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CASE STUDY

Enhancing coastal community participation in mangrove rehabilitation through structural equation modeling

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ABSTRACT

BACKGROUND AND OBJECTIVES: Mangroves are unique plants distributed in tropical regions, such as Indonesia. Mangrove areas and various mangrove ecosystems have been lost in the past decades. The purpose of this study is to investigate community participation using structural equations modeling to enhance involvement in mangrove forest rehabilitation. The study was conducted in two sub-districts in East Lampung Regency, Lampung Province.

METHODS: The study employed a survey method with quantitative descriptive analysis and Structural Equation Models analysis. The sampling method used was simple random sampling. The community under investigation is a part of the mangrove forest management group in Labuhan Maringgai and Pasir districts, Lampung, Indonesia. The total number of individuals who are members of the mangrove forest management group is 292, distributed with 140 in Margasari and 152 in Pasir Sakti District. The sample size in Margasari District was 81 respondents, and in Pasir Sakti, it was 87 respondents, totaling 168 respondents. The sample size determination was based on the Slovin formula, considering a precision of 5 percent when estimating the proportion of the population.

FINDINGS: This study's results show that the level of community participation in mangrove forest rehabilitation still falls within the low category, particularly in planning and evaluation, while implementation is categorized as medium. Community leaders often possess influence and authority that is recognized by community members. When these leaders actively support mangrove conservation, they can influence the opinions and actions of the entire community. In this capacity, they serve as role models, inspiring others to participate in mangrove conservation activities. Community participation includes planning, implementation, evaluation, and utilization of results. Participation influences welfare: the more active the community, the more space there will be to utilize mangrove products and interact with other community members, so that income, needs for food, and adequate housing can be met. Local working groups or initiatives that focus on mangrove conservation coordinate field activities and organize necessary resources and manpower.

CONCLUSION: The role of community leaders, farmer groups, government support, and non-government organizations plays a key role in increasing community participation in mangrove forest rehabilitation. Additionally, the increase in non-formal education (training and mentoring), type of work, number of family dependents, length of residence, and distance to the mangrove location are crucial factors in enhancing community involvement.

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
49	3	8

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INTRODUCTION

Mangroves are highly productive forests, encompassing both natural and non-natural mangrove environments. Mangroves are known for secondary metabolites such as amino acids, macro and micro nutrient, tannin content and proximate content (Ariyanto *et al.,* 2018a; Ariyanto *et al.,* 2019a; Ariyanto *et al.,* 2019b; Ningsih *et al.,* 2020). Mangroves are also recognized for their antimicrobial, antibacterial, and antifungal potency (Pringgenies *et al.,* 2021; Pringgenies *et al.,* 2023). Moreover, they can be utilized for carbon storage and sequestration (Hartoko *et al.,* 2015; Sigh *et al.,* 2023; Nwankwo *et al.,* 2023). Mangroves contribute to the food source for marine biota (Ariyanto, 2019) and harbor gastropod biodiversity (Ariyanto *et al.,* 2018b; Ariyanto *et al.,* 2020). Spalding and Arrett (2019) also revealed that mangroves can be utilized for tourism through activities such as exploration, facilities, and the appreciation of key species within mangrove ecosystems. Moreover, mangroves require a synergistic approach and other key elements in an action plan, including the control and regulation of destructive economic activities (Barbier *et al.,* 2011) and the dynamics of litter production (Ariyanto *et al.,* 2019c). Mangrove degradation is linked to livelihoods in fisheries and environmental services (Sadono *et al.,* 2020). In addition sustainability of mangrove forests has received positive perceptions from local communities (Setiyaningrum, 2019). The success of mangrove rehabilitation significantly affects the ecological, social, and economic values of coastal communities (Ellison *et al.,* 2020; Takrina *et al.,* 2023) combining both social and ecological parameters (Budiharta *et al.,* 2016). Chamberland-Fontaine *et al. (*2022) also reported that collaborative governance can systematically enhance the collaboration process. Djosetro and Behagel (2020) reported that open dialogue and local leadership are needed to manage natural resources. East Lampung Regency is a district that has 24 sub-districts, and there are 2 sub-districts that have mangrove forests: Labuhan Maringgai District and Pasir Sakti District. These two sub-districts have the largest mangrove forests compared to others in East Lampung Regency. The increased area of mangrove forests, apart from being influenced by environmental factors, is also influenced by community participation in preserving the environment around mangrove forests. As the area of mangroves increases, the potential for utilizing mangrove resources also increases. Labuhan Maringgai District and Pasir Sakti District have great potential in preserving and utilizing mangrove forests. Mangrove forest conservation in these two sub-districts has been initiated since 2005; therefore, the condition of the mangrove ecosystem is not damaged; however, community participation is needed for mangrove rehabilitation. This study was conducted in Lampung Province and consisted of the Pasir Sakti sub-district. The mangrove area from 2019 to 2021 increased from 350 ha to 374 ha, reflecting a 24-ha increase. This is not significantly different from the mangrove forest in Margasari sub-district, which also experiences yearly increases in forest area. Local communities can play a crucial role in protecting mangrove forests through policy and legislative measures (Taher *et al.,* 2023). However, the conservation of mangrove forests may face challenges, such as marginalizing key stakeholders (Gayo, 2022). To address this, strategic collaboration between institutions is deemed critical for ensuring sustainable rehabilitation (Damastuti *et al.,* 2023). Through community participation in managing and preserving mangrove forests, awareness of the surrounding environment can be heightened. At the end of 2004, a major tsunami disaster occurred, inspiring some individuals and the government about the significance of mangrove forests as natural fortifications against large waves. Additionally, mangrove forests serve as a habitat for the growth and development of various types of marine biota. However, presently, many people are cutting down mangrove forests to create ponds, despite the threat of criminal penalties awaiting them. Based on this explanation, this study aims to identify the best model for developing strategies to increase community participation in mangrove forest rehabilitation in East Lampung Regency in 2023.

MATERIALS AND METHODS

Materials

The survey method was employed to collect samples from the population in Labuhan Maringgai and Pasir Districts (Fig. 1.). Pasir Sakti District is geographically situated at 50°28’29.30” South Latitude 50°37’15.41” South Latitude and 105°42’58.27” East Longitude 105°49’21.30” East Longitude and experiences a tropical climate. The members of the mangrove

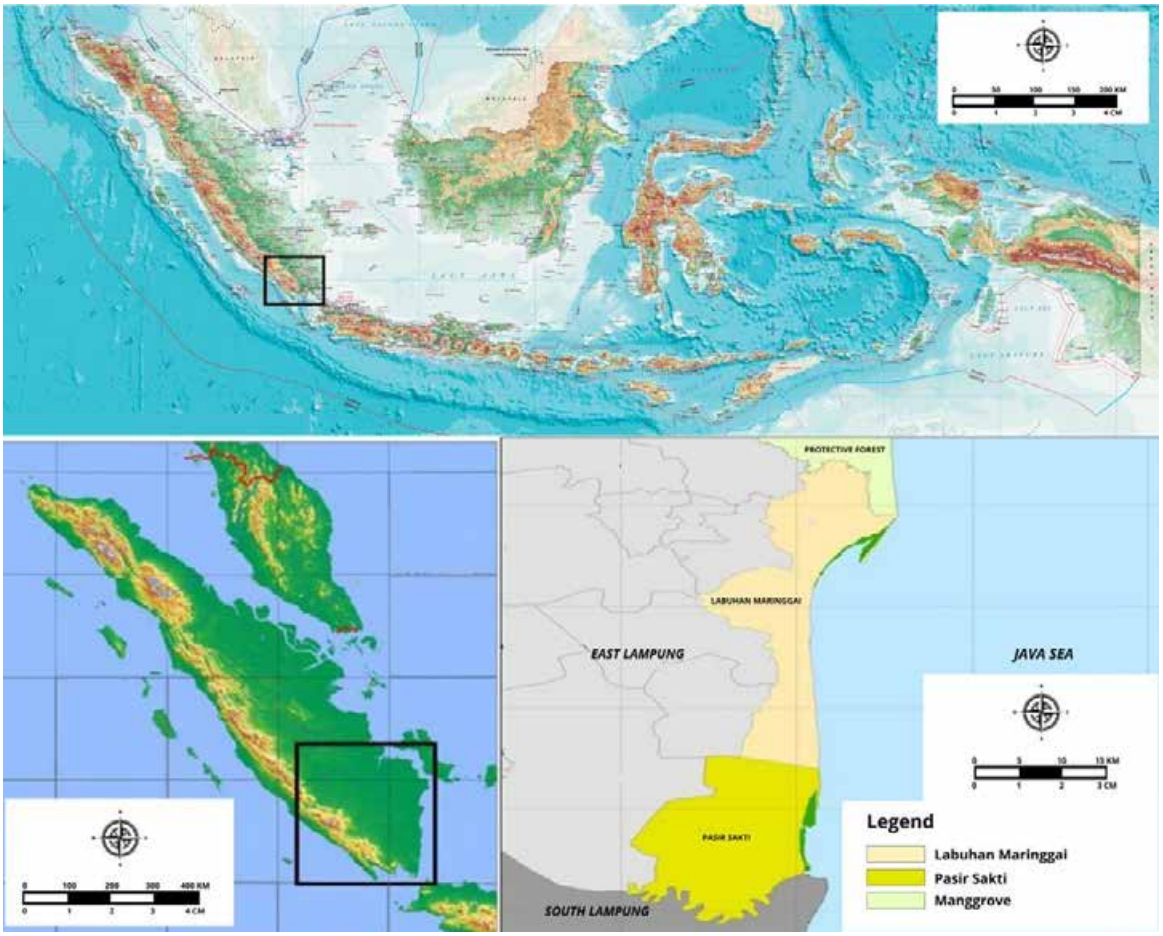


Fig. 1: Geographic location of the study site research, Labuhan Maringgai District and Pasir Sakti District, Lampung, Indonesia

forest management group are 292 people, with a distribution of 140 people in Margasari and 152 people in Pasir Sakti District. The number of samples in Margasari District was taken as 81 respondents, and the number of samples in Pasir Sakti was taken as 87 people, for a total sample of 168 respondents. This was determined using the Slovin formula based on estimating the proportion of the population with a precision consideration of 5 percent. The number of respondents in this study was 168, determined using the Slovin formula from a population of 292. The sampling method in this study employed a simple random sampling method. Questionnaires are created in various formats, either as answer choices illustrating the ranking of responses or in the form of a Likert scale. In a questionnaire featuring a Likert scale, several alternative answers are provided for each statement item, and respondents select the option that aligns with their experiences.

Data collection

The collected data were analyzed using both descriptive statistics and inferential statistics. To offer an overview of individual characteristics (X1), the role of community leaders (X2), the role of farmer groups (X3), government support (X4), NGO support (X5), community participation in mangrove rehabilitation (Y), and the level of welfare (Z), descriptive analysis was conducted employing frequency distribution tables. Meanwhile, to address the second objective, Structural Equation Model (SEM) analysis was employed. The purpose of SEM analysis was to estimate the population (generalization), examining the extent to which independent variables influence

dependent variables, and assessing the compatibility of the study's designed model (hypothetical model) with the real model. The strategy forming was based on the results of SEM analysis. According to Fan *et al.* (2016), SEM is a multivariate data analysis method designed to test measurement models and latent variable structural models. Three main characteristics of SEM can be identified, addressing its limitations:

(1) SEM is a combination of interdependence and dependence multivariate data analysis techniques, specifically confirmatory factor analysis and path analysis.

(2) The variables analyzed in SEM are latent variables (constructs), which are variables that cannot be directly observed (unobservable) but are measured through measurable indicators known as manifest variables.

(3) SEM does not aim to produce models but rather to analyze or confirm theory-based models, specifically measurement models and structural models.

Consequently, there are at least two research problems addressed through SEM:

(1) Descriptive research problems are concerned with describing or empirically confirming the conformity of construct models or "theoretical or hypothetical constructs," viewed according to indicators conceptualized as manifests of the construct.

(2) The problem of explanatory research involves explaining causal relationships between latent variables; this second problem is named the structural model.

Data processing and analysis utilized the SPSS (Statistical Product and Service Solution) version 21 and LISREL (Linear Structural Relationships) 8.8 programs. Qualitative data were employed to provide an explanation of the quantitative data. SEM was conducted using Eq. 1 (Stein *et al.,* 2011).

$$\eta = B_{\eta} + \tilde{I}\xi + \zeta \quad (1)$$

Where;

η = eta, a vector of endogenous variables (latent variable Y)

B = beta (large), a coefficient matrix that describes the influence of other endogenous variables

Ĩ = gamma (large), a coefficient matrix that describes the influence of exogenous variables on endogenous variables

ξ = xi, a vector of exogenous variables (latent variable X)

ζ = zeta, a vector of residuals or errors in the equation

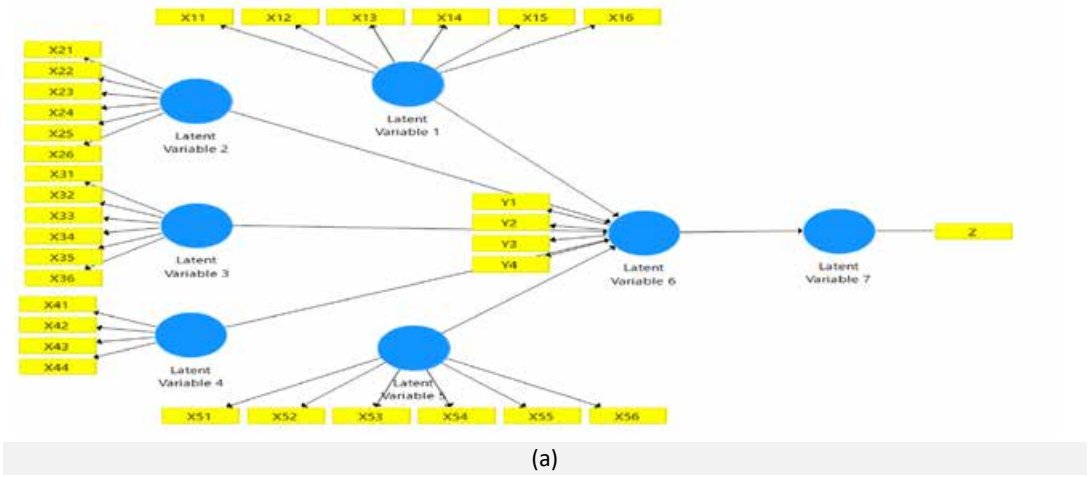
SEM is used to describe a system of linear equations for testing the suitability of the hypothesized "causal" model. Therefore, the initial step involves visualizing the hypothesized model or creating a "path diagram" based on previous theoretical studies. The visualization of the path diagram is presented in 2a and 2b. Both 2a and 2b do not have differences, with the only variation being the placement of Y, changed from being parallel to Z to a vertical position between Y and Z. (Fig. 2a. and Fig. 2b.).

Descriptive analysis is employed to address the initial objective; this analysis solely reveals the extent of participation and distribution of individual characteristics, markedly distinct from SEM analysis. SEM analysis is utilized to identify the best indicators for constructing models. In SEM analysis, if multiple variables and indicators lack influence, they can be eliminated from the structural equation model. The Likert scale was utilized in this study as a closed question type, and the data type utilized for this investigation is ordinal data. Data tabulation was employed to gather responses from the participants. The Smart PLS application, along with SEM analysis, was utilized to process the data. The Likert scale was utilized in this study as a closed question type. The data type used for this investigation is ordinal data. In this study, data tabulation was utilized to collect responses from respondents. The Smart PLS application with SEM analysis is used to process the data.

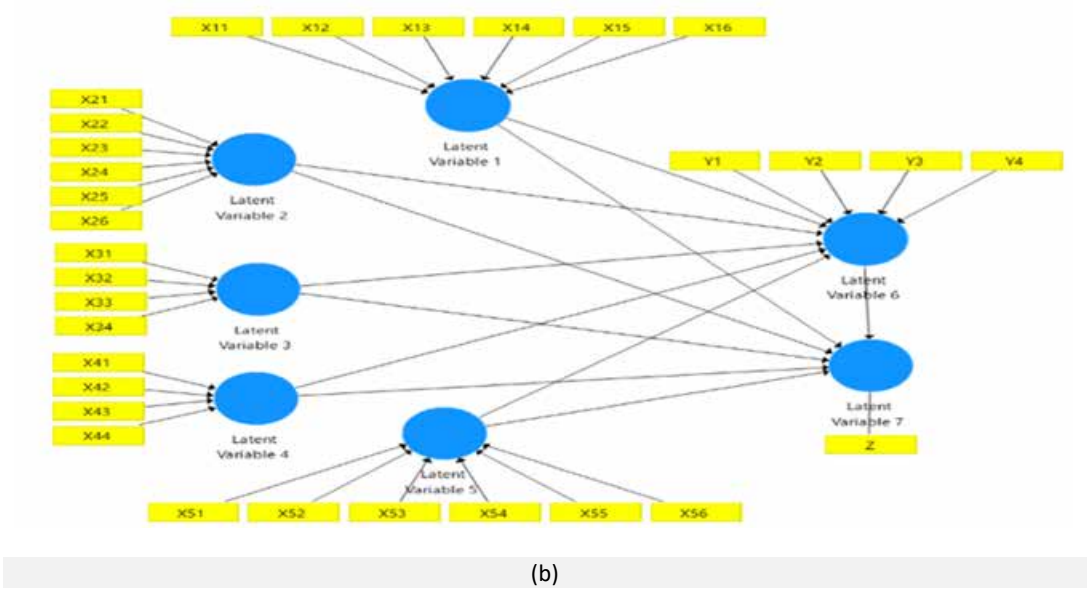
RESULTS AND DISCUSSION

Individual characteristics (X1)

Indicators of individual characteristics encompass age, level of formal education, level of non-formal education, number of family dependents, length of residence, and distance to the mangrove forest (Table 1). The three defined categories based on value include low (corresponding to the smallest score or bottom value), middle (spanning the range between the highest and lowest values), and high



(a)



(b)

Fig. 2: Initial model of strategy to increase the participation of coastal communities in mangrove rehabilitation (a) the first structural equation modeling (b) the second structural equation modeling.

(reflecting the biggest score or top value). The distribution of respondents by age group ranged from 19 to 72 years. The average respondent in the study was 42 years old, falling within the productive age category. Individuals in this age range typically possess good physical ability to engage in various activities, including participation in mangrove rehabilitation. Moreover, older communities remain active and eager about involvement in mangrove conservation. Elderly individuals, who bring more experience and knowledge, tend to feel satisfied with their achievements (Inayat and Jahanzeb Khan, 2021). Guo *et al*. (2015) revealed that training and policy development are necessary to alter the age at which farmers engage in regeneration. Other research has also suggested that farmers require education to effectively compete in a liberal economy (Fielke and Bardsley, 2014). All respondents in the study location have received education and have experience, enabling them to think critically and hold viewpoints on preserving mangrove forests. Most of the respondents had education at the junior high

Table 1: Individual characteristic

No	Characteristics	Classification	Class(score)	Number of people	%
1	Age Average 42 years old	Unproductive	0-14	0	0.00
		Productive	15-64	163	97.02
		Non-Productive	>65	5	1.41
2	Formal Education	Elementary School	6 years	27	16.07
		Middle School	9 years	65	38.69
		High School	12 years	62	36.90
		University	More than 14 years	14	8.33
3	Non-formal Education	Low	0-1 times	92	54.76
		Middle	1-2 times	59	35.12
		High	2-3 times	17	10.12
4	Number of Family 3 people	Low	0-2 people	60	35.71
		Middle	2-4 people	89	52.98
		High	4-6 people	17	11.31
5	Length of Stay 27,2 years	Low	11-32 years	110	65.48
		Middle	33-52 years	55	32.74
		High	53-72 years	3	1.79
6	Distance to Mangrove 2.32 kilometer (km)	Low	1-2 km	93	55.36
		Middle	2-3 km	45	26.79
		High	3-4 km	30	17.86

school level as 38 percent (%) and high school level (36%). Less than 10% of respondents had higher education. Formal education is considered one of the efforts to increase knowledge and change the mindset of individuals, as well as to help extension agents advance in their careers (Listiana *et al.,* 2019). Formal education serves to develop abilities, improve the quality of life, and enhance human dignity both individually and socially (Phiri *et al.,* 2020; Bellaire *et al.,* 2023).

Most respondents (61.29%) have attended non-formal education or training related to mangroves, with the majority (61.29%) having participated in training 1–2 times. The non-formal education encompasses seminars, training, and socialization related to mangrove conservation. Non-formal education can enhance people's practical skills in mangrove conservation, thereby strengthening their participation and having a greater impact. The more farmers participate in extension activities, the higher the success of the extension services delivered, subsequently increasing their knowledge (Antwi-Agyei and Tringer, 2021). The length of stay is the duration a person has lived in the area or the length of time people have inhabited an area. The respondents' length of stay was ranked between 11 and 32 years, comprising 65.48%, with an average of 27.2 years. Through participation in community activities, such as environmental conservation groups or local community organizations, communities can actively contribute to mangrove conservation efforts (Arifanti *et al.,* 2022).

The role of community leaders (X2)

Community leaders wield extensive influence and authority in society, actively leading, guiding, and influencing community direction and policy (Table 2). The role of a public figure refers to the role played by individuals in a group or community. As a result, these individuals were motivated to play a role in protecting mangrove resources. They expressed the urgent need for a new strategic approach to recover and conserve the resources, leading to the creation of the community network. The role of community leaders falls within the middle category; some people believe that community leaders have performed their duties and functions quite well. The role of community leaders is crucial in mobilizing community participation in mangrove conservation through motivation and inspiration, information delivery, education and training, as well as collaboration with opinion leaders. The presence of community leaders

Table 2: Level of community leaders' role

No	Statement	Classification	Number of People	%
X2	Role of Community Leaders	Low (7-10)	39	23.21
		Middle (11-14)	76	45.24
		High (15-18)	53	31.55
	Average (13.28)	Middle		
X21	Community leaders monitor RHL	Low	27	16.07
		Middle	70	41.67
		High	71	42.26
X22	Community leaders invite the community to take part in the RHL program	Low	23	13.69
		Middle	90	53.57
		High	55	32.74
X23	Community leaders provide information regarding the RHL program	Low	12	7.14
		Middle	63	37.50
		High	93	55.36
X24	Community leaders provide support in implementing the RHL program	Low	20	11.90
		Middle	73	43,45
		High	75	44,64
X25	Community leaders provide rewards/witnesses to RHL perpetrators	Low	46	27.38
		Middle	81	48.21
		High	41	24.40
X26	Community leaders set an example for preserving forests	Low	47	27.98
		Middle	65	32.34
		High	56	27.86

who support and are actively involved can positively influence communities to participate in mangrove conservation efforts.

The role of farmer groups (X3)

Table 3 shows the role of farmer groups in empowering their members. This role involves a series of activities and functions carried out by farmer groups, serving as a vehicle for learning, organization, cooperation, and as a forum for production units dedicated to learning. Farmer groups can serve as agents of community empowerment in mangrove conservation by providing education, training, and information to group members and local communities about the importance of mangroves and how to maintain their sustainability. In addition, farmer groups can mobilize their members and other communities to participate in mangrove conservation activities, such as mangrove tree planting programs or cleaning mangrove areas, by providing facilities and infrastructure. Farmer groups support the information flow and contribute to the best performance (Fischer and Qaim, 2012; Abdul-Rahaman and Abdulai, 2020).

Government support

Government support involves the involvement of the government apparatus in mangrove conservation. The indicators utilized include facilities, policies, guidance, and financing, which are then classified (Table 4). Mangrove conservation efforts in the community of Purworejo Village, Pasir Sakti District, according to respondents' assessments, have only received government support in terms of funding and supervision, extending from the neighborhood harmony level to the village. Additionally, the community has also contributed support. Through government policies, a legal basis for mangrove protection and management can be established. With regulations in place, the community will feel more encouraged to participate in mangrove conservation efforts and comply with existing rules. The government can encourage the empowerment of local communities in mangrove conservation through training programs, skill development, and authorization (Sam *et al.*, 2023). To support mangrove rehabilitation in Indonesia, the government is implementing the Mangrove for coastal resilience

Table 3: Level of farmer groups' role

No.	Statements	Classification	Number of people	%
X3	The Role of Famer Groups	Low (4-6)	44	26.19
		Middle (7-9)	50	29.76
		High (10-12)	74	44.05
	Average (8.85)	Middle		
X31	The place to learn	Low	32	19.05
		Middle	32	19.05
		High	104	61.90
X32	The place to organize	Low	32	19.05
		Middle	77	45.83
		High	59	35.12
X33	The place to collaboration	Low	39	23.21
		Middle	64	38.10
		High	65	38.69
X34	The place to production unit	Low	38	22.62
		Middle	73	43.45
		High	57	33.93

Table 4: Level of government support

No.	Statement	Classification	Number of People	%
X4	Government Support	Low (5-7)	34	20.24
		Middle (8-10)	100	59.52
		High (11-12)	34	20.24
	Average (9,16)	Middle	-	-
X41	The government provides policies to regulate mangrove forest conservation.	Low	21	12.50
		Middle	85	50.60
		High	62	36.90
X42	The government provides funding support for the RHL program	Low	18	10.71
		Middle	67	39.88
		High	83	49.40
X43	The government provides assistance/counseling regarding the RHL program	Low	17	10.12
		Middle	68	40.48
		High	83	49.40
X44	Rewards/Punishments from the government are given to RHL program participants	Low	23	13.69
		Middle	99	58.93
		High	46	27.38

(M4CR) program. This study can furnish valuable insights for the government to formulate suitable strategies aimed at enhancing community engagement in mangrove forest rehabilitation. As community participation in mangrove rehabilitation grows, so too will the resilience of the mangrove forest ecosystem.

The role of non-governmental organizations

Non-governmental organizations (NGOs) play a crucial role in encouraging community participation in mangrove conservation through education, community engagement, monitoring, advocacy, and collaboration with the government and other institutions. The beneficiaries of mangrove rehabilitation are the surrounding communities; however, this does not preclude the opportunity for outsiders to participate in mangrove rehabilitation. The involvement of NGOs in community empowerment programs entails a significant level

Table 5: Level of non-government organization' role

No.	Statement	Classification	Number of people	%
X5	Non-Government Organization	Low (8-11)	38	22.62
		Middle (11-14)	90	53.57
		High (14-17)	40	23.81
	Average (12.92)	Middle	-	-
X51	Contribute ideas about managing the RHL program	Low	18	10.71
		Middle	114	67.86
		High	36	21.43
X52	Provide assistance in managing the RHL program	Low	35	20.83
		Middle	61	36.31
		High	72	42.86
X53	Provide assistance/counseling regarding the RHL program	Low	5	2.98
		Middle	107	63.69
		High	56	33.33
X54	Involved in RHL program planning	Low	36	21.43
		Middle	80	47.62
		High	52	30.95
X55	Involved in implementing the RHL program	Low	19	11.31
		Middle	80	47.62
		High	69	41.07
X56	Involved in RHL program evaluation	Low	60	35.71
		Middle	64	38.10
		High	44	26.19

of active community participation (Table 5). The beneficiaries of mangrove rehabilitation are the surrounding communities; however, it does not preclude the opportunity for outsiders to participate in mangrove rehabilitation. The involvement of NGOs in community empowerment programs includes significant active community participation. NGOs are frequently engaged in education and environmental awareness activities related to mangrove conservation. For example, they organize educational programs about the importance of mangroves, the threats they face, and the benefits of conservation. Since community participation in mangrove rehabilitation is in the low category (49.75%), there is still a lot of room for improvement. In the Non-formal education variable, the significance value is 0.29, indicating a relationship between non-formal education and community participation. However, respondents' responses are in the low category (54.76%), showing that the majority of people have only been there once or have never received training, workshops, or related education on mangrove rehabilitation. The government can enhance existing programs to increase community participation. Personal approaches, socialization, training or workshops, routine supervision, as well as financial assistance, are suggested to improve the effectiveness of the planned programs.

Level of community participation in mangrove conservation

Mangrove conservation efforts involve various forms of actions taken to protect and maintain the sustainability of mangrove ecosystems. Community participation in mangrove conservation involves a comprehensive process that includes planning, implementing, evaluating, and utilizing the results, as depicted in Table 6. Notably, community-based mangrove management (CBMM) plays a crucial role in enhancing mangrove resource management and livelihoods (Damastuti and Groot, 2017). Additionally, Datta *et al.* (2012) highlight that socio-political and institutional factors can be influenced within the CBMM framework.

Table 6: Level of community participation in mangrove conservation

Component	Classification	Number of people	%
Community participation	Low	33	19.64
	Middle	116	69.05
	High	19	11.31
Planning	Low	122	72.62
	Middle	34	20.24
	High	12	7.14
Implementing	Low	22	13.10
	Middle	100	59.52
	High	46	27.38
Evaluating	Low	59	35.12
	Middle	98	58.33
	High	11	6.55
Result Utilizing	Low	14	8.33
	Middle	79	47.02
	High	75	44.64

Planning

Planning in mangrove rehabilitation involves determining the number of mangroves to be planted, the area of land to be planted, planting locations, planting time, and securing funding. However, some communities are not actively engaged in this process. The low participation of the community in planning can be observed through their reduced activity in submitting proposals related to mutual assistance and mangrove planting. Decisions regarding mangrove rehabilitation are predominantly made by community leaders and group administrators. To enhance livelihoods and promote sustainable management, local communities can increase their engagement and support (Mbeche *et al.,* 2021).

Implementing

The implementation of conservation involves activities such as mangrove planting, encompassing site selection, the right selection of mangrove types, and direct planting. The management and maintenance of mangrove conservation pertain to the community's role in overseeing and sustaining mangroves post-planting. Tasks include pruning, monitoring plant growth, cleaning designated areas, and protecting animals residing in mangroves, as outlined in Table 6. The overall implementation stage of mangrove conservation implementation indicators falls within the medium category on average.

Evaluating

Evaluation activities are related to the assessment of the impact of activities that have been carried out previously. The community is involved in assessing the impact of mangrove conservation activities on both the environment and local communities. Community participation in Labuhan Maringgai and Pasir Sakti subdistricts is classified as low, primarily because it relies solely on existing programs without significant personal awareness from the community. Ideally, if the community actively participates in mangrove rehabilitation, the resilience of the mangrove ecosystem can increase, thereby positively impacting community welfare. Monitoring activities can be tailored to local needs, aspirations, and capacities for forest restoration, providing accountability, scalability, and adaptability in the process (Evans *et al.,* 2018).

Structural equation testing increase community participation in mangrove rehabilitation

This test was conducted to identify the best strategy for increasing participation and to analyze factors thought to influence community participation in mangrove conservation. The community believes that government support for mangrove rehabilitation has not been optimal, and not all communities fully understand the importance of mangrove forests. Some individuals still open mangrove forests for use as ponds. To develop a model for determining the right strategy to increase community participation, it is essential to identify the main factors influencing community involvement. The factors influencing community capacity include X3, the role of figures;

X3, the role of farmer groups; X4, government support; and X5, NGO involvement. The welfare of the community is affected by Y, community involvement in mangrove rehabilitation. The results of hypothesis testing can clearly be seen in Fig. 3. The SEM analysis test results are clearly presented in the goodness-of-fit model testing table (Table 7). The final result of the structural model constitutes the answer to the study problem or hypothesis proposed, specifically predictions regarding causal relationships or influences between variables. Overall, to examine the direct and indirect influence between variables, the study performed a decomposition of the influence among variables. The decomposition of influence between

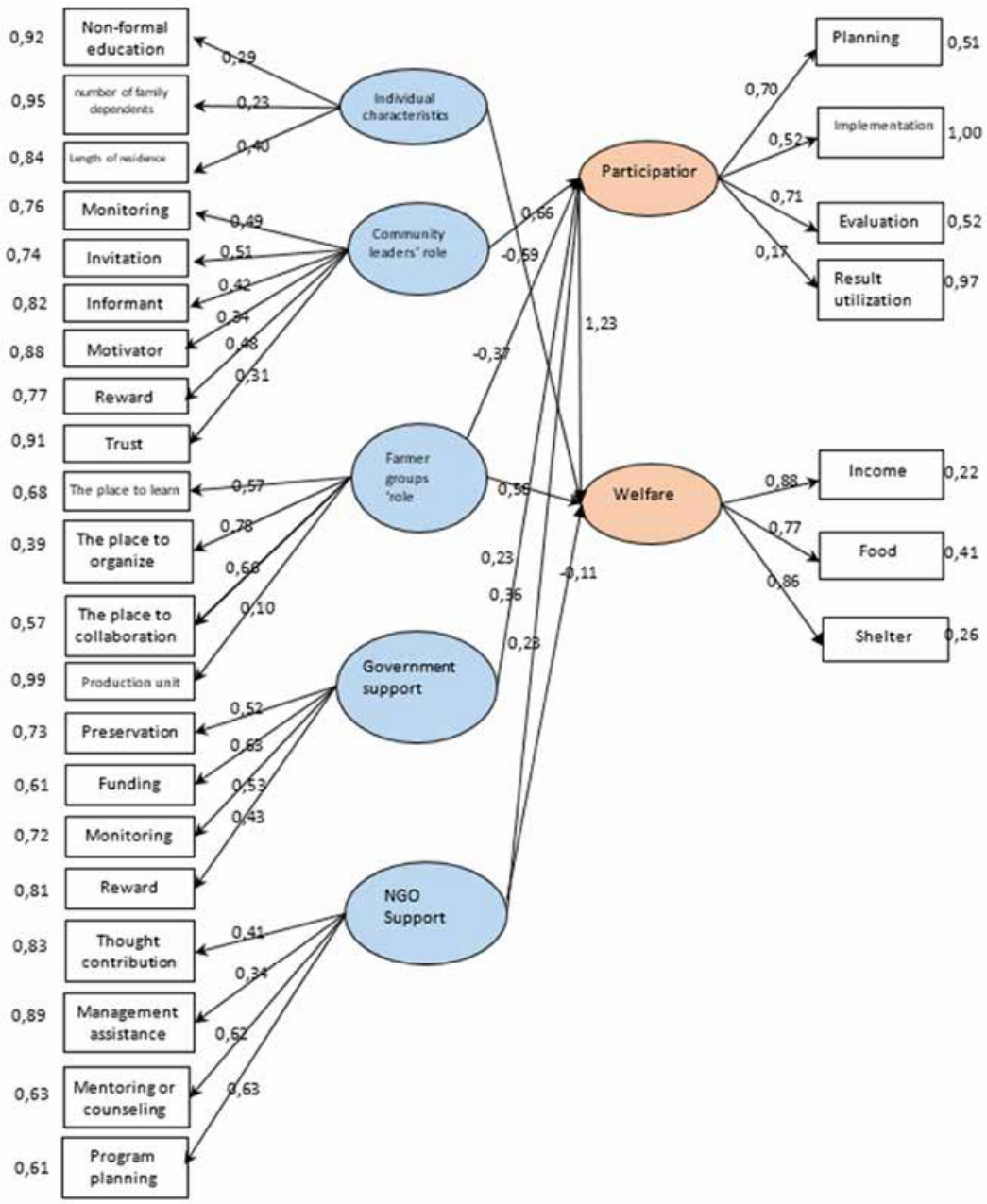


Fig. 3: Structural model of increasing community participation

Table 7: The goodness of fit model testing

Goodness-of-fit	Cut of value	Result	Conclusion
RMSEA	0,05≤RMSEA≤0.08	0.074	*good fit*
GFI	≥ 0.90	0.79	*fit*
AGFI	≥ 0.90	0.74	*fit*
CFI	≥ 0.90	0.83	*fit*
IFI	≥ 0.90	0.83	*fit*
NFI	≥ 0.90	0.73	*Fit*
NNFI	≥ 0.90	0.81	*fit*

Table 8: SEM model estimation results

Variables influence	Standardized loading factor	|t-hit| > 1.96	Conclusion
X_2 The Role of Community Leaders à Y Community Participation	0.66	2.78	Significant
X_3 The Role of Farmers Group à Y Community Participation	-0.37	-2.33	Significant
X_4 Government Support à Y Community Participation	0.36	1.32	Significant
X_5 NGOs' Support à Y Community Participation	0.23	1.14	Significant
X_1 Individual Characteristic à Z Income	-0.59	-1.48	Significant
X_3 The Role of Farmers Group à Z Income	0,56	1,37	Significant
X_5 NGOs' Support à Z Income	-0,11	-0,33	Significant
Y Community Participation à Z Income	1.23	2.73	Significant

variables involves separating the total influence into direct and indirect influences. Direct influence represents the impact of an independent variable on the dependent variable without going through any other variable. The influence of an indirect variable indicates the influence of an independent variable on a bound variable, occurring through one or more other variables conceptualized as intermediate variables. Drawing from the structural model parameter estimation image, one can elucidate the direct and indirect influences between the variables tested in the study. Table 8 presents a brief summary of the causal relationship between the study's latent variables, along with t-values as statistical tests.

SEM constitutes a flexible and comprehensive methodology for representing, estimating, and testing a theoretical model with the objective of explaining as much variance as possible. Referred to as causal models with a prominent presence in the field of consumer psychology, SEM allows for complex modeling of correlated multivariate data to elucidate interrelationships among observed and latent variables (Ramlal, 2016). This study employed SEM to analyze the factors associated with public participation in mangrove rehabilitation. (Fig. 3). The SEM analysis test results are clearly presented in the goodness-of-fit model testing (Table 7). The final result of the structural model provides the answer to the study problem or hypothesis proposed, specifically predictions about causal relationships or influences between variables.

Overall, to see the direct and indirect influence between variables, the study carried out decomposition of the influence between variables. Decomposition between variables involves the separation of total influence into direct and indirect influence. Direct influence refers to the influence of an independent variable on a dependent variable without the involvement of any intervening variables. In contrast, indirect influence signifies the effect of

an independent variable on a dependent variable mediated by one or more intermediate variables. Based on the image of the estimation of structural model parameters, it can be explained that the direct influence and indirect influence among the variables of the research can be explained. Table 8 presents a brief summary of the causal relationship between study's latent variables, along with the corresponding t values as statistical tests.

Factors related to extension capacity

The influence of community leaders' role with participation

Hypothesis testing was conducted to examine the relationship between the role variables of community leaders (X8) and community participation in mangrove conservation (Y). The statistical analysis employed the Spearman Rank test, revealing a correlation coefficient (rs) value of 0.424. Kongkeaw *et al.,* (2019) reported that internal success factors, particularly leadership, play a key role in mangrove management.

The effect of government support with participation

This hypothesis analysis revealed a correlation between government support (X10) and community participation in mangrove conservation (Y). The variables of government support (X10) and community participation in mangrove conservation (Y) were carried out using the Spearman Rank test, yielding a correlation coefficient (rs) value of 0.366. The significance level obtained, at 0.004, is smaller than α (0.01). Consequently, the decision is made to accept H1, indicating that government support (X10) has a significant positive relationship with community participation in mangrove conservation (Y). The magnitude of this close relationship between government support (X10) and participatory community involvement in mangrove conservation (Y) is 36.6%. Government support is significantly related to participatory community involvement in mangrove conservation. The government plays an important role in establishing policies and regulations that support mangrove conservation. With a clear legal framework and support from the government, communities will be more encouraged to be involved in mangrove conservation because they see the government's commitment and responsibility to protect these ecosystems. The government is supported by Regulation No. 03/MENHUT-V/2004 (Minister of Forestry and Environment) for protecting mangroves. Damastuti and de Groot (2019) reported that government institutions have various efforts to protect mangrove areas, such as addressing tidal floods and erosion in Demak. The government plays a role in monitoring mangrove ecosystems. By involving communities in mangrove monitoring and management activities, the government can strengthen community participation in decision-making related to conservation. This fosters a sense of responsibility and shared ownership of the mangrove ecosystem, thereby encouraging more active participation.

The Influence of non-government organization role with participation

The Spearman Rank test was conducted to analyze the relationship between non-government organization variables (X11) and community participation in mangrove conservation (Y). The correlation coefficient (rs) value obtained was 0.268. The significance level, calculated at 0.038, is smaller than α (0.05). Therefore, the decision is to accept H1, indicating that non-government organizations (X11) are significantly related in a positive direction to community participation in mangrove conservation (Y). The magnitude of the relationship between non-government organizations (X11) and community participation in mangrove conservation (Y) is 26.8%. NGOs often play a leading role in organizing mangrove conservation activities. They form local working groups or initiatives that focus on mangrove conservation, coordinate field activities, and organize necessary resources and manpower. Good leadership and coordination from NGOs can enhance community participation in mangrove conservation. NGOs can provide training and assistance to communities in mangrove conservation techniques, resource management, and skills development related to environmental conservation. By increasing the capacity of communities, NGOs enable them to engage more effectively in mangrove conservation and take an active role in field activities. NGOs play a major role in decision-making in an area so that the community can express their aspirations (Abiddin *et al.,* 2022; Rahman and Tasnim, 2023). Social participation activities involve interacting with others in the community and must specifically involve others

(Levasseur *et al.,* 2010). To increase community participation, Figure 3 proposes an approach that emphasizes the role of leaders. These leaders should fulfill several key functions: supervising community activities, inviting new members, providing information and motivation, distributing rewards to engaged participants, and building trust within the community. Additionally, the government should offer its full support by providing funding, supervision, rewards, and preservation efforts. Furthermore, NGO involvement is crucial for offering thought leadership, management assistance, mentoring, and program planning). The SEM results indicate that increasing community participation relies on enhancing the role of leaders. Leaders should undertake tasks such as supervision, invitation, Einformation provision, motivation of the community, offering rewards to engaged community members, and fostering trust. Full support from the government, including funding, supervision, rewards, and preservation efforts, is crucial. Additionally, NGO involvement, encompassing thought contribution, management assistance, mentoring, and program planning, plays a significant role. Participation influences welfare; the more active the community, the more space there will be to utilize mangrove products and interact with other community members. This interaction enables the fulfillment of income, food needs, and the provision of adequate housing. The type of training that could be arranged for the community is Ecological Mangrove Rehabilitation (EMR), which has been implemented in South and North Sulawesi. EMR has been successfully implemented and well-documented for the past several decades in New World mangrove systems (Lewis, 2005) and was selected as a best practice for adaptation and trials in Indonesia. Mangroves can be restored or conserved through specific actions. First, for a given area of mangroves or former mangroves, it is essential to define the existing watershed and document any changes to the coastal plain hydrology that may have impacted the mangroves. Second, careful site selection must take place, considering the history of the site. This will likely involve an investigation of historical maps, aerial and satellite photography, and mapping of changes over time. Third, clearly stated objectives and achievable, measurable success criteria should be defined and incorporated into the proposed monitoring program. Fourth, restoration methodologies should acknowledge a history of routine failures in efforts to rehabilitate mangroves and propose the use of techniques that have proven successful. Fifth, once the initial restoration activities are complete, the proposed monitoring program should be initiated and used to determine whether the project achieved interim measurable success to indicate whether mid-course corrections are needed. Finally, results should be made available for others to learn from documented successes and failures. Village administrators can play a crucial role in protecting mangrove conservation through village laws, and their role must be strengthened as a national agenda. Through the promotion of ecotourism activities, mangrove rehabilitation can contribute to enhancing community welfare. Ecotourism activities aim to conserve the ecosystem while also preserving or improving the welfare of local people. The ecotourism and educational functions in mangrove forests can be developed, such as sightseeing the beauty of flora and fauna, as well as boating around the mangroves. In districts like Labuhan Maringgai and Pasir Sakti, training programs in mangrove tourism, forest honey cultivation, and crab farming are offered. These activities could serve as viable alternative livelihoods for local communities. The enhancement of community welfare can be achieved through the generation of increased incomes from these ecotourism and sustainable economic activities.

CONCLUSION

This study concludes that community participation in mangrove ecosystem rehabilitation in Labuhan Maringgai sub-district and Pasir Sakti sub-district is in the middle category level. It involves a low planning process, high implementation category, low participation in evaluation, and a high category in the utilization of results. Community involvement in mangrove rehabilitation can be increased with support from the government, community leaders, and NGO involvement. Additionally, the existence of farmer groups needs to be reviewed so that their presence can increase community participation. Communities actively involved in mangrove rehabilitation, both in implementation and result utilization, can improve community welfare, including income and access to clothing and shelter. The findings of this study indicate that community engagement in mangrove forest rehabilitation activities in Labuhan Maringgai District

and Pasir Sakti District falls within the middle category. This suggests that there is still room for improvement in the level of participation, as the involvement of farmers in the middle category indicates a lack of public awareness regarding mangrove rehabilitation. Community participation, encompassing both the planning and evaluation of activity outcomes, remains in the low category. This could be attributed to the direct involvement of village administrators and officials in the development of mangrove rehabilitation strategies, with other members only being informed of decision outcomes. Similarly, the assessment of activities is conducted by village authorities and affiliated organizations. The level of engagement in mangrove rehabilitation initiatives, however, is in the high category. This is primarily because respondents were at the forefront of these endeavors, demonstrating their active participation in various activities such as planting, establishing nurseries, and advocating for mangrove conservation. The high level of participation in utilizing results is justified due to the community's direct and indirect exposure to the advantages provided by mangrove forests. Community participation in mangrove rehabilitation can be enhanced through the backing of governmental support, community leaders, and NGOs. However, to increase community engagement, an examination of the viability of farmer groups is necessary. Community welfare can be enhanced through the implementation and utilization of the results of mangrove rehabilitation, including income, access to clothing, and residence. The recommended strategy for mangrove conservation involves adopting an ecological systems approach. By employing this approach, coastal communities residing in mangrove forest areas gain a comprehensive perspective for studying environmental factors within mangrove ecosystems. The primary objective is to deepen understanding of organism development within these ecosystems. This approach views humans as integral components of the system, emphasizing a positive reciprocal relationship between humans and the environment. Various strategies for mangrove conservation planning incorporate Ecosystem Service Economic Valuation (ESEV). Ecosystem services, defined as the well-being provided by natural ecosystems to humans, necessitate a connection to human well-being and socio-economic values. This integration of human needs is coupled with environmentally friendly eco-farming practices, made accessible through boardwalks that promote ecotourism and public education. To enhance community participation in mangrove rehabilitation, the Participatory Rural Appraisal (PRA) method is employed. Implementation involves multiple communities facilitated by external entities such as NGOs and the Government. This approach adopts a "personal approach" by paying attention to and considering and addressing the specific needs of the community as the primary focus. Various mangrove conservation planning efforts include discussions and consultation activities. The community considers government support essential for mangrove rehabilitation, and communities understand the importance of mangrove forests. Community leaders have broad influence and authority in society, playing an active role in leading, guiding, and influencing community direction.

AUTHOR CONTRIBUTIONS

I. Listiana has designed research, collected data, conducted data analysis, interpreted data, and wrote the manuscript. D. Ariyanto has designed research, prepared the manuscript, wrote the manuscript, corrected the manuscript, and interpreted data.

All authors declare equal contributions.

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CONFLICT OF INTERES

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy have been completely observed by the authors.

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ABBREVIATIONS

%	Percent
α	Alpha
CO_2	Carbon dioxide
CBMM	community-based mangrove management
EMR	Ecological mangrove rehabilitation
ESEV	Ecosystem service economic valuation
km	Kilometer
LISREL	Linear structural relationships
M4CR	Mangrove for coastal resilience
MENHUT	Minister of Forestry and Environment
NGO	Non-governmental organization
PRA	Participatory rural appraisal
SEM	Structural equation modeling
SPSS	Statistical package for the social sciences

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