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NORTHEAST RAINFED AGRICULTURAL DEVELOPMENT PROJECT-- AN OPPORTUNITY FRAMEWORK

UNIVERSITY OF WISCONSIN MADISON

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NORTHEAST RAINFED AGRICULTURAL DEVELOPMENT PROJECT--AN OPPORTUNITY FRAMEWORK

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I. INTRODUCTION

This preliminary report has been prepared jointly by the University of Wisconsin Northeast Rainfed Agricultural Development Team and the designated staff of the Royal Thai Government. The Team consisted of Drs. William Bateson, John H. Ellis, Ved Prakash (Leader) and Thomas Trout and Mr. Edward Fallon in behalf of Regional Planning and Area Development, University of Wisconsin, Madison under USAID Contract No. AID/DSAN-C-0060. The members of the RTG staff who collaborated in this effort included: Miss Pansri Pooprakorn, Dr. Plodprasop Suraswaki, Mr. Pramuan Setarat, Dr. Prasoot Sittisoung, Mr. Thana Thongton (Coordinator), Dr. Vijai Noparomornbodi, Dr. Vises Prasert, and Dr. Wanee Samphantharak all of the Ministry of

Agriculture and Cooperatives and Mr. Sombhong Pattamavichaiporn of the Department of Technical and Economic Corporation.

Messrs. Robert Queener, Wayne Slotten, and Det Trishad all of the USAID Mission closely participated towards the preparation of this report and provided logistic support and invaluable assistance.

The Mission was carried out during the period June 24 through July 27, 1979. Meetings were held with various officials of the Royal Thai Government and others (Annex I). The period July 3-6 was spent in Northeast Thailand (for details, see Annex II).

The team was charged with the preparation of a prefeasibility study for Northeast Rainfed Agricultural Development.

The problems and the related constraints and issues for development of the Northeast are well documented and need not to be recounted in detail here.[1]

At the present time, less than three per cent of farmlands are serviced by irrigation system. Long range programming for irrigated agriculture envisions that a maximum of about 10 per cent of the Northeast farmers may benefit from irrigation compared to 20 per cent nationwide. Thus, even in the long run, 90 per cent of farmlands will be cultivated under rainfed conditions, implying very limited opportunities for double cropping.

Thailand has maintained rapid economic growth over the past two decades, averaging between seven and eight per cent per annum in real terms. It appears that the benefits of rapid growth have been enjoyed by large segments of the population. The Northeast has also experienced significant growth although the rate of growth of its regional product (and per capita regional product) has been below the national average.

A large proportion of the gains in the Northeast can be attributed to expansion of the areas under cultivation and increasingly important role of cash crops, and their relative prices. Over the past decades, substantial public resources have been transferred and significant measures have been undertaken to address the problems of the Northeast as a lagging region. The per capita level of infrastructural facilities and other services have improved. However, these facilities and services have been spatially concentrated.

Incomes in the urban areas of the Northeast are comparable with each other and with other urban areas of Thailand. However, the per capita product in the Northeast is considerably below that of any other region of Thailand. Further, the growth of the Gross Regional Product per capita in the Northeast is less than any other region except the North (see Annex III). Within the Northeast region itself, there are very significant spatial differences in both the per capita income levels and in their rates of growth in recent years.

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1. See for example, The World Bank, Thailand: Toward A Development Strategy of Full Participation. (Report No. 2059-TH, September 1, 1978.)

The major challenge for Northeast rainfed agricultural and rural development lies in increasing productivity, reducing risks which farmers (especially the small and poor) face due to unpredictability of rainfall, and ensuring more equitable distribution of benefits and income gains.

The next Chapter outlines major strategies for agricultural and rural development in the Northeast. Chapter 3 outlines the crucial elements for project approach. Institutional, organizational, and financial issues are discussed in Chapter 4. The final chapter includes recommendations and next steps towards development of the Project Paper.

II. A THEORY AND STRATEGY FOR AGRICULTURAL AND RURAL DEVELOPMENT

In this chapter we outline a simple model for increasing rural income and productivity which relates the roles of research, extension, institutional change, and the concept of area development.

2.1 A Simple Model of the Roles of Research and Extension in Increasing Incomes and Productivity

It is convenient to view the issues of income and productivity in terms of what is economically optimal and what actually is achieved by farmers. We define the economically optimal levels of income and productivity in terms of the highest level of net income which can be achieved under a given set

of input and product prices.[1] Income can change if the prices of inputs or products (or both) change. Income and the productivity of resources can also change if a new production technology becomes available. A new production technology will actually be adopted only if producers can increase their incomes or welfare by doing so.

Throughout this section we make reference to "optimal" income and productivity. The reader should understand that this refers to what is economically optimal and achievable in the context of known technology, existing resources, prices and risk factors. The optimal levels of income and productivity may be different for farmers who engage in market transactions and for (primarily) subsistence farmers.

It is widely observed that peasant farmers are responsive to market and non-market incentives and to the opportunities that may arise as the result of new technologies which raise the optimal level of income and productivity. Where farmers have faced attractive sets of input and product prices and have had adequate complementary production resources, they have been quick to adopt the main elements of the "green revolution" technology. Where the "green revolution" technology did not represent a substantial improvement in the potential or optimal use of farmers' resources due to product-input price levels and/or the lack of complementary resources,[2] the new varieties and inputs were slow to be adopted by farmers.

The dynamics of farmers' responses to new technology which increases the level of optimal income and productivity are complex. In general, the greater the gap between actual and optimal production, the more rapid is the rate of response by farmers. Clearly, if farmers do not have easy access to the knowledge of how to use an item of new technology or some critical input such as credit, fertilizer or plant protection services, their rate of response will be slower and less certain. In general, it has been larger farmers with risk bearing capacity and better than average access to extension services and markets who have been first to respond to the perceived benefits of an increase in optimal incomes and resource use. Smaller farmers may require assistance in the form of credit, marketing and extension (skills) in order to move toward the optimal income and productivity levels.

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1. In an agricultural economy which is characterized by a substantial non-market subsistence sector and a sector which may engage only marginally in markets, there are serious definitional and measurement problems associated with the concept of net income, prices and welfare. We acknowledge that these problems exist; however, these problems do not invalidate the <u>conceptual</u> usefulness of the ideas developed in this section.

2. Northeast Thailand is an appropriate example of a place in which high yielding varieties of rice do not yet represent a dramatic improvement in the optimum level of income and productivity because the paddy/input price ratio has been too low and because there does not yet exist a family of high-yielding varieties and cultural practices which have the drought and flood resistance characteristics which are necessary for that environment.

Clearly, in most farming communities, optimal income levels and resources use will differ with farm size, tenure arrangements, household labor endowments, etc. Where new production technology creates a new optimal income and productivity level, that technology may have different benefits for different farmers depending on farm size, etc. A technology development strategy which is consciously or unconsciously biased in favor of increasing the optimum income levels of large farmers rather than small farmers would have the effect of aggravating the existing income distribution.

Figure 1 is a simple schematic representation of the relationship between optimal and actual production. Input and product prices are taken as given and the resource base is held fixed. In the first period, optimal production stands at the level of A, as might be represented by a traditional technology. Actual production is represented as being very close to the optimum level. At the beginning of the second time period, the optimum level of production has shifted upward as a result of a technological innovation such as the discovery of an economically viable package of the high yielding technology. Farmers are seen to respond to the opportunities for higher incomes which result from the new technology. They acquire new skills and needed complementary resources. As they incorporate the new package of practices into their farming system, they close the gap between their historic production levels and the optimal level. The characterization in Figure 1 is that the greater the gap, the more rapidly it is closed. It is when a large gap has been created that farm production can be most rapidly accelerated by extension efforts and institutional innovations designed to give farmers better access to credit, inputs and new markets.

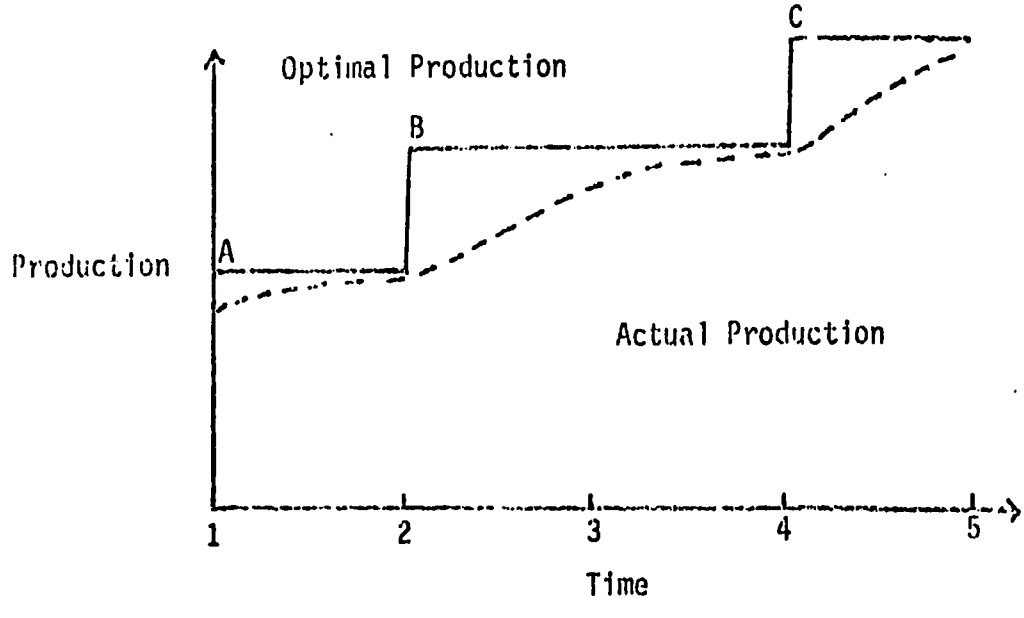

FIGURE 1. Schematic Relationship of Actual and Optimal Production over time.

In Figure 1, we have not given explicit consideration to the consequences of changes in prices. For the farmer whose production is large enough to allow him to market a portion of his production, the level of optimal income will shift up (or down) as a consequence of changes in product and input prices. The impact of such price changes will not be the same for the subsistence farmer.

In the real world of the peasant farmer, it is actual output and productivity which are important. Nevertheless, the level of actual output is always limited by the level of optimal output. Rapid increases in actual output are possible only if there is a gap between what is optimal and what is actual. Broadly speaking, rapid increases in farm output are desirable. We see two broad approaches or strategies to achieving increases in farm output:

a. Raise the level of optimal output in such a way that farmers will respond by closing the gap between the actual and optimal levels of production.
b. Provide inputs--e.g., credit, fertilizers, machines, etc.--which will hasten the closing of any existing gap between actual and optimal levels of output.

Any choice between approach A (gap creation) and approach B (gap closing), or a strategy which combines the two approaches, requires an appreciation or assessment of the benefits and costs involved. Such an appreciation is difficult. Frequently, it is a matter of judgment based on only a few facts. One issue is clear, however, <u>if there is no substantial gap between actual and optimal output, public and private resources spent on extension and farmer skill improvement will have a low rate of return</u>.[3]

The "green revolution" was fundamentally a product of a sudden upward shift in the level of potential production. The development of stiff-strawed, non-photo period sensitive, fertilizer responsive rice and wheat varieties created a large gap between the output farmers had been able to achieve and the optimal level of output.[4] In many places in Asia, farmers responded rapidly. Where the gap was large and farmers had the technical and institutional capacity to respond quickly, the improvements in rural welfare have been substantial. Where farmers lacked appropriate irrigation systems (or natural rainfall) and/or where the rice-to-fertilizer price ratios were less than one, the high yielding varieties were only an item of curiosity: they did not result in a upward shift in the optimal output level.

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3. Clearly, in the real world, there is no "average" farmer. Where inequalities exist in the level of skills, knowledge and resources of different farm families, there may be benefits to be gained through extension efforts, credit programs, land redistribution, etc.

4. The merits and demerits of green revolution varieties, and their adoption in different places will long be argued. Indeed, the welfare of the average Thai farmer was probably reduced by the discovery and adoption of the high yielding varieties in much of Asia. Without these varieties, India, the Philippines and much of the rest of Asia would offer a higher price for Thai export rice.

2.2 The Role of Institutional Change in Increasing Incomes and Productivity

In the development of our simple "gap model" of the dual roles of research (technology development) and extension, little explicit reference was made to the role of traditional institutions and the potential for income and productivity growth through institutional innovations. Clearly, an item of new technology will not represent a new, higher level of potential income and productivity if some essential input is not available at the farm level. It is also the case that some new opportunities will not be exploited by farmers, even progressive farmers, if a collective or community-wide change in behavior is necessary before any single farmer can change his individual behavior or farming practice.[5] An item of new farming technology which requires resources to which farmers do not have access or requires a community-wide change in behavior will probably be of little benefit to any individual farmer.

In cases when the adoption of an income or productivity enhancing item of technology requires institutional change, there is a strong case to be made for using an integrated area development approach. Such an approach allows planners to focus on the particular needs and problems of a particular group of people and to encourage their participation in finding solutions. An area development approach also allows planners and policy makers to monitor the distributional effects of an item of new technology or an institutional innovation.

In sum, we see the increase in rural incomes in Northeastern Thailand as depending on:

(a) technological innovations and product/input prices which raise the optimal level of production and create a gap which may be filled by farmers;
(b) the acquisition of skills and the adoption of new practices, mainly through extension, which will close the gap between what is optimal and what is actual; and
(c) institutional innovations which remove barriers to the adoption of new technology, reduce the risk of adopting new practices and promote the access of small farmers to new income and productivity enhancing practices.

2.3 The Growth of Incomes and Productivity in Northeast Thailand

The growth of rural incomes in Northeast Thailand has been uneven and uncertain in the past two decades.[6] Since 1960, there has been a steady

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5. For example, if it were the community custom to allow cattle to graze freely after paddy harvest, it would not be possible for an individual farmer to plant mung bean or ground nut after paddy. The cost of guarding the field against freely grazing cattle would be too great.

6. See Annex 3 and Annex 4. See also the on-going, joint research of the National Statistical Office and the World Bank entitled "Income and Poverty Alleviation in Thailand: Some Special Studies", now in preparation.

increase in the planted paddy area and a comparable, but more volatile increase in actual paddy production. At present, paddy yields (production per planted rai) stand very close to the level of 1959-61, despite an expansion in area of over 60 percent since 1959-61, yield figures do not exhibit any strong time trend.[7] Northeastern Thai farmers as a group have expanded their paddy production through the expansion of conventional inputs such as land, labor and draft power. However, the gap between the land available for paddy production and that which is now planted is being closed.

The risky nature of rice farming in Northeast Thailand is evident from the wide year-to-year variations in area planted and yield per rai planted. Given the rice varieties presently grown in most of the Northeast, there still exists a gap between optimal and actual production which may be filled by the application of modest, economically remunerative levels of chemical fertilizers,[8] pesticides and limited mechanization. However, a number of factors presently prevent farmers from exploiting the full potential economic gains from these inputs:

a. The ratio of paddy price to fertilizer prices has been such that the net returns to farmer for using fertilizers has been small;
b. The lack of irrigation facilities, the preponderance of soils with low water holding capacity and the unreliable nature of the monsoon rains are such that chemical inputs increase farmer risk beyond a level at which a substantial quantity of chemical inputs would be used by most prudent farmers;
c. An undeveloped input supply system and high credit costs may discourage many farmers from using chemcial inputs; and
d. Both the traditional and Rice Division varieties now grown and eaten in the Northeast will not accept more than modest levels of fertilizer inputs.

Some of these factors presently limiting actual production can be eliminated or reduced through institutional changes such as improved markets and improvements in the supply of production credit. Other limiting factors

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7. Simple time trends in yields (production per planted rai) are difficult to evaluate in the absence of methods ofestimate the impact of changes in weather and input levels. Time trends of yields are shown in Annexes 8 and 9 for different periods in the past two decades. These trends are subject to different interpretations.

8. Reportedly, over half of Northeastern farmers used chemical fertilizers on paddy in 1971/72, but at an undetermined level (see Annex Table 10c of Marketing, Distribution and Use of Fertilizers in Thailand, ARSAP, Bangkok, March 1977). See also Adulavidhaya, Kamphol "Socio-Economic Aspects of Rainfed Rice Production in Thailand: a Case of Northeast", Department of Agricultural Economics, Kasetsart University, January 1979, Table 6, where it is reported that about two-thirds of the Northeastern rice area received chemical fertilizers in 1973/74.

will require new technology and/or new resources. In particular, the development and introduction of new rice varieties, cropping and farming systems whichreduce the hazards of drought will have direct benefits in terms of production/income risk reduction and indirect benefits in terms of increasing the incentives to adopt other items of production increasing technology.

In the absence of a technological breakthrough which shifts the optimum level of prodcution upward without unreasonably increasing the risk of crop failure (and loss of invested cash inputs) due to drought, an extension effort to raise paddy yields in the Northeast is unlikely to produce significant results. At present, those farmers who are in a position to take advantage of any substantial gap between their acutal yield and potential yields are farmers who have low risk paddy land or have the economic resources to accept high levels of production risk. These same farmers are now using modest levels of cash inputs in the form of chemical fertilizers and mechanical tillage. These are not, in general, the poorer farmers of the Northeast.

Kenaf, maize and cassava[9] were relatively minor crops in the Northeast two decades ago. In recent years, they have come to occupy a key place in the region's cropping system. In the near future, sorghum, peanut, mungbean (and possibly cotton) may increase in importance. Each of these upland crops suffers from drought or flood to some extent. Moreover, because they are cash crops, they are subject to the hazards of market price variations. Cassava in particular is subject to an uncertain world demand situation. In the long run, it appears to be prudent to think in terms of upland crop diversification and the establishment of a strong domestic demand or price stabilization programs for all or most of these upland crops.

Despite a rapid growth of output of kenaf, cassava and maize[10], there appears to be a substantial gap between present and potential yields. Some observers believe that cassava (and to a lesser extent kenaf) yields will fall in the near future due to soil exhaustion. The relatively high return which farmers receive on their low-risk, household labor inputs into cassava and kenaf creates a strong incentive to clear new land for its cultivation. Similar incentives exist for kenaf area expansion. The consequent deforestation, exposure of scrub lands to accelerated erosion and creation of incentives for the incorporation of public lands into private holdings is a matter of national concern. The discovery and development of an economically remunerative and adoptable package of yield-increasing technology for cassava and kenaf hold the promise of increasing production from existing cassava and kenaf fields, thus reducing the incentive for farmers to degrade and destroy traditional community and national forests, woodlots and pastures.

9. In 1978, cassava was Thailand's leading foreign exchange earning export (10.7 billions or about $526 millions) are reported in KKU-IDRC Cassava/ Nutrition Project, Faculty of Agriculture, KKU, January, 1979)

10. Maize is a relatively minor crop in the Northeast on a whole. It occupies over 100,000 rai only in the provinces of Nakhon Ratchasima, Chaiyaphum, Si Sa Ket and Loei.

2.4 The Potential for Rapid and Sustained Growth of Incomes and Productivity in Northeast Thailand

It would be presumptuous and imprudent for us to announce that we see a discrete number of implementable and replicable technical and institutional interventions which have the power to place the rural population of Northeast Thailand on a rapid and sustained path to increased incomes and resource productivity. We are, however, encouraged by the discovery of what we feel are some important keys to the opening of a substantial gap between presently attained and potentially attainable levels of agricultural production.

We feel that several key technical constraints to productivity growth have been accurately identified and partially broken by agricultural researchers. The increasing attention and budgetary allocations of the Royal Thai Government to the problem of rainfed agriculture in general and Northeast Thailand in particular suggest that the efficiency and integration of services delivery to Northeastern farmer will improve.

Very broadly, Northeastern farmers rely on rice as their main food crop and on upland crops as a source of cash income. In recent years farmers with access to uplands have not achieved comparable rates of income growth. On the basis of our review of research documents, discussion with researchers and a brief group visit to (three provinces of) the Northeast we feel that the keys to productivity and income raising packages of practice for both upland and lowland rainfed crops now exist.

2.4.1 Paddy

Agronomists, rice breeders and other agricultural scientists have been working in Thailand for some time to develop varieties and cropping systems which will reduce the risk of drought. Much of their work may be described as an effort to "bring the crops to the water" in a way which will increase the level of potential production. Once the optimal level of production of paddy has been increased, farmers will be in a position to respond to the higher potential by increasing their actual production. Recent research results from the Rainfed Rice Improvement Pioneer Project in Northeast Thailand suggest that risk of failure of the paddy crop may be substantially reduced in some areas by the use of photo period insensitive rice varieties planted at a time such that they take full advantage of the most probable rainfall at the most critical growth stages. At present, this strategy of "bringing the rice to the water" is unsuitable for introduction at the farm level without further testing and the development of direct seeding and weed control aspects. If this risk reducing rice cropping technique is perfected, it will have the effect of substantially increasing the level of optimal production for some areas of the Northeast. The gap between the optimal and actual levels of production will have been widened for some farmers. With a wider gap, actual production will increase and the rate of adoption of complementary inputs such as fertilizer will increase because risk of crop failure will have been reduced.

Recent research on the use of azolla (See Annex 6) as a source of biological nitrogen suggests that a new, low cost, yield increasing item of technology may soon become available to Northeastern paddy farmers. Many problems remain to be solved (See Annex 6 for a brief discussion of some of these problems) before a package of practices incorporating azolla as a "home grown" substitute for purchased nitrogen becomes available to farmers. The solutions to technical problems of a "gap increasing" package of paddy fertilization practices incorporating azolla will require a continuing input from scientific researchers.

Perfection of a technical package of practices which incorporates azolla is unlikely, by itself, to create a substantial upward shift in the level of optimal income and productivity for any large number of Northeastern farmers. The essential inputs of a phosphatic fertilizer and an elastic seed source have to be made available The supply of these inputs requires the establishment of a set of supporting institutions. The supply of straight phosphorus fertilizers can probably be met by the private sector, once an initial demand has been established. The supply and multiplication of azolla seed at the village level is potentially a far more complex issue.

2.4.2 Upland Crops

About one-fourth of the total area of crop cultivated in Northeast Thailand in 1974 and 1975 was in upland crops. Cassava, kenaf, groundnut and mungbean are relatively widely distributed throughout the entire Northeast.[11] They must form the basis of sustained income and productivity growth in upland areas. There is a widely acknowledged need to replace some cassava areas with other crops, especially soil-building legumes. Based on research at the Northeast Agricultural Research Center, Khon Kaen, appropriate groundnut varieties and fertilization practices have been identified and may provide a profitable rotation with cassava and kenaf.

Improved marketing procedures and methods based on product grading appear capable of encouraging farmers to increase their income from cassava and kenaf by increasing the quality of the product they sell rather than by selling more of a low quality product. The granting of more secure occupation rights to farmers who may now be "technical squatters" on public lands has the potential to encourage better soil conservation practices and open access to public sources of credit for land improvement.

2.5 An Area Development Approach to Rural/Agricultural Development: A Search for a Viable Strategy for Northeast Thailand

In the preceding sections of this chapter we have developed a simple model of the role of research and extension, discussed briefly the role of institutional change, commented on some of the problems of Northeastern agriculture, and highlighted some keys to what we believe will constitute a source of productivity and income growth in the region. In this section we describe the

11. For the relative distribution of individual upland crops across the Northeast, see Annex 7, tables 1 - 4.

elements of an area development approach and suggest a development strategy which we believe is viable and replicable.

2.5.1 Agricultural Sector and Rural Development

In recent years the Royal Thai Government has put increasing emphasis on the problems of farmers living in the rainfed areas. The Development Assistance Group of Thailand met in April, 1978, and concluded that rainfed agricultural development deserved top priority attention, and suggested reliance on an integrated approach to deal effectively with the interlocking constraints on an area-specific basis. A recent seminar on rainfed crop research recommends multi-departmental, coordinated action programs within the Ministry of Agriculture and Cooperatives. The declaration by Prime Minister Kriangsak that 1979 will be "the year of the farmer" implies an unprecedented committment to rural development programs aimed simultaneously at increasing agriculture productivity and improving the income of the rural poor.

It is also important to note that the Royal Thai Government recently embarked upon several significant efforts towards decentralization of planning and administration of development programs and activities, e.g. provincial planning, new village development program, accelerated rural development and "economic village" demonstration sites. Thus, decentralization and "bottom-up planning", rainfed agricultural development, and target group oriented rural development are viewed as the core of the current development strategy.

During the past decade or so, agricultural development strategies in most of the developing countries in Asia have, in a broad sense, led to a situation in which the development process bypassed the bottom one-third of rural population. Thus, there is very little evidence of any "percolation effect" or "filtering or trickling down" impact being felt by the poor sections in the rural areas. Indeed, the contrary may be true. Based on the 1976 Asian Agriculture Survey, the Asian Development Bank concluded that its developing member countries have accomplished the agricultural development objectives with varying degrees of success; that a perceptible dynamism was evident in parts of the agricultural sector and certain rural areas in several countries; and that these enclaves were able to consolidate and build further on the advantages bestowed by technological, institutional and infrastructural improvements.[12] The experience in Thailand has been similar in that the Northeast rural farmers have not shared proportionately in the benefits of a decade or more of agricultural growth and prosperity. The poor, although they may constitute the majority in the Northeast, are at the margin of the socio-economic system. They do not effectively participate in the development process, and as Kötter points out:

> "This is a true vicious circle. Due to marginalization peasants remain inefficient and poor. Because they remain inefficient and become at least relatively poorer the process of marginalization is accentuated the more. Other sectors of the society are making progress. . . . However, any developing society which neglects in the

12. Asian Development Bank, Asian Agricultural Survey 1976 --Rural Asia: Challenge and Opportunity (Manila: 1977), p. 208.

long run the rural poor deprives itself from very important development resources." [13]

The experience to date suggests that sectoral programs, by and large, cannot be tailored to meet the specific needs of the rural poor. In other words, sectoral programs have not been and perhaps cannot be designed to serve a specific target group in rural society.[14] A number of complementary activities have to be undertaken simultaneously to make a sectoral program a viable development tool, e.g. on-farm production program accompanied by extension service, inputs, credit, off-farm employment, marketing, and so on. Thus, an area development, multi-component approach holds great promise if agricultural and rural development efforts are to be focused on the rural poor.

An area development strategy provides a framework for rural development in terms of specific area based programs. The methodology for area development is aimed at identifying target group populations and at promoting an integrated provision of agricultural and other services toward maximizing the net beneficial impact on the target groups. It is through this process that linkages between various programs and activities (public and private sectors) are analyzed and attempts are made to increase the opportunities and reduce the constraints. An area development approach also includes normative elements (goals, objectives, and targets). Further, it provides an appropriate system for monitoring an evaluation of performance for a given rural development program. Finally, an area development stragegy leads to action-oriented approaches for regional development planning

An area development strategy recognizes that action on a wide front will be necessary to achieve the rural development objectives requiring understanding of many fundamental aspects of rural life. Some far reaching changes may be necessary in the allocation of resources, agricultural price policies, quantitative and qualitative aspects of delivery of public and private services, role of local level praticipation (especially inputs from the target groups) and the quantum and distribution of benefits relative to development programs among rural households. An area development approach provides a comprehensive framework to capitalize on synergistic effects for a myriad of development activities. However, this strategy does not imply action on all fronts simultaneously. Instead a discriminative approach is called for depending upon the socio-economic context, at a particular point in time, in which corrective measures may be applied. In a sense a building-block approach is most appropriate.[15] Based on a study of rural development in Africa, Uma Lele advocates:

> "Establishment of priorities and combination of a few critical general interventions applicable to several regions, along with emphasis on development of capability of regional administrations to identify and ameliorate additional constraints

13. Herbert R. Kötter, "Constraints to Food Availability Imposed by the Human Work Force", Paper presented at the World Food Conference, Iowa State University, Ames, Iowa, 1976.
14. Asian Development Bank, op.cit., p. 220.
15. The Regional Planning and Area Development Project, University of Wisconsin is currently engaged in the development of such an approach, i.e. the sketch plan--concepts, process, and methodologies.

specific to individual groups."[16]

Although an area development approach provides a comprehensive framework and calls for a selective action program, it must be emphasized that the focus remains on specific area-based projects. The project(s) approach in this context provides a locus for an integrated program.

The identification of the overall program or the activity mix is crucial to the process of area-based projects' approach for rural development. In this regard, it is pointed out that:

> "The basic issues to be resolved are: (1) how priorities should be decided; (2) to what extent so-called non-productive activities should be mixed and integrated in the program; and (3) how phasing and sequencing of activities should be designed. At the local level, or at the project level, it is difficult to arrive at priorities without referring to the national, or at least, the regional priorities. Project priorities should "flow" from the national or regional plans. Ideally, rural development should form an important and integral part of the national plan. Since these plans basically serve as a counsel for perfection, the adjustments and adaptations have to be and should be made at the project level." [17]

Agricultural and rural development strategies, as well as the design of programs and their implementation, must be based on the recognition and understanding of the important linkages and interrelationships between technology and institutions. An institutional framework at a given point in time determines the distribution of access to productive resources among rural households. Institutions are thus defined or viewed in the broadest possible sense and include "those social norms and values or legal and administrative rules, on the one hand, define property rights (among other things) and, on the other hand, sanction an assignation of these among households, cooperative groups, or non-voluntary collective bodies." [18] Institutional changes include both a change in institutions, as well as an alteration in attendant organizational structures which allocate resources among various activities.[19] The changed organizational structures are aimed at improved integration/coordination both horizontally and vertically. It must be pointed out that coordination (in terms of what needs to be coordinated and appropriate mechanisms or devices) moves from general to specific when these issues are addressed at national and lower levels in governmental hierarchy.

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16. Uma Lele, Design of Rural Development -- Lessons from Africa (Baltimore: Johns Hopkins University Press, 1976), pp. 12-13.
17. Asian Development Bank, op.cit., pp. 224-225
18. Asian Development Bank, op. cit., pp 210-221
19. Important institutional changes for agricultural development include land reform, the reallocation of water rights, modification of agricultural support systems, creation of forums for local participation in decision-making, and provision of needed changes to facilitate the establishment of successful rural development and off-farm employment programs.

2.5.2 Area Based Agricultural Research

In recent years there has been an increasing realization that there is a profound, area-specific relationship between agricultural research and the growth of agricultural income and productivity. Central to this realization has been the understanding that the transfer of agricultural technology is often severely limited by differences in soil types and micro-climatic environments.[20] These differences are more pronounced for some crops than for others.[21] Cassava and kenaf do well throughout the Northeast: cotton and maize are grown extensively in only a few provinces. Improvements in the productivity of upland crops will require research to break productivity constraints which are specific to particular soil and micro-climatic environments. This problem alone is sufficient to justify an area based approach to much agricultural research.

2.5.3 On-Farm Testing and Package Development

On the basis of personal observation, the diversity of topographic features, rainfall pattern and population characteristics in the Northeast, it is clear that no single variety package of practices, multiple cropping or farming systems is likely to be adopted by a large proportion of farmers over an extensive area. Most items of new agriculture technology will prove adoptable only if they can be adapted to local, on-farm needs.

In the last ten years, important gains have been made in agricultural research capabilities in Northeast Thailand. Although packages of new practices have been recommended on the basis of field testing, the impact of the incomes and productivity in the rainfed areas have been modest at best.[22] We believe that it would be incorrect ot "fix blame" for this on either the agricultural researchers or the extension service. The problem appears to be more complex and to involve economic and institutional elements as well as an incomplete tailoring of packages of practices to the diverse needs of the farmers.

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20. See especially Boyce, James K. and Robert E. Evenson. Agricultural Research and Extension Programs, Agricultural Development Council, New York, 1975. Note also that there is an extensive and growing literature about "what has gone wrong" with "technology-based" approaches to agricultural and rural development.
21. Note that most of the maize and cotton in the Northeast is located in Korat and Loei where temperatures and soils are better suited for the currently available varieties. Groundnut, though widely distributed in the Northeast, tends to be concentrated in the Surin, Buri Ram, Korat, Chaiyaphum "belt" where soils are probably richer in calcium, a nutrient which is critical to groundnut yields.
22. The rapid and widespread adoption of the Niaw San Patong glutinous rice variety, however, is estimated to have had a significant effect in the Northeast. See "Agricultural Research Efficiency in Thailand: A Study of the Impact of Research on Agricultural Production" (mimeo, no author, no date).

2.5.4 A Strategy for Rainfed Farmers

The problems of rainfed farmers in Northeast Thailand are unlikely to be "solved" by a single "miracle" variety or package of practices. Increased inputs in the areas of: (1) commodity specific research, (2) cropping and farming systems research, (3) on-farm testing and (4) package improvement will be required. New skills, augmented farm resources, greater numbers of better trained extension agents, enhanced levels of government services, and institutional innovations will also be required. At this time, the elements of gap-creating technology for upland and lowland crops have been identified by the research stations and subjected to limited field testing. However, without a rigorous, area specific, on-farm testing process directed to the development of adoptable packages of practices and the provision of needed inputs, markets and services, these productivity and income-enhancing elements are unlikely to be adopted in any substantial area of the Northeast.

The strategy we suggest is one in which promising agricultural technology is given a thorough on-farm test in order to maximize the opportunity to prepare a package of practices which meets on-farm needs and on-farm constraints. As part of this process of on-farm testing and package development, it is essential that resource constraints, marketing, input supply and institutional problems be identified and steps be taken to remove or reduce these constraints to adoption. This can be done in an area-based approach with greater speed, efficiency and probability of success than would be possible in a geographically diffused commodity based approach.

III. PROJECT ELEMENTS

In this chapter we describe and discuss individual elements of a rainfed agricultural project for Northeast Thailand.

3.1 Cropping Systems

The choice of rainfed crops that can be grown and the cropping systems that are utilized by farmers in Northeast Thailand are severely limited by the types of soils and climatic conditions. Economic considerations are equally important. Because the soil is such an important factor in crop selection, it is appropriate to describe briefly the soils and related problems of

Northeast Thailand in order to evaluate the economic potential of various crops and cropping systems.

The Northeast is the largest of the four regions of Thailand. It covers a land area of approximately 106 million rai (about 17 million hectares). It is divided by the Phu Phan range, stretching from the Northwest to the Southeast. North of the range is the Sakhon basin. South of the Phu Phan range is the Korat basin. Although this area is aptly described as a plain or valley, Northeast Thailand is usually described as a low plateau with an average elevation of approximately 600 m.

Five main landforms are recognized in the region: alluvial plain, low terrace, middle terrace, high terrace, and hills and ridges. The general landscape of each landform consists of level to rolling surfaces except for the hills and low mountains around the edges and a few hills in the central part of the region.

3.1.1 Upland Crops

Soils found particularly on middle-high terraces of greatest agricultural importance in upland cropping in the Northeast are the Korat fine sandy and related soils; these are generally infertile, being characteristically sandy, acidic, low in available phosphorus, available potash, and organic matter.[1] High yields of crops cannot be maintained without measures to improve soil fertility. Being sandy and having a low organic matter content, the soils have a low moisture holding capacity. The available water in the surface soils usually ranges from 11 to 14 percent. They tend to offer luxury consumption to crops when moisture is available. Therefore, the available water is depleted by crops more quickly on these soils than by the same crops on heavier soils having the same moisture content. Although these soils are sandy, the clay content generally increases with depth. Often a sandy clay layer or lens is present at some depth. Thus a perched water table is often close to the surface and in many soils will not drop below one to two meters even during the dry season.

The presence of a water table significantly increases the soil water content for a distance of approximately 45 cm above the water table in Korat fine sandy loam soils. The water content of the 45 cm of soil above the water table is approximately five per cent higher than field capacity in the absence of a water table.[2] Although these soil-water relationships are inadequately understood by researchers, they enable Northeastern farmers to obtain reasonably high yields of watermelon and probably account for the ability of cassava to endure the severe moisture stress on sandy soils throughout the months of practically no rainfall.

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1. For a formal description of Northern Thailand's soils see Annex XI.

2. Intalap, Subhawat, R.E. Phillips, John H. Ellis and Thawat Vichiensaen, 1971, "Influence of Water Table on Distribution of Water in the Soil Profile and on the Growth of Watermelon", Annual Report of the Northeast Agricultural Center.

The uneven and unpredictable character of rainfall distribution in the Northeast seriously limits crop yields and the economic returns from using cash inputs. The average growing season is about 7 months during the "wet season", during which time the rainfall pattern is extremely variable. Rainfall in most of the area varies from 1100 to 1400 mm per year. Except for some of the southern and southeastern portions of the Northeast, the rainfall pattern is bimodal with peaks in late May and late September. Rainfall is quite variable in pattern and in quantity from year to year. Soil--water--crop management is essential for successful cropping operations. These weather risk factors, as well as the current economic situation, dominat the rainfed farmer's crop selection and cropping practices.

Field crop production in the Northeast includes kenaf, jute, cotton, cassava, sugar cane, corn, sorghum, peanuts, mungbeans, and soybeans. Several RTG agencies are conducting research on these crops. More recently cropping systems research has been conducted by universities, the Department of Agriculture and other agencies. Possible cropping systems include: (1) multiple cropping of kenaf-field crops, two successive field crops for upland, field crops before paddy and/or field crops after paddy; (2) intercropping of cassava and kenaf with other field crops, particularly legumes. Cropping systems research is still new to Northeast Thailand and considerable research work is still needed to make these cropping systems profitable enough to be accepted by farmers. Although some of the systems look very promising and may reach a recommendable level in the next 2-5 years, <u>there are no economically viable multiple or inter-cropping systems that can be recommended to the farmers at this time</u>.

Although cropping systems research is new in Thailand, the benefits of crop rotation have long been recognized and practiced. At present, the greatest impact on farm income may come from focussing attention on mono-cropping production in a crop rotation system rather than on multiple and/or intercropping systems. Due to marketing constraints, the principal field crops that can be recommended to farmers are limited to cassava, kenaf, jute, and legumes[3], particularly peanuts, mungbeans and soybeans. Because of the escalating prices paid for cassava for the past five years and the relatively low inputs required for growing satisfactory crops, cassava production has taken the lead as the best cash crop. Continual cropping leads to reduction in soil fertility because of the large quantity of nutrients removed from the soil. There are known fertilization practices to prevent a decline in soil fertility and crop yields. However, farmers have not adopted these practices because they have not yet been shown to be economically prudent under actual farm conditions.[4] There is also a reluctance to use good legume crops in rotation with cassava to improve soil fertility where immediate cash benefits from the rotation crop are not comparable with those received for cassava. This means that a rotation crop aimed at maintaining soil fertility must be able to offer some form of competitiveness to cassava such as quicker returns, possible double cropping, etc. At the

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3. This conclusion is also reached by the FAO/Thailand National Workshop on Rainfed Crop Production, January, 1979.

4. See Annex XII "A Note on Cassava Fertilization."

present time, groundnut is the crop that can fill these requirements better than any alternative crop. Should the price of cassava decrease and/or yields decrease substantially to the point where cropping becomes unprofitable, groundnut would be the best alternate cash crop. Additionally, preliminary findings from multiple cropping research indicates that groundnut is one of the most promising field crops when paired with rice, kenaf and cassava. Experience and skills in raising groundnut as a mono-crop or in rotation with cassava will improve the chances of economically incorporati groundnut into a multiple cropping system.

Groundnut

As a legume, groundnut requires less fertilizer than other crops if the tops are returned to the soil, thus enhancing the yields of crops which follow.

Groundnut is a short season crop with potential for cash returns in a relatively short period of time. The climate and soils of the Northeast are, in general, suited to groundnut production. Groundnut has considerable flexibility which enables it to fit into a cropping schedule (see Annex XVI).

Groundnut has been grown traditionally in the Northeast for many years. Over the past five years the Northeast has produced from 25 to 30 percent of the total Thai groundnut production. The potential for increased production is promising.

At present various RTG research stations in the Northeast have on-going groundnut varietal and cultural practices research programs which have produced improved technology (see Annex XVII). One new short season variety released by the RTG is well adapted to the Northeast. It is more productive and produces a nut which shells out 10 percent heavier than traditional varieties; even traditional varieties such as SK 38 give acceptable yields.[5] A yield of 676 kg/rai was obtained on experimental plots at the Northeast Agricultural Center near Khon Kaen.[6] Actual on-farm testing gave average yields of 350 kg/rai on 23 farms in six provinces in the Northeast.[7]

Groundnut has a variety of markets in Thailand. They are boiled and sold in local markets, they also are sold as dried nuts for domestic consumption and export, and may be pressed for cooking oil. Oil cake, a by-product from the pressing, will find a ready market in the growing Thai feeds industry. The domestic market utilizes 70 percent of the total peanut pro-

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5. See Ministry of Agriculture and Cooperatives, Department of Agriculture, Field Crop Division Annual Report 1976.

6. Ratnapradips, Paiboon and John H. Ellis, 1971, "Response of Peanuts to $CaSO_4$ Applications Grown on Korat Fine Sandy Loams", Annual Report of the Northeast Agricultural Center, pp 169-178.

7. Sirirugsa, Chumnarn, Nawarat Sermsri, Paiboon Ratanaprateep, Russel H. Brannon, and John H. Ellis, 1972. Economic Evaluation of a Technological Package for Peanut Production in Northeast Thailand. Annual Report of the Northeast Agricultural Center.

duction and is growing. The export market, traditionally Hong Kong, Singapore, Japan and Malaysia, is firm for both nuts and oil. Prices have risen steadily since 1971. The price during the 1976-77 crop year was more than twice that of the 1971-72 crop year. Indications are that the price will remain firm in the face of a growing domestic supply. In addition, since 1974, the price of groundnut has increased somewhat relative to kenaf, one of the major competitors for the upland cropping area of the Northeast. There are indications that the European market for cassava, another competing crop, may now be weakening, in which case, groundnut may offer a suitable alternative.

Groundnut also has the advantage of flexibility in the size of the crushing plant required for processing into oil. An expeller type crusher is required. It is possible to purchase various size crushers and associated equipment compatible with the production and other limitations of a particular location. This can range from a small investment, one-family operation, to a large, modern, sophisticated plant, depending on the economics of an individual situation, the infrastructure, capital, and management requirements.

Other legumes that have potential as a rotation crop with cassava are mungbean and soybean.

Mungbean

Some research has been done on mungbean, mainly fertility trials and variety testing as well as cultural practice. More recently mungbean research on multiple cropping, particularly before and after paddy, has been conducted. Mungbean is a short season crop requiring less time from planting to harvesting than peanuts or soybean. This characteristic makes it suitable as a first crop before paddy especially when the first rainfall period of a bimodal rainfall distribution is relatively short. It is theoretically possible to grow four consecutive crops on the same field. However, mungbean is less tolerant to drought than groundnut. There are available domestic and export markets for mungbeans.

Soybean

Soybean is another legume that has potential as a cash crop and as a rotation crop with cassava and kenaf. This crop has been identified by the RTG as having high priority for expanded production because of its favorable outlook in the world market. Soybean, like groundnut, has great potential as a means of increasing the domestic supply of high quality protein for human consumption. The Thai oil seed extracting industry is capable of processing 300 tons of soybean per day.

The main rainfed soybean planted areas are in the northern region. 81 percent of the soybeans are produced in the northern region as compared to only 2.4 percent in the Northeast. The major constraints to rainfed soybean production in the Northeast are:

1. the lack of high yielding varieties suitable for the Northeast;

2. the lack of effective rhizobium inoculum for specific soybean varieties; and

3. inadequate and variable soil moisture throughout the cropping season.

Until recently, little research work had been conducted with soybeans under rainfed conditions. Currently, trials are being carried out with fertilizers, liming, new varieties and rhyzobium inoculum to increase nodulation. In 1976 a new variety, SJ4, was released to farmers. This variety shows an increase in yield of over 15 percent over previously released varieties. In Korat, preliminary results indicate that proper rhyzobium inoculation matched with specific varieties alone can potentially increase yields by 50 percent. With a technological package of practices including rhyzobium inoculum, improved varieties, fertilizer, and cultural practices, the same trial showed yields of 2,200 kg per ha. (352 kg/rai) on farmers fields under rainfed conditions. Elsewhere in the northeast (Roi Et) yields up to 2,331 kg. per ha. (373 kg/rai) were obtained using these practices.[8] Thus, it appears that with additional testing, this new technology may be extended to farmers.

Kenaf

Kenaf is a high labor, low technology crop. It is well suited for the Northeast where it is primarily grown. Yields have declined since the late 1960's and through 1978. Also, the area planted to kenaf in the Northeast decreased from 2,642,000 rai in 1973/74 to 1,585,000 rai in 1977/78, following the recovery of jute production in Bangladesh. Even with this decrease in production, the Northeast accounted for approximately 99 percent of the total kenaf production for the whole kingdom. Research investments in kenaf have been limited compared to other important crops. No major yield breakthroughs have been achieved and none are immediately likely. As with cassava, the application of commercial fertilizer to kenaf is practically nil.

Cassava

Cassava has been grown for the past 30 years along the east coast of Thailand near Chonburi. In recent years it has spread very rapidly into the Northeast where it is competing with a traditionally grown crop, kenaf. For example in 1965, only 480 rai of cassava were recorded in Buri Ram. By 1976, the reported area planted to kenaf had grown to 295,941 rai. Yields are generally good on newly cultivated land - more than 30 tons per ha. (4.8 tons per rai) - however, continuous cropping of cassava reduces average yields to 12 tons (1.92 tons per rai) or less. A long term soil fertility research project at the Northeast Agricultural Center, Tha Phra, Khon Kaen, designed to determine the effects of continuous cropping of cassava and the ratio of fertilizer necessary to maintain soil fertility has been conducted. The results show that reasonable fertility levels can be maintained. However, at current fertilizer and cassava prices, it is not an attractive

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8. The average yield of soybeans in the Northeast in the period 1973-77 was 881 kg/rai (141 kg/rai).

program for farmers.[9] Farm level use of chemical fertilizer in cassava production is practically non-existent, but animal manures are used. The cultivation of soil fertility-building legumes in rotation with cassava could be economically attractive to Northeastern farmers on some soil types with appropriate prices, varieties and cultural practices.

Selection and testing of cassava varieties have been conducted for a number of years. Research work is also being conducted to determine the feasibility of inter-cropping with legumes in order to help maintain higher nitrogen levels in the soil. At the present time, the MOAC recommends a two-year rotation with a suitable legume alternating with cassava. Research on cassava, like kenaf, has been relatively limited, compared to research on other major crops. To date, no significant technological breakthroughs have been achieved.

Soil-Plant Relationships Research

Most upland agronomic crops in Northeast Thailand are grown on the Korat soil series. This soil series was previously described in this report as one having a clay content which increased with depth. In many areas, these soils have a clay lens over which a perched water table may remain within 1 to 2 meters of the surface throughout the dry season.

Preliminary research[10] exploring the relationship between the depth of water table, rooting pattern and yields of watermelon indicated a strong inverse correlation between yields and depth to the water table. Although not conclusive, these results indicate that it is possible as well as probable that a water table near the surface may be a major factor which accounts for other major crops such as cassava to produce acceptable yields even though a considerable length of its growth cycle occurs during the period of extremely little rainfall and on low moisture holding sandy soils. It may also account for drought tolerance shown by crops such as peanuts during 2-3 week periods of no rainfall during the "wet season".

These relationships suggest that research on soil-plant water relationships in the upland soils of the Northeast may make a quick and significant contribution to the development of adoptable technology for upland crops. The initial phase of such a study should:

1. determine the maximum height above a water table which will supply significant amounts of water to plant roots; and

2. determine the rooting depth of current crops as well as potential future crops under the soil and environmental conditions of Northeast Thailand.

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9. See Annex XII.

10. Research conducted at the Northeastern Agricultural Center, Khon Kaen.

If it is found that the presence of a water table at a relatively shallow depth is necessary for satisfactory crop yields in the absence of supplemental irrigation, then a detailed survey or map should be made showing the water table depth at several times during the year-especially at the beginning and end of the growing season of upland crops. (The water table referred to is not the permanent water table but is the perched water table which exists much of the year in Northeast Thailand.)

3.1.2 Paddy

Paddy yields in Northeast Thailand are low and variable by Asian standards. Only a small fraction of the region's paddy area is presently irrigated. It is estimated that a maximum of only 20 percent of the region's population lives on land which could be irrigated. The expansion of irrigation facilities over time will play a role in reducing production risk, expanding the area under dry season paddy and increasing yields. But it is clear that the impact of that role will be slow, relatively small, and concentrated on the better soils and expensive.

The rainfed paddy areas of the region are highly variable in slope, fertility, drainage capacity, water retention capacity and in their ability to catch run off water from uplands and higher lying fields. Many of the low lying fields are subject to prolonged inundation which results in seasons of reduced yield and total crop failure. The inter-provincial difference in average yields and "riskiness" of rainfed paddy is substantial. Annex IV reports the average yield (production per planted rai) and standard deviation by province.[11] Clearly, the long-term average yield is higher and less "variable" in some provinces than in others.[12]

The functional relationship between area planted, rainfall and yield is imperfectly understood. Recently it has been suggested that high field moisture is critical at the time of stem elongation, flowering and soft dough.[13] Most photo-sensitive varieties in Northeast Thailand flower after the period of maximum likelihood of standing water in paddy fields. Accordingly, it has been hypothesized that photo-insensitive varieties could be planted at a date which would cause them to flower at an optimum time in terms of soil moisture and expected rainfall. An experiment following this principle at Ubon in 1977 suggested an increase in yield of over 150 percent due to matching of the flowering date with the period of high rainfall (and, therefore) high soil moisture.

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11. We accept the yield (and area) statistics as being accurate. This may not be the case. See "Selected Issues in Rural Development", Working Paper #4 of Thailand Basic Economic Report No. 2059-TH, September 1, 1978, World Bank.

12. Annex IX reports estimates of time trends in yields by province. In the absence of a fuller understanding of how yield data were collected and a model to account for the effects of year to year variations in rainfall, it is not possible to speak confidently of either an increasing or decreasing trend in yields.

13. See "1978 Annual Report: Rainfed Rice Improvement Pioneer Project - Northeast Thailand", Rice Division, Dept. of Agriculture, MOAC, Bangkok, June 1979.

The 1977 Ubon experiment suggests that direct seeding of photo-insensitive varieties may be a key to increasing productivity and reducing risk for at least some farmers in some areas of the Northeast. However, it cannot be regarded as a practice which is sufficiently well understood to warrant its inclusion in a package of recommended practices. See Annex X for a discussion of our concerns about the potential and limitations of direct seeding of photo-insensitive varieties.

The use of azolla in a source of biological nitrogen in flooded paddy fields appears to have the potential for wide-spread use by large and small farmers in the Northeast. Azolla experiments conducted at Ubon in 1978 are described in Annex VI.

We see two problems which need to be resolved before azolla is likely to contribute to income and productivity in the Northeast:

1. ways must be found to multiply azolla seed so that a low cost (free?) supply is available to the individual farmer when and where he wants it; and

2. a supply of super phosphate must be available at competitive prices at the village level.

Given these two potential constraints on introduction and adoption of azolla, an area based strategy of farm testing and evaluating azolla seems more appropriate than a geographically diffused approach.

3.2 Management of Water Resources for Increased Production

Northeast farmers feel that their greatest need is for additional water. Secure year round water supplies for drinking, domestic use, livestock, fish production, and/or crop irrigation are lacking in many villages. The Accelerated Rural Development Project has identified 4,500 villages or about 20 percent of the total whose domestic supplies are severely lacking (ARD, 1979). Any program to develop supplemental irrigation supplies must first insure that human and animal water needs are adequately met. Only about three percent of the families in the Northeast farm irrigated land and 80 percent of the population live outside of areas which can potentially be irrigated from large reservoirs or with water pumped from permanent rivers (A.I.T., 1978(a)).

Royal Thai Government (RTG) agencies have recognized the need for additional water supplies and are actively pursuing programs to provide drinking, domestic, and livestock water for every village in the Northeast, and fish ponds and supplemental irrigation water where possible. The effort has also been given financial support by several international and foreign loan agencies.

The water resource development work has been divided between several departments in three ministries (AIT, 1978(a)). In 1978, the Prime Minister, recognizing that the effort must be coordinated in order to make the overall program more efficient, formed a task force led by Dr. Anat Arbhabhirama of

the Asian Institute of Technology (AIT) to coordinate and plan water resource development activities in the Northeast.

The initial report of the AIT group, Water for the Northeast (AIT, 1978(a)), effectively summarizes the water resource supply situation in the Northeast and the on-going programs of the various governmental agencies. The report proposes both an immediate and long term water resource development program for the Northeast, including the required institutional framework. It appears that the recommendations are being pursued in a timely manner by the RTG.

3.2.1 Supply Considerations

The applicable technologies for water resource development in non-irrigated areas of the Northeast are fairly well developed. Households often collect rainwater from their roofs in large jars or other containers for drinking. Both shallow and moderately deep wells, often supplied with hand pumps for domestic water supply, are being installed by several government agencies. Such wells are a viable drinking, domestic, and livestock water supply in most Northeastern villages. The groundwater aquifers are fairly impermeable in most areas of the Northeast and well yields are usually inadequate (less than 10 liters per second) for economical irrigation.

The traditional surface water storage is in depressions and swamps. Several government programs are now enlarging the storage capacity of these bodies by building dikes and dams. Wiers and small dams across natural drainage areas are also being constructed to collect and hold runoff for the dry season. Such water resource development can also play a major role in the reduction of surface erosion by retaining potentially destructive runoff water.

A possibly appropriate technology which should be explored is smaller, cheaper, locally fabricatable equipment to do the earthwork necessary for surface storage facilities. For example, implements which utilize farm tractor power, or dredges with anchored winches might be lower cost alternatives to bulldozers. Most existing surface storage in non-irrigated areas is insufficient for appreciable dry season irrigation due to small storage capacity and high evaporation and seepage rates. It is used primarily for domestic and livestock use, for raising fish, and when no other source is available, for drinking water.

Because of the present active RTG program of water resource development, it is felt that a new project concentrating on the supply side of the water issue is not necessary.[14]

The chosen sites should be surveyed for present and potential surface storage or groundwater pumping locations, as proposed in the AIT report.[15] RTG line agencies of private firms should be contracted to install the recommended facilities which are deemed economical and necessary. It is unlikely

14. However, investigations of tank seepage losses and means to reduce it, and the potential of multiple shallow wells with portable pumps for irrigation would be useful.

15. The survey must include farmer/user input of perceived needs and preferen

that potential development locations will be sufficiently dense that conflicts will arise between water supply techniques.

A dependable, healthful domestic water supply should always be insured before supplemental irrigation is proposed. Two domestic water supply techniques which should be pursued in areas where the groundwater is unsuitable or cannot be economically pumped, are:

1. encouragement, both via extension and subsidy or credit, of adequate storage capacity for rain water for dry season drinking; and

2. installation of shallow wells and handpumps below the dikes or dams of surface storage facilities to intercept the naturally filtered seepage water.

3.2.2 Water Use Considerations

Although significant work has been and is being done on both the technical and institutional aspects of supplemental water supply, little work has been done to determine the most efficient and economical use of the supplemental water. The physical techniques involved (i.e. hydraulics, soil-water movement and storage, and plant-water useage) are pretty well known. The climatological information is also available so that estimates of supplemental water needs can be determined within desired probabilities. What is lacking is to put together this basic information into a technological water use package for each type of water supply which efficiently serves the desired Northeast cropping and farming system, and is workable within the existing or potential institutional framework.

The first step of this procedure should be to prioritize the various water use needs and to determine conflicts between the various conjunctive uses. For example, a surface pond or tank used for domestic or livestock water cannot be used for irrigation unless a permanent residual supply is insured. A pond used to grow fish should contain water as long as possible, and preferably retain 30 percent of its surface area as residual water, not be too deep, and to be most productive, be fertilized with animal waste. The first factor may conflict with irrigation use while the last conflicts with domestic water supply requirements. Groundwater supply usage will not normally lead to conflicts since it is usually not depleted. Usage is regulated by the flow rate, but its desired benefits should be prioritized.

Three primary factors will affect the efficiency of supplemental water use for crop irrigation. The first is how long the supply must be stored and the loss rates during storage, i.e., evaporation and seepage from a pond. Second, the distance the water must be conveyed and the rate of losses enroute will determine the amount of supplemental water which is delivered to the field.[16] The third factor is the amount of crop which can be pro-

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16. It is expected that loss rates from channels constructed in the predominantly coarse-textured Northeastern soils will be high, and half of the conveyed water could be lost in 500m of conveyance channels.

duced (or profit gained) per unit of water delivered. Annex XIII illustrates the relative water requirements of crops irrigated at different times of the year with varying storage times and irrigation efficiencies. The actual numbers displayed were estimated from limited available data and should not be considered reliable, but the relative water requirements are instructive.

The first two factors imply that surface storage supplies should be used as soon as possible, and that irrigated fields should be as near as is practical to the water source. Installing shallow wells or planting deep rooted crops down slope from surface ponds to intercept otherwise wasted seepage water can improve actual water use efficiency. Growing vegetables on the banks of the ponds as the water level receeds involves no conveyance losses and uses seepage derived soil moisture.

The third factor implies that supplemental water will be most efficiently used in conjunction with rain water when, perhaps one critical irrigation can double the crop yield, rather than during the dry season when total crop-water needs must be supplied. Cursory analysis indicates that the most efficient use might be to insure sufficient water for the one critical rice crop, even if the water is actually utilized only 30% of the time. Insuring a consistent lowland paddy crop might also release upper paddy lands to crops which require less water and are more drought resistant.

After part of the risk is removed from the rice supply, the supplemental water could be used to extend the season so that two crops can be grown. For example, the residual soil moisture in paddy can probably provide part of the water requirement of an after-rice crop. One or two additional supplemental irrigations might be sufficient for a successful crop. It is doubtful that a second rice crop will be desirable since, unless paddy is grown on an extensive area, vertical and lateral seepage to the lower dry season watertable will probably be high.

More constant groundwater supply flows which cannot be stored for risk minimization can at least be used to benefit the greatest area if used in conjunction with predictable rainfall or soil moisture.

In order to evaluate the impact of replicating supplemental water projects, the Land Development Department or other appropriate RTG units may wish to develop a computer model for the soils, crops, and climatological conditions of the Northeast in general and the project sites in particular.[17] Such a model could be a useful management tool to efficiently allocate supplemental water, and to suggest changes in cropping systems that would decrease risk and/or increase output.

3.2.3 Better Utilization of Rainfall

The largest potential impact of water management in Northeast Thailand is not by effective utilization of supplemental irrigation water which will always be limited, but by increasing the efficiency of rain water usage.

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17. This task might be efficiently contracted for with A.I.T.

Total rainfall is sufficient most years for the Northeastern farmer to grow one and often two crops. The rainfall is usually adequate to meet crop water requirements during five months of the year (A.I.T. 1978, (b)). If runoff from higher areas is diverted to lower paddy areas, the water available far exceeds evapotranspiration. The problem is that the rainfall is very erratic, and the water holding capacity of most Northeastern soils is low. Part of the rainfall is thus lost to runoff from heavy rains and deep percolation from the light soils. Thus, intermittent drought periods make cropping risky and yields erratic.

Much can be gained, as discussed in the previous section, by adapting the cropping to the available rainfall; both by breeding short season or drought tolerant crops, and by adapting planting timing and techniques to the most predictable rainfall. Some potential also exists to improve on-farm water management to reduce the risk of crop failures.

Farmers are presently probably doing a good job of collecting as much rainfall as possible in their paddies, and a study of existing methods should preclude any improvement recommendations.

The early seepage from these paddies undoubtedly raises the perched water table under the lower paddies and decreases the seepage losses. Surface stored paddy water is frequently moved both by gravity and pumps in order to concentrate it in the desired paddies for rice nurseries or to insure that at least part of the fields do not suffer during drought periods.

This is a good water conservation system and the only suggested innovations would be to improve the present system. If ditches were dug down through paddy areas, the water could be moved to desired paddies much more efficiently than by the present method of moving water from paddy to paddy. The ditches could also be used to drain water out of upper paddies for tillage, direct rice seeding, or the cultivation of upland crops.

Small powered pumps to move water up to higher paddies, including the efficient axial flow pump designed for low lift conditions, are available and frequently used. However, the "scoop" commonly used to manually raise water to higher paddies is very inefficient. Introduction of a more efficient manual pump, such as the IRRI diaphragm pump, could greatly reduce the labor required to lift water and would be a viable alternative to petroleum powered pumps. Some land forming in the upland areas could direct runoff to the paddies, although extensive earthwork will not be economically viable. Erosion of upland soils can also be reduced by such techniques.

Because rice yields are very unreliable on the upper paddy lands, if consistent rice output sufficient for consumption needs can be insured on the low paddy land via breeding and water management and/or supplemental irrigation, it is proposed that upper paddy lands be converted to upland crops. Most upland crops have higher water use efficiency because ponded water is not required, have lower crop-water requirements because of shorter "full canopy" growing seasons, and are often more drought resistant than rice.

Growing upland crops on the upper paddy land requires that excess surface water can be judiciously removed from the bunded terraces, and that the

water table not rise to near the soil surface. This requires drainage. The ditches previously proposed for transferring water from paddy to paddy can be utilized for drainage of upper paddy land. The most difficult obstacles will probably be finding an outlet for the drainage water during heavy rain periods and acquiring the land right-of-way through lower fields which will not benefit from the ditches.

The most difficult water management problems to be solved will involve the decision-making and enforcement institutions. Supplemental water will serve a relatively small number of people. A local organization will be required to decide how to equitably and efficiently allocate the scarce resource. For example, trading during certain seasons may be required to reduce conveyance distances and losses. People whose land is flooded by an enlarged pond must be compensated. Land for drainage channel rights-of-way must be acquired from the farmers who may get little benefit from the ditch. A decision must be made when pond water can be used for irrigation and when it must be saved for fish production.

Models of several alternative social structures for making and enforcing water management decisions should be proposed, based primarily on local experience.[18] The role of the government agent in this process should be defined. The models should then be tested at the various project sites and adapted as necessary, and successful replicable models should be developed.

3.2.4 Steps in Planning and Implementation of Supplemental Water Projects

1. Selected project sites should be surveyed to determine both physical potential (Department of Land Development) and perceived needs (Department of Agricultural Extension) for water resource supply development. Based on the survey and analysis of the alternatives, a development plan should be formulated.

2. RTG line agencies (DLD, ARD, DMR) should be contracted to construct the desired structures, utilizing local resources when possible. Preferably, both groundwater wells and different types of surface storage facilities will be used. At least one irrigation water supply should be developed for each village.

3. A plan for efficient utilization of the supplemental water should be made considering both the physical system and user desires. An irrigation scheduling model should be developed to assist with the planning.

4. Institutional models for managing the supplemental water should be developed, adapted to local conditions, and tested.

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18. Examples of several existing forms of community cooperative activity relating to supplemental water usage have been observed.

5. A survey should also be made of the non-supplemented areas to determine potentials for improving rain water catchment and efficient movement (DLD). The resulting plan should be refined by the users and the users should provide at least the labor required for the recommended construction.

6. The possibility of using low cost and locally fabricatable equipment for constructing earthen dikes for surface water storage should be explored.

7. Surface channels to facilitate movement of water through paddy areas and surface drainage of upper paddy lands should be constructed and tested. On at least one site, upper crop lands should be shaped to reduce erosion and to direct runoff through the paddy area.

3.3 Livestock

Livestock has been an important source of cash income in the Northeast. Several institutional and animal health-related problems are presently seen as constraints which prevent Northeastern farmers from realizing the potential value of their breeding stock, pasture and supplementary feed resources.

Poor animal health and endemic parasite problems have added to farmers' risks and limited the potential marketability of live and slaughtered animals from the region. Legal restrictions on cattle slaughter and "extraordinary costs" in transporting livestock to the Bangkok market (and for export) have resulted in a farm level price which does not return the true value of livestock to the farmer.[19]

We were impressed with the aggressive and technically competent pasture research and extension effort centered at Khon Kaen.[20] The work there has led to the development of robust, mixed species pasture types which can withstand heavy grazing and drought. Under today's economic conditions, however, we question whether or not pasture can compete economically with upland crops for land use. Any consideration of a pasture component in a rainfed agriculture project in the Northeast must be preceded by a careful economic analysis of the returns from improved pastures.

For the small farmer in Northeast Thailand, and elsewhere in Asia, cattle are a multi-purpose element in the farming system. They provide draft power, manure, cash income and frequently serve as a form of liquid savings. Animal health maintenance is an input which farmers are frequently unable to manage without external assistance from the government.

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19. We understand that legal restrictions on cattle slaughter are now being lifted.

20. See also "Khon Kaen Pasture Improvement Project: Annual Report 1977".

We believe that the implementation of the Department of Fisheries' program in the Northeast will be complementary to a rainfed agriculture project. However, we observe that it need not be dependent on the funding and implementation of such a project. In one dimension--azolla seed multiplication--there may be a conflict between fish and paddy production, as the effect of azolla multiplication on fish tanks has not been fully explored.[22]

Finally, we believe that the Department of Fisheries' careful consideration of institutional barriers to their program may provide some answers and models for use by an area-based rainfed agriculture project.

3.5 Farming Systems

At this point it is premature to give extensive consideration to the potential for new or improved farming systems for Northeast Thailand. Improved farming systems will be developed by farmers using improvements in cropping systems, livestock, fisheries and markets as they develop. The initial role of a rainfed agriculture project should be to provide improvements in the elements from which farming systems are built. It would be appropriate for the project design team to give a fuller consideration to potential farming systems based on their detailed evaluation of the cropping systems, livestock, fisheries and marketing/processing elements. Considerations of farming systems innovations will also be site-specific and should wait until the project sites have been chosen.

3.6 Land Tenure

Official statistics indicate that the proportion of Northeastern farmers having to pay rent for access to land is quite low when compared to other regions of Asia. In most areas of the Northeast, the proportion of agricultural land tilled by tenants is less than five percent. In numerous cases the farmers renting land may be children or sons-in-law expecting to eventually inherit the land which they are currently renting. Limited evidence indicates that tenancy rates may be increasing gradually, particularly in areas where the land frontier appears to have been reached. In such locations farmers without access to land of their own may be forced to rent land through either a formal written or informal oral contract; the latter is more often the case, especially where the "landholder" himself has less than full legal title to the land. Holders of such land include relatively prosperous farmers, civil servants born in the local areas, and entrpreneurs who have invested in land which may have become "available" through road construction and/or logging activities.

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22. The Department of Fisheries and Agriculture might launch a modest, joint research effort to determine the effects of phosphorus fertilization and azolla multiplication on the sort of fish tanks envisioned for the Northeast. If this were done in natural tanks in the selected provinces in the Northeast in 1980, it could answer the question of conflict of interest in tank use before project implementation.

At present the relatively small proportion of agricultural holdings which are rented in most of the Northeastern provinces is not seen as a serious social problem.[23] In almost any agricultural economy some renting of land contributes to improved economic welfare of both owners and tenants.[24] Table 1 on the next page suggests that the fraction of the agricultural population which are "landless" is small in absolute terms and small relative to other regions of Thailand.

More serious than the issue of rented land in the Northeast are the problems associated with cultivation by farmers who lack clear legal titles to their land. In recent years, the Department of Land in the Ministry of Interior has been carrying out a program of issuing certificates of land occupancy based on aerial photography. While less exact than titles based on traditional cadastral surveys, the "Nor Sor Sam Kor" (Certificate of Utilization) currently being issued provides a record of land-holding. It also serves as a document which can be used as collateral for borrowing money for investment in agricultural inputs from public and private institutional sources.

Most of the land currently being registered in the Northeast falls into the categories of "lower" and "upper" paddy lands--the former being flooded and planted in rice each year, the latter offering possibilities of growing either paddy, upland rice, or other upland crops, depending on water conditions and the farmer's choice in a given year. The potential for land tenure problems arises in upland areas which have been put into cultivation (especially kenaf and cassava) in recent years.

An analysis of large samples of agricultural households of several provinces in the Northeast has been carried out in the last two cropping years by the Department of Land Development. The analysis reveals that in settled village areas the proportion of farmers growing either kenaf or cassava ranges from zero in many areas which are poorly suited for upland crops to almost universal cultivation of either or both of these crops in areas where suitable land can be cleared and cultivated. Thus, often in the same amphur (e.g., in the case of Muang district of Khon Kaen Province), in some villages each one of the twelve randomly selected agricultural households grew

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23. In Korat (Nakhon Ratchasima) and four nearby provinces (Chaiyaphum, Buri Ram, Surin and Maha Sarakham) which have better-than-average access to Bangkok input and project markets, an average of 15 percent of agricultural households rent in at least <u>some</u> of their land. The comparable percentage for more distant provinces in the region is about 5 percent.

24. There is an extensive and inconclusive literature describing landlord-tenant relationships as they relate to the issues of economic efficiency and productivity. Because relatively little land is rented in Northeast Thailand, we do not address this issue.

Table 1. Total Land Agricultural Holdings and Tenure Status by Region and for Northeastern Provinces, 1973

	Total Area (in rai)	% of Land in agricultural holdings	% of area of agricultural holding rented	% of agricultural households renting in
Thailand	321,149,000	35.16%	12.25%	20.84%
Central Region	64,636,875	42.20%	29.27%	41.31%
South Region	43,868,125	31.20%	4.42%	17.48%
North Region	106,252,750	21.83%	15.74%	26.71%
Northeast Region	106,391,250	45.86%	3.27%	8.68%
Kalasin	4,781,250	49.25%	2.02%	5.40%
Khon Kaen	8,377,500	49.85%	2.20%	5.66%
Chaiyaphum	6,742,500	37.99%	5.82%	17.38%
Nakhon Phanom	6,093,125	31.42%	1.35%	5.58%
Nakhon Ratchasima	12,243,750	48.07%	5.56%	14.30%
Nong Khai	4,514,375	39.46%	2.07%	8.95%
Buriram	6,731,875	61.02%	7.34%	17.84%
Mahasarakham	3,600,000	77.37%	2.45%	10.98%
Yasothorn	2,781,875	57.12%	1.39%	N.A.
Roi Et	4,910,000	61.08%	2.06%	5.24%
Loei	6,835,000	10.60%	0.51%	1.51%
Srisaket	5,508,125	46.84%	2.34%	6.67%
Sakol Nakhon	5,961,875	40.88%	1.45%	3.55%
Surin	5,490,000	57.51%	3.56%	10.96%
Udorn Thani	10,378,125	47.49%	3.17%	5.86%
Ubonrachathani	11,441,875	42.06%	1.95%	5.25%

Source: Compiled from Statistical Bulletin No. 1009, "Holding Areas and Agricultural Households in Thailand", Agricultural Land Reform Office, November 1976.

kenaf while in other villages in the same district not a single household in the sample grew kenaf; similar contrasts in cassava cultivation are found as well.

There is great diversity within districts (see Table 2) and even tambols

TABLE 2 LAND TENURE STATUS AND PLOT SIZE FOR FARMERS GROWING CASSAVA AND KENAF IN 4 NORTHEAST PROVINCES, 1977-78 AND 1978-79

Provinces	No. of villages sampled	No. of rural households sampled	% growing cassava and/or kenaf	Cassava: % of sample growing cassava	Cassava: Average no. of rai in cassava	Cassava: % of sample without registration*	Cassava: % of area without registration	Kenaf: % of sample growing kenaf	Kenaf: Average no. of rai in kenaf	Kenaf: % of sample without registration	Kenaf: % of area without registration	% of farmers growing both kenaf & cassava	% of farmers growing neither
Khon Kaen (1977/78)	32	384	47.9%	29.6%	8.3	34.2%	39.7%	28.6%	5.7	19.0%	15.4%	10.3%	52.1%
Udornthani (1978/79)	34	312	44.2%	29.5%	13.3	42.7%	46.0%	26.3%	7.0	36.6%	47.3%	11.6%	55.8%
Roi-Et (1978/79	24	288	30.2%	20.1%	4.8	34.5%	22.8%	14.2%	4.3	9.8%	9.6%	4.1%	69.8%
Surin (1978/79)	29	360	25.8%	2.2%	10.4	-	-	25.3%	4.1	16.5%	20.9%	1.7%	74.2%
4 Provinces	109	1,344	37.4%	19.5%	9.5	35.5%	39.2%	24.1%	5.7	21.6%	25.5%	6.2%	62.6%

SOURCE: Calculated from unpublished data gathered by Land Policy and Planning Division, Land Development Department, Ministry of Agriculture and Cooperatives, and compiled under the direction of Mr. Prajiad Busari. Raw data is available for 6 other Northeast Provinces.

* "Without registration" means here that the farmer does not possess any title deed (chanoot), certificate of utilization (Nor Sor Sam or Nor Sor Sam Kor), certificate of occupancy (Sor Kor Nyng) or Permit of Temporary Occupancy (Bai Cap Cong). In many case however the farmer may have a receipt for the nominal local development tax (Phor Bor Tor Hok) paid to the tambol headman.

as to the proportion of cultivators growing these two most important cash crops. Clearly, the estimate of 39.2 percent and 25.5 percent, respectively, of cassava and kenaf areas being cultivated without registration is a matter of concern. Farmers who raise crops on unregistered land may have little incentive to manage the soil appropriately or to use productivity and income-enhancing inputs. Further, without an appropriate certificate of registration, such lands cannot be used as security on which farmers can borrow money for land improvement or other productive activities from either public or private lending institutions.

Where incentives and opportunities for environmentally and economically rewarding soil management and input use are absent, farmers may be expected to deplete the fertility of a field and then clear more brush, pasture or forest lands for new fields.[25] This accelerates deforestation, soil erosion and watershed degradation.

While it is impossible to document the full extent to which forest and other public land has been cleared and planted in upland crops in the Northeast in recent years, it appears plausible on the basis of the evidence discussed above that half or more of the cassava grown in that region in the recent boom has been on land which has been cleared in a technically illegal fashion. This raises a number of potential concerns for more detailed investigation in the course of planning further development of Northeast rainfed agriculture. These concerns are likely to be especially critical in considering cropping systems that may include cassava:

1. Destruction of Forest and Watersheds. Programs involving support of upland crops should investigate carefully the likely effects of improved varieties, technology and other inputs, markets cropping and farming systems which might effectively provide higher financial rewards for destruction of the Northeast's already greatly diminished forest land.

2. Incentive for Soil and Water Conservation. In areas that have already been cleared and may not be technically or financially feasible for early reforestation, cultivation practices by farmers expecting to use the land for only three or four years are likely to be directed almost ex-

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25. The extent of clearing of upland areas for cassava cultivation has been especially rapid in certain areas which were unsettled until quite recently. Thus in Public Land Section No. 270401 in District Phorncharern in Nongkhai Province, a 1977 Agricultural Land Reform Office study found more than 16,000 rai of a total area of 33,796 had been planted to cassava, in addition to some 3,400 rai to rice. In the entire area, only one individual held a legal certificate of occupation, while 491 farmers had no more than a tax receipt (Phor Bor Thor Hok). The ALRO report (Discussion Paper No. 22, dated June 24, 1977) notes that only seven of the holdings were of sizes above 100 rai, with all these seven combined totalling some 900 rai.

clusively at maximizing short-run cash income. Various land improvement, water management, fertilization and soil-improving cropping systems that offer a return on investment in cash and labor only over several crop seasons will be less attractive to farmers who feel they have little assurance of future access to land. The government agencies concerned might consider the advantages and disadvantages of offering a greater degree of security to small-holders who have cleared family-size plots; such a policy would provide an incentive for farmers to refrain from migration and additional clearing in other areas. By use of soil and water conservation practices made more attractive by security in the land, small-holders may be able to take advantage of appropriate inputs and technology to increase the long-run productivity of existing upland plots.

3. Access to Inputs. Since most government agencies are reluctant to provide extension services to farmers who are regarded as illegal squatters, it is possible that there would be severe problems of delivery of technology and other inputs to a larger portion of farmers growing cassava and other upland crops if they continue to clear and cultivate land for which they hold no legal tenure document. Certain technology packages that are highly profitable might spread rapidly enough through the private sector, but access to institutional credit for major inputs might remain a major obstacle to adoption of more productive land-conserving methods.

The Department of Land Development sample survey shows that only a minority of Northeastern farmers have been growing cassava and kenaf; this conclusion is given further support by the 1978 crop year figures for areas planted in major crops, provided by the regional MOAC office at Khon Kaen.

Table 3 on the next page presents the figures for several of the provinces, as well as for the Northeast as a whole, and for the Northeast with the exception of Nakhon Ratchasima, whose relatively large areas in cassava, maize, and beans may make the Northeast as a whole appear to be more diversified agriculturally than most of its provinces really are.

The continued heavy reliance on rice in many of the Northeast's poorer provinces underlines the argument that a broad-based rainfed agricultural program in this region must address the problem of reducing the area which the farmer feels he must devote to rice to meet his family subsistence requirements. A strategy which provides higher yielding and drought/flood resistant glutinous and non-glutinous rice varieties and cultural practices without requiring substantial additional investment in inputs would enable the near-subsistence farmer to allocate at least some of his "upper paddy" land to upland crops as technology, inputs and markets for these crops expand over time. If he can be brought to do this on land

Table 3: Percent Agricultural Area Planted to Selected Major Crops in Seven Northeastern Provinces

	Rice	Kenaf	Cassava	Maize	Legumes*	Other Major Crops**
Nakhon Ratchasima	47.8%	2.0%	23.3%	22.9%	2.9%	1.1%
Khon Kaen	72.5	7.9	10.7	5.8	1.1	2.0
Udorn	74.7	7.5	7.1	5.5	0.6	4.6
Srisaket	81.9	6.1	1.1	7.6	3.4	0.0
Mahasarakham	84.2	5.7	9.1	0.1	0.2	0.7
Surin	91.2	5.6	2.3	0.2	0.6	0.1
Roi-Et	94.5	2.2	2.5	0.2	0.4	0.0
All of NE	76.8%	5.1%	7.9%	7.1%	1.6%	1.5%
NE excluding Nakhon Ratchasima	81.4%	5.6%	5.5%	4.5%	1.3%	1.7%

* Peanuts, Soy Beans, and Mung Beans
** Sugar Cane, Cotton, Sesame, Sorghum and Jute

Source: Calculated from unpublished provisional 1978 crop-year data gathered by the Northeast Regional Office (Khon Kaen), Department of Agricultural Extension, MOAC.

which clearly belongs to him (i.e., ordinarily with Nor Sor Sam), he will have new opportunities for sustained income and productivity growth without exacerbating the problems of watershed and timber destruction.

3.7 Marketing and Processing

Northeastern farmers earn the bulk of their non-wage cash income from the sale of livestock, rice, cassava and kenaf. We foresee the addition of

groundnut and possibly mungbean to that list and a consequence of a successful rainfed agriculture program.

3.7.1 Rice Marketing

The Thai private sector is considered by many to be relatively efficient in rice marketing. The particular rice marketing problem of the Northeast appears to lie in transmitting the effective export price to the farm gate and in finding international markets for glutinous rice. These are macro policy measures which are not subject to intervention within the scope of this paper.

3.7.2 Cassava

The rapid supply response of the Northeastern farmer and the private sector to the export opportunities for cassava are deserving of great respect. We see three areas of concern and opportunities for improvement in cassava marketing:

1. The price of cassava products in Bangkok and at the farm gate in the Northeast has shown a high degree of instability.

2. A strong domestic market for cassava and cassava products has not been found.

3. Farmers do not receive a price for cassava based on an objective measure of the quality of the product they deliver.

The potential role of an area-based rainfed agricultural development project in addressing the second and third points should be an important item on the agenda of the project design team. Improvements in local utilization (for animal feed or alcohol) and the establishment of a grading system which provides farmers with incentives to earn higher income through better cultural and harvesting[26] practices need not depend on a political solution with the EEC.

3.7.3 Kenaf

Kenaf, like cassava has been heavily dependent on international markets. In recent years Thai domestic demand for kenaf has grown relative to production. The possibility of using kenaf as an input to a domestic paper pulp industry is encouraging.[27] In the short run, however, kenaf demand will be dominated by the demand for traditional uses of kenaf and jute.

We understand that fiber quality is a problem in the international market for kenaf products. The potential for improved on-farm processing and grading of fiber should be explored and evaluated.

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26. See especially the introductory chapter to the "KKU-IDRC Cassava/ Nutrition Project".

27. See Kenaf for Paper Pulp in the Lower Mekong Basin by Joseph E. Atchison Consultants, Inc., May 1976.

3.7.4 Livestock

Reference to livestock marketing problem has been made in Section 3.3 above.

3.7.5 Groundnut

If groundnut is to become an important source of income and productivity growth, the farmer must be assured of a price which reflects true market value for his product. At present, we are told, the principal demand for groundnut is as a confection, and not as an oil seed. We have also heard that both the private and the public sector are establishing groundnut oil extraction facilities in the Northeast. It will be essential that the project design team explore the existing market and processing facilities for groundnut and provide for an interim marketing arrangement at project sites, if the private sector is not immediately responsive.

3.8 Project Approach, Extension, and Site Selection

As discussed in earlier sections of this Chapter, we believe that the elements of productivity and income enhancing set of packages of upland and lowland cropping practices have been identified and offer sufficient promise to warrant careful on-farm testing at appropriate project sites. The likelihood of developing suitable packages and chances of their success will increase substantially, if the proposed research and other preparatory activities are undertaken immediately.

3.8.1 Project Approach

At any point in time, there are bound to be certain gaps in knowledge as well as in the skills and methodologies for their potential extension and application. Such gaps do exist and will continue to exist in developing suitable packages for Northeast rainfed agricultural development. Additionally, the packages must be site and time specific and thus they may vary greatly in composition and emphasis for different locations (e.g. differences in rainfall patterns, soil moisture conditions, accessibility to markets, extension, and other services and so on) and change somewhat for the same site from one period in time to another.

Agricultural and rural development should go hand in hand with each other. However, to ensure a desirable distribution pattern of productivity and income gains according to target groups, an area development strategy and methodology are indispensable. The scope of activities and programs -- agricultural and non-agricultural -- included in, and the success (or otherwise) of an area development approach, may necessitate selective changes in institutional and organizational behavior so that critical resources can be brought to bear on this process. Institutional innovations and organizational creativity in designing appropriate interventions are a key to successful mounting of an integrated approach. These considerations call for a building block and continuously evolving approach. A suitable monitoring and performance evaluation system should provide the needed feedback.

In light of the above discussion, it is desirable that the Northeast rainfed agricultural development project should have built-in flexibility and openendedness, especially with regard of resources between different activities and objects of expenditures. We feel that action oriented, experimental/pilot projects should be undertaken in two districts in each of the two selected provinces in the first year. The experience gained from this intensive effort would permit an extension of the project to one additional province each year thereafter for four years.

The role of the action oriented experimental/pilot projects in area based agricultural/rural development strategy is a very crucial one.[28] Since availability of tried technology, supplies of materials and skilled manpower, and institutional/organizational changes and innovation must operate within various degrees of severity of constraints, the experimental/pilot projects have a distinct role to play regarding decisions to replicate or multiply projects in large numbers. Such projects can serve three useful functions: (1) they can prove the effectiveness of a certain kind of approach; (2) they can furnish experience in learning about problems related to such an approach; and, (3) they can serve as training grounds for personnel to organize and administer similar programs.[29] It is pointed out that the experience with pilot projects has not been very satisfactory because:

> ...pilot projects have been conceived by foreign experts as development "models" and, in effect, imposed in communities from the outside. Once the foreign expert is withdrawn such projects soon disintegrate. Another common weakness of pilot projects is that there is no built-in mechanism by which lessons learned from these projects are reflected in the regional or national programs.[30]

3.8.2 Extension

It was argued in Section 2.1 that if no substantial gap exists between actual and optimal or potential production, there is only a limited value in extension work. The approach advocated in this paper is one of gap creation through the perfection and packaging of new agricultural technology.[31] It

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28. Dennis Rondinelli suggests that the sequence in which projects should proceed is experimental to pilot to demonstration. In this process more understanding and lessons learned are built into project design and implementation successively.

29. A.T. Mosher, Projects of Integrated Rural Development (Agricultural Development Council Reprint Series), p.6.

30. Asian Development Bank, op. cit., p. 223.

31. Gap creation is also possible through the market mechanism and through the agency of institutional change. The project design team may wish to explore these gap creating opportunities in greater depth.

has been argued that an effective gap creation strategy for Northeast Thailand requires an area based approach. Little has been said about gap closing and the actual realization of potential productivity and income gains by real farmers.

We envision that the Department of Agricultural Extension will make an important contribution to gap closing in the contemplated rainfed agriculture project. The details of Extension's role are properly a topic for consideration by the project design team. However, it is appropriate at this time to suggest that an area based approach has the potential to capitalize on the present strengths of Extension and to provide needed on-the-job training which will improve the ability of the extension agent to meet farmers' needs.

We envision an organization of researchers, extension workers and project staff who will focus on the problems of on-farm testing and package design. In this process, extension workers will be expected to apply their formal education to farm level problems (including package design) and to acquire (1) an appreciation of farmers' problems, and (2) an actual capacity to use and modify the packages of recommended practices.

Once specific packages of practices which meet on-farm needs have been developed at project sites, extension workers from other areas of the same and neighboring provinces can be trained in the use of the new techniques. This training could be coordinated with farmer training programs. By training farmers and extension workers side-by-side, an environment is created in which each can learn from the other. Those extension workers who have participated in on-farm testing and package improvement and who have acquired the necessary farming skills at one project site can be deputed to non-project districts and/or to a replication of the project approach in another province.

The appropriateness and potential effectiveness of this approach to using extension agents must be evaluated by the project design team.

3.8.3 Site Selection

The issue of site selection is critical to the structuring of an efficient, action oriented, replicable, potentially successful, rainfed agriculture project for Northeast Thailand. RTG and USAID officials should give immediate consideration to the selection of an initial two provinces. We have considered a broad range of criteria for site selection and have broken the issue into two elements:

1. choice of provinces; and

2. selection of Districts within provinces.

Choice of Provinces

We have concluded that the selection of the initial provinces should be based on the level and rate of growth of provincial per capita income,

paddy fields, the riskiness of paddy production, access to research facilities with a developed competence in rice and field crops and rainfall pattern.

Estimates of the level and annual growth rate of gross domestic product by province are given in Annex III. Estimates of paddy yield and risk by province are given in Annex IV. The provinces were ranked from highest (1) to lowest (15) for per capita income, rate of growth of per capita income and paddy yield. They were ranked from lowest (1) to highest (15) on the measure of paddy risk. The rankings for ten selected provinces are presented in the following table. The un-weighted sums of these ranks are given under the heading "Indicator Sums". (See Table 4 on the following page.

The "Indicator Sums" for Roi Et, Si Sa Ket, Maha Sarakham and Surin are high relative to the others, indicating that they compare poorly with the remaining Northeastern provinces in the categories of per capita income, rate of growth of per capita income, paddy yield, and variability in paddy yields.

The category "Access to Research" has been added in recognition of the fact that we contemplate a "technology driven" gap creation strategy to be most likely to bring income and productivity gains to the rainfed Northeast. Provinces lying within the triangle formed by the research stations at Khon Kaen, Ubon, and Pimai were given a plus; the provinces lying on the edge or outside of that triangle were given a minus; and the provinces of Khon Kaen, Ubon, and Korat were given a zero. The theory behind ranking is that the combined research from these stations will have a greater potential gap creating effect on the provinces lying within the triangle than at the corners or on the sides. We did not give explicit consideration to logistical questions such as transportation and housing of project personnel.

The issue of establishing a headquarters province which is reasonably centrally located and well connected in terms of communications with the remainder of the Northeast and Bangkok is important. It is also important to consider that some areas of the Northeast have a typically bi-modal monsoon rainfall pattern and others have a typically uni-modal distribution. Broadly, the provinces of Ubon, Si Sa Ket and Surin experience a uni-modal rainfall distribution, the remainder of the Northeast having a bi-modal distribution of some sort.

On the assumption that the rainfed project will begin in two provinces, we suggest that the RTG and the USAID consider one in the Si Sa Ket - Surin area where the poverty and risk indicators are high and the rainfall is uni-modal. A logical second province would be in the bi-modal, central area of the Northeast. Among that group of provinces, Roi Et and Maha Sarakham exhibit a high degree of poverty. Khon Kaen, though not high ranked in the poverty index should also be considered because of its advantages as a headquarters site.[32]

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32. Since replication of the project to additional provinces is anticipated from the second year, it is not essential that a project "headquarters" be located in one of the first provinces selected.

TABLE 4: PROVINCIAL SITE SELECTION INDICATORS

Province	* Per Capita Income	* Income Growth Rate	* Paddy Yield	** Paddy Risk	§ Indicator Sums	§§ Access to Research
Korat	2	9	9	7	27	0
Khon Kaen	7	10	11	9	27	0
Maha Sarakham	12	14	13	9	48	+
Yasothon/Ubon	5	8	15	4	32	0
Kalasin	11	5	7	4	27	-
Si Sa Ket	15	13	12	14	54	-
Surin	13	11	10	14	48	-
Buri Ram	10	15	5	12	42	-
Chaiyaphum	9	8	2	6	25	-
Roi Et	14	12	14	15	55	+

* Ranking from highest to lowest among the 15 Northeast provinces.

** Paddy risk is judged on the basis of the ratio of the standard deviation of annual yields to average yield over the period 1963-77. Ranking is from lowest to highest.

§ Sum of the four ranked indicators.

§§ (+) denotes provinces lying within the triangle formed by Pimai, Khon Kaen and Ubon rainfed research facilities, thus presumed to be provinces in which some of the area specific research from all three stations may have applications;
(0) denotes the provinces in which the three major research stations are situated;
(-) denotes provinces lying on the edge or outside the Pimai-Khon Kaen-Ubon research triangle.

Selection of Districts

It is proposed that the initial provinces be selected by mutual agreement between RTG and USAID officials at the earliest possible date. After this has been done, the experience and data resources of the National Statistical Office, the Office of Agricultural Economics, the Departments of Agricultural Extension, Agriculture and other Departments of MOAC can be directed to the issues of selecting two appropriate districts in each of the selected provinces. It is anticipated that a comprehensive set of data on the districts of the selected provinces can be assembled from existin sources and made ready for careful consideration by the project design team even before that team makes field visits. In this way, the project design team will be able to focus most productively on the issue of district selection. The team will also be better able to judge the potential impact of technical and institutional innovations and to give fuller consideration to other design details. See Annex XX for our suggested criteria/guidelines on district selection.

3.9 Problems for Immediate Attention

There are several issues which should be addressed jointly by RTG and USAID within the next several months. Among them is the issue of the selection of the first two provinces and the acceleration of research and field testing which will add to the stock of knowledge about promising new techniques for the selected provinces.

3.9.1 Site Selection

As stated in Section 3.8.3, RTG and USAID officials should give immediate consideration to the selection of the initial two provinces. Once these provinces are named, informational resources about those provinces can be brought efficiently to the attention of the project design team which should be responsible to pick two districts in each province for project initiation. In anticipation of placing a project design team in the field by January 1980, we urge RTG and USAID officials to refer to our comments on the criteria for province selection and to name the two initial provinces not later than mid-September 1979.

3.9.2 Additional Research and Field Testing

We feel that the potential for the effective on-farm testing and packaging of the new techniques which we have identified as being keys to increased incomes and productivity will be enhanced by an accelerated level of research and field testing in the 1980 rainy season (or sooner, where applicable). The following items are listed with our judgement as to their relative priority.

1. An extensive set of field tests using direct seeding of photoinsensitive paddy varieties, on typical rainfed fields should be conducted in the selected Provinces. Each test should have a local variety, photosensitive check plot. Most plots should use fertilizer applications not radically different from those used by farmers on their traditional varieties. We believe that the Rice

Division can design and carry out these field tests with their present personnel. If additional budgetary resources are required, an appropriate donor should be approached. The principal objective of these experiments should be:

(1) to test the hypothesis that photo-insensitive varieties planted at a date which will maximize the likelihood of their flowering in a period of heavy and sustained rainfall will yield more and be less risky than is the case with traditional photo-sensitive varieties;

(2) to evaluate alternative seeding techniques (including transplanting where appropriate; and

(3) to evaluate weeding problems.

2. Extensive field tests using azolla with various appropriate levels (including zero level) of phosphorus and potassium should be conducted under a variety of typical conditions in the selected provinces. These tests will not be equivalent to on-farm tests since the researchers who conduct them will not be concerned with azolla seed supply for an entire community, the problems of straight phosphorus (and potassium, if necessary) fertilizer supply or possible negative impacts of azolla multiplication on tank fisheries. Simultaneously, Thai researchers may wish to engage in the following non-site specific activities with respect to azolla:

(1) isolation of pure native azolla strains in the laboratory for the purposes of identifying and evaluating strains with different characteristics of vigor, nitrogen fixing capacity, growth rates, etc.;

(2) visitation by Thai biologists and scientists of the Fertilizer Branch of the Rice Division to azolla research facilities at IRRI and in Hawaii, California, and China; and

(3) the effects of phosphorus fertilization and azolla seed multiplication on fish populations.

We suspect that the Rice Division's budget for azolla research is limited, and that if this research is to be pursued on a desirable scale, external resources will be required.

3. Field tests of traditional and new promising groundnut varieties together with an appropriate fertilizer response test and planting date design should be initiated in the selected provinces. The effects of side-dressed gypsum (calcium sulfate) at the time of "pegging" and before should be the focus of the fertilizer tests. In addition to recording the yields from these tests, the quality of the groundnuts for both traditional uses and as oilseed should be judged.

4. Soil-plant-water relationship research should be initiated at the initial project sites as soon as a decision has been reached on the districts and provinces for initial project implementation. This research should follow the lines suggested in the final paragraphs of Section 3.1.1. We have seen and briefly reviewed a proposal by the Field Crops Division of the Department of Agriculture which would staff, equip and fund a significant research effort in the area of soil-plant-water relationships. Their proposal indicated a need for foreign material, training and technical assistance which appeared compatible with the resources and abilities of U.S. academic institutions (and possibly with those of ICRASAT). Interim financing of such a project with research objectives initially limited to site specific problems in the selected provinces could serve the joint needs of a Northeast rainfed agriculture project and assist the Department of Agriculture in launching a broader, more comprehensive research activity sponsored by whatever donor might be most appropriate.

5. This report holds out the prospect that groundnut and other legumes might replace some of the area presently under cassava and kenaf in the Northeast. For the purposes of planning input requirements, potential export earnings, shifts in land utilization and regional (and sub-regional) income impacts from a high yielding groundnut package, the Office of Agricultural Economics might be requested to use its Northeastern Regional Model under several reasonable alternative sets of product prices and potential groundnut productivity coefficients.

6. Research of Khon Kaen University suggests that maize may be economically replaced by cassava and fish meal in swine and poultry rations. If groundnut is to become an important crop in the Northeast, it would be desirable to begin exploring the potential for swine, poultry and cattle feeds using cassava and groundnut cake as a replacement for maize. We understand that the IDRC assistance to the KKU Cassava/Nutrition Project has terminated. It is not clear whether personnel, equipment and budget allocations now at KKU are adequate to undertake the proposed research or whether external resources would be necessary and desirable.

IV. INSTITUTIONAL, ORGANIZATIONAL, AND ADMINISTRATIVE ASPECTS

4.1 Agriculture and Area Development: Institutional Linkages

As discussed in Chapter II, if agricultural development strategy in the Northeast is to be successful, it must be based on the recognition and understanding of the inter-relationships between technology, institutions, and organizational behavior. In the design and formulation of agricultural development projects and implementation thereof, early consideration must be given to:

1. Identification of a set of programs, their sequencing, phasing, and locations.

2. Identification of organizational and institutional devices needed to execute the programs and projects.

Although agricultural development is the principal mechanism by which the target group's problems are addressed, its linkages with rural and area development strategies must be taken into consideration in designing alternative organizational and administrative devices. To the extent that these linkages can be foreseen and inter-institutional relationships are feasible, it is important that organizational and administrative arrangements for agricultural development be so devised as to complement the other elements of rural and area development programs.[1] Among others, there are two major national programs (specifically aimed at area development) currently or soon to get underway, namely, the Provincial Planning and Development and the Program for Development of Under-developed Rural Areas of Northeast and North Thailand (to be financed from the recently approved Sixth Year Loan from the Government of Japan). Both these programs imply strengthening vertical and horizontal coordination among governmental agencies, developing institutional, administrative, and decision-making capacities at provincial and local levels, and attempting new mechanisms for resource allocation on area based development programs.

Administration must be viewed as an important dimension of development, not an appendage. To separate administration from development is a necessary analytical abstraction. Reassembled into the whole, administration and institutions are the development process in action.[2]

4.2 Opportunities for Project Management

An integrated (systems) approach for this project is essential. Such an approach requires an "active, continued cooperation among peer-group multifunctional specialists which allows new plans and solutions to emerge from

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1. A recent World Bank Report stressed four major organizational prerequisites to ensure success of a rural development program:
   1. A national plan or program of action for rural development, together with supporting national and regional policies and adequate center-local financing arrangements.
   2. A strong organization at national level to coordinate vertically organized, central government sectoral departments.
   3. Greater decentralization with effective machinery at the regional and local level to coordinate the sectoral activities of national departments operating in the region and regional and local departments.
   4. Participation by the rural poor in the planning and implementation process through local government, project advisory committees, cooperatives and other forms of group organizations.

   (World Bank, "An Abridged Paper on Rural Development" --mimeo, p.17)
2. Guy Hunter, "Administration and Institutions", report prepared for the Asian Development Bank (mimeo) in connection with the Asian Agricultural Survey, 1976.

iterative attacks upon a commonly-defined program."[3] It must be conceded that active and continual cooperation among different agencies/departments is not easy to achieve. One solution that holds great potential is a unified "project budget which funds active participation by various agencies under one overall budgetary mechanism." [4] It is interesting to note that such an approach is envisaged in the implementation of the aforementioned Program for Development of Under-developed Rural Areas of Northeast and North Thailand. We believe that a unified project budget mechanism is feasible within the existing resource allocation process in Thailand.

The practice of assigning or seconding staff from different agencies/departments to a project or a committee has often been employed in Thailand These efforts are aimed at, among other things, facilitating coordination of pre-implementation planning. We believe that the inter-disciplinary and inter-departmental staff that may be assigned to the Northeast Rainfed Agricultural Development Project should devote a substantial proportion of their time to the project. In other words, staff participation on the project should not be an"add-on" to their existing responsibilities and on-going activities. Provision of consolidated office space for the project staff would facilitate identification with and commitment to the project purposes. Sharing common space and facilities will provide an environment likely to foster coordinated problem-solving approaches.

To ensure effective planning, programming, management, and execution of the Northeast Rainfed Agricultural Development, we propose the following organizational and administrative arrangements (See also Annex XVIII), for review by the Royal Thai Government and the USAID Mission. These preliminary proposals are offered to initiate an early discussion of one of the critical elements in our conceptual framework and strategies.

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3. Development Alternatives, Inc., Rural Development Strategies in Thailand: A Review of the Organization and Administration of Rural Development for AID (June, 1979), p. B-1.
4. Ibid., p. B-2.

1. A National Rainfed Agricultural Development (NRAD) Policy Committee be Established

A. Composition

1.	Under-Secretary of State, MOAC	Chairman
2.	Director General, Department of Agriculture	Member
3.	Director General, Dept. of Agri. Extension	"
4.	Director General, Department of Land Development	"
5.	Director General, Department of Fisheries	"
6.	Director General, Department of Livestock	"
7.	Secretary General, Office of Agricultural Economics	"
8.	Director, Projects Division, Office of Under-Secretary of State, MOAC	"
9.	Director, Northeast Agricultural Center, Tha Phra	"
10.	A representative of NESDB	"
11.	A representative of DTEC	"
12.	Full or Part-time staff to be designated by the Under Secretary of State, MOAC	Secretary

B. Duties and Responsibilities

1. Set policy guidelines, administer, command, and solve problems arising from execution of agricultural development programs.
2. Select Provinces, and designate sites.
3. Approve programs submitted by the Provincial Agricultural Development Committees (PADC), approve budgets for each province.

2. Technical Secretariat or Office of Rainfed Development be Established in the Office of Under-Secretary of State, MOAC

A. Composition

1.	Secretary of NRAD	Project Director
2.	Agronomist(s)	Staff
3.	Agricultural Extension	"
4.	Regional Planning and Area Development Specialist	"
5.	Agricultural/Development Economist	"
6.	Agricultural Engineer	"
7.	Other staff as required	"

B. Duties and Responsibilities

1. Provide staff function for NRAD and administer the project.
2. Prepare plan of operations for approval of NRAD.
3. Review work programs submitted by each of provincial agricultural development committees.
4. Provide technical assistance to PADC in respective provinces.
5. Monitor and evaluate the agricultural development activities in respective provinces and make recommendations to NRAD for revising and/or detailing policy guidelines.

6. Contact persons or organizations for assistance and provide linkages with other rural area development programs.
7. Be the counterpart agency and staff of foreign experts in respect to rainfed agricultural development projects.

3. Provincial Agricultural Development Committee (PADC) be Established in Each Selected Provinces

A. Composition

1.	Governor	Chairman
2.	Deputy Governor	Vice Chairman
3.	President, Provincial Council	Member
4.	Provincial Administrator	"
5.	Provincial Agricultural Extension	"
6.	Provincial Treasury Officer	"
7 - 10.	Provincial/Regional Representatives from Fisheries, Livestock, Agriculture, and Land Development Departments of MOAC	Members
11.	Full or part-time staff to be designated or appointed by the Project Director, NRAD in consultation with the Governor	Secretary

B. Duties and Responsibilities

1. Formulate detailed work program for agricultural development activities in the designated districts or subdivision thereof for submission to NRAD.
2. Prepare budgets in respect to the above for submission to NRAD.
3. Coordinate agricultural development projects with other related activities in the Province.
4. Facilitate inputs, advice, and assistance from other agencies.

4. Provincial Agricultural Development Office be Established in Each of the Selected Provinces

A. Composition

1.	Secretary, PADC	Project Manager
2.	Full or part-time inter-disciplinary staff, e.g., extension, soils, engineering, economics, etc.	Staff

B. Duties and Responsibilities

1. Provide staff function to PADC, execute and administer the program.
2. Undertake on-farm testing and assist in the development of cropping and/or farming packages for specific sites.
3. Prepare periodic report for the Office of NRAD.

The exact organizational form and administrative arrangements are properly the joint responsibility of the MOAC and those who will write the Project Paper. We hope that the above structure will serve as a useful point of departure for that process. Finally, we feel that both the MOAC and the USAID should develop the organizational and administrative arrangements in a way which will permit and facilitate positive interaction and cooperation with activities which will be forthcoming under the Provincial Planning Project and the Sixth Yen Loan Projects.

V. SUMMARY AND RECOMMENDATIONS

1. Despite an economic growth record of which Thailand must be proud, the per capita income in Northeast Thailand lags seriously behind other regions. Equally distressing is the fact that much of the Northeast's past growth has been built on a rapid expansion of the area under cultivation and an increasing reliance on cash crops for which the world market is uncertain, at best. Exhaustion of the land frontier and the twin risks of crop failure due to weather and price failure due to international events suggest that new sources of income and productivity growth must be found for the rainfed Northeastern farmer.

2. We see little prospect of dramatic improvements in rural incomes and agricultural productivity based on the simple technological innovations

which have fueled the "green revolution" elsewhere in Asia. However, we have seen what we feel are some keys to improved incomes and productivity in both paddy and upland crops. For paddy, the use of azolla as a technique of biological nitrogen fixation and the use of direct seeding of photo-period insensitive varieties timed to flower at the time of optimal soil moisture appear to have promise. Both innovations have the potential to increase yields at little or no additional risk to farmers. For the upland farmer, appropriately fertilized groundnut may compete vigorously with kenaf and cassava while providing farmers with a soil building crop which is less subject to wide fluctuations in international demand. Other, complementary potentials appear to exist in the areas of supplemental irrigation development (and water management), livestock and fisheries.

3. Technological innovations are seldom adoptable by farmers in the exact form they are discovered by research workers. Before packages of practices using azolla, direct seeding of paddy and groundnut are recommended, they need to be subjected to an intensive round of on-farm testing. On-farm testing differs from field testing in that it examines the impact of an innovation in the context of present farming systems and the market/institutional support structures which presently exist or which may need to be provided in order to encourage adoption.

4. The productivity of technological innovations is seldom fully realized without institutional change and support. Better, more stable product prices and timely supply of required inputs at assured prices should continue to be a regional and national policy goal. Further, government may need to speed up the process of granting land titles on which farmers can obtain credit for farm improvements. Finally, where technical services, extension, input supply and marketing constraints need to be overcome before a new farming practice or item of technology can be adopted, government may need to make the required special arrangements.

5. Given the area specific nature of agricultural research, the need for on-farm testing of technological innovations, the requirement that recommended package of practices fit farmers' area specific needs and the need for institutional innovations to supply inputs, provide incentives, etc, we feel that an area-based approach to a rainfed agricultural development project is essential. An area-based approach is an opportunity framework within which the keys to income and productivity growth can be tailored for the benefit of and rapid adoption by farmers.

6 Both the RTG and the USAID are rightly concerned that a project to improve income and productivity in the rainfed areas of the Northeast should be extended as rapidly as possible to all provinces. We agree. The spread of the project must recognize the area specific needs for:

   a. on-farm testing;
   b. packages of appropriate, adoptable packages of practices; and
   c. institutional innovations.

In view of these realities, we propose that the project begin initially in two districts in each of two provinces and expand to one additional province in each of the four following years. After five years, six provinces would be included. Clearly, adoptable packages of practices and institutional innovations are free to spread beyond the districts and provinces in which they are introduced, as rapidly as their suitability and the availability of supporting inputs permit.

7. If growth in incomes and productivity are to be sustained and are to reach farmers with diverse resource endowments in the entire Northeast, a continuing flow of new technology and institutional innovations is required. This will require an enhanced level of input and commitment for agricultural research in Northeast Thailand by both the RTG and international donors.

8. We feel that the following steps or sequence of events should be considered jointly by the RTG and the USAID:

   a. Comments on this paper from RTG, USAID and others are in order. We will respond to those comments as best we can.
   b. If the RTG and USAID believe that this paper constitutes an appropriate theme or theory on which a rainfed agricultural development project can be built, representatives of the RTG should sit together with USAID personnel to write a Project Identification Document, to be completed in September, 1979.
   c. Based on this paper and the Project Identification Document, terms of reference for a Project Identification Team should be drawn up jointly by personnel for the RTG and USAID. That team might be placed in the field as early as January, 1980 and produce a completed report on which a Project Paper might be based not later than May, 1980.
   d. In anticipation of RTG/USAID agreement on pursuing a Northeastern Rainfed Agricultural Development Project, a list of research topics has been suggested.

9. The University of Wisconsin team appreciates the frank and effective working relationship which developed with the RTG counterpart group ...both on an individual and on a joint team level.

ANNEXES

ANNEX I

MEETINGS WITH RTG OFFICIALS AND OTHERS

1. RTG Working Group on Northeast Rainfed Agriculture Development Project
2. MOAC Counterparts on Northeast Rainfed Agriculture Development
3. Department of Agriculture Director General, Deputy Director General, and staff
4. Department of Agricultural Extension Staff
5. Department of Land Development Director General and Staff
6. National Inland Fisheries Institute Staff
7. NESDB Staff on Agriculture and Water Resources Development
8. Ministry of Industry Ground Water Division Director
9. AIT Staff on Water Resources Development
10. Office of Agricultural Economics Deputy Secretary General and Staff
11. EEC Consultant Team on Cassava
12. IBRD Staff

ANNEX II

SITES OF VISITS

1. Nakhon Ratchasima Provincial Agricultural Extension Office
2. Nonthai District Office
3. Village #1 Ban Pang Tiam, Canton Pang Tiam, Nonthai District, Nakhon Ratchasima
4. Village #1 Ban Tap Rang, Canton Tap Rang, Nonthai District, Nakhon Ratchasima
5. Nonsung Upland Crop Experiment Station, Nonsung District, Nakhon Ratchasima
6. Phimai Rice Station, Phimai District, Nakhon Ratchasima
7. Regional Agricultural Extension Office, Khon Kaen
8. Upland Crop Experiment Station, Khon Kaen
9. Land Development Center, Khon Kaen
10. Village Sawang Pattana, Ban Phai District, Khon Kaen
11. Chaiyaphum Provincial Agricultural Extension Office
12. Rice Farm in Chaiyaphum, Muang District
13. Cassava and Kenaf Processing Plant, Chaturat District, Chaiyaphum
14. Cassava Farmers in Chaturat District, Chaiyaphum
15. Northeast Regional Office of Agriculture at Tha Phra, Khon Kaen

ANNEX III

LEVEL AND AVERAGE ANNUAL RATE OF GROWTH OF GROSS REGIONAL PRODUCT PER CAPITA, BY PROVINCE

Province	GRP/Capita, 1976		Average annual rate of growth of per capita GRP, 1970-76 in constant prices, percent	
	฿	Rank	%	Rank
Nongkhai	4390	1	6.7	1
Korat	4050	2	2.3	9
Udon	3980	3	5.4	4
Sakon Nakhon	3860	4	5.5	3
Ubon/Yasothon	3580	5	2.7	8
Nakhon Phanom	3550	7	4.5	6
Khon Kaen	3550	7	1.8	10
Loei	3520	8	5.6	2
Chaiyaphum	3430	9	2.7	8
Buri Ram	3030	10	-1.8	15
Kalasin	2880	11	4.9	5
Maha Sarakham	2650	12	-1.1	14
Surin	2620	13	0.9	11
Roi Et	2300	14	0.4	12
Si Sa Ket	1940	15	0.2	13
REGIONAL AVERAGES				
Northeast	3144		2.1	
North	5458		1.5	
South	7238		2.8	
Central (excl. Bangkok)	11,730		5.9	

Source: Computed from IBRD "Selected Issues in Rural Development", Background Working Paper #4, November 1978, p. 132, and IBRD "Thailand: Toward a Development Strategy of Full Participation--A Basic Report", September 1978, Tables R1.1 through R2.1D.

ANNEX IV

AVAILABILITY OF RICE PER HEAD OF RURAL POPULATION, PADDY YIELD AND STANDARD DEVIATION OF YIELDS, 1963-77, BY PROVINCE

Province	Rice Availability[1] Kg/Capita (Rural)		Paddy Yield (per rai planted) 1963 - 1977		
	Ave 73-77	Rank	Means of Annual Yield	S.D.	S.D./mea
Nongkhai	201	9	210 (6)[2]	56.96	.27 (11
Korat	128	15	191 (9)	42.81	.22 (7)
Udon	299	1	223 (4)	42.76	.19 (5)
Sakon Nakhon	251	2	223 (4)	34.46	.15 (1)
Ubon/Yasothon	205	8	144 (15)	25.26	.18 (4)
Nakhon Phanom	187	10	206 (8)	37.09	.18 (4)
Khon Kaen	159	12	181 (11)	47.37	.26 (9)
Loei	138	14	347 (1)	92.17	.27 (11
Chaiyaphum	236	5	279 (2)	54.88	.20 (6)
Buri Ram	236	5	213 (5)	65.91	.31 (12
Kalasin	245	3	207 (7)	38.03	.18 (4)
Maha Sarakham	223	7	168 (13)	43.22	.26 (9)
Surin	229	6	187 (10)	60.03	.32 (14
Roi Et	171	11	146 (14)	48.18	.33 (15
Si Sa Ket	140	13	170 (12)	53.87	.32 (14
Mean (NE)	201	-	206[3]		
Median	205	-	206		

[1] Paddy converted to rice at 0.65 units of paddy equal to one unit of rice.

[2] Rank in parentheses, highest = 1 for mean, lowest = 1 for S.D./$\bar{y}$

[3] Simple average of 15 provinces.

ANNEX V

RATES OF GROWTH OF AREA PLANTED TO PADDY, NORTHEASTERN THAILAND, BY PROVINCE

Province	Compound Rate of Growth of Area Planted to Paddy in percent per year[1]					
	1963 - 1972			1963 - 1977		
	%	t-value	r^2	%	t-value	r^2
Nongkhai	5.9***	6.11	.82	4.1***	7.73	.81
Korat	0.0	0	-	2.6*	2.08	.24
Udon	2.7	1.64	.25	4.3***	5.50	.68
Sakon Nakhon	3.4***	9.29	.92	2.8***	14.02	.93
Ubon/Yasothon	0.1	0.76	.07	2.4***	5.84	.71
Nakhon Phanom	3.9***	11.61	.94	4.9**	2.68	.93
Khon Kaen	-0.7	-0.20	.01	2.3	1.27	.10
Loei	0.4	-0.18	-	6.4***	3.04	.40
Chaiyaphum	-4.1	-1.19	.15	1.8	0.78	.04
Buri Ram	11.5***	4.07	.67	6.6***	4.43	.58
Kalasin	3.9**	2.60	.46	2.8***	3.10	.40
Maha Sarakham	15.5**	2.45	.43	9.6***	3.75	.50
Surin	3.1***	3.36	.58	4.4***	4.61	.60
Roi Et	3.2*	2.20	.38	2.4***	3.20	.42
Si Sa Ket	1.6	1.58	.24	1.6	1.73	.18
All Northeast	2.8**	2.47	.43	3.2***	6.17	.75

[1] Estimated by least squares regression model $\ln R_t = \ln A + rt$ where R_t is rai planted to paddy in year t. This regression model provides estimates of the parameters in the familiar compound rate of growth expression: $R = Ae^{rt}$, where r is the compound rate of growth.

* 2-tailed t-test at P = .90
** 2-tailed t-test at P = .95
*** 2-tailed t-test at P = .99

ANNEX VI

NOTE ON THE USE OF AZOLLA IN RICE CROPPING

In 1977 and 1978, experiments using azolla as a method for biological nitrogen fixation were conducted at Ubon. Azolla is a floating, aquatic fern which is indigenous to Northeast Thailand (and other parts of Asia). Its value to farmers comes from the fact that it maintains a symbiotic relationship with blue-green free nitrogen-fixing algae.

An eight-treatment test of azolla in flooded paddy fields was conducted at Ubon in 1978.* The treatments and the yields from this experiment are reported in the table on the next page.

Comparing Treatments #1 and #2, we observe a response to nitrogen of 30 kg of paddy per kg of N. This is a high response rate. We would have anticipated a response to a split application of N to be in the range of 15 to 20 kg of paddy per kg of N.

Comparing Treatments #1 and #5, we observe an average increase of 317 kg/rai of paddy due to azolla. If one kg of N produces 30 kg of paddy (as inferred from a comparison of treatments #1 and #2), the nitrogen equivalent of azolla in treatment #5 is about 10 kg of N. Using the more modal figure of 1 kg N = 20 kg of paddy, the nitrogen equivalent of azolla in treatment #5 is about 16 kg of N.

If P_2O_5 and K_2O are priced at their January-March 1976 levels (฿18.33/kg and ฿6.57/kg respectively), the cost of chemical fertilizer in this azolla package is about ฿100/rai, plus azolla seed and labor. The return is 317 kg of paddy. The "profitability" of azolla (with phosphorus and potassium) as a source of nitrogen in paddy fields appears to be great.

A package of practices for the use of azolla remains to be developed, as azolla requires inputs of phosphorus (and possibly potassium), a supply of seed and possibly other inputs or management skills. Management problems do not appear to be especially complicated; however, this issue can be assessed only on the basis of observing its use by farmers. A potential package of practices built around azolla might require cash inputs of about ฿100 per rai (for phosphorus and potassium) plus azolla seed and farmer labor to transport azolla seed from a seed source to his field. If a community azolla seed source can be established, the cost of azolla seed may be minimal. The cost of a balanced fertilizer (N, P and K) with a

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* See "Azolla Research Studies in Thailand" by Prayoon Sawatdee, W. Seetanun, C. Cheevmsiri, C. Kanareugsa and J. Takahashi (Fertilizer Branch, Rice Division, Department of Agriculture, MOAC, Bangkok), a paper presented at the International Rice Research Conference, IRRI, Los Baños, Philippines, April 16-20, 1979.

Treatment					Yield
Treatment Number	Azolla	N kg/rai	P_2O_5 kg/rai	K_2O kg/rai	Kg/rai
1	No azolla	0	4	4	186[d]
2	No azolla	6*	4	4	367[b]
3	No azolla	6	4	4	352[b]
4	Azolla seeded at planting, not plowed in	0	4	4	304[bc]
5	Azolla seeded at planting, not plowed in	0	4**	4	503[a]
6	Azolla seeded at planting, plowed in	0	4	4	232[cd]
7	Azolla seeded at planting, plowed in	0	4	4	287[bc]
8	Azolla seeded 20 days before planting	0	4	4	464[a]

* N in split application.
** P in split application.

Number of replications not reported.

Results at two experimental sites in Central Plains are not given here.

productive capacity equal to azolla plus ฿100 of phosphorus and potassium is estimated to be in the range ฿250 to ฿300 per rai. For the small, risk-prone farmer, the investment of ฿250/rai in chemical fertilizers may be unwise. The same farmer, however, may be able to take advantage of an azolla package because it offers him the chance to substitute his own labor for a cash input. For the small farmer, labor is usually relatively abundant and cash relatively scarce.

At first glance, the use of azolla in paddy fields would seem to be a practice which could be adopted by many or most farmers without the need for additional on-farm testing or any special extension effort. In fact, this is probably not the case. The growth of azolla is known to be limited by the available phosphorus. It is also known that a split application of phosphorus makes the azolla more productive than a single application. Discovering the proper quantity, timing and method of phosphorus applications under actual farm conditions by farmers will be important to maximizing the

productivity and income enhancing effects of azolla. No single package of azolla practices will be optimal (or even suitable) over a wide range of soil fertility conditions, soil water-holding capacities, farm sizes, etc. Azolla may be an important key to increasing farm income and productivity in Northeast Thailand, but substantial work probably remains to be done before this key can actually raise the level of optimum income and productivity for a significant number of farmers having different resource endowments over a broad area of the Northeast.

Beyond the technical aspects of preparing a set of packages of practices which incorporate azolla, there are problems of phosporus supply* (and possibly credit) and azolla seed supply. At present there is no market incentive to make phosphates available in the Northeast. Without phosphate, azolla is merely a botanical curiosity** which will have no effect on raising the optimal level of incomes and productivity for any Northeastern farmers. In addition to the need for an institutional intervention to provide phosphatic fertilizers (and possibly credit), the usefulness of azolla will depend on the availability of azolla seed to farmers at the time it will be most useful. Preliminary indications are that it can be multiplied rapidly and spread from field to field as soon as there is standing water in the paddy fields. Existing community tanks and swamps might be used for seed multiplication, but the effect on fish populations has not been determined. Further, there will probably be a need for some mechanism to price or ration a limited seed supply at a time of high seasonal demand. Thus, even if a "gap creating" technical package of practices incorporating azolla is developed, the failure to develop institutions which are capable of supplying large quantities of low cost seed at the time when farmers want it will limit the capacity of many farmers to exploit the income and productivity gains which an azolla package would open to them.

An area-based approach to the development of an azolla package of practice would allow the problem of phosphate supply and seed supply/multiplication to be monitored and would improve the chances of eliminating supply bottlenecks before they become serious constraints to adoption.

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* Chemical fertilizers are widely available throughout Northeast Thailand. According to the ARSAP Report, Annex--Table 10C, 54 percent of the area planted to rice in the Northeast received chemical fertilizers in 1971-72. However, very little is available in the way of straight phosphatic fertilizers in Thailand. Since azolla needs phosphorus but not nitrogen, a source of triple super phosphate must be developed at the farm level.

** Azolla strains which are native to and widespread in Northeast Thailand are reportedly superior to many strains found elsewhere in Asia. Presumably azolla is not an element in traditional Northeastern paddy farming practices because the soils are generally phosphorus deficient. Both (North) Vietnam and China are reported to use azolla.

ANNEX VII

TABLE 1: PERCENTAGE DISTRIBUTION BY PROVINCE OF AREA PLANTED TO MAIZE IN NORTHEAST THAILAND, 1973-78

Province	1973	1974	1975	1976	1977	1978
Nakhon Phanom	--*	--	--	--	--	0**
Loei	18	26	34	25	29	24
Sakon Nakhon	--	--	0	--	--	0
Nongkhai	--	--	0	0	--	0
Udon	--	--	3	3	4	6
Ubon	--	--	3	--	--	2
Yasothon	--	--	0	--	2	--
Kalasin	--	--	0	0	--	1
Khon Kaen	--	--	1	0	2	6
Maha Sarakham	--	--	--	--	--	--
Roi Et	--	--	0	--	--	0
Si Sa Ket	14	11	7	7	14	7
Surin	--	--	0	0	--	3
Chaiyaphum	3	7	5	4	6	7
Korat	64	56	45	60	43	44

* indicates no area reported for that province that year

** zero indicates less than 1/2 percent

Source: For 1973-77, from area reported in Agricultural Statistics of Thailand, Crop Year 1977-78, Division of Agricultural Economics, MOAC, Bangkok, 1978. For 1978, handwritten provisional figures.

TABLE 2: PERCENTAGE DISTRIBUTION BY PROVINCE OF AREA PLANTED TO PEANUT IN NORTHEAST THAILAND, 1973-78

Province	1973	1974	1975	1976	1977	1978
Nakhon Phanom	1	2	2	2	1	2
Loei	5	5	3	4	10	4
Sakon Nakhon	3	2	2	1	8	2
Nongkhai	1	1	1	1	2	1
Udon	2	3	3	5	0	2
Ubon	3	2	2	6	24	5
Yasothon	1	1	1	1	2	1
Kalasin	2	3	4	5	3	4
Khon Kaen	2	3	2	2	1	4
Maha Sarakham	3	1	1	0	0	1
Roi Et	3	3	4	5	9	4
Si Sa Ket	7	11	2	3	6	15
Surin	6	1	17	15	3	9
Buri Ram	20	23	20	9	2	18
Chaiyaphum	9	10	7	5	1	4
Korat	34	21	29	35	29	24

Source: For 1973-77, from area reported in Agricultural Statistics of Thailand, Crop Year 1977-78, Division of Agricultural Economics, MOAC, Bangkok, 1978. For 1978, handwritten provisional figures.

TABLE 3: PERCENTAGE DISTRIBUTION BY PROVINCE OF AREA PLANTED TO KENAF IN NORTHEAST THAILAND, 1973-78

Province	1973	1974	1975	1976	1977	1978
Nakhon Phanom	1	2	2	0	2	3
Loei	3	2	1	0	2	2
Sakon Nakhon	0	0	0	1	1	1
Nongkhai	1	1	1	3	3	0
Udon	3	5	5	5	10	11
Ubon	7	10	10	6	10	10
Yasothon	3	4	4	7	5	4
Kalasin	6	7	7	3	4	7
Khon Kaen	17	13	13	9	13	12
Maha Sarakham	12	7	7	18	9	9
Roi Et	5	3	4	1	3	3
Si Sa Ket	7	8	10	2	8	7
Surin	5	4	5	3	8	8
Buri Ram	8	6	10	12	6	4
Chaiyaphum	12	8	13	21	13	13
Korat	8	20	9	11	3	5

Source: For 1973-77, from area reported in Agricultural Statistics of Thailand, Crop Year 1977-78, Division of Agricultural Economics, MOAC, Bangkok, 1978. For 1978, handwritten provisional figures.

ANNEX XV

A BRIEF LIST OF KEY IRRIGATION / WATER MANAGEMENT PROFESSIONALS AND INSTITUTIONS IN THAILAND

People Visited

1. Charoen Piencharoen, Director, Groundwater Division, Department of Mineral Resources
   - information on groundwater exploration and mapping and DMR well drilling program.

TABLE 4: PERCENTAGE DISTRIBUTION BY PROVINCE OF AREA PLANTED TO CASSAVA IN NORTHEAST THAILAND, 1973-78

Province	1973	1974	1975	1976	1977	1978
Nakhon Phanom	3	2	1	1	2	2
Loei	1	1	0	0	1	0
Sakon Nakhon	2	1	1	0	1	1
Nongkhai	3	2	2	2	6	4
Udon	8	6	5	6	8	7
Ubon	1	1	1	2	1	1
Yasothon	1	0	1	1	2	1
Kalasin	7	5	8	9	11	8
Khon Kaen	9	5	9	7	15	10
Maha Sarakham	2	1	3	6	7	4
Roi Et	1	2	3	3	3	2
Si Sa Ket	0	0	0	0	1	1
Surin	18	9	6	2	3	5
Buri Ram	7	28	12	12	11	10
Chaiyaphum	4	4	6	13	9	6
Korat	51	41	43	34	23	40

Source: For 1973-77, from area reported in Agricultural Statistics of Thailand, Crop Year 1977-78, Division of Agricultural Economics, MOAC, Bangkok, 1978. For 1978, handwritten provisional figures.

ANNEX VIII

TIME TRENDS IN AREA AND YIELD OF PADDY, NORTHEAST THAILAND, 1959-1978

The table on the following page reports area, total production and yield of paddy for 20 years in Northeast Thailand. The time trends in area planted and total production are clear. The compound rate of growth in area planted in the decade 1959-1968 is 1.4 percent per year. For the decade 1969-1978, the rate is 3.4 percent per year. Both rates of growth are highly statistically significant. Rates of growth of area planted to paddy, by province, are given in Annex V for the periods 1963-72 and 1963-77. The general pattern is one of an increasing rate of growth over time for most provinces, individually. However, there are great differences in the rates of growth of area between different provinces. These differences do not suggest a consistent pattern of expansion of area and deserve further study. For instance, the rate of growth of paddy area in Maha Sarakham* far exceeds the rates in Roi Et, Kalasin, and Khon Kaen.

Time trends in paddy yield are difficult to interpret due to the large effect of the highly variable monsoon rains on paddy. Before the hypothesis of "declining yields" can be fully addressed, a weather-paddy-yield model needs to be developed. We have estimated the time trend of yields for the Northeastern region with the simple model $Y_t = b_0 + b_1T$ where Y_t is yield (in kg/planted rai) and T represents years. Thus b_1 is the (least squares) estimate of the change in yield per year over the time period under consideration. The results suggest that one can confirm or reject almost any reasonable hypothesis about yield over time by a careful selection of the time period over which the data are examined.

Regression Number	Time Period	Parameter Estimates b_0§	b_1	r^2
1	1959-68	187	-1.16 (t = 0.52)	.03
2	1959-73	165	+4.03 (t = 2.62)	.35
3	1959-77	183	+1.15 (t = 0.90)	.05
4	1959-78	173	+2.56 (t = 1.82)	.16
5	1969-77	259	-9.80 (t = 3.64)	.65
6	1969-78	231	-1.96 (t = 0.39)	.02

§ b_0 is the yield axis intercept term and is the "predicted" yield in 1958 for regressions 1-4 and in 1968 for regressions 5 and 6.

* The rates of growth in Maha Sarakham are very large and may be due to an improvement in statistical reporting rather than an expansion in area actually planted to paddy.

AREA, PRODUCTION AND YIELD (IN KG/PLANTED RAI)
OF PADDY IN NORTHEASTERN THAILAND, 1959-78

Year	Area Planted (thousands of rai)	Production (thousands of metric tons)	Yield (kg/rai)
1959*	15,419	2.521	163
1960*	14,556	2,775	191
1961*	15,406	2,809	182
1962*	17,820	3,666	206
1963*	16,970	3,516	207
1964*	15,471	3,302	152
1965*	15,332	2,734	178
1966*	19,630	3,796	193
1967*	15,160	2,350	155
1968*	17,860	3,192	179
1969*	20,240	4,580	226
1970*	20,460	4,920	240
1971*	21,471	5,432	253
1972*	18,223	4,188	230
1973*	22,139	4,611	208
1974*	20,635	3,773	183
1975*	24,990	5,323	213
1976*	23,735	4,673	197
1977**	24,746	4,671	143
1978***	28,425	8,680	305

* Data for 1959-76 as published in World Bank Report No. 2059-TH (Thailand: Toward a Development Strategy of Full Participation--A Basic Economic Report, September 1, 1978), Table R7.3.

** As reported in Agricultural Statistics of Thailand, Crop Year 1977-78, MOAC, Bangkok, 1978.

*** Unpublished, provisional figures from Northeastern Regional Extension Center, Khon Kaen.

ANNEX IX

a/
PADDY YIELD TRENDS, BY PROVINCE

Province	1963 - 72			1963 - 77		
	b_0	b_1	t-statistic	b_0	b_1	t-statistic
Nakhon Phanom	144	12.3	5.93***	192	1.7	0.75
Loei	384	-3.0	-0.34	407	-7.5	-1.41
Sakon Nakhon	206	5.5	1.61	240	-2.1	-1.04
Nong Khai	210	-1.0	-0.13	199	+1.4	0.41
Udon	206	1.3	0.28	200	2.9	1.13
Ubon/Yasothon			not computed,	data incomplete		
Kalasin	138	10.8	4.85***	161	5.7	3.24***
Khon Kaen	154	4.2	0.64	161	2.5	0.88
Maha Sarakham	124	8.0	1.70	153	1.9	0.73
Roi Et	103	7.7	1.69	135	1.4	0.48
Si Sa Ket	95	14.6	5.79***	156	1.8	0.54
Surin	104	16.6	2.93***	167	2.4	0.66
Buri Ram	132	16.0	2.12*	194	2.2	0.54
Chaiyaphum	279	1.9	0.37	298	-2.3	-0.69
Korat	206	-1.3	-0.26	215	-3.1	-1.23

* two-tailed t-test significant at .90
** " " " " " " .95
*** " " " " " .99

a/ Yield in kg/planted rai estimated by ordinary least squares technique in regression model.

$y_t = b_0 + b_1T$, where Y_t is yield and T is Year (1 = 1963, 15 = 1977). Thus, b_1 = estimated change in yield in kg/rai per year. b_0 is the predicted yield in 1962.

ANNEX X

CONSIDERATIONS ON THE POTENTIAL OF DIRECT SEEDING OF PHOTO-INSENSITIVE PADDY VARIETIES UNDER RAINFED CONDITIONS IN NORTHEAST THAILAND

The potential risk-reducing and productivity-enhancing benefits of direct seeding of photo-insensitive paddy varieties have been raised as a consequence of an experiment at Ubon in 1977. In that experiment*, a photo-insensitive variety was direct seeded at a time such that it would flower in the period of high likelihood of rainfall and optimal soil moisture conditions. The great majority of photo-sensitive varieties used in the Northeast flower in October, a time when rainfall is less certain than in the period from mid-August through mid-September.

The 1977 Ubon experiment compared a photo-insensitive variety direct seeded on May 9, which flowered on August 13 (yielding 600kg/rai) with a photo-sensitive variety sown on July 6 which flowered on October 9 (yielding 222kg/rai).** The difference was attributed to the fact that rainfall in the October 3-22 period was insufficient to maintain an optimal level of soil moisture. The argument is also advanced that the probability of optimal soil moisture in the first three weeks of October is uncertain at best.

A number of questions remain to be answered about the potential of planting photo-insensitive varieties so that they will flower in the mid-August to mid-September period.

- Will harvesting be difficult or impossible if heavy rains continue through October when the photo-insensitive variety which flowered in August could be ready for harvest?

- Is reliance on a direct seeding method really risk-reducing if early rains flood the farmer's fields and he is unable to drain those fields?

- Will an earlier harvest date allow a crop of groundnut or mungbean to be raised on residual soil moisture after paddy?

- Since earlier flowering photo-sensitive varieties exist to the North of Ubon, why have farmers not adopted those varieties at Ubon?

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* See "1978 Annual Report: Rainfed Rice Improvement Pioneer Project--Northeast Thailand", Rice Division, DOA, MOAC, June 1979.

** In 1977 the average paddy yield in Ubon was reported to be only 99kg/rai.

- What proportion of the paddy area of the Northeast is potentially suitable for direct seeded, photo-insensitive varieties?

- What are the problems of weed control which may occur as the result of direct seeding?

We observe that in some parts of the Northeast (including Ubon), there appears to be positive correlation between area planted and yield (production per planted rai). Since an increase in the area planted results from an increase in the proportion of higher lying, less fertile paddy fields with poor water holding capacity, a reasonable initial hypothesis is that area planted and yields should be negatively correlated. In Khon Kaen, for instance, there is no significant time trend for either area planted (see Annex V) or yield (see Annex IX). Still, the following relationship between yield and area planted holds:

$Y_t = 66 + 0.092\ R_t$, where Y_t is yield in kg/rai planted and R_t is thousands of rai planted in a given year. ($t = 3.14$) This positive relationship suggests a number of hypotheses about the relationship between rainfall and yield. A model of the relationships between inputs and production in the numberous rice farming environments of the Northeast would be very useful in evaluating the potential of direct seeded photo-insensitive paddy varieties.

ANNEX XI

A BRIEF DESCRIPTION OF THE SOILS OF NORTHEAST THAILAND

Soils of the NE have been studied and differentiated into broad groups based on soil landscape relationships as follows:*

1. Soils occurring on flood plains: Soils on this landform consist of very deep, well drained and poorly drained soils developed from recent alluvium. Soils occupying natural river levies are well drained, medium textured soils. They are usually used for garden crops. Soils in river basins are poorly drained, fine textured and are used for rice cultivation. The soils developed on this type of landform generally fall in the great groups Ustifluent and Tropaquept according to the U.S. Soil Taxonomy classification system.

2. Soils occuring on low terraces: These soils have variable characteristics such as soil depth, texture, and salinity. They are moderately to poorly drained and are extensively used for rice production. They are classified in the great soil groups; Paleaquult; Plinthaquult; Natraquaf; Halaquept; and Dystropept.

3. Soils occupying middle-high terrace: Soils developed on this type of landform are composed of soils that have varied diagnostic characteristics which include color, soil, depth, and texture. All are well drained and are usually devoted to upland crop production or forests. These soils are classified as: Paleustults, Phinthustults, Haplustults, Haplustox, Rhodustults, Dystropepts, and Quartzipsamments.

4. Soils occuring on erosion surfaces: Soils occurring on this landform are also variable in texture, color, soil reaction, soil depth, etc. These differences in properties occur primarily because of differences in parent materials. The soils occur mainly in the southern and western part of the region. They are generally heavier textured than soils of the middle to high terraces. These soils are classified as Paleustults and Haplustults.

5. Soils occupying hilly areas: These soils occur on hilly and mountainous areas and are usually included in mapping units as "Slop complex soils".

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* Unpublished (Memo), no date, no Author. Supplied by Dr. Wanee Samphantharak, Department of Land Development, July 1979.

ANNEX XII

NOTE ON CASSAVA FERTILIZATION RESEARCH AND ECONOMICS

A four year cassava fertilization study was conducted at the Northeast Agricultural Research Center, Khon Kaen over the period 1974-77. Nine different fertilizer levels/nutrient combinations were used, with three replications per combination per year. Data for the control plot and the most profitable fertilizer trial are given here:

Yield (kg/rai)

Treatment	1974	1975	1976	1977
Control	5341	4492	2904	3253
6-12-6	5836	5071	4180	4308
difference	495	579	1276	1055

The average rate of decline in the cassava yields are 19 percent per year for the control and 11 percent per year for the 6-12-6 treatment.

In the long run, it is reasonable to expect the Khon Kaen cassava grower to receive a farm level price of about ฿500 per metric ton for cassava.*

The application of 6-12-6 used in the reported experiment is estimated to have a farm level cost of ฿345 in early 1976.*** At this price, use of an application of 6-12-6 per rai would have resulted in a loss for the first two years.

One may see the lack of profitability in using fertilizer by observing that of 1976 price, an annual input of ฿345 in fertilizer costs would be required. With a farm level price of cassava of ฿500/MT, the situation would be as follows:

	Year 1	Year 2	Year 3	Year 4
Value of added yield (฿)	247	289	638	527
Cost of fertilizer at 20% interest*	414	414	414	414
Profit (loss)	(167)	(125)	224	113

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* This estimate is based on a Bangkok export price of about $80/MT for cassava pellets, a price of which cassava should be an economic substitute for barley and maize in animal feeding rations in Europe and Japan.

** Based on average farm-level nutrient price of ฿14.31/kg for N, ฿18.33/kg for P and ฿6.57/kg for K as of January-March 1976 as reported in Annex Table 13 of Marketing, Distribution and Use of Fertilizer in Thailand. ARSAP, Bangkok, March 1977.

***At 20% annual interest the cost of ฿345 of fertilizer becomes ฿414.

The farmer shows a profit on the fertilizer package only in the third year. If the losses of the first two years are carried forward at a 20 percent interest rate, the use of fertilizer remains unprofitable for the full four years. At the end of the fourth year, the use of a package of 6-12-6 would have resulted in a loss of about ฿87. This package would reasonably be expected to show a profit only in the fifth year.

If farm level fertilizer prices more closely reflected world fertilizer prices, or if fertilizer costs were reduced so that the farm level costs were two-thirds of the 1976 level, the 6-12-6 package used with the same results as in the experiment described here would be profitable in the second year. The picture would be as follows:

	Year 1	Year 2	Year 3	Year 4
Value of added yield (฿)	247	289	638	527
Cost of fertilizer*	276	276	276	276
Profit (loss)	(29)	13	362	251

With profits (net of losses) carried forward, the experiment would have shown a substantial net profit in the third year. Three years is still a long gestation period, and it is unlikely that many small farmers would undertake to adopt such a package of fertilization practices.

The Khon Kaen experiment was designed to show that moderate levels of fertilization could maintain soil fertility. It was not designed to test the economic return to fertilizer in natural farm conditions. In fact, there is reason to believe that farmers who apply fertilizer to cassava fields whose yields have fallen to the 1500-1800 kg/ha level would find an immediate and substantial response in terms of yield. This hypothesis can be tested only by conducting experiments on farmers' fields.

Research on cassava-field crop intercropping combinations and fertilizers trials for cassava-legume intercropping** fail to show any significance on substantial ecomonic benefit from intercropping cassava with legumes. Neither do they indicate any economically profitable levels of fertilizer yield on cassava. Judging from the high yield levels on the control plots (4.8 MT/rai) as opposed to actual farm yields (1.2-1.8 MT/rai), we feel that the potential farm level economic feasibility of cassava fertilizer has not been adequately evaluated.

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* With a 20% interest on investment and with fertilizer at 2/3 of January-March 1976 level.

** See 1976 Annual Report of KKU-Ford Foundation Cropping Systems Project.

Cumulative Effects on Chemical Fertilizers
on Cassava Production, Yield, kg/rai

Treatment	1974	1975	1976	1977
0 - 0 - 0	5341	4492	2904	3253
6 - 6 - 6	5006	5321	3620	3814
6 - 6 -12	5313	4800	3715	3698
6 -12 - 6	5836	5071	4180	4308
6 -12 -12	5204	5067	3329	3820
12 -6 - 6	5295	4534	2219	5665
12 -6 -12	5075	5096	3145	5392
12-12 - 6	4255	4509	2995	5222
12-12- 12	5287	5209	2935	4898
12-18 -12	4592	5071	2805	5171

Northeast Research Center, Khon Kaen

3 replications

ANNEX XIII

ESTIMATED CROP-WATER NEEDS FOR FOUR CROPS GROWN DURING DIFFERENT SEASONS UNDER VARIOUS IRRIGATION AND STORAGE WATER EFFICIENCY CONDITIONS

Crop/Season	Irrigation Required @ 100% Irr. Eff. (mm.)	Irrigation Water Required Per Hectare		Storage Vol. Req. per Ha. @ 80% Irr. Eff. and Tank Less @ 10%/mo (m^3 /ha) 3/
		@ 80% Irr. Eff. (m^3 /ha)	@ 60% Irr. Eff. (m^3 /ha)	
Peanut				
Early Wet	70 1/	880	1,170	(6 mo.) 2,200
Post Wet	300 2/	2,400	5,000	(2 mo.) 3,000
Dry	400	5,000	6,670	(4 mo.) 8,333
Mung Bean				
Early Wet	70 1/	880	1,170	(6 mo.) 2,200
Post Wet	250 2/	3,130	4,170	(2 mo.) 3,913
Dry	350	4,380	5,830	(4 mo.) 7,300
Rice				
Wet	100 1/	1,250	1,660	(0 mo.) 1,250
Dry	1,100	13,750	18,330	(4 mo.)22,917
Vegetables				
Dry	190/mo.	2,380/mo.	3,170/mo.	(4 mo.) 3,967/mo.

1/ Required supplemental water during drought periods with an 85% probability of adequacy (A.I.T., 178 (b)).

2/ Assumes 50 mm of available soil moisture.

3/ A tank 2 m deep would evaporate more than 10% of its total per month.

ANNEX XIV

WATER RESOURCE MANAGEMENT

References and Suggested Background Literature

1. Asian Institute of Technology, 1978 (a). Water for the Northeast Vol. I, Main Report. Prepared for The Water Resources Planning Subcommittee of the National Economic and Social Development Board. AIT, Bangkok, September, 1978 . (Note: Vol. II is not yet available) (Available from Dr. Anat, AIT, and the USAID Library).

2. Asian Institute of Technology. 1978 (b). Water for the Northeast: Drought Analysis. Part I: Rainfall Analysis, and Part III: Low Flow Statistics. Prepared for the Water Resources Planning Subcommittee of the National Economic and Social Development Board. AIT, Bangkok, Dec. 1978. (Limited copies available from Dr. Anat, AIT).

3. Committee for the Coordination of Investigations of the Lower Mekong Basin (Mekong Committee). 1974. (a). Analysis of Rainfall in Northeast Thailand as a Basis for the Planning of Irrigated Agriculture. Working Paper MKG/13 Bangkok, Sept. 1974.

4. Committee for the Coordination of Investigations of the Lower Mekong Basin (Mekong Committee). 1946 (b). Summary of Monthly and Yearly Hydrometeorological Data in the Thai Part of the Lower Mekong Basin. Mekong Secretariat, Bangkok October, 1975.

5. Hawworth, Howard F., Pongpan Na Chaingmai, and Charoen Phiancharoen. 1966. Groundwater Resources Development of Northeastern Thailand. Groundwater Division, Dept. of Mineral Resources, Groundwater Bulletin No. 2, Bangkok, 1966. (Available from USAID Library Call # 628 Haw) Note: NE Geohydrology map was updated in 1973.

6. National Economic and Social Development Board. 1979. "Northeast Village Water Project-Request for New Technical Assistance Project" (Loan request to Australia) (Available from Dr. Anat, AIT).

7. National Institute of Development Administration. 1978. Evaluation of Rural Water Supply Projects in Thailand. Prepared for the Rural Water Supply Planning Sub-Committee of the National Economic and Social Development Board. Sept. 1978. (Available from Infrastructure Projects Division, NESDB)

8. Office of Accelerated Rural Development. 1979. Project Planning Organization and Management for the Implementation of the Well Construction of the ARD Khon Kaen Well Drilling

8. Center. Prepared by Thai Engineering Consultants Co., Ltd. Jan. 1979. (loan copy available from Padoong Torramin, Team Consulting Engineers Co., Ltd.)

9. World Bank. 1978. Thailand Northeast Irrigation Project II: Staff Appraisal Report. Report No. 1901-TH Oct, 1978. (Available in U.S. AID Library: call # 631.7 Wor).

ANNEX XV

A BRIEF LIST OF KEY IRRIGATION / WATER MANAGEMENT PROFESSIONALS AND INSTITUTIONS IN THAILAND

People Visited

1. Charoen Piencharoen, Director, Groundwater Division, Department of Mineral Resources
   - information on groundwater exploration and mapping and DMR well drilling program.

2. Somchet Taeracoop, Assistant to the Director, Water Resources Planning Subcommittee, Infrastructure Projects Division, NESDB (the director, Mr. Charan, was not available)
   - general information about condition of water resources development in the Northeast

3. Dr. Anat Arbhabhirama, Vice President for Research, AIT (also director of special task force on Water Resource Development for the Northeast)
   - information about on-going and planned projects in the Northeast water resource development, both technical and administrative.

4. Dr. Apichart Anukularmphai, Department of Agricultural Engineering, AIT (technical assistant to Dr. Anat)
   - good source of information on technical work being done relative to Northeast water resources.

5. Dr. Padoong Torranin, Team Consulting Engineers Co., Ltd.
   - information on ARD well drilling program

6. Mr. Dauphin, Mekong Committee (Van Liere was not available)
   - information about irrigation development in the Northeast and climatological data

Recommended Visits (not made)

1. RID: Nukul Thongtanwee, Khon Kaen and Bangkok offices
   - information regarding pond and small tank construction in the Northeast

2. World Bank: Dick Sandler, Solly Angle, and Marcia Brewster, Bangkok
   - information on World Bank funded projects and research

3. Khon Kaen University: Dr. Sucha, Civil Engineering and Dr. Verd

   - information on Small Water Resources Center, KKU

4. Northeast Agricultural Extension Research Center: Dr. Thanya Teerasart

5. ARD Well Drilling Center, Khon Kaen: Prasit Vilailak, Director and Sawat Bangsainoi, Deputy Director

   - ARD well drilling program in the Northeast

6. Mekong Committee: Mr. DeJong, FAO Research and Training Center, Khon Kaen

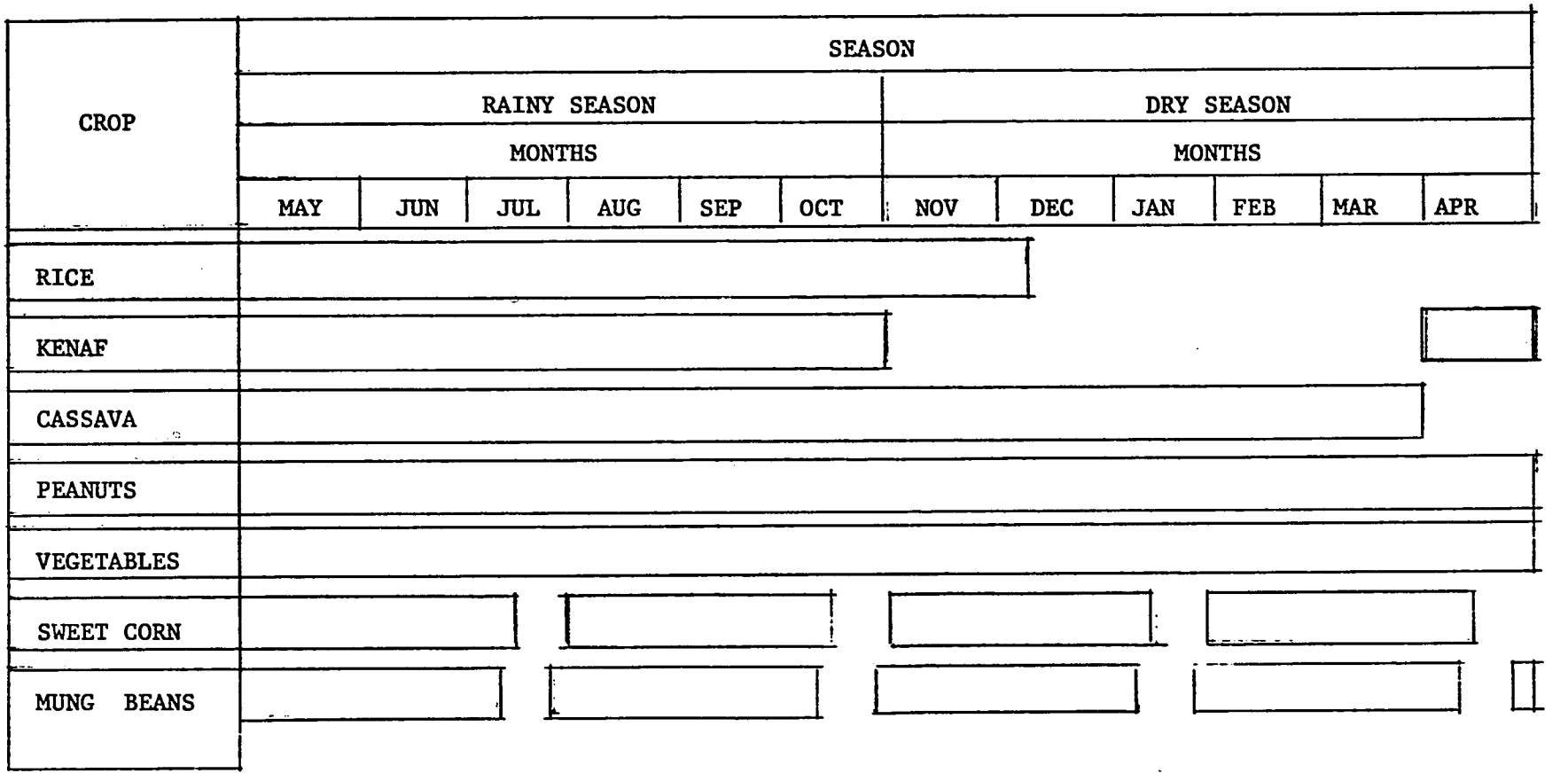
   - Socio-economic study of farmers in irrigated areas

ANNEX XVI

SELECTED NORTHEAST THAILAND RESEARCH INSTITUTIONS AND CAPABILITIES FOR RAINFED CROPS

Name of Institution	Place	Research Carried On
1. Northeast Region Agricultural Research Center (NEAR) : MOAC	Tha Phra, Khon Kaen	Kenaf, mungbeans, soybeans peanuts, maize and sorghum. and rice.
2. Nong Sung Kenaf and Jute Station: DOA, MOAC	Nakhon Ratchasima	Kenaf, Jute and rice
3. Yang Talad Oil Crop Station: DOA, MOAC	Kalasin	Legume Crops
4. Seed Multiplication Stations: DOA, MOAC	Si-Sa-Ket, Surin Kalasin, Nakhon Phanom Chaiyaphum, Sakon Nakhon Khon Kaen, Maha Sarakham Udon Thani, Buriram	Improved cultural practices and seed multiplication for various rainfed crops.
5. Experimental & Demonstration Farm for Irrigated Agriculture: FAO	Kalasin	Various rainfed crops
6. Faculty of Agriculture of Khon Kaen University, Plant Science Division: University Bureau	Khon Kaen	Soy beans, sorghum and soil fertility depletion by cassava
7. Faculty of Agriculture of Kasetsart University: University Bureau	Bangkok	Various rainfed crops

ANNEX XVII

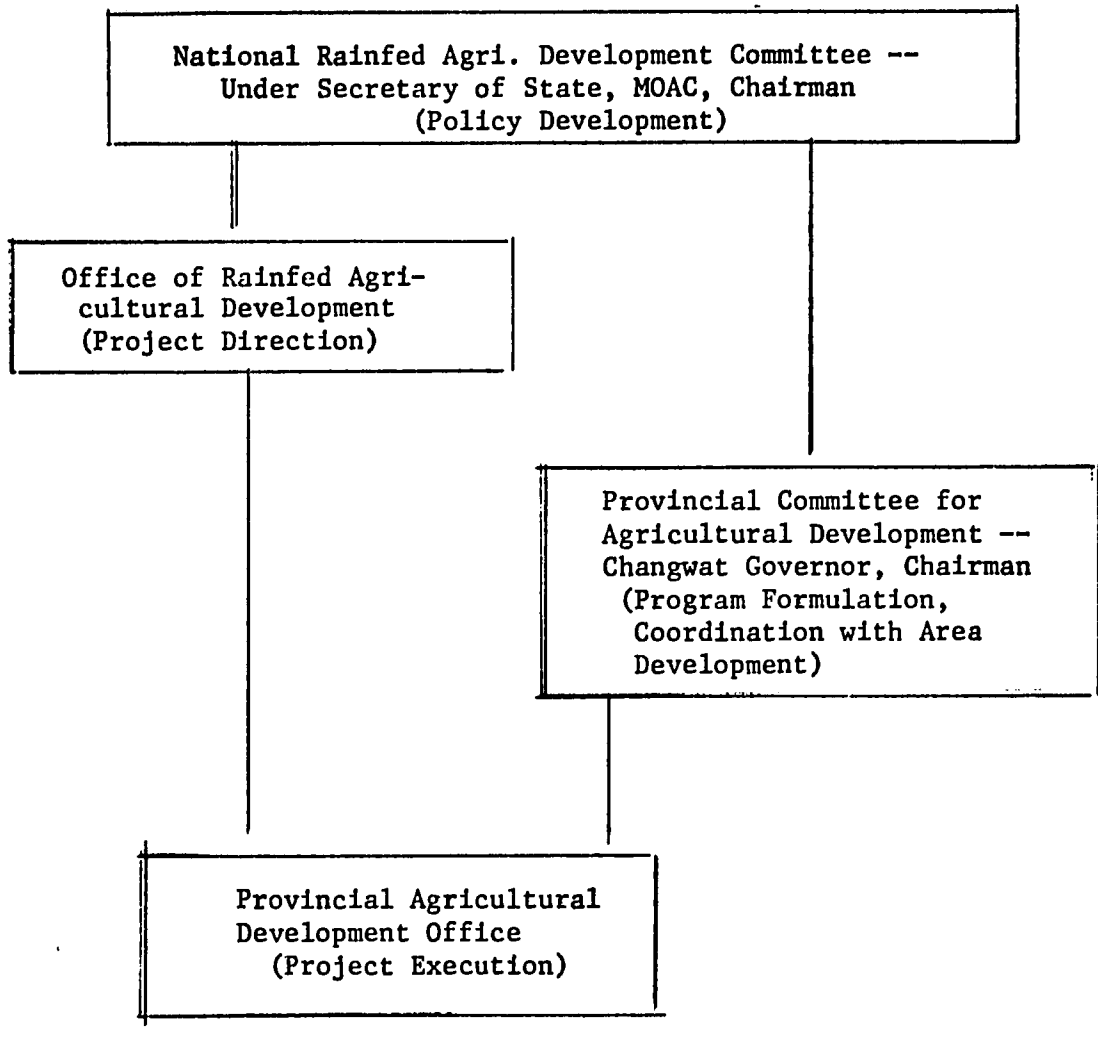


Cropping Time Chart for Major Crops Grown in Northeast Thailand

ANNEX XVIII

NORTHEAST RAINFED AGRICULTURAL DEVELOPMENT PROJECT

ORGANIZATION CHART



ANNEX IXX

RESEARCH STUDIES IN WATER MANAGEMENT WHICH WOULD SUPPORT THE NORTHEAST RAINFED PROJECT

A cursory investigation into possibilities for improved rainfall and supplemental irrigation water management in the Northeast has led to the identification of several aspects where a lack of information will limit the ability to prescribe improved practices in an action program. Research studies which will lead to a better understanding of the surface and subsurface hydrology, water use efficiencies, and crop-water requirements in the Northeast, given in the list on the following page. They could be undertaken individually or grounded together into integrated studies. Study one could be undertaken by the Department of Food and Agricultural Engineering or Water Resources Engineering at A.I.T. with assistance from ICRISAT where similar work has previously been undertaken. These AIT groups could also support work proposed in studies 2, 3, and 6. The engineering section of DLD could, with some outside input, undertake studies 5 and 6. Study 4 could be integrated into the preliminary phases of the rainfed project.

1. Irrigation Scheduling Model

Construct an irrigation scheduling type computor model adapted to the land forms, soils, and subsoils of the Korat plateau. The model, when given rainfall and evapotranspiration data, should be able to predict required supplemental water amounts and scheduling at given crop stress allowances for desired crops. Inversely, it can predict crop stress degree and periods for various non-supplemented cropping patterns, from which at least qualitative evaluations of yield depression can be estimated. The model will indicate supplemental water requirements for the various crops grown during different seasons of the year. Once a supplemental water supply is fixed, the probabilities of crop yield depression can be predicted by running the model using existing rainfall data while efficiently allocating the supplemental water.

2. Irrigation Efficiency Studies

Field studies should be undertaken to determine actual conveyance and application efficiencies of supplemental irrigation water. The studies will involve flow measurement at the storage or pump outlet and at the field, and measurements of soil moisture before and after each irrigation, seepage rate determination from both water channels and paddy fields, as well as evapotranspiration measurements will result in a better understanding of water losses. Irrigation efficiency determination will allow crop-water requirements to be adjusted to water required at the source (tank or pump).

3. Water Balance Study of Small Watersheds

In order to understand the hydrology of watersheds in the Northeast, a water balance study should be undertaken. Such a study involves intensive measurements of incoming water via rain water or some supplemental supply, the paths of the water through the area (i.e. surface flow, lateral subsurface flow, farmer directed movement), and how and where the water leaves the area (i.e. deep percolation to a permanent watertable and consequent outflow, lateral subsurface flow from a perched watertable, surface runoff, and evapotranspiration from both cultivated and non-cultivated areas). Such a study will involve a large investment in manpower and a moderate investment in instrumentation. It will lead to a better understanding of rain water usage and wastage, potential means of increasing water use efficiency, and management techniques to retain a higher percentage of the available rainfall in the watershed for crop use.

4. Rainfall Water Management

Utilizing the findings from studies 1 and 3, a water management package which will increase crop production from given rainfall should be designed and tested. The package will involve collection of rainfall, directing it to the desired areas, and minimizing both surface and subsurface outflow from the area, except to remove excess water. Surface, soil, and shallow water table storage will be used. The goal would be to remove the risk from the present cropping pattern and extend the season when possible to two crops. The work will involve intensive field tests of proposed management systems utilizing extension personnel to promote the practices and technicians to monitor the results.

5. Development of Alternative Earthmoving Equipment for Tank and Pond Construction

Bulldozers and other heavy earthmoving equipment are presently used by government agencies to construct tanks and ponds. Because of transport and maintenance problems and high initial costs, it is conceivable that smaller, locally fabricatable equipment may be more efficient for construction of some of the large number of small water resource earthwork projects needed in the Northeast. Equipment adaptable to farm tractors or even stationary winches with a scoop or dredge might be viable alternatives. The potential for alternative equipment should be analyzed and if present, designed and tested.

6. Tank Seepage Studies

A study of several new and older tanks should be made to measure seepage loss rates and the factors affecting the seepage rates. Methods developed in other areas to reduce seepage rates in light textured soils should be tested. Determination of tank loss rates will enable prediction of water availability during different seasons of the year from surface storage, or inversely, surface storage capacity required to meet water requirements during different times of the year.

ANNEX XX

CRITERIA/GUIDELINES FOR DISTRICT SELECTION

The following criteria/guidelines have been highlighted as important in the choice among districts within the selected districts.

1. Agronomic Characteristics

   (a) Topography should include both upland and lowland areas.
   (b) Upland soils should be the Korat series and additionally perhaps other similar soils. Lowland, or paddy soils may be Roi et, Phi Mai or similar soil series. (Alluvial - poorly drained soils).
   (c) Should have an established tank for fish and livestock and domestic water supply, or should have depression area for tank construction.
   (d) Rainfall and weather pattern should be typical for the N.E. e.g., should have the bimodal wet-season rainfall pattern.
   (e) Cropping pattern should include at least one of the three crops: (1) cassava; (2) kenaf; (3) groundnut; (preferably all three.)

2. Characteristics related to the development of supplemental irrigation

The two alternative sources of supplemental irrigation water supply are from surface storage and groundwater exploitation. Their supply characteristics are very different and thus different usage strategies will be required. It would be desirable if both types could be developed at the project sites.

The Korat plateau is underlain by an extensive groundwater aquifer which produces fresh water from the upper strata over most of the Northeast (80% of the area). However, the water yields from the primarily shale and sandstone materials are too low in most areas for economical irrigation use. Probably less than 10 percent of the cultivated area of the Northeast could be served by wells with yields above 10 liters per second. It is proposed that one study site be selected with the intent of developing the groundwater resource for irrigation. Selection can be based on information from the Groundwater Division of the Department of Mineral Resources and from the proven yields of previously drilled wells. Irrigation wells should be installed in every village in the project area, if possible.

Surface storage potential depends primarily on the local topography and the soil permeability. If large watersheds drain through the area, larger reservoirs can be constructed, or weirs across the drainage can be used to facilitate wet season irrigation. Small tanks can be constructed on small watershed drainages. Natural depressions can be enlarged with dredging and /or dike construction. Surface storage facilities should always be constructed in relatively impermeable soils or where an impermeable subsurface layer exists. Sites which include

potential for all three types of storage facilities should be chosen. Preferably, each village in the project area should have at least one surface storage facility with potential for supplementary irrigation water supply. An in-depth survey of the potential project areas will be required to locate potential surface storage sites, including both physical surveys and discussions with the local residents.

Estimated average initial costs of the various types of water resource supply facilities are:

1. deep well with engine: ฿250,000
2. tank: ฿7 per m^3 storage capacity
3. dug pond: ฿10 per m^3 storage capacity.

A deep well with 10 liters per second flow rate could be used to constantly irrigate about 3 hectares during the dry season plus provide supplemental water for perhaps twice that area during the rainy season. A tank with a capacity of 100,000 m could supply domestic water for the village; be used to raise fish; and irrigate 4 hectares of a post-rice upland crop, 2 1/2 hectares of dry season vegetables (1/8 rai per household), and provide supplemental water for the wet season rice nurseries.