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Analysis of Stability of Rainfed Rice Cultivation in Northeast Thailand

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Abstract

Northeast Thailand is the poorest zone in Thailand mainly because of the unstable rice production under rainfed condition. This study aims at evaluating quantitatively rice productive force and stability of rainfed rice cultivation in Northeast Thailand. An intensive questionnaire and hearing survey was conducted in two villages in Khon Kaen Province. As a result, it was clarified that the basis of the present rice cultivation for self-sufficiency was under a weakening trend because of the recent massive changes in socio-economic structures. In order to evaluate stability of rice cultivation, two indices were developed and applied to each farming household in the two villages. The first index is used for evaluating stability of production level; the second one is used for evaluating stability of rice farming for self-sufficiency. Validity of the indices was examined through comparing calculated results with the data obtained from the questionnaire survey. It was found that the farming scale does not influence stability of production level, but influence stability of rice farming for self-sufficiency. "Stability distribution," which is obtained by combining these two indices, was adopted to evaluate the rice productive force of each farming household. The results indicated that significant gaps in the productive force among farming households exist in each village.

I Introduction

In Northeast Thailand, rice cultivation has long been practiced for self-sufficiency mainly under rainfed condition. It has so far been reported that the rainfed rice production in the area is unstable with low yield. In the meantime, the rapid economic growth in Thailand in recent years has brought massive changes to rural life and economy. The style of the rice cultivation is also compelled to change.

Under the circumstance, to depict future prospects of rainfed rice cultivation, an

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analysis of the present status of rice production structure is required. The objectives of this study are as follows:

(1) To grasp the actual status of rice production systems in Northeast Thailand;
(2) To propose stability indices and to evaluate quantitatively stability of the rice cultivation in each farming household using the indices; and
(3) To evaluate quantitatively rice production force in the study area.

II Site Description and Data Collection

II-1 *Study Area*

The study area is situated in a suburb of Khon Kaen City in the central region of Northeast Thailand. Two villages, Hin Herb village in Phra Yun district and Pa Manao village in Barn Fang district were selected as the study area. They are located about 40 to 45 km southwest of Khon Kaen City as shown in Fig. 1. Table 1 shows the basic statistics of the two villages. Both villages are located in the watershed of Huai Yai River,

Table 1 Basic Statistics of Two Villages in 1994

Items	Hin Herb	Pa Manao
Area (rai)	5,100	1,000
Living area (rai)	380	50
Agricultural area (rai)	3,256	950
Population	940	206
Number of households	190	37

1 rai = 1,600 m²

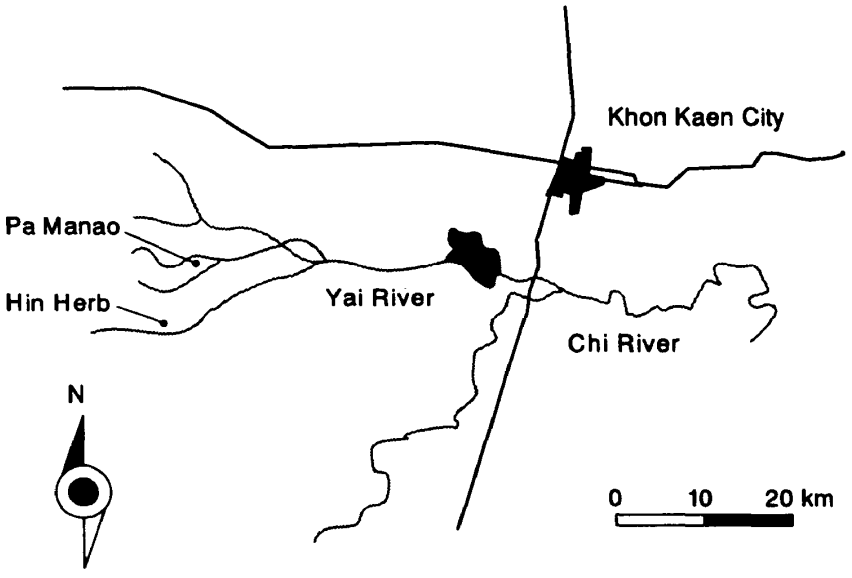

Fig. 1 Location of Study Area

a tributary of the Chi River, and are typical of rainfed rice growing villages in Northeast Thailand. Hin Herb is situated on the upper basin of the Yai River and the land is a little hilly. The main crop is rice but other crops like mulberry and cassava are also grown there. On the other hand, Pa Manao is situated on the lower reach of the Yai River and the land is relatively flat. Rice cultivation is also dominant there. In the dry season, some farming households grow vegetables for seed under contract with a seed company. It is clear that from the topographic point of view Pa Manao has better conditions for rice cultivation than Hin Herb.

II－2　*Field Investigations*

Field investigations consisting of an intensive questionnaire survey and a complementary hearing survey were carried out in 1996 and 1997 for obtaining the fundamental data of agricultural production, rural life and economy in the villages. The hearing survey was conducted to selected villagers for collecting detailed data of production and consumption of rice. The hearing survey was also conducted to the district (*ampoe*) offices and heads of the villages (*phu yai ban*) for obtaining general information.

The questionnaire consisted of the following items: agriculture (land holding, rice yield, irrigation, upland crops, livestock, machinery and employment), farming household economy (income, expense and debt), services (market, procurement and needs for support). The numbers of samples were 50 (households) in Hin Herb and 30 (households) in Pa Manao. These samples were selected at random from the two villages. The interviewer visited villagers' homes and filled in the questionnaire forms.

III　Results of Field Investigations

III－1　*Questionnaire Analysis*

1)　*Economy*

Fig. 2 shows answers concerning cash income sources in Hin Herb and Pa Manao. Non-agricultural income occupies more than half of the total income in both villages. This indicates that the side business is growing significantly. As a new trend, such income sources as salary and merchandise are found in Pa Manao. Furthermore, the portion occupied by rice in the agricultural income is basically low. Farming households seem to have a keen interest in profitable cash crops; therefore, their expectation in rice as a way of gaining money is quite low. From other items in the questionnaire, it is clarified that most households are borrowing money, and the average debt reaches as much as half of the average annual income.

2)　*Irrigation and Its Characteristics*

The number of farming households having no irrigation system is about half as shown in

Fig. 3. Small on-farm ponds, not included in Fig. 3, are often observed inside paddy field area. Irrigation in this area relies mostly on small on-farm ponds and fixed weirs on small streams.

The methods of the small weir irrigation are classified into two types: one is to divert flowing water and spread it directly to paddy fields; the other is to store water in the channel of stream and then to use the stored water mainly by pumping when needed. These small-scale irrigation systems, however, have just limited effects, because surface runoff on the small streams is found only for a short time after rainfall in the rainy season. In the years having less rainfall, these irrigation systems have little effect because of lack of water. Also, in the years having much rainfall, the significance of the irrigation systems is minimal. Water supply by these kinds of small-scale irrigation is

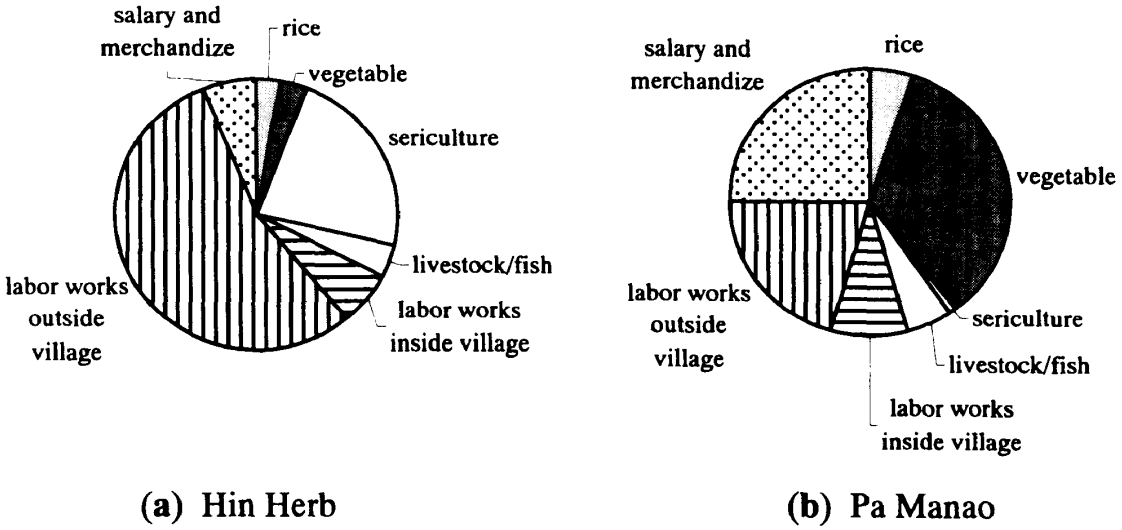

Fig. 2 Average Income Sources of Farming Households

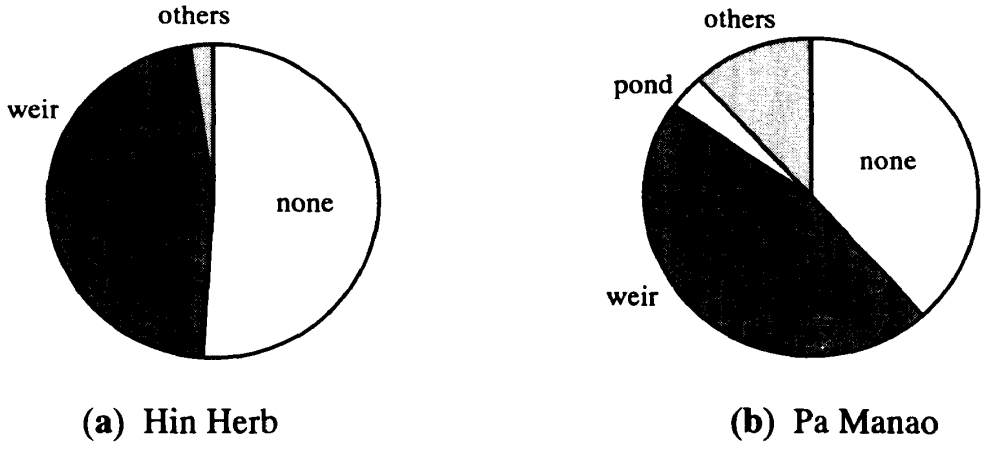

Fig. 3 Presence of Irrigation Facilities

quite frail and undependable. Accordingly it is concluded that the paddy fields in the study area are considered to be basically rainfed, irrespective of having some irrigation facilities.

3) *Recent Trends of Rice Cultivation*

In the recent years, broadcasting (direct seeding) has been quickly spreading as a mean of planting practice mainly because of labor force shortage. About half of the area of the paddy field is planted by broadcasting, though the farmers recognize that the yield is lower as a result of broadcasting, as shown in Table 2.

Buffaloes have been widely used for plowing in Northeast Thailand in the past years. Recently power-tillers have mostly replaced buffaloes for plowing (Table 3). It should be pointed out that farm mechanization in this area is progressing, although only one out of four farmers possess their own power-tiller.

4) *Limiting Factors*

The farmers point out that water resources, labor force and financing are limiting factors to agricultural production as shown in Fig. 4. These items correspond to the problems of

Table 2 Practice of Planting Rice in 1996
unit: percent

	Hin Herb	Pa Manao
Ratio of area		
Transplanting	59	42
Broadcasting	41	58
Yield of broadcasting compared to transplanting		
Lower	93	87
Same	7	13
Higher	0	0

Table 3 Means of Tillage Practice in 1996
unit: percent of number of households

	Hin Herb	Pa Manao
Buffalo	12	4
Power tiller		
Self possessed	26	22
Lease	26	37
Contract	36	37

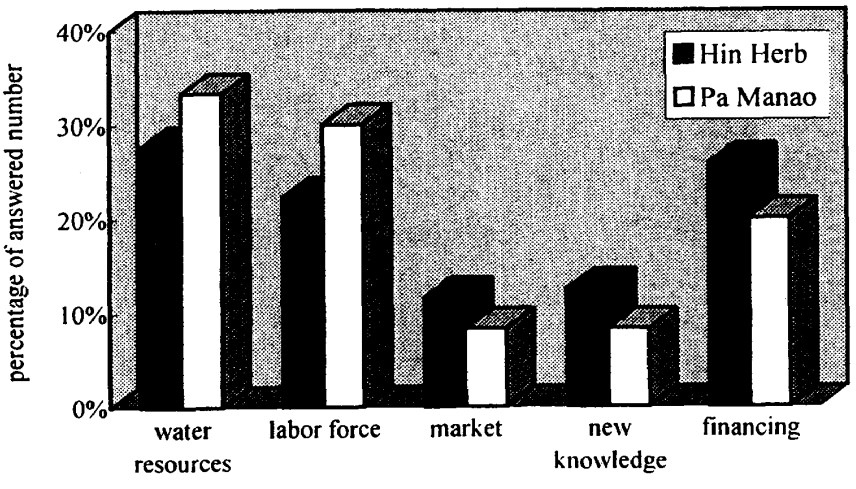

Fig. 4 Factors Limiting Agriculture

shortages of water for rainfed agriculture, decrease in labor force and the lack of funds for agriculture, respectively.

Ⅲ－2 *Rice Production and Consumption*

Combining the results of the questionnaire and the complementary hearing survey to the selected villagers leads to summarizing the actual situation of rice production and consumption. Table 4 shows that roughly about half of the households cannot produce sufficient amounts of rice for self-consumption in both villages. Table 5 concerns the results of the complementary hearing survey. It indicates that the degrees of self-sufficiency in rice have a wide range. For example, the farming household No. 221 in Table 5 is able to produce a sufficient amount of rice every year. Contrarily, No. 218, 202 and 225 are able to achieve self-sufficiency with storage, so these types can be called "beyond-year storage type." No. 205 is unable to produce a sufficient amount of rice in most years.

This area had a traditional custom in which relatives or neighbors support each other by giving rice when the harvest is poor. However, our hearing survey confirmed that recently the households sometimes buy rice from the market in the years when rice shortages occur. Moreover, just few cases of traditional mode of cooperation such as co-working and co-eating (*het nam kan, kin nam kan*) were observed in both villages.

Ⅲ－3 *Discussion on Present Situation and Prospects*

The results of the questionnaire and hearing surveys can be summarized as follows:

- Rapid changes in agricultural production systems in the study area were recognized.
- It was confirmed that the rice production of each farming household is generally

Table 4 Achievement of Self-sufficiency in Rice
unit: number of household

	Hin Herb	Pa Manao
Able	25	19
Unable	25	11

Table 5 Actual Status of Rice Production and Consumption
(5 Households in Pa Manao Village)

No.	Harvested Rice (100 kg)			Rice Demand in a Year (100 kg)	Self-sufficiency Type
	Good Year	Ordinary	Poor Year		
221	80	80	80	30	every year
218	80	55	20	30	beyond-year storage
202	30	22	10	20	beyond-year storage
225	14	10	6	10	beyond-year storage
205	30	15	5	30	unable

unstable.

- Capability of producing rice (rice productive force) of farming households is spread over a wide range.
- Throughout-the-year employment is becoming less exceptional in suburban areas of big cities such as provincial capitals.
- Labor force shortage and less attractiveness of rice farming causes more extensive rice cultivation.

Rapid economic growth has brought massive exodus of people from Northeast Thailand to cities unlike earlier seasonal labor migrations [Funahashi 1996]. This kind of exodus also caused a shortage of labor force in the two villages of our study area. New opportunities such for throughout-the-year employment emerged in suburban areas as shown in section Ⅲ−1. From these facts, it is concluded that the rural economy is shifting to a monetary economy and the weight of rice cultivation for self-sufficiency in rural life is decreasing.

The basis of the rice cultivation for self-sufficiency was found to be weakening, because of the drastic changes in socio-economic structures. This weakening trend will most likely result in the general direction to abandonment of the traditional farming style of rice cultivation for self-sufficiency. The present rice cultivation style will also most likely change and new styles of rice cultivation will emerge. The heterogeneity of farming households would become clearer.

Ⅳ Evaluation of Stability

Ⅳ−1 *Development of Stability Indices*

In the above section, the wide range spread of rice productive forces was recognized among farming households. Rice productive force is determined by the production amount and its stability namely how stably how much rice can be produced by a farming household. In the marginal area of rainfed rice cultivation such as Northeast Thailand, the rice productive force largely depends on the stability of rainfed rice cultivation. The stability of rainfed rice cultivation can be expressed by two stability indices, namely, stability of production level and stability of rice farming for self-sufficiency. The former stability index is determined by the land and water condition for rice cultivation; the latter stability index is determined by the landholding size (rice farming scale) and the number of people in a household in addition to the land and water condition. Thus, two stability indices are proposed to evaluate the stability of rainfed rice cultivation in this section.

1) *Stability of Production Level*

Stability of production level is evaluated by following two factors: the magnitude of

fluctuation in annual production and the production level. This stability is obtained by multiplying these two factors.

First, the fluctuation magnitude of annual production is calculated with the coefficient of variation (standard deviation / average) of annual production of each farming household for successive years. Second, the production level is the ratio of average production to potential production. The stability of the production level is obtained by multiplying these two:

$$FLM = 1/(1+CV) \quad \text{Eq. (1)}$$

$$PRL = Pave/Ppot \quad \text{Eq. (2)}$$

$$Spro = FLM \times PRL \quad \text{Eq. (3)}$$

where FLM is fluctuation magnitude of annual production, PRL is production level; $Spro$ is stability of production level; CV is coefficient of variation of successive annual production; $Pave$ is average of successive annual production and $Ppot$ is potential production. Since it is difficult to estimate the potential production under actual cultivation condition, maximum annual production of the farming household is employed for potential production. Actually $Spro$ express yield level, although "production" is used as the name of the index.

The value of $Spro$ ranges from 0.0 to 1.0. The value approaching 1.0 means higher stability and the value approaching 0.0 means lower stability.

2) *Stability of Rice Farming for Self-sufficiency*

The basis of rice farming for self-sufficiency lies on whether rice demand in each farming household is steadily satisfied or not. The point is how long of a period should be taken for evaluating the balance between demand and production. It is known that farming households in Northeast Thailand store rice of good harvest years for two or three years to supplement the possibility of poor harvests. Therefore the moving average of three years is used for expressing the effect of storage.

Using the moving average production for three years and rice demand in the year, the degree of self-sufficiency in rice of each year is calculated. The stability of rice farming for self-sufficiency is obtained by the geometrical average of the degree of self-sufficiency in rice:

$$Dsel_i = Pav_{i\text{-}2 \text{ to } i}/D_i \quad \text{Eq. (4)}$$

$$Ssel = \{\prod_{i=1}^{n}(Dsel_i)\}^{1/n} \quad \text{Eq. (5)}$$

where $Dsel_i$ is degree of self-sufficiency in rice of i-th year; $Pav_{i\text{-}2 \text{ to } i}$ is moving average production from the year i-2th to i-th; D_i is amount of rice demand in i-th year; $Ssel$ is

stability of rice farming for self-sufficiency.

The *Ssel* takes non-negative values. The value larger than 1.0 means achievement of self-sufficiency in rice. The value approaching to 0.0 means more unstable.

From the complementary hearing survey, values of rice demand (unhusked rice) in each household were collected from five households in each village. As a result, 413.1 kg in Hin Herb and 423.3 kg in Pa Manao was obtained as rice demand per person per year.

Previous studies tried to estimate the annual rice demand in Northeast Thailand. Nakada [1995] mentioned that rice has various uses in Northeast Thailand; for example, selling out, eating, taking out by seasonal labor migration, animal feeding, barter, gifts and rent. Also the paper mentioned that rice consumption for eating was estimated about 300 kg per person per year. Other papers also estimated or used the rice demand. Miyagawa [1991] estimated the value as 376 kg per person per year including seed and social demand. Fukui [1996] used the assumption that 400 kg of paddy be consumed as food per person per year for calculating rice budget.

Considering these values in the above previous studies, the values of rice demand from the hearing survey in this paper should correspond to amount of the rice demand which includes all uses. Therefore, in the evaluation, the value of 400 kg per person per year was used as rice demand.

Ⅳ－2　*Calculation Results*

The annual production data for successive four years (from 1993 to 1996) were obtained through conducting the questionnaire survey. Some of samples had to be eliminated because the samples belonged to non-farming households. Thus the numbers of object households used in this study were 43 (out of 50 samples) farming households in Hin Herb and 25 (out of 30 samples) farming households in Pa Manao.

Calculation results of stability of production level (*Spro*) are given in Table 6 expressed in a frequency distribution table. As the table shows, the evaluation values are

Table 6　Calculation Results of *Spro*

Class	Hin Herb (43)	Pa Manao (25)
$0.0 < Spro \leqq 0.1$	0	0
$0.1 < Spro \leqq 0.2$	5	0
$0.2 < Spro \leqq 0.3$	9	1
$0.3 < Spro \leqq 0.4$	15	5
$0.4 < Spro \leqq 0.5$	8	6
$0.5 < Spro \leqq 0.6$	4	6
$0.6 < Spro \leqq 0.7$	1	7
$0.7 < Spro \leqq 0.8$	1	0
$0.8 < Spro \leqq 0.9$	0	0
$0.9 < Spro \leqq 1.0$	0	0
Average	0.36	0.51

(　): Number of farming households analyzed
Spro: Stability of production level

Table 7 Calculation Results of *Ssel*

Class	Hin Herb (43)	Pa Manao (25)
$0.0 < Ssel \leqq 0.2$	1	0
$0.2 < Ssel \leqq 0.4$	1	2
$0.4 < Ssel \leqq 0.6$	6	1
$0.6 < Ssel \leqq 0.8$	5	2
$0.8 < Ssel \leqq 1.0$	7	3
$1.0 < Ssel \leqq 1.2$	6	1
$1.2 < Ssel \leqq 1.4$	6	2
$1.4 < Ssel \leqq 1.6$	2	0
$1.6 < Ssel \leqq 1.8$	2	1
$1.8 < Ssel \leqq 2.0$	2	0
$2.0 < Ssel \leqq 2.5$	5	5
$2.5 < Ssel \leqq 3.0$	0	3
$3.0 < Ssel \leqq 4.0$	0	4
$4.0 < Ssel \leqq 5.0$	0	1
Average	1.14	1.93

( ): Number of farming households analyzed
Ssel: Stability of rice farming for self-sufficiency

distributed widely and the average is around 0.5. On comparison between the two villages, the average value in Pa Manao (0.51) is higher than that in Hin Herb (0.36). The result reflects the difference in land and water condition for rice cultivation between the two villages.

Table 7 also shows the calculation results of stability of rice farming for self-sufficiency (*Ssel*). Evaluation values in the two villages also range widely. The maximum evaluation value of Hin Herb reaches about 2.5 and the average evaluation value is found around 1.0. On the other hand, the maximum evaluation value of Pa Manao reached about 4.5; the average evaluation value is about 2.0. In Pa Manao, while about 40% of the farming households are unable to achieve self-sufficiency levels, several farming households have the potential to produce surplus rice which can be sold. In addition to poorer land and water condition Hin Herb generally has a smaller farming scale than Pa Manao. The situation accelerates the lower value of *Ssel* of Hin Herb.

IV-3 *Analysis with Stability Distribution*

1) *Stability Distribution*

The combination of distributions of the two stability indices, which is named "stability distribution" in this paper, is expressed by plotting the evaluation values on the 2-dimensional plane taking stability of rice farming for self-sufficiency (*Ssel*) on a horizontal-axis and stability of production level (*Spro*) on a vertical-axis.

As for the achievement of self-sufficiency, Fig. 5 shows that calculation results of *Ssel* in the two villages agree with the results of the questionnaire survey. In the figure, the group achieving self-sufficiency in rice is mainly distributed in the range of more than 1.0 of *Ssel*. For exceptional cases, a few plots are seen in the inappropriate domain,

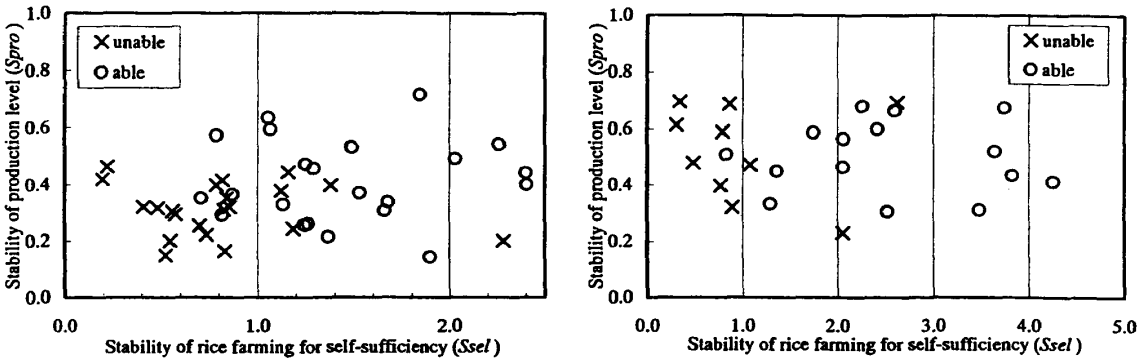

Fig. 5　Achievement of Self-sufficiency in Rice

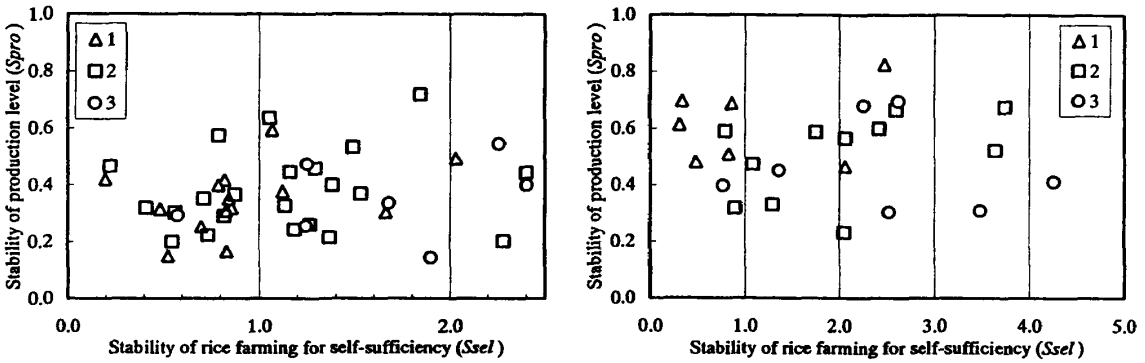

Fig. 6　Rice Farming Scale and Stability Distribution

Note: Symbol number means rice farming scale; 1: less than 10 rai, 2: more than 10 rai less than 20 rai, 3: more than 20 rai. (1 rai= 1,600 ㎡)

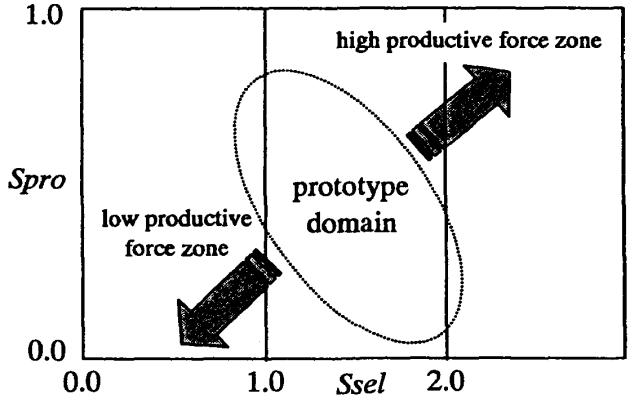

Fig. 7　Prototype and Productive Force in Stability Distribution

mainly because of the difficulties for estimating rice demand.

Secondly, the relationship between the evaluation values and farming scales is examined. Generally in the region where irrigation systems are well equipped, farming scale is one of the largest factors directly influencing rice productive force. In Fig. 6, while no relation between the evaluation values of *Spro* and farming scale is found, the tendency that the larger farming scale presents the higher value of *Ssel* is recognized. This shows that self-sufficiency in rice is achieved by holding larger paddy field land.

It is concluded that farming scale does not influence the stability of production level, but influences the stability of rice farming for self-sufficiency. As indicated in previous studies (for example [Kaida *et al.* 1985]), the size and the typical pattern of land holding as well as the rice storage have played big roles for avoiding the risk of unstable rice production and for achieving self-sufficiency in Northeast Thailand. The stability distribution can reasonably explain the general situation of rainfed rice cultivation in Northeast Thailand.

2) *Domain of Prototype Farming Households on Stability Distribution*

The prototype of farming households in Northeast Thailand is commonly recognized as those depending on rice production for self-sufficiency of the staple food and on seasonal labor migration for earning income in cash. It is reasonable to think that the evaluation values of this type should occupy the domain shown in Fig. 7. The prototype domain contains both farming households having low productivity with large farming scale and those having relatively stable production in small farming scale.

Not all plots are distributed in the prototype domain. Since a plot having high values of both two indices is considered to have a high productive force, two zones outside the prototype domain can be defined as: high productive force zone situated above right of the prototype domain and low productive force zone situated below left of the prototype domain, as shown in Fig. 7. The stability distribution is used as a tool to evaluate quantitatively rice productive force.

3) *Classification of Farming Households on Stability Distribution*

Farming households can be classified through the concept of the prototype domain in stability distribution. Fig. 8 shows the relationship between the stability distribution and income from selling rice. In Hin Herb as shown in Fig. 8 (a), the prototype domain is mainly occupied by the plots achieving self-sufficiency in rice but having no income from selling rice. This attribute of the group of plots characterizes the prototype more clearly. In Hin Herb, it can clearly be observed that another group exists in the low productive force zone. On the other hand Fig. 8 (b) shows farming households belonging to the prototype forms just a small group in Pa Manao. It is reasonable to suggest that farming style be diversified in Pa Manao. In both villages, the group of farming households producing surplus rice and selling the rice is found to exist in the high

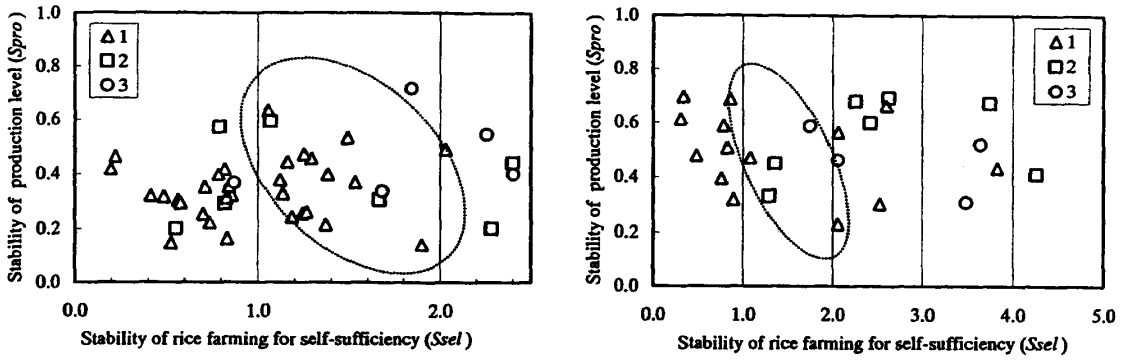

Fig. 8　Income from Selling Rice and Stability Distribution

Note: Symbol number means income from selling rice; 1: 0 Baht, 2: less than 10,000 Baht, 3: more than 10,000 Baht.

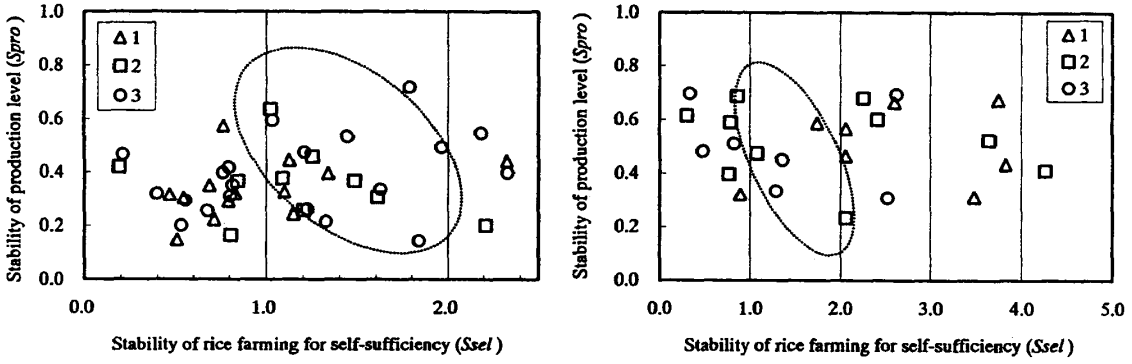

Fig. 9　Income Level and Stability Distribution

Note: Symbol number means income level; 1: less than 30,000 Baht, 2: more than 30,000 and less than 60,000 Baht, 3: more than 60,000 Baht.

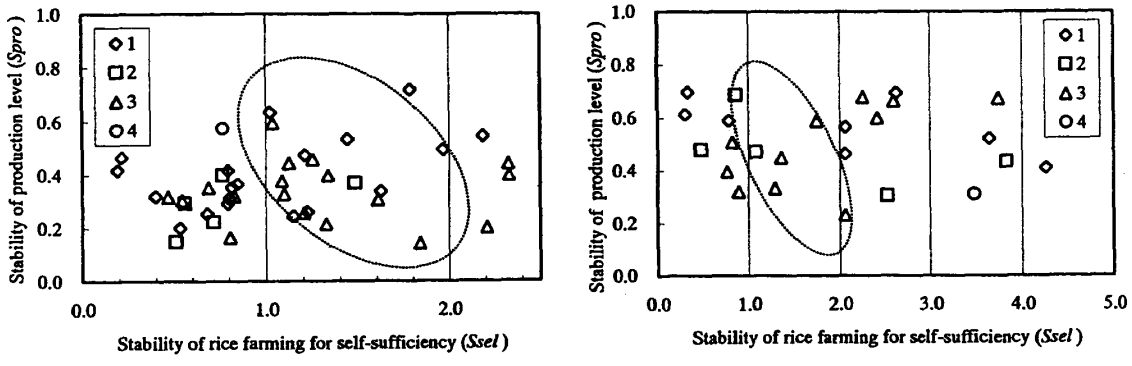

Fig. 10　Main Income Source and Stability Distribution

Note: Symbol number means main income source; 1: labor works outside village, 2: labor works inside village or salary, 3: agricultural income from other crops, 4: income from rice.

productive force zone.

Fig. 9 indicates that income level and stability distribution have little relationship. In Hin Herb, various income levels are found in the farming households not satisfying self-sufficiency. On the other hand, in Pa Manao, the farming households even below the self-sufficiency level keep relatively high incomes. Fig. 10 presents the relationship between main income sources and stability distribution. The figure indicates that each kind of main income sources is distributed over a wide range without a close relation with stability distribution in both villages. This fact explains the small relationship between income level and stability distribution.

As the results from Figs. 8 to 10, significant gaps in rice productive force is recognized among the farming households of the two villages. Based on the gaps, the farming households can be classified into three groups: prototype group, low productive force group and high productive force group. The effect of the difference in productive force to the income structure, however, is found to be trivial.

V Conclusion

Through the field investigations, it was recognized that the rainfed rice cultivation in this region is in the period of drastic change. The basis of the present rice cultivation for self-sufficiency was found to be in a weakening trend because of socio-economic changes.

Based on the recognition of present status, the two stability indices, stability of production level (*Spro*) and stability of rice farming for self-sufficiency (*Ssel*), were proposed to evaluate the stability of rainfed rice cultivation in Northeast Thailand. As a result, significant gaps in the stability indices among the farming households were recognized in each village.

Rice productive force was quantitatively evaluated in stability distribution which is a combination of proposed two indices. The prototype domain was defined in the stability distribution. The analysis for classification of farming households on stability distribution found the diversity in rice productive force other than the prototype group.

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