Assessing the Sustainability of Agriculture: A Case of Mae Chaem Catchment, Northern Thailand

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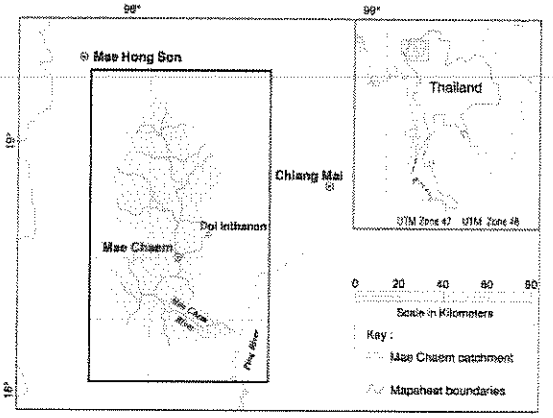
ABSTRACT

Sustainability is not a new concept rather a common prominent concept in the present time. Researchers have identified the sustainability indicators into economic, social and ecological aspects. Sustainability of agriculture in the context of development efforts has to meet production efficiency, resilience of ecosystems, appropriate technology, maintenance of the environment, cultural diversity, and satisfaction of the basic needs. The research objective is to determine the critical indicators of agricultural sustainability in the Mae Chaem Catchment, northern Thailand. In assessing sustainability, the authors applied the approach called sustainability indicator analysis developed by FAO. The results of the study show that food sufficiency in Wat Chan Sub-catchment is the most sustained issue among other indicators. The relatively least sustained issues in Wat Chan Sub-catchment are land holding size, land tenure, and water shortage. While expansion of agricultural land in the watershed area is not legally permitted, a practice of agroforestry is recommended. Insecure land tenure may result in less incentive to improve land productivity. Thus, official recognition of land ownership is required. As a problem of water shortage is more critical in the lower part, increased participation in the allocation scheme of downstream villagers should be encouraged. Finally, a construction of small-scale water storage in the lower part of the catchment to increase water supply should be considered.

1. INTRODUCTION

The development of highland agriculture in Thailand has long been under consideration of various organizations within and outside the country by having a similar long run goal for sustainable development direction. Most highland agricultural systems are practiced in the watershed areas where fragile natural resources are located and must be conserved. Assessing sustainability for highland agricultural system is, therefore, of high interest. The study area, Wat Chan Sub-catchment is located at the upper part of the Mae Chaem Catchment with the main stream of the Mae Chaem River and several minor tributaries (Figures 1 and 2). The history of agricultural development in Upper Wat Chan Sub-catchment began from the settlement of Karen for over a century. Irrigated paddy rice is cultivated along the river in the valleys by most farmers in the area. Upland rice and other crops are also planted in upland fields. Due to the increasing population since the mid-1950s, areas of paddy cultivation have been three-fold expanded while the upland cultivation remains unchanged. This situation implies that land for paddy is relatively scarce. Intensive production of paddy and expansion of upland cultivation are likely to occur in the near future. Thus, when sustainability in development is aimed, an assessment of agricultural activities in the Wat Chan Sub-catchment is essential.

Figure 1: Map of Mae Chaem Catchment, northern Thailand



Source: Integrated Water Resource Assessment and Management Project (IWRAM), Thailand (1999).

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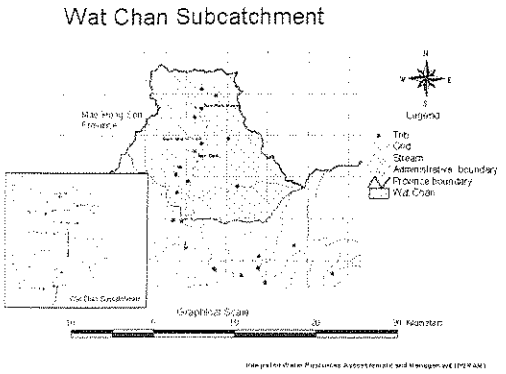
Figure 2: The study area in Wat Chan Sub-catchment, Upper Mae Chaem Catchment.



Source: Integrated Water Resource Assessment and Management Project (IWRAM), Thailand (1999).

In this study, three villages in Wat Chan Sub-catchment are sampled, including Huay Hom, San Muang, and Watchan. They are located at the upper, middle, and lower parts of the catchment, respectively (Figure 2). The data at farm-household level are gathered with 72 samples in the cropping year 1997/98.

2. ASSESSING SUSTAINABILITY

2.1 Conceptual framework

An attempt to keep future generation an option of being as well off as its predecessor is conceptually known for sustainable development. With a non-declining consumption path (Asheim, 1994) or maintaining a constant consumption path(Harwick and Olewiler,1998:392), an economy will find paths of natural resource use that lead to such a specific target. Randall, Sharma, and Munasinghe (1995:11) state that the overall goal of sustainable development is to maximize the flow of net benefits from a stock of resources in which the stability of natural resource base must be maintained. In other words, the use of resources today to meet present need does not adversely affect the environment or the economy's ability to produce goods and services in the future (H&O, 1998:50). When put into practice, the questions are raised to production and consumption patterns at each moment in time. Questions such as how much output can the economy produce to keep consumption level at a specific target or how much natural capital utilization can be allowed and how an economy can be balanced with human-made capital should be resolved. In a more specific context, environmentally adjusted net national product (known as extended net national product, ENNP) is currently a popular means for examining sustainability as an annual pay-off of both natural and man-made capitals at a national level. In measuring economic performance, non-marketed services derived from natural resources and depreciation of natural capital are taken into consideration.

Munasinghe (1993:3) suggests that when sustainability for development is an ultimate goal, this requires the balancing of environmental, social, and economic systems. In agricultural sector, goals for sustainability generally include maintenance or enhancement of the natural environment, provision of human food needs, economic viability, and social welfare (Smith and McDonald, 1998:18). Inevitably, an ability for a community to be sustained in agricultural activities over time depends on its own practice at the present time.

When only cross-sectional data are available, it is still helpful to examine at a point in time whether any economic activities move towards a sustainable path. More specifically, for agricultural activities to be sustained, they should be technically feasible, economically viable, socially acceptable, and environmentally sound.

Approaches commonly known by researchers in monitoring the sustainability are such as environmental or extended cost-benefit analysis (ECBA), multi-criteria decision mechanisms (MCDM), and sustainability indicator analysis (Mueller, 1997: 40). Among them, the sustainability indicator analysis is considered a less formal approach. It simply aggregates and integrates diverse information into a meaningful form. With less data and analytical skills required, sustainability indicator becomes a significant tool for sustainability assessment. Further, it is considered as a flexible analytical tool when applied to any country with given specific economic, environmental, and social conditions.

2.2 Sustainability indicators

In this paper, agricultural sustainability is assessed at various levels including household, village and sub-catchment. In general, sustainability of agriculture in the context of development efforts has to meet (i) production efficiency, (ii) resilience of ecosystems, (iii) appropriate technology, (iv) maintenance of the environment, (v) cultural diversity, and (vi) satisfaction of the basic needs (Mueller, 1997 and SEARCA, 1997).

3. SUSTAINABILITY INDICATORS OF UPPER MAE CHAEM CATCHMENT

3.1 Identification of sustainability indicators

Based on the above criteria, specific indicators for agricultural sustainability to be assessed in the Wat Chan Sub-catchment are developed at different levels: household, village, and sub-catchment. The sustainability indicators at farm-household and village levels are presented based on economic, social and environmental criteria (Table 1). The environmental indicators cover soil, water, and human resources. Their sustainability is indicated by soil erosion, water shortage and health impact from chemical pesticide use. The social indicators include land tenure type, education level, and size of paddy area needed to meet food sufficiency of the household. The economic indicators include farm and household income. Unfortunately, calculation of revenues and costs is still under way, only outputs and inputs that contribute to economic indicators such as farm productivity, land holding size, and number of farm labor are investigated.

Table 1: Sustainability indicators of agriculture at household and village levels

Environmental Indicators	Economic Indicators	Social Indicators
Soil erosion	Productivity of rice yield	Land tenure
Water shortage	Land size	Education
Health impact from chemical pesticide use	Farm labor	Food sufficiency

3.2 Reference system

In assessing sustainability, information from the field needs to be compared with the reference values to determine the sustainability level. Although these reference values do not guarantee that a sustainable situation will be achieved, the values should be defined scientifically and be less subjective (Mueller,1997:62). Several alternatives for defining reference values do exist in literature including those in OECD (1991) and Adeiaanse (1993) cited by Mueller (1997). They are: (i) threshold values or critical values of indicators, (ii) target values or certain standard values set by the government, and (iii) historical values which are supposed to represent a sustainable situation. Among them, target values are most commonly used. In this paper, the main reference system is adopted from the Thai Department of Land Development (DLD:1998) of which their identified sustainability indicators are established using data from highland agriculture in northern Thailand.

4. SUSTAINABILITY OF AGRICUL-TURE IN WAT CHAN SUB-CATCHMENT, UPPER MAE CHAEM CATCHMENT

4.1 Sustainability at household level

In assessing sustainability at farm-household level, only 59 out of 72 samples were undertaken for analysis at this stage. Since preliminary analysis is under way, only some parameters can be initially taken for evaluation. Nevertheless, the essential indicators are covered and defined.

In the first step, sustainability indicators at household level are established as illustrated in Table 1. In this paper, it is assumed that each indicator is equally important and contributed to agricultural sustainability. In the next step, scoring for each indicator is developed to formulate a reference value. The scores can be ranked from the lowest to the highest and categorized as non-sustained (N) to conditional sustained (C) and sustained (S) classes. The methods of score computation in this analysis follows those recommended by FAO sustainable land management evaluation, the concept of which DLD (1998) has applied to highland agriculture. For example, a household with land holding less than 0.48 ha[1] is classified as a non-sustained production unit. Another example, following the same computation steps used by DLD, productivity of rice yield for households over the sub-catchment is ranked descendently. The highest level of productivity is comparable to 100 with the given scores of 10 and the lower is calculated in proportion to the highest.

In the this step, data at each household are converted to scores. In the above example, a household with less than 0.48 ha obtains only one score out of 10. A household with 0.48-1.44 ha obtains 1.5 scores and is categorized as conditionally sustained unit.

In the third step, the scores are aggregated from all indicators and become cumulative scores for a household. They are used as a reference for sustainability class: cumulative scores less than 30 is classified as N, between 30-50 is C, and greater than 50 is S. Finally, overall scores for each household are calculated, compared with the above reference, and classified into sustainability class.

4.2 Sustainability at village level

Of the total 59 samples, 18 are from Wat Chan Village, 21 from San Muang Village, and 20 from Hauy Hom Village. Number of households

[1] This is equivalent to three rai (one ha equals 6.25 rai).

Table 5: Sustainability of agriculture in Hauy Hom Village, 1997/98

Indicator	Sustainability Index (%)	Performance value (score)
Land tenure	38	60
Land size	49	78
Education	73	116
Labor	73	116
Rice yield	75	120
Water shortage	79	126
Health impact	80	128
Soil erosion	94	150
Food Sufficiency	95	152
Performance percentage	72.6 %	

Table 6: Land tenure of farm-households at Wat Chan Sub-catchment, 1997/98

Type of land ownership	Number of household	Percentage
- without land title	37	51
- with conditional permission*	31	43
- with land title document	4	6
Total	72	100

* Permission is mainly obtained from Royal Forest Department (RFD) of Thailand.

Considering the overall performance at village level, the performance percentages indicate that Wat Chan ranks the lowest, while San Muang and Hauy Hom are in better position (Table 3, 4 and 5).

4.3 Sustainability at sub-catchment level

With limited data at sub-catchment level, only some indicators for agricultural sustainability are evaluated. A set of environmental indicators is slightly different from those presented in Table 1. While water shortage and health impact are remained, soil erosion is taken out but percentage of forest area to sub-catchment area is added. Economic indicators are evaluated for rice productivity, land size and farm labor, while social indicators include education and food sufficiency. With limited information on the reference system, all indicators are compared with the reference values at national level. Only environmental indicators on water shortage and health impact are evaluated within the sub-catchment without the reference values.

In assessing sustainability from environmental indicators, it is found that water shortage is relatively less sustained in the lower part than in the middle and upper parts of the catchment (Table 7). This result is consistent with the analysis at village level in the preceding section.

Table 7: Sustainability indicator of water shortage in Wat Chan Sub-Catchment, 1997/98

Village location	Indicator of water shortage (%)
Upper stream	79
Middle stream	62
Lower stream	43

Note: Sustainability indices (%) are used for the comparison.

In assessing health impact at the sub-catchment level, it is found that 56% of the households have adverse impact from using chemical pesticide. The impact is ranged from slight (11%) to moderate (32%) and severe (13%), as reported from the interview of the samples (Table 8).

Table 8: Number of households having impact of chemical pesticide, 1997/98

Health impact	Number of household	Percentage
Severe	19	13
Moderate	23	32
Slight	8	11
No problem	32	44
Total	72	100

According to Mueller (1997) and SEARCA, (1997), the percentage of forest reserves to the total land area is an indicator for the resilience of ecosystem. When using the existing proportion of forest area to total area at the national level as a reference, in comparison with the proportion at the sub-catchment level, the value is much lower to the latter (Table 9). According to the existing 8th National Plan (1997-2001), forest area is targeted to 40% of the total area of the nation. If this is used as a reference, the percentage of forest area at Wat Chan Sub-catchment is still at a much better position compared with the target value.

In assessing sustainability from economic indicators, it is found that the average land holding at national level is almost two folds greater than at Wat Chan Sub-catchment (Table 9). The number of farm labor is slightly less than the national level. Thus, Wat Chan Sub-catchment is in worse situation in terms of economic aspect compared with the national level.

According to the social indicators, it is found that education level and food sufficiency at Wat Chan Sub-catchment are much lower than the national level (Table 9). Thus, it is obvious that its social conditions need to be improved.

classified by sustainability class for each indicator are aggregated at village level. Table 2 summarizes the total number of samples in each village when water shortage, one of environmental indicators, is assessed.

Table 2 Number of samples in each sustainability class according to water shortage indicator.

Sustainability class	Wat Chan	San Muang	Hauy Hom
N	11	4	1
C	4	10	7
S	3	7	12
Total	18	21	20

With the same set of sustainability indicators as in Table 1, formulation of a sustainability index for each indicator is needed at village level. Calculation of an index comprises the following steps. Firstly, each sustainability class is given a specific coefficient: N with 0.2, C with 0.4, and S with 0.8 (DLD, 1998: 22). Secondly, the sustainable score for each sustainability class is computed by multiplying the given coefficient with number of samples in the respective class. Thirdly, the maximum score for each indicator is obtained from the maximum coefficient, 0.8, multiplied by total samples of the village. Finally, sustainability index, performance value, and performance percentage are calculated using the following formulas.

$$\text{Sustainability index} = \frac{\Sigma \text{ Sustainable score}}{\text{Maximum score}} \times 100$$

Sustainability index of each indicator is the percentage of the sustainable score to the maximum score. It indicates the significance of each indicator that plays role in sustainable agriculture. In this study, it will be used for the comparison of indicators within the village and the Sub-catchment.

$$\text{Performance percentage} = \frac{\text{Sum of performance value}}{\text{Maximum performance value}} \times 100$$

where:

performance value = Max. score of indicator x Σ Sustainable score

Performance percentage indicates the overall performance of sustainability from all indicators. In this study, it will be used for the comparison of sustainability among villages.

Wat Chan Village. The village is situated at the lowest part compared with the others. When the sustainability indices and performance values are ranked, water shortage is considered the most critical issue, followed by land tenure and land size. Food sufficiency is found sustained in the village (Table 3).

Table 3: Sustainability of agriculture in Wat Chan Village, 1997/98

Indicator	Sustainability index (%)	Performance value (score)
Water shortage	43	62
Land tenure	46	66
Land size	49	70
Health impact	64	92
Labor	69	100
Education	69	100
Rice yield	81	116
Soil erosion	92	132
Food sufficiency	97	140
Performance percentage	67.7 %	

San Muang Village. San Muang is located at the middle part of Wat Chan sub-catchment. Main problems incurred in agricultural sustainability at San Muang are land tenure, followed by land size and water shortage (Table 4). Likewise, food sufficiency is relatively most sustained issue in the village.

Table 4: Sustainability of agriculture in San Muang village, 1997/98

Indicator	Sustainability index (%)	Performance value (score)
Land tenure	41	68
Land size	57	96
Water shortage	62	104
Education	64	108
Labor	70	118
Health impact	76	128
Rice yield	83	140
Soil erosion	91	152
Food sufficiency	98	164
Performance percentage	72.3 %	

Hauy Hom village. Hauy Hom Village is located at the most upper part of Wat Chan Sub-catchment. In this village, land tenure is the least sustained issue followed by land holding size and education. Similarly, food sufficiency seems to be the most sustained issue in the village (Table 5).

Among the less sustained issues, the problems of land tenure and land holding size are found in all three villages (Table 3, 4 and 5). Thus, further investigation of land ownership is undertaken. It is found that about 50% of total farm-households having cultivated land without land title (Table 6). This implies a low incentive for a farmer to invest in land improvement when ownership is uncertain.

Table 9: Comparison of sustainability indicators between Wat Chan Sub-catchment and national level.

Indicators	Wat Chan Sub-catchment*	National level
% of forest to total area	70	25[a]
Prod. of rice yield (kg/ha)	2,281	2,413[a]
Land holding per hh. (ha)	2.21	4.03[a]
Labor availability per hh.	3	4[b]
Education (% of literacy)	43	91.5[c]
Food sufficiency (ha/hh.)	0.78	1.51[a]

Note: hh. denotes household.
*: data obtained from the survey (n=72).
[a]: Office of Agricultural Economics, 1996/97
[b]: Office of National Statistics, 1998a.
[c]: Office of National Statistics, 1998b.

5. CONCLUSIONS AND RECOMMENDATIONS

When sustainability at household and village levels is evaluated, food sufficiency is the most sustained issue compared with other indicators. However, it is only one-half of the national level. With the majority of Karen ethnicity in the sub-catchment for which subsistent production is the main objective, the level of 0.78 is probably considered sufficient. However, Thailand is one of the world rice exporters, the level of 1.51 on average should exceed the sufficiency level of household.

Land holding is one of the critical issue in the sub-catchment, according to the sustainability indices and when compared with the national level. As an economic indicator, with an increasing pressure on household production area due to increased population in the future, this may cause an adverse impact on their livelihood. While expansion of agricultural land in the watershed area is not legally permitted, alternatives to increase their productivity should be considered. A practice of agroforestry, where forest and agriculture could be combined, might be another option.

Among the social indicators, land tenure is the most critical component. Most farmers do not have land title in their production area. Thus, there is less incentive to improve land productivity. Official recognition of land ownership is required.

Water shortage appears to be an upstream-downstream issue, with an increasing problem in the lower part of the catchment. It is recommended that more effective water allocation schemes should be applied in the catchment area. Community-based management with equitable participation from downstream Wat Chan Village is required. Further, long-term planning on water management, such as a construction of small-scale water storage in the lower part of the catchment should be considered.

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