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A Summary of the NERAD Promising Processes, Methodologies and Technologies for Rainfed Agriculture in Northeast Thailand.

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ACKNOWLEDGEMENTS

This document represents part of the current effort within NERAD to consolidate, document and disseminate the major, important findings of the project before its completion in 1989. This vital task was initiated in response to a request from Mr. Doug Clarke, David Delgado and Thongkorn Hiranraks of USAID, Bangkok and we are grateful to them for their constructive suggestions and support for the NERAD consolidation effort over the past two years. The generous support, encouragement and involvement of Mr Chaisup Supsarn in all aspects of the Project is also greatly appreciated.

This report draws extensively from previously published project documents and technical papers prepared by staff of many Departments of the Thai Ministry of Agriculture and Cooperatives, USAID Officials, the NERAD technical assistance team and staff of the regional universities and other institutions. It represents the work of many individuals, too numerous to mention by name but without who's dedication and enthusiasm over the life of the project, the results summarized here would not have been possible. In particular, we would like to acknowledge the support, encouragement and constructive criticism received from Wisoothi Amaritsut, James Hopkins and Paisarn Choungcham during the preparation of this report.

NERAD was designed with an interdisciplinary perspective aimed at drawing on available expertise in a large number of fields from many institutions. In this respect, the Project has been extremely fortunate in having much of the needed assistance available at the regional universities in Khon Kaen and Chiang Mai. The help of the staff of these institutions over the past 5 years, especially in the development of analytical techniques and methodologies, is greatly appreciated. In particular, the assistance of Terd Charoenwatana, Viriya Limpinuntana, Attachai Jintawet, Dr. and Mrs. Grandstaff, Suriya Smutkhupt, Manu Seetisarn and Methi Ekasingh has been of vital importance to the Project.

NERAD has also received excellent support over the entire life of the Project from the Department of Technical and Economic Cooperation and the Ministry of Finance. We are extremely grateful for their assistance.

Finally, the patience, ingenuity and hard work of Northeastern farmers has been the single, biggest contributing factor to the development of the promising technologies described in this report. Many of the most successful technologies were designed by farmers themselves and farmers certainly played a vital part in the development of them all. If the farmers of the Northeast can be given a greater role in the development of the region, then success can be assured.

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PREFACE

This document has been printed and distributed by the Northeast Rainfed Agricultural Development Information and Coordination System (NERADICS) of the NERAD Project. The purpose of NERADICS is to establish, at the Northeast Regional Office of Agriculture, a system to manage Project-generated data and information in order to support the testing, transfer and dissemination of technologies, methodologies and approaches appropriate for integrated agricultural research and development in Northeast Thailand.

Technical working papers are produced with the objective of communicating project-generated information to the relevant research and development agencies in order to receive comments and feed-back and to help to ensure that the lessons learned within NERAD are made available to all interested individuals and organizations.

Working papers are produced on a number of topics and are grouped into three series according to their subject matter:

Problem Definition Series

Situation papers on the problems, constraints and opportunities currently facing rainfed agriculture and farm families in Northeast Thailand.

Methodology Description Series

Descriptions and methods of use of proven methodologies and techniques for the planning, analysis and evaluation of research and extension activities for rainfed agriculture.

Technology Documentation Series

Documentation of technologies considered appropriate for rainfed agricultural development in Northeast Thailand.

All papers in these series are listed in the Appendix of this report and are available on request from the Project Director. The papers are updated at appropriate intervals and NERAD invites comments and discussion from readers on any topic covered in the reports.

FORWARD

The Northeast Rainfed Agricultural Development (NERAD) Project is a joint Royal Thai Government and United States Agency for International Development effort to address the needs of the poor farmers in rainfed areas of Northeast Thailand. The need for a project such as NERAD was was first identified in the 1970's and these early ideas were nurtured and developed during the project-design phase with guidance and leadership from the late Kangwan Devahastin Na Ayuthaya, then Deputy Permanent Secretary for Agriculture. These design efforts culminated in 1981 when Project loan and grant agreements were signed for a seven year project with total funding of over fifteen million dollars, including RTG and USAID contributions. The agreement included funding for long-term technical assistance from the University of Kentucky and short-term assistance from both the United States and Thailand.

NERAD was designed as an integrated agricultural development effort, combining the resources of nine line agencies of the Thai Ministry of Agriculture to develop a replicable agricultural development program in eight sites representative of the predominant agroecological and socio-economic conditions in the Northeast. The MOAC line agencies involved are the Department of Agriculture, Department of Agricultural Extension, Office of Agricultural Economics, Department of Land Development, Livestock Development Department, Department of Fisheries, Cooperatives Promotion Department, Royal Forestry Department and the Office of the Permanent Secretary. Administrative structures and organizational processes were established, analytical techniques were developed and improved agricultural technologies were tested in the target sites by these line agencies in support of the Project's objectives.

Progress within NERAD has been an evolutionary learning process of adaptation and adjustment in the light of the experience gained in developing technical innovations compatible with agroeconomic conditions, farmer aspirations and institutional capability. Many mistakes have been made, but a clearer understanding of the problems and constraints to rainfed agricultural development is now emerging, alongside an increasing number of organisational processes, analytical techniques and improved technologies that can be used for solving the problems.

The purpose of this document is to briefly describe these promising components that have been identifed after six years of project implementation and to summarise their major objectives, potential benefits and remaining drawbacks to interested individuals and relevant institutions.

Utai Pisone

Dr. Utai Pisone
NERAD Project Director

ABBREVIATIONS, TERMS AND EQUIVALENTS

ABBREVIATIONS

AEA	=	Agro-Ecosystems Analysis
CPD	=	Cooperatives Promotion Department
CEC	=	Cation Exchange Capacity
DLD	=	Department of Land Development
DOA	=	Department of Agriculture
DOAE	=	Department of Agricultural Extension
DOF	=	Department of Fisheries
DOLD	=	Department of Livestock Development
FSRE	=	Farming System Research and Extension
FSRI	=	Farming System Research Institute
KKU	=	Khon Kaen University
MOAC	=	Ministry of Agriculture and Cooperatives
NERAD	=	Northeast Rainfed Agricultural Development Project
NERADICS	=	Northeast Rainfed Agricultural Development Information and Coordination System
NEROA	=	Northeast Regional Office of Agriculture
OAE	=	Office of Agricultural Economics
PRV	=	Papaya Ringspot Virus
RAT	=	Rapid Assessment Technique
RFD	=	Royal Forestry Department
RTG	=	Royal Thai Government
USAID	=	United States Agency for International Development

TERMS

Changwat	=	Province
Amphur	=	District
Tambon	=	Sub-District (the level above village and below Amphur)
Muban	=	Village

CURRENCY EQUIVALENTS

U.S. $1	=	Baht 25.5

AREA EQUIVALENTS

1 Rai	=	0.16 hectares
1 Rai	=	1,600 sq. meters
1 Rai	=	0.41 acres

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INTRODUCTION AND BACKGROUND

NORTHEAST THAILAND

The Northeast region of Thailand covers 170,000 square kms. It is bounded to the north and east by the Mekong River, and to the west and south by the Petchabun and Damrek mountain ranges, respectively. The Phu Phan mountains divide the region in a southeasterly direction into the Sakon Nakorn and Korat river basins. The former drains by the Sri Songkram river directly into the Mekong while the Korat basin or triangle is drained by the Chi and the Mun rivers which flow into the Mekong in Ubon. Both basins are at an elevation of approximately 200 meters above mean sea-level and are characterized by a gently rolling topography.

Rainfall patterns are dominated by both the southwest monsoon and tropical cyclones originating over the Indian Ocean. There is a distinct rainy reason from May to October which exhibits a bi-modal pattern with two peaks in June and September. Average annual rainfall varies from less than 1000 mm. in the rain shadow in the west to over 2,300 mm. along the Mekong in the northeast. The critical climatic factor affecting agriculture, however, is the extreme variability of rainfall both within and between years rather than the total amount of rainfall received.

There are 35 different soil types in the Northeast, but with the exception of some limestone areas in the hills, they are all derived from sandstone, shale or silt-stone and are therefore inherently low in potassium, calcium, magnesium and phosphorous and have extremely low organic matter levels and C.E.C.'s.

The region contains approximately 18 million people or about one third of the total population of Thailand and has an annual population growth rate of 2.3 percent. Farming is the major occupation of 80 percent of the population and on average, 75 percent of household-income comes directly from farming. Average agricultural household income for the region is 11,500 Baht or approximately U.S.$ 460 which represents only 60 percent of the national average. Agricultural incomes are actually falling in the region by an average of approximately two percent per year. The Northeasterners are extremely mobile and often migrate to the provincial centers, Bangkok or other regions to find work in the off-season to supplement their agricultural incomes.

THE NERAD PROJECT

The purpose of NERAD as stated in the Project Paper is:

> "To establish in representative tambons of Northeast Thailand a replicable agricultural development program for increasing farm productivity and farm income, particularly among lower income farmers in rainfed agricultural zones."

In implementing the project, equal weight has been given to both the design of a replicable process for developing technologies and to the technologies themselves. This two-pronged approach is in response to the belief that the only way to demonstrate and continually refine the effectiveness of any development process is through the technologies resulting from it.

Reference is made throughout the Project Paper to a farming systems research and extension (FSRE) approach as being the most appropriate means of achieving the project's stated purpose. Unfortunately, a systems approach often means very different things to different people, and this was a source of constant confusion in the early years of the project. However, there is now general agreement that the FSRE approach within NERAD embodies the following 5 strategic objectives:

1. It is an INTEGRATED approach where problems and opportunities are analysed in an interdisciplinary and interdepartmental manner and activities are coordinated to optimise the performance of the entire farming system rather than its individual components.

2. It RESPONSIVE to farmers needs by matching available technologies with real farmer problems or development opportunities by including farmers in the design and planning of activities as much as possible.

3. It uses on-farm research and extension techniques to develop SITE APPROPRIATE TECHNOLOGIES that are consistent with local agro-ecological and socio-economic conditions.

4. It makes full USE OF LESSONS LEARNED (both positive and negative) for future modifications and planning purposes.

5. It ensures that methodologies and technologies being developed are compatible with both MOAC and village institutions in order that they are SELF SUSTAINING AND REPLICABLE in other areas through the government system.

After 5 years of implementation, the Project has developed a number of organizational processes, analytical techniques and improved technologies that are considered to have high potential for benefiting future agricultural development programs of the MOAC in the region. The current, major thrust in the final year of the project is to institutionalize promising components in the regular programs of the relevant MOAC departments. This is to be achieved through a series of dissemination workshops and by the publication of supporting technical reports that describe the processes, methodologies and technologies in the form of simple 'Hand-Books' or 'Manuals' that can be easily followed by potential users to implement these components by themselves.

SECTION 1.

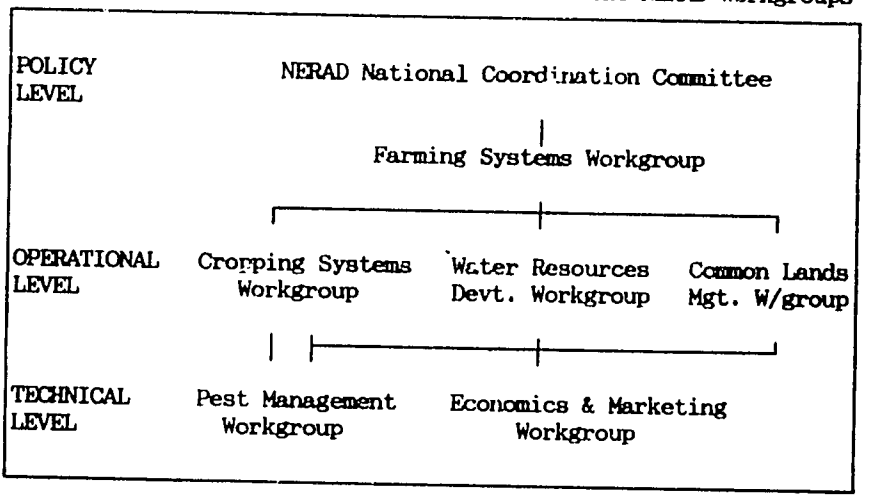
INTEGRATIVE STRUCTURES AND PROCESSES

1.1 TECHNICAL WORKGROUPS

The NERAD Project's development activities are technically diverse, covering a wide range of component disciplines implemented by nine different line agencies within the Ministry of Agriculture. Initially all activities were conducted by the responsible agencies in virtual isolation of each other and as a result, a number of serious conflicts began to emerge at the field level. Examples included the construction of water resource structures by DLD that were unsuitable for fish raising by DOF; cropping system demonstrations by DOAE that were in conflict with DOA's research findings and the planting of fast growing tree species on the paddy bunds by RFD that drastically reduced yields of DOA's cropping system trials.

In order to overcome these problems in line with the project's goal of integration, a number of workgroups were established comprising the relevant line agencies for each subject matter area. The workgroups are organized as shown in Figure 1.1.1

Figure 1.1.1 Organizational Structure of the NERAD Workgroups



The operational workgroups for cropping systems, water resources and common lands are responsible for coordinating all project activities falling under their responsibility and are supported in this by specific, subject-matter, technical workgroups such as marketing and economics and pest management. The technical level

workgroups are established when a particular problem arises and comprise people with the relevant expertise from appropriate agencies or institutions including those not directly involved with the Project. The activities of these technical and operational workgroups are then integrated by the Farming Systems Workgroup in a manner compatible with the FSRE approach, and administrative and budgetary procedures for this are established by the National Coordinating Committee.

This workgroup approach was useful for integrating the diverse project activities and helped to promote the practice of giving those responsible for implementing activities a role in the planning process. The approach also enabled NERAD to draw on expertise from other MOAC agencies not directly involved in the project or from institutions outside the MOAC such as the regional universities.

Work within NERAD is now focusing on ways of institutionalizing the use of workgroups within the regular MOAC programs using currently available structures and processes. This 'NERAD Model' is being pre-tested in Muang Suang district of Roi Et prior to replication elsewhere and is providing existing committees at the provincial and district levels with the analytical tools and methodological procedures necessary for them to assume the roles of the project's technical workgroups (See Section 1.6). In addition, the roles and responsibilities of a field-level workgroup are being developed and refined as part of the full-cycle, integrated model being tested in Nakorn Phanom (Prasartsri, 1988).

For further information and a more complete description of NERAD's technical workgroup approach, the reader is referred to the following publications:

1. Ragland. J.L., 1987. Rainfed Agricultural Development in Northeast Thailand. USAID Contract Completion Report, College of Agriculture, University of Kentucky, Lexington.

2. Anonymous, 1985. NERAD Project: Findings with High Potential for Rainfed Agricultural Development in N.E. Thailand.

3. Amaritsut, W. and Craig, I.A., 1987. Pre-Replication Test of the Consolidated NERAD Development Model in Amphur Muang Suang, Roi Et. Project Proposal, USAID, Bangkok.

4. Prasartsri, C. 1988. The rainfed agricultural development model for Amphur Na Waa , Nakorn Phanom. Proceedings, Fifth National Farminf Systems Conference, Kasetsart University, Kampaensaen, 4-7 April, 1988. In press. (In Thai)

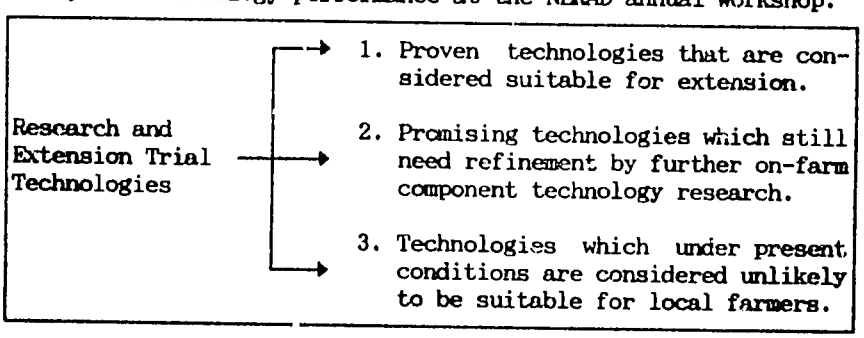
1.2 ANNUAL TECHNICAL WORKSHOPS

In NERAD's early years, separate and completely unrelated, cropping-systems research-trials were being implemented within the project by DOA and NEROA, DOAE were conducting cropping systems demonstrations that had no relation to the research trials, and OAE were collecting data only on farmers crops outside of the trials. There was little or no communication or exchange of information among these components and the planning and implementation of cropping system activities made no use of the information generated by these various components.

The Cropping Systems Work Group has been the basic mechanism used to promote the Project's objective of making effective use of the lessons learned from the research trials for the planning of future activities. The key event in the process is the Annual Cropping Systems Technical Workshop. In this workshop, which is held at the end of each cropping year, results are reviewed, technologies screened, problems communicated to the basic research agencies and research and extension trials are jointly planned by interdisciplinary, inter-departmental teams.

The workshop begins with a presentation of agronomic and economic results of the research trials from each site followed by the results of the extension trials where socio-cultural factors and feed-back of information from the farmers is emphasized. The next session entails breaking up into site-teams where researchers and extension personnel jointly review the results in detail and screen the technologies of all trials according to their agronomic, economic and social performance (Figure 1.2.1). The results of this joint screening process which is described in more detail in Section 2.3 of this report, are then used to set future research and extension priorities for the trials. In this way, extensionists are involved in research planning to ensure that it responds to the needs of local farmers, and researchers help extension personnel to design extension programs that are in line with research findings and are technically sound in terms of implementation recommendations and site selection.

Figure 1.2.1. Screening categories used for assessing cropping system technology performance at the NERAD annual workshop.



The annual workshop has proved successful in coordinating departmental roles and promoting the use of interdisciplinary analysis procedures. Planning is jointly conducted by all relevant departments who have clearly defined roles. Research results feed into the extension system in a coordinated manner and channels are established for the remaining problems to be referred back to basic research as necessary.

There are two key characteristic of the workshop that allow departments to work together constructively in a non-threatening manner. The first is that a feeling of 'joint ownership' of the trials is promoted; rather than DOA being responsible for research and DOAE being responsible for extension, both departments are given a stake in the entire process. Secondly, review and analysis of the results occurs in a setting of 'self evaluation' in which officials responsible for the trials are willing to be more self critical than they would be if a third party was responsible for evaluating their work, when they tend to become more defensive.

Work within NERAD is now focusing on ways of extending this annual technical workshop to include all elements of the farm system so that it can be used for the review, analysis and planning of all agricultural technologies currently being tested by the project.

For further information on organization and more details on the results and outputs of NERAD's annual technical workshops, the reader is referred to the following publications:

1. Anonymous, 1985. Proceedings of the NERAD Annual Cropping Systems Technical Workshop for the Crop Year 1984-85. Northeast Regional Office of Agriculture, Khon Kaen, Thailand. (In Thai)

2. Anonymous, 1986. Proceedings of the NERAD Annual Farming Systems Technical Workshop for the Year 1985-86. Northeast Regional Office of Agriculture, Khon Kaen, Thailand. (In Thai)

3. Craig, I.A., Watanabuti, W., Sukapong, C. and Suratikul, S., 1986. A Cropping Systems Technology Development Process: The NERAD Experience. Proc. 3rd National Farming Systems Conference, April 2-4, 1986, Chiang Mai University, Chiang Mai, Thailand.

4. Craig, I.A. and Sukapong, C., 1986. Agricultural Triage: a Methodology for Screening Trial Technologies and Prioritizing Research and Extension Activities. NERADICS Methodology Description Series, M2, Northeast Regional Office of Agriculture, Khon Kaen, Thailand.

1.3 CROPPING SYSTEMS TECHNOLOGY DEVELOPMENT PROCESS

In the early years of NERAD many problems were encountered in designing, implementing and evaluating the cropping systems r .search and extension trials. These included: ineffective use of existing information for planning the trials; an emphasis on yield maximization rather than meeting the farmers' real needs; the lack of a practical methodology for conducting on-farm trials compatible with available resources; lack of interest in the collection and analysis of data from the trials; inadequate documentation and use of the data generated by the trials and finally, little or no integration of the research and extension phases of the trials towards a common goal in a mutually supportive manner.

In line with the Project's third strategic objective, a systematic technology development framework was developed by NERAD in an attempt to overcome these problems and to improve integration between the departments responsible for agricultural research (DOA) and agricultural extension (DOAE). A diagrammatic representation and definition of each phase of the process are contained in Figure 1.3.1 and Table 1.3.1, respectively. There are 3 key characteristics of the process that are essential for its success. First, it is a two way flow; technologies are tested, screened and improved at each stage of the process but information gained also feeds back to previous phases. Secondly, the process is iterative and does not end with farmer adoption of the technology; as new technologies are adopted by farmers, then new constraints emerge as the farming system is adjusted to incorporate the improved technology. This requires the identification of new problems and the process begins over again. Finally, it must be flexible; as experience is gained in utilizing the process, it must be continually improved and adjusted according to the lessons learned in each phase.

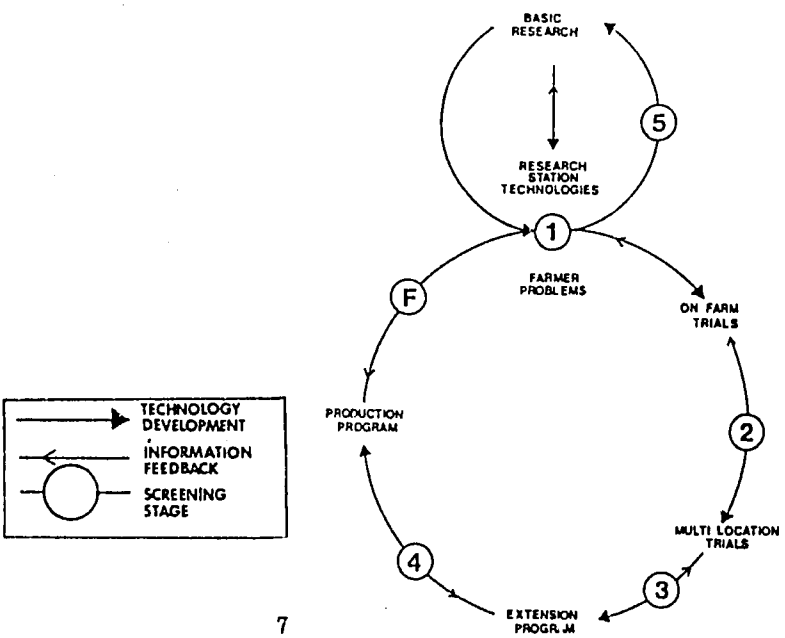


Table 1.3.1 Definitions of each phase of NERAD's cropping systems development process.

FARMER PROBLEMS: Problems with crop production systems OR constraints that are limiting development opportunities that are experienced by a significant proportion of the target farmers.
RESEARCH STATION TECHNOLOGIES: Currently available technologies that have been successfully tested on local research stations.
BASIC RESEARCH: Fundamental research within any discipline with the objective of discovering new techniques or solving problems associated with current technologies.
ON-FARM TRIALS: The testing of improved technologies in farmer fields, conducted jointly by researchers and the farmer. The farmer supplies labor and makes some day to day decisions but management is essentially under the control of the researcher.
MULTI-LOCATION TRIALS: Extension testing of promising on-farm trial technologies in farmers fields conducted jointly by extension, research and farmers. Technical advice and some essential inputs are supplied, but the farmer is expected to make most management decisions himself.
EXTENSION PROGRAMS: An extension phase using demonstrations, field days, radio-broadcasts, etc., to inform farmers about promising technologies from the multi-location phase and to evaluate farmer adoption patterns of the technology.
PRODUCTION PROGRAM: Programs to match production potential in an area with market capacity through credit and market-support programs, in a way that best integrates local production patterns with national policy objectives.

Effort in the final year of NERAD will concentrate on modifying and refining the cropping systems technology development process, as the technologies currently under development, pass on to later phases and the cycle is completed.

For further information and details of the technology development process, the reader is referred to the following publications:

1. Craig, I.A., Sukapong, C. and Suratikul, S., 1986. A Cropping Systems Technology Development Process: the NERAD Model. NERADICS Methodology Description Series M1, N.E. Regional Office of Agriculture, Khon Kaen, Thailand.

2. Craig, I.A., Watanabuti, W, Sukapong, C. and Suratikul, S., 1986. A Cropping Systems Technology Development Process: the NERAD Experience. Proc. 3rd National Farming Systems Conference, April 2-4 1986, Chiang Mai University, Thailand.

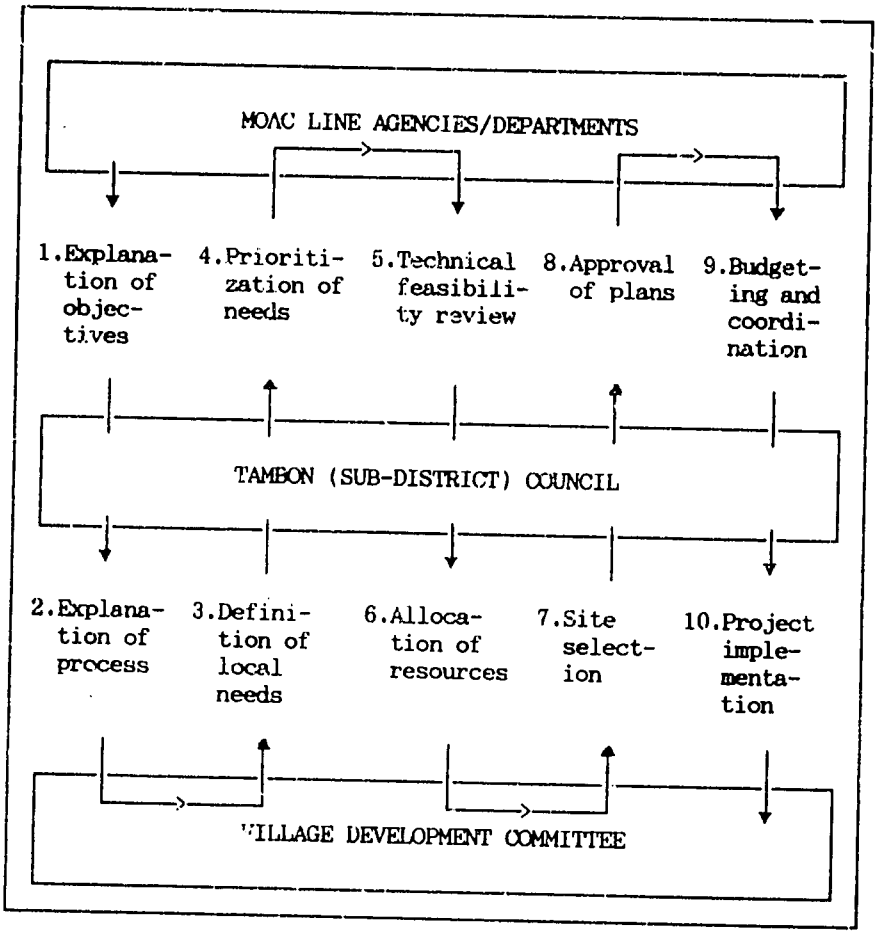
1.4 TAMBON PLANNING

NERAD activities in the first year of implementation were mostly defined by the project paper, regardless of local conditions or agroecological and socio-economic differences among project sites. As a result, early interventions were based on farmer problems as conceptualized by the Project design team, and were not always compatible with the farmers' real objectives and goals. The project was thus faced with the task of developing a replicable means of including farmer participation in the planning process in order to meet the Project's goal of being responsive to farmer's needs.

Tambon Councils, comprising village headmen and respected local elders and leaders, already existed in all project sites, and were subsequently used by NERAD as the most appropriate mechanism for obtaining a 'bottom-up' perspective to project planning. Tambon planning was first undertaken within NERAD before that of the Rural Poverty Alleviation Program (RPAP), so there were no guidelines available for use by Project personnel when conducting the first Tambon Agricultural Development Plan (TADP). Under implementation pressure, activities, determined as feasible in the design process were taken as first approximations of Tambon Council needs. The suggested set of activities were proposed to the council for approval, but their choice was mainly limited to site and farmer selection. Considerable confusion evolved on both the parts of the Tambon Councils and government officials, and significant problems with this planning process surfaced. Two Tambon Councils actually planned activities, which some of their constituents were not informed of nor in agreement with, and other means of making the process more participatory, and hence more responsive, were therefore explored.

The planning process was expanded so that Tambon Councils could review and critique activities in order to select those most appropriate to their needs and problems. In addition, new activities were also suggested, and a means of obtaining the participation of the Village Development Committees in the planning process were explored in one project site. This consisted of the local agricultural extension agent, the community development worker and project officials following the steps illustrated in Figure 1.4.1. As a result of this activity, Community development workers involved in the Project's tambon planning process for the first time, noted that the development plans emerging from the NERAD process were significantly superior to those from the regular Rural Poverty Alleviation Program outside the project. It represented the first time that the villagers themselves directly helped to identify development activities and thus helped to promote a feeling of project 'ownership' among them.

Figure 1.4.1 Structure, roles and phases of the NERAD tambon planning process.



Further development of the agricultural tambon planning process is needed in a number of areas identified during the testing phase. First, training in planning procedures needs to be arranged for the Tambon Councils in order to give them the necessary expertize for conducting 'bottom-up' planning. Second, it is recommended that a 'menu' of possible agricultural development activities is prepared, using visual techniques such as video films and slide-shows so that the Tambon Councils or Village Committees can choose appropriate interventions from the list. Finally, there is a need to simplify the requirements of the official government system for submitting development assistance requests because they are currently much too complex for Tambon Council members to understand and use effectively.

1.5 NERADICS INFORMATION AND COORDINATION SYSTEM

The NERAD Project has generated a large amount of wide ranging data and information over the past 6 years including: baseline socio-economic surveys, land use mapping, agro-ecosystem analysis handbooks, physical resource development surveys, rapid rural appraisal reports, economic and marketing studies, research trials data, development project results, technical and economic analyses, mini-evaluations, promising technology documentation, consultants' reports, and working papers. However, Project technical information functions were predominantly producer-driven, rather than user-driven, resulting in reports which were ends in themselves. Source data were rarely processed into different information formats to meet the needs of multiple users from different disciplines. The result was a situation characterized by data overload and information shortage, while data and information producers complained that their outputs were not being used by the recipients of their reports.

Technology documentation activities received high priority for improvement in mid 1986, resulting in the publication of two preliminary reports on technologies and processes with high potential for application in the region. Since then, data resource management and the production and communication of information have been managed to establish, at the Northeast Regional Office of Agriculture, an information system which supports the coordinated mobilization of resources for problem-based, integrated technology research and development in the region.

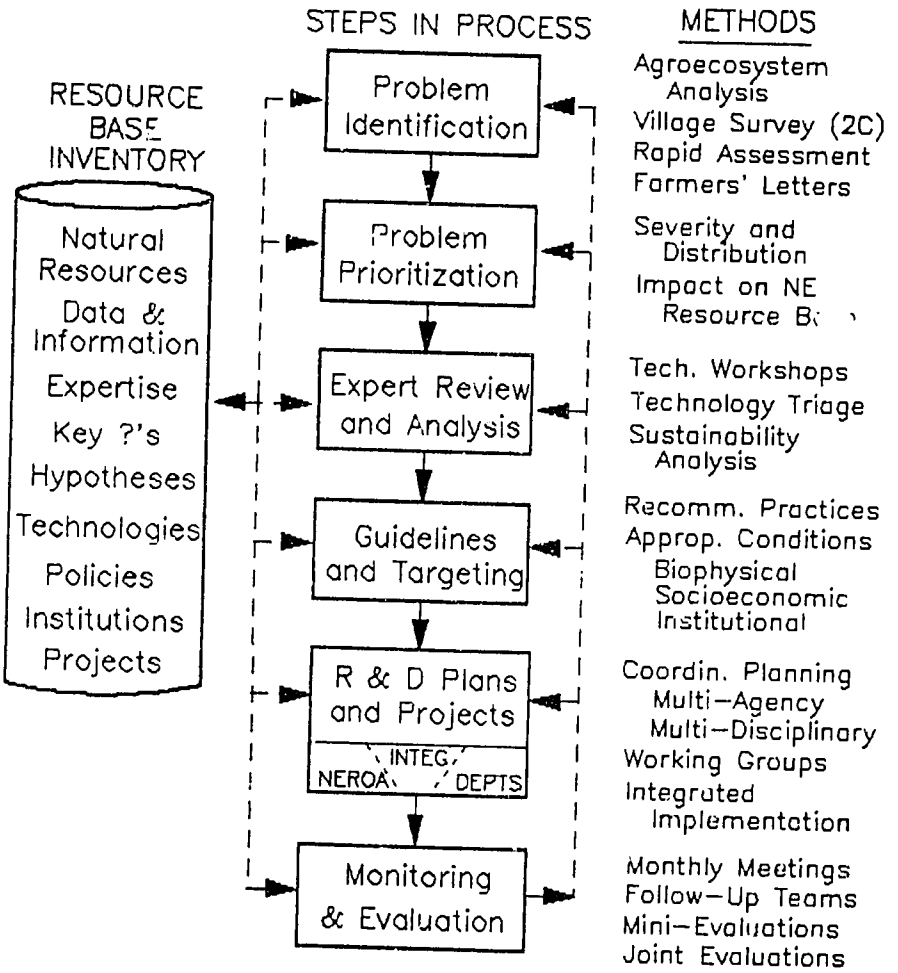
The major objectives of the Northeast Regional Agricultural Development Information and Coordination System (NERADICS) are as follows:

- to organize and document the lessons learned, and the methodologies and technologies developed by NERAD;

- to develop prototype systems for information management, appropriate for the future role of NEROA.

In aggregate, NERADICS is intended to function as a continuous adaptive learning process for optimizing the productive utilization of available resources in accordance with changes in area-specific natural, production, marketing and social environmental conditions. The key characteristics of the process are presented in Figure 1.5.1.

Figure 1.5.1 Key characteristics of the NERADICS framework.



For further information and a more detailed account of NERADICS the reader is referred to the following publications:

1. Hopkins, J., 1988. NERAD Agricultural Development Information and Coordination System (NERADICS): A Project Description. NERADICS Paper M3, Northeast Regional Office of Agriculture, Khon Kaen, Thailand.

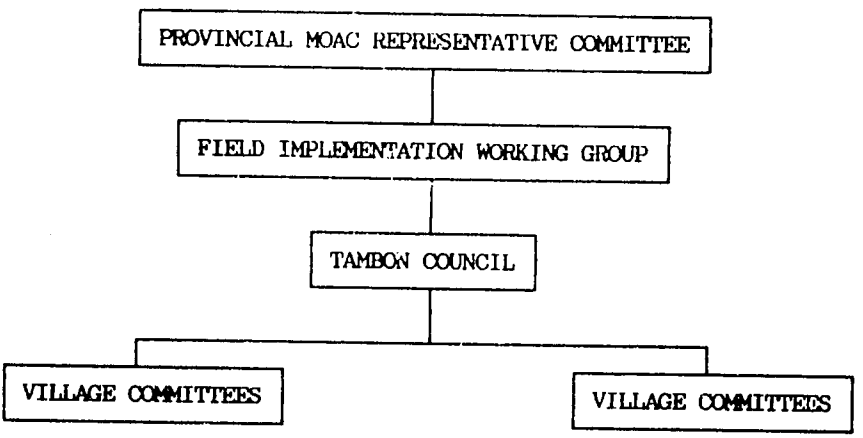
2. Hopkins, J. and Craig, I.A., 1987. General Methodology for the Technical Seminar/Workshop Component of NERADICS. NERADICS Paper M8, Northeast Regional Office of Agriculture, Khon Kaen, Thailand.

1.6. THE NERAD PRE-REPLICATION MODEL

After 5 years of development and testing, a number of promising organisational structures, methodological tools and improved technologies have been identified within NERAD. However, because of the size and diversity of the project, the promising areas identified are still scattered throughout NERAD as a series of only loosely-related components. There is therefore, a need to assemble these promising components into a coherent system or program for testing within the current MOAC system. To ensure the future replicability of the program under currently-available government resources, a new site where no biases, preconceptions or project infrastructure or activities currently exist was chosen as the test ground for the model. Amphur Muang Suang, Changwat Roi Et was selected by MOAC officials as a site meeting these criteria.

Organisational structures that have demonstrated proven benefit within NERAD and which are compatible with the MOAC system were adopted for the pre-replication test. Such structures included Changwat and field-level workgroups, the coordinating structures of the Field Manager and his staff and the decision making structures within the Tambon Councils and the Village Committees. An outline of the organisational structure used for the pre-replication test is shown in Figure 1.6.1.

Figure 1.6.1 Organisational Structure of the pre-replication test



The existing Changwat Representative Committees, recently established in every Changwat in the country by the MOAC, were activated and used by NERAD in the pre-replication test to promote an inter-disciplinary approach in the analysis, planning, implementation and evaluation of technical issues using techniques and methodologies developed by NERAD. This committee, which comprises the Provincial Heads of every MOAC line agency, was given

responsibility for conducting agroecosystems analyses for planning research and extension activities, coordinating departmental roles, integrating project activities following FSRE procedures, reviewing implementation results, assisting with problem solving and considering the implemention of promising components of the pre-replication test in regular Changwat programs.

The ability of Amphur extension officer to fulfill the coordinating role of the NERAD field manager was tested in Muang Suang by establishing an amphur level working group comprising the departmental representatives responsible for project implementation with Kaset Amphur as Chairman. This working group assists in needs-assessments and site selection, screens and selects appropriate technologies to meet the needs of the site, liases with the tambon councils and village committees in the planning process, requests budget according to guidelines established by the provincial committee, coordinates work at the amphur level, monitors progress and reports problems and constraints to the Provincial committee. It performs its coordinating role through monthly, interdepartmental review meetings and site-visits.

NERAD has demonstrated the benefits of utilizing the tambon planning process for project planning to ensure that project activities address real farmer-needs in each site. In the pre-replication test, the Tambon Council is used not only during the planning phase but also in evaluating the results of the trials implemented. In order to achieve this, training in needs-assessment and project planning is conducted by the Amphur working group. The techniques and methodologies developed by NERAD for ensuring that the needs of individual villages and farmers are adequately reflected in the tambon development plans, were also used in the pre-replication test. The village development committees were used to assist in problem prioritization, project-design, planning, implementation and evaluation to ensure that local needs and opportunities are adequately reflected in the tambon development plans.

During the pre-replication test, the order of steps taken were as follows:

1. Agroecosystems analysis and rapid rural appraisal techniques were used to conduct a site description which defined the local agro-ecosystem in terms of its key biophysical, economic and social characteristics.

2. Based on the results of the analyses, sites for implementation were chosen and assessed in detail by further RRA's.

3. Farmer problems and development opportunities identified above were prioritized and matched with technologies for their solution using triage techniques, and were implemented using NERAD's technology-development methodology-framework.

4. Activities were integrated, monitored and modified in line with lessons learned by the Amphur working group.

SECTION 2.

ANALYTICAL TOOLS AND TECHNIQUES

2.1 AGROECOSYSTEMS ANALYSIS

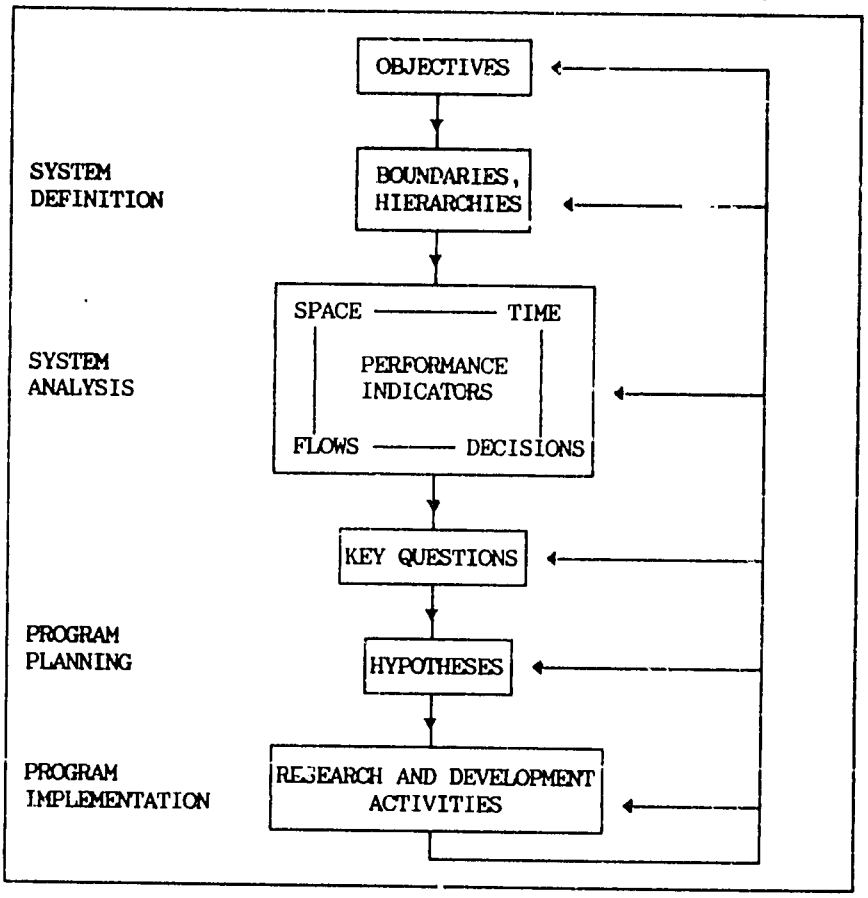
Many data and much information in the form of land-use mapping, base-line surveys, project design reports etc., were already available to NERAD when project implementation began in 1982. Very little use was made of this information when project activities were first planned and, as a result the activities implemented, reflected the current policy of each participating agency rather than the real needs of the target sites. NERAD turned to agro-ecosystems analysis (AEA) procedures as a means of defining locally appropriate research and development priorities. The AEA approach was still under development by the regional universities, and with their help, it was refined and simplified for use within the project.

Agroecosystems analysis comprises a body of interdisciplinary procedures and analytical tools for defining the major problems facing developing agricultural systems and for providing guidelines for research and development activities. It is based on the assumption that although large agroecosystems are complex, their important characteristics are determined by a limited number of key processes, the judicious manipulation of which can yield significant improvements. Agroecosystems analysis is designed to ensure that agricultural, ecological, socio-economic and management issues are raised simultaneously, allowing an interdisciplinary cross-fertilization of ideas out of which a limited set of key research and development questions emerge.

The procedure which is illustrated in Figure 2.1.1, is iterative in nature and as early key question begin to emerge, these are used to redefine the system and its key processes. AEA's are conducted in an interdisciplinary workshop setting which proceeds with a series of plenary meetings, interspersed with workgroup sessions and site visits. The procedure takes at least one week (but ideally much longer) and as a basic minimum, requires representatives from the following disciplines: agronomy, soil science, plant protection, extension, economics and sociology. There is a need for a meeting-room equiped with overhead projector, white-boards and wall maps and smaller rooms for workgroup sessions. All available data and information regarding the target area must be assembled in advance.

Despite the progress made by NERAD in refining and simplifying the approach, AEA is still perceived as a complex procedure requiring levels of expertise not generally found in the line agencies of the MOAC. Work within NERAD is therefore now focusing on defining AEA's component techniques and procedures and documenting them as individual tools that can be reassembled into 'user-tailored packages' according to specific program needs and the resources and expertise available.

Figure 2.1.1 Procedural framework for Agroecosystem Analysis



Source: After Conway, 1986.

For further details of AEA and associated procedures the reader is referred to the following publications:

1. Gypmantasiri et al., 1980. An Interdisciplinary Perspective of Cropping systems in the Chiang Mai Valley: Key Questions for Research. Multiple Cropping Project, Faculty of Agriculture, Chiang Mai University, Thailand.

2. Limpinuntana, V. and Patanothai, A., 1982. Handbook of the NERAD Tambons. NEROA, Khon Kaen, Thailand.

3. Conway, G.R., 1986. Agroecosystems Analysis for Research and Development. Winrock International, Bangkok.

2.2 THE RAPID ASSESSMENT TECHNIQUE

Early NERAD experience showed that assessments of farmer problems were usually made from a commodity-oriented perspective of a central or provincial based researcher. Based on the problems thus perceived, on-farm trials were similarly implemented by a single agency using the technologies available on the experiment stations. This led to trials that were invariably technology-based, usually mandated from the various commodity and technical institutes, with agronomists as the only discipline involved in trial implementation. As a consequence, linkages with extension and other agencies were weak.

The Rapid Assessment Technique (RAT) is a tool that can be used to overcome these problems. It was used by NERAD to determine the needs, problems and constraints facing target farmers and was found to be an effective technique for planning, implementing and analysing the trials conducted. It also helped to promote inter-departmental cooperation amongst the relevant agencies thereby fostering an interdisciplinary approach to agricultural research and extension.

RAT is a new technique, still undergoing development and refinement. It is essentially a needs-assessment procedure, utilizing semi-structured interviewing techniques and interdisciplinary analysis procedures conducted by a small group of experienced personnel who follow up on leads, revise questions and probe some areas in more depth than would be possible with a formal survey. The ability to submit the findings to rigorous statistical analysis is sacrificed in order to gain an in-depth, holistic understanding of the situation. At the same time, it allows the researchers to learn from the farmers themselves who have considerable technical knowledge valuable to the research and extension process. The procedure as used by NERAD, embodies a set of tools that are used at different stages of the RAT process. These are summarized in Table 2.2.1 and guidelines for their use can be found in the references cited at the end of this section.

Table 2.2.1 Summary of tools available for use during RAT's

DATA COLLECTION	DATA ORGANIZATION	DATA ANALYSIS
Data review Mapping Transect walks Farm calendars Semi-structured interviewing Triangulation	Flow charts Maps Transect diagrams Farm profiles Decision trees Diagrammatic models Lorenz curves	Agroecological zoning Map overlays Land use classification Critical path analysis Sustainability analysis Innovation assessment Equitability analysis

RAT's should be conducted by interdisciplinary teams. For crop related needs-assessments, the team should include (as a minimum) the disciplines of agronomy, soil science, plant protection agricultural economics, extension and rural sociology or anthropology. Smaller teams with a balanced mix of disciplines should be formed to conduct the interviews but the whole team should meet at regular intervals to discuss findings and exchange ideas. A typical schedule for conducting a RAT is presented in Table 2.2.2.

Table 2.2.2 Sample schedule for a typical field RAT.

DAY	MORNING	AFTERNOON
1	Review of objectives, time-table, etc. by whole team.	Village orientation and exploratory interviews.
2-3	Farmer interviews by sub-groups.	Evening meetings of entire team to exchange findings.
4	Plenary meeting to establish tentative hypotheses.	Further interviews to clarify initial hypotheses.
5	Analysis of findings and hypothesis generation.	Presentation of tentative findings to village meeting
6-7	Further interviews as necessary.	Report writing and planning of development activities.

For further details of the Rapid Assessment Technique and the component tools that it uses, the reader is referred to the following bibliography:

1. Alton, C., Craig, I.A. and Choungcham, P. 1987. The Rapid Assessment Technique (RAT): a Procedure for Identifying Farmer Problems and Development Opportunities. NERADICS Report No. M4. (Thai or English)

2. Khon Kaen University, 1987. Proceedings of an International Conference On Rapid Rural Appraisal. September 2-5, 1985, Khon Kaen, Thailand.

3. Conway, G.R., 1986. Agroecosystems Analysis for Research and Development. Winrock International, Bangkok.

2.3 AGRICULTURAL TRIAGE

The Farming Systems Research and Extension (FSRE) approach involves the on-farm testing of agricultural technologies in order to refine and improve these technologies in line with farmer needs. Most FSRE projects begin by testing a selection of agricultural technologies which are usually defined by the project paper, base-line surveys, agroecosystems analysis, RRA's, etc. Only a small proportion, if any, of the technologies tested are likely to be adopted by farmers without modifications. This is because some may not address real farmer problems, others will require further refinement to be successful and some may have serious technical problems that need to be referred back to basic research for correction.

The development and testing of improved agricultural technologies requires regular decisions to be made on which technologies are worthy of further testing and the form in which testing should be conducted. Ideally, the FSRE process should allow for the regular screening of trial technologies in order to direct future research and extension effort. Unfortunately, this rarely happens with the result that on-farm research programs remain highly diversified with a poorly directed research focus. Triage was first used by NERAD in 1984 within the cropping systems development component of the Project as a means of overcoming some of these problems. It attempts to improve objectivity and introduce multi-disciplinary analysis into the technology screening process by developing a step-by-step, inter-disciplinary analysis procedure for rating the performance of the technologies tested, based on the local agroecological and socio-economic conditions in the target site. It provides a framework for assessing the trade-offs among bio-physical and socio-economic parameters, thus allowing the technologies tested in an on-farm trials program to be classified into the following three categories:

1. Successfully proven technologies which are considered suitable for extension to other farm families.

2. Promising technologies which still require further modification or refinement by component technology research.

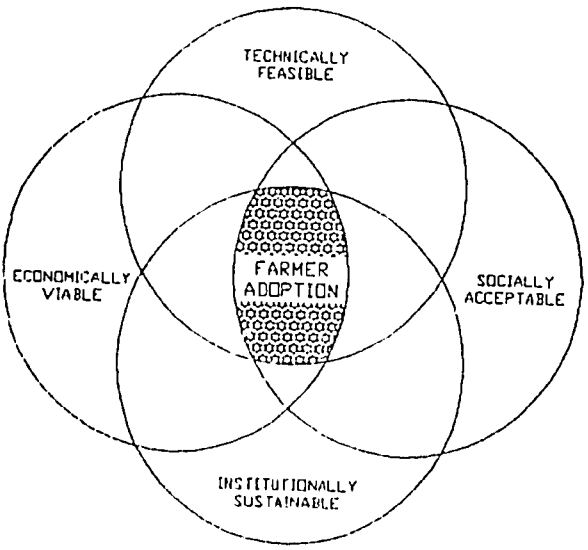
3. Technologies which under present conditions are unlikely to be successful and should be shelved or referred back for further basic research.

Before triage can be conducted, clear guidelines need to be established for deciding which technologies should be allocated to each category. Specific criteria will vary according to the type of technology being considered whether it be a cropping system, water resource, livestock, or other technology. However, some generalizations can be made as regards screening criteria for all technologies.

First, if any technology is to be adopted by farmers, it must

satisfy 4 basic criteria (Figure 2.3.1). It must be biologically or physically possible, economically viable and socially acceptable to the farmers and if it is to be supported by government research and extension programs, it must also be institutionally sustainable. Consequently, the screening or triage process must be conducted in an interdisciplinary manner. Biological or physical scientists will be needed to assess technical feasibility, economists will have to assist in analyzing economic potential and extension personnel and the farmers themselves must be consulted to judge the social acceptability of the technology. Finally, the responsibilities and available resources of the government departments involved, must be assessed by officials of these agencies to determine their ability to provide the necessary support.

Figure 2.3.1. Basic screening criteria used during Triage.



For further details of the triage process and guidelines for its implementation the reader is referred to the following:

1. Craig, I.A. and Sukapong, C. 1987. Triage: a Methodology for Screening Agricultural Technologies and Prioritizing Research and Extension Activities. NERADICS Report No. M2. NEROA, Khon Kaen, Thailand.

2. Craig, I.A., 1988. Agricultural Triage: a Technique for Evaluating Agricultural Technologies and Setting Future Research and Extension Priorities. In: Farming Systems Research and Development in Thailand: Illustrated Methodological Considerations and Recent Advances. Prince of Songkhla University, Had Yai, Thailand.

2.4 SUSTAINABILITY ANALYSIS

Although the triage technique proved useful in defining future research and development priorities for trial technologies, it was not very helpful in assisting in documenting the status of these technologies in a form appropriate for those responsible for the next phase of technology development. The NERAD triage teams felt that their job had been done once they had screened the technologies into their appropriate categories. The Project therefore began exploring ways of improving the documentation of the outputs of the triage process. With the assistance of staff of the International Institute for Environment and Development (IIED), NERAD began testing and refining the technique of 'sustainability analysis' for this purpose. The major objective of this activity was to develop a technique for defining the potential problems and constraints of each technology and identifying possible solutions to these in order to assist in defining recommendation domains and recommended practices for proven technologies, further development needs for promising technologies and basic research priorities for solving the remaining problems facing the unsuccessful technologies.

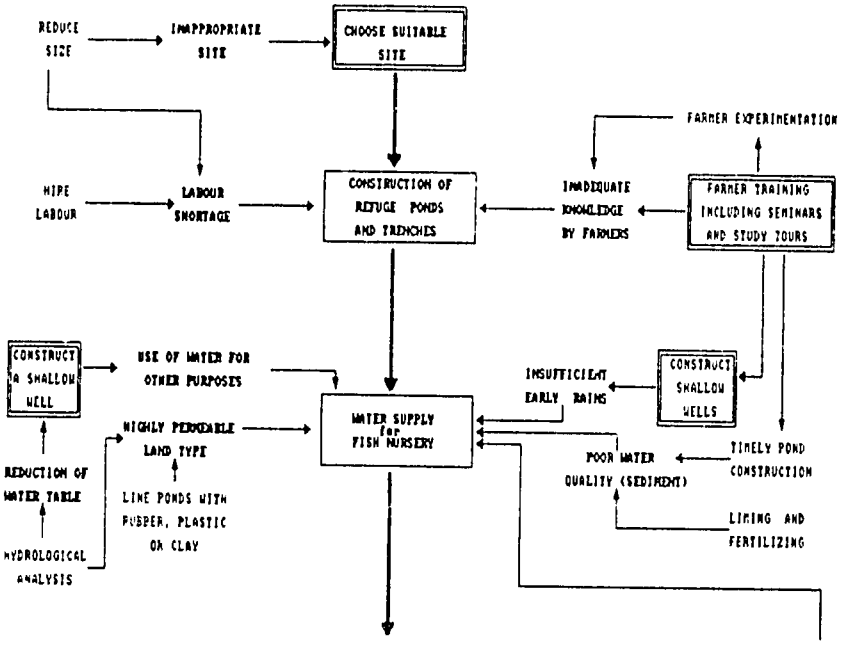
NERAD's sustainability analysis uses an interdisciplinary team, comprising those involved in the technology development process, who jointly analyse each technology according to a simple, step-by-step procedure. The technique involves producing a flow chart listing each implementation stage for the technology, followed by an analysis of the potential problems that may occur at each stage. Potential solutions to the problems identified are then proposed in order to assist in the definition of future development priorities for basic and adaptive research and extension. During the analysis process, a number of problems are identified as being of crucial importance, either because the magnitude of their effect is very high or because they tend to occur at a number of key stages during technology implementation. Similarly, some of the potential solutions to the problems are identified as being highly effective and/or capable of solving many problems simultaneously. These findings are then used to define key recommendations for implementation of the technology.

A sample section of the flow chart and the major findings of a sustainability analysis conducted for NERAD's fish in the rice paddy technology are presented in Figure 2.4.1. The procedure proved very helpful to NERAD for defining recommendation domains and developing useful advice on management practices for this technology. Sustainability analyses are currently being conducted for all the Project's trial technologies in order to assist in their documentation based on the needs of potential users.

For further information on the use of sustainability analysis and associated procedures, the reader is referred to:

Conway, G.R., 1986. Agroecosystems Analysis for Research and Development. Winrock International, Bangkok.

Figure 2.4.1 A sample section of the flow-chart and priorities emerging from a sustainability analysis of NERAD's fish in the rice-paddy technology.



STAGE	KEY PROBLEMS EMERGING	KEY SOLUTIONS IDENTIFIED
CHOICE OF SITE	Lack of security Poor water control Prone to flooding	Should be close to house Use modified shallow well Use mid-elevation paddy
FARMER TRAINING	Construction completed late Farmer is unwilling to dig trenches/ponds Lack of farmer knowledge on fingerling sources	Close farmer supervision Farmer-farmer study tours Media broadcasts Training on fish spawning
PREPARING MATERIALS	Netting and construction expensive	Farmer loans Farmer groups
FISH RELEASE	Lack of water Lack of fish-feed Effect of fish on rice-management and vice versa Inappropriate fish spp. mix	Use modified shallow well Nursery pond construction Use of crop/animal by-products (mixed farm) More research on rice-fish ecology needed As above
MARKETING	Lack of local markets	Farmer marketing groups

2.5 LORENZ CURVES AND EQUITABILITY ANALYSIS

Agricultural research and development has tended to emphasize increases in productivity or yield. Recent applications of the systems approach to agriculture, however, have demonstrated the importance of other technology performance-measures such as stability, sustainability and most recently, equitability (Conway, 1986). These factors, in particular the inequitable distribution amongst recipient farmers of the benefits of agricultural research conducted during the Green Revolution, have been one of the main reasons for the development of the farming systems approach. Although recognised as important, these system properties have tended to be ignored by many FSRE programs because of the difficulties associated with their measurement.

AEA's and RAT's conducted during the NERAD pre-replication test in Muang Suang, Roi Et, revealed that the inequitability of agricultural household-incomes in this area was a key determinant of both on and off-farm activities. With assistance from IIED, the use of Lorenz curves for measuring equitability was tested. The methodology developed requires data on individual family incomes from a representative, random sample of villagers for both agricultural and off-farm sources for all villages to be analysed. The equitability of the distribution of agricultural, off-farm and total income was then assessed for each village using Lorenz curves. The pictorial format of the output was found to be sufficiently simple and tractable for analysis even by quite inexperienced staff.

Lorenz curves are constructed individually for agricultural, off-farm and total income for each village according to the following procedure:

1. For all families sampled (n), calculate the total income of the entire sample (t), and express individual family incomes as a percentage of this.

2. Rank the percentage incomes obtained in '1' above in ascending order (P1, P2, P3... to Pn), and calcualate accumulated percentage incomes (I) for each (where I1 = P1; I2 = P1 + P2; I3 = P1 + P2 + P3 and In = sum[P1 to Pn]).

3. Define the x-axis of the Lorenz curve as the percentage of all families sampled, and mark it equidistantly with points X1-Xn.

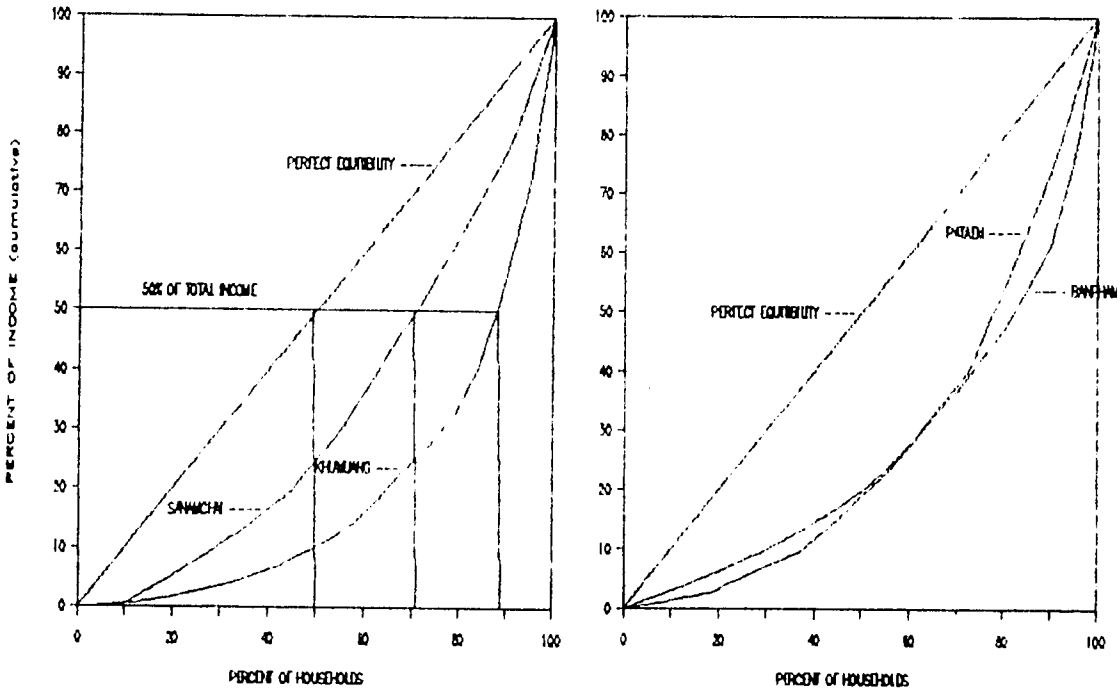
4. Plot P1 to Pn against X1 to Xn for the income-source being considered (agricultural, off-farm or total income).

5. Join up the points on the graph in the shape of a curve. This curve is then used to describe the equitability of the income-distribution for that village.

8. Continue the procedure for all other villages to be compared either on the same or on separate graphs that can then be analysed by overlay techniques.

Examples of Lorenz curves for villages in the NERAD site in Muang Suang are presented in Figure 2.5.1. As can be seen in the first graph, the curves for the two village are different. The diagonal line from the origin to the apex represents the hypothetical situation where income distribution is perfectly equitible (all families have equal income). The closer a curve is to this line, the higher its comparative equitability, thus income distribution in Sanamchai is more equitable than in Khu Muang. In the second graph, the two curves are similar, but the curve for Banpham is more equitable close to the origin, and that for Pataem is more equitable closer to the apex. This shows that inequitability is skewed in different directions in the two villages; Banpham has a relatively very wealthy minority while Pataem has a relatively very poor minority.

Figure 2.5.1 Lorenz curves for income distribution, Muang Suang.



For further details on applications of equitability analysis and the use of Lorenz curves, the reader is referred to:

Choungc..m, P. et al. 1988. Rapid assessment report: problems and potential of the Muang Suang site. NERADICS Technical Report P7, NERAD, N.E. Regional Office of Agriculture, Khon Kaen. (In Thai)

SECTION 3.

TECHNICAL INNOVATIONS AND IMPROVED TECHNOLOGIES

3.1 DIRECT SOWN RICE

Up to one third of the paddy land in Northeast Thailand remains unplanted each year due to insufficient water for transplanting. This unplanted area is mainly on the higher elevation 'upper-paddies' where it is difficult to accumulate water due to topographical and soil factors. In addition, up to 20 per cent of the land actually transplanted to rice is destroyed by periodic droughts. Average rice yields are low in the Northeast, 228 kg. per rai compared to 361 kg/rai in the Central Plains. These low yields are caused by erratic rainfall with long interspells, low soil fertility and poor soil-water-holding capacity.

Many agronomic experiments throughout the Northeast have shown that direct seeding of rice into dry or moist soils can help to overcome these problems by meeting the following objectives:

1. Ensure a rice crop every year on land that does not always receive sufficient rainfall for transplanting.

2. Reduce the risk associated with transplanted rice in conditions of erratic rainfall.

3. Increase rice yields when transplanting is delayed due to late rains.

4. Reduce labor requirements and remove labor bottle-necks at transplanting time.

5. Remove some of the more marginal upper-paddy land from rice production by guaranteeing subsistence-requirements from a smaller acreage, thus enabling the land to be put into field crop production for which it is more suitable.

NERAD's approach in the development of direct sown rice has been to take an agronomically-sound technology and develop it through on-farm trials into a form appropriate for local farmers. The breakthrough was achieved by the cooperation of DOA's Engineering Division in the development and testing of a simple and relatively inexpensive 2-row-seeder that enabled farmers to sow the rice in a simple, efficient and timely fashion with evenly spaced hills.

Direct sown rice involves early direct-seeding, utilizing rain from the first peak of the region's bimodal rainfall pattern for crop establishment. This allows the early planting of rice at a time when rainfall is often insufficient for transplanting, thus guaranteeing a crop and also reducing the yield losses often associated with late transplanting of the photo-sensitive rice varieties used in rainfed areas in the Northeast. Early, direct

seeding ensures adequate root development and thus produces a rice plant better able to withstand the water-stress periods common between the two rainfall peaks. This is because a deeper root system is established than in transplanted rice where root development is adversely affected by the following:

1. Pulling seedlings from the nursery-bed breaks off much of the root system and retards later root development.

2. Transplanting rice seedlings into a water-logged, puddled soil does not stimulate root penetration to deeper soil horizons.

Rice is sown in well-prepared land by means of a two-row-seeder that is now produced commercially in Thailand and currently retails for 2,500 Baht (See Section 3.6). It optimally requires two people to pull it (one strong man can use it himself) and one rai can be seeded per hour. Direct seeding by this method not only reduces the labor requirement for transplanting, but because the timing of direct sowing can be staggered, labor bottlenecks at planting time are also significantly reduced.

Direct sown rice can be used on any paddy land where reliable rainfall regularly delays or precludes transplanting. Either glutinous or non glutinous varieties can be used with comparable results. Direct sowing should not be done in periods of high probability of heavy rainfall as the newly germinated seedlings will be killed if the field is flooded immediately after planting or at the early seedling stage. Satisfactory weed control is essential for the success of the technology and direct sowing should not therefore be attempted in conditions of heavy weed infestation. Direct sown rice is especially appropriate in conditions of labor shortages for transplanting, because it significantly reduces labor requirements at this time.

Use of the two-row-seeder is considered essential for the successful implementation of this technology, consequently sufficient capital or adequate credit facilities to purchase the seeder are needed. Isolated pockets of adoption of the direct seeding method may lead to severe pest problems. If only a few fields are planted in any area, vertebrate and insect pests are likely to be attracted to this sole source of food which will significantly increase pest damage-levels.

For further details and recommended practices for direct-sown rice the reader is referred to the following publications:

1. Craig, I.A., Watanabuti, W., Sukapong, C. and Netpichit, W. 1986. Direct Sown rice: a Cropping Systems Technology for the Upper Paddies in N.E. Thailand. NERADICS Report No. T1, NEROA, Khon Kaen, Thailand.

2. Craig, I.A. and Baker, G.P. 1986. The Upper Paddies in N.E. Thailand: the Current Situation and Implications for Development. NERADICS Report No. P3, NEROA, Khon Kaen, Thailand.

3.2 COOPERATIVE BUYING GROUPS

The NERAD Project was designed with a farming systems development perspective. The primary result of this design focus was that the Project touched on a broad range of the villagers' problems and needs. This necessitated that it include most of the departments in Thailand's Ministry of Agriculture (MOAC). Based on interests in the MOAC's Cooperatives Promotion Department (CPD) and on perceived and documented needs of the villagers with whom the Project was working, an activity to assist villagers in forming cooperative buying groups was implemented. While most of the Project's activities were technically oriented (such as farmer-managed cropping trials), this activity was a social activity. The unique feature of this activity was that it was planned, implemented and monitored as if it were a test of a production technology. It was a rare opportunity to perform a social-science experiment. A secondary feature of this activity was that it allowed an opportunity for Project staff, to blend technology development and institutional development objectives.

CPD officials were interested in group marketing and suggested it as a NERAD activity in 1982. Office of Agricultural Economics (OAE) and NERAD staff conducted a feasibility study which documented the need for assistance in input procurement, indicated that villagers were familiar with the concepts involved in cooperative marketing and were interested in becoming involved. The feasibility study also identified a constraint, namely that villagers lacked the initial capital necessary to start a group.

The group buying activity was approved for implementation as a social "experiment". The objectives of the experiment were to determine if group buying could be successful in the test environment and, if so, how the groups should be organized and supported. While the broad objective was experimental, the secondary objective was to put functional, permanent groups into place in the villages. It was hypothesized that the buying groups would be successful if they were small (50 member families or less), members lived close to each other (either in the same or adjacent villages), had good leadership, had support from the local Cooperatives Department staff, and had an outside source of initial funds.

Buying groups were established in four tambons (sub-districts) during 1985 and 40 to 50 families, all within one village, were invited to join each group. All of the members were informed that they must be accepted by the other members because liability is shared. Some groups required that each member have two co-signers who are also members of the group. Each member was required to purchase a share in the group for 100 Baht. Each of the four groups established in 1985 received an initial revolving fund of 70,000 Baht from Project funds. The CPD arranged for

this fund to be used for the purchase of fertilizer through the Marketing Organization for Farmers. The types of fertilizers purchased were based on the preferences of each individual group.

Each group received, stored and handled the distribution of the fertilizer differently. Some allowed for cash and credit purchases. One group decided that credit was not a constraint for its members and sold all of the fertilizer on a cash basis. They then used the cash to make another fertilizer purchase.

The groups were able to provide fertilizer to their members at much lower prices than through the normal channels and total savings to members of the four groups were over 71,000 Baht. In addition, the groups earned a profit of about 23,000 Baht. Thus, the groups have done quite well at achieving the goal of lowering the price paid for fertilizer. When the groups were being established, the CPD surveyed fertilizer use of the villagers. It was expected that if fertilizer prices were lowered and credit made available, then fertilizer-use would increase, resulting in increased crop yields. Brief questioning indicated that this has occurred in all except one of the project areas (Sri Saket). This is probably due to the fact that fertilizer use in Sri Saket is already close to recommended levels. A third result has been additional purchases of fertilizer initiated by the groups themselves. Two of the groups, Tambon Tae in Sri Saket Tambon Nong Kaew in Roi Et, made additional fertilizer purchases in the first year. The Sri Saket group added to the revolving fund to make a total of 110,000 Baht for the second round of fertilizer purchases.

Now that the groups have been operating for 3 years and some have applied for and received the status of legal cooperatives, an evaluation of this activity is being planned for later in 1988. The objectives of the evaluation will be to document results and design a replicable model for implementation of this activity within the regular programs of the CPD.

For further information on NERAD's Farmer Buying Groups, the reader is referred to:

Meyer, A.L. and Infanger, C.L. 1987. Cooperative Buying Groups in Thailand: Results of a Social Experiment. NERADICS Report No. T2, Northeast Regional Office of Agriculture, Khon Kaen, Thailand.

Meyer, A.L. 1984. Economic and Marketing Issues within NERAD. Short-Term Consultancy Report, University of Kentucky Technical Assistance Team, NEROA, Khon Kaen, Thailand.

3.3 MODIFIED SHALLOW WELLS

In most areas of Northeast Thailand, water for vegetables and small plots of other high value crops can be obtained in limited quantities from shallow wells dug in the lower paddy fields. However, after 2-3 months the water table recedes and is too deep to supply sufficient water for crop production. These wells are used for subsistence vegetable production for 1-2 months after the end of the rains and are then abandoned. Their walls have no structural support and deteriorate during the rainy season and thus have to be re-dug each year.

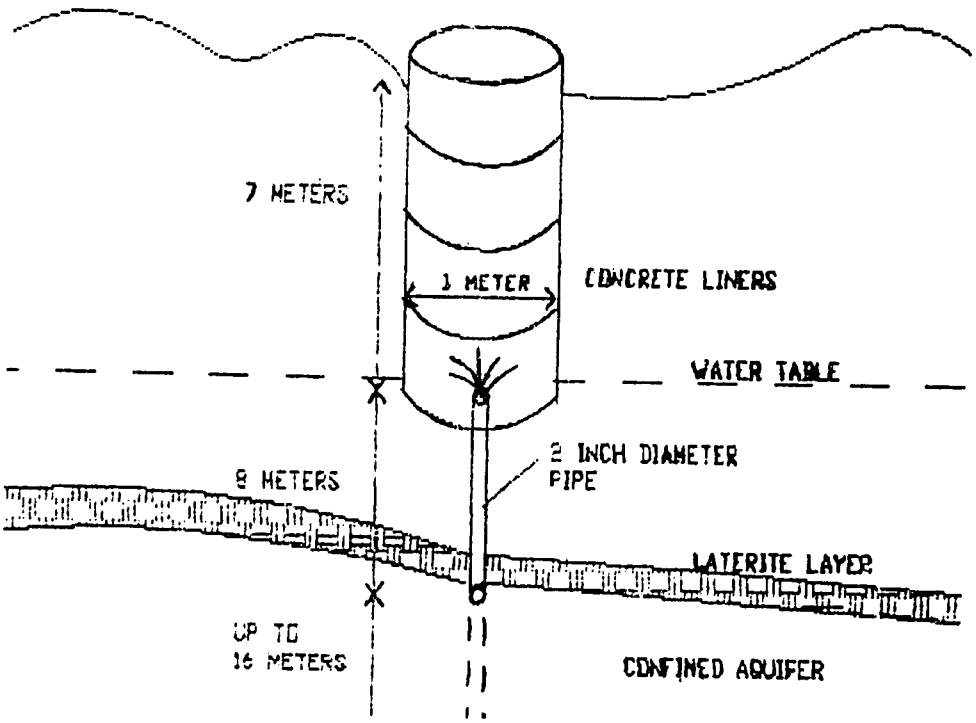
NERAD attempted to improve this traditional farmer practice by supplying concrete ring-liners to farmers who dug wells on their land. This had a number of advantages over the traditional system. Labor was saved as the wells did not have to be re-dug every year. Wells could be dug deeper as they now had structural support and could therefore tap the receding water-table longer into the dry season. Vegetable production could begin earlier after rice harvest as the wells were already in place and the labor conflicts between rice-harvesting and well-digging were overcome. This meant that vegetable crops matured during the cool period favorable to growth and at a time when prices were high. Farmer demand for the cement liners, grew rapidly and soon out-stripped the Project's budget for supplying them and, as a result, emphasis within NERAD changed to training villagers in cement ring construction, supplying construction materials and liner-molds so that the technology would be available to a larger number of farmers.

There are two problems that usually limit the water available from shallow wells. The perched water table is used up before the rainy season begins or the horizontal movement of water is so slow that the time required to recharge the well is excessive. In the NERAD site in Sri Saket the recharge rate of the wells was rather slow and a hard laterite layer prevented the construction of hand-dug wells through to the confined aquifer below. However, an innovative farmer in Tambon Tae of this Changwat who had been supplied with concrete ring-liners for his well by NERAD, improved the technology by constructing what has come to be known as a 'modified shallow well'.

This farmer hired a commercial well-driller to bore a small diameter hole through the laterite layer at the base of his well to access the confined aquifer below (See Figure 3.3.1). Because the water was under pressure, making a hole through the laterite caused the water to flow upwards giving an 'artesian' effect that kept the shallow well supplied with water. NERAD began extending this technology by using a commercial drilling rig to bore a hole from the soil surface down to and through the laterite layer until the confined aquifer was reached. A conventional iron pipe, with small holes in the walls at the lower end, was then forced into the bore-hole to a depth of about 8 meters, in order to prevent erosion of the bore-sides in the soil layer. Following this, a conventional one-meter diameter shallow well

was dug around the pipe to a depth of approximately 7 meters and the well was lined with concrete rings as used in the original technology. The iron pipe was cut off just above the laterite layer and the 'artesian' water was allowed to fill the dug-well to whatever height the water pressure would support. All but one of the 36 wells constructed by the Project were found to fill to within approximately 2 meters of the soil surface. The reservoir formed by the concrete rings gives sufficient volume of water for 2 inch diameter electric or gasoline pump-irrigation for up to 3 rai of vegetables or field crops. The total cost of these wells (excluding labor) was Baht 3,540, but by using locally-produced hand-drilling rigs this cost can be reduced by Baht 2,000.

Figure 3.3.1 Major characteristics of the modified shallow well.



For further details on well-design and construction guidelines the reader is referred to:

Craig, I.A. Phensupha, N. and Ragland, J.L., 1987. Modified Shallow Wells: a Farmer Developed Technology for N.E. Thailand. NERADICS Report No. T3, NEROA, Khon Kaen, Thailand.

3.4 PRE-RICE GREEN MANURING

Both of the major annual crops grown in Northeast Thailand are traditionally cultivated year after year with little or no fertilizer application. Both are extremely efficient at removing nutrients from the soil, submerged rice due to its ability to grow under reduced, water-logged conditions whereby nutrient availability is increased, and cassava by virtue of its physiological response to nutrient stress whereby it maintains leaf nitrogen levels and thus photosynthetic activity at the expense of leaf area index. Very little crop residues from either crop are returned to the soil, cassava due to its high harvest index, and rice because most of the straw is removed as cattle feed. The result is that traditional annual cropping in the Northeast has been eroding soil nutrient status. This continued 'mining' of soil nutrients has led to the situation where Northeastern soils are generally the poorest in S.E. Asia. Because of the limited availability of animal manure, the limited production potential for compost due to lack of raw materials and water, and the high cost of chemical fertilizer, attention within NERAD turned to green manuring as the only feasible, low-cost means of increasing soil-nutrient levels and improving soil condition to give significant improvements on a large scale.

The wet season in the Northeast lasts from May to October and exhibits a bimodal pattern with two peaks in June and September. The first rainfall peak is insufficient for rice transplanting but can, in some years, support short-duration upland cash crops. However, results are highly variable and farmers' risk attitudes generally preclude them from growing pre-rice crops on a large scale. NERAD has been exploring ways of utilizing the early rains to produce a green manure crop that is plowed under before rice-transplanting with the objective of increasing rice yields and improving, or at least maintaining soil condition and nutrient status in a low-cost, low-risk manner, acceptable to farmers.

Green manure trials using various crop materials, conducted in a number of project sites for five years, gave rice yield increases ranging from 3 to 20 percent (Table 3.4.1). In Nakorn Phanom and

Table 3.4.1 Results summary, NERAD green manure trials, 1983-87.

GREEN MANURE CROP MATERIAL	SITE	YIELD (Kg/Rai)			% INCREASE OVER CONTROL
		G.M.CROP	RICE	FALLOW-RICE	
COWPEA	ROI ET	4352	479	435	10
RED COWPEA	ROI ET	1836	446	435	3
BLACKGRAM	ROI ET	3728	482	435	11
SWORD BEAN	ROI ET	2208	449	435	3
SESBANIA	SISAKET	-	543	408	33
COWPEA	SISAKET	-	595	511	16

Chaiyaphum, where the land has been opened for a short period and natural fertility levels are high, farmer interest is low with negligible adoption rates. Farmer interest is high in Sri Saket and Roi Et, however, where soil fertility levels have declined much further, and farmers are beginning to adopt the technology. On these poor soils where green manure is acceptable to farmers, it is extremely difficult to obtain a satisfactory crop stand without the use of fertilizer which would make the technology too expensive for farmers. For this reason NERAD is attempting to combine green manuring with the traditional farmer strategy of applying available cattle manure to a few fields each year. By planting green manure in the fields that receive the cattle manure, it may be possible to obtain adequate growth.

Early trials used cowpea (Vigna sp.) because it was known to the farmers and seed was available in local markets. Results and experience have shown, however, that it does have a number of draw-backs as a pre-rice, green-manure material. First, although more tolerant to water-logging than mungbean (Phaseolus aureus) and some other legumes, it is still affected by water-logging after heavy rain. Second, beanfly (Melanagromyza phaseoli) is endemic in the region and prophylactic insecticide application, which adds significantly to production costs, is essential. Finally, in the 45-60 days available for crop growth, cowpea cannot rival many other legumes in terms of dry-matter produced.

Results of testing and screening a number of green manure materials within NERAD indicate that Sesbania rostrata is a good green manure crop under wet conditions but that cowpea and black-gram are more appropriate for dry conditions. It may not be possible to identify any one species that meets all the necessary requirements of a successful green manure crop because it is rare for any species to combine both drought resistance and water-logging tolerance. A mixed crop, however, containing both drought and flood tolerant species, may be appropriate for conditions of variable rainfall by virtue of its ability to compensate through intra-specific competition to produce a satisfactory crop during periods of stress. In order to test this hypothesis, trials were conducted last year to individually compare sesbania, cowpea and blackgram and also a species mixture of all three to test its ability to offset the effect of risk caused by the uncertainty of climatic factors. Climatic conditions turned out to be extremely dry, and although sesbania performed poorly, satisfactory sole-crop stands of cowpea and blackgram were obtained. Cowpea and blackgram dominated the mixed crop stand which successfully produced a total biomass similar to the cowpea and black gram sole crops. In a wet year, sesbania would be expected to dominate the mixed crop stand giving adequate dry matter yields.

For further details and currently recommended practices for green-manuring, the reader is referred to:

Craig, I.A. 1987. Pre-rice Crop Green Manuring: a Technology for Soil Improvement Under Rainfed Conditions in N.E. Thailand. NERADICS Report No. T4, NEROA, Khon Kaen, Thailand.

3.5 PAPAYA RINGSPOT VIRUS DISEASE CONTROL

Papaya (Carica papaya L.) is grown throughout the Northeast as the second most important subsistence crop after rice. It is used by the Northeasterners to produce 'Somtam', a green papaya salad that is eaten on its own or as a side-dish with rice and other foods. Although papaya is grown throughout the region, total fruit production is insufficient to meet demand and large amounts are imported daily from the Central Plains. Papaya ringspot virus (PRV), discovered in Northeast Thailand in 1974, is now the most serious limitation to papaya production in the Region. It belongs to the largest and economically most important group of plant viruses, the potyvirus group, and has a flexuous rod shaped morphology of about 700-850 nm in length and a narrow host range. Although a wide range of crops are infected by viruses in the group, PRV infects plants in the Cucurbitaceae family, and genus Carica. PRV can infect papaya at any growth stage being transmitted by many aphid species in a non-persistent manner. The most important vectors are Aphis gossypii (Glov.), A. craccivora (Koch.) and Hysteroneuria setariae (Thom.). Infection produces mosaic patterns and distortion of the leaves, ring spots on the fruit and leaves, and streaks on the stems and petioles. Diseased plants are stunted and fruit production is drastically reduced. The disease can also be transmitted mechanically but there is no recorded case of transmission by seed.

Work on PRV has been conducted at the Northeast Regional Office of Agriculture (NEROA) since 1979 and eradication programs have been tested with very variable success rates in a number of villages since 1983. In 1984, an RRA by NERAD's Pest Management Working Group identified PRV as a high priority research topic and a short-term consultancy was funded by NERAD to assess the potential for using cross-protection as a control measure for PRV in the Region. Initial findings were promising, and work on cross-protection was handed over to USAID's Agricultural Technology Transfer (ATT) Project for further testing and for the development of a replicable technology appropriate for the region.

Cross protection, is defined as "the use of a mild strain to protect plants against economic damage caused by a severe strain of the same virus". A prerequisite for cross protection is the availability of a suitable mild strain, which is evaluated in relation to its ability to limit economic damage relative to the effects of the natural severe strain(s) of the virus. The general procedure in cross protection trials is to infect plants with the mild strain and then inoculate them with the severe challenge strain. The plants are then observed, to see if cross protection has occurred fully, partially, or not at all. Additional control experiments help to determine the effects of the mild strain alone, severe strain alone, and challenge by the severe strain under various conditions.

Experiments were begun in the Northeast in June of 1986, using two mild mutants of PRV which originated from a severe PRV strain from Hawaii. The aims of the experiments were to test the reaction of the mild strains on Thai papaya, to establish optimal conditions for infecting papaya with the mild strains at NERQA; to determine the cross protection effectiveness of the mild strains against PRV isolates from Thailand by mechanical and natural infection, and to start limited field trials using the mild strains. Large scale inoculations of the mild strains to papaya were made in April 1987 and experiments were initiated in 18 villages to assess the potential for integrating cross protection with eradication for ringspot virus control. Experimental treatments comprised: cross protection combined with eradication (6 villages); cross protection only (6 villages) and eradication only (6 villages). The results demonstrated the potential for integrated control as a means of controlling papaya ringspot.

Breeding work is now also being conducted to cross the Florida tolerant type with the local Thai type of papaya in order to produce a fruit shape acceptable to local consumers while retaining the former's tolerance to ringspot.. In addition, efforts are being made to select mild strains which are derived from PRV strains from Thailand. Ten attempts at chemically inducing mutant mild strains have been conducted to date, without success. One mutant possessing mild strain characteristics was isolated but it later reverted to the severe strain and the chemical induction of mutations will therefore have to continue until appropriate strains are obtained.

A pilot extension program was initiated in 1988 with the objective of testing the suitability of cross protection and cross protection combined with eradication in large scale programs. Results are not yet available, but early indications are promising and farmer interest in the program is high. If production scale programs appear feasible, training programs for extension personnel will be conducted and mass innoculation systems for seedlings appropriate for the Northeast will be developed.

For further information on the background to the papaya ringspot problem and details of the progress made in the research conducted to date, the reader is referred to:

Gonsalves, D. and Prasartsee, V. 1987. Papaya Ringspot Virus: Disease Eradication and Cross Protection for an Important Subsistence Crop in N.E. Thailand. NERADICS Report No T5, NERQA, Khon Kaen, Thailand.

Prasartsee, V. 1987. Papaya Ringspot virus Disease in Thailand. Consultancy Report to the FAO Regional Office of Asia and Pacific. Bangkok, Thailand.

3.6 SIMPLE FARM IMPLEMENTS

Farm mechanization levels in Northeast Thailand are comparatively low but are increasing rapidly (Table 3.6.1). Only 2 percent of farm families own power tillers and land preparation for rice and upland crops relies mainly on animal power and human labor. Land preparation for some upland crops, most notably cassava, is done by large 4-wheel tractors almost entirely on a contract basis at the rate of 100-150 Baht per rai. Mechanization of crop management and post harvest activities is also uncommon in the region. Traditional exchange labor schemes for rice transplanting, harvesting and threshing still exist, but the practice is declining in importance. Diesel or gasoline water-pumps are used in areas with significant water resources and electric pumps are a popular means of utilizing water from smaller ponds or wells close to villages. In the case of smaller hand implements, most farmers own a plow, hoe, and sprayer, and bicycles, motorcycles and small 2-wheel push-carts or trailers are regularly used on nearly all farms for the haulage of a wide variety of materials.

The rapid increase in the use of agricultural machinery indicates a growing demand by Northeastern farmers for simple mechanization. However, given the periodic under and unemployment patterns and the current migration of labor to the cities and Bangkok, it would be unwise to indiscriminately encourage mechanization. Machinery development within NERAD's cropping systems component was seen as a means of helping to meet two major objectives. First, using improved implements to overcome labor bottle-necks which currently limit cropping intensification in the region and secondly, to encourage better agronomic practices. For instance, most farmers recognize the yield advantage of accurate crop spacing but find it too time-consuming to achieve under conditions of hand planting. A simple hand-drawn, two-row, upland-crop planter may for example, have potential for promoting accurate crop spacing.

A request was made by some farmers for training on the operation and maintenance of small-farm machinery and hand-tools. Because of this, an approach was made to the Thai/IRRI Project who agreed to make implements available for testing in NERAD's cropping systems trials. In addition, a training course for NERAD project personnel in the use, maintenance and demonstration of these implements was conducted by them. Afterwards, appropriate implements were demonstrated by NERAD and lent to farmers for testing on their own farms. As a result of the farmer testing, promising implements and needed modifications were identified.

In Roi Et and Srisaket, farmers, were very interested in the IRRI modified buffalo plows. The large plows speeded-up land preparation for the pre and post rice crops that are commonly grown in these areas, and there appeared to be sufficient interest to justify the local manufacture of these plows. As a result of the NERAD trials, a number of farmers purchased modified plows from the project, and a local manufacturer began producing them with technical assistance from the Thai/IRRI engineers.

Table 3.6.1. Agricultural [illegible]nery use in N.E. Thailand, 1986.

IMPLEMENT	TOTAL [illegible]ER		% INCREASE/YR		% OF FARMS	
	N.E.	NATION	N.E.	NATION	N.E.	NATION
POWER TILLERS	45,286	450,033	27	16	2.2	9.2
LARGE TRACTORS	5,428	34,823	17	18	0.3	0.7
WATER PUMPS	104,236	669,095	14	15	5.1	13.7
POWER THRESHERS	2,937	33,352	16	7	0.1	0.7
POWER SPRAYERS	6,394	123,008	7	24	0.3	2.5
HAND SPRAYERS	279,854	1.37M	70	48	13.7	28.2

In Nakorn Phanom, farmers were extremely enthusiastic about the rice transplanting machine but pointed out the disadvantages of the special seed-bed techniques required for its use. Rice Transplanters suitable for use with traditional seed-bed techniques do not currently exist, but IRRI engineers are now exploring their feasibility. Such a machine would have high potential in transplanted rice systems throughout the Northeast as a means of speeding up planting to ensure an adequate vegetative period for the photo-sensitive varieties grown under rainfed conditions. Pendulum-hoe-weeders were made available to many NERAD farmers for weeding field crops and a number of these hoes were lent to the NECDP project for use in their cassava-replacement crop trials. It was noticed, that the NECDP farmers were using these hoes for weeding their traditional cassava crop as well as the Project's trial crops. An assessment of the usefulness of this implement for weeding cassava in the Northeast is warranted because, if found to be suitable, its potential will be extremely high in the region where cassava is the major upland crop and requires one or two careful weedings for optimum yields. The machine considered to have the greatest potential and for which there is an urgent need for local manufacture and marketing is the two-row-seeder used in the direct sown rice trials in NERAD. The use of this machine has helped to ensure a rice crop every [illegible] on the upper paddies which normally only produce a crop in about one year in three.

For mechanical drawings and technical details of the implements, and for information on their approximate cost and names and addresses of local manufacturers, the reader is referred to:

Craig, I.A. 1988. Simple Farm Implements for Rainfed Agriculture in Northeast Thailand: Development Potential, Research Needs and Local Manufacturing Opportunities. NERADICS Report T6, N.E. Regional Office of Agriculture, Khon Kaen, Thailand.

3.7 RAISING FISH IN THE RICE PADDY

Northeastern Farmers traditionally obtain fish from their rice paddies; the fish move with the flood water in the rainy season and when water-levels recede, they become trapped in the rice paddies and are caught by farmers for family consumption and for sale in local markets. When NERAD began exploring ways of intensifying this traditional system by stocking the paddies with artificially reared fingerlings, the general response was that although possible for irrigated rice, this technology was not appropriate for rainfed conditions. However, despite opposition from some quarters, NERAD made plans for testing this technology in 1983 and trials began in the rainy season of 1984. By that time, a handful of farmers had been identified in the region who had been stocking their rainfed rice fields with fish, some for as long as 30 years, thus proving that the technology was potentially viable.

NERAD began testing the raising of fish in the paddies following the arrangement shown in Figure 3.7.1, stocking the plots with Common Carp (Cyprinus carpio), Tilapia (Oreochromis niloticus) and Rohu (Puntius gonoinotus) in the ratios shown in Table 3.7.1. Initial results were promising and farmer interest was extremely high. From only 13 participating farmers in 1984, the number increased to 65 and 1985 and 338 in 1986. Mean fish yields also increased from 18.2 kg per rai in 1984 to 43.8 kg per rai in 1985 with some farmers obtaining over 125 kg per rai.

Figure 3.7.1 Generalized layout of the NERAD rice-fish system.

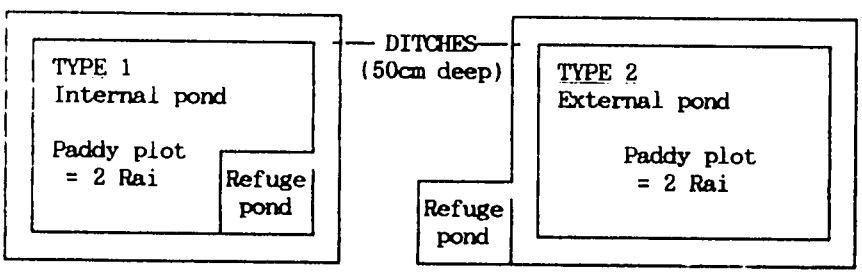
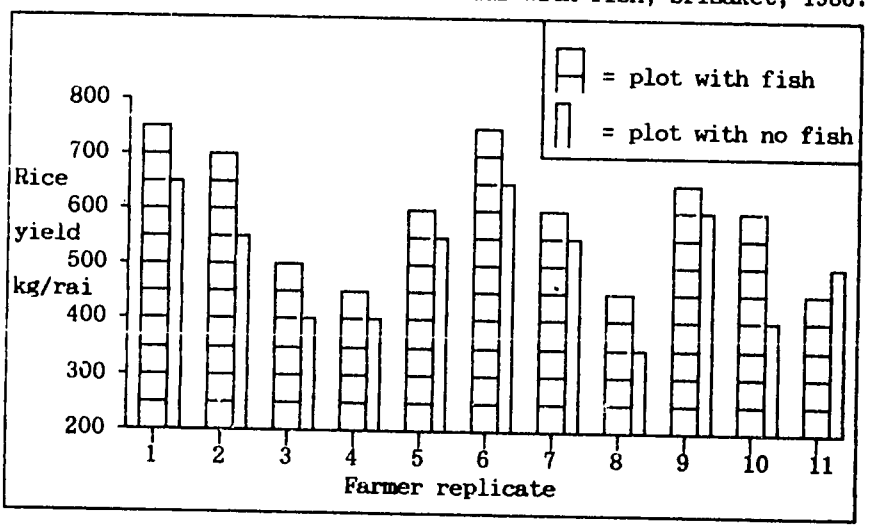


Table 3.7.1 Recommended stocking rates and fish species mixtures

RATIO	6 : 3 : 1			7 : 2 : 1			SIZE OF FINGER-LINGS
STOCK RATE	CARP	ROHU	TILAPIA	CARP	ROHU	TILAPIA	
800 /Rai	480	240	80	560	160	80	7-10 cms
1,000 /Rai	600	300	100	700	200	100	7-10 cms
1,200 /Rai	700	360	120	840	240	120	7-10 cms
1,500 /Rai	900	450	150	1050	300	150	3-5 cms

The NERAD trials also showed impressive increases in rice yields caused by the fish (Figure 3.7.2). Unfortunately, the nature of the interaction between fish and rice is still not properly understood and cannot, therefore, be manipulated to optimise the performance of the entire fish/rice system. Various hypotheses have been advanced to explain the effect including improved pest, disease and weed control, soil nutrient effects, physical effects of fish on the rice plant and its root zone, improved water management and improved cultural care of the rice. However, none of these effects have yet been quantified, and joint research involving the Department of Fisheries (DOF) and the Department of Agriculture (DOA) was initiated in order to identify the rice-fish interactions responsible for the increased rice yields.

Figure 3.7.2 Rice yields from fields with fish, Srisaket, 1986.



An analysis of rice yield components for these trials showed that yield increases are elaborated through increased grain weight and that fish have no effect on tillering or panicle initiation. This suggests that fish have an effect on soil nutrient availability during the grain filling stage. Results also showed that fish reduced some pest, disease and weed species by up to 50 percent. In some instances, such as stemborer and crown rot, the reduction was sufficient to account for the rice yield increases. However, the mechanism by which the fish have an effect on these pests is difficult to explain as there are no obvious stages in their life cycles when they are susceptible to direct predation by fish.

For a review of rice fish interactions the reader is referred to:

Craig, I.A. 1987. Problems and Opportunities for Farming Systems. Proc. 4th National Farming Systems Conference, Songkla, Thailand.

3.8 SHALLOT PRODUCTION FROM SEED

Farmers in Sri Saket traditionally plant shallots for sale in the Province and in nearby market centers in Ubol and Korat. The traditional system involves planting shallot bulbs at the rate of 400 kg/rai which have to be purchased for approximately 15 to 20 Baht per kg. Yields are usually in the region of 2,000 to 2,500 kg per rai and if shallot prices are satisfactory, good returns from the system are obtained. However, due to the extremely high input costs of the system (up to 8,000 Baht per rai for bulbs alone), it is extremely prone to risk caused by market price variations. In the 1982-83 season for instance, prices received by farmers for their produce dropped to 2 to 2.5 Baht per kg resulting in heavy cash losses in many cases.

In order to reduce input costs and thus decrease the risk associated with shallot production in this area, the NERAD project conducted trials on producing shallots from seed to replace the expensive bulb-planting technique. This system involves nursery-bed cultivation of shallots from seed in August. The shallots are then transplanted into the fields in October or November at an age of 30-65 days depending on seedling growth and labor availability. Results have shown that shallots grown by this method produce yields of 90 per cent of those obtained from bulb-culture, while reducing input costs by up to 8,000 Baht per rai.

Recommended cultural practices for shallot production from seed are as follows:

1. Broadcast shallot seed on well prepared seed beds basally fertilized with urea at the rate of 1 kg per 5 square meters. Cover the seed, water thoroughly and mulch with rice husks.

2. Seeds will germinate within 5 days, water every morning and evening, and keep the nursery beds weed-free and rogue any weak or diseased seedlings. Spray difolatan (captafol) for control of leaf blight as necessary.

3. Transplant seedlings at 30-65 days post-emergence into well prepared beds at a spacing of 20 x 20 cms and mulch with rice husks if available.

4. Water and weed the plots regularly and apply 13-13-21 or 15-15-15 at 25 kg per rai, 15 days after transplanting.

5. Flowering will occur approximately 60 days after transplanting and flowers should be removed for the production of saleable bulbs. Shallots can be harvested at about 90-120 days.

6. If seeds are to be produced for future planting, the best, healthy looking plants should be selected and the flowers retained. When seeds have matured they will have a black color and will be hard to the touch and the stem should be cut and seeds further sun-dried. Thresh and separate the seed and dry in the sun for 4-5 days. The seed collected from approximately 260 healthy and well-formed flowers will provide sufficient seed for planting 1 rai.

The use of this technology is aimed primarily at sites where shallots are traditionally grown and marketing channels are well developed. It could also be used in other areas where market opportunities exist or on a small scale for subsistence production in the farm-family's vegetable plot. This technology is currently being extended to such areas by NEROA's mobile extension and farmer training unit.

Experience has shown that this technology is an effective means of utilising water from the modified shallow wells, described in Section 3.3 of this report. The potential returns from shallot production justify the capital investment needed for a modified shallow well and the wells supply sufficient water for at least 1 rai of shallots. Although input costs are significantly reduced by the use of seeds, cash inputs and labor requirements remain relatively high. These are apparently at least partly off-set by farmer reports of yield increases in following rice crops. However, further trials are needed to substantiate these reports and to quantify the magnitude of the effect.

For further information on this technology the reader should contact the Mobile Training Unit, Northeast Regional Office of Agriculture, Khon Kaen. For technical details the reader is also referred to the following publications:

Anon. 1985. Shallot Cultivation. Farmer Training Manual, Mobile Training Unit, Northeast Regional Office of Agriculture, Khon Kaen. (In Thai)

Thamabood, S. 1984. Results of a Rapid Rural Appraisal to Evaluate NERAD's Cropping System Trials in Sri Saket. Northeast Regional Office of Agriculture, Khon Kaen. Mimeo. (In Thai)

Amaritsut, P., Boonphakdi, L. and Munwilai, P. 1987. Study on Shallots Grown from Seed. Northeast Regional Office of Agriculture, Tha Phra, Khon Kaen, Thailand.

3.9 KENAF VARIETAL IMPROVEMENT

Kenaf is an eminently well-suited crop for the agroecological and socio-economic conditions of Northeast Thailand. It can be grown as a low-risk, low-input crop on poor soils and, once established, is relatively tolerant to drought. Planting and harvesting dates are fairly flexible and labor requirements do not conflict with subsistence rice, other crop or livestock enterprises or off-farm activities. Once sown, it requires relatively little cultural care and a single hand-weeding is generally the only attention it receives from planting to harvesting. It normally receives zero or negligible inputs of fertilizer and pesticide and there are usually local market outlets for the retted fibre or dry stalks.

There are two major markets for fibre crops in the Northeast. The majority are sold as retted fibre but a significant proportion is sold as dry stalks to the Phoenix Pulp and Paper mill situated in Khon Kaen Province in the center of the region. Farmers generally receive lower prices for fresh stalks and the distance from the paper mill's collection centers also precludes some farmers from this market. The sale of kenaf as retted-fibre is constrained by labor availability for the dirty job of soaking and retting the fibre and also by the availability of suitable water resources for this task.

Thai Kenaf (Roselle), Cuban Kenaf and Jute are all grown in the region and two major types of fibre-crop-based cropping systems can be identified. First, Kenaf or jute as a monocrop or first crop in a double cropping system on the upland area and second, Thai or Cuban Kenaf as a pre-rice crop in the paddy land. The former is found throughout the Northeast on the higher, flood-free land generally in areas where cassava cannot be grown for reasons of soil suitability or distance from markets. Thai Kenaf is the most common crop in this stem but Cuban Kenaf is grown in some areas and jute is grown in this system on the better soils of the region. The paddy-based kenaf system is less common but occurs in Provinces in the center of the region, where the upland area is limited. This system has been adopted by farmers as a strategy for reducing the risk associated with erratic rainfall. In dry years, when rice transplanting is delayed or sometimes not even possible, the kenaf can be left in the ground and higher yields of kenaf compensate for the reduced rice yields. Conversely, in wet years, the kenaf is harvested early but the lower fibre yields are compensated for by improved rice production.

A number of problems associated with Thai Kenaf grown as a pre-rice crop in the latter system, were identified during RRA's conducted by NERAD. These included crop damage due to prolonged water-logging, Phytopthora root-rot problems, especially after water-logging, the need for rapid crop turn-around time between harvesting the kenaf and transplanting rice and the lack of water resources for soaking the stalks prior to stripping the fibre.

NERAD has been conducting trials to test the suitability of Cuban kenaf for this system because of its improved resistance to Phytopthora root rot and its ability to withstand prolonged water-logging by virtue of its capacity to produce aerial roots. Trial results have shown that Cuban kenaf is more appropriate for the lower paddies where water-logging is common but that it cannot compete with Thai kenaf in the upper paddies where it suffers from water stress and nematode problems (Table 3.9.1). Cuban kenaf, because of its shorter duration, exhibits lower yield reductions in wet years when it is harvested early to allow rice transplanting and it also has a greater beneficial effect on yields of the following rice crop.

Table 3.9.1 Results of kenaf trials, Nongkaew, Roi Et, 1985.

MEAN VALUES	CUBAN KENAF	THAI KENAF
YIELD (kg/rai)	310	287
PRICE SOLD (B/kg)	5	5
INPUT COST (B/rai)	256	257
NET RETURNS (B/rai)	1,294	1,178
RESIDUAL EFFECT ON RICE (% increase in yield)	32	16
SYSTEM RETURNS (B/rai)	1,576	1,303

The NERAD trials have also shown that row planting will significantly increase yields of Cuban kenaf over the traditional method of broadcasting and that it is responsive to nitrogen applications of up to 7.5 kg. per Rai. Neither of these recommendations have found favour with farmers, who are readily adopting the new varieties, but prefer to use traditional cultivation practices with them.

For further information on this technology and detailed results of the research trials, the reader is referred to the following publications:

1. Anonymous, 1985. Proceedings of the NERAD Annual Cropping Systems Technical Workshop for the Crop Year 1984-85. Northeast Regional Office of Agriculture, Khon Kaen, Thailand. (Thai)

2. Anonymous, 1986. Proceedings of the NERAD Annual Farming Systems Technical Workshop for the Year 1985-86. Northeast Regional Office of Agriculture, Khon Kaen, Thailand. (Thai)

3.10 NATIVE CHICKEN DEVELOPMENT

Approximately 80 to 90 percent of farm households in Northeast Thailand raise up to a dozen native chickens for both consumption and cash income. Traditional practices involve letting the chickens find their own natural food, with the owner providing some broken rice and leftover food in the morning and evening. Some farmers have small chicken coops, but mostly chickens sleep under trees, on the fences of buffalo pens, or scattered underneath the house. Little attention is paid to management, and if the chickens survive, they will be sold or eaten when mature. Native varieties are preferred, prices are good, and markets exist almost everywhere. Unfortunately, 80 to 90 percent of the chickens die due to various diseases, and farmers generally lack knowledge on disease control, feeding and general management.

In order to overcome the problems and to realize the true potential for native chicken production, the NERAD Project trained 4 farmers in every village in all Project sites as Poultry Specialists. These farmers once trained, act as a means of preventing disease epidemics, disseminating proper management practices, and form a communication link with DOLD officials.

The four major diseases on which the Project focuses are: Infectious Bronchitis, Newcastle Disease, Smallpox, and Cholera. Each year the Project provides vaccine for 400,000 chickens and ducks in nine Tambons through the Specialist farmers. Mortality rates have been reduced from an average of 80-90 percent to only 25-30 percent; the remaining mortality rate is attributed to malnutrition and parasites, especially fleas and roundworms. The Project provides M.P. strain vaccine for vaccinations of chicks aged two and a half months upwards. This was found to increase immunity to Newcastle Disease better than nasal drops, gives more reliable results, and is accepted with confidence by the farmers.

The prevention of diseases alone, without promoting improved management techniques is not enough. Through disease prevention, farm families have increased chicken populations from 11-12 to 30-45 per household at present. With these population levels, farmers are able to sell or consume 4-6 chickens monthly. Farmers are now unable to further increase native chicken production due to lack of feed, especially for chicks less than one and a half months old. Thus, the Project has recommended that farmers select full-grown chickens (1.2 - 1.5 kg) or adolescent chickens for sale, or alternatively provide adequate feed to avoid the problem of competition for food which is now a major cause of mortality in chicks. Farmers find this recommendation very difficult to follow because they are proud of their successful chicken-raising, and want to maintain double or triple the populations, they had previously. When populations reach this level however, malnutrition tends to occur and disease immunity provided by vaccination drops, eventually leading to

mortality of both young and full-grown chickens. The Project has urged farmers to select chickens for sale in order to reduce the density of the populations. The method involves selecting 60-70 chickens per year per household for consumption or sale and maintaining a population of 30-45 chickens of mixed ages throughout the year.

Specialist Farmers using proper management practices, additional feed, and improved chicken coops are capable of raising 150-200 native chickens per year. For example, farmers in the NERAD sites of Tambons Tae and Taket of Amphoe Utumphonpisai, Sisaket Province, are generating annual incomes of 4,000-6,000 Baht from poultry raising during the off-season, from November through July. Specialist Farmers select about 10-15 young female chickens to breed from in November; these hens produce about 300-500 chicks by July depending on the farmers ability to buy feed. These large population of chickens are alternately released into the farmer's rice fields and provided with adequate supplemental feed. By this method, chickens increase weight by about 15-18 grams per day with only 3-7 percent mortality rates. In comparison, native chicken development under rural conditions with traditional management practices produces live weight gains of only 10 grams per day (Table 3.10.1).

Table 3.10.1 Live-weight gain characteristics of traditional native chicken production systems.

AGE (days)	LIVE-WEIGHT (grams)	SAMPLE SIZE (chickens studied)
30	126.45	110
45	211.35	110
60	308.56	110
75	482.52	95
90	635.47	95
105	837.89	95
120	990.66	90
135	1,218.11	90

For further information on disease control and management of native chickens in Northeast Thailand the reader is referred to:

Anonymous, 1983. Proceedings of a Seminar on Native Chicken Development, 19-21, July, 1983. Northeast Regional Office of Agriculture, Tha Phra, Khon kaen.

3.11 SOIL FERTILITY IMPROVEMENT BY LIMING

A comparison study of 410 rice soils from Malaysia, Sri Lanka, India and Thailand found the 32 samples from Northeast Thailand to be the least fertile of all soils tested. This low fertility status is due to a combination of the inherently low fertility of the soil's parent materials and excessive weathering due to the extreme geologic age of the region (approximately 150 million years). Most soil specialists visiting the region saw the increased use of fertilizer as a simple solution to the problem. Typical feelings were summarized by Dr. Ernest Staker who stated:

> "It is inconceivable that thousands upon thousands of farmers in Thailand can continue raising crops with such low yields when by using small amounts of fertilizer and other practices they can increase yields from 50 to 200 per cent."

NERAD conducted research on soil acidity because soil pH's were frequently found to be below the levels that cause crop injury. Field trials showed that lime responses do not occur in rice, except under very dry conditions of pH 4.5 or less, because water saturation alone raises the pH above critical levels. Lime did give responses in upland crops, but low soil pH was not found to be the large, limiting factor originally suspected. Had soil acidity been a more generally limiting factor, the remedy would have been easy and inexpensive because of the country's abundant supply of limestone and the small amount of this needed to raise pH's in the relatively unbuffered, sandy soils of the Northeast.

NERAD's soil-acidity studies provided an improved understanding that may lead to future solutions. When soils are submerged, two important benefits to rice occur. The soil pH increases and with it, the availabilities of nitrogen, phosphorus, molybdenum and silicon. Submerging the soil increases pH because acidity is neutralized when ferric iron is reduced to ferrous iron as follows:

$$Fe(OH)_3 + 3H^+ \longrightarrow Fe^{+2} + 3H_2O \quad \text{(Equation 1)}$$

Phosphorus availability is increased, because the insoluble ferric phosphate, which is the predominant form in these soils, is made soluble by the chemical reduction of iron as follows:

$$Fe(H_2PO_4)_3 \longrightarrow Fe^{+2} + 3H_2PO_4^- \quad \text{(Equation 2)}$$

An unambiguous, soil-test procedure was developed by NERAD to measure the soil's capacity to release available phosphorus when submerged. The mean increase in plant available phosphorus was 40 percent for the soils tested, ranging from a small decrease to increases of 100 percent or more. Because increases in available phosphorus were correlated to increases in soil pH, measuring changes in pH between oxidized and reduced soil samples was pro-

posed as an indirect but easy way to predict the phosphorus supplying-power of soil when it is submerged. Such information helps identify soils that must be fertilized, and those which will release enough phosphorus from the effects of submergence alone. In the Northeast where fertilizer is used sparingly, this information is valuable for maximizing responses to applied nutrients. Alternatively, managing rainfall run-off to keep the soil submerged as much as possible is a low cost traditional way of increasing nutrient availabilities and rice yields. NERAD's activities aimed at capitalizing on this phenomenon include land-shaping, contour-bunding and the construction of diversion-weirs.

Alternate cycles of wetting and drying, throughout the growing season are common under rainfed rice production in the Northeast because of the region's uneven rainfall patterns. The effect of drying a previously submerged soil has a marked effect on phosphorus availability. Field observations suggest that as soon as enough water evaporates or drains from the paddy to re-admit atmospheric oxygen, the plant-available phosphorus decreases significantly. This is consistent with observations that a rice crop seems to slow or stop growing when a submerged paddy loses its standing water, even if the soil remains moist. This is explained by equation 3 and, at the same time, equation 2 is reversed and previously available phosphorus becomes unavailable.

$$Fe^{+2} + O_2 + H_2O \longrightarrow Fe(OH)_3 + 2H^+ \quad \text{(Equation 3)}$$

The question remains as to why the low clay and organic matter levels of these soils, caused by extreme weathering, prevents normal crop utilization of inorganic fertilizer nitrogen? NERAD has advanced the hypothesis that the soils are so poorly buffered against fluctuations in pH and redox potentials, that adding fertilizer moves these factors, especially pH, to extreme values and thus injures the crop by preventing nitrogen from being absorbed.

This nitrogen-use problem is a key constraint to the improvement of crop production systems in the Northeast. As long as limited or zero nitrogen-responses occur in these extremely infertile soils, the traditional low input, low yielding, single crop of transplanted rice will be superior to any multiple cropping schemes. Solving the nitrogen-use problem will not ensure the rapid development of agriculture in the Northeast. However, it is safe to conclude that such development will not be possible until this problem is solved. Yields are only a fraction of what is otherwise possible given the solar radiation, rainfall and labor that is available each year in the region.

For further information on soil acidity and liming the reader is referred to:

Ragland, J.L. 1986. End of Tour Report, University of Kentucky Final Quarterly Report, NERAD, NEROA, Khon Kaen, Thailand.

3.12 INTEGRATED WATER RESOURCE UTILIZATION

The NERAD Project Paper identified many water resource development opportunities including village ponds, embankment structures and swamp rehabilitation activities. These were implemented mainly in the first few years of the Project according to the guidelines contained in the PP. The Village Water Resources Development Workgroup was established within NERAD to coordinate their construction, to monitor their use and to integrate the utilization of the water provided, with other Project activities.

When evaluating the impact of these water resource development; on agricultural production in surrounding areas, the workgroup discovered that in many cases both NERAD and other water resources were:

- in a state of decay and were not providing the water for which they were designed,
- they were often far away from villages and were not being used effectively,
- the land surrounding the water was often owned by relatively few farmers and consequently their benefits were inequitably distributed,
- no water distribution structures or water management systems were provided for the resources and use of the water was very inefficient, and
- the water resources were designed and constructed mainly on engineering criteria and were often not compatible with the real needs of the local farmers.

As a result of these findings, the workgroup decided on two courses of action. First, to halt all future construction and re-assess water resource development structures in the light of farmer needs and water utilization potential, and second, to work with local farmers to develop improved water management and distribution systems to increase the equitability and efficiency of water-use from the storage structures already in place.

It was found that the majority of the structures already completed were designed to maximise water storage, with the result that many water utilization conflicts occurred. For example, DOF were unable to stock many of the ponds with fish as planned, because the water was too deep. To address these problems the workgroup conducted a series of interdepartmental meetings with all the concerned agencies to review the plans for all further construction and modify the design in line with future water utilization needs.

Once construction plans were modified to be appropriate for fish production, the Department of Fisheries conducted training for a group of farmers selected by the Tambon Council. These farmers were trained in fish rearing, feeding and management and were then organized into a village fisheries committee and given responsibility for management of the village fish pond. Funding for the stocking, feeding and management of fish for the village pond was provided by NERAD and administered by the village fisheries committee. When the fish mature, a harvest date is set by the committee and surrounding villagers are charged for joining the fish harvest according to the type of net used. All fish caught remain the property of the person who catches them and the proceeds from the sale of tickets go to both the village development fund and to the village fisheries committee for re-stocking the pond with fingerlings the next year. NERAD reduces financial support to the village fishery committee by 25 percent each year, so that after 4 years the village is technically and financially self-sufficient in fish-pond management.

Many of the NERAD-funded water resources were located on common land areas that are under the responsibility of the Tambon Council. All villagers have right of access to these areas for hunting-gathering, livestock grazing, etc. but no individual has the legal right to crop them. Official groups, however, such as 4H or Youth Groups can be given rights of use to this land. For these reasons, NERAD began exploring ways of improving water utilization from these sources by forming groups who would then jointly use the surrounding land and manage the water from the ponds. The type of groups formed varied according to local conditions and village needs but included housewife groups for mulberry growing, agricultural cooperatives for crop production, farmer groups that were trained by DOAE for fruit tree and vegetable production, youth groups for integrated farming activities and farmer livestock and fisheries groups for the development and demonstration of integrated pig/duck/fish farming systems.

The major lesson learned from NERAD's experience with water resource development was that it is unrealistic to assume that once water has been provided, it will be effectively utilized by farmers. The design and planning stage of water resource development must include a more thorough social assessment of farmer needs and opportunities in addition to the currently emphasized engineering considerations. In addition farmer training on water management and utilization systems are also essential once water has been provided and systems of credit are often needed to initiate appropriate activities.

For further information on NERAD's water resource development activities, the reader is referred to the following paper:

1. Pisone, U. 1987. The NERAD Farming Systems Development Process. Proc. 4th National Farming Systems Conference, April 7-10, Prince of Songkla University, Thailand. (In Thai)

3.13 SERICULTURE IMPROVEMENT

For many centuries, Northeastern farmers have produced silk thread that is dyed and woven into clothes for family use. With the introduction of synthetic fabrics and the appearance of cheap clothes in the rural markets, occurring simultaneously with the growing domestic and foreign recognition of the quality of Thai silk, sericulture has also become an increasingly important income-generating enterprise in the region. The production of silk thread, sometimes processed into high quality woven cloth products, is still predominantly conducted on a part-time basis using centuries-old, traditional techniques. It is eminently well suited to the current farming systems of the region as it requires relatively low cash inputs, does not conflict with other farm enterprises and the product can be locally processed or is easily marketed locally. Production systems are currently constrained by lack of mulberry leaves for silk worm production, low quality and unproductive worms and high worm mortality due to un-hygienic rearing practices.

NERAD has been addressing these problems with a two-pronged approach. Firstly, training for housewife sericulture specialists was conducted by the Department of Extension on silk worm rearing at the regional sericulture station in Korat. On their return to the villages the trainees were provided with improved rearing rooms and hybrid worms funded by the Project. The rearing rooms, costing 10,000 Baht each, were intended to demonstrate to other villagers how improved hygiene and modern rearing techniques can increase production by reducing mortality rates. The hybrid silk worms were promoted to improve the quality of the product in line with market demand. Secondly, improved mulberry varieties were provided to the sericulture specialists for planting, and training on mulberry production was given.

Although most sericulture specialists were able to produce more and better quality silk as a result of the NERAD training and support, a number of serious problems were identified with the program. First, training was long, intensive and away from home and paid little attention to the fact that sericulture activities were part-time and the people involved were mainly elderly women. As a result, many trainees returned home before completing their training to attend to their farms and families and of those that completed the training, many were young and returned home with new ideas that they were unable to implement because decision-making was in the hands of older ladies in the family who had not received the training. Second, the improved rearing houses, although used effectively by the specialists, were not an effective demonstration because they were beyond the means of the majority of local farmers due to their high capital requirement.

The sericulture program within NERAD was modified to avoid these problems. First, training was conducted in the villages on a part-time basis so as not to interfere with other farm-family activities for which the female trainees were responsible. More

care and different criteria were used for selecting participants so as to ensure that new ideas, if accepted, could be implemented after the training. In addition, the Project began to explore cheaper alternatives to the expensive rearing rooms previously used. In this respect, simple, fine-mesh nets suspended below the house above an improved cement floor were tested as a low-cost means of improving the hygiene of silk worm rearing. A summary of the results obtained from these low-cost rearing rooms is presented in Table 3.13.1.

Table 3.13.1 Comparison of silk production, costs and returns for traditional and low-cost, improved rearing rooms.

	TRADITIONAL	LOW-COST
Additional construction cost (฿)	0	<1500
Mulberry used (kg/tray)	8.57	9.50
Worms produced (trays/generation)	10	14
Worms produced (generations/year)	5	8
Silk yield (kg/generation)	0.6	1.1
Total silk produced (kg/year)	3.0	8.8
Price sold (Baht/kg - mean of large and small strands)	500	500
Gross returns (Baht/year)	1500	4400

Increases in mulberry production to support the higher worm yield possible from the improved rearing rooms proved somewhat more difficult. Recommendations on pruning were rarely adhered to by the sericulture specialists and although the new root-rot resistant mulberry varieties were acceptable, a lack of land for planting generally precluded their adoption.

In order to overcome the land shortage problem for mulberry production, NERAD helped to establish housewife groups so as to permit the use of common land around the villages as communal mulberry plots. Although no individual has the legal right to crop the common land, farmer groups do, and the housewife groups established by NERAD were given permission from the Tambon Council to establish mulberry plots there. Improved mulberry varieties with better root-rot resistance were provided and each group member was allocated a certain number of plant rows. This individual was then responsible for weeding, fertilizing, pruning and general management of their allotted rows and had the right to harvest leaves from them. In some cases the Project's modified shallow wells were also integrated with these mulberry plots so that production of mulberry and thus silk worms could be extended further into the dry season when the cool temperatures and lower humidity levels are more conducive to silk worm rearing.

APPENDIX

The following NERADICS Working Papers are available on request from the Project Director:

NERADICS Problem Definition Series

P1 Effects of Paddy-bund-planted Eucalyptus Trees on the Performance of Paddy Field Crops. Craig, I.A. and Wasunan, S., 1987. (English)

P2 Overview of Rainfed Agriculture in Northeast Thailand. Craig, I.A. and Pisone, U., 1987. (English)

P3 The Upper Paddies in Northeast Thailand: The Current Situation and Implications for Development. Craig, I.A., and Baker, G.P., 1986. (English)

P4 Current Pest Management Problems Facing Farmers in Northeast Thailand: Key Research and Development Priorities. Katanyakul, W., Amaritsut, W., Keerati-Kasikorn, M. and Craig, I.A., 1987. (English)

P5 Problems and Opportunities for Farming System Based Annual Crop Development in Northeast Thailand. Craig, I.A., 1987. (English)

NERADICS Methodology Documentation Series

M1 A Cropping Systems Technology Development Process: the NERAD Model. Craig, I.A., Sukapong, C. and Suratikul, S., 1986. (Thai and English)

M2 Triage: a Methodology for Screening Agricultural Technologies and Prioritizing Research and Extension Activities. Craig, I.A. and Sukapong, C., 1987. (Thai and English)

M3 NERAD Project Agricultural Development Information and Coordination System (NERADICS): A Project Description. Hopkins, J., 1987. (English)

M4 The Rapid Assessment Technique (RAT): a Procedure for Identifying Farmer Problems and Development Opportunities. Alton, C. and Craig, I.A., 1987. (Thai and English)

M5 Key Characteristics of the NERAD Full-cycle, Integrated Development Models. Songlin, R., 1987. (Thai)

M6 The NERAD Logical Framework: a Project Design Summary for Planning, Monitoring and Evaluation. NERAD, 1987. (English)

M7 Crop Protection and IPM for Rainfed Cropping Systems in Northeast Thailand. Amaritsut, W., Prasartsri, V. and Craig, I.A., 1987. (English)

M8 General Methodology for the Technical Seminar / Workshop Component of NERADICS. Hopkins, J. and Craig, I.A., 1987. (Thai and English)

NERADICS Technology Documentation Series

T0 A Summary of the NERAD Promising Processes, Methodologies and Technologies. Thamabood, S. and Craig, I.A. (Editors), 1988. (Thai or English)

T1 Direct Sown Rice: a Cropping Systems Technology for the Upper Paddies in Northeast Thailand. Craig, I.A., Wattanabhuti, W., Sukapong, C. and Netpichit, W., 1986. (Thai and English)

T2 Cooperative Buying Groups in Thailand: Results of a Social Experiment. Meyer, A.L. and Infanger, C.L., 1987. (English)

T3 Modified Shallow Wells: a Farmer Developed Technology for Northeast Thailand. Craig, I.A., Phensupha, N. and Ragland, J.L., 1986. (English)

T4 Pre-rice Green Manuring: a Technology for Soil Improvement Under Rainfed Conditions in Northeast Thailand. Craig, I.A., 1987. (English)

T5 Papaya Ringspot Virus: Cross Protection for an Important Subsistence Crop in Northeast Thailand. Gonsalves, D. and Prasartsri, V. (English)

T6 Simple Farm Implements for Rainfed Agriculture in Northeast Thailand: Research Needs, Development Potential and Local Manufacturing Opportunities. Craig I.A., 1988. (English)