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RESEARCH ARTICLE

Stakeholder perceptions on Community-Based Ecological Mangrove Restoration (CBEMR): a case study in Thailand

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Mangroves are a unique ecosystem that provides various benefits to people. In Thailand, Mangrove Action Project (MAP) has introduced Community-Based Ecological Mangrove Restoration (CBEMR), a novel technique to restore degraded mangroves. Unlike conventional tree planting, CBEMR does not require a planting phase. It emphasizes preproject assessments of mangrove ecology and hydrology to facilitate natural regeneration. Therefore, this study aims to (1) investigate the perception of stakeholders on the value of mangroves; (2) examine the understanding of stakeholders on conventional mangrove planting and CBEMR as mangrove restoration techniques; (3) understand the challenges and motivations of the CBEMR efforts in the Andaman Coast of Southern Thailand. We use Q Methodology, a semi-quantitative method that requires participants to rank a set of statements to analyze their perceptions according to the research questions. As a result, we can identify three clusters of perceptions; D1 demands more CBEMR and less conventional planting. D2 believes mangrove planting is good, given suitable conditions. D3 thinks restoring mangroves brings benefits, but most conventional planting often fails. This study highlighted that all CBEMR stakeholders believe inadequate technical knowledge is the root cause of mismatch restoration practices. Mangrove planting should be done with suitable species, conditions, and areas. Conventional planting of mangroves without considering ecological factors and local engagement should be avoided as it fails to achieve sustainable outcomes. Enhancing knowledge of mangrove ecology and restoration techniques is therefore a sustainable route to the long-term success of mangrove restoration in Thailand.

Key words: community-based management, ecological restoration, mangrove planting, Q Methodology, stakeholder perceptions, Thailand

Implications for Practice

- This study suggests reassessing the current policy on mangrove restoration in Thailand. Focusing on propagules and area targets may results in biodiversity loss from clearing areas to plant and putting any species available to fill areas.
- We encourage to investigate: (1) the conditions of potential planting areas; (2) suitable species; and (3) the possibility of natural regeneration before planting.
- Community-Based Ecological Mangrove Restoration as a novel mangrove restoration technique can cause "turning points" in the understanding of mangroves from direct experience and knowledge sharing.

Introduction

Mangroves are unique ecosystems, that can be found in intertidal zones (Dahdouh-Guebas & Cannicci 2021). Most mangrove forests are distributed along the coastline in tropical and subtropical countries (FAO 2007). Globally, Southeast Asia holds the biggest area of mangrove forest with 33.8% of the world's total mangrove cover (Thomas et al. 2017).

Mangroves provide various ecosystem goods and services to people. They contribute to the livelihood of coastal communities,

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providing shelter for terrestrial and marine flora and fauna (Zu Ermgassen et al. 2021). Meanwhile, they protect shorelines from tidal and surge waves (Blankespoor et al. 2017) and can store a high amount of carbon in mangrove trees and soils (Alongi 2014).

Despite the rich ecosystem services they provided, mangroves have been impacted by land-use changes (Richards & Friess 2016). About 62% of global mangrove loss was caused by land conversion to aquaculture and agriculture during 2000–2016 (Goldberg et al. 2020). Land degradation mostly affects people living in poverty in developing countries due to the loss of biological productivity, ecological integrity, or value to humans' livelihoods (Olsson et al. 2019). To halt the global ecosystem degradation, the Decade on Ecosystem Restoration has been declared from 2021 to 2030 (UNEP 2020).

Despite huge efforts around the world, most mangrove restoration projects focus merely on planting without assessing factors that cause mangrove loss and prevent natural regeneration (Bosire et al. 2008; Kodikara et al. 2017; Quarto & Thiam 2018). The study in Sri Lanka found that after 5 years of planting attempts, about 40% of the sites had a 0% of survival rate (Kodikara et al. 2017). Earlier, a study in Colombia also showed that Colombian mangrove plantations had failed, and that site selection and preparation are the keys to success in mangrove restoration (Elster 2000).

Lewis (2005) stated that mangrove forests can recover without active efforts if: (1) the normal tidal hydrology is not disrupted; (2) the availability of the close-by waterborne seeds or propagules is not blocked or limited; and (3) the stressors or drivers of mangrove loss are removed or controlled. Only when natural regeneration is proven to be impossible that human intervention is needed to facilitate aided natural regeneration, which is more cost-effective than replanting (Bosire et al. 2008). In addition, incorporating local needs into management strategies is crucial to enhance mangrove policy (Dahdouh-Guebas et al. 2006).

Mangroves in Thailand

Thailand has about 50% of its total coastline (2,614 km) as mangrove areas (Havanond 2008). The majority is located on the Andaman Coast (80%), while the remaining 20% is found in the Gulf of Thailand (Spalding et al. 2010). From 1961 to 1996, the cover of mangroves in Thailand decreased by about 55% from 2.3 to about 1 million Rai (1 Rai = 0.16 ha; Aksornkoae 2012). The main cause was overexploitation for charcoal production, shrimp farming, agriculture, mining, and urbanization (Pumijumnong 2014; IUCN 2016). Thailand was one of the countries affected by the Indian Ocean tsunami in 2004 (Barbier 2008). Since 2004, the Department of Marine and Coastal Resources (DMCR), under the Ministry of Natural Resources and Environment (MONRE), is responsible for mangrove management, conservation, planting, and education (IUCN 2016; Thompson 2018). Overall, Thailand records a total of 96 mangrove species, of which 41 species are true mangroves from 22 genera and 14 families (DMCR 2022).

Mangrove Tenure

Mangroves are defined as forest areas in Thailand. According to the Forest Act 1941, forests are any lands which have not been acquired by an individual under the 1954 Land Code. All forests are state-owned (RTG 1941; IUCN 2016). Therefore, forest lands are prohibited from issuing land titles (Lakanavichian 2004). Private land ownership depends on land certificates issued by the Land Department within the Ministry of Interior (IUCN 2016; Samuiforsale 2023).

Since 1997, the Constitution of Thailand and the National Economic and Social Development Plan have emphasized the rights of local communities in resource management (RTG 1997*a*, 1997*b*). However, community mangrove management is not formally recognized in Thailand (IUCN 2016). Local authorities, on the other hand, often recognize traditional usages of mangroves by local communities (Sudtongkong & Webb 2008; IUCN 2016).

Mangrove Restoration

After the mass exploitation of mangroves, the Thai cabinet invested approximately 450 million THB (about 12 million EUR; 1 EUR = 37 THB) in rehabilitating 40,000 ha of mangrove areas from 1992 to 1996. Despite the massive investment, Thailand's mangrove restoration efforts have been addressed as largely unsuccessful (Thompson 2018). According to the study in Thailand, mangrove planting is the only method that participants referred to as the way to restore mangroves (Kanchanarak 2017; Thompson 2018). The focus has been on the active planting of *Rhizophora* species on un-vegetated mudflats or degraded mangrove forest areas (Havanond 2008). According to Ellison (2000), Thailand was the only country in Southeast Asia that plant only one mangrove species (*Rhizophora apiculata*) in the 1990s. The species is known to be used specifically for wood and charcoal production. Planting is heavily guided by the national regulation on mangrove planting and maintenance (DMCR 2021). The regulation deems planting on salt flats, mudflats, and coastal swamps as feasible. It suggests first clearing out weeds in the area and planting with a 1.5 × 1.5 m distance between each sapling for the number of 710 saplings/Rai (about 4,438 saplings/ha). Replanting should be conducted immediately if the survival rate of planted mangroves is lower than 80%, with the number of 300 saplings/Rai (1,875 saplings/ha; DMCR 2021). It is worth noting that the equivalent words of "Restoration," "Rehabilitation," or "Reforestation" are absent in Thai. Therefore, restoration goals are not clearly defined unlike their definitions in English (Bosire et al. 2008).

Community-Based Ecological Mangrove Restoration

Mangrove Action Project (MAP) is a nonprofit organization based in the United States. MAP adopts the principles of "Ecological Mangrove Restoration" (EMR) developed by Lewis (2005, 2009) that aims to tackle the failures of mainstream planting efforts (MAP 2020). MAP incorporates the community-based (CB) approach to highlight community engagement and stewardship as the keys to sustainable restoration efforts. MAP is a partner of the UN Decade on Ecosystem Restoration and promotes the Community-Based Ecological Mangrove Restoration (CBEMR) in many countries worldwide (MAP 2021; UNEP 2021).

CBEMR differs from the traditional planting of mangroves in the Thai context on the following points: (1) CBEMR is a community-led process that aims to create a sense of ownership by engaging local communities from planning, implementing, to monitoring the projects (Quarto & Thiam 2018; MAP 2019). The planting method, in contrast, does not necessarily involve local communities (DMCR 2021).

(2) Ecological Mangrove Restoration—CBEMR does not require a planting phase, unlike the active planting method. CBEMR emphasizes correcting hydrological issues to facilitate natural mangrove regeneration rather than jumping to planting. Consequently, CBEMR is context-specific and adjusts to each area's condition. It involves local stakeholders from the start, provides technical training, and follows the six steps of the EMR process (Brown et al. 2014) including (1) ecological assessment: understand and analyze local mangroves; (2) hydrological assessment: understand the normal hydrological patterns that affect mangroves; (3) disturbance assessment: evaluate modifications that prevent natural regeneration; (4) land ownership resolution, planning, and design; (5) implementation; and (6) monitoring: by both academic and participatory methods.

In contrast, traditional planting follows precise planting density and numerical goals addressed in the regulation that implements nationwide (DMCR 2021). Therefore, it leaves no room to adjust to local conditions. It demands planting a fixed number of mangrove saplings (710 saplings/Rai) with a 1.5 m distance in between. It requires replanting when the survival rate is lower than 80% without clearly addressing the conditions of the area.

Since 2007, MAP has introduced CBEMR as a novel approach to restoring mangroves in Thailand. However, the adoption of CBEMR from diverse stakeholders remains challenging. Therefore, this study aims to understand the reasons behind conventional planting and address the underlying issues that prevent Thai stakeholders from adopting the CBEMR technique. The research objectives are to (1) investigate the perception of stakeholders in mangrove restoration on the value of mangroves; (2) examine the understanding of stakeholders on planting and using CBEMR as mangrove restoration methods; and (3) understand the challenges and motives of the CBEMR efforts in the Andaman Coast of Southern Thailand. We hypothesize that having the perception of mangrove planting as the only technique to restore mangroves prevent stakeholders from adopting the CBEMR method.

Methods

Study Sites

The study sites are located on the Andaman Coast of Southern Thailand. We selected six villages across four provinces with the help of the MAP. The sites were selected based on their involvement with MAP's "CBEMR Network" initiative which aimed to build capacities and exchange knowledge between communities throughout four provinces in Southern Thailand (Fig. 1). Each village has piloted the CBEMR method to restore degraded mangrove areas. It was worth noting that planting was long known as a conventional method to restore mangroves in Thailand. Therefore, the CBEMR method has recently been introduced to the study sites by MAP. Those include (1) Talae Nok Village in Ranong province, (2) Tha Sanook Village in Phang Nga province, (3) Nai Nang Village, (4) Klong Lu Village, (5) Lang Da Village in Krabi province, and (6) Bang Khang Khao Village in Trang province.

We addressed the past usage of the sites before restoration efforts in Table 1. All of the sites were degraded mangroves which have been converted to aquaculture or agriculture areas. The major work done was hydrological restoration by digging channels to improve water flow. Normal hydrology is the key to natural regeneration as the water flow brings in diverse mangrove seeds and propagules available in connected areas (Lewis 2005). Planting at some sites was to benefit local livelihoods, test planting, or accelerate natural regeneration.

Q Methodology

The Q Methodology (Q) is a semi-quantitative method that requires participants to rank a set of items (the Q-set) individually, based on their degree of agreement with the statements (Mukherjee et al. 2018; Zabala et al. 2018). Q has advantages in (1) combining the benefits of both quantitative and qualitative approaches; (2) allowing to cluster respondents with similar responses; and (3) reducing response biases by engaging participants to clarify the underlying reasons for their ranking of the statements.

In this study, we used the Q methodology to map the perception of CBEMR stakeholders on mangrove restoration in the Andaman Coast of Southern Thailand. We followed the four stages of the Q study from Zabala et al. (2018): (1) research design; (2) data collection (Q-sorting); (3) analysis; and (4) interpretation.

Stage 1: Research Design

In this study, we focused on (1) the perception of stakeholders on the value of mangroves; (2) the understanding of stakeholders on planting and CBEMR as mangrove restoration methods; (3) the drivers and challenges of mangrove restoration efforts in the Andaman Coast of Southern Thailand.

We developed the Q-set by filtering information that provided opinions on our research topics through four processes (Fig. 2). First, we conducted literature reviews on scientific publications and non-governmental organization (NGO) reports (Filter 1). We researched on the Web of Science and ResearchGate using the following keywords: mangrove restoration, CBEMR, mangrove restoration in Thailand, mangrove planting, and mangrove in Southern Thailand. We incorporated the regulations of the Department of Marine and Coastal Resources (DMCR) to understand the current practice regarding mangrove restoration in Thailand.

After that, we compiled information and developed a long list of relevant statements through Filter 2, according to our research topics. This step illustrated the comprehensive opinions available on each research question.

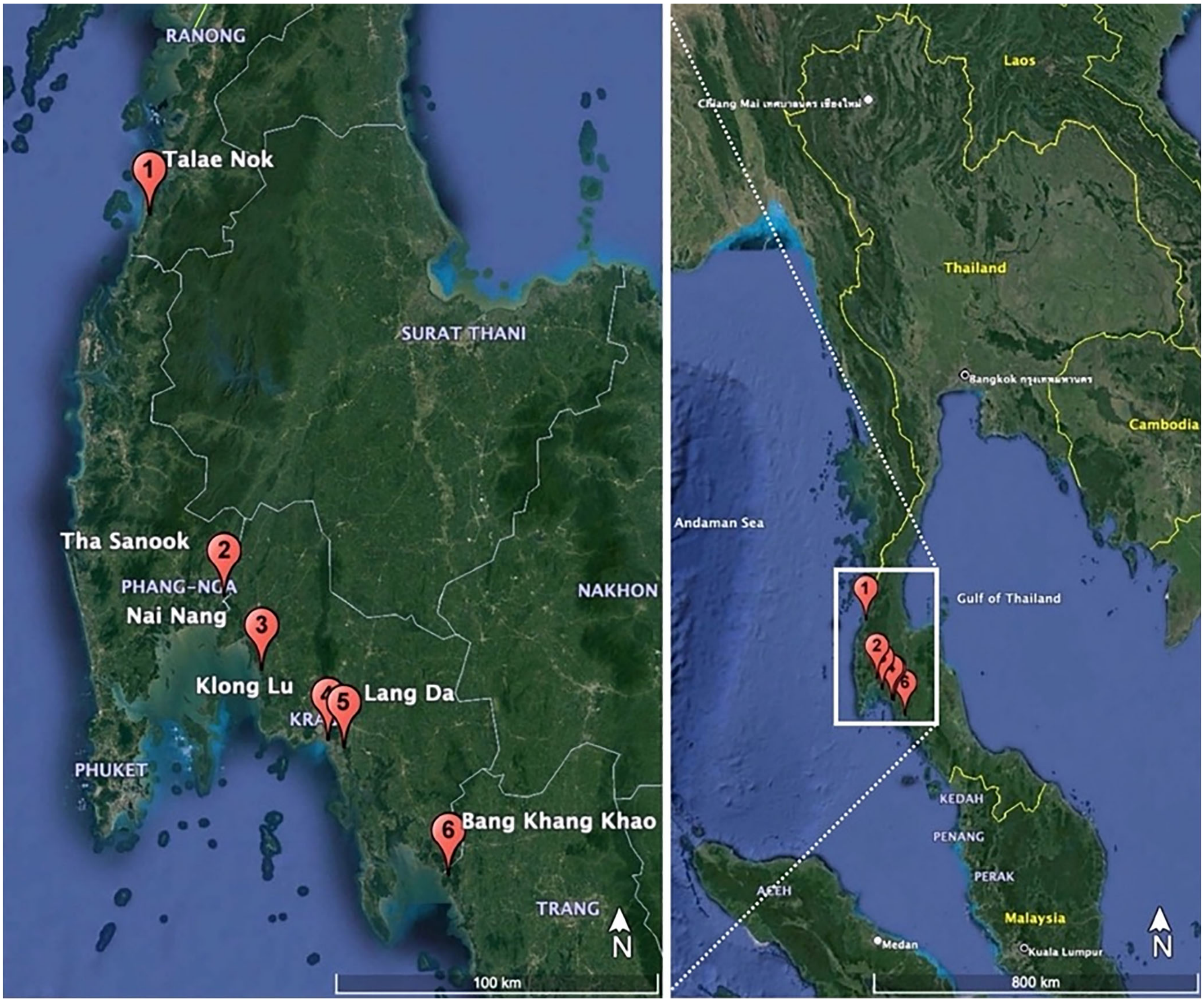

Figure 1. The study sites are located in six villages across four provinces in the South Andaman region of Thailand, including (1) Talae Nok Village in Ranong, (2) Tha Sanook Village in Phang Nga, (3) Nai Nang Village, (4) Klong Lu Village, and (5) Lang Da Village in Krabi, and (6) Bang Khang Khao Village in Trang province, adapted from Google Earth Pro (2022).

We then shortlisted the statements according to the local context by consulting with the MAP's experts (Filter 3). They held extensive experience working on mangrove restoration with all the CBEMR stakeholders on local, national, and international levels. This step allowed the Q-set to be tailor-made to the Q participants and facilitated post-sorting interviews. We considered three criteria in the shortlisting process including (1) relevance to the local context, (2) diverse opinions, and (3) wish-to-know opinions. First of all, we went through the long list of statements with MAP's experts to ensure that the contexts were relatable to participants. More tailored statements benefited the Q-sorting process because participants could express their opinions more in-depth compared to irrelevant statements. Secondly, we selected statements that covered distinct opinions among stakeholders on the following topics: (1) perceived value of mangroves; (2) mangrove restoration in Thailand; (3) planting method; (4) CBEMR method; (5) challenges and motives; and (6) policy and planning. We ensured that the statements stimulated diverse opinions to be agreed or disagreed with. Finally, we considered statements that uncovered wish-to-know opinions across stakeholders. Q allowed participants to express their opinions without biases from groupthink and dominance effects (Mukherjee et al. 2018). This allowed us to include statements relating to conflicts and sensitive topics in Thai culture that would be difficult to assess otherwise. After that, we mapped out Q-sorts by each potential diverse opinion and adjusted accordingly. For example, the positive or negative forms of statements would affect the overall Q-sort pattern. As a result, we shortlisted statements that most align with our research questions, cover crucial topics, and contain balance among possible opinions.

Table 1. Restoration sites using CBEMR method across six villages in the Andaman Coast of Southern Thailand.

				CBEMR Method	
Restoration sites	*Year started*	*Area (ha)*	*Past activities*	*Hydrology improvement*	*Planting phase*
(1) Talae Nok Village, Ranong	2009	0.6	Encroached by private investors post-tsunami	Yes By extensive hand digging	Planting on 1/3 of the area with Nypa palm (*Nypa fruticans*) seedlings for alternative livelihood.
(2) Tha Sanook Village, Phang Nga	2014	0.5	Abandoned shrimp ponds and fish aquaculture	Yes By creating water gates to drain the standing water and digging small canals	N/A
(3) Nai Nang Village, Krabi	2014	0.5	Abandoned shrimp ponds; attempted monoculture planting to restore mangroves	Yes	N/A
(4) Klong Lu Village, Krabi	2015	0.3	Abandoned shrimp ponds	Yes	Small-scale planting to test soil conditions and speed-up coverage.
(5) Lang Da Village, Krabi	2007	0.7	Abandoned shrimp ponds	Yes By improving site elevation by creating 32 hills (1 m height and 3 m width)	Planting propagules at base, mid-way and top of the created hills (*Rhizophora apiculata*, *Ceriops tagal*, *Bruguiera cylindrica*, and *Nypa fruticans*).
(6) Bang Khang Khao Village, Trang	2012	1.0	Aquaculture and coconut palm planting	Yes	Small-scale test planting after hydrological restoration.

We piloted testing the Q-set to ensure all statements were readily understandable with students in the Erasmus Mundus Joint Master Degree in Tropical Biodiversity and Ecosystems (TROPIMUNDO) programme at Université libre de Bruxelles (Filter 4). We made necessary adjustments after receiving feedback. As a result, we had a representative set of 48 statements (the Q-set) for participants to rank. We then translated the shortlisted Q-set into Thai.

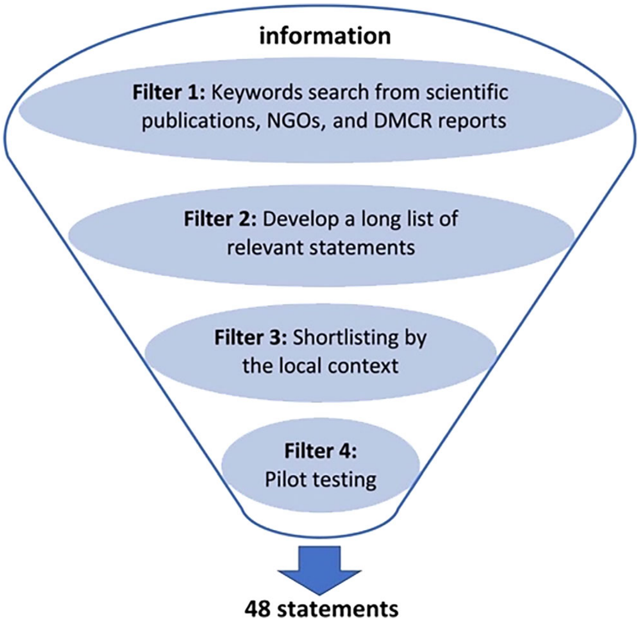

Figure 2. Processes in developing the Q-set consist of filtering information through four filters.

Selection of Participants

We aimed to extract various perceptions on mangrove restoration of the CBEMR stakeholders at the Andaman Coast of Southern Thailand. It was worth noting that this study was focused on CBEMR stakeholders, which was not the mainstream method of mangrove restoration in Thailand. Therefore, the respondents were specified as those who have been trained and/or interacted with MAP on mangrove restoration using the CBEMR method.

Overall, the stakeholders consisted of eight categories with a total number of 23 participants (Table 2). The DMCR under the MONRE played an important role as the responsible governmental agency in mangrove management and restoration in Thailand (Thompson 2018). Non-Governmental Organizations (NGOs) acted in a facilitating role to engage many corporations in mangrove restoration through CSR projects (Mather et al. 2014; Apperloo 2021). Scientists and researchers played a role in providing technical guidance and conducting research to assess rehabilitation attempts. Other stakeholders were CBEMR community leaders or local leaders, fishermen or fisherwomen, community women's group representatives, ecotourism entrepreneurs, and funders of CBEMR projects. We intentionally selected these various respondents to incorporate

Table 2. Characteristics of Q participants on mangrove restoration in the Andaman Coast of Southern Thailand.

Category	*Number of Q participants*
Department of Marine and Coastal Resources (DMCR)	1
Non-Governmental Organizations (NGOs)	6
Scientists and researchers	3
CBEMR/village leaders	6
Fishermen/fisherwomen	1
Community women's group representatives	3
Ecotourism entrepreneur	1
Funders of CBEMR projects	2
Total	23

a wide range of extreme opinions on the CBEMR stakeholders in the Andaman Coast of Southern Thailand.

Stage 2: Data Collection (Q-Sorting)

Before our interview, all respondents were provided with Informed Consent sheets to provide information and obtain their permission. All respondents signed the informed consent document. After that, we began with the Q methodology. We provided the 48 Q-set statement cards for the respondents to sort within an empty matrix in a near-normal "forced" distribution (Table S1) to capture participants' viewpoints (Hugé et al. 2016). We asked participants to rank the Q-set from the lowest level of agreement to the highest agreement using a -3 to $+3$ Likert scale (Fig. S1). This ranking was named Q-sort. It expressed the participants' viewpoints on certain statements and ranked their perceptions relative to one another.

We visited all study sites and conducted the Q-sorting in person with each local participant. It took on average about an hour for one participant to complete the sorting. We conducted online interviews in the case that respondents could not have in-person meetings. For example, due to the COVID-19 situation or living at a distance. In total, we conducted 15 face-to-face Q-sorts including all local participants. The other eight respondents participated online (these participants included a DMCR officer, NGO officers, researchers and funders who were familiar with online meetings). We organized the meetings via Google Meet using QMethodSoftware.com for interactive Q-sorting. We asked the participants to share their screens while sorting the statements to ease the process and facilitate any questions they may have. After the Q-sorting, we clarified their extreme viewpoints (most agree and disagree) in qualitative post-sorting interviews.

Stage 3: Analysis

We analyzed data using the qmethod package (Zabala 2014) in RStudio 2022.02.2 with R 4.2.0 open-source software. We grouped "likeminded" participants with the same pattern of Q-sorts together with principal component analysis (PCA) to later describe the discourses they supported (Vande Velde et al. 2019). First, we determined the number of factors to extract and rotate. According to Watts and Stenner (2012), we started extracting one factor for 6–8 participants ($n = 23$). We accepted factors that had two or more significant factor loadings at $p < 0.01$, and their eigenvalues were more than one, according to the Kaiser–Guttman criterion (Brown 1980; Watts & Stenner 2012). We then rotated factors using Varimax rotation (Hugé et al. 2016) to maximize explained variance while retaining orthogonal axes. After that, we calculated participant loadings to indicate how much each participant's Q-sort correlated with each rotated factor. We then group participants with significant loadings (flagged Q-sorts) on the same factor together.

In addition to the standard analysis, we employed the Bootstrapping Q by Zabala and Pascual (2016). The approach was developed to enhance the accuracy of the analysis and interpretation of the Q Methodology. This method allowed variability measures, such as standard errors of each statement, to be visually presented (Zabala et al. 2017). We ran bootstrap in 3000 steps using PCA and varimax rotation with the package "qmethod" in R software (Zabala & Pascual 2016; Zabala et al. 2017).

Stage 4: Interpretation

To interpret the results, we used the statement z-scores (Zabala et al. 2017) which illustrated how each factor responds to each statement. The z-scores indicated the "weighted average of the values" (Zabala & Pascual 2016) given by the respondents which were grouped into factors. We analyzed distinguishing statements for each factor (Hugé et al. 2016) and incorporated data from qualitative interviews to explain the distinctive characteristics of each factor.

Results

Factor Analysis

We identify three factors that explain 63% of the total variance (Table S2), which is much higher than the range of 35–40% variance explanation proposed by Watts and Stenner (2012). It is also higher than the median value of 52 Q studies reviewed by Zabala et al. (2018). The three factors, therefore, describe most of the variation in Q-sort patterns. The first factor belongs to the majority of participants (16 out of 23), which explains about 37% of the total variance. Meanwhile, factors 2 and 3 explain 16% and 11% of the total variance, with 4 and 3 loaded participants.

Following the Kaiser–Guttman criterion, the eigenvalue (EV) of each factor is higher than 1 ($p < 0.01$). Each EV of the 3 factors is higher than 2, which means more than two participants are loaded significantly in each factor. In addition, the three factors distinct groups of participants in alignment with their post-sorting interviews. Considering the criteria, we also explore four and five factors manually. However, the approaches result in repetitive group characteristics compared

Table 3. Q Statements and statistics: *z*-scores (*Z*), ranks (R), and distinguishing statements (grouping). *Note on Grouping: (1) (2) (3) means "Distinguishes all" when all comparisons between each pair of factors are significantly different at $p < 0.05$. When the comparisons of a given factor is significant ($p < 0.05$) and not the rest, (1) or (2) or (3) indicates "Distinguishes fx only." "Consensus" means the comparisons between factors are not different ($p < 0.05$; Zabala & Pascual 2016).

		Factor 1		*Factor 2*		*Factor 3*		
Q statements		*Z*	*R*	*Z*	*R*	*Z*	*R*	*Grouping**
Perceived value of mangroves								
1	Mangroves are most important in providing food and income (e.g., fish, timber, honey).	0.85	1	1.82	3	1.2	2	
2	Mangroves have little potential to store carbon and mitigate climate change.	−1.3	−2	−1.92	−3	0.13	1	(1) (2) (3)
3	Mangroves act as bioshield that protect coastal areas from ocean surges and wind.	1.47	2	1.43	2	2.15	3	
4	Mangroves attract tourists by providing unique ecosystem and recreational activities.	0.7	1	1.52	2	−0.73	−1	(1) (2) (3)
Mangrove restoration in Thailand								
5	Conversion of mangrove habitat to agriculture and aquaculture is a major factor in mangrove loss.	0.87	1	0.89	1	−0.3	0	(3)
6	Natural regeneration processes cannot recover mangroves from degradation.	−0.99	−1	−0.8	−1	−0.51	−1	Consensus
7	Mangrove restoration is a cost-effective form of ecosystem management.	0.38	0	1.6	3	0.12	0	(2)
8	Mangrove restoration programs have positive impacts on local livelihoods (timber, fish, tourism etc.) in Thailand.	0.72	1	1.66	3	2	3	(1)
9	It is not important to investigate why mangroves cannot regenerate naturally.	−1.41	−2	−1.57	−2	−1.08	−2	Consensus
Planting method								
10	Planting is the only method to restore mangroves.	−1.78	−3	−1.21	−2	−0.07	0	(1) (2) (3)
11	Restoration of mangrove vegetation results in the presence of fauna in the area.	0.81	1	0	0	0.78	1	(2)
12	The Department of Marine and Coastal Resources (DMCR) pays great attention to the hydrological assessments of mangrove areas before planting.	−0.61	−1	0.92	1	0.16	1	(1) (2) (3)
13	Mangrove planting increases awareness across stakeholders on the importance of mangroves.	0.85	1	1.25	2	−0.54	−1	(3)
14	Mangrove planting encourages people in the community to work with the government.	0.23	0	1.03	2	0.57	1	
15	Planting of mangroves is necessary only if natural regeneration cannot occur.	0.56	1	−0.13	0	−1.31	−2	(1) (2) (3)
16	Survival rates of mangrove planting have no relation to post-planting-care.	−0.59	−1	−1.47	−2	−1.31	−2	(1)
17	Mudflats and salt flats are suitable for planting mangroves.	−1.16	−2	−0.53	−1	−0.39	0	(1)
18	Although mangrove planting can speed up the recovery of an area, it can result in low biodiversity.	0.95	2	−0.98	−2	0.04	0	(1) (2) (3)
19	After mangrove planting, the replacement of dead plants is necessary.	−0.2	0	0.67	1	0.92	2	(1)
20	Weeding is necessary to help planted mangroves establish.	−0.64	−1	−0.86	−1	−1.82	−3	(3)
21	Mangrove planting is a fun community activity.	0	0	0.22	0	−0.28	0	Consensus
22	Mangrove planting timing depends on national days or special events rather than an ecological consideration.	−1.12	−1	−1.73	−3	−1.32	−3	
23	Restoring mangroves by using the widely practiced planting of mangroves, particularly *Rhizophora* sp., is the solution to mangrove loss.	−1.3	−2	0.93	1	0.05	0	(1) (2) (3)
24	Most mangrove restoration projects investigate first why natural recovery has not occurred before planting mangroves.	−0.6	−1	0.36	0	0.08	0	(1)
25	Most mangrove planting in Thailand often fails due to not removing the cause of mangrove degradation before planting new seedlings or propagules.	1.46	2	−0.71	−1	2.02	3	(2)
26	Mangrove rehabilitation projects should focus on achieving propagule number and area targets.	−1.48	−3	−0.09	0	0.8	1	(1) (2) (3)
CBEMR method								
27	Community-Based Ecological Mangrove Restoration (CBEMR) facilitates nature to regenerate mangroves.	1.7	3	1.17	2	0.78	1	(1)

Table 3. Continued

Q statements		Factor 1		Factor 2		Factor 3		
		Z	R	Z	R	Z	R	Grouping*
28	Involving local communities is not essential for Community-Based Ecological Mangrove Restoration (CBEMR).	−1.55	−3	−1.21	−2	−0.7	−1	
29	Community-Based Ecological Mangrove Restoration (CBEMR) is the most effective restoration method because it ensures normal tidal inundation in mangrove areas.	1.53	3	0.71	1	1.98	2	(2)
30	Successful mangrove restoration projects may not require a planting phase.	0.85	1	−0.68	−1	−0.27	0	(1)
31	It is not important to consider tidal inundation of the area when restoring mangroves.	−1.37	−2	−1.82	−3	1.03	2	(3)
32	There is a great need for the wider dissemination of the Community-based Ecological Mangrove Restoration (CBEMR) to improve the success of mangrove restoration.	1.52	3	−0.04	0	0.8	1	(1) (2) (3)
Challenges and motives								
33	Current mangrove restoration matches the rate of mangrove destruction and loss	−0.88	−1	−0.09	0	−1.05	−2	(2)
34	The main challenge in restoring mangroves is restoring natural tidal flushing in the area.	1.45	2	0.16	0	0.67	1	(1)
35	The main challenge in restoring mangroves is the grazing pressure from domestic animals (e.g., goat and cattle).	−0.19	0	−0.45	−1	−2	−3	(3)
36	The main challenge in restoring mangroves is returning of non-planted species (plants, animals and microbiota).	0.79	1	0.32	0	1.35	2	
37	It is a challenge to create a long-term sense of ownership in mangrove restoration projects.	0.43	0	−0.58	−1	−0.28	0	(1)
38	Local governments coordinate efficiently with communities to restore mangroves.	−0.23	0	0.48	1	0.8	1	(1)
39	The success of mangrove restoration has not been limited by the social and ecological knowledge of interested parties.	−0.53	−1	−0.32	0	−1.01	−2	Consensus
40	Assessing the success of the restoration action is difficult because of a lack of systematic reports and long-term monitoring.	1	2	−0.17	0	−0.4	0	(1)
41	The private sector has not played a significant role in scaling up the mangrove restoration efforts.	0.13	0	−1.02	−2	−1.07	−2	(1)
42	People in the community are not involved in deciding mangrove species and areas to restore.	−0.12	0	−0.67	−1	−0.42	−1	
43	Everyone involved in mangrove restoration projects shares a common goal.	−0.02	0	0.51	1	0.78	1	
44	There are no conflicts between people over ownership of restored mangrove lands.	−1.27	−2	−0.4	0	−0.44	−1	(1)
45	Mangrove restoration projects have adequate financial support for long-term monitoring.	−1.06	−1	0.45	1	−0.12	0	(1)
Policy and planning								
46	The success of mangrove restoration is often judged by the percentage of surviving seedlings at 5 years.	0.34	0	0.85	1	−0.69	−1	(3)
47	The Department of Marine and Coastal Resources (DMCR) suggested planting more species to increase mangrove biodiversity.	−0.23	0	1.02	2	−0.42	−1	(2)
48	The national regulations on mangrove planting and maintenance (DMCR 2021) need to be amended to achieve greater mangrove restoration success.	1.03	2	−0.54	−1	−0.67	−1	(1)

to the three factors. Therefore, the three factors are the most suitable representatives of participants in this study.

The 23 participants are loaded on 3 factors according to their similar pattern of Q-sort (Table S3). Each factor sorts Q statements in a different pattern as shown in Table 3. The *z*-scores of each factor indicate the weighted average ranking of each statement. When the scores are significantly different, they distinguish factors apart. On the other hand, the consensus statements mean that the comparisons between factors are not different ($p < 0.05$). All of the participants then share a set of mutual perceptions, regardless of whether the statements being agreed, disagreed with, or were neutral.

Bootstrapping

Comparing the standard analysis with bootstrapping, we obtain identical results regarding the general factor characteristics, flagged Q-sorts, and distinguishing statements. Therefore, we

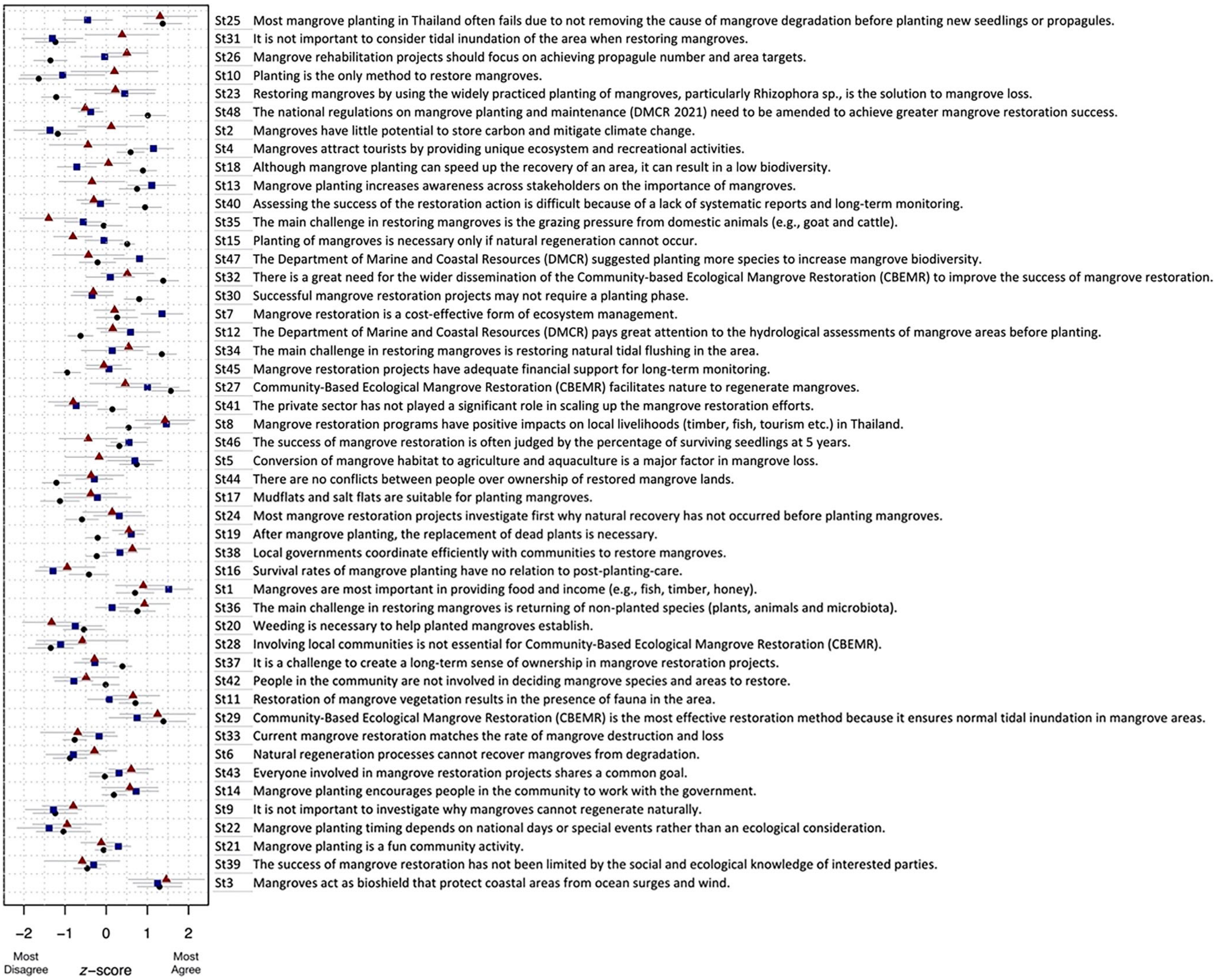

Figure 3. Bootstrap estimates of three z-scores on each Q statement sorted by the most divergent perception (top) to the most mutual perception (bottom) between three factors with ±SE. • represents Factor 1, ■Factor 2, and ▲Factor 3.

present the result based on the standard analysis (Tables S3 and 3).

Bootstrapping shows z-scores and standard errors (SE) of each statement by each of the three factors (Fig. 3). The statements are listed from the most divergent perception (top) to the most mutually agreed upon perception (bottom).

As a result, we can identify three discourses and the overall shared perceptions among participants (Fig. 4). The statements in the figure have been modified to their rankings (agree or disagree). A discourse is described as a set of shared "group viewpoints" which contains both distinct and share perceptions among a group of participants. We label discourses based on what each group highlights. Despite their differences, all participants have three shared perceptions in common.

Shared Perceptions. Participants highlight inadequate knowledge of natural regeneration and socio-ecological systems as the main limiting factor to success in mangrove restoration (St6, St9, St39). For example, P1 states: "Most people do not know that mangroves can regenerate naturally." P16 says: "If we look at it from the perspective of someone who does not know about this, they will not pay attention."

We record participants' turning points on the understanding that mangroves can regenerate naturally. Local participants find the knowledge comes naturally to them from direct observations, while others shifted their understanding in different ways, including (1) direct experience observing mangroves, (2) acquiring knowledge from teachers and publications, and (3) engaging in MAP's CBEMR projects.

Despite the highly disagreeing with planting on national holidays (St22), participants repeatedly report evidence. To illustrate, P16 addresses that planting on special days means prioritizing convenience over survival rates: "Planting on special days is an event-based methodology. It is not a result-based methodology. So, you want to plant for engagement and

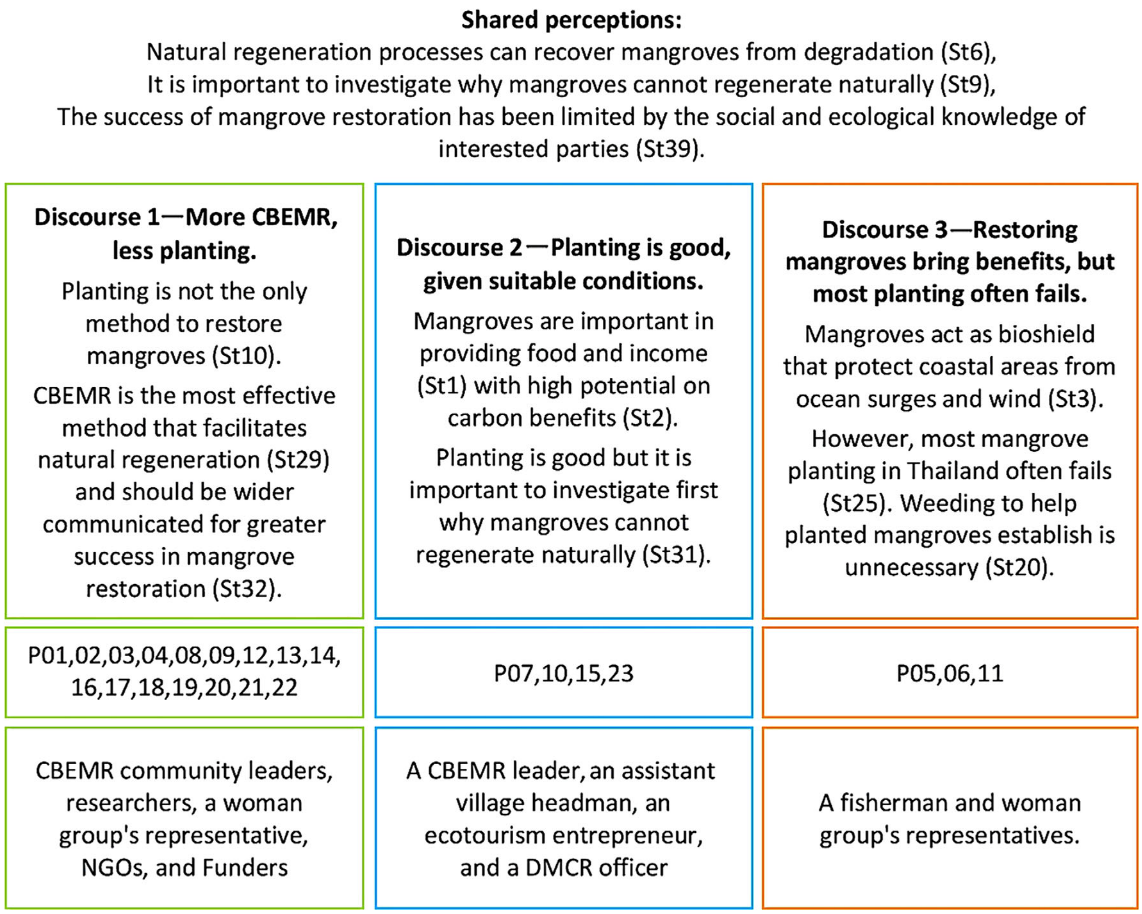

Figure 4. Mapping perceptions of participants with the shared perceptions (top) and three discourses with participants' characteristics.

awareness. Period. Therefore, you cannot expect those saplings to survive. That is a second agenda."

Discourse 1—More CBEMR, Less Planting

Restoration Method. D1 highlights that planting is not the only method to restore mangroves (St10). Mangrove planting is only necessary if natural regeneration cannot occur (St15) because it results in low biodiversity (St18). Also, D1 believe that successful mangrove restoration projects may not require a planting phase (St30). P12 states: "Planting is not necessary when there are enough propagules, normal sedimentation, normal hydrology and water flow in the areas." P17 addresses that planting comes in at the beginning after the prohibition of concession for charcoal: "planting was still the fastest way to restore mangroves."

Regarding the reasons underlying planting mangroves, D1 believes it is because planting gives good images. For exmaple, P12 states: "Planting gives the image of doing good things to the environment. This is the main problem for Thai people. We spend billions on planting to create this image."

D1 highlights that planting *Rhizophora* is not the solution to mangrove loss (St23) and disagrees with targeting propagule numbers and planting areas as measures of success (St26). P4 states: "Restoring 15 rai, it gets 15 rai and that is it. But they did not look at in 15 rai what happened inside there. It might turn to some other forest type." P12 points out that focusing on target numbers might result in cutting down trees: "If we focus on this target, there will be clearing the areas and keep planting to get the restoration funding."

D1 emphasizes that mudflats and salt flats are not suitable for planting mangroves (St17). P1 states: "This is the worst thing (…) I hate that they force one ecosystem to be the other." Also, most mangrove restoration projects (St24) and the DMCR (St12) do not investigate the areas first before planting. P9 states: "…mostly they will only plant where there is an empty space without investigating which species are suitable for the areas."

D1 believes that CBEMR is the most effective method that facilitates natural regeneration (St29) and should be wider communicated for greater success (St32). P9 addresses: "CBEMR is needed to be communicated clearly to the government agency because the government sector is the one who plants the idea of planting." P16 points out that the low adoption of CBEMR is caused by the lack of clear evidence on the cost-effectiveness and socioeconomic and ecological benefits. P16 says: "But for the conventional practice, they have clear numbers that 1 rai equal to 700 trees, 1.5×1.5 equal to 1 sapling."

Challenges and Motives. D1 believes restoring natural tidal flushing in the area (St34) is the main challenge. P1 states: "This depends on the condition of the areas for how much it has changed." Moreover, D1 mentions assessing outcomes is difficult due to the lack of systematic reports (St40) and financial support for long-term monitoring (St45). P21 thinks donors do not find monitoring as exciting: "A lot of donors want to support the actual planting of trees, because they can see clearly the result of it…".

D1 addresses conflicts over ownership of restored lands (St44). P22 points out conflicts on mangrove tenure: "it is very unclear that nobody will draw a clear line on the land ownership." P18 mentions: "I definitely saw people kill off mangroves when they start to regrow in ponds because they are afraid that the government will then take ownership of that land (…) once it becomes a forest, it becomes state-owned."

Policy and Planning. D1 requests changes in Thailand's national regulations on mangrove planting and maintenance (St48) to achieve greater success. This is even when many participants are unsure about the regulation (P1, P4, P18, P19). For example, P1: "… I do not know what is written, but I understand that they set goals in numbers of saplings or planting areas. That cause what happened nationwide, it accelerates results in that way, in a quantitative aspect only." Meanwhile, P16 is concerned about the fixed restoration goals because once it is legally enforced, officers need to follow and monitor them accordingly.

In addition, participants point out that aiming for carbon might result in biodiversity loss. P22 addresses that mainly fossil fuel companies are interested to offset their large carbon footprint by investing in mangrove restoration. P22: "The private sector proposes to restore forests for 400,000 rai. However, DMCR only has 300,000 rai that can be restored." These efforts need to comply with the DMCR's regulation, which is the conventional planting method.

Discourse 2—Planting Is Good, Given Suitable Conditions

Restoration Method. D2 differs from D1 because D2 believes that planting does not result in low biodiversity (St18) and that planting *Rhizophora* is the solution to mangrove loss (St23). For example, P7 addresses: "*Rhizophora* is best because it can protect coastal areas from erosion or wind surges. It is their nature, their roots that God has given." In terms of biodiversity, P23 thinks planting creates more biodiversity compared to abandoned areas.

While agreeing that planting is not the only method to restore mangroves (St10), D2 believe that planting is good if done well by investigating first the cause that prevents mangroves from regenerating naturally (St31). For example, P7 states: "We need to plant, but we need to look at the area. In the areas for planting Rhizophora, we need to plant Rhizophora."

Comparing natural regeneration with planting, P23 thinks both are effective. CBEMR takes more time but does not cost money, while planting is faster but cost money. Concerning replanting (St19), P23 says: "…if the government sector plant, they surely need to re-plant or else they do not reach their goals. They have indicators for if you plant, how many percentages should survive."

In contrast to D1, P23 mentions implementing CBEMR from the government sector's view: "It is almost impossible that the government sector will use this model in mangrove restoration." P23 addresses constraints in mangrove tenure and budget calculation. P23: "Even though there are new techniques, it takes time and is difficult to change." Unlike D3, D2 disagree that most mangrove planting in Thailand often fails (St25). P23 explains: "Most of the increased area is from planting (…) If you say that those are failures then that is incorrect, I disagree."

Challenges and Motives. D2 believes mangroves are important in providing food and income (St1), attracting tourists (St4) and with high potential for carbon benefits (St2). In terms of the carbon benefits, P23 addresses the private sector investing in restoring mangroves to obtain carbon credits. P23: "The government sector is responsible for finding the areas. Private sectors invest and plant and maintain."

Policy and Planning. D2 agree that the DMCR suggested planting more species to increase biodiversity (St47). P23 addresses the work on the ground as opposed to the department's guideline: "We want to plant mangroves to increase biodiversity. But in practice, it might not show the result as that (…) The department has suggested but it depends on those who plant."

Discourse 3—Restoring Mangroves Brings Benefits, but Most Planting Often Fails

Restoration Method. D3 highlights negative experiences of the government agency's mangrove planting and its results. D3 believe most mangrove planting in Thailand often fails (St25) due to not removing the cause of mangrove degradation before planting. Also, Mangrove planting does not help increase awareness (St13). For example, P6 states: "In the past, they just brought the saplings in, and the community does not know what they would bring in. They just brought in and decided on the area to plant. But it did not give 100% results. It died off mostly. They should study the area first on where and what to plant." D3 believes that weeding is unnecessary (St20). For example, P5 states: "It is not needed (…) There should not be any weeds in restoring mangroves." And P11: "There is no need for weeding."

Challenges and Motives. D3 highlights mangroves as bioshield that protect coastal areas from ocean surges and wind (St3). For example, P6 states: "When the mangroves are dense, it reduces the wave energy." D3 has never seen grazing in restored sites by domestic animals (St35).

Policy and Planning. D3 does not have any specific comment on the policy. Participants in D3 are local people and unsure about the national regulation on mangrove restoration.

Discussion

Shared Perceptions

The conventional planting method is perceived as the fastest way to restore mangroves after the mass exploitation in the past, as aligned with Ellison (2000). However, recent studies have shown that most planting efforts often fail (Bosire et al. 2008; Kodikara et al. 2017; Thompson 2018).

Inadequate ecological knowledge is highlighted as the main barrier to successful mangrove restoration in Thailand. The interview results show that CBEMR stakeholders understand factors that are important to natural regeneration and restoration. The key is to identify the cause of degradation at a site and to consider species-zonal associations for planting (Datta et al. 2012). In contrast, the stakeholders define the majority of Thai people as less aware, which might result in jumping to planting. This leads to inappropriate hydrology and soil conditions which lower the survival rates of mangroves (Kodikara et al. 2017). The previous study reports that Thailand still perceives mono-species plantations as equal to ecological restoration (Memon & Chandio 2011). As a result, restoration often fails to assess the causes of mangrove degradation and facilitates natural regeneration before planting (Bosire et al. 2008).

Why We Plant

As opposed to our hypothesis, most participants in D1 do not label planting as right or wrong. Their focus is more on whether it is done in appropriate conditions with suitable species. Planting is mainstream because it is a convenient way to show rapid progress without clear evidence of failure. On the other hand, D2 believes planting is the right way to restore mangroves and does not promote CBEMR in contrast to D1. In terms of D3, they view planting as the wrong way to restore mangroves.

Planting on national holidays is common but highly disagreed with by all participants. Planting is a symbolic act of caring for the environment. Nevertheless, the result suggests that it should be clear on trading off between survival rates or creating engagement. Moreover, the interviews reveal that only planting is insufficient to create awareness because of its quick finish process.

Replanting is revealed to be repeatedly done by government officers due to the need to meet targeted survival rates. According to the DMCR, the national regulation commands planting 710 saplings/Rai (4,438 saplings/ha; DMCR 2021) which is comparable to the reforested plot in Kenya (Bosire et al. 2008). The regulation is enforced nationwide. As a result, government officers comply with this pattern all over the country. Centralized and top-down planning is highlighted as the cause of overlooking ecological conditions at planting sites (Havanond 2008). The guideline addresses planting with a 1.5×1.5 m distance between each sapling. From interviews, planting in organized ways is a result of the past study conducted to calculate suitable density to allocate restoration budgets from the Budget Bureau of Thailand. Moreover, its look indicates clearly which areas have been actively putting in an effort by the government sector.

Globally, mangrove planting has been increasingly questioned on its effectiveness. According to the review of mangrove planting across 11 countries, the number of propagules planted, planting areas and project costs are not significantly resulting in increasing mangrove area or tree survivorship in the long run (Lee et al. 2019). The same applies to other ecosystems. Tölgyesi et al. (2022) urge the need to replace "tree planting" with "restore native vegetation" in terrestrial ecosystems. It is addressed that monoculture planting is supported by climate strategies to reforest areas, resulting in habitat conversion.

CBEMR Versus Conventional Planting

Despite their mutual perceptions, each discourse differs in its perception of restoration methods. D1 demands more CBEMR instead of planting, D2 insists on planting, and D3 is disappointed by planting. They promote different methods based on their experiences and understanding. D1 favors CBEMR over conventional planting because they have seen better results. D2 promotes mangrove planting because they witness success cases and are thus optimistic about planting. D3 has unpleasant experiences with conventional planting and as a result, is discouraged from planting. Consequently, providing clear evidence is crucial for the wider adoption of the CBEMR technique.

In addition, our results address resistance to adopting CBEMR as a novel restoration technique. While many participants demand that the DMCR implements the CBEMR, the stakeholder refuses that it is possible. The limitations are on mangrove tenure, national budget allocation, and the fixed goal of mangrove survival rates. The CBEMR assesses each area and improves the land depending on its condition. This is addressed to be difficult to implement and monitor nationwide. To achieve landscape-scale benefits, developing mechanisms to combine mangrove community-led projects is needed (Lovelock et al. 2022).

Moreover, the DMCR officer in D2 reports gaps between policy design and policy implementation, which aligns with the finding of Thompson (2018). Even though the department aims to plant diverse species, the results show only several species available in planting plots. Closing this gap would result in higher success in biodiversity and resilience of mangrove restoration.

Mangrove Restoration and Beyond

The interviews show that the private sector, as investors, can dictate the future of mangrove restoration over the next 10 years under the current carbon credit scheme (DMCR 2021). Aligning with Thompson (2018), corporations have the decision-making power to choose communities to work with. Furthermore, the demand to offset carbon emissions is higher than the available mangrove areas (Lovelock et al. 2022). Conventional planting is likely to continue under the current national regulation on mangrove planting and maintenance (DMCR 2021). Although the study has shown that biodiversity maximizes the capacity of mangroves to store carbon (Rahman et al. 2021). Following conventional planting could result in failing to recognize biodiversity and local livelihood, according to the CBEMR stakeholder perceptions.

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Supporting Information

The following information may be found in the online version of this article:

Table S1. An empty matrix for Q-sorting.
Figure S1. Ranking of Q statements (Q-sorting) in Thai by participants.
Table S2. General characteristics of the three factors
Table S3. Factor loadings and flagged Q-sorts indicating three groups of Q participants.

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