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Eco-Efficiency Assessment of Sustainable Community Forest Management in Chiang Mai Province

Research Article

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Abstract

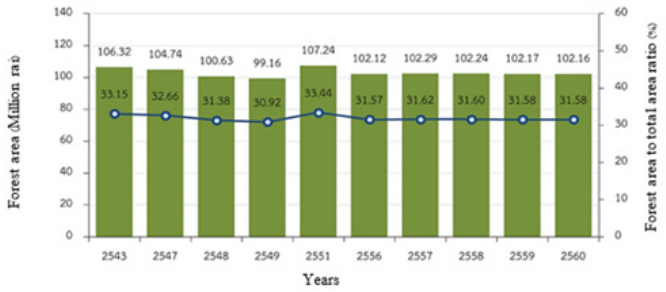
This study presents community forest management and eco-efficiency assessment of the community forest management in 19 districts of Chiang Mai Province. The study utilized in-depth interview questionnaire using quota sampling method. Descriptive statistics were used to analyze participation in community forest management. The ecological efficiency assessment of community forest management was analyzed using the data envelopment analysis (DEA) method. The study demonstrated that most of the community forest management in Chiang Mai area was derived from the support of sub-district administrative organization. The village committees were responsible for the community forests. The responsibilities of most participants included fire prevention, forest ordination ceremony, dam making, and reforestation. Community forest areas had laws and regulations, including penalties for those who committed smuggling and deforestation. Measuring the level of eco-efficiency of community forest management in Chiang Mai showed that total technical efficiency (CRS) at very high level, moderate level, and high level were 45.30%, 41.99%, and 12.71%, respectively. Technical efficiency rating VRS of most areas were at very high level (61.33%), followed by high level (24.31%), and moderate level (14.36%). For the scale efficiency SE, the majority of places was at very high level (85.64%), followed by high level (11.05%), and moderate level (3.31%). However, the efficiencies of community forest management characterized by IRS, CRS and DRS were 64.01%, 30.09%, and 4.97%, respectively.

Keywords: Community Forest; Community Forest management; Eco-efficiency.

Introduction

Forests are considered to be a vital resource for human and animal life. This is because forests are used in many ways such as shelter as well as food and medicine sources. Therefore, humans are bound to the forest. Nowadays, however, the population has been increasing and the urban areas have been being expanded. The industry has been growing rapidly, causing forest areas to be invaded. In 2017, Thailand had forest area of 102.16 million rai or 31.58% of the country area. However, in the same year, forest areas in the National Reserved Forests have been invaded for 107,932.90 rai (an increase of 1,649.46 rai from 2016); 106,283.44 rai were of compromised forest areas (Office of Natural Resources Policy and Planning and Environment, 2018). Considering the past four years (2014 - 2017) as shown in Figure 1, the rate of forest loss tended to be slower. This is because the government has focused on increasing the forest area to achieve the goals set out in the National Forest Policy of 1985, the National Economic and Social Development Plan, Issue No. 12 (2017 - 2021) and the National Reform Plan on Natural Resources and Environment.

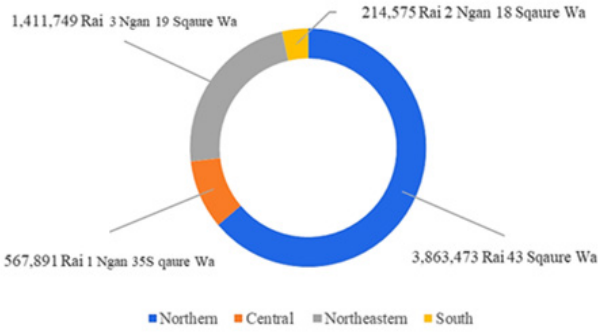
According to the 12th National Economic and Social Development Plan (2017-2021) and the National Reform Plan on Natural Resources and Environment with the goal of increasing the forest area at least 40% of the country area, the Royal Forest Department has emphasized sustainable forest management by promoting and encouraging people to take part in the management of their own local forests, allowing communities to play an important role on forest management together with the state in the form of community forestry. The communities are allowed to participate in the management of forest resources legally by creating community forest projects for approval by the Royal Forest Department and the government sector to provide knowledge and support to create an understanding of the value of the forests (Office of Community Forest Management, 2018).



Source: Office of Natural Resources and Environmental Policy and Planning (2018)

Figure 1: Forest areas of Thailand during 2000 – 2017.

The community forests in the north of Thailand are divided into four areas: the Forest Resources Management Office 1 (Chiang Mai, Lamphun), the Forest Resources Management Office 2 (Phayao, Chiang Rai), the Forest Resources Management Office 3 (Lampang, Uttaradit), and the Forest Resources Management Office 4 (Kamphaeng Phet, Sukhothai and Tak). Considering the community forest areas, the northern region has the largest area of 3,863,473 rai and 43 squares wah [see Figure 2] and Chiang Mai has the second largest community forest area in the northern region, with a total area of 285,523 rai 1 ngan 82 square wah (Information and Communication Technology Center, Royal Forest Department, 2019).



Source: Office of Natural Resources and Environmental Policy and Planning (2018)

Figure 2: Forest areas of community forests from 2000 – 2018.

This research focuses on analyzing the ecological efficiency assessment of community forests in Chiang Mai Province as it has many community forest areas and there is lack of research on ecological efficiency assessment. The research utilizes data envelopment analysis (DEA) to analyze the efficiency and evaluate the results.

Literature review

Theories of management

Management refers to the processes that allow activities of people and resources of the organization to perform effectively and efficiently [1,2]. The effectiveness of the process in the meaning of management refers to the various functions of management, including planning and controlling. The details of management are described in the following sections.

Modern management theory

Every organization needs to be managed well. Good management is the beginning of the operation of the organization. The growth and existence of organizations, especially in the 21st century, are faced with rapidly changing environmental factors (social, economic, globalization and technology). Organizations need modern management practices to cope with this rapid change. Modern management concepts including management process, theory of participation and theory of efficiency are presented in the following topics.

Management process

At the beginning of the 20th century, Henri Fayol suggested that every manager or executive must perform five organizational activities known as management movements: planning, organizing, commanding, coordinating, and controlling (POCCC). In the mid-1950s, scholars from UCLA adjusted management movements to planning, organizing, staffing, directing, controlling (POSDC). POSDC has been used as a framework for writing texts for over 20 years. Later, five management movements of POSDC were shorten into four basic functions: planning, organizing, leading/influencing, and controlling. However, the tasks in each part of the management process are interrelated and interrelated.

Theory of participation

There are five theories of participation. Raphiphat, [3] summarized those theories as follows:

Mass persuasion: Maslow mentioned that persuasion refers to the use of speech or writing to build trust and action Raphiphat, [3]. Persuasion is useful in resolving operational conflicts. Persuaders must have the art of creating an interest in subjects to seduce, especially on the needs of people. According to Maslow's theory of the hierarchy of needs, people's needs are in 5 ascending orders as follows.

a. Physiological needs are the basic needs of human (survival needs) such as food, medicine, clothing, shelter, medicine and sexual needs.

b. Safety and security needs include the need for a safe place to live and a stable life in society.

c. Social needs (e.g. love) are the need for society to accept themselves as a part of society.

d. Self-esteem needs, namely pride, are outstanding need in a subject that is to be regarded by another person. This is a high-level need of self-confidence in the competence and importance of the person.

e. Self-actualization needs are the ultimate system needs that want to be successful in everything in their own way, in order to develop themselves to the best they can.

National morale: People have physical and mental needs. The results of work will be high if the morale is good and vice versa. Creating good morale requires the attempt to create a positive attitude towards co-workers. If the working person has good morale, a sense of responsibility will bring good results to the organization. Therefore, it is likely that the morale of a person, especially a person with good morale, is one of the factors that lead the person to participation in various activities Roongngam, [4].

Nationalism: One of the factors that contribute to participation is the creation of a national sense, meaning a sense of self-dedication or emphasis of the values of the common interests of the nation Roongngam, [4].

Leadership: Leader is a key factor in joining and motivating a group of people to work willingly to achieve their goals. Generally, there are both positive leaders (dynamic leaders) and negative leaders (uncreative leaders). Building leadership results in mobilization, collaboration, morale, quality of work, initiative, creativity, and co-responsibility. Therefore, creating a good leader will inevitably led to good participation in various activities Roongngam, [4].

Administration and method: It is easy to use a management system to mobilize cooperation. The law is the tool for the implementation, but the results of cooperation are not the best. In regard to the nature of people, if they work on a voluntary basis, they will work with love. However, if they are not controlled at all, the outcomes might not comply with the goal of the organization Roongngam, [4].

Thammawong [5] mentioned that participative management referred to management by allowing individuals in the organization or those who involved in the decision-making process to use creativity and management expertise to achieve objectives or solve problems arising from management. Suwatthi [6] discussed the four fundamental aspects of individual participation. First, a person who had the ability to participate was a competent person to participate in various activities such as planning and managing. Second, a well-equipped person who took part must have economic, cultural, and physical conditions that allowed for participation. Third, a person who wished to participate must not be compelled or pushed to participate without their wish to participate. Fourth, a person who had the possibility to participate should have an opportunity to make decisions and determine appropriate activities in order to decentralize the individual.

Worapradit [7] reported that community involvement was driven by the desire to participate in any activity affecting the needs of the group of people in accordance with the social way of life. To be truly involved of the community, organizing activities must consider lifestyles, values, traditions, and attitudes of individuals to create voluntary participation. Community groups differ in their personal, economic and information characteristics. In this regard, the participation of the community is summarized in 5 steps:

i. analysis and synthesis of community problems,

ii. appropriate planning and alignment with the way of life,

iii. activity determination,

iv. activity implementation, and

v. evaluation of activities.

Theory of Efficiency

Efficiency means working the right way. The efficiency is a comparison between inputs and outputs. If productivity achieved is greater by using less or equal inputs, it means work is more efficiently. The input factor for management is the resources of organization, namely staff, money, raw material, equipment, machinery and capital. Such resources are limited and cost the operation of the organization. Therefore, good management must try to minimize the use of resources but maximize the productivity. Management effectiveness refers to achieving a set goal or objective. Management with just efficacy is not sufficient. It is important to consider whether the productivity is in line with the intended goals.

The measurement of efficiency is one of the important factors in determining the performance of organization. The performance values obtained from the assessment can also be used in comparing the work units and considering the levels of competence in the operation of agency. The efficiency of organization can be assessed as follows:

Efficiency = Output/Input

A popular method of measuring performance is benchmarking. This method compares the performance value calculated in each production unit to the benchmark value. In comparison between production units, best practice is used as the standard. For comparing all units, the production units are the frontier, while others are the inefficiency. The comparative performance of production units can be assessed as follows:

Relative Efficiency = Total weight of outputs/ Total weight of inputs

For measuring efficiency, the frontier approach is a border-oriented concept. There are two methods of measuring performance: non-parametric approach and parametric approach. However, this research uses only a non-parametric approach which is DEA method. This method has no definite function format defined. The efficiency boundary is mathematically calculated. Therefore, it is called linear programming and is compared with the performance score. Hence, DEA of production unit is called the decision-making unit (DMU). Guidelines for selecting a method for measuring efficiency depend on the capacity of the unit of production. Input-orientated DEA yields a constant value for each unit. The boundaries were determined by finding the reduction in the proportion of utilization of as many inputs as possible. In case of output-orientated DEA, the inputs are constant, analyzing the possible proportional increase in the yield. Atthong [8] stated that, for DEA model, input-orientated and output-orientated considerations can be obtained from linear programming as shown in [Tables 1 and 2].

Table 1: Constant returns to scale (CRS).

Input orientated	Output orientated
Min$\theta,\lambda\theta$	Max $\varphi,\lambda\ \varphi$
Subject to $-yi + y\lambda \geq 0$	Subject to $-\varphi yi + y\lambda \geq 0$
$\theta xi - x\lambda \geq 0$	$xi - x\lambda \geq 0$
$\lambda \geq 0$	$\lambda \geq 0$

Table 2: Variable returns to scale (VRS).

Input orientated	Output orientated
Min$\theta,\lambda\theta$	Max $\varphi,\lambda\ \varphi$
Subject to $-yi + y\lambda \geq 0$	Subject to $-\varphi yi + y\lambda \geq 0$
$\theta xi - x\lambda \geq 0$	$xi - x\lambda \geq 0$
$N1/\lambda \leq 1$	$N1/\lambda \leq 1$
$\lambda \geq 0$	$\lambda \geq 0$

Related research

The studies and relevant researches are divided into two topics: researches involving community forestry, and researches involving the use of DEA to measure ecological efficiency.

Research involving community forestry

Rahut et al. [9] identified the factors influencing household participation in community forest management programs and assessed the effects of community participation in forest management on household income and poverty levels in Bhutan. The study was based on a comprehensive dataset of 4,173 rural households from all the agro-ecological regions of Bhutan. The estimation on the factors influencing household participation indicated that educated, young and wealthy households were more likely to participate in the community forest management program. The propensity score matching (PSM) approach was employed to correct the potential sample selection bias that arose due to systematic differences between the participant and non-participant households. The PSM analysis was carried out by employing different matching algorithms i.e. nearest neighbor matching, kernel-based matching, radius matching and mahalanobis metric matching. The empirical results indicated that participating households had higher income levels in the range of Ngultrum 2,605–3,169. In addition, the study revealed that the participation in community forest management by households may reduce poverty in the range of 5–12%. The participating households had higher food security levels in the range of 12%–19%, compared to non-participating households.

Muttaqin et al. [10] examined 9 communities in the provinces of Papua, Central Kalimantan, and Riau. The study found that these communities faced some constraints that impeded their role in reducing deforestation and forest degradation. The interests of communities in joining programs to reduce deforestation and forest degradation were diverse. However, their capacity in planning and systematic use of forest, including carbon conservation programs, was relatively low. Strengthening community-level organizational structures and developing robust plans for sustainable management of forest ecosystem services were needed to support communities' participation in reducing deforestation and forest degradation. Wood et al. [11] showed that community forest management (CFM) has been increasingly recognized as a potentially effective way of maintaining forests, especially in the Global South. Despite the growing adoption of this approach, the results have been mixed and there was a need to explore both ways in which a wider range of benefits could be obtained and how CFM could be implemented more effectively. New forest legislation on community forest management in the Southern Region of Ethiopia in 2012 alongside the development of a highly devolved method of CFM provided a natural experiment for testing the effectiveness of this method as a way of maintaining forest and also supporting biodiversity conservation and carbon storage. The specific circumstances and details of the methods applied also provided an opportunity to compare this approach against other experiences of CFM to assess factors seen to be influencing success. This study was undertaken in an area of montane forest in south-west Ethiopia, which includes some of the remaining stands of wild Coffea arabica, and so it also sought to create supportive conditions for the in situ conservation of the wild coffee. Analyses of this approach to CFM over the six years showed that the loss of forest was reduced to 0.18% per annum in the CFM managed areas compared to 2.6% per annum in the non-CFM forest, while biodiversity, in terms of species diversity, richness and evenness of distribution, was maintained in the natural forest managed under CFM. Carbon storage also increased in the natural forest managed under CFM. Meanwhile the long-term results were only seen after several decades. The study also showed that the use of a highly devolved form of CFM was some of the positive influences which helped achieving multiple impacts towards sustainable forest management and wild coffee conservation.

Research involving the use of DEA to measure ecological efficiency

Yuyu et al. [12] studied the transformation of water conservancy from traditional to eco-hydraulic aiming at sustainable development. The study aimed to develop a methodology for evaluating the eco-efficiency of water systems of 31 administrative regions in China. Considering the multiple attributes of water systems and a piecewise linear technological frontier, the Rough Set Theory (RST) and DEA model were combined to analyze the eco-efficiency of water systems. An input and output index system was established based on RST. The eco-efficiency for the water system of 31 administrative regions in China was calculated by DEA, and the characteristics of its spatial differences were discussed. The results showed that there was a significant difference in eco-efficiency of water systems. The efficiency value of the north of China was slightly higher than the south. In the eight sub-regions of China, the north coastal area gained the highest efficiency score and the middle reaches of the Yangtze River obtained the lowest efficiency. There were 11 out of 31 regions of the best practice frontier. The spatial difference in eco-efficiency of the water system was a common phenomenon, which reflected the direct or indirect influence by economic, political, legislative, historical, as well as cultural factors and social development.

Gómez-Limón et al. [13] studied olive farming in the rural areas of Andalusia (Spain) which is the most important olive oil-producing region in the world. Unfortunately, this olive farming region has been exerted significantly environmental pressures with regard to soil erosion, use of polluting input, excessive water consumption and biodiversity reduction. This study used DEA technique and pressure distance function to contribute a farm-level assessment of the eco-efficiency of samples of 292 Andalusian olive farmers. The findings demonstrated that eco-inefficient management was a widespread practice across olive farmers, mainly due to widespread technical inefficiency. Furthermore, the most eco-efficient production system was the traditional plain growing system. Moreover, soil-climate conditions strongly influenced managerial eco-efficiency in cultivation systems. According to relevant researches, two research areas are studied. The first area is researches relating to community forests using qualitative research methodology to collect the data. The second area is a review of concepts, theories and researches relating to the use of DEA to measure ecological efficiency. Emphasis is placed on the evaluation of efficiency, utilizing the method of efficiency measurement using DEA technique via DEAP-2.1 package to calculate the efficiency score level.

Research method

Sample group

The sample group in this research was community forest management staff in Chiang Mai Province, comprising 19 districts (Chom Thong, Chiang Dao, Doi Tao, Doi Saket, Doi Lo, Fang, Phrao, Mae Chaem, Mae Taeng, Mae Rim, Mae Ai. Wiang Haeng, Samoeng, San Sai, San Pa Tong, Omkoi, Hot, Mae Wang and Mae On).

Instruments used for data collection

This research was based on primary information. The data were collected from questionnaires by interviewing the community population and community forest workers. The questionnaire was conducted into 5 parts. Parts 1 – 4 were closed-ended questions and part 5 was open-ended questions. The specific question for each part is as follow:

a. the budget spent in community forests, including funding and the amount spent in community forests.

b. general information for each area, including population of the community, number of staff who look after the forest, and number of areas in the community.

c. information about community forest, consisting of the total area of community forest in the area, type of community forest, the use of community forest.

d. information about engagements (community participation in managing community forests, problems and obstacles in the establishment of community forests) and government services (government promotion as well as support, and the laws to support community forest).

e. additional suggestions.

DEA was used to assess the eco-efficiency of community forest management.

Data collection

Information used in this research consists of primary and secondary data.

i. Primary data was collected from questionnaires interviewing village headmen and community forest workers in 19 districts of Chiang Mai. The interviews concerned community forest management in Chiang Mai Province. Four types of inputs, 1 output and 6 independent variables were used to analyze the data and summarize the results of the study.

ii. Secondary data was obtained from studying theoretical concepts, related documents, researches, and contents concerned management theory, participation together with management efficiency. The effectiveness was measured using DEA method, along with various researches relating DEA and community forest, as well as online resources to form the basis of this study.

Data analysis

The research model used input and output variables to analyze community forest ecological assessments. The variables used in studying ecological efficiency of community forest were shown in Table 3.

Table 3: Variables used in studying ecological efficiency of community forests.

	variable	unit
Output	Community forest area	Rai
Input	Budget	baht
	Population	people
	Officer	people
	Number of households	households
Independent Variables	Community participation	Definition of variable:
		have = 1, none = 0
	Barriers	Definition of variable:
		have = 1, none = 0
	State policies	Definition of variable:
		have = 1, none = 0
	Characteristics of forest areas	Definition of variable:
		plain = 0, foothill = 1,
		mountain = 2, slope = 3,
		others = 4
	Types of forests	Definition of variable:
		reserved forest = 0,
		forest Act. = 1, royal land = 2

Results of Data Analysis

General information of community forest in Chiang Mai Province

General information of community forests in Chiang Mai Province gained from the survey is shown in Table. 4. It was shown that total population in the community forest areas in Chiang Mai was 102,375 people residing in 288,498.42 rai of community forest areas, located in 19 districts of Chiang Mai. The budget mostly came from the support of the Royal Forest Department and the private sector providing a total budget of 1,880,000 baht/year for forest care and fire protection. Most staff of the community forests were the village committees. The number of forest workers depended on the village committee of each area, totaling 3,252 people.

Most of the community forest areas in Chiang Mai Province located at foothill in the national forest area. The forests found consisted of 2 types i.e. deciduous and mixed forests.

Community participation

The survey found that the community participation in community forest management in Chiang Mai resulted from villagers living in the community with the following participation:

Participation in forest care activities

Village committees and villagers in the community organized annual activities including fire prevention, forest ordination ceremony, dam construction, water retention, and tree planting in community forest areas.

Participation in meetings and setting sanctions for those who violated the rules

Village committees and villagers in the community jointly considered and imposed penalties for those who violated the rules. There were penalties for pre-authorized logging, entering the forest for hunting, encroaching forest land, and firing forest. Therefore, any person who violated would be prosecuted under the law of the Royal Forest Department.

Efficiency analysis's results of community forest management in Chiang Mai Province

Table 5 shows the effective analysis of community forest management in 181 areas (community forests) in 19 districts using DEA method. As shown in the table, 55 community forests in Chiang Mai were effective (TE = 1). Other 126 community forests were ineffective, efficiency score < 1, due to the excessive use of input.

Among 126 ineffective community forests, 116 community forests were found to have CRS less than VRS (increasing returns to scale: IRS). This indicates that all of these 116 community forests have less optimal production scale. Thereafter, these community forests can still be increased by inputs. The other 9 community forests had CRS higher than VRS (decreasing returns to scale: DRS), meaning that these 9 community forests are larger than their optimal production scale. Therefore, these community forests should not expand the area or increase the production factor. Moreover, only one community forest had CRS same as VRS, characterized by a fixed size return. Therefore, this community forest should not increase or decrease the area size and production inputs.

Figure 3,4 depicts analysis results of efficiency scores of community forest management in Chiang Mai Province. As shown, community forests had a technical efficiency score under CRS with an average of 0.865, which was high. The average technical efficiency scores under VRS and SE were of 0.979 and 0.909, respectively, which were very high.Considering a score scale, it was found that all community forests had a technical efficiency scores CRS, as shown in Chart 4. Most of them had CRS at a very high level (82 areas, accounting for 45.30%), followed by a moderate level (76 areas, accounting for 41.99%), and a high level (23 areas, accounting for 12.71%).

Table 4: General information of community forests in Chiang Mai Province.

District	Number of community forests (places)	Community forest area (Rai)	Budget(baht)	Officer (person)	Population (person)	Number of households (households)
Chomthong	19	25,687.11	1,24,000	315	7,375	3,144
Chiang Dao	12	7,662.67	1,26,000	222	75,93	2,634
Doi Tao	4		34,000	64	1,735	1,022
		1,587.69				
Doi Saket	6	54,546.69	72,000	90	24,11	871
Doi Lo	1	101.05	5,000	20	367	101
Fang	9	4,829.87	55,000	171	13,141	3,874
Phrao	7	1,742.65	15,000	105	3,328	1,634
Mae Chaem	31	36,352.60	3,97,000	542	17,493	5,264
Mae Taeng	5	1,794.95	30,000	109	2,793	960
Mae Rim	7	14,841.96	59,000	108	2,555	807
Mae Ai	5	1,836.68	62,000	80	5,483	2,151
Wiang Haeng	1	839.18	10,000	20	506	250
Samoeng	8	869.7	1,28,000	143	3,886	951
San Sai	2	3,874.08	15,000	35	1,395	611
San Pa Tong	4	1,269.59	60,000	100	1,854	867
Om Koi	15	38,284.49	1,30,000	269	5,979	2,417
Hot	18	70,360.23	2,24,000	319	12,110	3,771
Mae Wang	8	1,201.71	48,000	146	3,316	1,133
Mae On	19	20,815.52	2,86,000	394	9,055	3,173
Total	181	2,88,498.42	18,80,000	3,252	1,02,375	35,635

Table 5: Efficiency of community forest management in Chiang Mai Province.

No.	District	Community Forest	CRS	VRS	SE	
1	Chomthong	Ban Huai Phatthana	1.000	1.000	1.000	-
2		Ban Huay Muang Fang Sai	1.000	1.000	1.000	-
3		Ban Huay Saphad	0.978	0.99	0.987	irs
4		Ban NamTok Mea Klang	0.839	0.967	0.868	irs
5		Ban Sob Kai	0.896	0.926	0.968	irs
6		Ban Pha Mon	1.000	1.000	1.000	-
7		Ban Huay Pu	0.773	0.878	0.88	irs
8		Ban Den	1.000	1.000	1.000	-
9		Ban Nong Daeng	0.689	0.765	0.901	irs
10		Ban Nong Chet Nuea	0.959	0.978	0.981	irs
11		Ban Wat Chan	1.000	1.000	1.000	-

12		Ban San Muang	0.608	0.715	0.85	irs
13		Ban Huai Hom	0.609	0.716	0.851	irs
14		Ban Nong Hai Samakkhi	0.641	1.000	0.641	irs
15		Ban Kiew Pong	1.000	1.000	1.000	-
16		Ban Mae Ta La Tai	0.591	0.794	0.745	irs
17		Ban Huai Jo	1.000	1.000	1.000	-
18		Ban Tha Kor Muang	0.646	0.844	0.766	irs
19		Ban Buak Ha	0.638	0.816	0.781	irs
20	Chiang Dao	Ban Mae Mae	0.85	0.975	0.872	irs
21		Ban Pang Ma-O	1.000	1.000	1.000	-
22		Ban Pa Bong	0.931	1.000	0.931	irs
23		Ban Mae Sai	1.000	1.000	1.000	-
24		Ban Mae Ya	0.684	0.76	0.9	irs
25		Ban Huai Jo	0.668	0.755	0.885	irs
26		Ban Mae Ka	1.000	1.000	1.000	-
27		Ban Muang Khong	1.000	1.000	1.000	-
28		Ban Mae Tho	1.000	1.000	1.000	-
29		Ban San	0.742	0.744	0.996	irs
30		Ban Mueng Ngai Tai	1.000	1.000	1.000	-
31		Ban Mueng Ngai	1.000	1.000	1.000	-
32	Doi Tao	Ban Nong Moul	0.698	0.766	0.911	irs
33		Ban Pong Tha	0.78	0.827	0.944	irs
34		Ban Thung Khok Chang	1.000	1.000	1.000	-
35		Ban Nong Phak Bueng	0.997	1.000	0.997	irs
36	Doi Saket	Ban Huai Mo	1.000	1.000	1.000	-
37		Ban Mae Waan	0.594	0.744	0.799	irs
38		Ban Pang Nam Thu	0.699	0.773	0.905	irs
39		Ban Wang Than	0.522	0.702	0.744	irs
40		Ban Pa Sak Ngam	1.000	1.000	1.000	-
41		Ban Thung Yao	1.000	1.000	1.000	-

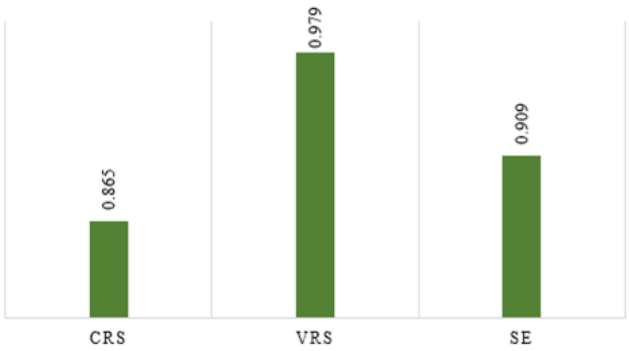
42	Doi Lo	Ban Rai Bon	0.856	0.928	0.923	irs
43	Fang	Ban Nong Aom	0.836	0.837	0.999	drs
44		Ban Huai Khrai	0.601	0.669	0.897	irs
45		Ban San Doi Nak	1.000	1.000	1.000	-
46		Ban Mueng Rea	0.543	0.676	0.804	irs
47		Ban Pa Ngae	1.000	1.000	1.000	-
48		Ban Pang Poi	0.6	0.702	0.855	irs
49		Ban Suan Cha	0.689	0.826	0.834	irs
50		Ban Wiang Wai	0.553	0.833	0.664	irs
51		Ban Nong Phai	1.000	1.000	1.000	-
52	Phrao	Ban Huai Sai	0.793	0.859	0.923	irs
53		Ban San Hok Fa	1.000	1.000	1.000	-
54		Ban Nong Pid	0.904	0.924	0.978	irs
55		Ban San Pong	1.000	1.000	1.000	-
56		Ban San Sai	0.801	0.88	0.91	irs
57		Ban Tha Makieng Nuea	0.812	0.887	0.916	irs
58		Ban Tha Makieng	0.808	0.884	0.914	irs
59	Mae Chaem	Ban Mae Ganga	0.651	0.673	0.967	irs
60		Ban Kong Kaek Nuea	0.651	0.678	0.961	irs
61		Ban Omeng	1.000	1.000	1.000	-
62		Ban Na Ruen	0.735	0.772	0.951	irs
63		Ban Huai Hai	1.000	1.000	1.000	-
64		Ban Rai	0.626	0.692	0.904	irs
65		Ban Lao	0.598	0.671	0.891	irs
66		Ban Pa Daet	1.000	1.000	1.000	-
67		Ban Yang Luang	0.793	0.815	0.974	irs
68		Ban Thap	0.705	0.743	0.949	irs
69		Ban Mae Tum	1.000	1.000	1.000	-
70		Ban Phu Tai	0.6	0.666	0.901	irs
71		Ban Mae Eo	0.813	0.839	0.969	irs
72		Ban Sop Waak	0.654	1.000	0.654	irs

73		Ban Mae Najon	1.000	1.000	1.000	-
74		Ban Sop Mae Satob	0.668	0.833	0.802	irs
75		Ban Mae Suek	0.551	0.705	0.781	irs
76		Ban Na Klang	1.000	1.000	1.000	-
77		Ban Pang Ung	1.000	1.000	1.000	-
78		Ban Pang Kia	1.000	1.000	1.000	-
79		Ban Na Hong	0.56	0.751	0.746	irs
80		Ban Na Hong Tai	0.545	0.691	0.789	irs
81		Ban Kong Kan	0.788	0.854	0.922	irs
82		Ban Amrad	0.742	0.778	0.953	irs
83		Ban Mae Khu Mook Noi	0.96	0.994	0.965	irs
84		Ban Mae Khu Mook	0.55	0.939	0.585	irs
85		Ban Khun Pon-Huai Wok	0.561	0.766	0.732	irs
86		Ban Kong Kai	1.000	1.000	1.000	-
87		Ban Mae Ming	0.879	0.914	0.962	irs
88		Ban Thung Yao	0.901	0.926	0.973	irs
89		Ban Bon Na	0.512	0.65	0.788	irs
90	Mae Taeng	Ban Mon Ngo	1.000	1.000	1.000	-
91		Ban Kai Noi	0.971	0.971	1.000	-
92		Ban San Pu Loei	0.602	0.604	0.996	irs
93		Ban Pang Hang	0.554	0.67	0.828	irs
94		Ban Mae Lod	0.66	0.727	0.908	irs
95	Mae Rim	Ban Phra Bat Si Roy	0.683	0.791	0.864	irs
96		Ban Mueng Ka	1.000	1.000	1.000	-
97		Ban Mae Ka Piang	0.608	0.803	0.757	irs
98		Ban Mae Khi	0.857	0.87	0.985	irs
99		Ban Buak Tei	0.817	1.000	0.817	irs
100		Ban Mae Ann	0.615	0.727	0.846	irs
101		Ban Nong Plaman	0.53	0.691	0.767	irs

102	Mae Ai	Ban Mai Pho Ngam	0.895	0.919	0.975	drs
103		Ban Huai Luang Pattana	1.000	1.000	1.000	-
104		Ban Mae Salak	0.776	0.877	0.885	irs
105		Ban Huai Khok Moo	0.752	0.864	0.871	irs
106		Ban Meung Nong	1.000	1.000	1.000	-
107	Wiang Haeng	Ban Pa Phai	0.537	0.605	0.887	irs
108	Samoeng	Ban Pa Kia Nai	0.578	0.66	0.876	irs
109		Ban Den Hom	1.000	1.000	1.000	-
110		Ban Nong Kisu Nai	0.646	0.715	0.904	irs
111		Ban Mae Yang Ha	0.728	0.768	0.948	irs
112		Ban Kong Khaok Noi	0.576	0.966	0.597	irs
113		Ban Mae Tung Ting	0.938	0.967	0.97	irs
114		Ban Mae Khan	1.000	1.000	1.000	-
115		Ban Pak	0.609	0.667	0.912	irs
116	San Sai	Ban Huay Kaew	0.665	0.703	0.946	irs
117		Ban Phae Mae Faek	1.000	1.000	1.000	-
118	San Pa Tong	Ban Huai Tong	0.774	0.851	0.91	drs
119		Ban Rong Wua	1.000	1.000	1.000	-
120		Ban San Nuea	0.882	1.000	0.882	drs
121		Ban Hua Fai	0.784	0.884	0.887	drs
122	Om koi	Ban Mae Long Noi	0.714	0.852	0.838	irs
123		Ban Mae Long Luang	0.679	0.835	0.814	irs
124		Ban Pha Poon Dong	1.000	1.000	1.000	-
125		Ban Sa Bom Hat	1.000	1.000	1.000	-
126		Ban Huay Nam Khao	0.555	0.613	0.905	irs
127		Ban Yang Pao Tai	0.568	0.623	0.912	irs
128		Ban Lim	0.558	0.617	0.904	irs
129		Ban Ma Hin Luang	0.506	0.576	0.879	irs
130		Ban Dong	0.581	0.723	0.803	irs
131		Ban Yang Pao Nuea	1.000	1.000	1.000	-

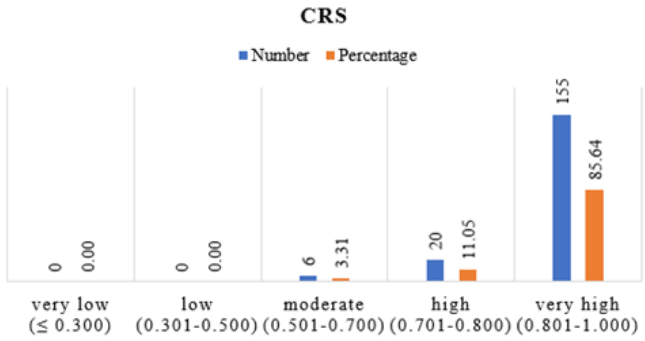
132		Ban Dong	0.791	0.933	0.848	irs
133		Ban San Ton Muang	0.709	0.852	0.832	irs
134		Ban San Ton Pin	1.000	1.000	1.000	-
135		Ban Pa Kha	0.529	0.725	0.73	irs
136		Ban Huay Din Mo	0.612	0.725	0.843	irs
137	Hot	Ban Mae Nguot	0.537	0.636	0.844	irs
138		Ban Mae Lai Duong Jun	0.645	0.72	0.896	irs
139		Ban Huay Hin Dam	0.696	0.767	0.908	irs
140		Ban Thung Luang	1.000	1.000	1.000	-
141		Ban Bo Sa-lee	0.757	0.861	0.88	irs
142		Ban Mai Thung Son	0.535	0.687	0.779	irs
143		Ban Mae Van	0.572	0.71	0.806	irs
144		Ban Wang Kong	0.575	0.768	0.748	irs
145		Ban Mae Sanam	0.568	0.674	0.843	irs
146		Ban Bo Luang	0.598	0.709	0.844	irs
147		Ban Bo Sa Ngae	1.000	1.000	1.000	-
148		Ban Bo Phawan	0.633	0.71	0.892	irs
149		Ban Mae Heut	0.685	0.913	0.75	irs
150		Ban Kiew Lom	0.736	0.796	0.924	irs
151		Ban Tian Ang	0.572	0.682	0.839	irs
152		Ban Khun	0.505	0.654	0.773	irs
153		Ban Thung Pong	1.000	1.000	1.000	-
154		Ban Den Sar-aphi	0.516	0.729	0.708	irs
155	Mae Wang	Ban Huay Kaew	0.591	0.746	0.791	irs
156		Ban San Pu Loei	0.645	0.745	0.866	irs
157		Ban Sop Win	0.602	0.702	0.857	irs
158		Ban Mae Moo	0.821	0.857	0.958	irs
159		Ban Mai Pha Poon	1.000	1.000	1.000	-
160		Ban Huai Yuak	0.588	0.803	0.732	irs
161		Ban Pang Khilek	0.611	0.972	0.628	irs

162		Ban Nong Yen	1.000	1.000	1.000	-
163	Mae On	Ban Huai Bong	1.000	1.000	1.000	-
164		Ban Huai Yap	0.506	0.588	0.861	irs
165		Ban Mai	0.559	0.613	0.911	irs
166		Ban Thung Lao	0.72	0.886	0.813	irs
167		Ban On Klang	0.753	0.808	0.932	irs
168		Ban Sahako-rn 4	0.861	0.936	0.92	drs
169		Ban Sahako-rn	1.000	1.000	1.000	-
170		Ban Sahako-rn 8	0.823	0.92	0.894	drs
171		Ban Sahako-rn 3	1.000	1.000	1.000	-
172		Ban Sahako-rn 6	0.731	0.774	0.945	drs
173		Ban Mae Khuha	0.822	0.894	0.92	drs
174		Ban Tha Kham	0.699	0.726	0.963	irs
175		Ban Kho Klang	1.000	1.000	1.000	-
176		Ban Tamon	1.000	1.000	1.000	-
177		Ban Mai Don Chai	0.709	0.735	0.964	irs
178		Ban Pa Not	0.698	0.727	0.96	irs
179		Ban Huai Sai	0.684	0.709	0.964	irs
180		Ban Huay Kaew	0.647	0.753	0.859	irs
181		Ban Mae Tao Din	1.000	1.000	1.000	-
	Mean		0.784	0.856	0.909	



Source: From the calculation

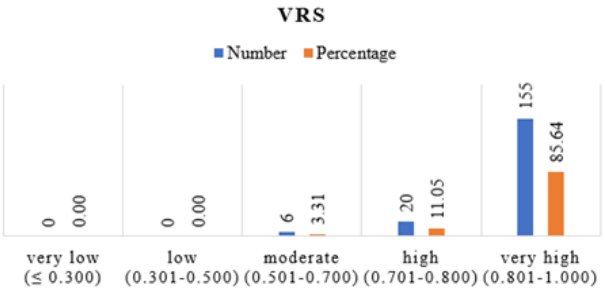
Figure 3: Average efficiency scores of community forest management in Chiang Mai.



Source: From the calculation

Figure 4: Scores of technical efficiency CRS in Chiang Mai area.

Figure 5 demonstrates technical efficiency rating under VRS. As observed, most of community forests were at a very high level (111 areas, accounting for 61.33%), followed by high level (44 areas, accounting for 24.31%), and moderate level (26 areas, accounting for 14.36%).



Source: From the calculation

Figure 5: Technical efficiency score under VRS in Chiang Mai area.

Figure 6, SE is shown. As observed, the majority of places were at very high level (155 areas, accounting for 85.64%), followed by high level (20 areas, accounting for 11.05%), and moderate level (6 areas, accounting for 3.31%).The overall efficiency of community forest management in Chiang Mai Province is very high. This is a consequence of performing of the rangers and the communities with good resource management without defects. Moreover, the forest areas are suitable for caring by staff and the community, thus enabling them to be token care thoroughly.

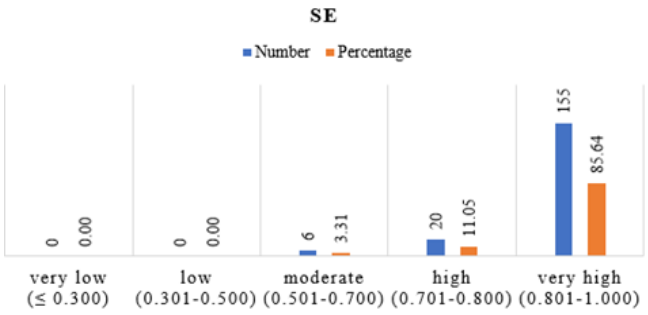


Figure 6: SE in Chiang Mai area

Figure: From the calculation

Conclusions

This study used DEA method to measure the ecological efficiency of community forests in Chiang Mai Province. The samples used in the study were 181 community forests in 19 districts, in Chiang Mai, consisting of Chom Thong, Chiang Dao, Doi Tao, Doi Saket, Doi Lo, Fang, Phrao, Mae Chaem, Mae Taeng, Mae Rim, Mae Ai, Wiang Haeng, Samoeng, San Sai, San Pa Tong, Omkoi, Hot, Mae Wang, and Mae On. The results are concluded as follows.

Information and participation of community forest in Chiang Mai Province

Community forest management could be obtained from the support of the Tambon Administrative Organization or local government for use in forest care and fire protection. The Village Committee was responsible for the care of community forests. Most of the community forests in Chiang Mai were sloping hills located in the National Reserved Forests. Participation in the management of community forests was mainly for fire prevention, forest ordination ceremony, dam making, and reforestation. The way of life of people in the community forests depended on the community forest resources which were the important food source in the area. People in the areas of community forests were able to collect various types of mushrooms at the beginning of the rainy season; most people consumed the mushrooms in their households. The community forest was home to the local foods: vegetables, bamboo shoots, and herbs. If there was a need to use wood for the benefit of the village, permission must be obtained from the village head to bring the matter to the village committee meeting. However, community forest areas had laws and regulations, including penalties for those who committed smuggling and deforestation. If anyone violated, the sanctions would be taken by community forest regulations of the village and laws of the Forest Department to prosecute.

Efficiency evaluation results

The results of measuring the ecological efficiency level of community forest management using DEA method demonstrated that community forest management in Chiang Mai province was technically efficient under CRS, most of which was very high (82 areas, accounting for 45.3%), followed by a moderate level (76 areas, accounting for 41.99%), and high level (23 areas, accounting for 12.71%). Technical efficiency rating under VRS of most areas were at a very high level (111 areas, accounting for 61.33%), followed by high level (44 areas, accounting for 24.31%), and moderate level (26 areas, accounting for 14.36%). For technically efficient under SE, the majority of places was at very high level (155 areas, accounting for 85.64%), followed by high level (20 areas, accounting for 11.05%), and moderate level (6 areas, accounting for 3.31%). However, the efficiencies of community forest management characterized by IRS, CRS and DRS were 64.01%, 30.09%, and 4.97%, respectively.

Suggestions

To improve the ecological efficiency of community forest management in Thailand and to maintain a high level of the efficiency, governments should implement policies that promote community forest management funding. It is necessary to enforce laws relating to encroaching community forests to prevent the destruction of community forests. As a result, the evaluation of the efficiency of community forest can be reduced. The government needs to strengthen the dissemination of information on community forest management and environmental protection in society to further enhance eco-efficiency.

References

1. Certo SC (2003) Modern Management. Upper Saddle River NJ Prentice Hall.
2. Decenzo DA Robbins SP (2004) Human Resource Management. 6th Edition New York: John Wiley & Sons Inc.
3. Raphiphat A (1984) Community Involvement in Rural Development in Thai Socio-cultural Conditions in Thawee Thong Hongwiwat People Participation in Development. 104-111.
4. Roongngam Y (2002) Participation of Government Officials Bureau of the Budget in Bureaucratic Reform. Master of Arts National Institute of Development Administration.
5. Thammawong S (2008) Development of Information Management System on the Office Website Mae Hong Son Province Public Health. Chiang Mai: Graduate School Chiang Mai University.
6. Suwatthi P (2008) Marketing in the Tourism Industry. Bangkok: Institute of Administration Development.
7. Worapradit S (2010) Community Participation Information Work Office of the Promotion of Non-formal and Informal Education Office of Non-formal and Informal Education Trat Province.
8. Atthong A (2004) Application of DEAP 2.1 Program for Efficiency Analysis Using Data Envelopment Analysis. Social Research Institute Chiang Mai University.
9. Rahut DB, Ali A, Behera B (2015) Household Participation and Effects

of Community Forest Management on Income and Poverty Levels: Empirical Evidence from Bhutan. Forest Policy and Economics 61: 20-29.

10. Muttaqin MZ, Alviya I, Lugina M, Hamdani FAU, Indartik (2019). Developing Community-based Forest Ecosystem Service Management to Reduce Emissions from Deforestation and Forest Degradation. Forest Policy and Economics 108: 101938.
11. Wood A, Tolera M, Snell M, O'Hara P, Hailu A (2019) Community Forest Management (CFM) in South-west Ethiopia: Maintaining Forests, Biodiversity and Carbon Stocks to Support Wild Coffee Conservation. Global Environmental Change 59: 101980.
12. Yuyu L, Caizhi S, Shiguo X (2013) Eco-efficiency Assessment of Water Systems in China. Water Resource Management 27: 4927-4939.
13. Gómez-Limón JA, Picazo-Tadeo AJ, Reig-Martínez E (2012) Eco-efficiency Assessment of Olive Farms in Andalusia. Land Use Policy 29(2): 395-406.
14. http://www.onep.go.th/env_data/2016/01_23/.
15. https://cloud.forest.go.th/s/9iH8ZYFTJRmrqwp#pdfviewer.
16. http://www.onep.go.th/env_data/2016/01_23.
17. http://www.onep.go.th/env_data/2016/01_27.