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Analysing factors influenced the sustainable fishing port model in East Java Province, Indonesia

Eris N. Dirman*, Nuddin Harahab, Bambang Semedi, Arief Rachmansyah

Universitas Brawijaya, Postgraduate School, Doctoral Program of Environmental Science, Jl. MT Haryono 169, 65145, Malang, Indonesia

* Corresponding author

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Abstract: Sustainable fishing ports play a vital role in ensuring the long-term health of marine ecosystems and supporting the livelihoods of coastal communities. This article explores the factors that contribute to the development of sustainable fishing ports, which consider environmental, social, and economic aspects in a balanced way. This research aims to develop a model of sustainable fishing port considering significant factors which influenced the sustainable fishing port, especially for fishing ports located in East Java Province, Indonesia. In this term, the sustainable fishing port is well known as an eco-fishing port. Purposive sampling was used to choose 215 participants from representatives of the government, private sectors in the fishing field, and fishing communities of six potential fishing ports in East Java Province, Indonesia. The data was analysed using a partial least square (PLS) approach with SmartPLS 3. The findings of the research indicate that eight hypotheses (H1, H2, H3, H4, H5, H7, H8 and H11) are supported while three hypotheses (H6, H9, and H10) are not supported. The study reveals a significant correlation between market demand, community welfare, infrastructure, environmental carrying capacity, and regulation. It is also found that market demand, community welfare, infrastructure, environmental carrying capacity, and regulation have significant positive relations with eco-fishing ports. The positive relationship indicates that adherence to these regulations fosters responsible fishing methods, preventing overexploitation of fish stocks, and contributes to the conservation of marine environments, ensuring the port operates in harmony with natural ecosystems and local communities.

Keywords: eco-fishing port, economic, environment, social, sustainable

INTRODUCTION

Implementing sustainable fisheries practices that are environmentally friendly is an essential undertaking in order to guarantee the enduring sustainability of fisheries resources (Oloruntuyi *et al.*, 2023). The Food and Agriculture Organization (FAO) advocates for the implementation of efficient fisheries management practices to secure the sustainable utilisation of fishery resources. This includes stringent oversight of fishing and aquaculture practices to protect marine ecosystems. Furthermore, FAO supports transparency in international fish utilisation and trade activities. This entails providing clear and detailed information about fish catches, aquaculture practices, and international trade (Bi *et al.*, 2023). Hence, sustainable fishing harbours are crucial for maintaining the overall well-being of marine ecosystems and sustaining the economic activities of coastal populations (Hsu and Chen, 2023).

In East Java Province, Indonesia, a multitude of factors play a role in the creation and upkeep of sustainable fishing ports. This region is known for its abundance of fish, making it imperative to understand the key elements that foster sustainability in fishing ports. This article explores the factors that contribute to the development of sustainable fishing ports in East Java Province, which consider environmental, social, and economic aspects in a balanced way (Lubis *et al.*, 2020; Muafi and Hadi, 2023).

One of the primary factors contributing to sustainable fishing ports in East Java is a keen focus on environmental considerations (Aida, Illahi and Pramesthy, 2023). This involves implementing practices that minimise the ecological impact of fishing activities, such as using sustainable fishing methods, regulating catch quotas, and protecting critical habitats. The integration of eco-friendly technologies and a commitment to biodiversity conservation are paramount in ensuring the resilience of marine ecosystems while sustaining the availability of fish stocks for future generations.

The active involvement and empowerment of local communities are instrumental in fostering sustainability in fishing ports (Clark and Harley, 2020). Engaging fishermen, coastal residents, and relevant stakeholders in decision-making processes ensure that the needs and concerns of the community are considered (Pata *et al*., 2023). Through community-based management approaches, initiatives can be tailored to address the unique challenges faced by East Java's fishing communities, ultimately promoting a sense of ownership and responsibility for the sustainable use of marine resources (Triharyuni *et al*., 2023). Efforts are made to explore alternative livelihoods and income sources for fishing communities. This includes promoting eco-tourism, supporting small-scale fisheries enterprises, and facilitating access to markets for value-added fishery products (Roscher *et al*., 2022).

A robust regulatory framework and effective governance are pivotal in achieving sustainability in fishing ports. East Java Province benefits from clear policies and regulations that guide fisheries management, including the establishment of no-take zones, enforcement of fishing gear regulations, and monitoring of compliance (Stefanus and Vervaele, 2021). Transparent and accountable governance structures contribute to the prevention of overfishing and the promotion of responsible fishing practices within the fishing port areas (Chen, Xu and Li, 2023).

The adoption of technological innovations and the development of infrastructure play a vital role in enhancing the sustainability of fishing ports (Quintano, Mazzocchi and Rocca, 2020). The efficient waste management system is related to environmental protection, these advancements contribute to reducing environmental impact and improving overall operational efficiency (Czekała *et al*., 2023). Investments in modernising port facilities and equipment also enhance the safety and productivity of fishing operations, aligning with the principles of sustainability in the long run (Othman, El-Gazzar and Knez, 2022).

Fishing ports also play a critical role in meeting the demands of both domestic and international market (Rodríguez *et al*., 2021). Domestically, fishing ports serve as key hubs for the landing, processing, and distribution of freshly caught seafood, ensuring a timely and consistent supply to meet local market needs (Harahab *et al*., 2023). Internationally, fishing ports are essential for the export of seafood products to meet global market demands. They serve as points of export for processed and unprocessed fish products, contributing to international trade in fisheries (Liu *et al*., 2023).

The aim of the study is to develop a model of a sustainable fishing port in East Java, Indonesia. The method is adapted from the framework of blue ports in some fishing ports in the world, observing the environment and other significant factors that influenced the sustainable fishing port. Moreover, in the final phase, the study provides possible sustainable fishing port scenarios within East Java fishing. In this case, it is applied to the fishing elements of the six fishing ports in East Java, in order to evolve these concepts further.

Sustainable fishing port in East Java Province is a vital infrastructure for supporting environmentally friendly fishing practices. The effective management of significant environmental aspects is essential for fishing ports to actualise the implementation of the eco-fishing port concept (Wicaksono, Susanto and Nurdin, 2023). This involves adhering to facility and infrastructure standards by existing regulations, enforcing discipline and implementing regulations, providing guidance and socialisation, ongoing monitoring of the green economy, ecological and environmentally friendly management (Abakumov *et al*., 2022).

This study places the eco-fishing port as an implementation of the sustainable fishing port in East Java. This research aims to establish a model of sustainable fishing port in East Java Province due to several reasons, including environmental preservation, economic development, community livelihoods, regulatory compliance, and education and awareness of marine ecosystems in East Java. By prioritising biodiversity conservation, habitat preservation, and promoting sustainable fishing practices, the model ensures economic stability for local communities while operating within effective regulation. Furthermore, it includes initiatives for guiding and socialising eco-friendly fishing practices, enhancing fishermen's understanding of sustainability, and raising awareness about environmental conservation.

MATERIALS AND METHODS

STUDY SITE

The study was conducted at six fishing ports in East Java province, Indonesia including the fishing ports of Prigi, Brondong, Pondok Dadap, Mayangan, Puger, and Tamperan. The selection of these six fishing ports in East Java Province, Indonesia, likely aligns with the research objectives for several reasons, including geographical representation, variety of fishing practices, community engagement, infrastructure and facilities, previous research, and data availability (Sukayat *et al*., 2023). These ports may have been chosen to ensure a diverse geographical representation across the province. East Java is known for its coastal areas, and selecting ports from different regions allows for a comprehensive assessment of the various environmental and socio-economic factors influencing sustainable fishing practices. Each fishing port might represent different types of fishing practices and provide insights into the different challenges and opportunities associated with implementing sustainable fishing practices across various fishing sectors (Aida, Illahi and Pramesthy, 2023).

Selecting ports in different communities engages the research with a broader spectrum of stakeholders, including fishermen, local authorities, and residents (Buana and Barlian, 2023). This facilitates a more inclusive approach to understanding the needs and perspectives of different communities regarding sustainable fishing initiatives. The chosen ports likely vary in terms of their existing infrastructure and facilities to define the opportunities in implementing standards of eco-friendly fishing practices (McCallum, 2022). The availability data and the previous study in the selected fishing port, make it easier to establish baseline conditions and track changes over time.

Based on data from the Ministry of Maritime Affairs and Fisheries (Ind.: Kementerian Kelautan dan Perikanan) and BPS-Statistics East Java Province (Ind.: Badan Pusat Statistik Provinsi

Jawa Timur) for 2022, the six fishing ports have a significant contribution to the fishing production in East Java (Pusat Data Statistik dan Informasi, 2022; Badan Pusat Statistik Provinsi Jawa Timur, 2023). The fishing port of Prigi, situated in Trenggalek Regency, boasts a fishing production of 15,707.36 $Mg \cdot y^{-1}$, with tuna fish as the dominant catch. Similarly, the fishing port of Brondong, nestled in Lamongan Regency, yields a substantial production of 149,272.20 Mg, primarily focusing on tuna fish. Pondok Dadap, located in Malang Regency, contributes 17,358.18 Mg to the fishing industry. Additionally, Mayangan, located in Probolinggo Regency, contributes 23,739.47 Mg. Puger, in Jember Regency, boasts a production of 16,903.61 Mg, predominantly tuna fish. Tamperan, found in Pacitan Regency, stands out with a fishing production of 29,271.23 Mg. These six potential fishing ports in East Java, critical to the study, are highlighted in Figure 1.

DATA PREPARATION

The survey method was employed in this explanatory research design, using questionnaires and Google Forms for quantitative data collection. Variable indicators, presented as statements, were analysed through respondents assigning scores on a scale ranging from strongly disagree to strongly agree, using a numerical range of 1 to 5. The data collection period spanned from May to September 2023, and 215 respondents. The respondents were selected using a purposive sampling method based on specific criteria, characteristics, experiences that are match to the research objectives. It involves intentionally choosing individuals or units that possess certain attributes deemed important for the study (Chafe, 2023). Therefore, the respondents of this research were selected from the Ministry of Maritime Affairs and Fisheries as government representatives, private sectors in the fishing field, and fisherman communities in six fishing ports, constituting 65.3, 10.3, and 2.4%, respectively. The participants possess varying levels of experience within the fishing industry, categorised into four groups: those with less than 5 years, 5–10 years, 10–15 years, and more than 15 years of experience, constituting 3.8, 30.9, 52.9, and 12.4% of the total, respectively. Respondents were drawn from various fishing ports such as Brondong, Prigi, Mayangan, Pondok Dadap, Puger, and Tamperan, representing 20.2, 19.4, 13.3, 17.7, 15.2, and 14.2%, respectively. They participated in and completed the guided questionnaire, meeting the minimum sample requirements for

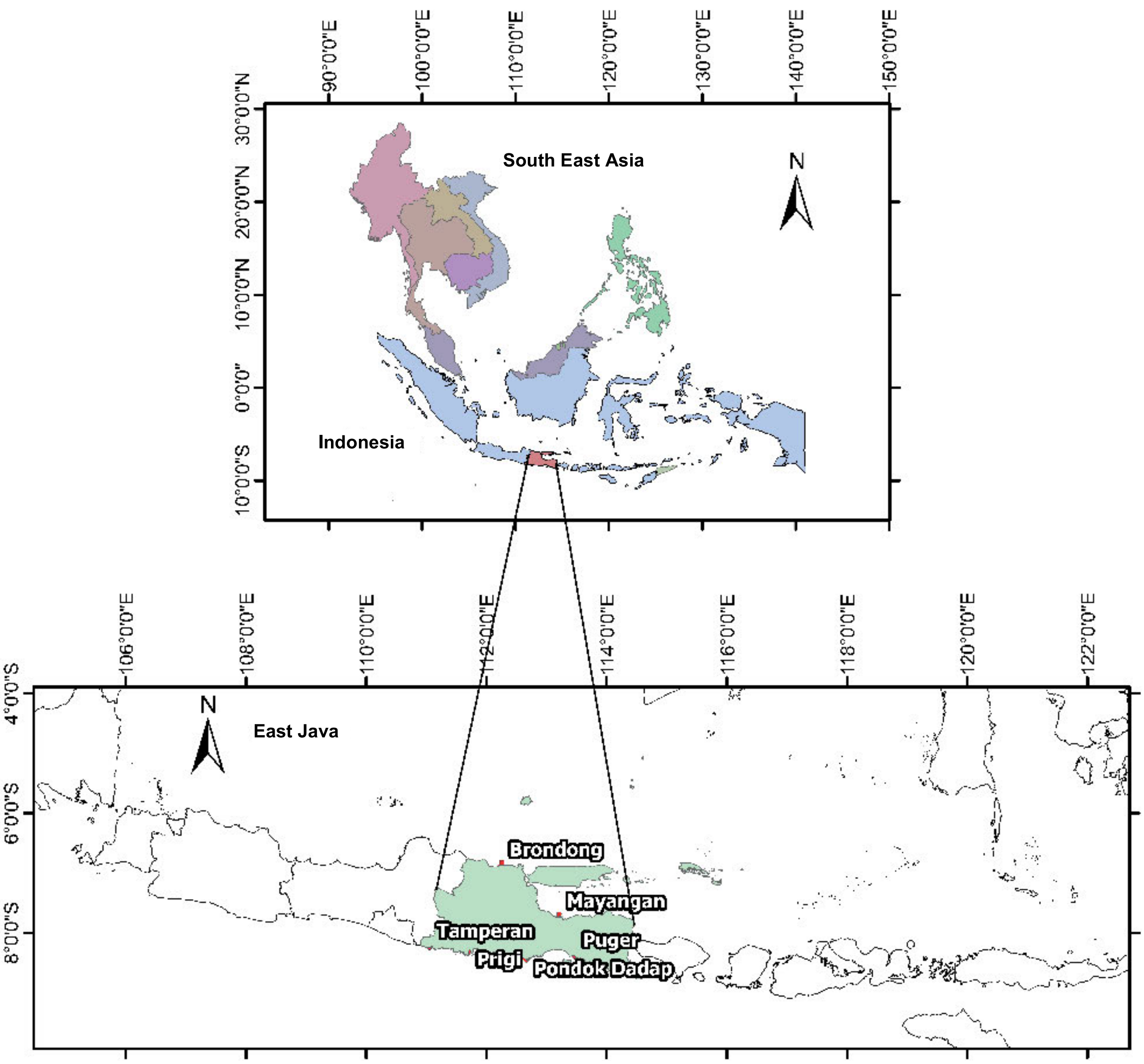

Fig. 1. Map of fishing ports in East Java Province; source: own study

the partial least squares structural equation modelling (PLS–SEM) analysis according to the guidelines established by (Hair Jr. *et al.*, 2021).

DATA ANALYSIS

This study utilised PLS–SEM as its analytical method with exogenous, endogenous latent, and indicator variables (Hair Jr., Howard and Nitzl, 2020). The model includes latent variables (constructs) and indicators (manifest variables or observed). The PLS–SEM approach adopted here is formative, indicating that the arrows denote a direction from the indicator to the latent variable. The latent variables utilised in this study comprise exogenous (independent) and endogenous (dependent) variables, along with several indicators (manifest variables). This research variable was divided into exogenous variables: market demand (md), community welfare (cw), infrastructure (if), environmental carrying capacity (env), community empower (ce), regulation (rg) and endogenous variables (eco-fishing port: ef). A measurement model was appropriately employed to illustrate the relationships between latent/construct variables and their respective indicators, referred to as outer relations.

DEVELOPMENT OF RESEARCH MODEL

Numerous studies emphasise the importance of adopting sustainable fishing practices in the fishing ports. Sustainable practices include measures to prevent overfishing, protect marine ecosystems, and promote responsible fishing techniques (Harahab *et al.*, 2023). A fishing port that implements sustainable fishing practices is well known as "eco-fishing port". The development of an eco-fishing port requires an approach that considers the environmental, social and economic aspects in a balanced way of its design and operation (Stachowiak *et al.*, 2021; Hernanda *et al.*, 2023).

The following hypotheses can be proposed based on previous studies and theoretical foundations.

- H1: The market demand (md) positively impacts the regulation (rg).
- H2: The market demand (md) positively impacts the eco-fishing port (ef).
- H3: The community welfare (cw) positively impacts the regulation (rg).
- H4: The community welfare (cw) positively impacts the eco-fishing port (ef).
- H5: The infrastructure (if) positively impacts the regulation (rg).
- H6: The infrastructure (if) positively impacts the eco-fishing port (ef).
- H7: The environmental carrying capacity (env) positively impacts the regulation (rg).
- H8: The environmental carrying capacity (env) positively impacts the eco-fishing port (ef).
- H9: The community empower (ce) positively impacts the regulation (rg).
- H10: The community empower (ce) positively impacts the eco-fishing port (ef).
- H11: The regulation (rg) as mediating in the eco-fishing port model.

In this study, the positions of variables regulation (rg) are also referred to as mediation variables (Fig. 2).

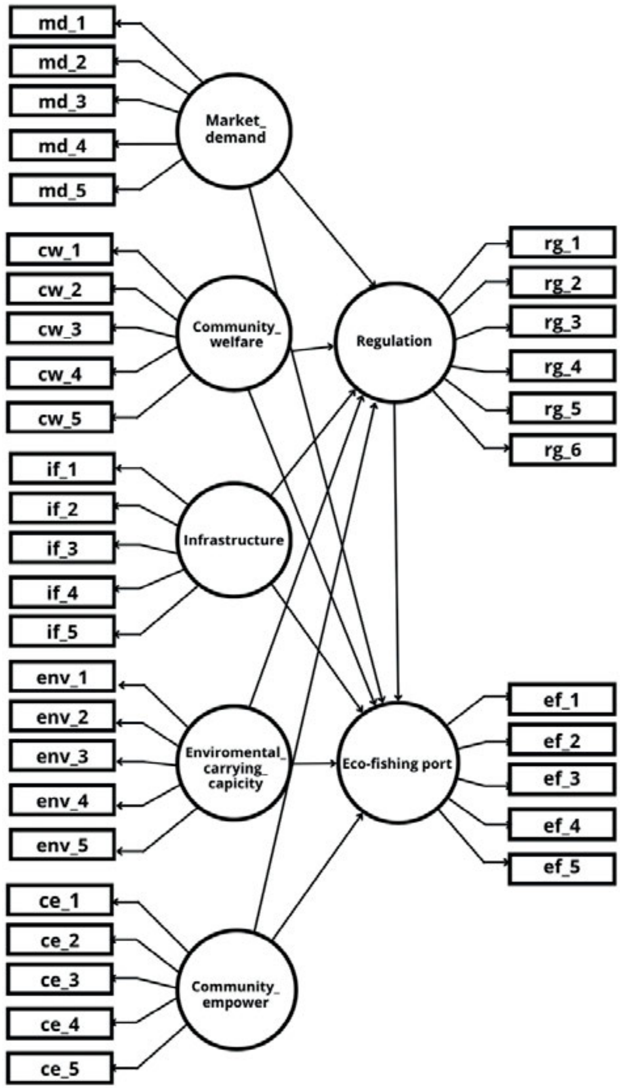

Fig. 2. Theoretical framework of the research model; source: own study

RESULTS AND DISCUSSION

TREND OF FISHING PRODUCTION IN EAST JAVA

The six fishing ports in East Java where the study was conducted are fishing ports which have availability of fresh fish for domestic and international markets. These six ports contributed to the remarkable success of East Java's fisheries, making a significant mark in the export market. In 2016–2021, data from the Ministry of Maritime Affairs and Fisheries revealed that East Java led the nation in fishery exports, reaching an impressive 348,003 Mg. These achievements position East Java's fisheries as the leader of excellence on a national scale in the fishing sectors (Fig. 3).

SCENARIO OF SUSTAINABLE FISHING PORT MODEL IN EAST JAVA

This study incorporated some of the best practices and previous research from sustainable fishing port projects worldwide. The scenarios for these sustainable fishing ports assessed environmental and other critical factors, related to the case study of sustainable fishing ports in East Java. For example, the Port of

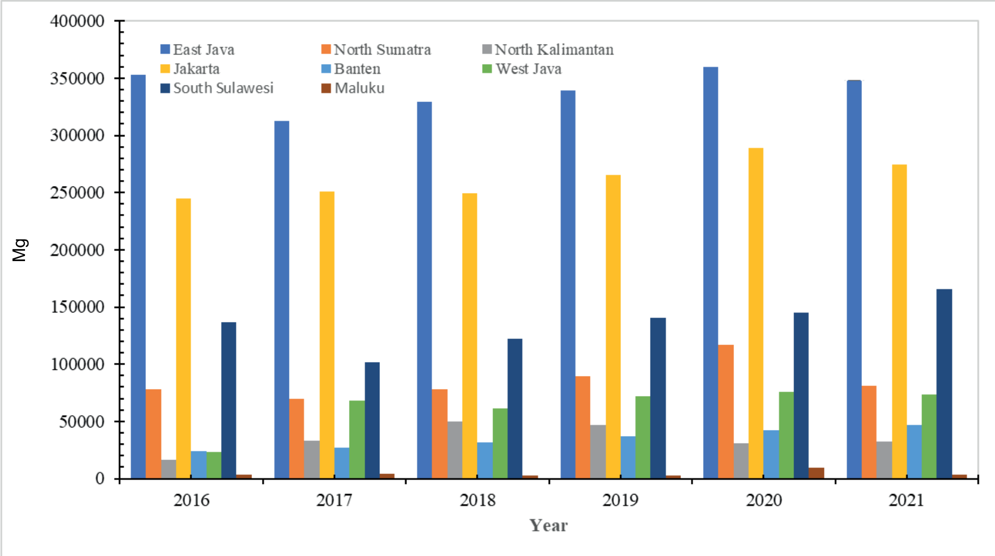

Fig. 3. Volume of fishing products exported of Indonesia's eight provinces (2016–2021); source: own elaboration based on BPSPJT (2024)

Tangier in Morocco is dedicated to environmental preservation. The previous research on sustainable fishing ports has also been conducted in the Port of Vigo, in Spain. To enhance its sustainability strategies, the Port of Vigo focuses on several key aspects of its fishing operations: anticipating growth, staying abreast of sustainability legislation and contemporary trends, and exploring diversification opportunities, acknowledging that the port has feasible options to broaden its business scope beyond conventional fishing activities (Ramos Velasco *et al.*, 2022). The other example is the Port of Vancouver in Canada which has achieved self-sufficiency in energy production and is renowned for its aims to safeguard whales from noise pollution. In the Caribbean region, the Port of Guadeloupe has established the Cayoli program to uphold environmental balance and preserve natural spaces. Additionally, Ceuta in Spain has implemented an environmental vigilance program along with sentry stations to uphold water quality and conduct monitoring efforts. Additionally, the Port of Busan in the Republic of Korea is executing a strategic project centred around fishing villages as part of the Port New Vitalization Promotion Project of Korea, spanning from 2023 to 2027 (Molares, Estors Carballo and López Aragón de, 2023).

The compilation of best practices, previous studies, and frameworks forms the basis for the sustainable fishing port scenario in East Java. The scenario of a sustainable fishing port model in East Java focuses on establishing a comprehensive framework that ensures the long-term viability of fishing ports operations while promoting marine conservation, contributing to the prevention of overfishing and benefiting both the environment and local communities.

This model integrates significant factors to develop fishing activities that meet the market demand both domestically and internationally, while also preventing overexploitation of fish stocks. The model prioritises the welfare of local fishing communities through education, healthcare, and sanitation for local communities. It also encourages safe fishing practices, equipping vessels with proper safety equipment, and establishing emergency response standards to mitigate risks at sea. Moreover, the model emphasises the development of modernised and secure infrastructure, including docks, processing plants, storage facilities, and information technology to support the fishing industry through efficient port operations. The model also preserves marine ecosystems and ensures that fishing activities remain within the carrying capacity of the environment. Additionally, it encourages the local community to participate in decision-making for fishing activities and collaborate with government or non-profit organisations. Furthermore, the model advocates for the implementation of clear and enforceable regulations, including fishing quotas, obedience of illegal unregulated unreported (IUU) fishing, gear restrictions, and seasonal closures, to prevent overfishing and protect marine biodiversity (Molares, Estors Carballo and López Aragón de, 2023).

ASSESSMENT OF THE MEASUREMENT MODEL

The theoretical model in this study was examined utilising SEM PLS through the SmartPLS software. The aim of employing the measurement model is to appraise the reliability and validity of both observed and unobserved variables (Hair *et al.*, 2021). Several statistical tests were conducted to evaluate the measurement model. Table 1 presents each construct alongside its indicators, along with the results of the outer loading test, internal consistency, and convergent validity. Initially, the contribution of indicators to each construct was assessed through the outer loading test. This test determines the strength of the relationship between indicators and their respective constructs by calculating bivariate correlations. In this study, the outer loadings of all 215 indicators in the initial hypothesis model were compared against the threshold value. Upon revision, all external loads exceeded the threshold, as depicted in Table 1.

The next step involved testing the internal consistency of the revised PLS–SEM model. Two parameters were considered for this assessment: composite reliability (*CR*), and Cronbach's alpha (α). These parameters serve to gauge the consistency of indicator scores within each construct. The employed composite reliability value has been tested following the recommended threshold of 0.7 as suggested by Hair Jr. *et al.* (2021). The main difference between Cronbach's alpha and composite reliability is in how they handle

Table 1. Summary result of the measurement model

Variable	Indicator	Cronbach's alpha coefficient	Composite reliability	Average variance extracted	Loading factor
Market demand (md)	biosecurity (md_1)	0.855	0.972	0.946	0.831
	traceability (md_2)				0.815
	conservation (md_4)				0.772
	fish stock (md_5)				0.873
Community welfare (cw)	price protection (cw_3)	0.943	0.863	0.679	0.975
	quality of life (cw_5)				0.971
Infrastructure (if)	dock handling (if_1)	0.924	0.949	0.903	0.720
	fish handling (if_2)				0.957
	transportation access (if_4)				0.938
	communication technology (if_5)				0.956
Environmental carrying capacity (env)	water resources (env_3)	0.893	0.943	0.807	0.954
	cultural and local wisdom (env_5)				0.947
Community empower (ce)	education and training (ce_2)	0.789	0.894	0.678	0.814
	institution (ce_3)				0.713
	business collaboration (ce_5)				0.931
Regulation (rg)	fish protection (rg_3)	0.917	0.948	0.858	0.930
	monitoring (rg_5)				0.920
	enforcement (rg_6)				0.928
Eco-fishing port (ef)	implementation of friendly fishing practice (ef_2)	0.922	0.951	0.865	0.935
	long term strategy (ef_4)				0.924
	social responsibility (ef_5)				0.931

Source: own study.

loading indicators. Cronbach's alpha assumes that all loading indicators are equal, whereas composite reliability does not make this assumption. Despite this difference, both parameters share the same threshold value of 0.70. In this study, all constructs successfully met the threshold for the internal consistency reliability test, affirming that the requisite conditions for variables have been met, and the questionnaire data has undergone reliable testing.

The convergent validity test, which calculates the average variance extracted (*AVE*), is also confirmed as shown in Table 1. The *AVE* represents the proportion of variance captured by latent variables relative to measurement errors stemming from substantial variances (Santos dos and Cirillo, 2023). As per recommendations, an *AVE* value below the threshold of 0.5 is acceptable only if the *CR* exceeds 0.60 (Dash and Paul, 2021). The acceptable *AVE* range falls between 0.40 and 0.50, with values below the lowest tolerance (0.40) considered unacceptable. In this study, the *AVE* values met the acceptance criteria.

The assessment of individual item reliability involved examining the loading factor values, indicating the strength of the relationship between latent variables and their corresponding indicators. A loading factor exceeding 0.7 is deemed favourable, signifying an effective ability to measure or elucidate the latent variable. Subsequently, indicators with values below 0.7, such as md_3, cw_1, cw_2, cw_4, if_3, env_1, env_2, env_4, ce_1, ce_4, rg_1, rg_2, rg_4, ef_1, and ef_3, were excluded from further consideration. Additionally, the loading factors in Table 1 indicate that all variables meet the criteria of >0.3 or are statistically significant. A visual representation of these findings is presented in Figure 4.

ASSESSMENT OF MODEL FIT

An indicator for evaluating the overall fit of a model in partial least squares structural equation modelling (SEM–PLS) to extract additional information beyond what is specified (Sarstedt *et al.*, 2022). In this study, the model fit was assessed using standardised root mean square residual (*SRMR*), normed fit index (*NFI*), unweighted least squares discrepancy (*d*_ULS), and geodesic discrepancy (*d*_G) as measurement indicators. The *SRMR* serves as an indicator of the estimated model fit, representing the average of standardised residuals between the observed and hypothesised covariance matrices. A study model is considered to have a good fit when *SRMR* is <0.08, with a lower *SRMR* indicating a better fit (Matthews, Hair and Matthews, 2018).

In Table 2, the *SRMR* values for the current study are presented, revealing a value of 0.043, indicating a good fit for the study model. The overall model fit is further evaluated using *NFI*,

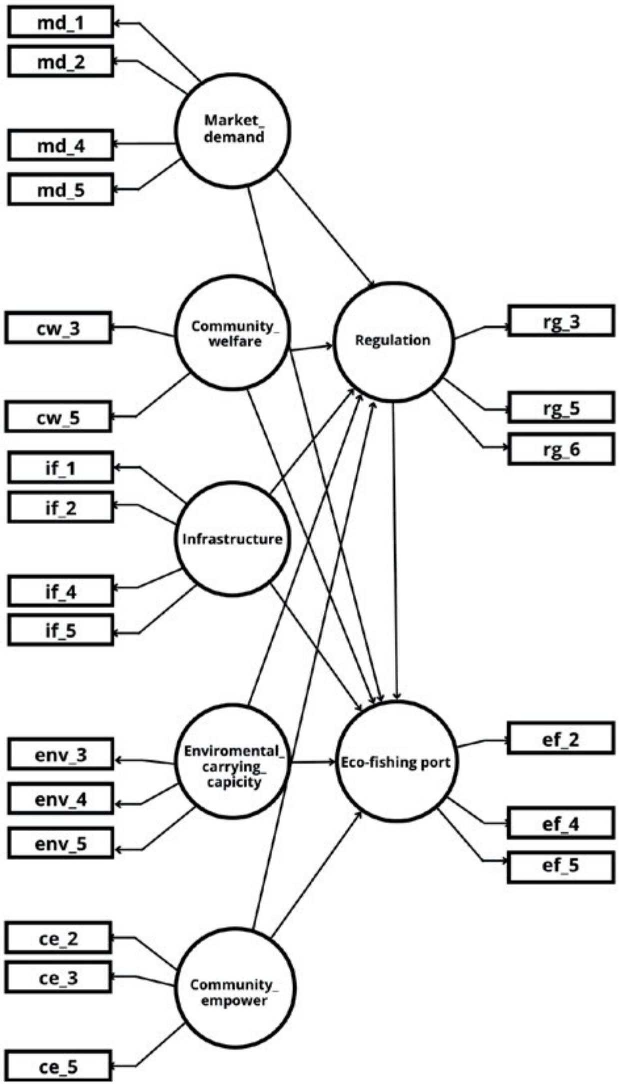

Fig. 4. The path of sustainable fishing port model; source: own study

Table 2. Summary result of the model fit and quality indices

Model fit and quality index	Result	Criteria	Information
SRMR	0.043	<0.10 or <0.08	fulfill, accepted
NFI	0.769	0–1	fulfill, accepted
*d*_ULS	0.516	confidence interval > observed parameter value	fulfill, accepted
*d*_G	0.477	confidence interval > observed parameter value	fulfill, accepted

Source: own study.

*d*_ULS and *d*_G values, which are based on statistical inference rather than heuristic rules. The *NFI* is calculated by subtracting the chi-squared value of the proposed model from the chi-squared value of the null model, then dividing by the chi-squared value of the null model. This yields a value between 0 and 1. A higher *NFI* indicates a better fit. The closer the *NFI* is to 1, the better the fit (Yusif *et al.*, 2020). The *d*_ULS and *d*_G values themselves do not hold any inherent significance. They are only the result of the Bollen–Stine bootstrap procedure for assessing the overall model fit, as provided by SmartPLS (Bollen and Stine, 1992), which enables the interpretation of the results. Bootstrap-based testing of exact model fit (i.e., *d*_ULS and *d*_G) was performed, followed by a comparison of the original values with confidence intervals generated from the sample distribution. These confidence intervals should encompass the original values. Thus, the upper limit of the confidence interval should be greater than the original values of the fit criteria *d*_ULS and *d*_G to indicate a "good fit" of the model. Confidence intervals typically have upper limits set at either 95% or 99% confidence levels. The *NFI* value in this study is 0.769, meeting the criteria. Additionally, the *d*_ULS and *d*_G values in this study are found to be below the upper bound of the 95% confidence interval, confirming the overall good fit of the model (Benitez *et al.*, 2020).

ASSESSMENT OF STRUCTURAL MODEL

The assessment of the structural model includes testing the suggested connections between variables. The significant criteria for assessing the structural model include the coefficient of determination (R^2), path coefficient (β value), t-statistics value, and model fit.

Subsequently, to examine the hypothesis of the PLS model, it involves recognising statistically significant coefficients between variables. Achieving a p-value below 0.05 is essential for significance. Moreover, a relationship is considered significant when the t-value is less than 1.96 (Purwanto *et al.*, 2021). The determination coefficient test is employed to assess the combined explanatory power of endogenous variables on exogenous variables within the structural model, serving as an indicator of the model's predictive accuracy.

Hair *et al.* (2021) classify the R^2 value as strong when it surpasses 0.67, moderate if it falls between 0.33 and 0.67, and weak if it ranges from 0.19 to 0.33. In this study, the result of the R^2 value for the latent variable regulation is 83.5%. This means that 83.5% contribution of regulation to an eco-fishing port formation can be explained by factors such as market demand, community welfare, infrastructure, environmental carrying capacity, and community empowerment. The remaining 16.5% is explained by other variables outside the model. The R^2 value for the latent variable eco-fishing port is 88.1% explained by factors such as market demand, community welfare, infrastructure, environmental carrying capacity, community empowerment, and regulation. Both of the R^2 values are considered strong, indicating that the inner model fits well with the data. This implies that the study can be deemed valid and reliable.

HYPOTHESIS TESTING

The research hypothesis was tested using empirical data obtained from 215 respondents. The path coefficients in PLS and the standardised β coefficients in regression analysis share similarities. The β values for each path in the proposed model are calculated, where a higher β value indicates a more significant impact on the endogenous latent construct. However, it is essential to validate the significance level of the β value through the t-statistics test. The investigation also employed the p-value with alpha levels <0.05. To assess the significance of the hypothesis (Hair Jr. *et al.*, 2014), a bootstrapping procedure was employed. Specifically, a bootstrapping process involving 5000 subsamples, with no sign changes, was conducted to examine the significance of both the path coefficients and *t*-statistics value. Consequently, 8 hypotheses were accepted, except for H6, H9 and H10. In Table 3, the hypothesis test results are presented, including the path coefficient values, along with the *p*-value indicating the level of significance.

Table 3. Summary result of hypothesis test results

Hypothesis	Path	β	t	p-value	Result of hypothesis test
H1	md→rg	0.489	6.202	0.000	supported
H2	md→ef	0.303	3.474	0.001	supported
H3	cw→rg	0.242	2.436	0.015	supported
H4	cw→ef	0.488	4.724	0.000	supported
H5	if→rg	0.186	3.828	0.000	supported
H6	if→ef	–0.062	1.418	0.157	not supported
H7	env→rg	0.809	30.020	0.000	supported
H8	env→ef	0.285	3.297	0.001	supported
H9	ce→rg	0.144	1.275	0.203	not supported
H10	ce→ef	–0.152	1.527	0.127	not supported
H11	rg→ef	0.151	1.972	0.047	supported

Explanations: md, rg, ef, cw, if, env, ce as in Tab. 1.
Source: own study.

In Table 3, the constructed variables of market demand are shown, community welfare, infrastructure, and environmental carrying capacity are found to positively and significantly directly determine regulation at a level of *p*-value <0.05. The result also found that the constructs variables of market demand, community welfare, environmental carrying capacity, community empowerment and regulation are found to positively and significantly directly determine regulation at a level of *p*-value <0.05 and the *t*-statistic >1.96, however H6 (the direct relationships between infrastructure and eco-fishing port) and H9 (the direct relationships between community empower to regulation and eco-fishing port) are insignificant.

In Table 3, the SEM result of regulation and eco-fishing factor with market demand, community welfare, infrastructure, environmental carrying capacity, and community empowerment is described. It shows evidence that market demand (β = 0.489, t = 6.202), community welfare (β = 0.242, t = 2.436), infrastructure (β = 0.186, t = 3.828), and environmental carrying capacity (β = 0.809, t = 30.02) have positive and significant contribution on the regulation. On the other hand, market demand (β = 0.303, t = 3.474), community welfare (β = 0.488, t = 4.724), and environmental carrying capacity (β = 0.285, t = 3.297) have positive and significant contributions to the eco-fishing port. The result also shows a positive and significant mediation relationship between regulation and eco-fishing ports (β = 0.151, t = 1.972). Therefore, H6, H9, and H10 were not supported.

The findings of the study indicate that eight hypotheses (H1, H2, H3, H4, H5, H7, H8 and H11) are supported while three hypotheses (H6, H9, and H10) are not supported. The study reveals that there is a significant positive correlation between market demand, community welfare, infrastructure, environmental carrying capacity, and regulation. This finding is supported by Lee *et al.* (2022), Tran *et al.* (2022), Chen *et al.* (2023), Cunha da *et al.* (2023), and Triharyuni *et al.* (2023). Therefore, H1, H3, H5, and H7 are supported.

It is found that market demand, community welfare, infrastructure, environmental carrying capacity, and regulation have significant positive relations with eco-fishing ports (Hasbi *et al.*, 2022; Muntaha *et al.*, 2023). Therefore, H2, H4, H8, and H11 are supported.

The market demand is influenced by environmental regulation (Zhilin *et al.*, 2020; Shao *et al.*, 2022; Hao and Zhang, 2023), fish capture regulation including traceability of fish caught (Khasanah, Saputra and Taufani, 2020; Desalegn and Shitaw, 2021; Stefanus and Vervaele, 2021; Dirhamsyah, Umam and Arifin, 2022), healthy and hygienic fish processing standards (Dirhamsyah, Umam and Arifin, 2022), and sustainability of fish production (Desalegn and Shitaw, 2021). Collectively, this establishes a foundation for a comprehensive understanding of how the model can respond to regulatory requirements, market dynamics, and sustainability requirements (H1 supported). Therefore, the market demand will support the development of sustainable fishing ports (H2 is supported).

The study has found a significant positive relationship between community welfare and regulation (Nur, Suadi and Suwarman, 2023). Hence, H3 is supported. Regulations are often implemented to ensure public safety, maintain economic stability, contribute to improved health outcomes for the population, ensuring that products and services meet certain standards of safety and quality. The significant positive relationship between community welfare and eco-fishing port is sustainable fishing practices that contribute to the long-term health of fisheries, ensuring a stable and reliable source of income for local fishermen and sustained availability of fish for the community; this supports H4 (Gushendri, Aimon and Sentosa, 2022; Junita *et al.*, 2022).

Hypothesis H5 described a significant positive relationship between infrastructure and regulation (Abdul-Rahaman and Adusah-Karikari, 2019). The development of infrastructure, such as waste management systems and eco-friendly facilities, supports compliance with these regulations, contributing to the overall environmental conservation efforts of the port. Infrastructure development in the form of regulated fishing equipment and vessel facilities ensures that the fishing activities align with these standards, promoting sustainable and responsible fishing practices. This infrastructure helps implement regulations related to fisheries management, ensuring that fishing activities are within sustainable limits and that the health of fish stocks is monitored. This infrastructure ensures that the fishing port is prepared to handle emergencies and enforce safety regulations, contributing to the well-being of fishermen and the community (Salinas-Zavala *et al.*, 2022).

The environmental carrying capacity represents the maximum level of fishing activity that the ecosystem can sustain without the long-term depletion of fish stocks. Regulations are designed to establish catch limits and fishing practices that prevent overfishing, ensuring that the fishing effort aligns with the regenerative capacity of fish populations. The H7 reflects a significant positive relationship between environmental carrying capacity and regulation (Wang *et al*., 2023).

This study suggests that environmental carrying capacity is positively related to eco-fishing ports (H8). The environmental carrying capacity represents the maximum level of fishing activity that the ecosystem can sustain without long-term harm. To ensure sustainable resource management, an eco-fishing port must be designed and developed in a way that aligns with this carrying capacity. This includes setting catch limits, implementing sustainable fishing practices, and adopting measures to prevent overexploitation of fish stocks (Wei, 2023).

The H11 is a positively significant mediation relationship between regulation and eco-fishing ports. Regulations in an eco-fishing port are designed to promote and enforce sustainable fishing practices. The positive relationship indicates that adherence to these regulations fosters responsible fishing methods, preventing overexploitation of fish stocks and promoting the long-term health of marine ecosystems. Regulations in an eco-fishing port often focus on environmental conservation, including habitat protection, pollution control, and biodiversity preservation. The positive relationship suggests that compliance with these regulations contributes to the conservation of marine environments, ensuring the port operates in harmony with natural ecosystems (Wu, Cui and Liu, 2023).

In addition to regulatory compliance, fostering community engagement and ensuring the well-being of local fishermen and communities are critical aspects of eco-fishing port management. Responding to market demand for sustainably sourced seafood by obtaining certification from reputable eco-labelling will incentivise fishermen and fishing ports to comply with sustainable practices (Kyvelou, Ierapetritis and Chiotinis, 2023). Meeting certification standards demonstrates a commitment to environmental stewardship and can enhance market access and profitability for fishing enterprises. Strengthening enforcement mechanisms, enhancing surveillance and monitoring capabilities, and fostering international cooperation are key strategies for addressing illegal unregulated unreported (IUU) fishing activities within and beyond eco-fishing ports. Effective regulation in implementing adaptation and mitigation strategies, such as habitat restoration, coastal zone management, and sustainable aquaculture practices, can help build resilience to climate change within eco-fishing ports (Owusu *et al*., 2023).

CONCLUSION

This study explores factors that contribute to the development of a sustainable fishing ports model in East Java Province, Indonesia which considers environmental, social, and economic aspects in a balanced way. The study validates the hypotheses regarding the significance of the factors which contributed to the development of the sustainable fishing ports model (eco-fishing ports).

It was found that eight hypotheses (H1, H2, H3, H4, H5, H7, H8, and H11) are supported while three hypotheses (H6, H9, and H10) are not supported. The study reveals that there is a significant positive correlation between market demand, community welfare, infrastructure, environmental carrying capacity, regulation, and eco-fishing ports. The positive relationship indicates that adherence to these regulations fosters responsible fishing methods, preventing overexploitation of fish stocks and promoting the long-term health of marine ecosystems. The positive relationship suggests that compliance with these regulations contributes to the conservation of marine environments, ensuring the port operates in harmony with natural ecosystems and local communities.

This suggests that developing and implementing eco-fishing ports can be a beneficial strategy for promoting sustainable fisheries and improving the overall well-being of fishing communities. The study revealed the importance of a holistic approach to fisheries management. It emphasises that the development of eco-fishing ports considering various factors like market demand, community welfare, infrastructure, environmental carrying capacity, and regulations is crucial for ensuring the long-term sustainability of the fisheries sector.

CONFLICT OF INTERESTS

All authors declare that they have no conflict of interests.

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