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Assessment of Sustainable Utilization of Ecosystem Services in Different Stages of Mangrove Forest Restoration at Klong Khone Sub-district, Samut Songkhram Province, Thailand

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Abstract

Understanding the function of the ecological restoration of mangrove forests leads to appropriate sustainable utilization (SU) of ecosystem services (ES) during development stages of mangrove ecosystem for sustaining the local livelihood and maintaining the mangrove ecological production. The study aims to identify the SU which was changed relying a development of ES at Klong Khone (KK) Sub-district, Samut Songkhram Province, Thailand. The SU was collected by in-depth interview with 20 key respondents, questionnaires survey with 140 fishermen and statistical scientific data on developed mangrove forest areas. Descriptive statistics and event analysis were employed to analyze the data. The study found that bottom-up management tools based on a local people's participation were applied to determine a way of harvest of ES. An application of these local tools including a common property right, land use zoning, application of local knowledge, human resources, and financial and technological transfer resulted in different utilizing activities of ES during the development of mangrove forest restoration stages. The results showed that the ES produced during mangrove stand initiation stage were mainly harvested for food (90%) and during the young forest regrowth stage (87%) (N = 140). They were also widely used for operating aquaculture during mangrove stand initiation stage (39%), but they were harvested with more concerns about environmental impacts during the young forest regrowth stage (47%) (N = 140). The cultural services during young forest regrowth stage were increasingly utilized for diversified incomes from ecotourism (46%) and education learning program (50%) (N = 140). The ES from developed mangrove forest were harvested effectively based on an application of SU tools which were locally developed by local people's participation. The SU tools can be proposed and applied in other communities where have similar ecological, social and cultural conditions as KK sub-district to support the SU of ES.

Keywords: Ecosystem services; Mangrove forest restoration; Sustainable utilization; Community-based participation

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Introduction

Natural resources of Klong Khone (KK) Sub-district, Samut Songkhram Province, Thailand was overexploited by global frozen shrimp industry promotion [1-4]. Mangrove forests in the sub-district rapidly decreased from about 32 km^2 in 1984 to the degraded forest patches of 1.4 km^2 in 1986 [5-6]. The stresses on mangrove forest brought about a scarcity of ecosystem services [4-8]. The replacement of build-environment such as shrimp farms, industries, residents and infrastructures diminished ecological structures of mangrove forest ecosystems especially rich species diversity of plant and fauna [4-8]. Consequently, social structures were deformed, people in the sub-district left culture of local fishery and abandoned homeland occupancy to be employed as a labor in frozen seafood factories [5, 7]. Effects of vanished mangrove forest also resulted in broken family relationship and weak socio-economic status [6-7].

Referring to the Sustainable Development Goals (SDGs) especially Goal 1, 14 and 15 indicated a poverty of local communities must be alleviated and sustainable uses of natural resources such as marine resources and ecotourism should be promoted [9]. The Article 8(j) of Convention on Biological Diversity (CBD) also encouraged all contracting parties to respect and preserve the local knowledge-based sustainable utilization (SU) for effective management of the natural resources in the disruptive changes [10-12]. The SU tools commonly developed based on the local knowledge to harvest the natural resources and restore the ecological functions [13-19] and to cope with environmental extremes [20, 21]. The SU tools were adapted in response to a changing array of ecological succession stages especially, in plant species composition together with their services in different environmental characteristics such as amounts and quality of litter (leaves and fine roots) input, nutrient uptake by mangrove trees, and soil microbial decomposition. An application of these SU tools in mangrove forest restoration resulted in a recovery of a wide range of ecosystem services (ES) such as fishery resources, fuelwood, carbon storage and sequestration, soil stabilization coastal erosion protection, nursery grounds and breeding sites, and ecotourism for human's well-being [22-26]. It also recovered community's benefits and support local people's way of life such as a form of people's thoughts, ways of living, religious beliefs and rituals, culture, and local occupation [27-29].

The local people at KK Sub-district experienced in developing the SU tools based on their local environmental knowledge to reestablish ecological succession and sustainably utilizing mangrove forest responding the change of ecological forest structures and environmental characteristics. They adjusted different holistic management in consuming and conserving ES which provided during the mangrove development stages of stand initiation (stage I: 1990 to 2007, 17 years) and young forest regrowth (stage II: after the Phase I, starting from 2008 to 2019, more than 12 years). Subsequently, they obtained benefits from restored mangrove forest in term of an opportunity of diversified incomes and local knowledge sharing. However, the SU tools of each local community were specific to ecological, social, cultural, economic and legal conditions. The unique SU tools determined utilization strategy of each community which resulted in different utilizing activities of ES during the stages of mangrove forest restoration. To reveal the SU of ES at different stages of mangrove forest development at KK Sub-district, the SU tools that were developed and applied to determine the local people's utilizing activities of developed ES were identified.

Materials and methods

1) Research framework

A research framework of this study focused on two main parts. The first part was the SU tools which were applied to determine the

mangrove forest management during the stand initiation stage and young forest regrowth stage. Another part was the ES which focused only on provisioning and cultural services harvested during two stages of mangrove forest restoration for the local people's well-being at KK Sub-district (Figure 1).

2) Study area

The KK Sub-district is located in Samut Songkhram Province which consists of 7 villages covering areas around 33.7 km^2 [37]. The sub-district was coastal plain and filled with a dense mangrove forest around 6.6 km^2 along the coastal line [38]. The mangrove forest areas were divided into two zones based on the cabinet resolution. They included protection zone which referred to the mangrove forest in cabinet resolution area, and reforestation and utilization zone which referred to the mangrove forest outside cabinet resolution area (Figure 2). The mudflat on a foreshore zone was public area where allowed the local people to harvest blood cockle and krill. It also used for additional planting of mangrove saplings (Figure 2).

According to the basic information of June 2016 from Civil Registration Section of Muang Municipality of Samut Songkhram Province, it showed that there were population in KK Sub-district approximately 3,319 persons with 902 families. There were 1,584 males and 1,735 females [39]. Main occupations of local people at KK Sub-district were coastal fishery along with the making of shrimp paste and aquaculture such as mussel and blood cockle farming [7, 39]. The local people majorly earned their incomes from a utilization of ES from mangrove forest. However, an extreme reduction of mangrove forest areas due to shrimp farming caused adverse impacts on mangrove ecological production which further affected the local people's income and livelihood [4-8]. Several shrimp ponds at KK Sub-district were abandoned and some ponds were used for blood cockle farming instead [4]. Consequently, the former village headmen and their volunteering local people initiated mangrove reforestation projects in 1990 to restore the mangrove ecosystem for poverty solving [5, 8]. After restoring the mangrove ecosystem and solving poverty crisis, an ecotourism business was initiated in 2008 to generate diversified income and occupations for local people [7].

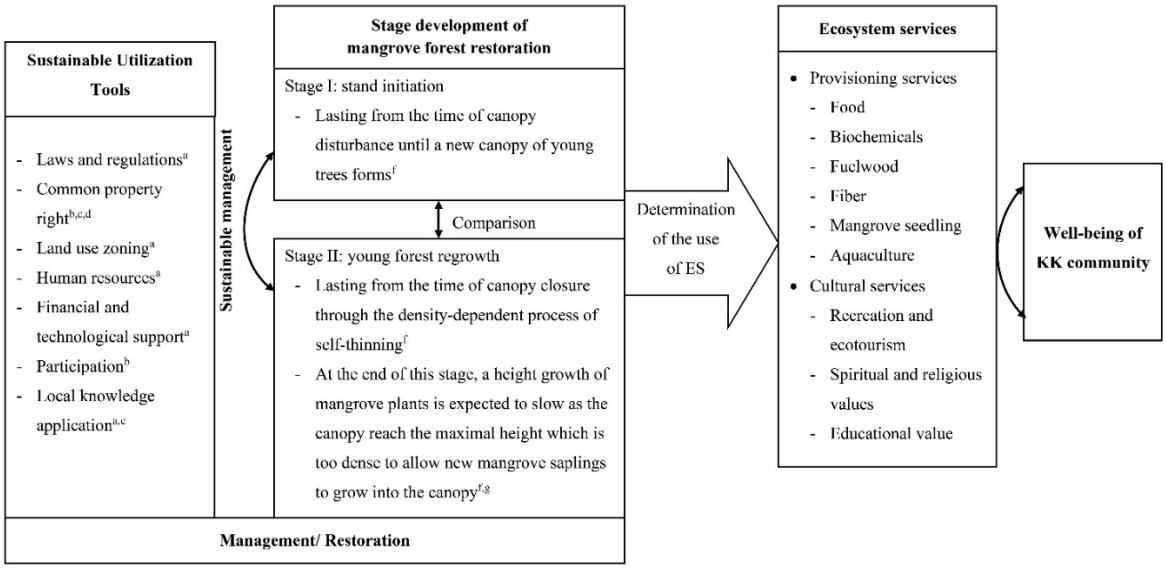

Figure 1 Research framework of the study.
Sources: [a][30], [b][31], [c][32], [d][33], [e][34], [f][35], [g][36]

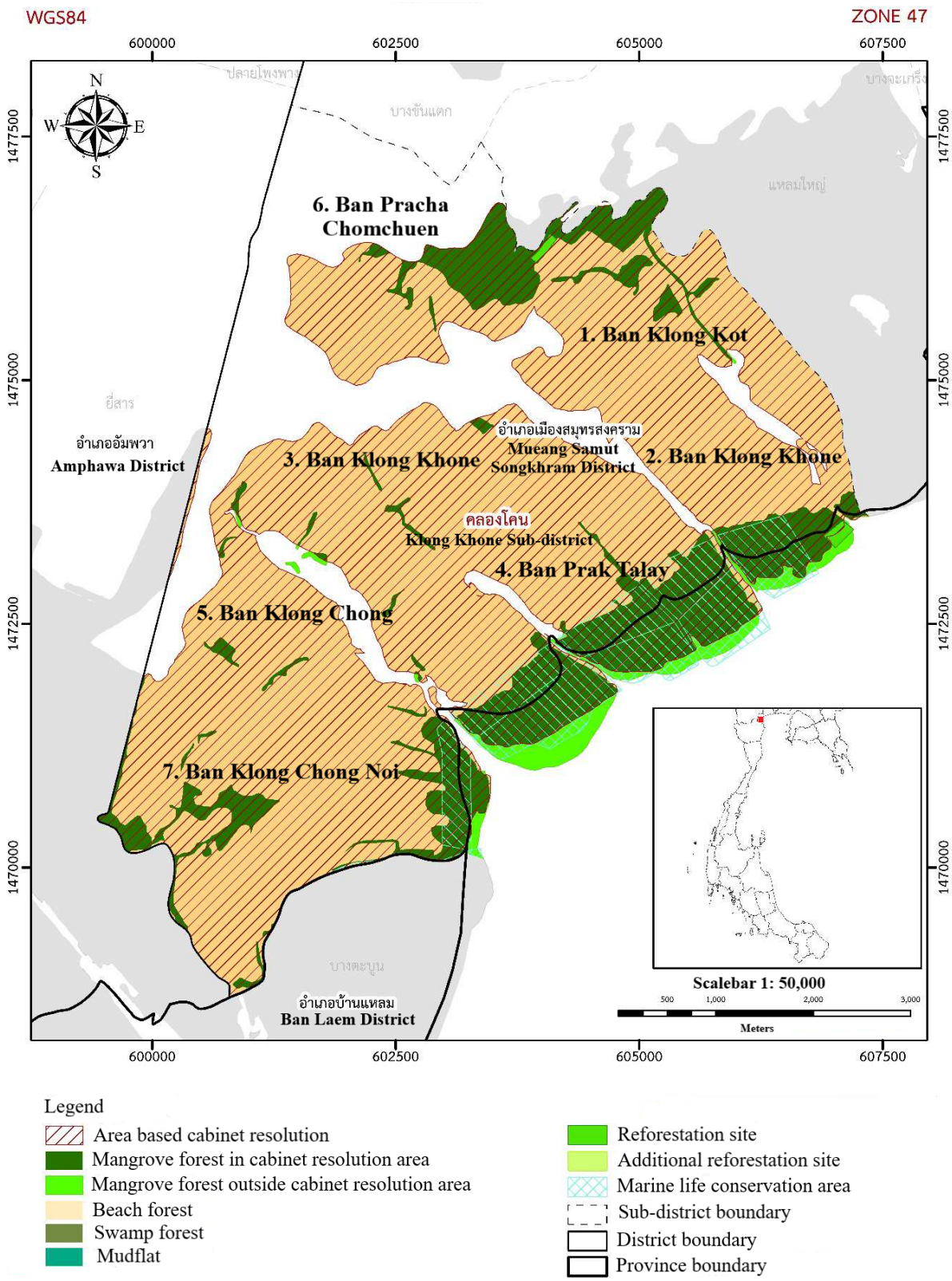

Figure 2 Location and zones of mangrove forest at KK Sub-district at Samut Songkhram Province. Source: [40]

3) Data collection, sample sizes, and data analysis

The SU tools which determined the utilization of ES from mangrove forest during two stages of stand initiation and young forest regrowth were collected by desk reviews, field observation, in-depth interview, and questionnaire survey with multiple choices. The data collection was conducted in August to October 2017. A selection of respondents at KK sub-district were determined based on their social and legal authorities and functions in the community involving the SU tools during two stages of mangrove stand initiation and young forest regrowth. The study collected data from 160 respondents which consisted of two main groups. The first group was 20 key respondents who were selected for in-depth interviews. They were purposively selected based on their different roles and responsibilities involved the mangrove forest restoration and SU of ES during two stages of mangrove forest development. They included former and current village chiefs, local governmental agencies, community enterprises, local philosophers, and mangrove forest conservation groups. Another group was 140 fishermen who were experienced in utilizing the ES from mangrove forest for sustaining their daily subsistence. The fishermen were randomized for questionnaire survey. They were sampled by multi-stage random sampling based on 7 administrative zones of KK Sub-district. This sample method consisted of two steps. Firstly, the sample sizes of fishery households at KK Sub-district were calculated by using Yamane formula at a 95% confidence level. The number of sample sizes of fishery households was 140 households. The second step was a calculation of proportional sample from 140 households by using a proportional stratified random sampling to calculate the numbers of fishery households of each administrative zone.

Results obtained from questionnaire survey was analyzed by a descriptive statistical analysis, while the interviewed data was interpreted by an event analysis. They were analyzed to reveal the tools applied to the ES uses during two stages of mangrove forest restoration at KK Sub-district.

Results and discussion

1) SU tools of mangrove forest restoration

The results showed that a common property right, participation of local people, human resources, local knowledge application, land use zoning, laws and regulations, and financial and technological support were the important SU tools which were applied to restore the mangrove forest and determine the local people's utilizing practices (Table 1).

Table 1 SU tools of mangrove forest restoration at KK sub-district ($N = 140$)

SU tools	Yes		No		Do not know	
	N	%	*N*	%	*N*	%
Common property right	128	91	11	8	1	1
Participation	121	86	10	7	9	6
Human resources	119	85	6	4	15	11
Local knowledge application	108	77	8	6	24	17
Land use zoning	97	69	16	11	27	19
Laws and regulations	80	57	32	23	28	20
Financial and technological support	41	29	29	21	70	50

Remark: Multiple responses were possible.

The study found that the SU tools at KK Sub-district were categorized into long-term and short-term tools. The common property right, land use zoning and laws and regulations were long-term tools as they were determined and applied in both stage I and stage II, while human resource, financial and technical support, participation, and local knowledge application were short-term tools as they changed in stage II.

1.1) Common property right

An allocation of common property right to mangrove-dependent communities was required to encourage the local people to participate in the SU of developed ES from restored mangrove forest [32-33]. The study found that 91% of respondents (N = 140) indicated that the common property right on publicly owned mangrove forest supported the participation for the SU of ES because it involved with a creation of a sense of ownership (Table 1). A former village chief indicated that the local people who highly depended on the mangrove forest will have a sense of ownership and voluntary for participation [41]. As a result, the common property right had a high influence on the local people' decision making on their way of harvest of developed ES from mangrove forest in sustainable manner.

1.2) Enforcement of forest laws

A Forest reserve Law, Marine and Coastal Management Promotion Act, and a cabinet resolution which classified mangrove forest into three zones including conservation zones, economic zone A, and economic zone B [42, 43] were applied and enforced to determine, regulate, and monitor the local people's sustainable practices. Over half of respondents (57%, N = 140) indicated that an enforcement of these laws and regulations were required for controlling the local people's utilization of ES. (Table 1).

1.3) Mangrove zoning for conservation and utilization

A zoning of mangrove forest into conservation and utilization zones was developed based on community commitment. Sixty-nine percent of respondents (N = 140) indicated that a land use zoning was applied in determined the restoration site and utilization area. (Table 1). The former village headmen revealed that the land use zoning was applied before an enforcement of laws and cabinet resolutions related a cancellation of mangrove forest concession and classification of mangrove forest to determine, regulate, and monitor the local people's harvesting methods of ES.

1.4) Participation of local people

The participation approach was found dominantly in a success of SU and management of mangrove forest [41, 44-45]. It promoted in an effective process of decision-making, monitoring, and reducing conflicts associated with mangrove management [44]. Eighty-six percent of respondents (N =140) indicated that their participation allowed them to sustainably harvest the ES by using their own methods based on their own experiences and cumulative knowledge regarding their livelihood (Table 1). The engagement of local peoples enabled them to integrate their traditional values, social norms, and local livelihood for SU of ES. Their participation in mangrove management also allowed them to learn how to harvest the developed ES appropriately based on their sense of ownership, community commitment, land using zoning, and legal enforcement.

The study also found that the participation of local people in mangrove forest restoration at KK sub-district was motivated by an interpersonal trust which involved with an emotional attachment of local people to their village chiefs and charismatic domination of HRH Princess Maha Chakri Sirindhorn. From in-depth interview with

former village headman, he revealed that the local people increasingly participated in mangrove restoring activities after the first royal visit of HRH Princess Maha Chakri Sirindhorn for planting mangrove saplings in 1997. He indicated that the local people were so proud of welcoming HRH Princess Maha Chakri Sirindhorn's royal visits and intended to pass on their pride to their descendants by continuously conserving the mangrove forest and sustainably utilizing the ES produced from restored mangrove forest. The trust-induced participation reflected a superior -inferior relationship which was embedded in Thai cultural village organization. Moreover, it also implied an affective relationship such as love, trust, and reverence of the Thai people to a royal family which was rooted in their beliefs and attitudes, and unique to the Thai culture.

1.5) Human resources, financial and technological transfer

Generally, the human resource was a valued asset which is widely mentioned in business field [46]. It referred to the staffs from various unit in an organization. They had different functions, knowledge, skills, behaviors, and values in supporting an organizational performance and productivity [47]. In case of KK Sub-district, the human resource (85%, N = 140) was a key tool for the SU of ES produced from restored mangrove forest as it involved several groups of people who had different functions in monitoring the local people's harvest of developed ES (Table 1). These group of people included local people, village heads, local governmental agencies, academic institutions, and private companies. A chief of Mangrove Forest Development Station 7 (MFDS 7) revealed that the functions of MFDS 7 was a protection of the mangrove forest from illegal cutting and encroachment, provision of training programs to educate local people and visitors for mangrove restoring, and distribution of the mangrove saplings for plantation. The village heads and local governmental agencies had functions in providing financial and technological support for restoring mangrove forest. The local people also had functions in assisting the MGFDS 7 through safeguarding the mangrove forest from illegal encroachment. Academic institutions provided scientific knowledge and technical advices to local people in observing and assessing the local people's harvest of ES to avoid making disturbances on mangrove ecological production.

The study found that the groups of people who had functions involved in the stage I and stage II of mangrove forest restoration were also different. The former village headmen, former provincial governor, and volunteering local people played important roles in restoring the mangrove forest by providing financial support and serving as labors. During the stage II of young forest regrowth, the governmental agencies, academic institutions, private sectors, and non-governmental organizations (NGOs) increasingly engaged in providing financial support, trans ferring scientific knowledge and technologies, serving as labors to plant the mangrove seedlings.

1.6) Application of local knowledge on mangrove ecosystem

A local knowledge was regarded as an importance SU tool at community level. Seventy-seven percent of respondents (N =140) indicated that an application of local knowledge was important to restore mangrove forest and sustain local people's means of subsistence (Table 1). The local knowledge was important for the SU of ES because it was specifically created from an intimate interaction and relationship between local people and mangrove forest [48-51]. It integrated in the local culture and social values which showed in a form of local people's SU of ES [28, 49]. Moreover, it was continuously developed through integrating with a shared scientific knowledge in respond to a change of ecological, social and cultural conditions for

restoring and harvesting the developed ES in sustainable manner [52].

According to an interview with former village headman, he revealed that the local knowledge which was applied during two stages of mangrove forest restoration was also different. The local knowledge which was used in the stage I of stand initiation related to mangrove pioneer plant species, tidal current, pests, and mangrove forest zonation with aiming to restore the mangrove forest. During the stage II of young forest regrowth, the local knowledge on tidal current was applied only to monitor the restored mangrove forest and determined mangrove planting activities.

These SU tools were developed based on the community-based participation to determine various effective methods of sustainable utilizing those ES produced from only 6.6 km^2 of developed mangrove forest stages for diversified income. They can be rejuvenated and revitalized during the stages of mangrove forest development by integrating scientific knowledge and technologies and cooperating with the governmental agencies and academic institutions responding the changes of ES.

An application of these SU tools resulted in a gradual increase of mangrove forest areas [5-8] (Figure 3). The mangrove forest areas increased from 1.4 km^2 in 1986 to 6.6 km^2 in 2017 [5, 38] (Figure 4). While a rate of mangrove forest degradation from 1975 - 1986 was 2.17 km^2 per year, a rate of mangrove forest restoration from 1990 to 2017 was only 0.18 km^2 per year. It implied that an increase of mangrove forest areas spent a long time. A former village headman revealed that a restoration of mangrove forest in a stand initiation stage was time-consuming process because it relied on several factors including a preparation of mangrove seedlings, limited duration for mangrove planting, and availability of local labors. A former village headman revealed that mangrove seedlings which were collected from mangrove forest had to be planted in nursery for 4-5 months before planting on mudflat and can be planted only between September to January during a low tide at daytime. Moreover, the local people were available from making a living only 2 days a month to assist the village headmen to plant the mangrove seedlings.

Figure 3 Boundary of mangrove forest areas increased in 2000 (green line), 2002 (yellow line) and 2010 (pink line) at the KK Sub-district.
Sources: [53]

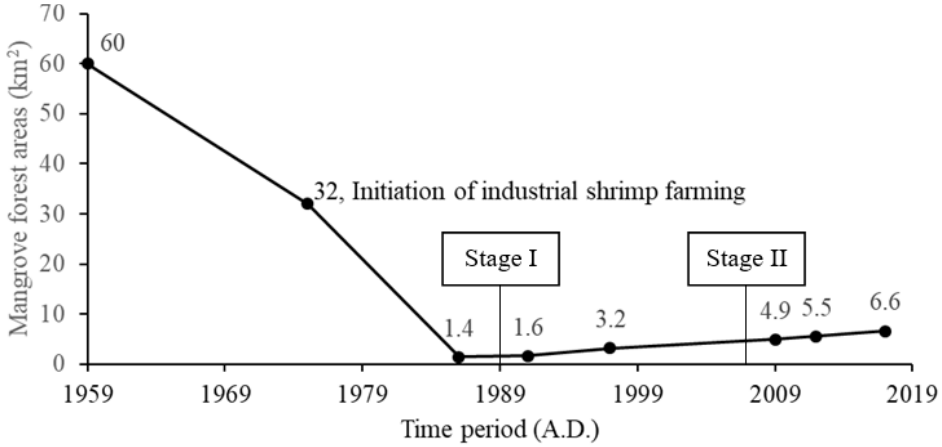

Figure 4 Mangrove forest areas at KK Sub-district from 1959 to 2017. Sources: [4]-[6], [8], [40]

2) Changing utilization of ES during stand initiation and young forest regrowth stages of mangrove forest restoration

The ES produced during stand initiation and young forest regrowth stages of mangrove forest restoration at KK Sub-district were utilized differently responding a change of specific benefits of ES for utilization under a control of SU tools. During the stand initiation stage, the ES were gradually restored especially, an increase of fishery resources. The local people's poverty was alleviated by selling these aquatic animals. After restoring the mangrove forest, the developed ES were utilized to diversify the local people's income. As a result, the utilizing activities of ES during two stages of mangrove forest restoration were different.

2.1) Food

The mangrove provisioning services was mainly utilized as a source of food for household consumption and trade, especially fishery resources such as blood cockles, fishes, and krill. The results showed that the ES produced during a mangrove stand initiation stage were harvested for food consumption and trade (90%, N =140) (Figure 5). They were still harvested for food (87%, N = 140) in the young forest regrowth stage (Figure 6). The harvest of ES for food did not much change after restoring the mangrove forest because the local people's livelihood and income still mostly depended on the ES provided by the mangrove forest.

2.2) Aquaculture

The aquaculture was widely conducted at KK Sub-district during two stages of mangrove forest restoration. Thirty-nine percent of respondents (N = 140) revealed that the shrimp farming was operated during mangrove stand initiation stage (Figure 5). However, a collapse of intensive shrimp farming according to a polluted seawater and bacterial disease resulted in a mangrove forest degradation, disappearance of many natural aquatic animals, abandoned shrimp ponds, and local people's loss of income. After restoring the mangrove forest, the aquaculture remained a major occupation of local people (47%, N = 140) (Figure 6). However, the aquaculture was operated with more concerns about environmental impacts. The former village heads and headman of KK Mangrove Forest Conservation Center (KKMFCC) revealed that the local people changed their aquaculture from an intensive shrimp farming to an extensive blood cockle and mussel farming which only relied on a natural productivity. It means that the nutrients in sediment trapped by mangrove roots and seawater were very important to the extensive aquaculture production. It also implied that the utilization of ES for

aquaculture had to be carefully operated in order to maintain a healthy mangrove ecosystem and clean seawater.

2.3) Fiber and fuelwood

Before a loss of mangrove forest from shrimp farming, the mangrove forest was cut for constructing dwellings and making charcoal. The study found that the mangrove timber was harvested to construct dwellings (26%) and make fuelwood (25%) (N = 140) in the mangrove stand initiation stage (Figure 5). However, a demand of mangrove timber for dwelling construction (14%) and fuelwood (11%) was decreased in the young forest regrowth stage (N = 140) due to a clearance of mangrove forest for shrimp farming which affected to a supply of mangrove timber (Figure 6). Moreover, the Forest Act and cabinet resolutions related to a cancellation of mangrove forest concessions also prohibited a wood cutting and illegal encroachment. As a result, the harvest of mangrove timber for dwelling construction and fuelwood was reduced in the young forest regrowth stage.

2.4) Ecotourism

Generally, the mangrove forest at KK Sub-district was used as recreational area for local people (16%, N = 140) (Figure 5), but its recreational and aesthetic value was not utilized as business for generating income for local people. However, the study found that the recreational value of mangrove forest was increasingly utilized for an ecotourism (46%, N = 140) during the young forest regrowth stage (Figure 6).

The mangrove ecotourism at KK sub-district was initiated in 2007 and was implemented by the KKMFCC, a community enterprise. It aimed to diversify an income and generate more job opportunities to local people. Moreover, it also served as an educational area for a learning program and student camp to transfer local knowledge and experiences in restoring mangrove ecosystem, values of ES from mangrove forest, and local livelihood to visitors. A headman of KKMFCC revealed that a community-based mangrove ecotourism at KK Sub-district was initiated by an encouragement of the former provincial governor and former village heads. He shared his experiences in developing mangrove ecotourism which was very new to KK Sub-district. He revealed that the ecotourism business development and ecotourism activities were reviewed and observed from local tourism at Amphawa Community. He mentioned that a tourism at Amphawa Community used a cultural capital of old markets which was a community heritage as a tourism attraction. In case of KK Sub-district, the headman of KKMFCC used an ecological capital of mangrove forest and social-cultural capital of local community as a signature tourist attraction and activities. Many recreational activities such as mangrove planting, blood cockle collecting, and wakeboarding on wooden sled were created based on the local people's livelihood to provide services to visitors. The mangrove planting activities of ecotourism program also indirectly supported an increase of mangrove forest as it allowed the governmental agencies, private sectors, academic institutions and tourists to plant the mangrove forest.

A headman of KKMFCC revealed that the ecotourism activities were conducted under a control of local governmental agencies and local people's monitoring in order to ensure that their activities did not affect to the mangrove ecological production and local livelihood. However, A chief executive of Klong Khone Sub-district Administrative Organization (KKSAO) indicated that that some of restaurants and resorts which were established to facilitate ecotourism at KK sub-district released wastewater affecting mangrove ecosystem and produced noise pollution disturbing local people's livelihood. It means that the ecotourism at KK sub-district still required to be improved to avoid any disturbances on mangrove ecosystem and local livelihood.

2.5) Educational area

Generally, the mangrove forest served as an informal educational area for local people (30 %, N = 140) who learned to harvest mangrove plants and fishery resources to support their subsistence (Figure 5). After restoring the mangrove forest and establishing the KKMFCC, the restored mangrove forest was increasingly used as a non-formal education learning program (50%, N = 140) for disseminating a local knowledge and benefits of ES to visitors (Figure 6).

The major ES that were differently harvested during the stand initiation stage and young forest regrowth stage were fuelwood, fiber, ecotourism, and educational area. The fuelwood and fiber were harvested in the stage II less than in the stage I according to the community commitment for mangrove forest restoration, enforcement of law and regulations, and land use zoning. The ecotourism and educational area were more utilized in the stage II to diversify the local people's income. In summary, the sustainability of KK sub-district focused on the utilization of ES produced from restored mangrove forest for ecotourism attraction and knowledge dissemination site for ecological mangrove restoration.

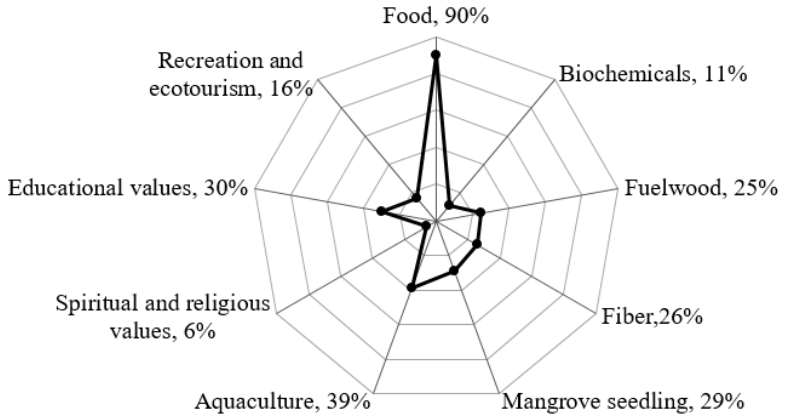

Figure 5 Mangrove provisioning and cultural services used during stand initiation stage (N = 140).

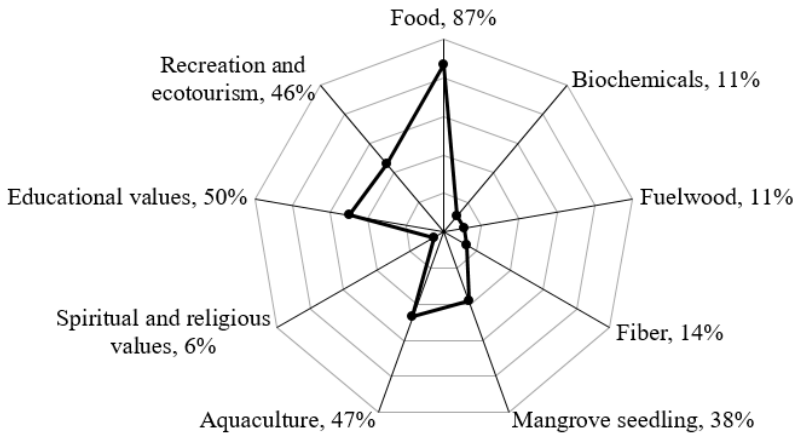

Figure 6 Mangrove provisioning and cultural services used during young forest regrowth stage (N = 140).

Conclusions

The SU tools, which were applied to determine and regulate the sustainable harvest of ES during stages of stand initiation and young forest regrowth, were developed from the community-based participation. The common property right on mangrove forest encouraged the local people to sustainably utilize the ES

because it indirectly created the local people's sense of ownership. The participation of local people was also motivated by the sense of ownership. It facilitated the local people to integrate and apply their local knowledge and traditional practices for the SU. It also allowed them to learn how to harvest the developed ES appropriately based on their sense of ownership, community commitment, land using zoning, and legal enforcement. The participation of local people implied an availability of human resource who possessed the different knowledge and functions in monitoring the local people's utilizing activities of developed ES. The laws and regulations were also enforced to regulate the local people's harvest of ES in sustainable way. These SU tools were important to determine the methods of harvest of developed ES in order to avoid making disturbances on mangrove ecological production and maintain the local people's income and livelihood. However, the SU tools of each community were different depending unique ecological, social, cultural, economic, and legal conditions. An application of these SU tools resulted in different harvesting activities of ES produced during the developmental stages of mangrove forest restoration. The major different ES which were increasingly utilized in the young forest regrowth stage were the cultural services or aesthetic values of mangrove forest including ecotourism and educational values. They were effectively harvested to diversify local people's income, generate job opportunities, and transfer local knowledge and experiences related mangrove forest restoration and benefits of ES from mangrove forest to visitors. The SU of ES which was determined by the SU tools revealed an effectiveness of utilizing methods of ES produced from only 6.6 km^2 of developed mangrove forest for diversified income. Even though, the mangrove forest areas at KK Sub-district increased only 0.6 percent per year from 1.4 km^2 in 1986 to 6.6 km^2 in 2017, and the recovery of aquatic animal species still be limited, the social structure, family relationship, and socio-economic benefits were resurrected.

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