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CASE STUDY

Structural equation modeling for social capital empowerment in supporting mangrove rehabilitation

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ABSTRACT

BACKGROUND AND OBJECTIVES: Improving welfare requires continuous and various efforts, including enhancing social capital and local institutions for the preservation of mangrove forests. Reinforcing local social and institutional capital to enhance mangrove ecosystems is crucial for understanding the intricate social systems necessary to conserve, manage, and restore mangrove ecosystem services. The purpose of this study is to determine the relationship between social capital and social institutions with the sustainability of mangrove rehabilitation in the Teluk Pandan and Padang Cermin districts of Lampung, Indonesia, in 2023.

METHODS: This study analyzes the role of local social and institutional capital in the welfare of communities residing around mangrove forests in the Way Ratai district of Pesawaran Regency. This study employs a survey research approach, drawing samples from the population, and utilizes both quantitative and qualitative data analysis. A sample of 300 respondents was selected based on the guidelines for Structural Equation Model analysis. The study was carried out in two sub-districts of Pesawaran Regency. The districts were deliberately chosen due to the fact that they are designated mangrove forest rehabilitation areas. Data collection took place from July to December 2023. Data analysis involved tabulation techniques and Structural Equation Model analysis using Linear Structural Relations.

FINDINGS: The findings suggest that social institutions, such as customary practices, sanctions, and conflict, have a negative impact on mangrove rehabilitation and welfare. Increasing the social capital of communities surrounding mangrove forests has a significant influence on mangrove rehabilitation and welfare, including the fulfillment of basic needs like shelter, food, access to healthcare, and education. Community leaders oversee activities, encourage community involvement in mangrove rehabilitation, and ensure the smooth running of government programs.

CONCLUSION: Social capital can be enhanced through group meetings, social gatherings, initiatives to raise awareness about tourism, and mangrove conservation groups. The goal of empowerment is to create self-sufficient and socially empowered communities capable of meeting their physical, economic, and social needs. This fosters self-confidence and allows them to voice their aspirations, secure their livelihoods, engage in social endeavors, and face life independently. Social capital influences community participation in mangrove rehabilitation.

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INTRODUCTION

There is a large distribution of mangrove ecosystems in Indonesia—the largest in the world. These ecosystems are characterized by their complexity, housing flora and fauna (Ariyanto *et al.,* 2018; Ariyanto, 2019; Ariyanto *et al.,* 2020). Mangroves are resilient plants that thrive in high-salinity and waterlogged areas. They have many functions, such as fighting bacteria and fungi (Pringgenies *et al.,* 2021; Pringgenies *et al.,* 2023a), providing protein and tannin (Ariyanto *et al.,* 2019a), element contents (Ariyanto *et al.,* 2019b), and amino acids (Ningsih *et al.,* 2020). They also serve as natural batik dye (Pringgenies *et al.,* 2023b), boosting local economies (Su *et al.,* 2021). The primary responsibility of development programs is to empower communities. This empowerment can be traced across various domains, including the economic, physical, and material domains, as well as within institutions, cooperative endeavors, and intellectually. Moreover, it entails a mutual commitment to implementing empowerment principles. In the context of this study, empowerment is closely related to the concept of community independence. The objective of development programs is to cultivate independent and prosperous individuals and communities. Components of social capital that can be used to preserve mangrove ecosystems include trust (mutual trust and transparency toward the community), networks (mangrove rehabilitation must be carried out collectively), and norms (there are penalties for destroying mangroves; if broken, programs would be unable to provide assistance and participate actively). Local institutional components in preserving mangroves include customs, sanctions (punishments for destroying mangroves), and conflict (communities can reduce conflicts that disrupt mangrove rehabilitation and mangrove management). Community independence is a state in which communities possess the capacity to analyze, decide, and take appropriate action to address challenges using their inherent capabilities (Green, 2016). This state is realized when communities are economically prosperous and have access to necessities such as clothing, habitation, proper nutrition, health care, and educational facilities. Achieving community welfare necessitates continuous learning, facilitated by the reinforcement of social capital and social institutions (Watson, 2019; Shrestha, 2021). Enhancing community welfare requires a collective effort that impacts individual well-being. Thus, societal welfare improvement necessitates the development of a collective societal identity (Castellacci, 2023; Hietschold *et al.,* 2023). Improving the welfare of coastal communities is a form of empowerment aimed at optimizing and sustainably managing mangroves and marine resources to enhance their well-being. The primary objective of mangrove resource management is forest conservation, which necessitates the reinforcement of social capital, local institutions, and social structures, particularly among vulnerable groups facing internal challenges such as perceptions or external pressures from unjust societal systems. Consequently, enhancing welfare is both a process and a goal involving a series of activities to empower communities, especially those in need. Economic reasons were the major motivation for replanting mangroves (Aheto *et al.,* 2016), and the allocation of property rights is a prerequisite to integrated conservation (Roy, 2016). As one of the regions in Lampung Province, Pesawaran is endowed with mangrove forests. The mangrove forests in Pesawaran are actively preserved, and some parts are designated for ecotourism purposes. The study was deliberately done in the Padang Cermin and Teluk Pandan districts because both districts have ongoing mangrove rehabilitation programs and mangrove forests designated for ecotourism that involve local communities and community leaders. These programs align with the goal of this study, which is to investigate whether social capital, social institutions, and stakeholder roles influence mangrove rehabilitation and well-being. Conservation has the potential to facilitate emission reduction and enhance environmental stewardship (SaberiKamarposhti *et al.,* 2024) and sequestration (Kamyab *et al.,* 2024). The problem addressed in this study revolves around assessing the levels of community welfare and mangrove rehabilitation, as well as examining the roles of social capital and social institutions. The purpose of this study is to determine the relationship between social capital and social institutions and the sustainability of mangrove rehabilitation in Teluk Pandan and Padang Cermin, Lampung, Indonesia, in 2023.

MATERIALS AND METHODS

Study area

Surveys were the main sampling method employed

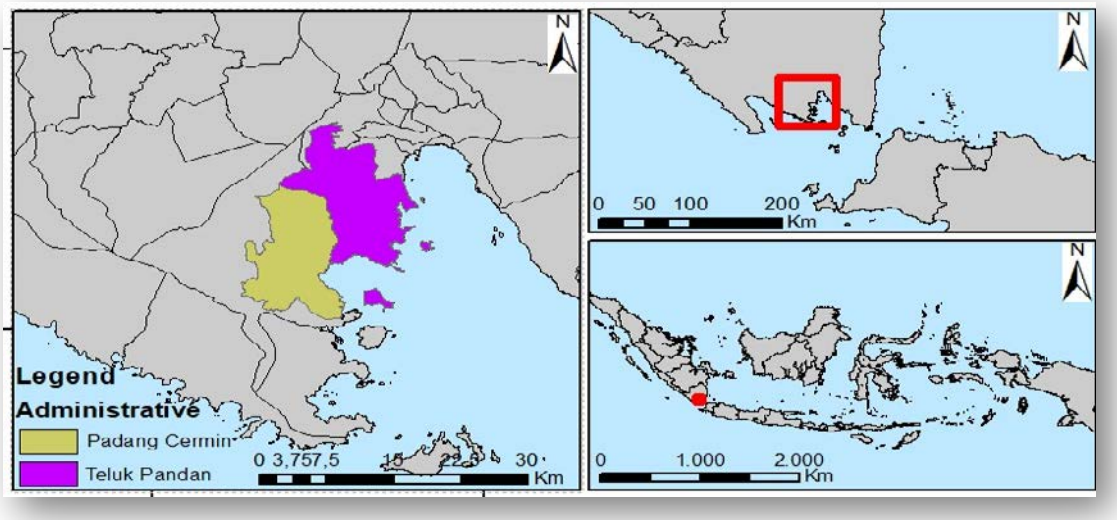


Fig. 1: Geographical location of the study area in the Teluk Pandan and Padang Cermin districts of Lampung Province, Indonesia.

in this study. The survey focused on the community residing around the mangrove forest affected by the mangrove rehabilitation program in Teluk Pandan and Padang Cermin (Fig. 1). Data were collected from July to December 2023. About 720 families reside in this community. A sample size of 300 respondents was determined following the general guideline stipulating that the sample size should be several times larger (at least 10 times) than the number of variables under study, with a minimum of 150 respondents. The sampling approach utilized in this study involved simple random sampling. Padang Cermin is located at 5.60428 degrees north (N), 105.11 degrees east (E), and Teluk Pandan at 5.5083 N and 105.12 E. The climate is tropical, with high rainfall.

The location of the study is limited to the Padang Cermin and Teluk Pandan sub-districts because, in both sub-districts, there are mangrove ecotourism locations resulting from community involvement. Therefore, we want to see how social capital and local institutions can increase community involvement in their rehabilitation. After obtaining strategies from the research results, the results can be shared with those in other locations where the level of community involvement in mangrove rehabilitation is still low.

Data collection

The collected data were analyzed using descriptive statistics and inferential statistics. Descriptive analysis, encompassing frequency distribution tables, charts, and other tools, was employed to provide insights into social institutions in villages (X1) (prevailing customs, applicable sanctions, conflict intensity), social capital (X2) (trust, networks, norms), the community's role in mangrove rehabilitation (Y1) (seeding, planting, maintenance), and welfare (Z). The questionnaire proposed questions and statements using a Likert scale to assess the respondents' opinions and attitudes toward the components being discussed. The questionnaire contained a minimum of 5 questions attached to the statements strongly agree, agree, doubtful, disagree, and strongly disagree.

Statistical analysis

Structural equation modeling (SEM) was used to estimate the extent of the influence of independent variables on dependent variables and evaluate the alignment between the hypothetical models and real models (Fig. 2).

Data processing and analysis were conducted using the statistical package for the Social Sciences version 21 and Linear Structural Relationships 8.8 programs. Qualitative data was employed to provide explanations for quantitative data. SEM was conducted using Eq. 1 (Stein *et al.,* 2011).

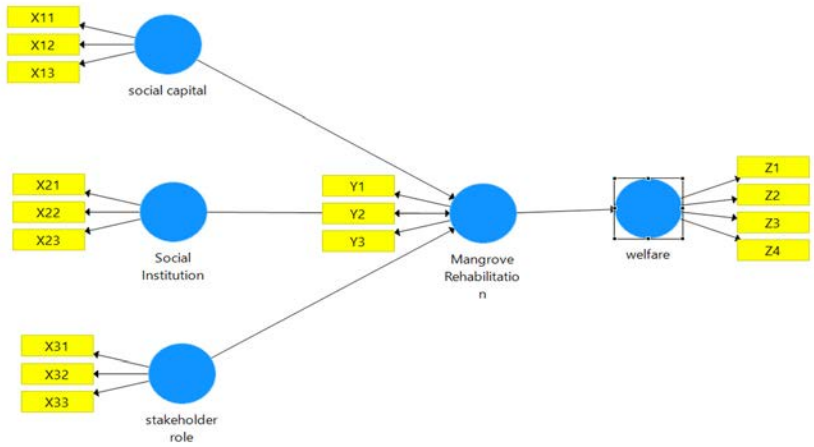


Fig. 2: Structural equation model for social capital empowerment and social institutions in supporting mangrove rehabilitation in Lampung

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

Where;

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

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

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

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

ζ = zeta, a vector of residuals or errors in equations

SEM was used during the study to determine research problems relating to descriptions or to empirically confirm the suitability of the model according to indicators conceptualized by the construct. The second problem, known as a structural model, explains the causal relationship between latent variables.

RESULTS AND DISCUSSION

The results of this study list the constraints and their solutions so that the government can harness social capital and local wisdom to improve community welfare. The utilization of social capital and local wisdom by the government will enhance the community's self-reliance and food sovereignty. Several studies have shown that social capital and local institutions have not been optimally utilized to enhance food security and farmer welfare. Social capital and social institutions within communities play a significant role in development, especially in fostering empathy and community involvement in mangrove forest rehabilitation in Teluk Pandan and Padang Cermin.

Social capital

Social capital is assessed based on trust, networks, and norms among community members in the study area. The social capital empowerment needed to achieve food sovereignty among farmers and fishermen has not been extensively studied, especially in the study area. Government strategies or policies that utilize social capital to achieve food sovereignty and community welfare have not been widely implemented. The findings in Table 1 shows that most of the community members trust each other, there is harmony within the community, and individuals rely on and care for each other. This can be observed in the daily lives of the community, where the values of mutual cooperation are firmly held. People help each other in various situations, such as celebrations or moving houses. The findings in Table 1 indicate that only three percent (%) of community members have a low social network, while the rest have established strong social networks among themselves. They support each other, maintain connections, and build networks among themselves. Community members establish networks with one another based on mutual trust, enabling them to engage in mangrove preservation activities together. The norms existing within coastal communities, especially around mangrove forests,

Table 1: Distribution of community assessment

Parameters	Classification	Class (score)	Number (people)	%
	Low	5 – 11	41	13.66
Trust	Medium	12 – 18	76	25.33
	High	19 – 25	183	61
	Low	7 – 18	8	3.00
Networks	Medium	19 – 27	101	33.67
	High	28 – 35	191	63.33
	Low	4 – 9	19	6.33
Norm	Medium	10 – 14	88	29.33
	High	15 – 20	193	64.33

Table 2: Distribution of community assessments on social institutions

Parameter	Classification	Class (score)	Number (people)	%
	Low	6 – 14	35	11.66
prevailing customs	Medium	15 – 22	77	25.33
	High	23 – 30	188	62.00
	Low	4 – 9	16	5.33
applicable sanctions	Medium	10 – 14	214	71.00
	High	15 - 20	70	23.33
	Low	10 – 23	123	41.00
Conflict Intensity	Medium	24 – 36	100	33.33
	High	37 – 50	77	25.66

constitute a set of rules for all members of the social network, enabling unified regulations and sanctions within the community (Table 1). In the communities of Teluk Pandan and Padang Cermin, there are both written and unwritten norms or rules. Most community members already understand the existing written and unwritten rules. The community's understanding of these rules is linked to the roles of community leaders and the government in teaching the agreed-upon norms. About 19 respondents, or approximately six percent of the community, still did not fully understand the prevailing norms due to the lack of concern from some members in the activities organized by groups or village activities.

Social institutions (X2)

One form of local wisdom is the presence of local institutions in areas that are currently neglected and being replaced by institutions from the central government. Institutions from the central government are formed instantly and perceived as coercive, resulting in suboptimal participation from community members. Therefore, it is necessary to create a model (social engineering) to strengthen social institutions and promote the welfare of farmers. Elements of social institutions include prevailing customs, sanctions, and conflicts. The prevailing customs in the study area have merged into the national culture, such as mutual cooperation ("sambatan") and religious events like torchlight processions to welcome Ramadan. Meanwhile, the original cultures of the local area are almost nonexistent because the study location is home to various ethnicities, such as the Lampung, Palembang, Javanese, Sundanese, Bugis, Batak, and others. The sanctions present in the study area are social sanctions and legal sanctions. The community is quite aware of the sanctions in place if they damage the mangrove forest. In the study location, no residents were punished for damaging or encroaching on the mangrove forest to convert it into ponds. However, not far from the district location, some time ago, some residents cut down mangrove forests to be used for ponds. They were reported to the authorities and faced a 10-year prison sentence and a fine of 10 billion Indonesian Rupiah. This incident served as a lesson to the community that mangroves should be protected and preserved. Conflict is a condition of emotional tension that can lead to physical tension. In the study area, conflicts related to mangrove management occur but do not escalate to physical conflict (Table 2). Conflicts arising in mangrove rehabilitation are related to the

Table 3: Distribution of community assessments on the role of stakeholders

Paramaters	Classification	Class (Score)	Number (people)	%
	Not involved	4 – 9	80	26.33
the role of government	Involved	10 – 14	147	49.00
	Highly involved	15 – 20	73	24.67
	Not involved	10 – 23	33	11.00
Role of groups	Involved	24 – 36	121	48.67
	Highly involved	37 – 50	146	40.33
	Not involved	10 – 23	32	10.00
the role of community leaders	Involved	24 – 36	83	27.33
	Highly involved	37 - 50	185	61.67

management of sunset ecotourism in Teluk Pandan and cukunyinyi ecotourism in Padang Cermin. The intensity of the conflict is low, and conflicts that arise can be resolved among residents by sitting together to address the causes of conflict. Although some residents may not be satisfied with the outcome of these discussions, they agree to abide by the agreements made collectively.

Role of stakeholders (X3)

There are three stakeholders in this study: the government, activist groups, and community leaders' agencies of the government consisted of the Environment, Tourism, Fisheries, and Marine Agencies, which are always present. According to Table 3, most of the community (61%) believes that the government plays a large role in supporting the community to carry out mangrove rehabilitation activities, and in improving community welfare.

The roles of existing groups within the community can be defined as a series of activities in which community members share information, learn together, and collaborate within a framework to achieve both individual and collective goals (Table 3). Community members believe that the presence of groups in Teluk Pandan and Padang Cermin plays a role in mobilizing the community in mangrove rehabilitation activities, thus enhancing the well-being of residents. Groups in the study locations included PKK groups, Tourism Awareness Groups, Mangrove Forest Preservation Groups, and farmer groups. Concurrently, endeavors to safeguard and revive mangroves on land are burgeoning globally. Non-governmental organizations (NGOs), government agencies, community groups, and the private sector have amassed considerable expertise in various facets of mangrove management, conservation, and rehabilitation, ranging from field techniques to funding.

Mangrove rehabilitation

Community participation in mangrove conservation involves various actions and active involvement from local communities in preserving, protecting, and developing mangrove ecosystems. The scope of mangrove restoration or rehabilitation and the incorporation of additional services, such as ecotourism, entail various expenses (Table 4).

Community well-being

Community empowerment in coastal areas began to be emphasized in the 2000s as a paradigm of development in Indonesia. After observing fishing communities, it is evident that poverty faced by coastal communities is difficult to overcome. To improve the well-being of coastal communities, the government has opened alternative employment opportunities besides fishing, one of which is preserving mangroves and turning them into ecotourism areas. The level of community well-being in the study area was relatively high, with only 13% of residents having low well-being levels. Most residents have easy access to basic needs, education, and health facilities. Welfare is directly associated with household income and consumption (Chegini *et al.,* 2021). Welfare is predominantly viewed through the lens of consumption, encompassing essential aspects such as health insurance, housing, direct financial aid, education, and various facets of social welfare. In the context of mangrove ecosystem conservation, community involvement is crucial. Local communities can be motivated through both monetary incentives, such as cash rewards, and non-monetary welfare initiatives, such as the development of public infrastructure (Boshoven *et al.,* 2022). Consequently,

Table 4: Distribution of community activities of mangroves

Parameter	Classification	Class (Score)	Number (people)	%
Seedling	Low	6 – 14	142	47.33
	Medium	15 – 22	106	35.33
	High	23 – 30	52	17.33
planting	Low	6 – 14	68	22.67
	Medium	15 – 22	134	44.67
	High	23 – 30	98	32.67
maintenance	Low	5 – 11	30	10.00
	Medium	12 – 18	76	25.33
	High	19 – 25	194	64.67
well-being levels	Low	16 – 42	40	13.33
	Medium	43 – 68	111	37.00
	High	69 - 80	149	49.67

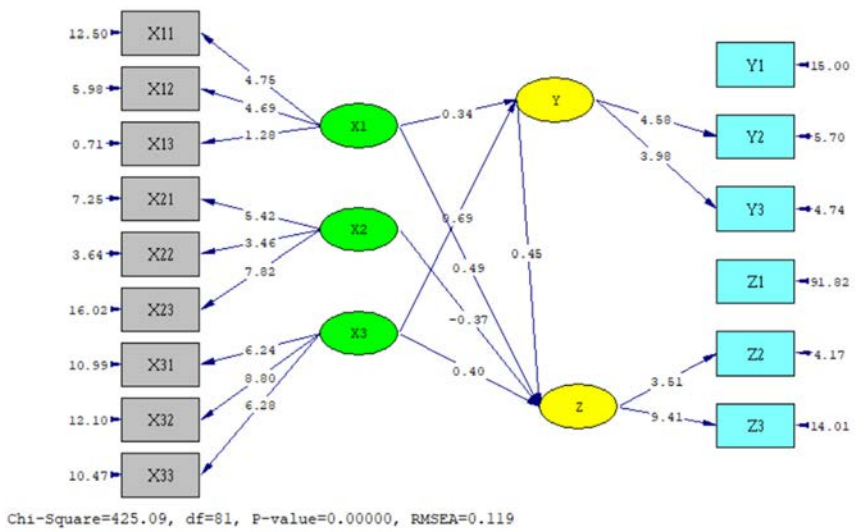


Fig. 3: Structural model for community well-being enhancement.

mangroves play a significant role in enhancing human welfare, aligning with the objectives outlined in the sustainable development goals (SDGs) (De Neve and Sachs, 2020).

Structural equation model testing for social capital and local institutions' empowerment in supporting mangrove rehabilitation in Lampung

This testing was conducted to find the best strategies for improving community well-being and to measure factors suspected to impact community involvement in mangrove rehabilitation activities. The hypotheses regarding the influence of variable X on variables Y and Z can be observed in Fig. 3.

The results of the SEM analysis tests are showcased in Table 5. The outcome of the structural model offers insights into the problem and provides predictions concerning causal relationships or influences between variables.

Overall, to clearly understand the influence among the study variables, including X1 social capital, X2 social institutions, X3 stakeholder roles, Y mangrove rehabilitation, and Z community well-being, refer to Table 6.

From Table 6, if written in equation form (Stein *et al.*, 2011), the results of the structural equation analysis yield two equations (Eqs. 2 and 3).

Eq. 2: *(Data processing results):*

$Y = 0.34*X1 + 0.69*X3$, Errorvar = 0.047, $R^2 = 0.95$ (2)

(0.047) (0.053) (0.015)
7.18 12.90 3.14

Eq. 3: *(Data processing results):*
Z = 0.45*Y + 0.49*X1 - 0.37*X2 + 0.40*X3, Errorvar= 0.084, R^2= 0.92 (3)
(0.25) (0.15) (0.12) (0.19) (0.022)
1.82 3.31 -3.03 2.10 3.84

The results of the LISREL calculation were used to find the best model for enhancing community well-being around mangrove forests through strengthening social capital, social institutions, stakeholder roles, and mangrove rehabilitation. Two equations were derived from the calculations. Social capital and stakeholder roles showed the effects of community-driven mangrove rehabilitation activities; however, social institutions had no effect in the first equation. Social capital, which encompasses trust, networks, and community norms, plays a significant role in community-driven mangrove rehabilitation. The stronger the trust within the community, the better the networks, and the stronger the adherence to norms and written rules, making the community's activities in mangrove rehabilitation more impactful. With the strong social capital present in communities within Padang Cermin and Teluk Pandan, there is a sense of togetherness and a strong awareness of the importance of mangrove conservation. Strengthening social capital in the community will facilitate the government's involvement of communities in programs aimed at preserving mangrove forests. In addition to social capital, stakeholder roles also influence community-driven mangrove rehabilitation activities in Padang Cermin and Teluk Pandan. Community involvement in mangrove rehabilitation can be optimized with external encouragement; therefore, communities need to be motivated to actively participate in mangrove conservation efforts. The higher the stakeholder's role in assisting communities in mangrove conservation, the greater the community's involvement in rehabilitation activities. Stakeholder roles include financial assistance, manpower, training, mentoring, and other necessary support for communities. Equation 2 illustrates the influence of social capital, social institutions, stakeholder roles, and mangrove rehabilitation on enhancing community well-being around mangrove forests in Padang Cermin and Teluk Pandan. All variables affect community well-being,

Table 5: The goodness of fit model testing

Goodness-of-fit	Cut of value	Result	Conclusion
Root mean square error of approximation	0,05≤RMSEA≤0.08	0.119	Fit
Goodness of fit index	≥ 0.90	0.84	Fit
Adjusted goodness of fit index	≥ 0.90	0.84	Fit
Comparative fit index	≥ 0.90	0.97	Good fit
Comparative fit index	≥ 0.90	0.97	Good fit
Normed fit index	≥ 0.90	0.96	Good fit
Non-normal fit index	≥ 0.90	0.96	Good fit

Tabel 6: SEM model estimation results

Variables influence	Standardized loading factor	|t-hit|> 1.96	Conclusion
X_1 Social Capital → Y mangrove rehabilitation	0.34	2.78	Significant
X_3 stakeholder role → Y mangrove rehabilitation	0.69	-2.33	Significant
X_1 Social Capital → Z welfare	0.49	1.14	Significant
X_2 Social Institusion → Z welfare	-0.37	-1.48	Significant
X_3 stakeholder role → Z welfare	0,71	1,37	Significant
Y mangrove rehabilitation → Z welfare	0,45	-0,33	Significant

but mangrove rehabilitation activities have a small effect on community well-being, while social institutions have a negative impact. Social capital is a series of relationships among people supported by networks, norms, and social trust that enable efficient and effective coordination and cooperation for mutual benefit and welfare. Social capital is an essential asset for communities to achieve their life goals (Klärner *et al.,* 2022). Social capital is a crucial concept in human development because communities determine the direction of development. Social capital serves as one of the components in fostering togetherness, ideas, mutual trust, and mutual benefits to achieve collective progress. Social capital comprises trust, networks, and norms. There is a sense of mutual care among community members; if one person experiences hardship or misfortune, others assist in alleviating their burden (Table 1). This leads to heightened levels of trust, broadened participation in various activities, and the capability to address more intricate issues (Berkes, 2009). This is especially crucial in participatory assessments, where commitment to objectives hinges on shared social capital, such as enduring partnerships and power dynamics that differ from hierarchical policymaking (Borg *et al.,* 2015). Social network analysis was employed to investigate how participation ideals, such as social cohesion and empowerment through trust and information sharing, create successful participatory projects (Ruzol *et al.,* 2020). Effective cooperation is rooted in learning through participation (Napier *et al.,* 2005). The social networks of community members in the study areas are built on trust and the belief that each of them shares connections and common interests. This belief encourages active participation in mangrove rehabilitation efforts. Community participation in mangrove conservation entails a comprehensive process encompassing the planning, implementation, evaluation, and utilization of the outcomes (Listiana and Ariyanto, 2024). Participation in mangroves encompasses five different processes. These are maintaining popular legitimacy, facilitating democratic ideological discussions, fostering norms and networks, promoting equal power among all participants and viewpoints, and emphasizing the necessity of leadership and compromise (Webler *et al.,* 2001). The study's findings also indicate that there are still many community members (29.33%) who are quite familiar with the prevailing norms. Currently, no written rules are used in mangrove forest management. However, the community's understanding of unwritten rules is considered adequate, indicating that they adhere to these unwritten norms in mangrove forest management. Threats to mangroves, such as pollution, encroachment of urban development, and limited livelihood options, should not only be assessed from the perspective of professional field surveyors but also from the experiences of local communities, including the norms of policy prohibitions against environmental hazards (Datta *et al.,* 2012). The community perceives prevailing customs as generally accepted and not conflicting with existing norms. The culture that remains strong is the involvement of family members in assisting each other. Fishermen maintain a positive attitude towards involving their children in their work and engaging them in tasks alongside their parents to enhance their comprehension of nature. This serves as a natural avenue for acquiring knowledge about societal customs and traditions while also demonstrating respect for parents as they collaborate by sharing responsibilities (Maya Jariego *et al.,* 2023). Sanctions for damaging mangroves range from a warning to criminal sanctions. This is done to ensure that the community continues to preserve mangrove forests. Regulations pertaining to mangrove protection services imply that measures should be implemented to safeguard rehabilitated mangrove forests from logging and destruction. Different regions enforce various sanctions for illegal mangrove logging. For instance, severe penalties are imposed for cutting down a single mangrove tree, necessitating the planting of a minimum of one thousand trees, with no option to substitute sanctions with fines (Damastuti *et al.,* 2023). Frequent conflicts occur due to disrupted interest functions, with some community members having their interests disrupted, which is one of the causes of conflict. The involvement of the community in mangrove rehabilitation cannot proceed independently; there must be an active role from local community leaders. It is believed that leaders are highly responsible for driving community involvement, as evident in Table 3. However, 13% perceived the role of the government as low, and 23% of the community assessed the government's role as average. The high role of the government in this study

is in line with several previous studies that claim that agricultural extension workers in Negeri Katon have a high role in helping farmers improve their capacity (Listiana *et al.,* 2023). The government plays a crucial role in endeavors aimed at reinstating mangroves in adjacent watersheds and coastal areas, such as through local government units spearheading mangrove reforestation projects and receiving assistance (technical, financial, and logistical) to expedite mangrove rehabilitation initiatives (Duncan *et al.,* 2016). It is the government's duty to establish and enforce a sustainable legislative framework to enhance mangrove conservation and restoration. A robust regulatory framework is essential to regulate, guide, and reshape human conduct toward sustainable coastal practices, thus facilitating successful mangrove protection and restoration (Sam *et al.,* 2023). These roles involve a series of activities and functions performed by farmer groups to enhance production, improve access to resources, develop agricultural technologies, increase participation, and empower their members (Listiana and Ariyanto, 2024). This encompasses entities such as the International Union for Conservation of Nature (IUCN) Mangrove Specialist Group, an organization of experts dedicated to advancing mangrove conservation efforts and evaluating the conservation status of all mangrove species (Worthington *et al.,* 2020). Community leaders have extensive influence and authority within the community and play an active role in leading, guiding, and influencing the direction and policies of the community (Table 3). The role of community leaders refers to the role played by individuals within a group/community (Duncan *et al.,* 2016). The presence of community leaders who support and actively participate can have a positive influence on mobilizing the community to participate in mangrove conservation efforts. Community leaders can utilize their influence and connections within the community to disseminate relevant messages. Trusted and respected community leaders can help convey information in easily understandable ways and motivate the community to participate in mangrove conservation (Duncan *et al.,* 2016). Community participation in the management of mangroves is crucial because it can be económically beneficial. The model's findings show that mangrove rehabilitation can improve community welfare and increase community participation by developing social capital and increasing the role of stakeholders. The level of community welfare is influenced by social capital, stakeholder support, and sustainable mangrove forests. The better the condition of the mangrove forest, the more attractive the mangrove ecotourism will be. Increasing the number of mangrove ecotourists will, directly and indirectly, improve the economies of local residents. Local residents can sell local food, souvenirs, transport services, etc. The level of community welfare can be seen in the ease of people accessing basic needs, education, health, freedom of religion, freedom to express opinions, and freedom to socialize with other citizens. In general, almost 50% of the people in the research location are in the very prosperous category, while 37% are prosperous, and only 13% in the community are not prosperous. This indicates that meeting their physical, economic, and social needs can create a sense of self-confidence within the community.

Mangrove rehabilitation

Mangrove ecosystems are rehabilitated through nurseries, by planting on empty land designated for mangroves, and by maintaining existing plants. Assistance and monitoring are carried out continuously by the regional government with the help of community leaders. The existence of mangrove forests can increase the incomes of local communities. By fostering ecotourism, cultivating forest bees, and engaging in activities that do not damage the mangrove ecosystem, locals can increase their income using the mangrove ecosystem. The cost of rehabilitation includes plantation costs (such as seed production, plantation establishment, maintenance, infrastructure, administration, and supervision) and monitoring costs (including physical validation, institutional assessment, and project benefit assessment) (Primavera and Esteban, 2008). Mangrove rehabilitation activities include seedling propagation, planting, and maintenance. Coastal productivity in relation to the connections between mangroves, seagrasses, and estuarine shallow water habitats is not yet well understood (Nagelkerken, 2009). The key to successful forest plantation management in an even-aged silvicultural system lies in determining the optimal harvesting age. Generally, carbon sequestration in forest stands can influence the age at which the crops are harvested (Asante and

Armstrong, 2012). Failures in mangrove rehabilitation projects often stem from technical issues, with poor site/species suitability being a common reason for planting failure. This involves selecting species that are unsuitable for the location (Aung *et al.,* 2011; Lewis *et al.,* 2016). The characteristics of community governance play a crucial role in determining decisions regarding rehabilitation strategies and post-planting management. These strategies encompass various aspects, such as the scale of rehabilitation, selection of location, species, monitoring, and maintenance (Damastuti *et al.,* 2023). Stakeholders appear to protect the mangrove ecosystem; namely, the regional government's function is to make strict rules and sanctions for perpetrators of mangrove destruction and provide financial assistance, seeds, training, and assistance. The group functions as learning, a vehicle for cooperation, socializing government policies, and assisting community leaders in implementing local government policies. Community leaders ensure that government programs run smoothly, oversee activities, and invite the community to actively participate in mangrove rehabilitation. Government policies have a significant impact on supporting mangrove rehabilitation and improving community welfare. Pro-environmental government policies will encourage people to participate and become accustomed to participation. Without government policies that support mangrove rehabilitation, it would be difficult to mobilize the community through social institutions to play an active role in mangrove rehabilitation. People's participation in mangrove rehabilitation helps increase social capital, consequently improving their access to information and services (Valenzuela *et al.,* 2020). Vulnerable actors often perform civil, economic, and judicial actions, while dominant actors perform technical and political actions (Auer *et al.,* 2020). Social capital plays a role in enhancing the community's participation in the multi-level governance of marine resources (Nenadovic and Epstein, 2016).

CONCLUSION

This paper examines the role of social capital, local institutions, and stakeholder engagement in mangrove management in Padang Cermin and Teluk Pandan through elements of social capital, namely networks, norms, and trust. Social institutions are viewed through customary elements, conflicts, and sanctions. Stakeholder roles encompass the roles of the government, community groups, and community leaders. Based on these variables, the strongest influences on mangrove rehabilitation are social capital and stakeholder engagement. The function of social capital and stakeholder engagement in mangrove rehabilitation serves to enhance information exchange, foster community cohesion, improve members' capabilities through education and training, and transform the socio-economic conditions of members, leading to increased community well-being. The goal of empowerment is to create self-sufficient and socially empowered communities capable of meeting their physical, economic, and social needs, fostering self-confidence, voicing aspirations, securing livelihoods, engaging in social endeavors, and facing life independently. Sanctions for damaging mangroves range from a warning to criminal sanctions. This is done to ensure that the community continues to preserve mangrove forests. Regulations pertaining to mangrove protection services imply that measures should be implemented to safeguard rehabilitated mangrove forests from logging and destruction. The social institutions in this study include customary practices, sanctions, and conflicts. Therefore, the tighter the adherence to customary practices, the higher the conflicts, and the more sanctions imposed, which will decrease community well-being. Although there are still visible customary practices, they do not restrict the movement of community members for daily activities. Conflicts and sanctions are rare in the study area, and if conflicts arise, they are mostly related to differences in decision-making opinions and can be resolved promptly without escalating. The study findings also indicate that there are still many community members (29.33%) who are quite familiar with the prevailing norms. Currently, no written rules are used in mangrove forest management. However, the community's understanding of unwritten rules is considered adequate, indicating that they adhere to these unwritten norms in mangrove forest management. To conserve mangrove ecosystems, we recommend empowering local communities to look after, preserve, replant, and not destroy existing mangrove forests. We also recommend strengthening social capital and local institutions by involving relevant stakeholders. The recommendations from this study will be given to local governments

as well as related agencies, community leaders, universities, non-governmental organizations, and communities. Social institutions do not affect mangrove rehabilitation and have a negative effect on welfare. The most influential factor in mangrove rehabilitation is social capital. Social institutions do not affect mangrove rehabilitation. Social capital in society needs to be developed to increase public awareness of mangrove rehabilitation.

AUTHOR CONTRIBUTIONS

I. Listiana, interpreted the results and prepared the manuscript. D. Ariyanto interpreted the results and prepared the manuscript. All authors contributed equally.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interests 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
AGFI	Adjusted Goodness of Fit Index
CFI	Comparative Fit Index
df	Degree of freedom
E	East
GFI	Goodness of Fit Index
IFI	Incremental Fit Index
IUCN	International Union for Conservation of Nature
LISREL	Linear structural relationships
NGO	Non-governmental organization
NFI	Non-Normed Fit Index
N	North
p-value	probability
PNFI	Parsimony Normed Fit Index
RFI	Relative Fit Index
RMSEA	Root Mean Square Error of Approximation
SEM	Structural equation modeling
SPSS	Statistical package for the social sciences

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