

Trees in Paddy Fields in Northeast Thailand

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Agricultural landscapes result from the natural characteristics of an area, such as terrain, climate, soil, and native vegetation, and from the effects of human actions, both intended and unintended. The study of both sets of factors is well developed and influences scientists, business operators, government officials, and farmers alike. The agricultural scientist who works on technologies for growing rice, for example, has a basic idea about what a rice paddy is and how it is used or should be used. The presence of trees in rice paddies is not a part of this generally held view, yet a striking feature in Northeast Thailand is the numerous trees in most rice paddy fields.

These trees could be of considerable significance to agricultural researchers and development workers in the area, particularly with regard to the technologies they develop and the way such technologies are assessed. Cost-benefit computations, for example, might need to examine the value of trees compared to the value of extra space and sunlight for rice. In designing tools such as plows, one might take account of the need to get around trunks and roots. Chemicals to be used in rice fields might need to be assessed for their effects on trees. In breeding rice varieties, mild shade tolerance could be a desirable characteristic. Studies on the role of trees in paddy fields can help to decide whether such changes might be needed. There is an even more compelling reason to study trees in paddy fields. Agriculture in Northeast Thailand suffers from low yields because of low soil fertility and weather instability. Attempts to improve agriculture in the Northeast have not been very successful because of the difficulty in ameliorating these two factors, but also perhaps partly due to a lack of understanding of some of the other factors in the rice environment. Trees in rice paddies are one of the least understood of these factors.

An array of research methods called rapid rural appraisal (RRA) is proving useful in many agricultural areas of Southeast Asia. This chapter describes

how RRA was used to study the human ecology of trees in the rainfed paddy fields of Northeast Thailand.

RAPID RURAL APPRAISAL

As practiced in the Khon Kaen University-Ford Foundation Project on Rural Systems Research, RRA provides a forum through which primary researchers can interact with those from other disciplines and with villagers to enhance learning and conceptualization. This form of intensive research can be a study in itself or part of a larger research process involving more conventional methods. It can help develop better questions for a formal survey or help find out what the data from such a survey may mean. It can be used to assist in planning action projects, as well as to help monitor and evaluate such projects. A series of RRAs over the long term can also significantly increase researchers' knowledge and understanding of rural conditions and problems. RRA can contribute to learning on a deeper and more lasting level than many other types of less interactive research. The anthropological "year in the village" with participant observation can claim a similar and more comprehensive result, but it is far more time-consuming and usually suffers the limitations of knowledge of a single village for a single year.

The RRA that studied trees in paddy fields was one in a series that focused on a variety of rural resource issues. This type of RRA is done by a small team and can have a wide geographical scope in a short period of study (usually about four to six days in the field). It focuses on one particular aspect or issue in a rural resource system. Interdisciplinary concepts and methods are used to guide the exercise so that best results can be achieved during the time available. RRAs of this type are used to increase knowledge on a topic to a level where much better questions, hypotheses, and understanding of relationships can emerge. These may have direct implications for action programs, and they can be used to guide further research more productively. An RRA report such as the one in this chapter also aims to convey information quickly and provoke thought. It should not attempt to be complete in itself, nor should it attempt to have the last word on a subject.

For the topic of trees in paddy fields, several of the many RRA methodological forms seemed advantageous:

1. *Observation*—Direct observation provided information about specific trees and configurations of trees and fields; it was also helpful in guiding the questions to be asked.
2. *Assessment of indicators*—Indicators may be qualitative or quantitative; a ranking of the sites visited in terms of the density of trees on dikes compared with the density of trees on paddy field floors (i.e., in the paddy fields themselves) proved to be indicative of the degree of human management of trees in rice paddy areas.

3. *Semi-structured interviewing*—This method presumes that local inhabitants have reliable knowledge about conditions in their locality that is useful to researchers. It is usually the most valuable method used in rapid appraisal, especially when researchers interview together in small interdisciplinary teams. The overall lines of questioning are guided, but specific questions are thought up during the interview itself. This allows the application of many useful techniques, such as "probing" (see Appendix for an example). Semi-structured interviewing can elicit information of a range and depth that is not attainable through the use of a questionnaire.
4. *Using resource persons*—Resource persons who had both local and scientific expertise in plant identification accompanied the team on parts of the fieldwork. Reference texts also were taken to the field, and some plant samples were taken back to the university for species identification.

Initial Conceptualization

Before planning field visits, the team consulted secondary sources (Pen-
dleton 1939, 1943; Wacharakitti 1979, Heckman 1979) and discussed possible ways trees in rice paddies might be related naturally or socioeconomically to the rice paddies and to the villagers' needs and their management of resources. The team started with the following issues, possible interrelationships, and questions:

1. What species are there, where are they (in paddies, on dikes, on mounds), how dense are they, and what are their patterns? How long have they been there, how did they get there, and which ones are planted (where, when)? If not planted, are they protected when young?
2. Why do some paddies have trees and others not, even in small local areas? What are the moisture conditions, ages of trees, soil types, and distance to a forest?
3. What possible uses or roles do trees have, directly and indirectly: fodder or shade for livestock, fuelwood, lumber, good and bad effects on rice production (shade, litterfall, pests, and diseases)? Habitat for amphibians, reptiles, insects, birds, or mammals? Increased difficulty of plowing or planting? What are their patterns of use (individual, common use, exchange)?
4. Do trees have any effects on other crops or uses relating to other crops? What other types of plants and shrubs are in the plant community? Do they have any relation to trees?
5. What changing patterns are there in tree species, density, and uses?
6. Do trees have any effect on post-wet-season residual soil moisture in paddy fields?

The researchers used these questions as guidelines for observation and discussion, not usually as questions to be asked directly in interviews. The

list was revised repeatedly as the RRA proceeded and more knowledge and understanding were attained. For example, more specific issues were developed with regard to livestock fodder, the age of paddies, dikes vs. paddy floors, property rights, and so on. The RRA was not able to probe deeply on all issues, but this is to be expected with a rapid methodology.

Site Selection and Conduct of the RRA

The researchers decided to do a few site visits near the university before planning a longer trip. Interviews were conducted at several sites, and observations were made in the areas between sites as well. Discussion among team members confirmed that the initial conceptualization was generally workable. New information influenced further questioning, which was reviewed frequently and revised during subsequent visits.

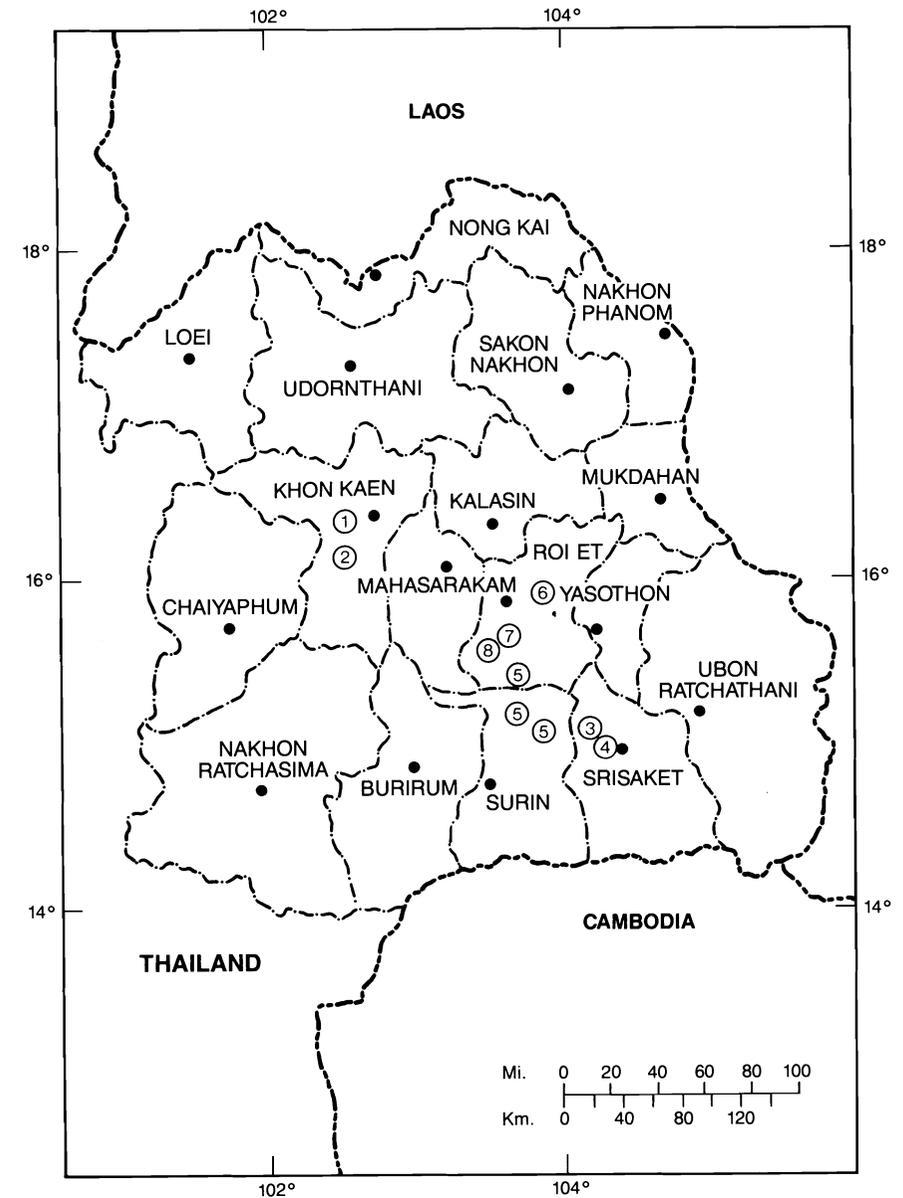
Selection of initial sites was more or less random, but the sites were fairly well separated by distance and terrain type (Figure 13.1). Before the longer trip, the team assembled village data from the Northeast Rainfed Agricultural Development Project (Limpinuntana and Patanothai 1982) and chose both general areas and specific village sites. Based on tentative hypotheses and previous interviews, it was reasoned that lumber and fuelwood needs, agricultural land shortages, moisture conditions, the age of fields, and the presence of upland fields and forest were all likely factors affecting the presence, amount, and types of trees in rice paddy fields. Field sites and travel routes were chosen to get variation on these factors. The team could then make comparisons among sites, try to infer time dimensions (e.g., new vs. old fields, heavily populated vs. still sparsely populated areas), and use observation and interviewing to probe in more detail in local areas.

The main field trip lasted four days. The team continuously compared notes, discussed findings, and planned key points to examine and probe during interviews. On return to Khon Kaen the field notes were revised and circulated, and a report was drafted.

WHY ARE THERE TREES?

Trees exist in Northeastern paddy fields for both physical and socioeconomic reasons. Physical conditions facilitate both establishment and survival of the trees. Most Northeastern fields were built on areas that were previously covered by forest containing many of the same species now found in paddy fields. After the paddies were built, some of these trees were able to survive. New trees grow naturally on dikes and higher places with seed sources from existing trees, nearby forests, and "sacred groves." Most trees survive better on relatively higher ground. Once paddies are established, any natural tree regeneration occurs on dikes or mounds, and that is also where farmers plant trees. Some of the large trees remaining from forest can survive on paddy floors, even through periods of heavy flooding. Others may die out after several years of normal paddy water regimes. Young seedlings on paddy floors are even more prone to succumb to paddy water conditions and are

Figure 13.1. Rapid Rural Appraisal Sites^a



^aSites are numbered in the order visited during January–February 1984.

also highly susceptible to destruction by livestock and humans, especially during plowing and harrowing.

Physical conditions alone cannot fully explain the existence of trees in Northeastern paddy fields in the numbers they are observed. In the paddy field environment the people themselves determine whether new trees will be planted, existing trees will be removed, or seedlings will be protected, transplanted, or destroyed. The RRA found that trees are maintained in Northeastern rice paddies because the perceived net values of maintaining them override those of not having such trees. When paddies are built, trees with high lumber value are retained specifically for that reason. Other trees are retained for various uses, especially for food, medicine, and fodder. Trees are also planted by the field owners, primarily for food (e.g., lontar palm, *Cassia simea*, tamarind), but also for fodder (e.g., *Streblus asper*, rain tree) and various other products and uses (e.g., bamboo, rain tree for lac). Most planted trees have more than one usage. The mix of naturally occurring trees and planted trees varies widely, as does the mix of species of planted trees and the reasons for planting them.

If paddy field trees play such an important role in Northeast Thailand, why are there so few trees in paddy fields in many other areas, such as Central Thailand? There may be both physical and socioeconomic differences between the Northeast and the Central plains that could account for this. The Northeast has a more rolling topography and sandier, better-drained soils, moisture regimes less likely to encourage root rot or induce waterlogging, and fewer days of cloud cover during the rice-growing season. While study by means other than RRA would be needed to determine the relative influences of such factors, we can be fairly certain they would make it more difficult to grow trees in Central Thailand paddy fields. There may also be less obvious but important constraints on the use of higher ground. In any case, a greater investment is probably required to establish trees in Central Thailand, but why such investment has generally not been made remains an open question for further study. One would certainly want to examine how Central Thais meet all the various needs that trees in the Northeast are meeting (e.g., food, fuelwood, fodder).

In order to better understand the patterns of paddy field trees in Northeast Thailand it is useful to look at the mix of natural and human factors—first, in terms of the transition occurring in paddies over time and, second, in terms of some specific uses and interactions. For the first approach, an attempt is made to infer a general, time-related process from a comparison of areas. For the second approach, the similarities and differences, as well as the processes, of specific uses and interrelationships are discussed.

PROGRESSION OF TREES IN PADDY FIELDS

Some of the variations in land-use patterns throughout Northeast Thailand are known to be related to stages of demographic transition. Other land-use variations are related more to specific locations and natural environments.

Both sources of variation are well enough understood that it seemed worthwhile to try to interpret some of the differences in tree conditions found among study sites in terms of a time-related process. A time-related portrayal has many advantages. It offers a compelling and sweeping way of understanding what might otherwise appear to be unrelated diversity. It also gives some basis for anticipating changes useful to policymakers and planners. Nevertheless, simultaneous comparison of a few areas to infer a time process does have risks. There is really no practical way, in a short study, to be sure we have taken account of all the factors that influence the stages of transition of trees in paddy fields. Thus, the results of this approach should be reflected upon, refined, and tested against further findings at every opportunity but not taken as a definitive detailed explanation in itself.

With these limitations in mind, it is possible to present trees in Northeastern paddy fields in four stages of progression through time. The speed and specific nature of the progression may vary at different times and places because of dissimilarities in such factors as initial state of forest cover, presence and quality of nearby forests, and demand for wood—the last two of which are affected by changing demographic conditions.

Stage One

In stage one, forested or partially forested areas are converted to paddy fields. A swiddening stage may be involved (Hanks 1972) or, as we found in one area of Roi Et province, paddies may be built directly in the forest. In the “new fields” we visited, the forest was not too dense or tall, making it possible to establish the fields without cutting many trees. It may have been secondary forest on land used earlier for upland fields, or selective removal of trees may have occurred (or both). Farmers choose trees they want to keep and eliminate those they do not want based on their assessment of paddy field requirements and uses they plan for the trees. Efforts are made to build the dikes to connect with termite mounds and some of the trees farmers wish to retain. How well this can be done, however, is influenced by the need to control water on the particular terrain, which is the primary function of dikes. If shading is too severe, more trees may be cut or pruned.

Tree thinning continues in this stage for a number of years. Farmers in Roi Et say it is their intention to reduce tree density in these fields gradually until it approaches a more acceptable level. They feel this will improve rice yields, which in this case are already lower than in the more open, older fields nearby. A few trees are removed each year, the first priority being dead or dying trees. Most of the stumps we saw were on paddy floors, not on dikes. Farmers felled these trees first, perhaps because the trees would be more likely to die from the effects of waterlogging, the rice would receive more sunlight, and field labor requirements would decrease if some of these trees were removed. Both labor and wood use affect the speed of the paddy conversion process. In felling trees, wood use is the more important factor;

in stump removal, it is labor. Trees are cut only as fast as wood can be used, and more useful trees are being retained in preference to less useful ones. Stumps are usually left in place until they rot enough to be removed easily.

Newly established fields in the Roi Et site (the area we saw had fields about ten years old) are still characterized by villagers as being in a "not-yet-finished-clearing" process, a transitional stage to regular paddies. Farmers are converting these fields slowly, despite a loss of rice yields and the extra time and effort needed for plowing, indicating the relative value farmers place on trees. This may have been less true in the past when trees in nearby forests were more abundant.

Stage Two

Once paddy fields are "finished," tree density continues to decline, but more slowly as flooding (root rot, waterlogging) or natural mortality takes some remaining trees and others are cut for lumber. Thus, many of the original trees retained selectively for their usefulness eventually disappear. The "old fields" in Roi Et may be seen as representative of this stage in tree-paddy transition. Most species here occur naturally, but they seem overmature and do not have to be pruned to reduce shading on rice. When seedlings come up on dikes, they are not protected and may be cut off during plowing. In stage two some forest and nearby fodder sources are still available, and more intensive tree management in paddy fields is not yet a priority. Most of the timber good for lumber in the Roi Et area was felled more than ten years ago, and the remaining trees, although perhaps having some modest value for lumber, fruit, or leaves, take up space and make plowing more difficult. However, people here believe that "a rice paddy without trees will not prosper," so the remaining trees are not removed.

Stage Three

Not much nearby forest is available by stage three, and timber is becoming scarce. Protection or planting of trees in rice paddies begins to occur more frequently. If large trees most useful for lumber still exist in the paddies, as in many places near Khon Kaen, they are preserved "for the children" even though they may be in the middle of the paddy and require heavy pruning.

Tree density in this stage seems greater than in stage two, with a higher percentage of planted species and thus more trees on dikes. As the naturally occurring trees die out or are harvested for lumber, other trees are planted on dikes and high places. In this stage trees are not planted for lumber, probably due to the long growth period before cutting, but farmers may plant fruit and nut trees, bamboo, or trees whose leaves are used as food or medicine. Naturally occurring species thought to be of value are protected, even transplanted. There is more limited access to the use of trees than in stage two, but not as limited as in stage four. People other than the

owners are allowed to take twigs and leaves from naturally occurring species, and small deadwood can be taken with permission.

Stage Four

The area visited in Srisaket serves as a model for this stage. How this stage occurs and whether it may occur in the future in other areas, however, may depend on the local terrain, what trees will grow there, the demand for tree products, and alternative sources of supply. In this stage the tree density looks similar to stage three, but most of the trees have been planted. Almost all are on dikes and mounds, with very few trees on rice paddy floors. Trees are generally not used for lumber but are managed to produce bean poles, human food, fuelwood, animal fodder, and other items. Property rights over trees are more highly developed than in other areas—no communal rights exist for anything on a person's land, including anything from trees and even rice stubble in the fields.

There is no forest around, and reduced farm sizes in the Srisaket area have contributed to a more highly managed system. With smaller farm sizes, farmers are hoping higher education will help their children obtain jobs off the farm although household labor will be in short supply while the children are in school. Some farmers hope that trees can provide a commercial crop less labor consuming than field crops planted after rice.

USES OF TREES

Trees undoubtedly have been an important part of life in Thailand, with the possible exception of areas directly in the Central Thailand flood plains. In the old days when forests were in abundance, trees were taken for granted; like air and water they were free goods. Under today's conditions, however, farmers are very aware of the importance of trees in their resource base. This importance can be seen in the many uses and roles of trees discussed in this section. Table 13.1 contains a list of paddy field trees encountered during the RRA, together with the uses that interviewees described. (This list is only a sample of the trees in Northeastern paddy fields. More studies undoubtedly would produce a much longer list.)

Shade

One of the primary uses of trees in paddy fields is shade for humans and livestock. In one of the hottest parts of a tropical country like Thailand, this is not a trivial usage. Although trees exist in much greater abundance in Northeastern paddy fields than are needed for this purpose alone, the wide distribution of trees over the paddy fields means shade is never far from human activity. Livestock spend much of their time resting in the shade of trees and a greater percentage of grazing can be done in or near shade, a vital advantage in the dry season when temperatures are highest and water sources upon which buffalo must depend to cool themselves are largely unavailable.

Table 13.1. Tree Species Found in Paddy Fields

Scientific Name ^a (common name)	Local/Thai Name	Natural (N), Planted (P), or Both (NP)	Uses ^b				Other Products
			Food, Medi- cine	Fod- der	Lum- ber	Tim- ber, Util- ity	
<i>Acacia auriculiformis</i> (wattle)	<i>Kratin narong</i>	P ^c		x			
<i>Adina cardifolia</i>	<i>Kwaaw</i>	N				x	Furniture
<i>Albizia lebbekoides</i>	<i>Khang</i>	N					
<i>Anisoptera curtisii</i>	<i>Kabaak</i>	N				x	
<i>Anthocephalus chinensis</i>	<i>Kosom</i>	P	x		x		
<i>Artocarpus lakoocha</i>	<i>Mahaad</i>	N	x				
<i>Arundinaria ciliata</i>	<i>Chot</i>	N	x	x			
<i>Azadirachta indica</i>	<i>Sadao</i>	NP	x		x		
<i>Bambusa arundinacea</i> (bamboo)	<i>Phai paa</i>	P	x	x		x	
<i>Blumea balsamifera</i>	<i>Naad</i>	N	x				
<i>Borassus flabellifer</i> (lontar or palmyra palm)	<i>Taan</i>	P	x			x	Sugar, sweets, liquor
<i>Buchanania siamensis</i>	<i>Ruang sai</i>	N	x				
<i>Canarium kerrii</i>	<i>Ma kok luem</i>	N	x		x	x	
<i>Capparis tenera</i>	<i>Leb maew</i>	N	x				
<i>Carissa carandas</i>	<i>Nam khi had</i>	N					
<i>Cassia fistula</i>	<i>Chaiyapruak</i>	P	x				
<i>Cassia siamea</i>	<i>Khee lek</i>	P	x			x	
<i>Ceiba pentandra</i> (kapok, silk cotton tree)	<i>Nuun, ngiw</i>	P	x			x	Grows valuable edible fungus
<i>Combretum quadrangulare</i>	<i>Sakae naa</i>	P	x				Bean poles, charcoal
<i>Cratoxylon formosum</i>	<i>Tiew som</i>	N	x			x	
<i>Dipterocarpus intricatus</i>	<i>Sabaeng/kraat</i>	N			x		
<i>Dipterocarpus obtusifolius</i>	<i>Hiang/saad</i>	N			x		
<i>Dipterocarpus tuberculatus</i>	<i>Kung/pluang</i>	N			x	x	Roofing, wrapping
<i>Erioglossum rubiginosum</i>	<i>Ma huat</i>	N	x				
<i>Erythrophloeum succirubrum</i>	<i>Phan chat</i>	N			x		
<i>Eugenia cumini</i>	<i>Waa</i>	N	x		x	x	
<i>Eupatorium odoratum</i>	<i>Sab sya</i>	N	x				
<i>Ficus microcarpa</i>	<i>Hai hin</i>	P	x				Flowers
<i>Homalium damrongianum</i>	<i>Man pa</i>	N					
<i>Hymenocardia wallichii</i>	<i>Mai huu ling</i>	N				x	Charcoal ^d
<i>Irvingia malayana</i>	<i>Maak bok/kabok</i>	N	x				
<i>Leucaena glauca</i>	<i>Kra tin</i>	P	x	x			
<i>Litsea glutinosa</i>	<i>Mai mee</i>	N					
<i>Mangifera indica</i> (mango)	<i>Ma muang</i>	P	x	x			
<i>Melanorrhoea laccifera</i>	<i>Nam kiang/rak yai</i>	P	x	x			Lacquer For silk worms
<i>Morus</i> sp. (mulberry)	<i>Mon</i>	P					Holds dikes
<i>Pandanus</i> sp.	<i>Ket</i>	P					Livestock eat fruit
<i>Parinarium anamense</i>	<i>Phok</i>	N				x	Holds dikes, bean poles, charcoal
<i>Phyllanthus polythyllus</i>	<i>Ton sio</i>	P					
<i>Psidium guajava</i> (guava)	<i>See daa/farang</i>	P	x				
<i>Pterocarpus macrocarpus</i>	<i>Pra du</i>	N			x		

Table 13.1. (continued)

Scientific Name ^a (common name)	Local/Thai Name	Natural (N), Planted (P), or Both (NP)	Uses ^b				
			Food, Medi- cine	Fod- der	Lum- ber	Tim- ber, Util- ity	Other Products
<i>Samanea samans</i> or <i>Enterolobium saman</i> (rain tree)	Chamcha/chamchuree	NP	x	x			Insects produce red dye and lac
<i>Schleichera trijuga</i>	Ta khraw	N					
<i>Sesbania grandiflora</i>	Khae	P	x				
<i>Shorea floribunda</i>	Khayom/pha yom	N	x		x		
<i>Shorea obtusa</i> (Burma sal, Siamese sal)	Jik/teng	N			x		
<i>Sindora siamensis</i>	Tae	N	x				
<i>Sphaerocoryne clavipes</i>	Lam duan	N					
<i>Spondias pinnata</i> (hog plum)	Makok	P	x				
<i>Streblus asper</i>	Ton khoi	NP		x			Teeth cleaner
<i>Tamarindus indica</i> (tamarind)	Ma khaam	NP	x				
<i>Ulmus lancifolia</i>	Ta kai	N	x				
<i>Xylia xylocarpa</i> (iron wood)	Mai daeng	N			x		
<i>Zizyphus jujuba</i>	Phud saa	N	x				

^aThis table follows the taxonomic nomenclature of Smitinand (1980) and Suvatti (1978).

^bFuelwood and shade uses are not marked since nearly all species may be used for these purposes.

^c*Acacia auriculiformis* is an introduced species that the government is promoting because it is fast growing and can be used for fuelwood and other purposes; it has been in Thailand for at least twenty years.

^dLivestock can eat the fruit; humans can eat the seeds.

The effect of shade on plant growth and soil moisture was not investigated at all sites, but at one site near Khon Kaen farmers said post-wet-season grass growth on paddy floors is more dense and has a longer growing season under trees. Livestock can stay in the shade while eating grass. The importance of this difference cannot be determined without more exact study. In February, when the RRA was conducted, grass under trees was thicker and greener although the amount of grass seemed scant compared to the feed requirements of buffalo and cattle. Grass not under tree cover generally dies out during the dry season before April, but grass under trees sometimes remains green until the rains arrive in May or June. Wet-season moisture should also be investigated to determine if tree shading helps rice survive critical dry periods during the growing season. A more subtle effect of tree shade concerns the fact that whenever rice is not growing in the fields, livestock spend much of their time in the shade of trees depositing most of their dung there. It is possible that this has differential effects on both grass and rice growth.

The negative effects of too much shade on rice were well understood by all farmers interviewed, and this is the main reason for tree pruning (except in the Srisaket sites where trees are managed intensively for production, the smaller branches harvested regularly). It is possible that nutrient effects of tree litter may interact with the effects of shading. According to interviewees, too much shade causes rice to grow faster and taller, making it susceptible to lodging. Even if it does not lodge, however, fewer tillers form, and they are less productive with less grain and less filled grain per panicle. This may have been more of a problem at the stage one site in Roi Et where forest clearing was still in progress: overshaded rice plants were cut and fed to livestock. It is possible, however, that some degree of tree cover may even be beneficial for rice in the Northeast where, due to weather conditions, paddies probably receive more direct solar radiation and have a more fluctuating moisture regime than in other parts of Thailand. This issue needs investigation by other means.

Human Food and Medicines

Many tree species, both naturally occurring and planted, provide human food and medicine. Young leaves and flowers of *Cassia siamea* frequently are used in making a type of curry and, in more concentrated form, a laxative. *Azadirachta indica* leaves and flowers are commonly used as vegetables. Bamboo shoots are an important vegetable. The lontar palm is a widespread paddy tree favorite for sugar, liquor, and desserts, as well as numerous nonfood uses. Many types of fruit and nut trees are also planted in paddy areas. The vast majority of planted trees and many of the naturally occurring species retained in Northeastern paddy fields seem to have food and medicinal uses (Table 13.1).

Livestock Fodder

Except during the rice-growing season, livestock in many areas can feed directly on tree foliage within their reach in the fields. Where favored

foliage is within reach, it is a common dry-season sight to see buffalo or cattle virtually mobbing certain trees. When grazing is more controlled or where leaves are out of reach, humans harvest the leaves and feed them to livestock. The volume of such usage is probably quite significant, and its usefulness in livestock production may exceed its nutritional content per se. Farmers in Srisaket indicate that at critical times tree leaves are mixed with old straw to make the straw more palatable to buffalo.

The leaves of three principal species are used widely as livestock feed in the areas visited: *khoi* (*Streblus asper*), *du* (*Pterocarpus macrocarpus*), and *chamcha* (rain tree). Bamboo leaves and *Leucaena* were also mentioned, and in one area livestock seemed to like the young leaves of a recently introduced species (*Acacia auriculiformis*). *Maduea* leaves (*Ficus* sp.) were also used as buffalo feed near Roi Et.

Fuelwood and Property Aspects of Tree Products

Depending on the seasons and local rules (and seemingly connected to the four stages of transition), paddy fields and their contents are subject to both private and public property rights. In many areas except the stage four sites in Srisaket, paddy fields not under cropping are open to grazing and other forms of communal use. Although good lumber is probably always private property, access to fuelwood, small branches, and tree leaves seems to vary from area to area, depending on scarcity and value. Planted trees also may be different from naturally occurring trees. In an area near Khon Kaen, for example, people from the market regularly come to cut the leaves from big, naturally occurring *Dipterocarpus tuberculatus* in private paddy fields. These leaves are used to wrap food and have commercial value. Field owners do not interfere in any way with this harvesting, nor do they receive any compensation from it. In Srisaket sites, however, even the leaves are private property. Livestock are not allowed to forage on other people's land.

At all sites visited, fuelwood is taken from any species of local trees. For charcoal there are certain preferred woods such as *Iringia malayana*. In areas like the Roi Et site anyone may cut off or even saw off dead branches from a privately owned tree at any time without permission, including branches three or four inches in diameter. Small branches are considered worthless, even for fuelwood. If an entire snag (dead tree) disappears, however, it is considered theft. Near Khon Kaen, leaves and loose dead branches may be taken by anyone, but permission is needed to cut off dead branches of any appreciable size. At the Srisaket site, private property is the rule. Few dead branches are available at Srisaket because trees are pruned for uses such as bean poles and fuelwood. Much fuelwood is taken from the Roi Et site by people from another village where trees are more scarce. Local fuelwood supplies are insufficient at the Khon Kaen and Srisaket sites, where costly trips are made to distant forest areas for additional fuelwood.

The issue of whether any trees are planted specifically for fuelwood was explored at a number of sites. No trees were planted (without outside

initiative) solely for fuelwood, but in several instances in Srisaket and Khon Kaen this was clearly one of the intended uses. These trees tend to be fairly fast-growing species. Fuelwood usage allows for a wide range of species substitution so trees are planted for values in addition to their fuelwood value. It is possible, however, that if a species were sufficiently productive for fuelwood only, it might find favor in fuel-scarce locations.

Trees as Habitats

Trees in paddy fields provide habitats or partial habitats for a variety of wildlife, both useful and pest species. According to farmers, insects living in trees are not harmful to rice. The eggs of red ants in trees are edible, and some of the small reptiles that live in trees are also eaten. In certain areas roots of paddy trees are partial habitats for rats that harm rice, but the rats are caught and eaten and may be important sources of protein at specific times of the year. Perhaps the most widespread populations in trees, however, are birds. Many species of birds are hunted and eaten. Many of these wildlife products also are acquired for sale. Birds in Srisaket are hunted mostly by specialists who go out at night with large nets to catch the birds while they are roosting. In some areas birds are also serious pests in rice paddies.

Major Lumber

The vast majority of good lumber trees in paddy fields are naturally occurring, not planted. Lumber usage of trees seems in all cases strictly a matter of private property. Despite the obvious perceived value of trees for lumber, however, virtually no trees are being planted solely for that purpose. For example, one farmer near Khon Kaen said, "If anyone were to give us trees to plant, we would choose fruit trees, not lumber trees." Apparently the high value of trees for lumber is counterbalanced by the long wait before harvesting the lumber.

Small Timber

Trees may be planted to provide materials, tools, and utensils, especially in stages three and four. Bamboo is an ideal tree for such purposes. Thorny bamboo makes excellent fencing and protection for water holes. Split bamboo has a variety of uses, is durable, and is easier to work with than wood. *Sadao* (*Azadirachta indica*) is fast growing, can be used for posts and poles, and has edible leaves and flowers. *Ton sio* (*Phyllanthus polythyllus*) is a multipurpose shrub/tree that farmers near Srisaket claim they first domesticated about twenty years ago, but it is now planted widely in several other provinces as well. Its roots help hold crumbly dikes in place, and its sparse foliage means it can be planted fairly densely without excessively shading the rice. The *ton sio* is apparently both drought and flood tolerant. Its branches are used for bean poles, fences, and fuelwood. According to one woman near Roi Et, its trunk and larger branches can even be used to make charcoal.

Small branches and leaves from many trees have different uses as materials, tools, and utensils. Some trees (e.g., lontar palm) are used for smaller items such as baskets, container frames and bases, and roofing leaves. Furniture is made from branches of several other trees. *Dipterocarpus tuberculatus* leaves are used for wrapping, walls, and roofing. Small branches from *Strebulus asper* can be used for trellises, poles, and basket bases.

Other Tree Products

Valuable tree products most susceptible to theft are preferentially grown in house plots. When the small house plots are full, however, trees such as mango, tamarind, guava, and papaya may be planted in paddy field areas. Other valuable trees planted in paddies include kapok and mulberry. Another tree product of some value is red lac, a shellac product produced by insects on the rain tree (*Samanea samans*). There are likely to be many other products from trees in paddy fields. Sap from dipterocarps, for example, is valuable for such things as torches and fire starters. Beeswax, honey, and decorative flowers are also valuable tree products cited by farmers.

Litterfall

Leaves and twigs falling from trees into rice paddies may have important relationships with rice field ecology. Trees may act as "nutrient pumps," their roots tapping nutrient sources below the level reached by the roots of rice and other crops. The effect of litterfall on rice growth and farmers' perception of this effect is important but could not be investigated adequately during this RRA. There is reason to believe, however, that at least some farmers observe or suspect a positive relationship between litterfall and rice growth. This may be due to mineral nutrient availability, moisture retention, soil structure, or a combination of these and other factors. The topic deserves further research and is a key question affecting future paddy field development in the Northeast. In the stage one fields visited in Roi Et, litterfall was so heavy that leaves had to be raked into piles and burned. Farmers stated that rice grew better where ashes remained from the burning, but they also regarded the raking and burning as a bother.

Trees and Paddy Dikes

In many areas of the Northeast, soils have a low clay content and weak structure, so dikes are very crumbly and quite difficult to keep in shape. *Ton sio* is planted extensively on dikes primarily because its dense root structure helps hold the dikes. It can be planted at close spacing to accomplish this purpose because its sparse foliage does not overshadow the rice. It has the added advantage of providing fuelwood and a variety of other uses. In very sandy areas *ket* (*Pandanus* sp.) was observed planted at close spacing on dikes. The plant is quite short and seems to cause even less shading than *ton sio*, but it is apparently not nearly as useful for other purposes besides holding the dikes in shape. On an earlier RRA, farmers also mentioned bamboo for this purpose. Its rapid growth, thick foliage,

and extensive root system, however, make the bamboo more suitable for use on field area boundaries than on dikes within the fields themselves.

Trees and Straw Stacks

In many areas around the Northeast, rice straw is placed in trees after threshing if it is to be stored in the field rather than taken home. Storing the straw in trees saves both labor and wood that would be used to build a raised platform or a fence around a mound or threshing floor. This practice is particularly helpful when communal grazing is allowed, as any straw to be saved must be removed from the reach of livestock.

PADDY FIELDS AS MULTIRESOURCE SYSTEMS

This RRA found that trees are "at home" in the biophysical (but human managed) environment of Northeastern Thailand rice paddy fields. Not all of their biophysical relationships with other things (e.g., rice, small fauna, livestock) in this environment are well understood, and some certainly deserve further study by other means. The RRA found sufficient indication of specific relationships, however, that it is possible to be fairly certain that trees are indeed important to the maintenance and overall production of the paddy field area (i.e., not just rice), and perhaps especially important to particular components such as livestock. There are likely to be many important ecological linkages among components. In terms of the effects of trees on soil fertility, for example, litterfall may be important, but livestock are also important in converting tree leaves, straw, and rice stubble to manure.

The biophysical relationships among soils and nutrients, trees, livestock, and rice should be studied to include relationships between litterfall, varying degrees of shade, and rice vegetative growth and grain production. Further exploratory study should also be done on the possible relationships between trees, crops, and soil moisture at various times of the year, grasses in relation to animal consumption during the times rice is not growing in the fields, and the relationship between trees and paddy field type (upper and lower paddies).

Although trees may be the most conspicuous resource other than crops in Northeastern paddy fields, many other important resources have not been studied. Grasses on dikes are a very important source of livestock fodder in the wet season. After the water recedes from the paddies, the natural grasses that emerge are also important to livestock. Many sources of protein important to human consumption come from wildlife in paddy fields. Crabs, frogs, and snails live in the fields and are hunted all year round, even when they retreat below ground and into dikes during the dry season. Fish, eels, and shellfish are also important foods. "Pools" are often created or fishponds built at the lower end of fields, even at the expense of some rice cultivation, to increase fish availability. Rats and insects are also eaten.

The RRA also found that trees in paddies are of high perceived value to Northerners for a variety of human purposes: shade, fuel, food, and other uses. It was found that people make sacrifices in terms of land, rice production, and labor in order to maintain and plant trees in paddy areas. It is likely that people will continue to promote trees in paddy areas and in some situations increase their density. These findings make study of the biophysical interrelationships even more important, to enable farmers to receive as complete information as possible on which to base decisions about trees in their fields.

The RRA also produced some fairly specific findings useful to organizations with action and extension activities. First, the *ton sio* example and other fuelwood usage of trees in paddy areas where fuelwood is scarce suggest that some villagers may be interested in experimenting with fast-growing trees for fuelwood planted on privately owned paddy dikes. If such trees were also suitable for holding the dikes together in areas where soil is crumbly, it would further increase their attractiveness. If livestock find them edible, however, it will be more difficult to protect young trees in many areas. In Srisaket this is solved by no communal grazing, which has its costs in human time and labor. Perhaps a technological solution could be found (physical protection by inexpensive devices, for example). If not, an area already about to move from communal grazing to private grazing would offer the best chance for a social-organizational solution such as has occurred in the Srisaket sites. In any case, paddy access, alternative uses of dikes, and costs (especially labor in establishing the trees) are likely to be the key constraints. The Royal Forest Department is now experimenting with fast-growing species on paddy dikes (using *Eucalyptus camaldulensis*), and the results of their trials should be examined closely.

In areas where nearby forests are gone and important forest resources are no longer available to villagers, trees in paddies could help meet particular needs. Farmers are conducting tests themselves to see what forest species can be grown on paddy dikes. They could benefit from advice on species selection and other techniques. It also may be possible that agricultural crops (e.g., cashew) that provide a wood by-product in addition to their agricultural production would find favor in such situations.

For livestock development, the major finding at this stage of research is the importance of tree leaves for livestock diets at key times in the year. The specific nutritional roles need to be better understood. If these are limiting factors, it may be possible to increase livestock production through the promotion of tree leaves as a part of dietary needs. It might also be worthwhile to compare livestock diet and health under communal grazing and privately managed conditions. Shrub forms of palatable and nutritious species such as *Leucaena* may have potential where livestock feed is an important factor.

Tree products are a significant factor for human nutrition and health in the Northeast, and they are one of the main reasons trees are protected and planted. The implication is that the use of tree products and the

management of trees could become one focus of extension activities designed to improve human nutrition.

Perhaps the most important conclusion of this study is that paddy field areas in Northeast Thailand are not just "rice paddies" but actually contain many important interrelated resources upon which humans depend. The promotion of agricultural changes, especially those involving rice, should examine the effects of such changes on trees in paddies and indeed on all the other major components of these multiresource systems. Effectiveness of extension agents will be increased when they can point out beneficial or neutral effects to farmers. Where conflicting effects occur, the farmer and the extension agency can use this information to decide whether the intended change is worthwhile. It is most unlikely, however, that these multiresource systems can be best improved until all their major components are studied in *interrelationship*. The above RRA findings indicate there are potentials in these interrelationships, not just drawbacks to separate component designs. For Northeast Thailand, and for every other agricultural area of the world with similarly diversified farms, there should presently be no higher research priority.

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APPENDIX: AN EXAMPLE OF PROBING* (SRISAKET AREA)

- Q. Do buffalo eat leaves from any of these trees?
 A. Oh yes—they eat several kinds.
 Q. What kinds?
 A. *Khoi, du, chamcha*.
 Q. Any others?
 A. (Discussion among interviewees—these three are the main ones) But they only eat fresh leaves, not dry ones.
 Q. How do they get the leaves? (Interview team observed few, if any, branches in the areas within reach of buffalo.)
 A. We cut the leaves and give them to the buffalo.
 Q. When do you do that?
 A. Anytime. Now if you want.

*A technique used during semi-structured interviewing in rapid rural appraisal.

Q. But when do you normally do it?

A. Around the sixth (lunar) month. We have less straw then and the straw is old, tough to chew—their gums get sore so you have to mix the leaves with the straw or they won't get enough to eat.

Q. Any other principal times?

A. During the transplanting—we're all out in the fields and the grass on the dikes hasn't come up enough to cut yet . . .

Q. Is that when you prune the trees? (They had mentioned earlier that they pruned them.)

A. No. We prune (half the trees each year, i.e., each tree every two years) around the twelfth month, at rice harvest time. It makes the trees full in the second year after.

Q. Why prune at that time?

A. Because we need the branches for bean poles. (They grow beans after rice.)

(Probing continued for about half an hour, resulting in delineation of a whole managed system involving bean poles, firewood, and buffalo fodder from trees, straw, and fertilized grass on paddy dikes.)

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