

**Farmer Perceptions of Water Availability,
Soil Erosion, and Yield Relationships in Rainfed Paddy and Upland Fields
on Two Transects in a Watershed in Nong Saeng Village,
Khon Kaen Province, Thailand**

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Abstract

A transect survey was conducted to assess farmers' perceptions of effects of water shortages and soil erosion in a small watershed in Nong Saeng village, Khon Kaen Province, Thailand. A map of watershed fields was presented to 24 watershed farmers, who placed transect 1 midway and transect 2 near the head of the watershed. Transects were surveyed over three days. The transects covered 25% of the crop area (83% sticky rice and sugarcane) of 10 transect farmers. Rice yields were more stable on transect 1 (stability index 0.32) than on transect 2 (stability index 0.11). Normal or better rice yields were obtained on transect 1 in nearly 3 years out of 5, and failures occurred less than 1 year out of 10 (35 plot-seasons over 5 years). The primary factor affecting yields was water availability. On transect 2, normal yields were obtained less than 1 year out of 10, and failures occurred more than 4 years out of 5 (19 plot-seasons over 5 years). Soil erosion was the main reason for crop failures. On transect 1, soil erosion affected less than 5% area in 5 of 7 paddy plots. Three plots lacked water for 3-6 weeks, but supplemental water was available 50%-67% of the time. These plots obtained yields normal or greater 2 out of 5 years. Two plots had approximately 12 weeks without water, but the number of years with normal or better yields increased from 2 to 4 when pond water availability increased from 25% to 50% of the dry weeks. In a plot without water for 5 weeks but with supplemental water available in all dry weeks, yields that were normal or greater were obtained 4 out of 5 years. In a plot without pond water for 8 weeks and complete lack of access to pond water, normal yield was achieved only 1 out of 5 years, and crop failure occurred 3 out of 5 years. Sugarcane yields were more stable (stability index 0.56) than rice yields. A range of factors affected sugarcane yield, and soil erosion was more important than water availability. Research on pond number and placement, reduction of pond water loss, wet season soil erosion control, and dry season water application is recommended for improvement of small watershed productivity and sustainability. Similar surveys in other representative soil type-topography combinations could extend the applicability of these methods.

Additional key words: farm ponds, rice, stability, sugarcane

Introduction

The linkage between natural resources, farmers, and technology development is difficult to achieve. Farmers manage land individually, but both soil and water from adjacent fields can affect their fields and the crops they grow on them. Agroecosystems analysis¹⁾ has been developed to provide a holistic understanding of natural resources in a common environment. The transect, a survey across a representative cross-section of topographical conditions and land use, is one technique used in agroecosystems analysis. It enables researchers to learn from farmer knowledge of land management and to obtain a holistic understanding of land use. However, in practice agroecosystems analysis has been used primarily in a descriptive sense, such as in the transect diagram of the Mae Klong agroecological zones²⁾.

Improvements in resource management have been traditionally carried out by agencies such as the Land Development Department (LDD) in Thailand, or the Soil Conservation Service in the United States. These agencies provide farmers with new options to reduce soil erosion and conserve scarce water. However, they have traditionally not provided support for changes in crop production practices that might be combined with soil and water management. Crop production research has traditionally been carried out on a discipline (agronomy, horticulture) and commodity basis on been experiment stations, and research results have then been made available to extension services.

From the late 1970s, most Asian countries introduced programs to link crop research and farmers, through on-farm research. Khon Kaen University initiated cropping systems research in 1975, carrying out research on cropping patterns simultaneously on-farm in five villages and on-station. In the early 1980s, agroecosystems analysis was developed by Conway and others and brought into the program. As a result, four broad agroecological systems were identified: the Korat Triangle, the Mekong Provinces, the Western Hills, and the Southern Hills. Within the target villages, rapid rural appraisal was followed by household-based monitoring and record-keeping³⁾.

Crop production on-farm research has traditionally used the farm household as its unit of analysis. Most on-farm research has focused on evaluating technology

options for one commodity or an intercrop in terms of the overall farm, without attempting to modify the remaining soil, water, and crop management practices beyond the target crop. In the Khon Kaen program, trials focused on intercropping combinations involving cassava or kenaf intercropped with legumes or field grains, and examined plant spacing, planting dates, and fertilization alternatives within the intercrop combinations³⁾.

In the 1980s, the Northeast Rainfed Agricultural Development Project introduced techniques such as sustainability analysis⁴⁾ and preference ranking⁵⁾. Transect analysis was used as a tool for analyzing overall problems. During the same period, the Department of Agriculture used farming systems methods for commodity on-farm research⁶⁾. On-farm research in support of extension provided farmers with choices of technologies and tested modifications proposed by farmers, but this was likewise carried out on a commodity basis rather than on a natural resource basis⁷⁾.

The Ministry of Agriculture has recognized the limitations of these fragmented approaches. Under the King's new initiative for self-sufficiency, and in the spirit of the new Constitution, increased emphasis is being placed on developing local capabilities for natural resource management, and on integrating agricultural support services⁸⁾.

The Japan International Research Center for Agricultural Science (JIRCAS) has worked closely with the Department of Agriculture (DOA) in Northeast Thailand to develop crop production technologies that can improve the sustainability of farming systems in the region. How to integrate these technologies into existing farming systems, in a way that addresses farmers' needs for improved livelihood and sustainable natural resource management, has been unclear. To address the need for development of methods that can better link natural resources, farmers, and technology development, LDD and JIRCAS chose a small watershed to adapt agroecosystems methods for identification of opportunities for farmer-participatory technology testing. The transect method was used in a survey to obtain information from farmers on their perceptions of soils, water, crop production, and reasons for natural resource and crop management choices. The objectives of this survey were: (1) to develop methodologies analogous to geographic information systems at the

level of resolution of individual fields; (2) to integrate biophysical and socioeconomic information; and (3) to identify opportunities for future farmer-participatory technology testing on a small-scale watershed basis.

Materials and Methods

The village of Nong Saeng, Khon Kaen Province, Thailand, was selected based on a reconnaissance of several areas in Khon Kaen Province in June 2000. Nong Saeng is located approximately 30 km southeast of Khon Kaen City. Nong Saeng was chosen based on its undulating topography with paddies and upland fields forming small watersheds. Between June 2000 and March 2001, fields were surveyed by LDD and JIRCAS specialists, dimensions of paddy and upland fields measured, and maps made which showed the boundaries of all fields in two watersheds. One of these watersheds was chosen for the transect survey.

Two transects were chosen in collaboration with farmers. All farmers with fields in the watershed were invited to a meeting on March 20, 2001, to determine the locations of the transects. A total of 24 farmers participated in the meeting. Maps showing all fields in the watershed were presented, and farmers were asked to consider what placement of two transects would best capture both representative conditions and key problems in the watershed. After approximately one hour of discussion in two groups, farmers placed transect 1 approximately midway in the watershed, while they placed transect 2 upstream near the head of the watershed (Fig. 1). The two transects were approximately 1.2 km apart. Because farmers generally held land perpendicular to water flow in the watershed, with



Fig. 1 Location of paddy plots (in green) and upland crop fields (in yellow) on transects 1 and 2, Nong Saeng, Thailand, March 2001.

upland fields on either side of the paddy fields, farmers proposed that the transects be placed diagonally. This allowed more farmers to contribute to the survey, while maintaining the essential characteristic of the transect method: obtaining a representative cross-section of the topography of a natural resource management area.

The survey was carried out over three days, March 21-23, 2001. On each day, farmers with fields on the transect were present in the field. The survey team consisted of two soil cartographers and one agricultural economist from LDD, and one farming systems agronomist from JIRCAS. Questions covered soil types and characteristics, soil erosion and erosion control measures, age of the field, a relative ranking of yields over the past 5 years and reasons for the yield levels obtained each year, dry spells and periods of excess water over the past 3 seasons, measures taken to deal with these water problems, effects on crops, pond characteristics and use, crop areas, numbers of livestock, poultry, and tractors, household demography, and off-farm employment. Approximately 1 to 1 1/2 hours were spent in each farmer's field. Where adjacent small paddies had identical soils and cropping histories, responses obtained for the group of paddies were treated as a single field unit.

For the assessment of yield levels, each farmer indicated the number of years of 5 relative yield levels based on what he or she considered to be normal yield for the given plot (greater than normal yield obtained; normal yield obtained; yield less than normal but at least half of normal yield obtained; yield less than half of normal yield obtained but not zero yield; no yield obtained or failure). Variation in rankings for a given plot thus indicated the degree of variation in yield of the plot in question over the 5 year recall period, and not variation between the plot and other plots on the transect, or between the plot and average yields for the entire watershed or village.

Survey data were entered in a spreadsheet file, arranged in the sequence of the transect. For qualitative data on farmers' reasons and perceptions, a list of all responses was made, and responses were grouped into categories⁹). Results were analyzed and plotted for identifying variables on both an overall transect and individual plot basis.

The stability of rice and sugarcane yields was

estimated by applying the stability index *Spro* of Suzuki et al.10). For this purpose, farmer relative yield rankings were assigned the following values: farmer-defined normal yield = 1.00; greater than normal = 1.33; less than normal but greater than half normal yield = 0.67; less than half normal yield but not zero = 0.33; no yield or failure = 0. This approach uses the farmer-defined normal yield level derived from experience over a longer period of time than the 5 years of recall of this study as the base reference point, and the maximum value is the value of the greater-than-normal yield level. A value of *Spro* of 0.75 would indicate that farmers achieved normal yields over the period evaluated. The maximum value of *Spro* of 1.00 would indicate that farmers achieved greater-than-normal yields over the period evaluated, generating surplus for less-than-normal years. For *Spro* values less than 0.75, the percentage $\%Spro = Spro/0.75 \times 100\%$ indicates the level of stability relative to farmer-defined normal yield.

Results

Farmer characteristics

The total area of land holdings of the 10 transect farmers was 371 *rai* (1 *rai* = 0.16 ha) divided between 135 *rai* of paddy and 236 *rai* of upland fields. Of these, 61 *rai* (16%), consisting of 13 *rai* of paddy and 48 *rai* of upland fields, were covered in the two transects. The principal crops grown by farmers were sticky rice and sugarcane. These two crops were grown by all or nearly all farmers, and made up 83% of their total crop area. Less than one third of the farmers had cassava in production, or grew vegetables, ordinary rice, or other upland crops, and these crops comprised only 17% of total crop area. (Fig. 2a).

All but one farmer had a walking tractor (power tiller), and 70-80% had large animals (cattle and buffalo) and poultry. Except in one case, farmers had either buffalo or cattle but not both, for an average of five large animals (Fig. 2b). Overall, 37 large animals were held by the farmers. Compared with land holdings, there was an average of 10 *rai* per large animal.

Average family size was 5 persons, with three active adult members. Half of the households worked as seasonal agricultural laborers, and approximately one-third had a family member who had migrated elsewhere

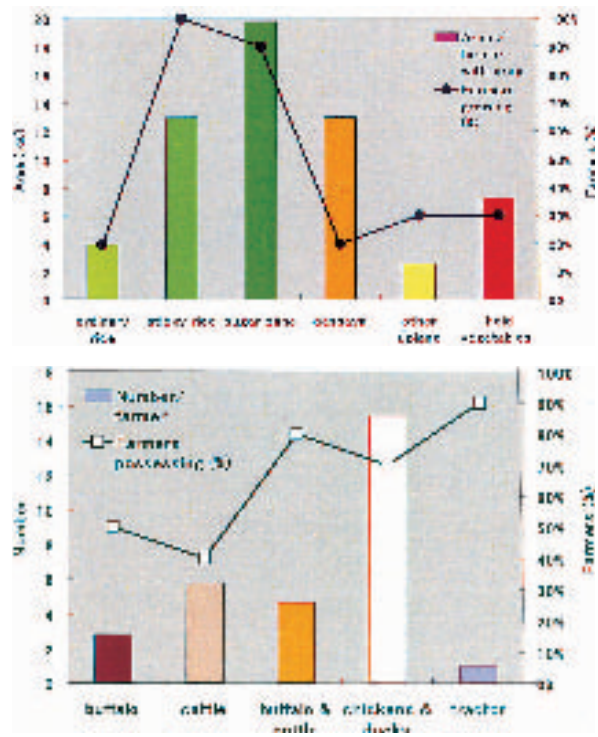


Fig. 2 Characteristics of transect respondents, Nong Saeng, Thailand, March 2001.

- a. Total area and percentage of respondents growing crops
- b. Number/respondent and percentage of respondents with livestock, poultry, and tractors

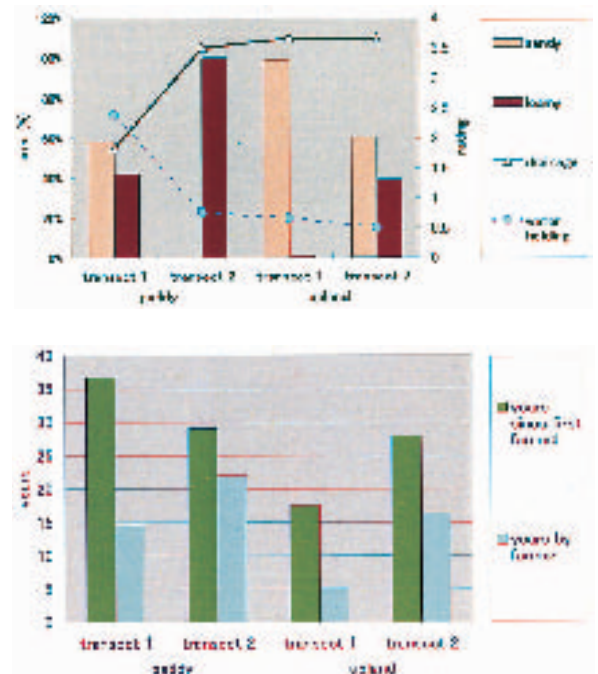


Fig. 3 Farmer perceptions of field characteristics, Nong Saeng, Thailand, March 2001.

- a. Soils, drainage, and water holding capacity
- b. Years in cultivation

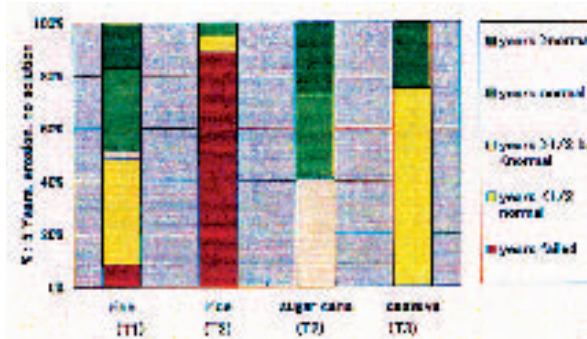


Fig. 4 Relative yields of rice, sugar cane, and cassava over 5 years, Nong Saeng, Thailand, March 2001.

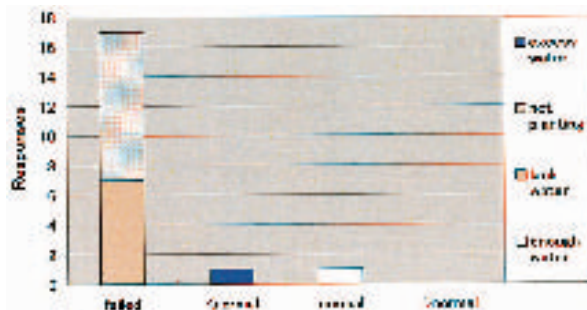
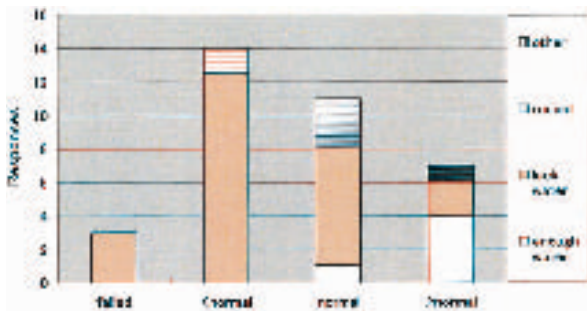


Fig. 5 Reasons for relative rice yields, Nong Saeng, Thailand, March 2001.
a. Transect 1
b. Transect 2

for employment.

Transect soil characteristics

The two transects had contrasting soil conditions. Over half (58%) the 9 *rai* of paddy field units on transect 1 had sandy soil, whereas on transect 2, all (100%) of the 4 *rai* of paddy field units had loamy soil. Nearly all (99%) of the 8 *rai* of upland fields on transect 1 had sandy soil, whereas 40% of the 40 *rai* of upland fields on transect 2 had loamy soil. Farmers perceived drainage and water holding capacity differently in paddy fields on transect 1 compared with transect 2: farmers on transect 1 perceived drainage to be poorer and water holding capacity to be better in their paddy fields, whereas farmers on transect 2

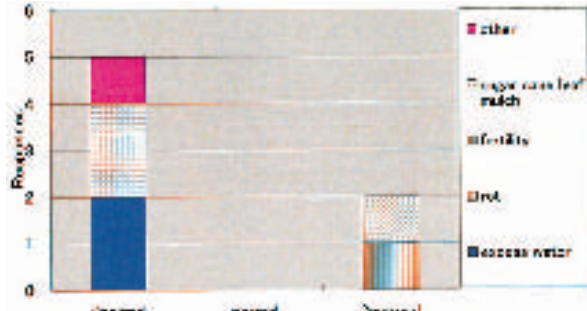
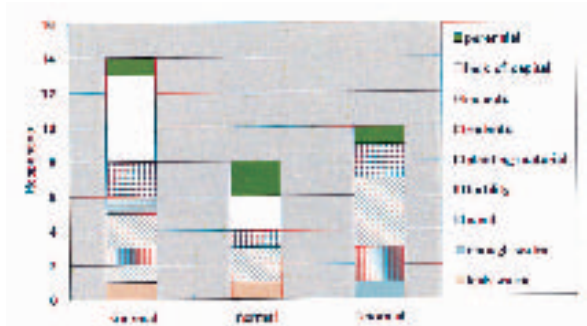


Fig. 6 Reasons for relative upland crop yields, transect 2, Nong Saeng, Thailand, March 2001.
a. Sugar cane
b. Cassava

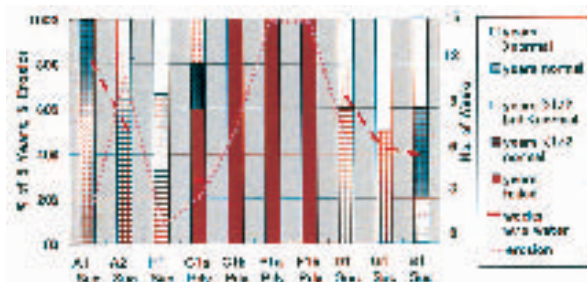
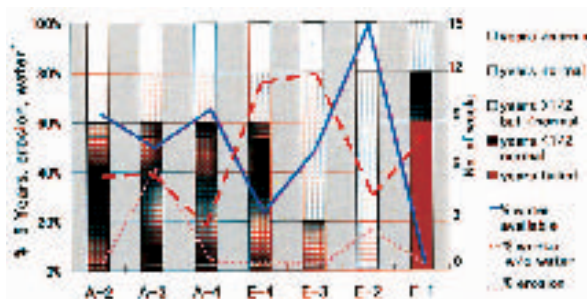


Fig. 7 Rice and sugar cane relative yields on transect plots over 5 years, Nong Saeng, Thailand, March 2001.
a. Transect 1
b. Transect 2

perceived drainage to be better and water holding capacity to be poorer in their paddy fields (Fig. 3a). Farmers on both transects perceived drainage to be similar in their respective upland fields. Paddy fields were older than upland fields on transect 1, whereas both types of fields had similar ages on transect 2 (Fig. 3b).

Overall rice, sugarcane, and cassava relative yields

Rice yields were much more stable on transect 1 than on transect 2. In nearly 3 years out of 5, rice yields were normal or better on transect 1, and failures occurred in the equivalent of less than 1 year out of 10 (35 seasons total over 5 years) (Fig. 4). The primary factor affecting yields was the availability of water (Fig. 5a). In normal years, rodent damage was also a factor. On transect 2, in contrast, normal or better yields were achieved in the equivalent of less than 1 year out of 10, and total failures occurred in more than 4 years out of 5 (19 seasons total over 5 years) (Fig. 4). Lack of adequate water or a decision not to plant due to lack of water were the reasons given for failures. Excess water caused less than normal yields, while normal yields were obtained when water was adequate but not excessive (Fig. 5b).

Only 3 years of sugarcane and cassava production were reported on transect 1, so only transect 2 data are presented for these two crops. In contrast with rice, sugarcane yields on transect 2 achieved the normal level in the equivalent of more than 2 years out of 3, and there were no crop failures (22 seasons total over 5 years) (Fig. 4). Neither soil erosion nor water availability were dominant factors in less-than-normal yield levels. Other factors including lack of capital (for fertilizer and labor), low fertility, and insect problems also contributed to less-than-normal sugarcane yields. Water availability was only one factor in above-normal sugarcane yields. Of greatest importance was planting material (change to new stalks), followed by fertility and absence of insect problems (Fig. 6a). Frequent rotation with cassava was given by one respondent as a means of reducing insect pressure on sugarcane.

Cassava was grown by 3 farmers over 4 seasons on transect 2. Yields were less than normal 3 out of 4 years (Fig. 4). Excess water and root rot were the main reasons for poor yields. Sugarcane leaf mulch and fertility were the reasons for greater-than-normal yields (Fig. 6b).

Effects of soil erosion and pond water availability across transects

Fig. 7a shows relationships among yields, soil erosion, weeks without water, and lack of solutions to address water deficits in paddy plots on transect 1 over

35 plot-seasons. In all but two plots, soil erosion affected less than 5% of the plot area, and the maximum area affected was 40% in plot A-3. Water availability was the dominant factor affecting rice yield. Plots A-2, A-3, and A-4 suffered from 3-6 weeks lack of water, but supplemental water was available from ponds 50%-67% of the dry weeks. In these plots, yields fell below half normal yield in 3 years, while in 2 out of 5 years, yields were normal or above normal. Plots E-3 and E-4 both had a high number of weeks without water, approximately 12 weeks, but the number of years with normal or better yields increased from 2 to 4 when pond water availability increased from 25% (E-4) to 50% (E-3) of the dry weeks. In plot E-2, there were 5 weeks without water, but pond water was available in all dry weeks, and normal yields or yields greater than normal were obtained 4 out of 5 years. In contrast, in plot E-1, where water was inadequate for 8 weeks and no pond water was available, normal yield was achieved in only 1 out of 5 years, and total crop failure occurred in 3 out of 5 years.

Fig. 7b shows relationships among yields, soil erosion, weeks without water, and lack of solutions to water shortages in sugarcane and paddy plots on transect 2 over 19 plot-seasons. Here, soil erosion was the predominant factor affecting rice yields. Plots F1a and F1b were severely eroded, with gullies and sand deposits from upland fields. Over half (60%) of the area of Plot C1b was affected. Rice failed or was not planted in all 5 years on these three plots. Only on plot C1a, where soil erosion affected only 20% of the plot area, was any rice yield obtained. However, water was inadequate for 4 weeks in this plot, and normal yields were obtained in only 1 year.

Upland fields had 6-12 weeks without water, but normal or greater yields were obtained in 3-5 years in plots A1, H1, and B1, where soil erosion was less than 20%. In contrast, plot A2 was over 70% eroded, and yields were below normal in all years. Plot D1 had 40% of its area eroded, and it had normal yields in only 2 of 5 years (Fig. 7b).

Discussion

The two transects presented contrasting situations. Paddy fields on transect 1, at the upper end of the

watershed, are severely affected by erosion, whereas erosion is not a serious problem in paddy field areas on transect 2. The maximum width of the paddy fields perpendicular to the flow of water through the paddy series was 2.7 times greater in the paddy area of transect 1 (245 m) than in the paddy area of transect 2 (90 m). However, the width on upland fields perpendicular to the paddy area was 2.1 times greater on transect 2 (270 m) than on transect 1 (130 m). Water from a larger upland area is concentrated into a smaller paddy area on transect 2. Measurement of slopes, surface water flow rates and quantities, and soil removal and deposition from upland fields to the paddy areas would be needed to quantify differences in water movement and soil erosion indicated by farmers and observed in the field during the transect survey.

Farmers' perceptions of soil characteristics on transects 1 and 2 initially appear contradictory. Although transect 2 has more loamy soil in the paddy area than transect 1, farmers perceive drainage to be faster and water holding capacity to be lower on transect 2. This apparent contradiction may reflect both the concentration of water into the paddy area on transect 2, and the flow of water from the upper end of the watershed, where transect 2 was placed, in the direction of the lower end of watershed. The apparent rapid flow of surface water through the paddy series in transect 2 may be creating a perception of poor water holding capacity. At transect 2, further downstream in the watershed, the paddy area is wider and water can spread out over a greater surface area. This may make drainage appear to be slower in these paddy fields, despite their having more area with sandy soil. This farmer perception is consistent with the higher water stress observed at the high end of watersheds in Don Daeng village, also located southeast of Khon Kaen City¹¹). Measurement of water flow rates, quantities, and slopes both parallel and perpendicular to the direction of water flow within the two paddy areas could provide the data needed to quantify these farmer perceptions.

The contrast in the primary constraint between the two transects suggests a hierarchy of problems. Where soil erosion and sand deposition are serious, as on transect 2, rice planting itself is compromised, and the question of water availability during dry spells in the

rainy season cannot arise. Where soil erosion is less, as on transect 1, water availability becomes the determining factor for rice yield. Suzuki et al.¹⁰) found that farmers considered water to be the most important constraint in two villages 40-45 km to the southwest of Khon Kaen City.

The variability of rice yields from year to year is consistent with other results in Khon Kaen Province. In Don Daeng village, also southeast of Khon Kaen City, Kaida et al.¹¹) found as much as a 10-fold difference in rice yields between bumper years and crop failure years based on farmer recall over a six year period. Within the same year, they found as much as a 5-fold difference between plots in the same year. These differences reflect the fact that Khon Kaen Province, like several other provinces in Northeast Thailand, fall into the "rain shadow," in which rainfall is highly variable during all rainy season months except September. Over the six years studied in Don Daeng village, rainfall in a given week varied by 100%, and the timing and length of dry spells was highly variable from year to year.

The transect results reported here show that plot location, soil erosion, and supplemental water variability within the same watershed further increase rice yield variability. Soil erosion from upland fields has seriously affected rice production in the upper portion of the watershed, represented by transect 2. The value of the stability index S_{pro} over 5 years for rice on transect 2 was 0.11. In the study by Suzuki et al.¹⁰), only 11% of 43 farm households in the less stable village Hin Herb had S_{pro} values below 0.20. Relative to farmer-defined normal yield, % S_{pro} was only 14%.

In contrast, in the upland fields of transect 2, the value of the stability index S_{pro} over 5 years for sugarcane was 0.56. Relative to farmer-defined normal yield, % S_{pro} was 75%. Farmers are achieving their normal yield level at a 75% level of stability. The analysis of farmer reasons for relative yield levels of sugarcane showed that soil erosion (indicated by "sand") comprised only 7% of the reasons given for less-than-normal yields in sugarcane production. Soil erosion was not a factor in less-than-normal cassava yields grown in rotation in the upland fields. Hence, paddy fields are receiving greater damage due to soil erosion from upland fields than the upland fields themselves are. This again shows the concentration effect of water and soil movement into the small paddy

area, highlights the necessity to view watersheds as a whole, and indicates the importance of cooperation among watershed users to address problems.

When small-scale ponds cannot supply adequate water during dry spells, rice production and yields are also compromised. The value of *Spro* over 5 years for rice on transect 1 was 0.32. This was slightly less than the mean *Spro* of 0.36 of the above-mentioned less stable village Hin Herb¹⁰⁾. Moreover, even on transect 1, relative to farmer-defined normal yield, %*Spro* was still only 42%. Stability is less than half farmer-defined normal yield.

These results show the importance of pond water availability for rice production. A key farmer strategy prevalent in this region is to grow as much rice as possible in good rainfall years, to guard against deficits in poor rainfall years^{11,12)}. Increasing supplemental water during dry periods can to a large extent compensate for a poor rainfall year. Increasing food security may enable farmers to allocate more financial resources and take greater risk in market-oriented agricultural production.

A combination of technologies developed by JIRCAS-DOA collaborative research might be tested to address the first constraint of soil erosion. Agroforestry strips¹³⁾ could be placed at appropriate intervals in one set of sugarcane fields, and effects on sand movement into paddies, soil erosion in sugarcane fields, and yields and economic returns of both rice and sugarcane compared with another set above or below in the watershed. A subsoiler¹⁴⁾ could be used in half of the area of each set to assess the effect of breaking the plow layer on water infiltration, sand erosion, and yields and economic returns (Fig. 8). On-farm testing involving farmers in both upland and paddy fields could also serve as a

catalyst for increasing understanding of common watershed problems and cooperation in addressing them among watershed users.

In the agroforestry system, periodic topping of the trees is necessary to control growth¹³⁾. This generates leaf material which may either be incorporated into the soil to regenerate soil fertility, or fed to animals. Calculations of leaf feed production relative to the calculated land area of 10 *rai* per large animal could be made to assess the contribution of agroforestry to animal production, relative to its contribution to soil fertility. With nearly all households using the hand tiller, new roles for buffalo, formerly used in land preparation, and cattle where dairy marketing is not developed, are needed to provide economic value to these large animals. The development of animal-crop systems linked to stabilization of paddy production would require a higher level of integration with market assessment.

Collaborative JIRCAS-LDD research is underway to assess the overall potential of the watershed to support farm ponds, and determine their optimum placement and number in watersheds. Improved farm ponds could be developed using hardening agents for reducing water loss from small-scale ponds¹⁵⁾, reinforcement with plant material (personal communication, Pichai Wichaidit, LDD, Thailand, 2001), and optimization of pond size¹⁶⁾. Water levels and amounts of water applied from improved ponds and unimproved ponds could be compared, together with soil moisture and yields in paddies with or without supplemental irrigation. Economic budgets of materials and labor costs and benefits could also be developed and used to assess economic viability.

A further experimental factor that could be integrated into the above comparisons would be water use for vegetable production during the dry season. An experiment could compare water use and effects on one or two vegetable crops using farmers' irrigation methods with small-scale pumps versus water-saving irrigation methods such as trickle irrigation and plastic or biological mulch. Crops would be chosen based on market potential and farmer experience, knowledge, and interest. Economic budgets of different combinations of pond type, crops, and irrigation methods could be compared to determine relative

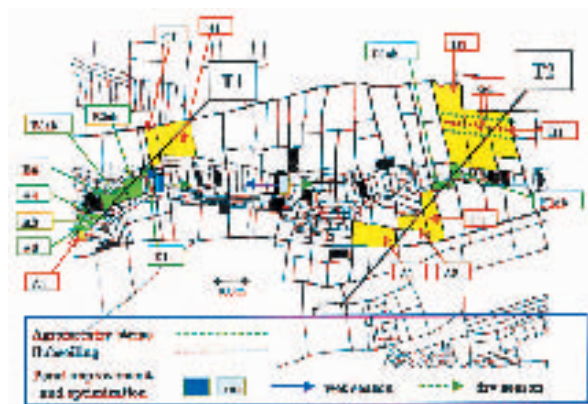


Fig. 8 Possible Future Technology Menus on Transects.

profitability and risk of the combinations. The economic value of ponds could also be increased through integration of fish culture¹⁷⁾. Such diversification of crops and income sources could help reduce the risks associated with over-dependence on rice production, especially on transect 2.

After 2-3 years, results from both sets of experiments could provide a basis for recommendations for improved watershed and crop management. Similar surveys could simultaneously be carried out in other representative soil type-topography combinations, to assess the potential applicability of the results of the experiments under the soil and topographical conditions of this study. Results could be combined using spatial techniques linked with action research¹⁸⁾ and GIS techniques developed by JIRCAS-LDD collaborative research¹⁹⁾.

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水状況、侵蝕、および収量の関係に対する農家の捉え方 —タイ国コンケン県ノングサエング村の天水田と畑地の事例—

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摘 要

タイ国コンケン県ノングサエング村の小流域における水不足と侵蝕の影響に対する農家の捉え方を把握するために踏査線調査を行った。小流域の圃場を示す地図を小流域利用農業者24人に提示した結果、農業者は踏査線1を小流域中部に、また踏査線2を上流に配置した。踏査線調査は3日間行った。踏査線圃場は、10人の踏査線上圃場利用農業者の作物全面積(83%が餅米稲とサトウキビ)の25%を占めた。稲の収量は踏査線2(安定指数0.11)と比べ、踏査線1(安定指数0.32)においてより安定していた。踏査線1においては、標準かそれ以上の収量は5年に3年近く得られ、不作は10年に1年以下の割合であった(5年中、累積3.5圃・年)。収量にいちばん影響を与えたのは水状況であった。踏査線2においては、標準かそれ以上の収量は10年に1年相当を以下しか得られず、不作は5年に4年以上であった(5年中、累積1.9圃・年)。侵蝕は不作の主要原因であった。踏査線1の天水田7筆のうち、5筆は面積の5%以下しか侵蝕を受けていなかった。3筆では水不

足が3週間あったが、補給的給水は不足期間の50%–67%でき、標準かそれ以上の収量を5年中2年得られた。2筆では水不足は12週間前後あったが、溜め池による給水が不足期間の25%から50%に増えると、標準かそれ以上の収量が5年中2年から4年に増加した。5週間の水不足の全期間中給水できた1筆では、標準かそれ以上の収量は5年中4年であったが、8週間の水不足期間中給水が全然なかった1筆では、標準収量は1年しか得られず、不作年が4年であった。サトウキビの収量(安定指数0.56)は稲よりも安定していた。収量に影響する要素は多岐に亘り、その中で侵蝕は水状況より重要であった。小流域の生産性と持続性を向上させるためには、溜め池の数、配置および漏水防止、雨期における侵蝕防止、乾期における水利用などの研究が待望される。土壌と地形が異なる他の代表的な土地類型で類似の調査を行えば、このような結果をさらに広げられるであろう。

キーワード：溜め池、稲、安定、サトウキビ