with a proposed program for the further development of these resources. The northeast, the poorest region in the country, has been recognized by the Government of Thailand as a priority area for accelerated regional development efforts.
(KEY TERMS: water distribution; development; small scale irrigation systems; northeast Thailand; water resources planning strategies.)

INTRODUCTION

This paper discusses strategies for the development of water resources within the broader context of rural development. Water resources development in this context implies the delivery of reliable water supplies, for both domestic and production purposes, to every village and to every farmer. This necessitates a shift of emphasis from the construction of a few large projects at choice locations, to the development of smaller projects, accessible to farmers throughout the land. It necessitates a shift from the construction of large storage reservoirs utilizing high technological inputs, to the construction, operation, and maintenance of water distribution systems capable of reaching the largest number of farms. It also necessitates a shift from projects that benefit the few, to projects that benefit the many. Each of these shifts requires a major emphasis on distribution. Distribution in this context takes on three interrelated meanings: a geographical meaning, a technical meaning, and an economic meaning. Each of these will be examined separately in the following sections.

The geographical meaning focuses on the spatial distribution of the recipient population as a key to identifying the proper distribution of water projects in physical space, and is discussed in Section I. The technical meaning relates to the physical distribution of water through canal systems to the farmers' fields. Section II focuses on the failure of traditional approaches to deliver water to farmers and emphasizes the need to develop appropriate implementation procedures for the construction, operation, and maintenance of water delivery systems. The economic meaning refers to the equitable distribution of benefits from water projects: examining and correcting situations in which small numbers of families reap large economic benefits, while the majority receive no benefit at all. Economic aspects of distribution are discussed in Section III.

The purpose of the present paper is to provide, by means of a specific example, an illustration of the need for a major emphasis on distribution. A brief account of the state of development of water resources in northeast Thailand is given, with a proposed program for the further development of these resources. This program is presented in Section IV.

The northeastern region, which borders on Laos and Kampuchea, has been recognized by the Government of Thailand as a priority area for accelerated regional development efforts. The development of reliable water resources is seen by farmers in the northeast, as well as by policy makers and administrators, as the highest priority for rural development.

The northeast remains the poorest region in Thailand, subject to considerable fluctuations in wet season rice yields, as a result of inadequate supplementary irrigation during drought periods. Where water is available, farmers are unable to develop year-round cultivation because of incomplete distribution systems for delivering it to the farm. In many areas remote from available water resources, water is insufficient to meet the minimum requirements of domestic supply for people and animals, subsistence agriculture, and related activities. The resources for the development of the northeast are limited and

[1]Paper No. 81013 of the *Water Resources Bulletin*. Discussions are open until February 1, 1982.
[2]Respectively, Professor of Water Resources Engineering, Asian Institute of Technology and Deputy Minister of Agriculture and Co-operatives, Ministry of Agriculture and Co-operatives, Rajdamnoen Ave., Bangkok 2, Thailand; Associate Professor and Chairman, Human Settlements Division, Asian Institute of Technology, P.O. Box 2754, Bangkok, Thailand; and Associate Economic Affairs Officer, United Nations Economic and Social Commission for Asia and the Pacific, UN ESCAP Bldg., Bangkok 2, Thailand.

must, therefore, be spent on projects that hold the promise of real benefits if water reaches the farmers in adequate quantities, and if it is effectively used by farmers to increase agricultural production, and to improve the quality of their lives.

The strategy for achieving water policy objectives in the northeast must be premised on the delivery of adequate water supplies to the largest number of farmers in the shortest possible time. Natural topography, land capability, and rainfall constraints make it impossible, within present knowledge and resources, to provide for year-round irrigated agriculture throughout the northeast. Large areas remain inaccessible to reliable water supplies. At the same time, development cannot be restricted to areas suitable for irrigated agriculture. The Government is committed to spreading the benefits of water throughout the region.

Thus, water policy for the northeast must follow a two-pronged approach: (1) the effective distribution of available water resources from large reservoirs and reliable rivers to the people adjacent to these sources, and (2) the development of small water resource projects to meet basic water requirements in areas which are far from large reservoirs and reliable rivers.

I. THE SPATIAL DISTRIBUTION OF THE RECIPIENT POPULATION

The two-pronged water policy mentioned above applies to relatively distinct geographical zones in the northeast. Emphasis on physical distribution from existing sources applies to two major zones: the downstream areas of major reservoirs (Zone I) and the zone accessible by canals from the three main rivers (Zone II). This approach is further elaborated in Section II. Meeting basic requirements applies to a third major zone which comprises arable land not accessible by canals from existing reliable water resources. The spatial distribution of projects applies particularly to Zone III, the area requiring small water projects: small reservoirs, weirs, ponds, and wells.

The key priority of spatial distribution is to reach every village and supply each with basic water requirements. Gravity irrigation schemes from existing and planned reservoirs could serve a maximum of approximately 8-9 percent of the farm families of the northeast, while pump irrigation may distribute the benefits of irrigation during the wet season and for small plots during the dry season to an additional 10 percent of farm families. This means that the benefits of irrigation from the major reservoirs and reliable rivers are limited to less than 20 percent of the farming population. Thus, 80 percent of the farmers will continue to rely on rainfed agriculture, or partially supplemented rainfed agriculture, in the foreseeable future.

The total farming population of the northeast comprises approximately two million rural households living in approximately 20,000 villages in 16 provinces.

The total area of the northeast is 16.7 million ha. Arable land is estimated at 10.0 million ha, of which 3.6 million are suitable for paddy, and 6.4 million for upland crops (see Table 1). However, a large amount of land now planted with paddy is unsuitable or marginal land, as can be seen from the agricultural land use figures. Land used for paddy cultivation is estimated at 5.6 million ha while land used for upland crops is estimated at 1.3 million ha (IBRD, 1976).

TABLE 1. Estimates of Arable Land, Water Storage, and Irrigable Land in Northeast Thailand.

1. Total area (ha)	16,729,600 ha
2. Arable land (ha)	
Suitable for paddy	3,622,400
Suitable for upland crops	6,387,200
Total arable land	10,009,600 ha
3. Land use (ha)	
Paddy	5,600,000
Upland crops	1,300,000
Total cultivated land	6,900,000 ha
4. Effective storage (million m^3)	
In existing large reservoirs	4,833
In existing tanks	778
Total existing storage	5,611
In planned reservoirs (excluding Pa Mong)	7,867
In planned tanks	915
Total planned storage	8.782
Total potential storage	14,393
5. Irrigable area (ha)	
From existing large reservoirs	190,928 ha
From existing tanks	177,951
From pumping	304,000
Total irrigable area from existing resources	672,879
From planned large reservoirs (excluding Pa Mong)	354,984
From planned tanks	120,727
Total irrigable area from planned resources	475,711
Total potential irrigable area	1,148,590 ha

Source: Water Resources Planning Subcommittee, 1978.

Although it is difficult to estimate the geographical sizes of the different zones with any degree of precision, for purposes of planning the sizes, both existing and potential, of the three major zones have been estimated as well as the population inhabiting each zone (see Figure 1).

Zone I: Areas Irrigable by Large Reservoirs

Seven large reservoirs, with a total effective storage of 4,833 million m^3, had been completed in the northeast by the late 1960s (see Table 2). These reservoirs provide flood protection and hydroelectric power, as well as water for irrigated agriculture. Although the distribution systems of these reservoirs have not been completed, the potential irrigable area from them amounts to almost 191,000 ha. The total number of families currently within the irrigable area is estimated at approximately 60,000 but recent investigations suggest that the number is growing through inmigration to project areas. A socioeconomic study carried out in the Lam Pao reservoir area

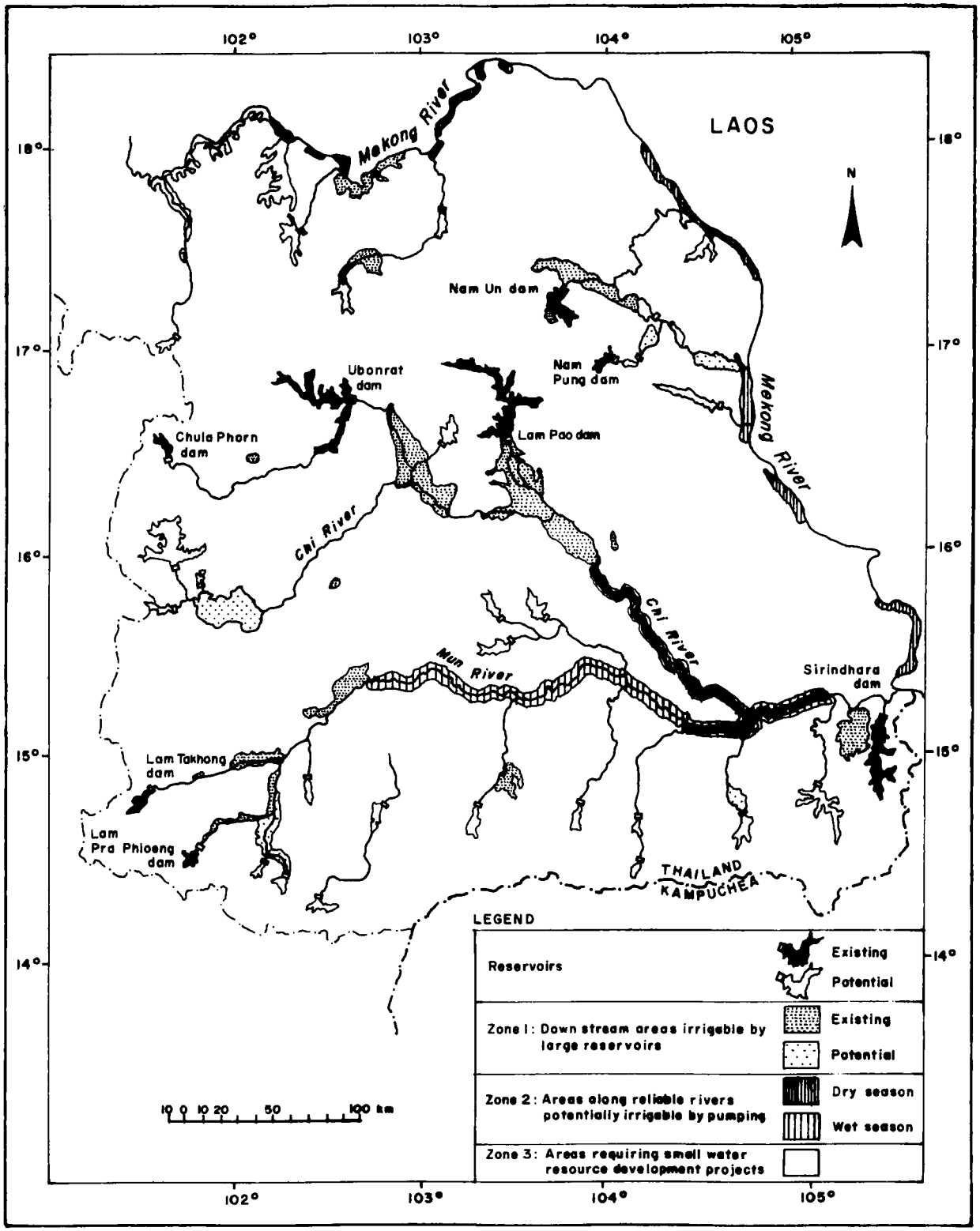

Figure 1. Major Irrigation Zones in Northeast Thailand.

(School for Oriental and African Studies, 1978) estimated the number of families at 20,800, 60 percent larger than the estimate of 13,000 made earlier by the World Bank (IBRD, 1978). Roughly, then, the population in Zone I amounts to about three percent of the rural households in the northeast.

TABLE 2. Irrigable Areas From Existing Large Reservoirs in Northeast Thailand.

Reservoirs	Effective Storage (million m^3)	Irrigable Area (ha)	Number of Families
Nam Pong	1,650	47,000	14,500
Lam Pao	1,260	48,600	13,000
Lam Dom Noi	900	24,000	7,500
Lam Nam Oon	475	29,728	9,891
Lam Takhong	290	19,700	8,000
Lam Phra Phleng	145	9,100	3,000
Huai Luang	113	12,800	4,000
Total	4,833	190,928	59,891

Source: Water Resources Planning Subcommittee, 1978.

There are a number of plans for constructing new large reservoirs in the northeast. Over and above the existing proposals for four large dams by the Royal Irrigation Department, the Mekong Committee (1978) has recently published preliminary analyses suggesting that an additional 24 dam sites would provide reasonable internal rates of return. The total effective storage of new potential large reservoirs amounts to 7,867 million m^3, with an irrigable area of 355,000 ha. Assuming an average farm holding of 3.2 ha per family, an additional 110,000 families may benefit from these new projects. (The Pa Mong Project, promising to irrigate approximately 800,000 ha in Thailand and Laos has not been taken into account in this analysis.) Thus, the total population that may benefit from irrigation projects in Zone I amounts to a total of eight to nine percent of the farmer families in the northeast, if all projects are completed. There are considerable difficulties in completing large reservoir projects at an accelerated pace, and it would be optimistic to expect completion within the next 15-20 years; hence, the emphasis on distribution from existing reservoirs.

Zone II: Areas Irrigable by Pumping From Reliable Rivers

There are three large rivers and their associated tributaries flowing through the northeast: the Chi, the Mun, and the Mekong. Approximately 20 rivers and tributaries in the region usually have some water flowing through them throughout the year. However, the runoff and the drainage patterns produce flows in the rivers roughly following the pattern of rainfall. When there are heavy rains, the flows in the rivers increase rapidly, and when there are no rains, the flows in the rivers decrease rapidly. This is true for all the rivers and tributaries except the Mekong, to some extent the lower Chi River, which is fed by upstream reservoirs throughout the year, and to a much lesser extent the Mun River. Flow virtually ceases in all other tributaries, and, without dams, their potential for pump irrigation is minimal. The flow in the rivers in the northeast is reduced to a minimum in April and reaches a maximum in August and September. Peak demands for irrigation are in May and June for supplementary wet season irrigation, and in January for dry season irrigation. During the month of May, the mean flow in the Mun river is reduced to 7 m^3/sec before joining the Chi. It reaches a total of 119 m^3/sec before flowing into the Mekong (see Table 3). In January the mean flow in the Mun River is 18 m^3/sec before flowing into the Mekong. Given realistic irrigation requirements, the total amount of water available in the Mun-Chi basin for pump irrigation can supply an upper limit of 144,000 ha in the wet season, and 51,200 ha in the dry season. While the soils adjacent to the rivers are good alluvial soils, other limitations may reduce these amounts by as much as 50 percent. Moreover, these calculations are based on mean monthly flows. Flows reach considerably lower limits during dry years, and the amount of area irrigated in a dry year may be considerably smaller.

Pump irrigation along the Mekong is of quite a different nature. The observed mean monthly flow in the Mekong in May is 1,480 m^3/sec and in January 2,030 m^3/sec. Rainfall in the provinces bordering on the Mekong is quite sufficient for wet season crops and the supply of irrigation water for the wet season and even the dry season is practically unlimited. Twenty-five per cent of the available water in January can irrigate 320,000 ha of land. Major restrictions in this case are good locations for pump irrigation, areas with good soils, and good drainage. The levee soils along the banks of the Mekong are already being irrigated by private pumps for growing dry season upland crops such as tobacco (UNDP, 1973). Pumping projects may have to be restricted, in many cases, to areas beyond the immediately accessible levee soils.

The authors estimated, for purposes of planning, that the total irrigable area along the Mekong River is on the order of 160,000 ha. This brings the total upper limit of area irrigable by pumping in the northeast to 304,000 ha in the wet season and 211,200 ha in the dry season. The data are summarized in Table 3.

It is difficult to estimate correctly the population that may benefit from pump irrigation. Until recently pumping has been restricted to the narrow strip along the river banks, where land holdings are usually small. It may be considered that families along the river plant only 1.6 ha of rice during the wet season; if the distribution system from pumping is extended to its limits, and water use is regulated, it may be possible to reach 190,000 families in 12 northeastern provinces, or 10 percent of the region's farm households. It is noted that the population of the northeast is heavily concentrated along the reliable rivers. Roughly 20 percent of the population is within 3-4 kilometers from reliable rivers, and about 40 percent within 9 kms (see Figure 2).

An intensive program of pump irrigation may thus distribute the benefits of reliable supplementary wet season irrigation and a reasonable plot of dry season crops to a large number of people within a relatively short period of time.

TABLE 3. Estimated Areas Irrigable by Pumping in Northeast Thailand.

	1967-1972 Observed Mean Monthly Flows (m^3/sec)			Supplementary Wet Season Irrigation (ha)	Dry Season Irrigation (ha)
	May	June	January	May	January
1. Total Mun River (Rasi Salai, before joining Chi)	6.96	46.33	18.02	8,320	8,800
2. Total Chi River (Maha Chana Chai, before joining Mun)	91.59	150.15	65.32	112,000	32,000
3. Total Mun-Chi River at Ubon	106.35	262.81	88.43	128,000	42,400
4. Total Mun-Chi River, before joining Mekong (Pak Mun)	119.14	482.87	107.48	144,000	51,200
5. Mekong River	1,480.00	4,120.00	2,030.00	160,000	160,000

Source: Water Resources Planning Subcommittee, 1978.

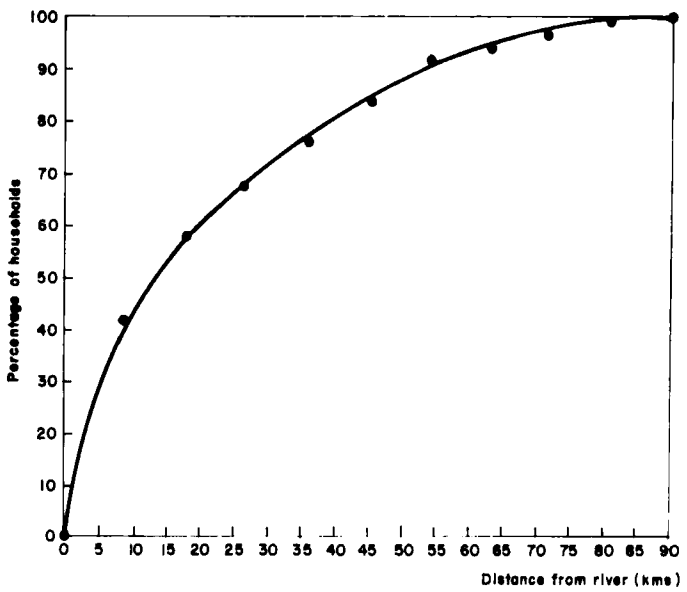

Figure 2. Cumulative Percentage of Rural Households in Northeast Thailand as a Function of Distance From Reliable Rivers. (Source: Population data from Provincial Electricity Authority, Rural Villages Directory, September 1976 (in Thai). For purposes of constructing the graph, the population of each district was assumed to be concentrated at the district town center. The density of villages is generally higher along the major rivers, and therefore the above figures may be underestimating the population along the major rivers.)

Zone III: Areas Inaccessible From Large Reservoirs and Reliable Rivers

The distribution of available water resources in the northeast can only benefit a maximum of 20 percent of the farming population, if all downstream reservoir areas are properly functioning, and if pumping from reliable rivers is maximized. The remaining 80 percent of the population, living in more than 15,000 of the 20,000 villages in the region, will continue to subsist on rainfed or partially supplemented rainfed agriculture. In this large area, classified as Zone III for planning purposes, there are two basic strategies for water resource development: an accelerated program of construction of small reservoirs in good locations, after proper surveys and designs have been made, and a much larger program of meeting the basic water requirements of every village. Since villages are located one to three km apart on average, water from the smaller reservoirs cannot be expected to reach more than two, or at most three adjacent villages, unless extensive canals are constructed. A program for meeting basic requirements is of necessity one that begins by reaching a village, assessing its need, and then implementing a water project to meet this need. This contrasts with the large reservoir program which begins by identifying suitable sites for water projects and deals with actual farmers at a much later stage.

Benefits from water projects in the northeast must be spread out to reach the entire population. This necessarily means a strong commitment to meeting the basic water requirements of every village, which include water for domestic use, for animals, for supplementary wet season irrigation of nurseries, and for small garden plots in the dry season.

The development of water supplies in Zone III relies on the development of small water projects of different types. The main types that have been identified in the northeast are small reservoirs or tanks, natural or dug ponds, weirs, and shallow or deep wells. All these types of small water resource projects have already been successfully implemented in Zone III in the northeast.

II. THE PHYSICAL DISTRIBUTION OF WATER TO FARMERS

The first priority for water resource development in the northeast is a strong emphasis on the distribution of available water resources to farmers. Coupled with this priority is the need to consider distribution of water an essential component of water projects, to be budgeted for and developed simultaneously with the construction of reservoirs, in an integrated manner. Both considerations emphasize the delivery of water as an essential component of water resource development.

Significant increases in productivity are not possible without assured and regular water supplies. The farmers of northeast Thailand have been plagued for centuries by unreliable rainfall, especially in the early months of the wet season. That is one of the main reasons why their yields remain the lowest

in Thailand, and among the lowest in Asia. Yet there is considerable water stored in reservoirs and flowing through rivers which could be used as a supplement during the early months of the rainy season. The economic growth prospects of the northeast will improve only when farmers can depend on one good rice crop per year or on a dry season cash crop. The quickest and most effective way to realize the potential of the existing rivers and reservoirs is to distribute their water, complete the distribution systems, and operate them efficiently.

Irrigable vs. Irrigated Areas

Existing water resources in the northeast include seven large reservoirs, a number of smaller reservoirs, and the three main rivers: the Mekong, the Chi, and the Mun. The estimated total irrigable area from existing sources is approximately 672,000 ha.

As a result of serious difficulties in the completion of reservoir projects, the area actually irrigated by reservoirs is considerably smaller. Estimates of irrigated areas vary considerably. High estimates are 193,800 ha for wet season irrigation and 8,800 ha for dry season irrigation in 1975 (IBRD, 1975). Low estimates are 30,000 ha for wet season irrigation, and 8,000 ha for the dry season in 1978 (IBRD, 1978). A study of three small reservoirs reports irrigated areas amounting to 18 percent, 16 percent, and 43 percent of their estimated potential irrigable areas in 1973 (IBRD, 1973). Surveys of tank irrigation projects carried out by the field survey team for this study revealed that none of the projects surveyed had a completed distribution system, and a large percentage had no distribution facilities at all.

Areas where main canals did exist had neither the necessary secondary and tertiary canals, nor the necessary ditches and drainage canals. Operations and maintenance procedures have been left to the local people, with little explanation or assistance from the agencies. Thus, many of the systems were incomplete, nonexistent, or in serious disrepair.

This situation has been recognized by the Government and now forms a major thrust of government efforts for irrigation in the northeast. Rather than increasing the volume of water storage, the key issue is the emphasis on distribution: distributing available water to farmers rapidly and efficiently.

Existing Projects Emphasizing Distribution

There are several major projects already underway in Thailand, which emphasize distribution from existing water resource projects. The Royal Irrigation Department's Northeast Irrigation Improvement Project, Phases I and II, aims at completing the downstream irrigation areas of four large reservoirs. Phase I, from 1974 to 1980, is to complete distribution systems to service 37,300 ha of irrigable land commanded by three existing reservoirs and canal systems (IBRD, 1978). Phase II of the project is aimed at upgrading and completing irrigation works in the command area of two large reservoirs covering 51,300 ha. It is scheduled for completion in 1984 and, if carried out as planned, would bring the total irrigated area from large reservoirs to 85,400 ha by the mid-1980s. Other projects for improvement of existing distribution systems now being considered by foreign lending agencies would bring the total irrigated area to 143,828 ha.

Recent experience in areas which now have adequate distribution systems shows a rapid acceptance of dry season cultivation by farmers and the adoption of higher yield varieties of rice where water supplies have become more regular. Irrigation of downstream areas of large reservoirs thus holds considerable promise for economic development. Rehabilitation of small reservoirs could also be beneficial and has been studied by both the World Bank and the United States Agency for International Development (USAID). A total of approximately 300 old and new small reservoirs in the northeast are in need of distribution systems.

There is thus considerable scope for improving irrigated agriculture in northeast Thailand without constructing new storage reservoirs. Available budgets may have to be restructured so that distribution systems for existing reservoirs are completed before new structures are built. In the future the dam and the canals must be built simultaneously, as integrated projects in irrigated agriculture.

Another agency involved in distributing water is the National Energy Authority (NEA), which in 1968 initiated a program to utilize electricity for pumping water from reliable rivers. By now it has accumulated considerable experience, standardized its practices, and gained wide acceptance by farmers. In 1978 NEA operated 49 large pumping stations irrigating an estimated area of 23,520 ha (NEA, 1978). Projects are located along the banks of the three main rivers with canals reaching approximately 1 km from the river bank, mostly on rich alluvial soils. Each project irrigates an average area of 480 ha, mostly by concrete lined canals. Water charges cover the cost of electricity. Dry season irrigation is on the increase in these projects, and land values in project areas have risen steeply. The projects can be rapidly implemented, with crops being irrigated less than one year after the scheme is introduced.

RID also has a mobile pumping scheme for distributing water from the three main rivers. One thousand RID mobile pumps provide supplementary wet season irrigation to farmers during drought periods, as well as dry season irrigation. These mobile pumps can reach areas not served by electricity, and can serve larger areas by moving on trucks and boats from one location to another. These pumping operations do not rely on concrete lined canal systems, but supply water to canals which farmers dig themselves.

The cost of expanding the RID and NEA systems will rely heavily on the technology of canal construction, and on the amounts paid by farmers for water. Both programs will require political support to accelerate their development and their potential for reaching farmers in the majority of the northeastern provinces.

Planning With Distribution in Mind

Following existing practices, RID constructs small reservoirs which include the main irrigation canal. The farmers in the area are expected to build the lateral canals, the sublaterals,

the farm ditches, and the drains. However, as one observer notes (Wang, 1973):

> In fact, farmers have no equipment, techniques or financial resources to do such work even if they were interested; . . . . instead 60 per cent of the constructed system was damaged by farmers during the first five years of the project. The construction of a water distribution system and its good operation and maintenance become the bottleneck to introducing irrigated agriculture to the region. The real useful life of all the irrigation structures is probably half or one third of their expected survival life.

Distribution is not technically difficult. However, it requires precise surveys of the irrigable land. A good distribution system requires high standards of mapping and design. Good canals also require knowledge, and farmers in developing countries cannot be expected to know how to dig them by themselves.

Distribution systems in reservoir projects are, therefore, expensive. Wang (1973) estimates the breakdown of costs for a small reservoir in the northeast to be as follows: reservoir, 37 percent of total cost; main canal, 34 percent; subsidiary canals, farm ditches, and drains, 21 percent; and road construction, 7 percent. In addition, distribution systems require proper operation and maintenance, which usually means an annual budget of 1-2 percent of the initial total cost of the reservoir.

Planning water projects with distribution in mind requires a budget for distribution as an integral part of the total project, to be executed by the agency constructing the dam. Alternatively, it can be accomplished with two budgets for each small reservoir project: one for dam and main canal construction, and one for distribution. If the people are to participate in construction, they must be supported and organized. A technical survey team, using proper survey techniques, will be needed to help locate canals.

III. THE EQUITABLE DISTRIBUTION OF BENEFITS FROM PROJECTS

Planning for Economic Benefits

There seems to be a consensus among government engineers in Thailand that the construction of small reservoirs and other small projects cannot be justified in economic terms, but is necessary for political reasons or for social benefits. This usually means, in practice, that projects are implemented for the sake of satisfying requests from villagers, local politicians, or military personnel, without much regard for costs or expected benefits. Since specific benefits are not expected to materialize, the appearance of a project becomes the primary objective.

The field survey carried out to identify various project types and the benefits accruing from each type revealed projects where an inordinate amount of money was invested to provide household water, as well as numerous small projects where the direct economic benefits far exceeded costs. In general, however, small water projects which have been constructed during the last 20 years have not yielded the promised theoretical benefits; and thus the experience, with small dams in particular, has been discouraging. These experiences have been valuable, however, and require a more thorough evaluation.

There is a wide range of technologies which can provide water to the villages of the northeast. These range in size from the largest dam to the smallest shallow well. Different technologies apply in different villages. Villages in Zone I may have direct canal access for gravity water supply from the large dams while villages in Zone II may have direct access to water pumped from the rivers. In villages where small streams are available, small reservoirs or diversion weirs may be constructed, while in others dug ponds or deep wells may provide the only solution.

Each village will require an appropriate technology for water supply to meet its basic water requirements. Villages in good locations may further benefit from larger projects that may yield a good economic return through year-round cultivation. The various types of technologies for water resources development in the northeast are presented below with a brief evaluation of each.

A comparison of costs of large and small dams indicates that, while costs per cubic meter stored in large dams are lower than in small dams, when the costs of an extensive distribution system are added to those of storage, the cost per ha of irrigable area may be higher in the large projects than at well selected small project sites. Furthermore, when it is considered that full development of large projects has in practice required 15 years or more, and if the value of future benefits is discounted against expenditures made earlier, the benefit/cost ratios of these projects have in reality been considerably lower than their theoretical returns. At present, however, there are many constraints to implementing small water resource projects in Thailand, including lack of experience, personnel, finance, and equipment. In order to reach every village, the people will have to participate and contribute funds and labor.

Small reservoirs have a greater potential to reach a larger number of people than large ones; however, the flat topography, permeable soils, and excessive evaporation in the northeast make it difficult to find good locations for them. Where the watershed is available and land for inundation can be found, a large number of small reservoirs have been successfully constructed. Considering existing and planned RID tanks for irrigation and assuming average cultivated rice plots of 1.6 ha, a total of 170,000 families or 8.5 percent of the rural population may benefit from small reservoirs.

Unfortunately, government agencies constructing small reservoirs usually do not clearly define how the stored water is to be used. For domestic water supply, only 2,700-21,600 m^3 is required per village; therefore, dams storing 100,000 m^3 are excessive and expensive for this purpose. The water could be used for supplementary and some dry season irrigation, if distribution systems for irrigation were built, which should not add appreciably to the cost. On the other hand, construction of small reservoirs presents the same technical complexities as large dams, and it would be necessary to train farmers to

regulate water use, and operate and maintain the project, themselves.

Dug ponds or farm ponds may include ponds on an individual's land as well as larger ponds which may serve small groups or villages. They may be built by deepening natural depressions where water already collects or by digging on higher ground. Ponds typically provide household water, water for livestock, fish and irrigation of vegetable plots, and fruit trees around the perimeter. The benefits from ponds depend on the intensity of vegetable or fruit cultivation or fish raising. Farm ponds do not require flooding large areas of paddy land or the survey and design of complex canal systems. However, the cost of digging a pond is at least $\$0.50/m^3$, compared with $\$0.05\text{-}0.25/m^3$ for small reservoirs.

Safe yield from ground water well supplies in northeastern Thailand is estimated at 10,800 million m^3, of which only 85 million m^3 are being utilized at present. Ground water development for domestic water supply is capable of supplying most villages with acute water needs, and in some areas it may be used economically for intensive irrigated agriculture. Deep wells are an economic means of providing household water, costing less than $50 per family with few organizational or technical problems. However, operating costs for pumping may be too expensive to use the water for irrigation, except for vegetables. Shallow wells can tap the water created from seepage which is available 1-25 m below the surface. This water can be used in the household or for small garden plots of vegetables.

Diversion weirs are not useful for dry season irrigation, since most streams run dry, but during the rainy season, they are a cheap and effective means of using water which would otherwise run off unutilized. Farmers in the region build simple temporary barrages to help irrigate the rice crop, and some of the larger weirs have been made permanent with government assistance. Farmers generally support implementation of such projects because: no land is flooded, they can increase their incomes, and technical requirements are not complicated.

Pumping from rivers for irrigation has had very high economic returns in many parts of the northeast. Farmers using the RD-7 high yielding rice variety in the area obtained average yields of 2,500 kg/ha, or almost twice the average rainy season yield. Net benefit from the single crop was more than enough to pay for the operating costs of the pump, and to pay for the amortization of a loan, if the farmers wanted to buy the pump themselves. The explanation for this remarkable success is the combination of a reliable water supply with agricultural extension services which provided all the necessary inputs on credit when they were required. Farmers surveyed indicated a willingness to pay operating costs of pumping, up to $30 per ha per season. The benefit from supplementary irrigation, which is estimated at $75 per ha per season, justifies the investment in pumps even if water is only sufficient for wet season paddy.

The foregoing brief comparison of alternative project types on the basis of economic return and ease of implementation indicates that pumping from reliable rivers is the most attractive alternative. Small farm ponds are also attractive, but only for small numbers per project, while deep wells are the most effective means to supply village domestic water needs. Shallow wells and diversion weirs are economic but only some areas have suitable sites. Large and small reservoirs can be economically viable, but successful implementation is impeded by technical complexity, problems of land acquisition, and socio-political obstacles to organizing the distribution system.

Villages in Zone III will benefit economically from a small project program aimed at meeting basic village water requirements. A proper survey of all the communes in the northeast is required to identify appropriate water projects for each village. Appropriateness must depend on village needs, existing shortages, economic potential, and willingness to participate in planning, building, financing, and maintaining projects. In addition to the needed survey, demonstration sites for the various types of small projects must be carefully chosen and assigned to research organizations, to determine planning parameters for small projects, as well as to find ways and means to maximize potential benefits.

Profits From Irrigation Projects

The present policy of constructing large systems which benefit relatively few people is inequitable in its distribution of benefits, as can be seen from a few simple calculations. If one takes an average family holding in the northeast as 3.2 ha and assumes that a completed irrigation system permits a dry season crop of rice or a higher value crop on at least half that land, it is seen that the income of the farmer can double. Results from a socioeconomic survey carried out at one of the large dams in the northeast revealed that average incomes increased by 130 percent per family from 1971 to 1976 (School for Oriental and African Studies, 1978).

Furthermore, the value of land in areas with completed distribution systems has increased disproportionately to other areas. Farmers located in the command area of a large pumping project proudly reported that the value of their land had increased from $625/ha before the project to $6,250/ha in 1978. Even farmers in command areas of small tanks reported large increases in land values. Although their reports may be exaggerated, it can be assumed that land values have risen two to three times in areas with working irrigation projects. Thus, the installation of an irrigation system in an area, with no cost recovery measures, amounts to a capital transfer of $2,000 to $4,000 to each family fortunate enough to live in areas served by completed irrigation systems.

The Government pays in full for the benefits which these families receive. The cost per family of four large dams in the northeast at the time of construction (see Table 4) ranged from $1,285 to $4,600 per family. In order to make the dams function as irrigation systems, the World Bank, the Asian Development Bank, and USAID are planning to extend loans to the Royal Irrigation Department to complete the distribution systems. This entails a further capital investment per family ranging from $875 to a projected $3,260. Even the rehabilitation and extension of distribution systems for old tanks is estimated by USAID at a cost of $3,600 per family over the next few years.

TABLE 4. Investment Per Family in Large Reservoir Irrigation Projects in Northeast Thailand.

Reservoirs	Date of Completion	Irrigable Area (ha)	Total Investment (million U.S. dollars)	Number of Families (no.)	Investment Per Family (U.S. dollars)
Nam Oon					
– Reservoir	1974	29,728	12.7		1,284
– Downstream Irrigation	1982		32.0	9,891	3,230
Total			44.7		4,514
Lam Pao					
– Reservoir	1968	48,600	33.6	7,300	4,596
– Canals, Roads	1977		2.5	13,000	188
– Tertiary, Drains	1984		33.4		2,569
Total			69.5		7,353
Lam Takhong					
– Reservoir	1969	19,700	15.1		1,885
– Diversion Dams, Canals	1984		11.7	8,000	1,467
Total			26.8		3,352
Lam Phra Phleng					
– Reservoir	1969	9,420	7.5		2,513
– Canals, Roads, Drains	1974		2.4	3,000	783
Total			9.9		3,296
10 RID Tanks					
– Rehabilitation		16,232	15.2	4,130	3,608
				Weighted Average	4,370

Source: Water Resources Planning Subcommittee, 1978.

If the proposals are carried out as planned, it means that over the period 1963 to 1984 the Government will have spent an average of about $4,370 per family located in these selected large reservoir irrigation systems. These irrigation projects benefit only about two percent of the people in the northeast.

On the other hand, the RID proposal to Japan, the "Accelerated program for rural development: small scale irrigation project" (December 1977) outlined a program for the construction or rehabilitation of 1,876 small projects from 1977-1980. A gross projection estimated that 253,000 families would benefit, costing an average of only $308 per family (Small Project Construction Division, 1977). Many of these projects have already been implemented. Of course, the families do not benefit as much as those in the large schemes who were helped in the past, but at least six percent of the population in the northeast stands to benefit in some measure.

IV. AN IMPLEMENTATION PROGRAM WITH AN EMPHASIS ON DISTRIBUTION

The proposed program for implementing the strategies discussed in the previous sections focuses on the five-year period 1980-1985 as critical for reaping the maximum benefits from water projects. Both political and economic considerations require that results be obtained within this period. Thus, long term projects, including the construction of large dams, have not been considered here.

The report prepared for the Water Resources Planning Sub-Committee of Thailand's National Economic and Social Development Board outlines a six-point program of action for implementing the strategy. This program was designed to make maximum use, with minor innovations, of a number of recent developments, both in the Thai Government's administrative procedures and in funding procedures. The essence of the proposed program is a commitment to the provision of economically beneficial water projects to villages in the northeast within the next five years. In order to reach the great majority of villages, a strong sense of direction will be needed to guide the actions of field agencies, as well as provincial governments and village committees. There are six key recommendations which form the backbone of the program.

Recommendation I emphasizes the need to move rapidly toward the adoption of a water resource development strategy for the northeast by the recently established Accelerated Water Resources Development Committee, and to set in motion the Water Resources Information Center to monitor the implementation of this strategy.

A Water Resources Master Plan for the northeast, standards for project development, allocation of administrative responsibilities to provincial offices and field agencies, and review and scheduling of budget allocations for various activities, may all

be used as mechanisms to strengthen the commitment of implementing agencies to the strategies adopted by the Government.

The Water Resources Information Center has begun to perform a number of essential services for the Accelerated Water Resources Development Committee, without which it would be difficult for the Committee to perform its important tasks. It compiles existing information on water resources, as well as plans and budgets of line agencies and provincial planning offices. It has begun to monitor the performance of projects in the field, as well as accumulate data from specially commissioned research projects.

The Water Resources Information Center, in conjunction with field agencies and academic institutions, may select a number of projects as demonstration sites, monitor the development of these sites, and use the information thus obtained for reviewing existing policies. The current lack of successful projects seriously hinders progress in policy making, as benefits cannot be properly estimated.

Recommendation II emphasizes the need to lend support to the large number of existing programs which now deliver water to farmers in the northeast and to improve the capabilities of line agencies to implement projects, without restricting their ability to act. The Accelerated Water Resources Development Committtee will need to provide incentives for cooperation among agencies. Meetings among agency representatives may be set up for the purpose of compiling lists of projects to be carried out by each agency. Specific forms of cooperation between agencies can be streamlined, to enable two or more agencies to work together on the same set of projects. Budgetary incentives for cooperation can be provided by increasing the budget allocations of joint projects.

Recommendation III focuses on the need to strengthen the capabilities of provinces to plan and supervise the implementation of a large number of small scale water projects by increasing authority, budgets, and technical and managerial personnel at the provincial level. The Government has now established a clear policy of decentralization, a policy aimed at strengthening the provincial administration as the local decision-making unit, by building up the capability of the provinces to plan, and by channeling funds for rural development programs through the provincial administration.

The province appears to be the most appropriate level for planning and coordinating the implementation of programs to meet the basic water requirements of villages, as well as planning for distributing water supplies from reliable rivers. Water planning will involve the gradual preparation of provincial master lists of proposed commune and village level projects, which can later evolve into the provincial master plans, and become an integral part of the provincial development plan. An experienced engineer with managerial ability will have to be attached to each provincial planning office to prepare water plans and monitor projects in the field.

Channeling funds for rural development directly to the provinces is an important development which needs to be continued. The procedures for transferring provincial development funds for line agency projects have been roughly established, but appear to be cumbersome. In the future, flows of budgets from provincial development programs to the line agencies will need to be streamlined and agreed upon in advance, so that equipment and manpower can be made available upon request. In this manner, line agencies may be encouraged to use the funds made available to them directly, as well as funds provided annually through central budgetary allocations.

Recommendation IV concerns the initiation of a program to meet basic village water requirements by setting in motion a provincial water survey, to be contracted out to private firms for immediate execution. The survey will aim at identifying a water project for every village, examining both technical and economic opportunities.

Several competent Thai consulting firms may each be engaged to survey one or two provinces. The consultants may employ small teams of engineers and economists which will visit every village and, working with villagers, identify feasible projects and prepare preliminary engineering designs. The survey will require two to three years, with implementation of projects proceeding as soon as each commune is surveyed. Five to ten percent of the total funds available for the village water requirement program may be needed for surveying, planning, and designing good projects.

Coupled with this survey, a promotion campaign will be initiated, using community development workers to mobilize villagers to participate in selecting and planning village projects. Promotion may be accompanied by a small project manual which describes each system available, and each village would be able to choose the alternative which fits its needs and resources. An adequate budget must be available for promotion, especially during the first year of the program.

Recommendation V emphasizes the need to allocate subsidies for village water projects, based on a fixed amount of subsidy per family, and to make these budgets available immediately upon the presentation of approved project plans. Subsidies must necessarily be limited, both by financial constraints and by the critical need to make villages self-reliant in the future, capable of taking care of their own needs without further assistance.

A rough estimate of the amount of subsidy required for implementing the village water requirement program and the distribution of water from reliable rivers is of the order of $500 million during the five-year period, an average of $250 per farm family. An expanded provincial development budget and enlarged agency budgets can be used for this purpose.

Subsidies must be used in conjunction with loans and farmers' contributions, to ensure that projects are designed and implemented with economic returns in mind. To instill a sense of responsibility and ownership, those farm families which benefit greatly from receiving water on a timely basis will pay for it and those who receive lesser benefits will at least contribute their labor and minor fees for upkeep of projects. The Government has already decided in principle that for all new irrigation projects it will recover all operation and maintenance costs and as much as possible of the investment costs directly from the beneficiaries.

Recommendation VI is concerned with strengthening the ability of villagers to own and operate village water projects

effectively by forming village water committees, securing their legal status, involving them in the initial planning stages, providing them with small budgets for an initial growth period, and training villagers in operation and maintenance of small water projects. To develop a strong sense of ownership, villagers must participate in real, rather than nominal terms, in the initiation, selection, and planning of village projects. They must also participate through labor and monetary contributions, if they are to feel that the result really belongs to them. Finally, they must take ownership of projects, repair and clean them, and operate them effectively. The program to meet village water requirements puts increased village self-reliance as an objective, as well as a means to achieve the other goals of the program. Successful water projects will increase village self-reliance, and this will increase the chances of success of village water projects.

The mechanisms for participation in water projects will need to be based on existing structures. In particular, the commune council will play an important role in initiating and coordinating village projects, and in submitting compiled project lists to the provincial planning authorities. The village itself will play an important role in implementation through the village water committee, which may be established by using existing groups or by forming a new group, which will need to have both legitimacy and a legal status to operate village projects successfully. To be successful, the committee will need to be strengthened by assistance in organizing villagers, by a small budget which will be needed until farmers have confidence in the supply of water and can pay water charges by themselves, and by training villagers in operation and maintenance of water projects.

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