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RESEARCH ARTICLE

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Ethnobotanical knowledge against the combined biodiversity, poverty and climate crisis: A case study from a Karen community in Northern Thailand

Pavlos Georgiadis

Department of Societal Transition and Agriculture (430b), University of Hohenheim, Stuttgart, Germany

Correspondence
Pavlos Georgiadis, Department of Societal Transition and Agriculture (430b), University of Hohenheim, 70599 Stuttgart, Germany.
Email: pavlos.georgiadis@uni-hohenheim.de

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Societal Impact Statement

Global biodiversity is eroding at alarming rates due to anthropogenic factors, such as climate change and unsustainable land use management. These interrelated challenges often push forest ecosystems to their limits, leading many species to disappear before their characteristics and potential are explored. As a result, indigenous rural communities inhabiting the world's biodiversity hotspots are losing a vital resource that supports their subsistence and livelihoods against persistent poverty. This research documents traditional ecological knowledge of a Karen community inside the Doi Inthanon National Park, Northern Thailand, reporting ethnobotanical uses of 125 plant taxa. It provides a ranking of culturally important trees that can inform the selection of framework species for ecosystem restoration and sustainable development in the region's montane forests.

Summary

- Climate change, population growth and persistent poverty are applying pressure to the world's most fragile ecosystems and biodiversity hotspots in unprecedented ways. There is an urgent need to document species that provide important ecological services and contribute to overall human quality of life.
- Participatory rural appraisal tools and collection of herbarium specimens were used to elicit ethnobotanical knowledge of an ethnic community inside the mountain forest of Northern Thailand. Statistical analysis was performed on the basis of quantitative indices to rank the cultural significance of the reported species in a Karen community inside Doi Inthanon National Park, Northern Thailand.
- This article presents an ethnobotanical inventory of 125 plants, including data on important botanical families, use categories and useful plant parts. A prioritisation of 30 culturally important tree species is attempted on the basis of four quantitative indices.

In Memory of Dr. J.F. Maxwell
Dr. J.F. Maxwell, a valued member of the botanical community of Thailand and Southeast Asia, provided valuable mentoring and reviews of this work. He inspired commitment, attention to detail and a true dedication to the conservation of Thailand's most important forest ecosystems, and he is deeply missed.

- Most of the reported plants are neglected and underutilised in need of further research and development for the diversification of agriculture, diets, livelihoods and landscapes. The integration of cultural criteria in the selection of framework species for ecosystem restoration embeds local community needs in conservation efforts, increasing their potential for success and fostering an integrated approach to sustainable development.

KEYWORDS

agricultural diversification, biodiversity conservation, ecosystem restoration, neglected and underutilised species, sustainable rural development, traditional ecological knowledge

1 | INTRODUCTION

Northern Thailand represents a distinct floristic region (Maxwell, 2004) lying at the centre of Indo-Burma, the largest and one of the most geographically diverse global biodiversity hotspots (Myers et al., 2000), surrounded by key centres of plant and animal endemism (Tordoff et al., 2012). The diversity of landforms and climatic zones within the Indo-Burma Biodiversity Hotspot generates a wide variety of natural habitats for an estimated 13,500 vascular plant species, of which about 7000 (52%) are endemic (van Dijk et al., 2004). This unique biodiversity is facing imminent threats due to a series of factors, including overexploitation of natural resources, habitat loss, degradation and fragmentation, pollution, invasive species and climate change (Trod et al., 2020). With only 5% of its natural habitat remaining intact and with the largest human population than any other biodiversity hotspot, Indo-Burma is ranked in the planet's top 10 hotspots for irreplaceability and in the top five for threat vulnerability (Mittermeier et al., 2004).

The complex topography of the hilly terrain of Northern Thailand is dominated by the Thanon Thongchai Range, a mountain complex representing the southern extension of the Shan Hills of Myanmar, which form the southernmost part of the Himalayan foothills (Teejuntuk et al., 2003). The highest point of this gneiss granitic massive is Doi Inthanon, a dome-shaped mountain forming the tallest summit of Thailand at 2565 meters above sea level (MASL) (Gardiner et al., 2016). Along its altitudinal gradient, Doi Inthanon features a uniform monsoonal climate with a strong alternation between a very humid rainy season of seven months (May through November) and a dry season of 5 months (December through April) (Khamyong et al., 2008). The temperature variation between these distinct seasons ranges between sub-zero and 40°C in the winter and the dry season, respectively (Sungkajanttranon et al., 2018). Coupled by differences in topography and soil properties (Jindaluang et al., 2009), this climatic diversity is reflected in the different vegetation zones of Doi Inthanon (Sahunalu et al., 2001), forming an array of unique natural habitats supporting a rich plant biodiversity. This includes endemic and vulnerable species, especially in the more humid and higher altitude areas (Khamyong et al., 2008; Printarakul et al., 2013; Teejuntuk et al., 2003). By virtue of its importance and fragility, the region was designated a protected area and the Doi Inthanon National Park was established in 1972 and expanded in 1978. It now covers an area of 482.4 km^2 with ranges across three districts: Chom Thong, Mae Wang and Mae Chaem (Khamyong et al., 2008).

Another feature of Northern Thailand is the cultural diversity reflected on the presence of numerous ethnic minorities, often described as "hill tribes" (Anderson, 1993). Their colourful, rustic and often romanticised lifestyle and craft have attracted the interest of domestic and international visitors in recent decades, aptly fuelling Thailand's tourism industry (Trupp, 2014). In the background of this diversity, there is a mosaic of rich indigenous cultures defined by complex interactions with the natural environment, local languages, belief systems and traditional practices which are shaping the landscape and development legacy of Northern Thailand (Phumthum et al., 2018; Phumthum & Balslev, 2019). Therefore, ethnic minorities are an integral part of the uplands of Northern Thailand, with their livelihoods directly depending on the local ecosystems, while at the same time having a profound impact on it. This fact has generated various degrees of conflict over time, regarding the roles, rights and practices in land tenure, natural resource management and biodiversity conservation (Dearden et al., 1996; Hares, 2009).

The Karen people are the most populous ethnic minority in Northern Thailand. With their origins at the high Tibetan Plateau, they have settled in the region following large migration flows from neighbouring Myanmar since the 18th century. They have a distinct culture which is reflected in their traditional way of life, customs, cuisine, craftsmanship and clothes, as well as their language that belongs to the Sino-Tibetan language family. Over time, the Karen have established numerous self-sufficient agrarian communities, often located in remote and isolated areas close to streams inside forests. The landscapes in the valleys around their small upland settlements are carved by the traditional activity of swidden agriculture and wet rice cultivation. The connection of the Karen with the natural environment surrounding their villages is reflected in their largely animist religious beliefs. Although some have converted to Buddhism or Christianity, most Karen practice traditional rituals and rites related to the omnipresence of ancestral home, forest, farm and land spirits. According to one of them, the umbilical cord of a newborn child is tied around a forest tree, which then becomes a guardian spirit that needs to be protected for a lifetime. In spite of scepticism around the consistent portrayal of the Karen as "conservationists" (Walker, 2001), they maintain a strong relationship with nature, manifested in the dependence on local sacred forests and farming ecosystems for food, medicine, construction materials and other primary resources for meeting key everyday needs. As a result, they possess a rich traditional knowledge on the uses of local plants, and they have attracted the interest of numerous ethnobotanical and ethnomedicinal studies (Phumthum et al., 2020).

This study investigates the uses of plant resources in a Karen village inside one of Thailand's most protected natural areas. It aims to record and document traditional ecological knowledge, providing insights into the diversification of agricultural production, diets and livelihoods. It also attempts a prioritisation of tree species that can be used in large-scale ecosystem restoration, especially in the context of joint climate and biodiversity action (BGCI, 2021; Strassburg et al., 2020). As such, it demonstrates the contribution of ethnobotanical research in the context of solving problems related to contemporary environmental, social and economic challenges (see Hidayati et al., 2015) and sustainable rural development in face of the triple biodiversity, poverty and climate crisis.

2 | MATERIALS AND METHODS

2.1 | Research area

This study was conducted in Mae Klang Luang village (18.5425°N, 98.5469°E) in Chom Thong District, at an elevation of approximately 1200 meters above sea level (MASL). The village is located on the foothills of Doi Inthanon and belongs to the S'gaw Karen ethnic minority, consisting of 63 households of about five hundred inhabitants. The wider area around Mae Klang Luang is covered by evergreen seasonal hardwood and mixed evergreen-deciduous forests and patches of cleared agricultural land dominated by terraced paddy fields along the Mae Klang river. The primary economic activity in the village is agriculture, which besides the raising of cattle, buffaloes and pigs includes the cultivation of upland rice, maize and soy based on rotational swidden systems. Other cash crops such as cabbage and peppers are grown with the support of Thailand's Royal Project, and there is a small shaded coffee plantation inside the village.

Mae Klang Luang is a destination for tourists, promoted as an accessible stopover on the way to Thailand's highest peak. As a result, small ecotourism enterprises also support the local economy. A number of lodges and wooden guest houses have been constructed during the last decade, while some locals offer homestays and guided tours in the surrounding forest tracks. Some women are also generating a modest income by selling locally weaved traditional clothes and handicrafts to visitors. The biodiversity of the local forests around the village is the foundation of this local economy, providing important ecosystem services, a source of food and medicine and construction materials that support local subsistence.

2.2 | Data collection

The methodological approach of this ethnobotanical study draws upon two sources of knowledge, forming an interdisciplinary research merging plant taxonomy and rural sociology. Fieldwork has utilised a combination of participatory rural appraisal tools (Chambers, 1994)—such as free listing, semistructured interviews and participant observation—as well as collections of voucher herbarium specimens (Cunningham, 2001; Martin, 1995) for the identification and characterisation of locally used plant resources. During free listing, a random sample of informants ($n = 30$; 15 female, age: 25–63; 15 male, age: 31–70) were asked to mention fifteen plants they collect from the wild using their local names. This resulted in an extended inventory of plants identified by their vernacular names, which was used during collection walks with a local plant expert in order to locate the relevant plant taxa in their natural habitats. Plants were photographed, collected and pressed, and dried specimens were later used during semistructured interviews (Thomas et al., 2007; Zambrana et al., 2018) conducted in the Karen language with the help of an interpreter.

The plants were identified to the species level, and where necessary to the subspecies and variety level, with the help of dichotomous keys in the Flora of Thailand and through comparison with the collection at Chiang Mai University (CMU). Other floras consulted include Flore du Cambodge, du Laos et du Viêtnam and Flora Malesiana. To ensure that identification and classification of the recorded taxa is consistent with up-to-date plant nomenclature, grouping of species into families was subsequently made according to the Angiosperm Phylogeny Group (APG) classification (Stevens, 2001). The current name of all families was cross-referenced with the Tropicos botanical database (Tropicos, 2021). All field notes were recorded on printed two-sided labels attached on each plant specimen, and vouchers were registered and stored in duplicates at the CMU Herbarium. Digitised voucher specimens are available online via the Global Biodiversity Information Facility database (GBIF.org, 2021).

All procedures related to this research comply with the principles of the International Society of Ethnobiology Code of Ethics (International Society of Ethnobiology, 2006), as well as cultural protocols, social customs and etiquette of the Karen people in the study area. The nature, scope, data collection methodologies and ultimate purpose of the study were clearly disclosed and approved prior to fieldwork, during meetings with the village head and community leaders of Mae Klang Luang. It was agreed that all informants would be asked individually for their prior informed consent before any interview was undertaken.

2.3 | Indexing technique

Statistical assessment of informant consensus on plant utilisation was conducted by means of four quantitative indices used in the ethnobotanical literature. Data collected by free listing were used to estimate the number of uses (NU) reported for each plant; use reports (UR), for example, the sum of different uses mentioned by all informants for each species; and the frequency of citation (FC), for example, the number of informants mentioning a useful species. These three basic values were used to estimate the cultural importance (CI) index (Tardío & Pardo-de-Santayana, 2008), relative frequency of citation (RFC), relative importance (RI) index (Pardo-de-Santayana, 2003) and cultural value (CV) index (Reyes-García et al., 2006) for each recorded species.

3 | RESULTS

3.1 | Inventory of useful plant resources

This research documents 557 UR for 125 plant species belonging to 65 botanical families. The ethnobotanical inventory (Table S1) presents botanical and author names, transliterations of vernacular names (Karen and Thai), plant habits, uses and voucher specimen numbers of each recorded taxon, as well as whether it grows in the wild or in cultivation. Where possible, links to digitised voucher specimens (GBIF.org, 2021) are provided. The number of species and UR documented for each plant family were used in order to rank them according to their ethnobotanical importance (Figure 1). The reported plants correspond to 79 trees (63.2%), 22 herbs (17.6%), 15 climbers (12%), 4 shrubs (3.2%), 2 bamboo species (1.6%), 1 fern (0.8%), 1 palm (0.8%) and 1 rattan species (0.8%).

The majority of these plants (106 species) are growing in the wild in the immediate vicinity of Mae Klang Luang, inside the forest or on cleared areas and farmed terraces. Some of the plants (14 species) are growing in the wild, but they have also been brought into cultivation in home gardens or along the margins of paddy fields. The inventory includes *Prunus persica* (L.) Batsch (Rosaceae), *Prunus cerasoides* Buch.-Ham. ex D. Don (Rosaceae), *Artocarpus heterophyllus* Lam. (Moraceae), *Sambucus javanica* Blume subsp. *javanica* (Viburnaceae), *Zingiber bradleyanum* Craib. and *Zingiber zerumbet* (L.) Roscoe ex Sm. (Zingiberaceae), which are cultivated for their ethnobotanical uses. The following cultivated trees were also mentioned during the free list interviews but are not included in the analysis: mango (Anacardiaceae: *Mangifera indica* L.), longan (Sapindaceae: *Dimocarpus longan* Lour. ssp. *longan* var. *longan*), papaya (Caricaceae: *Carica papaya* L.), guava (Myrtaceae: *Psidium guajava* L.), pomelo [Rutaceae: *Citrus maxima* (Burm.) Merr.], litchi (Sapindaceae: *Litchi chinensis* Sonn.), avocado (Lauraceae: *Persea americana* Mill.) and coffee [Rubiaceae: *Coffea canephora* Pierre ex. Froe. var. *robusta* (Linden ex De Wild.) Chev.].

3.2 | Use categories and plant parts

The ethnobotanical UR of the recorded plant species fall into one or more of the following categories (Table 1): human food including spices and condiments; technology including wood for construction, tools and crafts; medicine including veterinary uses; other uses including plant parts used for ornaments, lacquers, poison antidotes, pesticides, dyes, detergents, storage, chewing and smoking; food for domesticated animals and wildlife; firewood and fire starters; and symbolic uses including parts used as incense.

The majority of the reported plants are valued for their edible fruits (45 species, 36%), which are consumed unripe, ripe or dried depending on the species and form an important part of the local diets. The wood of 32 species (25.6%) is used for the construction of buildings, fences, tools and other technological implements. The locals are aware of the wood properties of different trees and are able to distinguish the most appropriate for each construction. Interestingly, the wood of certain species has symbolic meaning, that is, *Morus macroura* Miq. (Moraceae) is not used for the construction of houses because this would bring bad luck according to local cultural belief. The recorded medicinal plants are used as tonics and warmers, as well as raw ingredients for herbal remedies for a range of ailments. These include cough and sore throats, inflammations, treatments of irritated skin and wounds, myoskeletal problems and bone fractures, gynaecological issues, respiratory or digestive problems, kidney stones, diabetes and malaria. Four plant species are used for treating wounds or skin ailments and one for inducing lactation of animals.

The leaves of 40 species (32%) have various uses, namely, as food for humans and animals when young and tender (27 and 1 species, respectively), as medicines (nine species) and for other purposes (five species). The bark of 20 species (16%) is used as medicine or tonic (eight species), a detector or antidote to poisons (three species), as spice (two species), chewed (three species), for producing natural dyes (three species) and as cosmetic and incense (three species). The stems of 15 plants (12%) are used as food for humans and animals (eight and two species, respectively), for light constructions and handicrafts (four species) and as medicine (one species). The flowers of 11 plants (8.8%) are edible to humans. The roots and rhizomes of 16 plants (12.8%) are used as medicine or herbal tonic (14 species), as spice (one species) and for preparing baits in mouse traps. The seeds or nuts of five plants (4%) are edible by humans and wildlife (three and two species, respectively) or used for the creation of ornaments (one species). The exudates (sap or resin) of seven plants (5.6%) is used medicinally (five species) or for the making of lacquer (two species). The whole aerial parts (e.g., shoots, young leaves and tender stems) of six plants (4.8%) are used as human food (two species), medicine (two species) and poison (two species). The cambium or inner stem of four species (3.2%) and the young shoots of one species (0.80%) are edible by humans. The culms of two bamboo species (1.6 species) are used as human food (one species) and to yield fibre for bindings or light constructions (one species).

3.3 | Ranking of culturally important tree species

The CI index is the sum of the proportion of informants that mention each species use, derived from the FC and not just the NU reported for each species. It is, therefore, considered to be one of the most objective quantitative indices used to reflect the cultural aspects of

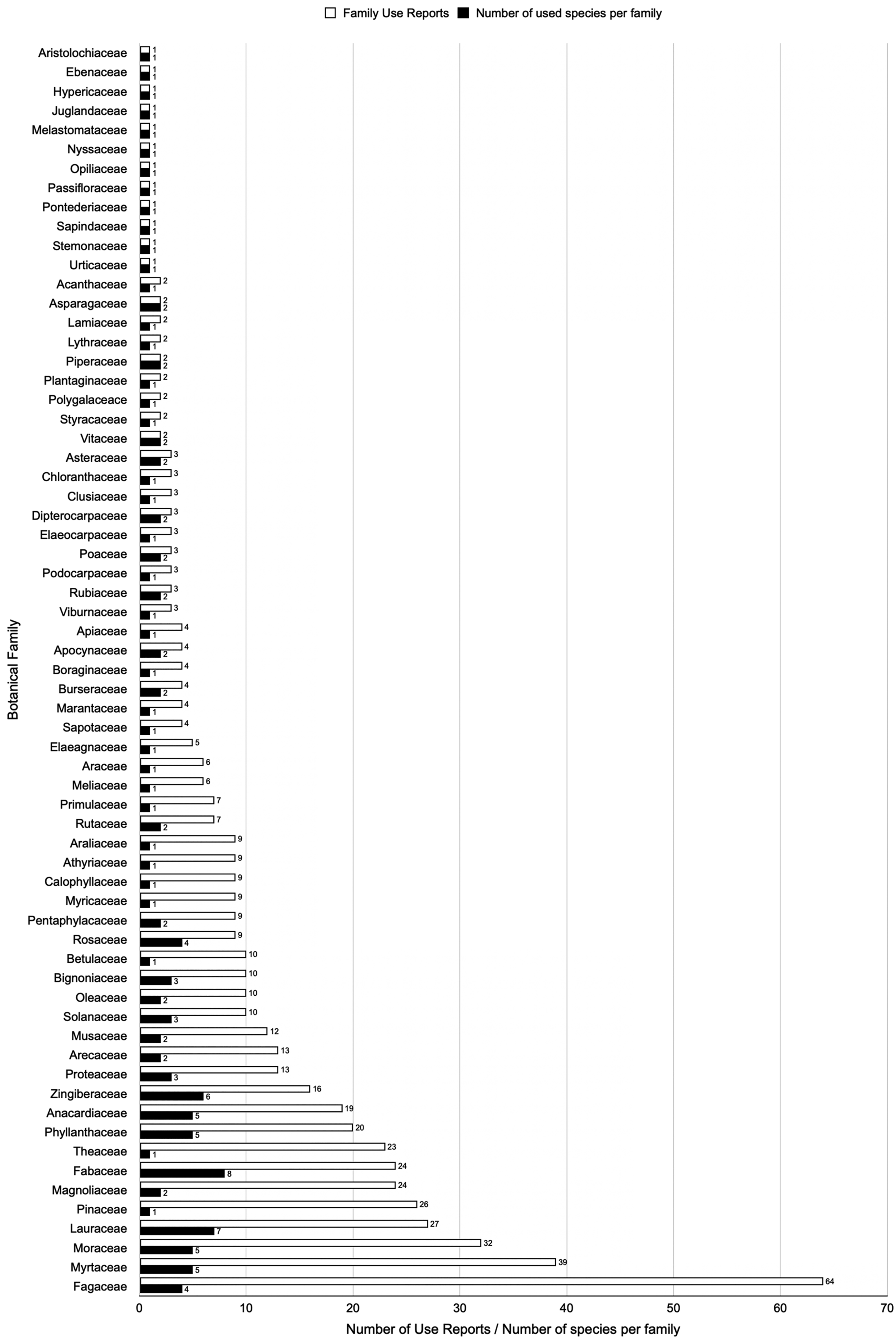

FIGURE 1 Botanical families ranked according to the highest number of use reports (white bars) and the number of reported species within them (black bars). Numbers on the right of each bar indicate the basic values of each metric

TABLE 1 Number of use reports (UR) and percentage of use categories

Categories	No. of UR	Percentage (%)
Human food	240	43.09
Technology	168	30.16
Medicinal	72	12.93
Other	35	6.28
Firewood	18	3.23
Animal food	17	3.05
Symbolic uses	7	1.26
Total	557	100

plant utilisation. Therefore, the ethnobotanical inventory of this research (Table S1) presents the recorded plant taxa by descending order of their CI index. Table 2 presents a ranking of thirty tree species according to their CI index, as well as three further indices. The RFC reflects the number of informants mentioning a useful species divided by the total number of informants consulted in the survey. The RI index takes into account both the number of informants who mention the useful species and the different uses for it. The CV index considers the relationship between the NU, RFC, UR and the number of participants in the survey.

4 | DISCUSSION

Thailand represents one of the most biodiverse countries in Southeast Asia, with forests covering approximately 32% of the country's total area (Royal Forest Department, 2019). Like in most of Southeast Asia, a range of socio-economic factors have been driving deforestation and habitat loss in the country over the last seven decades (Sodhi et al., 2004). The montane forests of Northern Thailand have experienced this pressure in the form of unsustainable farming practices, logging, hunting and the construction of development infrastructure such as roads and human settlements, leading to rapid ecosystem fragmentation (Pattanavibool & Dearden, 2002). Population growth and persistent poverty within the ethnic communities of Northern Thailand generate conflicts between agricultural and forest land, which is still evident even inside protected areas.

Land use and farming practices depend on numerous location-specific variables such as climate, ecology, geography, demography, affluence and regulation. The productivity of agricultural ecosystems depends on the biodiversity of soil microorganisms, pollinators, predators of agricultural pests and the genetic diversity of crops and livestock. Combined together, these form complex and interrelated ecosystems which are in turn responsible for water quality, carbon regulation, nutrient cycling and soil health (WBCSD & IUCN, 2008). The ability of land use systems to support or degrade these vital processes is inextricably linked to food and climate security. It is, therefore, important to embed the conservation of forest and agricultural biodiversity in rural development priorities (FAO et al., 2020). This is highly relevant to the study region, which strives to align commercial agriculture (Tipraqsa & Schreinemachers, 2009) and ecotourism activities (Jiraya & Zhang, 2019; Youdelis, 2013) with the protection of nature.

This research does not attempt an investigation into the root causes and enabling factors of the interconnected biodiversity, poverty and climate crises. It presents an ethnobotanical inventory of 125 plant taxa (Table S1) of high cultural and subsistence value in need for further research and development to support food and nutrition security, healthcare, sustainable agriculture, biodiversity conservation and climate resilience (Heywood, 2011; Howes et al., 2020; Hunter et al., 2019; Ulian et al., 2020). Field observations and plant identifications complementing this inventory contribute to the race against time to document and catalogue species (see Antonelli et al., 2020) that play important roles in ecosystems (Guerry et al., 2015) and contribute to overall human quality of life (Brauman et al., 2020), economic and social development.

The study region represents one of the most important and protected montane forest ecosystems of the Indo-Burma biodiversity hotspot, which provides a reference model for unassisted natural regeneration (Chazdon et al., 2020) and ecosystem restoration (Elliott et al., 2019). Along with ethnobotanical uses of plants, it prioritises the 30 most culturally important tree species in the region (Table 2), using multiple cultural indices. Though widely used in the ethnobotanical literature, ranking on the basis of quantitative indices entails certain limitations (Albuquerque et al., 2006; Thomas et al., 2009), and debate exists about the degree of bias they introduce in demonstrating the cultural value of plants. The CI used here, for example, aggregates all plant uses as equally important. Nevertheless, it provides a robust methodology for introducing cultural criteria in the selection of framework species for ecosystem restoration supporting native biodiversity and sequestering atmospheric carbon (Jantawong et al., 2017).

Plant diversity provides a large share of local subsistence that translates into direct and indirect economic benefits for the community. The wide range of reported wild foods acts as an important dietary buffer, not only adding nutritional diversity but also forming a rich culinary culture that attracts visitors to the village. The enrichment of restored forests with locally useful plants, like the ones reported and prioritised here, can potentially generate reciprocal effects between locally driven economic development and forest conservation (Georgiadis, 2008). As long as sustainable management and harvesting practices are maintained, the reconciliation of scientific objectives with everyday needs of the community may be the defining success factor for ecological restoration projects (Di Sacco et al., 2021; Elliott et al., 2012; Gann et al., 2019) and sustainable rural development. The observed subsistence and option value of wild plants in Mae Klang Luang is yet to be researched (Faith, 2021) to enable traditional ecological knowledge to drive strategies for biodiversity conservation, poverty reduction and climate resilience.

Community members are aware of the ecosystem services of certain species, such as water retention and prevention of soil erosion.

TABLE 2 Ranking of thirty tree species on the basis of four quantitative indices: Cultural importance (CI), relative frequency of citation (RFC), relative importance (RI) and cultural value (CV)

	Basic values			Indices				Ranking			
Species	FC	UR	NU	CI	RFC	RI	CV	CI	RFC	RI	CV
Castanopsis diversifolia king ex Hook. f. [Fagaceae]	18	33	3	0.660	0.60	0.88	0.2829	1	1	1	1
Eugenia albiflora Duthie ex Kurz [Myrtaceae][b]	13	28	4	0.404	0.43	0.86	0.2311	2	5	2	2
Pinus kesiya Royle ex Gordon [Pinaceae][a]	14	26	3	0.404	0.47	0.76	0.1733	3	4	3	3
Schima wallichii (DC.) Korth. [Theaeae]	15	23	2	0.383	0.50	0.67	0.1095	4	3	4	4
Magnolia baillonii Pierre [Magnoliaceae]	16	16	1	0.284	0.53	0.57	0.0406	5	2	6	7
Castanopsis argyrophylla king ex Hook. f. [Fagaceae][b]	10	21	2	0.233	0.33	0.53	0.0667	6	6	8	5
Artocarpus heterophyllus lam. [Moraceae]	8	17	3	0.151	0.27	0.60	0.0648	7	10	5	6
Trevesia palmata (Roxb. Ex Lindl.) Vis. [Araliaceae]	9	9	1	0.090	0.30	0.38	0.0129	8	7	20	14
Calophyllum polyanthum wall. Ex Choisy [Calophyllaceae]	9	9	1	0.090	0.30	0.38	0.0129	9	8	21	15
Myrica esculenta Buch.-ham. Ex D. Don [Myricaceae]	9	9	1	0.090	0.30	0.38	0.0129	10	9	22	16
Magnolia garrettii (Craib) V.S. Kumar [Magnoliaceae]	8	8	1	0.071	0.27	0.35	0.0102	11	11	25	19
Choerospondias axillaris (Roxb.) B.L. Burtt & A.W. hill [Anacardiaceae]	6	10	2	0.067	0.20	0.42	0.0190	12	14	15	10
Betula alnoides Buch.-ham. Ex D. Don [Betulaceae]	6	10	2	0.067	0.20	0.42	0.0190	13	15	16	11
Chionanthus ramiflorus Roxb. [Oleaceae]	6	9	1	0.060	0.20	0.29	0.0086	14	17	28	24
Tamarindus indica L. [Fabaceae][a]	5	10	3	0.056	0.17	0.51	0.0238	15	20	9	8
Baccaurea ramiflora lour. [Phyllanthaceae][a]	7	7	1	0.054	0.23	0.32	0.0078	16	12	27	25
Persea chartacea Kosterm. [Lauraceae]	6	8	3	0.053	0.20	0.54	0.0229	17	13	7	9
Artocarpus nitidus Trécul [Moraceae]	6	7	2	0.047	0.20	0.42	0.0133	18	16	17	13
Melicope pteleifolia (champ. Ex Benth.) T.G. Hartley [Rutaceae]	6	6	1	0.040	0.20	0.29	0.0057	19	18	29	28
Protium serratum (wall. Ex Colebr.) Engl. [Burseraceae]	6	3	1	0.040	0.20	0.29	0.0057	20	19	30	29
Castanopsis tribuloides (Sm.) A. DC. [Fagaceae][b]	4	8	3	0.036	0.13	0.49	0.0152	21	23	10	12
Phyllanthus emblica L. [Phyllanthaceae][a]	5	6	2	0.033	0.17	0.39	0.0095	22	21	18	21
Oroxylum indicum (L.) Kurz [Bignoniaceae]	5	6	2	0.033	0.17	0.39	0.0095	23	22	19	22
Phoebe lanceolata (Nees) Nees [Lauraceae]	4	7	2	0.031	0.13	0.36	0.0089	24	26	23	23
Phoebe cathia (D. Don) Kosterm. [Lauraceae][b]	4	6	3	0.027	0.13	0.49	0.0114	25	24	11	17
Toona ciliata M. Roem. [Meliaceae]	4	6	3	0.027	0.13	0.49	0.0114	26	25	12	18
Helicia nilagirica Bedd. [Proteaceae]	4	6	2	0.027	0.13	0.36	0.0076	27	27	24	26
Adinandra integerrima T. Anderson [Pentaphylacaceae][b]	3	7	3	0.023	0.10	0.46	0.0100	28	28	13	20
Decaspermum parviflorum (lam.) A.J. Scott subsp. *parviflorum* [Myrtaceae][b]	3	5	3	0.017	0.10	0.46	0.0071	29	29	14	27
Glochidion sphaerogynum (Müll. Arg.) Kurz [Phyllanthaceae]	3	2	2	0.013	0.10	0.33	0.0038	30	30	26	30

Note: Three basic values for the estimation of the four indices are also provided: frequency of citation (FC), number of use reports (UR) and number of uses (NU).
[a]Species growing both in the wild and in cultivation in the study area.
[b]The fruits or nuts of species edible by seed-dispersing wildlife.

This ethnobotanical knowledge is passed orally from generation to generation and informs traditional practices that can support climate resilient land use and agriculture. This can potentially contribute to the diversification of food systems and incomes of ethnic minorities inhabiting the Doi Inthanon National Park (see FAO, 2019; Kassam et al., 2019). The opportunity exists, because urban populations in Thailand are reportedly willing to pay for products of organic farming which combine biodiversity conservation and ethical marketing, over those produced in chemical-intensive, commercialised systems (Sangkapitux et al., 2017). Further research on these neglected and underutilised food plants can support the shift to healthy diets, integrating sustainability considerations, and contributing to reductions in environmental impacts on land, energy, water use and the climate (FAO et al., 2020).

5 | CONCLUSIONS

The world's hotspots of biological diversity are under pressure from the triple biodiversity, poverty and climate crisis. As important life systems supporting human well-being, food and climate security are reaching critical tipping points, there is a need to rethink agricultural production, while massively scaling up ecosystem restoration work. Local communities and indigenous people are custodians of rich ethnobotanical knowledge on neglected and underutilised species that can contribute to sustainable land use systems, livelihood diversification and climate resilience.

This research investigates local plant knowledge of a Karen community in the Doi Inthanon National Park, Northern Thailand. However, the objectives, methodologies and insights discussed here are not only relevant to the study region. They demonstrate the potential contribution of ethnobotany and traditional ecological knowledge in the design and implementation of multifunctional land use systems that combine food and livelihood security with biodiversity conservation and climate mitigation. Integrating cultural criteria into land use planning and management does not only embed the livelihoods and well-being of local communities in conservation work. It can also provide incentives for the regeneration of rural areas, by creating synergies across environmental, social and economic objectives. This is relevant to the aspirations of the United Nations Decade on Ecosystem Restoration (2021–2030), which aims to leverage political support, scientific knowledge, implementation capacity and financial muscle to drive the societal transition required for protecting the world's most fragile ecosystems.

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CONFLICT OF INTEREST

The author declares no conflict of interest.

AUTHOR CONTRIBUTIONS

P.G. planned and designed the research, collected data using Participatory Rural Appraisal tools, collected and identified voucher plant specimens, performed data analysis, wrote the manuscript and acquired funding.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ORCID

Pavlos Georgiadis https://orcid.org/0000-0002-0938-0586

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