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REGULAR RESEARCH ARTICLE

Plant Diversity, Traditional Utilization, and Community-Based Conservation of the Small-Scale Nong Sakae Community Forest in Nakhon Ratchasima, Thailand

Thanakorn Saengsanga [1,*], Sarochinee Kaewthani [1], and Tarntip Rattana [1]

AFFILIATIONS

[1.] Faculty of Science and Technology, Nakhon Ratchasima Rajabhat University, Nakhon Ratchasima, Thailand.
*Corresponding author: thanakorn.s@nrru.ac.th

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ABSTRACT

This study aimed to investigate plant diversity, traditional utilization, and create a web-based application for sustainable community-based utilization management of the small-scale Nong Sakae Community Forest, Dan Chak sub-district, Non Thai district, Nakhon Ratchasima, Thailand. Our results revealed 29 plant species belonging to 21 genera. Notably, the Fabaceae family dominated the forest and comprised seven species, including two recognized as invasive species. Diversity indices revealed a moderate level of species diversity, with Shannon–Weaver (H') and Simpson's diversity indices at 1.7844 and 0.6076, respectively. Species richness indices involving Margalef and Menhinick were 4.3805 and 1.1869, respectively, whereas evenness was 0.5414. The most ecologically significant species was *Vietnamosasa ciliata* A. Camus, which exhibited the highest importance value index (IVI) at 63.4321. Furthermore, the community forest served as a sustenance for the local community for food, medicinal herbs, and timber, emphasizing its significance in supporting their livelihoods. However, this forest has faced encroachment, forest fires, and littering. A web-based mapping system has made forest information more available and understandable, enabling informed decision making and effective forest management. This study offers valuable insights into biodiversity and ecosystem functions in the Nong Sakae Community Forest, emphasizing the need for collaboration and effective policy development in conservation efforts.

KEYWORDS

Community Forest; Biodiversity; Community-based forestry; Conservation; Non-timber forest products (NTFPs).

1. INTRODUCTION

Globally, approximately 4.17 billion people living outside urban areas currently reside within 5 km of a forest, with an additional 3.27 billion living within 1 km (Newton et al., 2022). Forest resources play a pivotal role in sustaining the livelihoods of nearby individuals such as food, medicine, and fuel, and income generation and employment opportunities. For instance, non-timber forest products (NTFPs) were revealed to be essential sources of livelihood for lower-income families across diverse regions worldwide. These goods, including wild fruits, medicinal plants, and handicraft materials, serve as primary income sources and contribute significantly to the well-being and economic stability of rural communities (Thammanu et al., 2021)

In Thailand, forested areas cover approximately 31.57% of the country's total land area (RDF, 2022). Extensive forest coverage is a critical component of Thailand's natural landscape. Thailand boasts an extraordinary wealth of biological resources, with over 15,000 plant species constituting approximately 8% of the world's plant species (ONEP, 2009). This wealth of plant species contributes significantly to global biodiversity and underscores the ecological significance of forest in Thailand. Furthermore, Thailand's commitment to forest conservation is evident in the more than 12,000 community forest sites, covering approximately 1.2 million hectares, as reported by the Information Technology and Communication Center (RDF, 2023). Community forests are essential

ecosystems that are managed and maintained by indigenous populations and local communities according to their traditional way of life. These community forests are crucial for providing a multifaceted array of ecological, social, and economic benefits to the surrounding communities. They serve as biodiversity hotspots, contribute to local livelihoods through sustainable resource use, and foster a sense of community ownership and responsibility towards forest conservation. The holistic value of these ecosystems is not limited solely to the ecological realm but extends to the cultural and economic dimensions of Thailand's diverse landscape (Khongswasdi, 2022).

The diversity of plant species within a community forest is crucial for maintaining the proper functioning of the ecosystem and mitigating the adverse effects of climate change (Brockerhoff et al., 2017). This diversity contributes to local economies and supports various uses of forest resources, including collecting and trading non-timber forest products (NTFPs). Furthermore, recent data shows that the global number of NTFP users was 3.5 and 5.76 billion for the lowest and median approximations, respectively (Shackleton & de Vos, 2022). Expanding upon the significance of NTFPs, Noinarai et al. (2020) documented the utilization of various NTFPs, including bamboo shoots, mushrooms, vegetables, bamboo culms, and medicinal plants, in 71 surveyed villages surrounding Phu Laen-Kha National Park in Chaiyaphum province, Thailand. Moreover, the utilization of medicinal plants in community forests, a practice with a century-old tradition, remains prevalent in contemporary times. These forests are abundant reservoirs for diverse plant species with valuable medicinal properties. Numerous global ethnobotanical investigations have been conducted, exemplified by studying the diversity and utilization of medicinal plants for maintaining women's health in Northern Banyumas, Indonesia (Utaminingrum et al., 2022). A similar study conducted across different regions of Ethiopia documented 145 plant species with practical applications in treating approximately 72 different ailments afflicting both livestock and humans. Notably, the Fabaceae family accounted for 22% of the total, with Asteraceae and Lamiaceae at 11% and 9%, respectively. Regarding growth forms, shrubs emerged as the dominant category, representing 40% of the species, whereas herbs closely followed at 26.5% (Bekele et al., 2022). Moreover, medicinal plants used in rural barangays in Mina, Iloilo, the Philippines, were observed. A survey discovered the utilization of 111 medicinal plant species from 98 genera and 49 families. These plant resources have been exploited to treat 82 symptoms in 17 disease categories. Among the 109 plant species identified at the species level, 74% were of non-native origin, while 26% were indigenous, with an additional 7% of these native species unique to the Philippines (Cordero et al., 2023). Another research initiative was undertaken within the Khok Nhong Phok Forest, Kosum Phisai District of Maha Sarakham Province, Northeastern Thailand. One hundred plant species and 52 families were systematically recorded within the Khok Nhong Phok Forest, Kosum Phisai District of Maha Sarakham Province, Northeastern Thailand. These species were subsequently classified into three distinct categories based on traditional knowledge: 50 for culinary use, 69 for medicinal purposes, and 42 for construction, household appliances, and fuel (Saisor et al., 2021).

Geographic Information System (GIS) technical advancement has transformed how spatial data is visualized. Presently, a web map is available universally and serves as a potent source of geographic information, not only displaying maps but also functioning as a tool for spatial analysis. Web-based mapping utilizes online platforms and GIS applications to visualize and analyze biodiversity-related geographical data. These tools enable collaborative exploration, integrating diverse datasets for essential information in conservation research and strategic planning (Phuong, 2022).

Biodiversity databases are essential for documenting, organizing, and maintaining knowledge about various species and genetic diversity in the community forest. These databases serve as foundational resources, catering to diverse needs across scientific, conservation, and governance domains for various stakeholders such as researcher, local people, conservationist, policymakers and local governments. The Nong Sakae Community Forest, located in the Dan Chak sub-district, Non Thai district of Nakhon Ratchasima province, Thailand, is important for biodiversity conservation because it plays a vital role in sustaining the livelihoods of the local community by providing diverse forest products and services. Therefore, developing a comprehensive biodiversity database and implementing effective biodiversity conservation practices within this local community constitute fundamental components of optimal forest management strategies. Hence, this study aimed to investigate the diversity of plant species and utilization of plants within community forests and create community-based conservation through local people and Dan Chak sub-district administrative organization collaboration.

2. METHODOLOGY

2.1 Study site

A small-scale community forest located Ban Nong Sakae, Dan Chak sub-district, Non Thai district, Nakhon Ratchasima province, Thailand, was selected as the study area. It is located at approximately 15.210920 N and 102.116657 E (Figure 1a). Approximately 670 households surrounding the community forest, including people from main four villages (Village No. 5 - Ban Ta Khro, No. 9 - Ban Nong Sakae, No. 12 - Ban Non Makha, and No. 13 - Ban Ta Khro II) and other villages, utilized the NTFP products.

2.2 Data collection and analysis

A field survey was conducted from October 2022 to September 2023. Plant species diversity was collected systematically, and eight 20 m × 20 m (Q1) sampling plots were established in the community forest (Figure 1b). In each plot, plants with a diameter at breast height (DBH) ≥ 4.5 cm were identified and measured in every 10 × 10 m sub-quadrat (Q2). Within 10 m sub-quadrats, samplings with DBH<4.5 cm and height >1.30 m were recorded in 4 m × 4 m sub-quadrats (Q3). Plant species outside the sample plot were also surveyed by line transect. Survey routes were determined to represent the essential residential areas accepted by the community, and sample plots were placed by laying out the survey line (Line transect).

Species diversity indices including Shannon and Weaver index (H') (Ortiz-Burgos 2016), Simpson's diversity index, Margalef index, Menhinick index, and evenness were calculated (Mulya et al., 2021). These indices were widely utilized and provided the most effective indicator for every community. The formulas are as follows (Sulistiyowati et al., 2023).

$$\text{Shannon and Weaver index (H')} = -\sum_{i=1}^{S} pi \ln pi \quad (1)$$

$$\text{Simpson's diversity index} = 1 - \frac{\sum n(n-1)}{N(N-1)} \quad (2)$$

$$\text{Margalef index} = \frac{S-1}{\ln(N)} \quad (3)$$

$$\text{Menhinick index} = \frac{S}{\sqrt{N}} \quad (4)$$

Where,
S: the total number of species in a community

n: number of individuals of species i
N: The number of individuals of all species
pi: ni/N

The criteria for the diversity index's score are as follows:
H' < 1: low diversity
1< H' ⩽3: moderate diversity
H'> 3: high diversity

In addition, the Important Value Index (IVI) of a species was determined by the sum of relative density, relative frequency and relative dominance (Kent & Coker, 1992). The formulas are as follows:

Importance value (IVI) = RD + RF +RD0 (5)

Relative density (RD) = $\frac{Total\ No\ of\ individual\ species\ A}{Total\ No\ of\ individuals\ of\ all\ species} x\ 100\%$ (6)

Relative frequency (RF) = $\frac{Relative\ frequency\ of\ species\ A}{Frequency\ of\ all\ species} x\ 100\%$ (7)

Relative dominance (RDo) = $\frac{Dominance\ of\ species\ A}{Dominance\ of\ all\ species} x\ 100\%$ (8)

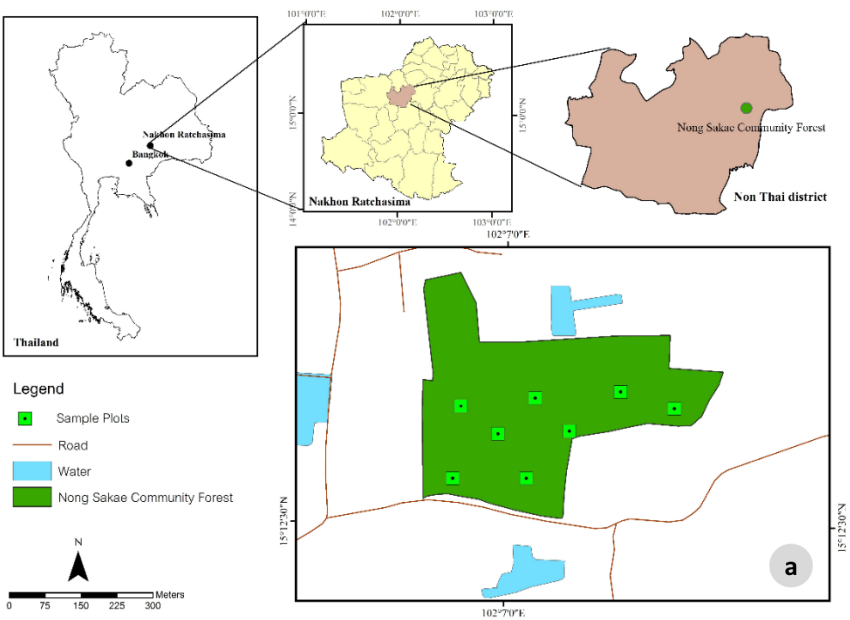
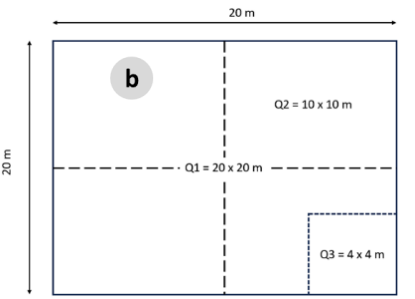


Figure 1. Map of the study site: (a) Nong Sakae Community Forest in northeastern Thailand (a) and (b) layout of the quadrate.



2.3 Questionnaire design and data collection

The data collection for this study occurred during the period spanning from April to September 2023 after obtaining ethical approval (Certificate number: HE-030-

2023) from the Ethics in Human Research Committee at Nakhon Ratchasima Rajabhat University. Prior to the initiation of the research, comprehensive written informed consent was meticulously acquired from all participants, who were carefully selected based on specific eligibility criteria. These criteria encompassed individuals with prior expertise in plant utilization, a demonstrated proficiency in reading and writing, a minimum age of 20 years, and residency within the specified study areas. The process of selecting informants from each village was conducted precisely, ensuring representation proportional to their respective populations. In total, 52 informants were interviewed for this study, employing a selection methodology meticulously designed to maintain proportionality following the population sizes of four villages within the Dan Chak district of Nakhon Ratchasima province. A semi-structured questionnaire was employed to assess demographic characteristics, traditional utilization and community-based conservation and impact and community forest management participation in Nong Sakae Community Forest. The participants were instructed to document all instances of plant utilization meticulously.

2.4 Development of online web mapping application

Thailand actively promotes digital transformation within its local government organizations. Ninety-five % of the country's population has embraced smartphones, signifying a profound societal adoption of digital technologies (National Statistical Office of Thailand, 2021). This widespread use of smartphones holds substantial implications for local governance, potentially revolutionizing citizen engagement, service delivery, and administrative efficiency.

This study developed online web mapping for displaying and querying spatial data, community participation in data collection, analysis, and decision-making processes, fostering a sense of ownership and involvement, and providing decision-making processes in Dan Chak's sub-district administrative organization. Briefly, data collection involved acquiring information from diverse sources, including field data collected using GPS devices to record precise geographic coordinates within the Nong Saka Community Forest. Local experts were interviewed to gain valuable insights into the community forest. The subsequent stages detail the process of establishing Geographic Information System (GIS) data and creating online maps:

(i) A thorough plant survey was conducted in the Nong Saka Community Forest, collecting geographical coordinates using GPS devices.
(ii) A structured plant data table, including plant names and coordinates, was created in Microsoft Excel, and exported in .csv format for integration into GIS software.
(iii) The .csv data table was imported into ArcMap, and the Display XY Data command was used to generate precise plant location points, creating a plant data layer in .shp format.
(iv) Interactive web applications were created from ArcGIS online web maps using Instant Apps.

The website interface includes two main sections: the map layer display and the pop-up section, which details the studied and surveyed plants. Simultaneously, the Nong Saka Community Forest website was constructed using Google Sites, organized into sections offering detailed information about the community forest and its resources. The website also includes a Web Map for users to access plant information in the Nong Saka Community Forest.

2.5 Creating collaboration in conserving the small-scale Nong Sakae Community Forest

Collaboration in conserving the Nong Sakae Community Forest involves various stakeholders and strategies. The users surrounding community forests and local government organizations are key stakeholders in creating a collaborative and sustainable framework for conserving the Nong Sakae Community Forest. A comprehensive discussion was conducted concerning the assessment of plant diversity and the potential risks to rare species. This exchange of information took place with stakeholders, including local utilizers, government officers, elected officials, and community leaders within the Dan Chak sub-district administrative organization situated in the Non Thai district of Nakhon Ratchasima province.

3. RESULTS

3.1 The quantitative indices value of the plants

In this investigation, we systematically documented 21 botanical families, and comprising 29 distinct species (Table 1). The predominant botanical families were Fabaceae, Capparaceae, and Menispermaceae. The Fabaceae family consisted of 7 species: *Acacia ampliceps*, *A. harmandiana* (Pierre) Gagnep., *Dalbergia nigrescens* Kurz., *Erythrophleum succirubrum* Gagnep., *Pterocarpus macrocarpus* Kurz., *Senna timoriensis* (DC.) H.S. Irwin & Barneby, and *Xylia xylocarpa* (Roxb.) Taub. Notably, *A. ampliceps* and *A. harmandiana* (Pierre) Gagnep. are recognized as invasive species. In the Capparaceae family, 2 species were identified: *Crateva adansonii* DC. and *Maerua siamensis* Kurz. Within the Menispermaceae family, 2 species, including *Tiliacora triandra* (Colebr.) Diels and the rare *Decaschistia parviflora* Kurz. was observed. Additionally, *Vietnamosasa ciliata* A. Camus, a species classified under the Poaceae family and typically found in dry deciduous dipterocarp forests in Thailand, was the most abundant in the Nong Sakae Community Forest. Some species of plants in the Nong Sakae community forest are illustrated in Figure 2.

Diversity indices were demonstrated in Figure 3. The Shannon and Weaver index (H') and Simpson's diversity index were 1.7844 and 0.6076, respectively. Species richness, evaluated through the Margalef and Menhinick indices, resulted in values of 4.3805 and 1.1869, respectively, while evenness (E) was 0.5414. Additionally, *V. ciliata* A. Camus exhibited the highest importance value index (IVI) at 63.4321, followed by *F. indica* (Burm.f.) Merr. (10.7713), *X. xylocarpa* (Roxb.) Taub. (8.5883), and *B. siamensis* Miq. (8.5301).

Table 1. The list of species and quantitative indices of the plants.

No.	Family	Scientific name	pi ln pi	IVI
1	Anacardiaceae	*Buchanania siamensis* Miq.	-0.1138	8.5301
2	Asteraceae	*Chromolaena odorata* (L.) R. M. King & H. Rob.	-0.1216	5.0033
3	Caesalpinioideae	*Cassia garrettiana* Craib.	-0.0266	7.6793
4	Capparaceae	*Crateva adansonii* DC.	-0.0191	4.2461
5	Capparaceae	*Maerua siamensis* Kurz.	-0.0266	5.1004
6	Celastraceae	*Salacia chinensis* L.	-0.0632	4.9352
7	Combretaceae	*Combretum quadrangulare* Kurz.	-0.0191	5.0591
8	Dipterocarpaceae	*Dipterocarpus intricatus* Dyer	-0.0335	3.1558
9	Ebenaceae	*Diospyros ebenum* Kurz.	-0.0401	5.9928
10	Euphorbiaceae	*Suregada multiflora* (A. Juss.) Baill.	-0.0685	7.8713
11	Fabaceae	*Acacia ampliceps*	-0.0191	5.4299
12	Fabaceae	*Acacia harmandiana* (Pierre) Gagnep.	-0.0266	6.1357
13	Fabaceae	*Dalbergia nigrescens* Kurz.	-0.0335	6.4104

No.	Family	Scientific name	pi ln pi	IVI
14	Fabaceae	*Erythrophleum succirubrum* Gagnep.	-0.0462	7.0750
15	Fabaceae	*Pterocarpus macrocarpus* Kurz.	-0.0685	7.0176
16	Fabaceae	*Senna timoriensis* (DC.) H. S. Irwin & Barneby	-0.0462	6.3692
17	Fabaceae	*Xylia xylocarpa* (Roxb.) Taub.	-0.0521	8.5883
18	Flacourtiaceae	*Flacourtia indica* (Burm.f.) Merr.	-0.1975	10.7713
19	Malvaceae	*Microcos tomentosa* Sm.	-0.0578	6.3168
20	Melastomataceae	*Memecylon scutellatum* Naudin	-0.0191	5.0591
21	Meliaceae	*Azadirachta indica* A. Juss.	-0.0191	5.4656
22	Menispermaceae	*Tiliacora triandra* (Colebr.) Diels	-0.0685	7.3933
23	Menispermaceae	*Decaschistia parviflora* Kurz.	-0.0578	5.0591
24	Moraceae	Streblus *ilicifolius* (S. Vidal) Corner	-0.0191	3.4331
25	Phyllanthaceae	*Phyllanthus emblica* L.	-0.0266	6.2429
26	Poaceae	*Vietnamosasa ciliata* A. Camus	-0.2974	63.4321
27	Rubiaceae	*Catunaregam tomentosa* (Blume ex DC.) Tirveng	-0.0785	7.3933
28	Rutaceae	*Feroniella lucida* (Scheff.) Swingle	-0.0785	7.9987
29	Tiliaceae	*Colona auriculata* (Desf.) Craib	-0.0401	2.3590

Figure 2. Some plant species in the Nong Sakae Community Forest, Dan Chak sub-district, Non Thai district, Nakhon Ratchasima province.

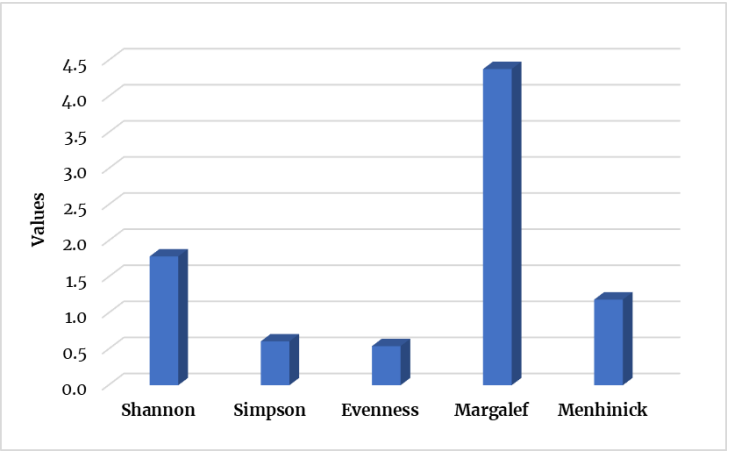


Figure 3. Species diversity indices of plants in the Nong Sakae Community Forest.

3.2 Traditional utilization and community-based conservation

3.2.1 Demographic profiles of the informants

The informant's demographic characteristics are presented in Table 2. A total of 52 informants completed the questionnaire on the traditional utilization and community-based conservation in the Nong Saka community forest. Out of these, 30.77% were the people who live in village no.5, followed by village no.13 with 26.92%. There were more females, with 82.69% and males with 7.31%. The informant's ages were between 20 – 79 years old, and the three majority of them were 34.62% (60 – 69 years), 19.23% (50 – 59), and 28.85% (40 – 49 years). Nearly three-quarters (67.31%) of the informants graduated from elementary school, and 19.23% graduated from junior high school.

Table 2. The demographic data of informants

Characteristics	Frequency	Percentage (%)
Village		
no. 5	16	30.77
no. 9	8	15.38
no. 12	6	11.55
no. 13	14	26.92
others	8	15.38
Gender		
Male	9	17.31
Female	43	82.69
Others	0	0.00
Age (year)		
20 – 29	1	1.92
30 – 39	4	7.69
40 – 49	15	28.85
50 – 59	10	19.23
60 – 69	18	34.62
79 – 79	4	7.69
> 80	0	0.00
Education background		
Elementary school	35	67.31
Junior high school	10	19.23
High school	6	11.54
College	1	1.92

3.2.2 Traditional utilization and community-based conservation

An investigation into resource utilization frequency within Nong Saka Community Forest revealed varied usage patterns: 15.38% of informants reported monthly utilization, 44.24% indicated visiting 2-3 times a month, and 40.38% stated they utilized it more than 4 times per month (Figure 4a). These findings emphasize the pivotal role the forest plays in supporting the livelihood of the surrounding community. Significantly, it functions as a critical source of food (80.95%), medicinal herbs (10.48%), and timber (8.57%) (Figure 4b and Figure 5).

In our analysis of Nong Sakae Community Forest usage, it was determined that a substantial majority of informants, precisely 81.36%, are actively involved in utilizing the forest for their livelihoods. The activities such as food acquisition, NTFP harvesting, and the collection of edible mushrooms for personal consumption. Moreover, a noteworthy segment of individuals, specifically 18.64%, participate in the cultivation and use of medicinal herbs to augment their household income (Figure 4c). Concerning the environmental benefits linked to Nong Sakae Community Forest (Figure 4d), a substantial majority of participants (84%) underscored its potential for enhancing the overall welfare of the community. In contrast, 10.2% of the respondents emphasized the significance of maintaining environmental equilibrium within the community. Conversely, the remaining respondents emphasized its importance as a wildlife habitat and as a model for forest conservation and preservation.

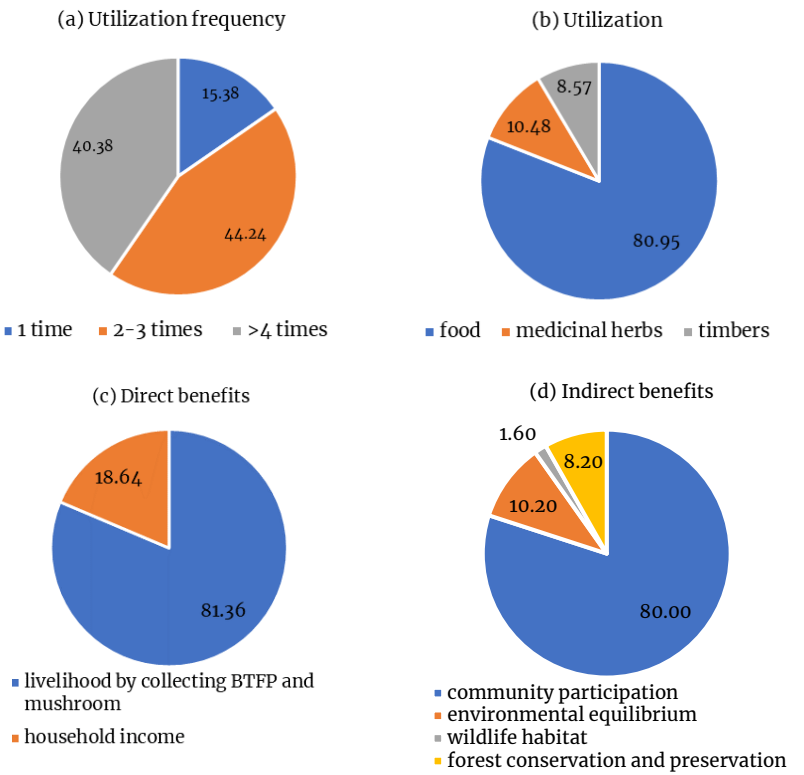


Figure 4. Traditional utilization and community-based conservation.

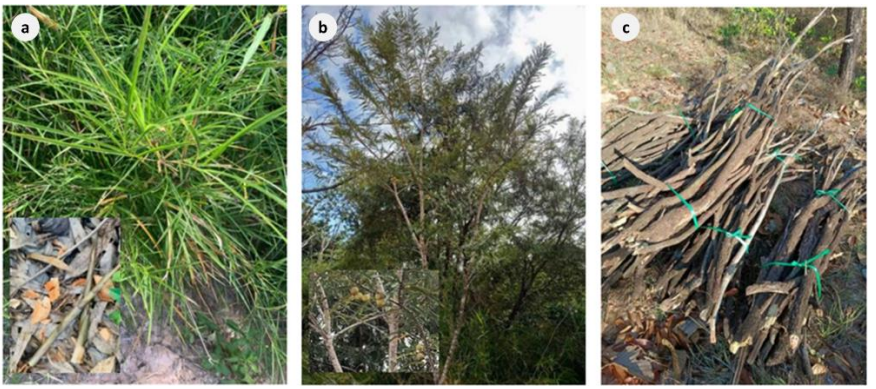


Figure 5. An example of utilization of plants (a) for food *V. ciliata* A. Camus, (b) medicinal herb, *Phyllanthus emblica* L. and (c) timber plant in the Nong Sakae Community Forest.

3.2.3 Impact and community forest management participation

Table 3 illustrates impact and community forest management participation in Nong Sakae Community Forest. The survey participants primarily presented data demonstrating encroachment into forested areas (49%) and identified fire outbreaks as a significant factor contributing to forest fires (49%). Minimal littering and the residual use of waste within households were likewise reported (1%). Furthermore, 1% still held the belief in the forest's abundance.

Table 3. Impact and community forest management participation

Factors	Percentage
Deforestation causes	
- Encroachment and expansion of arable land into forest areas	49.00
- Forest fire	49.00
- Solid waste	1.00
- Still abundant	1.00
Environmental impacts	
- Decreased mushroom	45.36
- Diversity loss	43.30
- Unsightly landscape	6.19
- Climate change	5.15
Participation in forest conservation	
- No	84.61
- Yes	15.39
Ideas or involvement on community forest management	
- Afforest	45.57
- Food and medicinal plantation	41.77
- Creating awareness	6.33
- Set time limit to use	3.80

Based on the preceding data, the survey informants contributed further information highlighting the environmental consequences of encroachment and fire outbreaks. These concerns are associated with a decrease in edible mushroom quantities (45.36%), a reduction in plant species diversity (43.30%), the development of unsightly landscapes (6.19%), and alterations in the climate (5.15%). The management of Nong Sakae Community Forest resources was primarily under the jurisdiction of the Dan Chak subdistrict administrative organization. In the communities surrounding these resources, approximately 84.61% expressed no active engagement. Merely about

15.39% conveyed their active engagement in community forest conservation, either through collaboration with local organizations or community-based initiatives. The community members articulated the necessity for additional tree planting in areas showing signs of degradation (45.57%) and the cultivation of forest food and medicinal plant species (41.77%). These objectives align with various methods, including the promotion of conservation awareness among youth (6.33%) and the establishment of specified periods for the collection of forest resources (3.80%).

Furthermore, the conservation of local biodiversity resources also depends on indigenous knowledge, which is utilized for sustainable community forest management. As an example, concerning the collection of mushrooms, it is recommended to leave spores for regeneration, and only fully mature fern shoots should be harvested. In terms of concerns related to community forest management, a dearth of knowledge exists concerning the maintenance of forest equilibrium and the susceptibility of forests to drought. Ultimately, community members are strongly inclined to engage in community forest conservation due to survey informants' recognition of the imperative nature of deriving benefits from the forest's biological resources.

3.3 Development of a web mapping

The Nong Saka Community Forest Map service consisted of two sections for displaying maps. The website's front page allows general users to access the Nong Saka Community Forest online map. The plant data viewing service, accessible through the web page's map (https://arcnrru.maps.arcgis.com/apps/instant/basic/index.html?appid=1c887500c4dc41fdb1c3a7e26b450929), offers the following functionalities:

(i) Positioned on the left side of the web page is the "Open Layer List" function, which enables the toggling of map data layer visibility. Furthermore, users can utilize the zoom-in and zoom-out tools for map navigation, along with the 'Screen Shot' tool for capturing and exporting map screenshots in .png format.

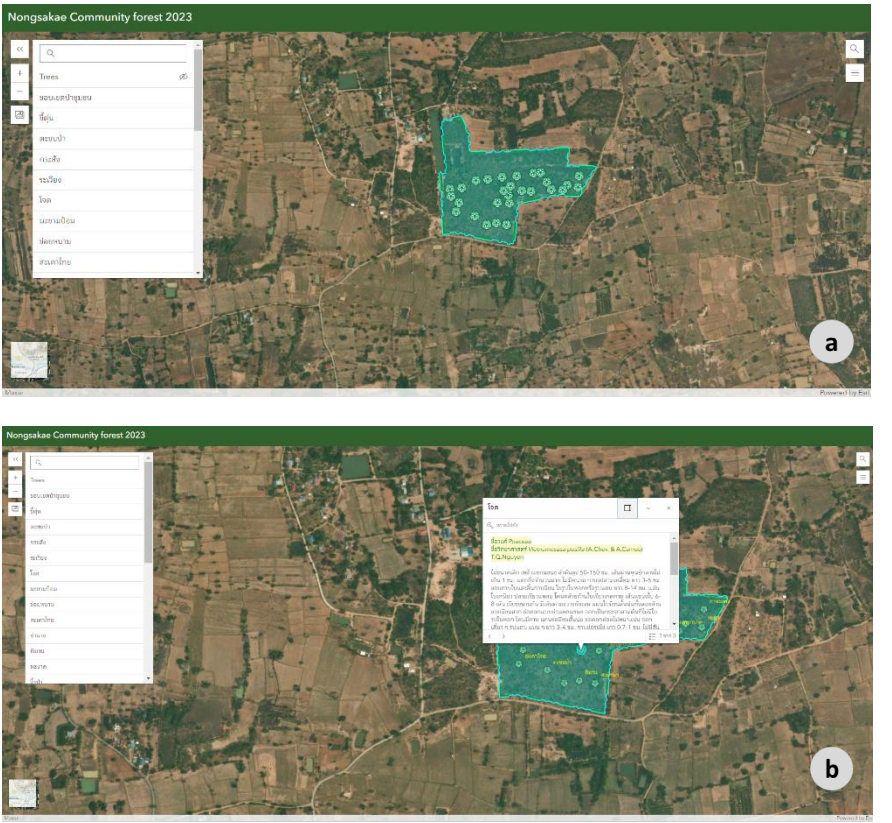
(ii) Located in the top right corner of the screen are search tools that facilitate the retrieval of plant-related data. Users have the option to input a plant's name, prompting the map to zoom in on the specific plant. Additionally, searches can be conducted by entering XY coordinates.

(iii) The base map provides a background of geographic context for the content in a scene. Users can switch between satellite imagery and topographic maps by clicking a toggle base map icon.

(iv) The display screen highlights plant positions through a dedicated data layer identified as 'Plants.' By selecting individual plant, users can access comprehensive information. An interactive pop-up window will appear with information about each plant type, supplemented by photographs obtained during surveys (Figure 6).

3.4 Creating collaboration in conserving the small-scale Nong Sakae Community Forest

Based on the information, which includes plant diversity indices and insights into how the local community utilizes the Nong Sakae Community Forest, we engaged in discussions with local utilizers, government officers, elected officials, and community leaders in the Dan Chak subdistrict, Non Thai district, Nakhon Ratchasima province. We aim to establish policies and action plans that enhance conservation efforts and ensure the fair and equitable distribution of benefits arising from the community forest's resources.



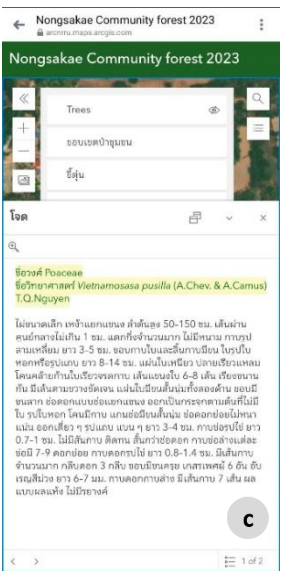


Figure 6. Interface of web map: (a) A location of the Nong Sakae Community Forest, (b) interactive pop-up displays the characteristics of plant, and (c) mobile view screenshot.

The process of establishing sustainable forest management encompasses the following key steps:

(i) A crucial facet of sustainable forest management is the collaboration between the public and government sectors to establish a robust community forest conservation system.

(ii) Motivating individuals to embark on new forest plantings in alignment with the academic principles of forest restoration development theory.

(iii) Elevating awareness and furnishing comprehensive educational initiatives on community forests and their governing rules through rigorous academic sources.

(iv) Precisely delineating the temporal parameters for individuals to utilize the land.

The initiative commences with a primary focus on the conservation of species within the community forest, with the overarching goal of rehabilitating the degraded forest ecosystem, as shown in Figure 7.

Figure 7. Collaboration in the rehabilitation of degraded forests.

4. DISCUSSION

Understanding the relationship between biodiversity and ecosystem function is an emerging field of ecological research, and there currently exists a great deal of discussion regarding the significance of generating aggregated estimates of ecosystem function and the best approach for quantifying multifunctionality (Manning, 2017). This study provides valuable insights into the botanical composition of the forest and its diversity indices. Recognizing the plant species and their distribution within the forest is crucial for conservation efforts. Our study found that a high number of the Fabaceae family, which is dominated in the deciduous dipterocarp forests across mainland Southeast Asia (Rundel et al., 2017). Furthermore, it is essential to highlight that a bamboo species, *V. ciliata* A. Camus, is among the plant species discovered in the Nong Sakae Community Forest. Nevertheless, the presence of invasive species, *Acacia* species (Magona et al., 2018), i.e., *A. ampliceps* and *A. harmandiana*, highlight the need for effective conservation strategies to protect the diverse plant life in the area.

In our analysis, we estimated biodiversity indices to assess plant variety in the Nong Sakae Community Forest. The Shannon-Weaver index (H') and Simpson's diversity index of 1.7844 and 0.6076 indicated a moderate level of diversity. The spatial extent of a forest significantly influences the biodiversity of its flora. Furthermore, the variation of geographic scales induces consequential alterations in the structure of plant communities and attributes of diversity (Liu et al., 2022). Evenness measures the distribution of people across species in a community. A value of 0.5414 for evenness demonstrates plant species distribution equilibrium, indicating no dominant species in the environment. The Margalef and Menhinick indices represent two quantitative methodologies for precisely evaluating species richness, a pivotal metric of biodiversity within distinct ecological regions. The Menhinick index exhibited a value of 1.1869, whereas the Margalef index had a value of 4.3805. The Margalef index provides a more accurate estimation of forest plant diversity due to its ability to account for the existence of rare species (Mulya et al., 2021). However, these indices demonstrate an increasing trend, reinforcing the association between species diversity and multifunctionality, thereby substantiating the hypothesis that there exists a positive correlation between species diversity and ecological multifunctionality (Maestre et al., 2012). In assessing the ecological significance of species within the Nong Sakae Community Forest, *V. ciliata* A. Camus exhibited the highest IVI at 63.4321, indicating its remarkable ecological significance of the forest. Among the species assessed, *F. indica* (Burm.f.) Merr., *X. xylocarpa* (Roxb.) Taub., and *B. siamensis* Miq. demonstrated notable high IVI values. This observation highlights their significant ecological contributions within the Nong Sakae Community Forest. Notably, these species are

abundantly found in the arid deciduous dipterocarp forests of northeastern Thailand (Kabir & Webb, 2006).

Community-based conservation involves local communities actively managing natural resources to maintain biodiversity and provide incentives for local people (Luz & Ruíz-Mallén, 2020). The research indicated that the local community heavily relies on the forest for various purposes, including food, medicinal herbs, and timber. This reliance emphasizes the importance of the forest for local livelihoods. Completing sustainable management needs the rigorous integration of traditional practices and the requisites of the local community into conservation strategies. Community forest management is effective in conserving tree cover and providing an extra layer of forest protection along with national forests and national parks. It has great potential for preserving forest ecosystems (Agarwal et al., 2022). Ghimire & Lamichhane (2020) discussed the successful and challenging aspects of community-based forest management in Nepal, highlighting its role in improving the supply of forest products, generating green employment, enhancing rural livelihoods, empowering women, and marginalized groups, rehabilitating degraded land, and increasing biodiversity. It also describes the shift from a state-dominated top-down approach to a community-based participatory approach in forest management, as well as the organizational and policy reforms that have taken place over the past four decades.

The development of web mapping is a valuable tool for both researchers and communities. It enhances transparency and accessibility of information about the forest, allowing for better-informed decision-making and management. This tool facilitates communication and collaboration among stakeholders and significantly maintains equilibrium between conservation and securing livelihoods. The collaboration between local utilizers, government officers, elected officials, and community leaders is a crucial step toward sustainable forest management. The study led to the protection of natural resources, the improvement of living conditions for those who make their living in the forest, and the maintenance of a steady flow of revenue for the government. Therefore, collaboration and policy development can lead to more effective and lasting conservation efforts.

5. CONCLUSION

In conclusion, the study emphasizes the significance of the small-scale Nong Sakae Community Forest for biodiversity and the well-being of the local community. Effective forest management requires considering traditional practices and community engagement. The community forest is a vital resource but faces challenges, including encroachment, forest fires, and littering. Community involvement is essential for forest conservation and includes managing and cultivating native plant species in degraded areas. In order to establish a conservation strategy that is simultaneously fair and systematic, the community and the government organization at the local level have to function collaboratively. The development of a web-based mapping system has significantly improved the accessibility and understanding of forest information, thus facilitating informed decision-making and promoting beneficial forest management practices. Our study emphasized the importance of comprehensive conservation initiatives that include traditional practices and community engagement to enhance the effective and sustainable management of forest resources.

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