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Developing Eco-Fishing Ports in East Java: A Structural Equation Modeling Analysis

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ABSTRACT

Eco-fishing ports play a pivotal role in achieving Sustainable Development Goals (SDGs), encouraging more environmentally responsible and economically sustainable practices for a viable future through the preservation and sustainable utilization of marine and fisheries resources. East Java, a province in Indonesia, boasting an extensive coastline and abundant marine resources, requires a fishing port with environmentally friendly management. This research aims to analyze the measurement models that affect the development of eco-fishing ports in East Java Province. Data analysis using Partial Least Squares Structural Equation Modeling (PLS-SEM) was employed to ascertain the relationship between latent and manifest variables. Purposive sampling was used to choose 215 participants from administrative offices, fishing companies, and fishing communities of six fishing ports in the province of East Java. This model comprehensively evaluates eco-fishing ports by considering 36 indicators of the seven following latent variables: Market Demand (md), Community Welfare (cw), Infrastructure (if), Environmental Carrying Capacity (env), Community Empowerment (ce), Regulation (rg), and Eco-Fishing Port (ef). The analysis test found that the AVE and the Construct Reliability values of 21 indicators all exceed the threshold of 0.5 and 0.7, respectively. It indicates that each latent variable has a valid and reliable measurement model. The result revealed that the eco-fishing port development model's latent variable strongly correlated with 21 indicators. These findings can guide future efforts to enhance the sustainability and resilience of fisheries management in East Java.

1. INTRODUCTION

The importance of environmental conservation and sustainable utilization of marine resources has increased global attention in recent decades [1, 2]. Issues such as climate change, declining fish populations, and the degradation of marine ecosystems have mobilized the international community to seek sustainable solutions Robotham [3]. The imperative to preserve marine ecosystems and fish populations has necessitated the development of eco-fishing ports [4]. Therefore, an eco-fishing port is a key infrastructure in preserving marine resources and supporting fishing communities' economic sustainability. According to Nur et al. [5], fishing ports are crucial in the fisheries supply chain.

The fishing ports serve as gateways for the processing and distribution of marine resources, thus making the management of fishing ports significantly important in sustaining the fisheries sector [6]. Eco-fishing port is a key to achieving sustainability in the fisheries sector. It is designed and managed considering minimal environmental impact and promoting sustainable fishing practices in economic activities [7, 8]. One of the significant aspects of an eco-fishing port is sustainable management strategies of marine resources. This includes implementing friendly fishing practices, such as non-destructive fishing, monitoring fish stocks and catch restrictions, and enforcing strict regulations against environmentally harmful fishing practices [9]. Eco-fishing ports can also provide facilities for scientific research to support a better understanding of marine ecosystems and the fish species. The eco-fishing port approach would not only protect fish populations but also ensure that fishermen can continue accessing abundant marine resources in the future [5, 10].

The fishing port supports efforts to preserve marine ecosystems and sustain fish populations, provides tangible benefits to local fishermen, and ensures the sustainable use of marine resources for future generations [11]. In pursuit of sustainable development goals, in-depth research on the impact of various aspects of the fishing port model is highly relevant [12]. This research expected to provide valuable insights for policymakers, researchers, and practitioners in efforts to maintain the sustainability of the fisheries sector through eco-fishing port in East Java [13].

This research examines previous similar research and successful sustainable fishing port initiatives from across the world [14]. This research examined how factors like future growth, current environmental regulations, and expanding beyond just fishing can influence sustainability of port of Vigo. Similarly, Mansour [15] conducted a study on a sustainable green port policy in Egypt, focusing on resource management, minimizes environmental impact from port operations, prevents pollution, and improves public and environmental health, striving to balance environmental, social, and economic well-being.

The analysis of previous studies and actual conditions of fishing ports in East Java, Indonesia summarizes six aspects affecting the sustainability of fishing ports, including market demand, community welfare, infrastructure, environment, community empowerment, and regulation aspects [16, 17]. Furthermore, the aspects that influence the eco-fishing port as a sustainable port model need to be further analyzed. This research uses exploratory factor analysis and confirmatory factor analysis to establish SEM for empirical analysis. The research will elucidate the Partial Least Square based Structural Equation Modelling (PLS-SEM) used to analyze the factors affecting the development of eco-fishing port, making it a significant contribution towards guiding steps to preserve marine environments and promote sustainability in the fisheries industry.

2. LITERATURE REVIEW

Sustainable development has become a crucial aspect of contemporary port management, with a growing emphasis on environmental, social, and economic considerations. This literature review explores the concept of sustainable ports, focusing specifically on developments and initiatives in East Java, Indonesia.

Sustainable port management involves integrating economic growth with environmental protection and social responsibility. Ports are vital infrastructure in global supply chains, and their sustainability is increasingly recognized as essential for long-term viability. The sustainable port development requires a holistic approach, considering environmental impact, economic performance, and societal well-being. In East Java, efforts have been made to enhance the environmental sustainability of ports [18]. Research by Wijitkosum [19] highlights the importance of reducing emissions and adopting cleaner technologies in port operations. Implementing green practices, such as shore power for vessels and using renewable energy sources, contributes to a more sustainable maritime infrastructure.

Sustainable ports also prioritize social aspects, emphasizing community engagement and the well-being of port workers. The significance of fostering positive relationships between ports and local communities [20]. Initiatives that support education, healthcare, and social infrastructure contribute to the overall sustainability of the port ecosystem. Economic sustainability remains a critical consideration in port development.

The economic benefits of sustainable port practices, emphasizing increased efficiency, cost savings, and improved competitiveness [20]. Integrating technology, such as automated container handling systems, enhances port performance and economic viability. The literature suggests that effective, sustainable port management requires supportive policy frameworks. The regulatory environment in East Java, emphasizing the need for clear policies that incentivize sustainable practices [20]. Collaboration between government bodies, port authorities, and private stakeholders is crucial for creating an enabling environment.

A methodology employing a comprehensive tool designed to capture the past, present, and future scenarios of fishing ports when applied to fishing port of Vigo, in Spain [14]. This tool is a significant contribution as it allows for a holistic analysis of a port's operations over time, considering multiple dimensions of sustainability. It examining factors such as future growth, the study emphasizes the importance of strategic planning for future expansion, anticipate the environmental impact and implement measures to mitigate negative effects. This proactive approach is critical in ensuring that expansion does not come at the expense of environmental sustainability. Current environmental regulations, and opportunities for diversification beyond conventional fishing activities, this study provides an understanding of how these factors interact to influence a port's green initiatives. The study highlights the pivotal role of adhering to current environmental regulations. Compliance with these regulations ensures that ports operate within legal frameworks designed to protect the environment. Moreover, this adherence often drives innovation, as ports seek new technologies and practices to meet stringent regulatory requirements. Another factor examined in this study was the expansion beyond traditional fishing activities as a key strategy for sustainability. Diversification can reduce dependency on a single industry, thereby enhancing economic resilience. Additionally, it opens up opportunities for adopting more sustainable practices in other areas, such as tourism and marine conservation.

The study on sustainable green port policy in Egypt focuses on six key areas: water, energy, air quality, waste management, sustainable development, and eco-friendly business practices [15]. This framework is valuable for its comprehensive approach to sustainability, addressing multiple environmental dimensions simultaneously. The study underscores the importance of transitioning to renewable energy sources and improving energy efficiency to reduce carbon footprints and combat climate change. It highlights the need to monitor and improve air quality by reducing emissions from ships and port machinery, benefiting public health. Proper waste management practices, including recycling and safe disposal of hazardous materials, are crucial for preventing pollution and protecting marine life. Integrating sustainability into broader development ensures that economic growth does not compromise environmental and social well-being, promoting sustainable land use and infrastructure development. Encouraging businesses to adopt eco-friendly practices, such as using environmentally friendly materials and reducing waste, can drive industry-wide changes towards sustainability. This approach can guide ports in Egypt, the Middle East, and Africa towards becoming sustainable.

East Java is one of province in Indonesia with abundant potential fish in Indonesia, making it a primary focus for understanding and enhancing sustainable fishing sector [21-23]. Establishing an eco-friendly fishing port poses challenges in adopting sustainable port practices, and various obstacles hinder the progress. The identify issues such as resistance to change, financial constraints, and technological barriers [24]. Recognizing these challenges is essential for developing targeted strategies to overcome obstacles and unlock the full potential of sustainable port management in East Java.

This article will delve into the fundamental concept of eco-fishing ports and highlight the significant relationship of measurement variable which affecting the development of eco-fishing ports [25]. Furthermore, as the fishing industry continues to grow, the emphasis on policy that consider environmental impacts on fishing sector becomes increasingly urgent. Through the eco-fishing port approach, the effort to reduce negative impacts on marine ecosystems and maintain sustainability in the fisheries sector will be increased [26].

3. METHODS

This explanatory research design employed the survey method. Questionnaires and google forms were utilized in this research. The analysis employed variable indicators presented as statements and respondents assigned scores on a scale for strongly disagree to strongly agree, using a numerical range of 1 to 5. This study employed PLS-SEM, which is particularly suited for complex models and theory development with multiple constructs and indicators. It is often encountered in sustainability studies involving various interrelated factors. Additionally, PLS-SEM does not require normal distribution assumptions, making it advantageous for this research as real-world data that may exhibit non-normality, and offering robust insights that can inform sustainable practices and policies. PLS-SEM utilizing exogenous, endogenous latent, and indicator variables as outlined [27]. A measurement model was appropriately employed to depict the associations between latent/construct variables and their respective indicators, referred to as outer relations.

The measurement model elucidated the connection between the latent variable and its indicator variable (manifest), commonly called the outer relation or measurement model. This model comprised both the formative indicator model and the reflective indicator model. The reflective model manifests when the latent variable influences the manifest variable. In contrast, the formative model clarifies that the manifest variable impacts the latent variable, with the causality direction flowing from the manifest variable to the latent variable. Eqs. (1) and (2) illustrate the reflective model as presented by [28]:

Measuring model equations are

$$X = \Lambda X\xi + \delta \tag{1}$$

$$Y = \Lambda Y_{\eta} + \varepsilon \tag{2}$$

Structural model equation is

$$X = \Gamma\xi + \zeta \tag{3}$$

ΛX and ΛY are the factor loadings of the index X (md, cw, if, env, ce) and two endogenous Y (rg and ef), δ and ε are the measurement errors of the explicit variables, ξ and η are the exogenous latent variables and endogenous latent variables respectively. ξ is the residual, Γ is the matrix of structural coefficient between the latent variables and the external dependent latent variables [29].

The latent variables consisted of five exogenous variables (md, cw, if, env, ce), an endogenous exogenous variable (rg), and an endogenous variable (ef). Table 1 outlines the specific indicators used to measure each latent variable components involved in the analysis.

Table 1. Latent/Construct variables

Latent Variables	Indicator Variables	Literatures	Item
Market Demand (md)	Biosecurity	[30]	md1
	Traceability	[31]	md2
	Environmental quality	[32]	md3
	Conservation of fish resources	[33]	md4
	Sustainability of fish stock	[10]	md5
Community Welfare (cw)	Income	[34]	cw1
	Business opportunities	[24]	cw2
	Price protection	[35]	cw3
	Elimination of high-cost economic practices	[36]	cw4
	Quality of life	[34]	cw5
Infrastructure (if)	Port performance	[5]	if1
	Fish handling infrastructure	[37]	if2
	Sanitation management infrastructure	[38]	if3
	Transportation infrastructure	[39]	if4
	Communication infrastructure	[40]	if5
Environmental Carrying Capacity (env)	Fishery resources	[1]	env1
	Export potential	[2]	env2
	Water resources	[41, 42]	env3
	Land availability	[43]	env4
	Cultural and local wisdom	[34]	env5
Community Empower (ce)	Community participation	[20]	ce1
	Education and training	[44]	ce2
	Institution	[45]	ce3
	Protection of fishermen	[46]	ce4
	Business collaboration	[47]	ce5
Regulation (rg)	Fish capture regulations	[48]	rg1
	Fish handling regulations	[49]	rg2
	Fish resource protection	[6]	rg3
	Fishermen community protection	[50]	rg4
	Regulation monitoring	[51]	rg5
	Enforcement of Regulations	[9]	rg6
Eco-fishing port (ef)	Environmental protection	[8]	ef1
	Implementation regulations	[9]	ef2
	Economic benefits	[52]	ef3
	Long term strategic plan	[53]	ef4
	Protection local communities	[54]	ef5

Table 2. Criteria model test

Latent Variables	Indicator Variables	Literatures
Outer Model (Indicator Test)	a. Convergent validity test (individual reliability) b. Discriminant validity test (internal consistency) c. Average Variance Extracted d. Composite reliability test (discriminant validity)	a. Load Factor above 0.7 b. Cross-loading correlation>correlation to other latent variables c. AVE>0.5 d. CR≥0.7

Primary and secondary data were both used in this investigation [55]. A systematic survey was used to evaluate the infrastructure and operations of the port, and in-depth interviews with key stakeholders and frequent port users yielded primary data [56].

The outer model (indicator test) was assessed according to the literatures as criteria outlined in Table 2. This assessment encompassed factors such as convergent validity (individual reliability), discriminant validity (internal consistency), average variance extracted (AVE), and composite reliability (discriminant validity).

This study was conducted in six fishing ports of East Java Province: The Prigi fishing port in Trenggalek Regency, the Brondong fishing port in Lamongan Regency, the Pondok Dadap fishing port in Malang Regency, the Mayangan fishing port in Probolinggo Regency, the Puger fishing port in Jember Regency, and the Tamperan fishing port in Pacitan Regency (Figure 1).

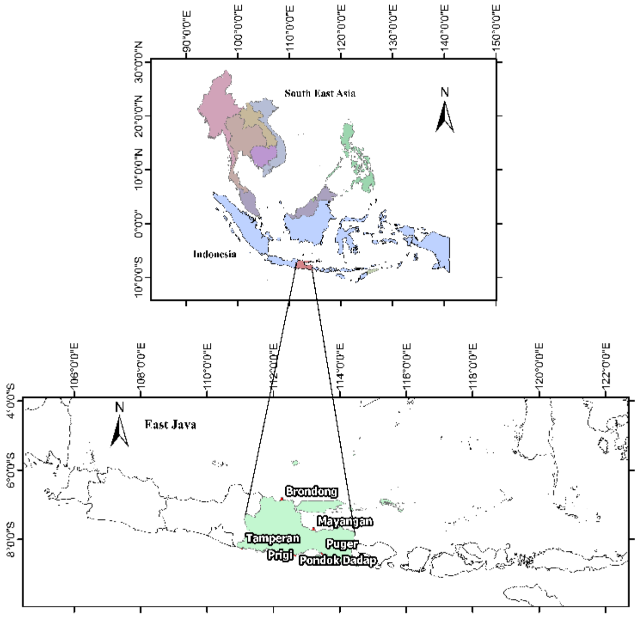

Figure 1. Site Study

The period of data collection was May to September 2023. Purposive sampling was used to choose 215 respondents from the administrative offices of the Ministry of Maritime Affairs and Fisheries., fishing companies, and fisherman communities from six fishing ports in the province of East Java participated and completed the guided questionnaire, fulfilling the minimum sample requirement criteria according to the guidelines for PLS SEM analysis [57]. Knowledge and experience are the key factors in choosing the respondents, as outlined by Hadi [44]. Reports and interview from related fishing port organizations, businesses, and establishments inside those fishing ports provided further secondary data. These sources offered valuable insights into operational practices, environmental impacts, economic impacts, social impacts, and regulatory compliance. Examining these insights enables an understanding of efficient operations, recognition of broader environmental, economic and social impacts, and an appreciation for the importance of regulatory compliance.

The collected data is first cleaned to address missing values, outliers, and inconsistencies. This step ensures the reliability and accuracy of the data before analysis. Initial descriptive statistics are generated to summarize the data and provide a basic understanding of the sample characteristics. The PLS-SEM involves model specification, measurement model assessment, structural model assessment, bootstrapping, and model fit. The parameter settings of PLS-SEM in this research used 215 data points and 5000 bootstrap samples to ensure robust estimates of standard errors and confidence intervals. A significance level of 0.05 is employed for hypothesis testing, and indicator loadings above 0.7 are retained to ensure a strong representation of the latent constructs [27]. The conceptual framework is illustrated in Figure 2.

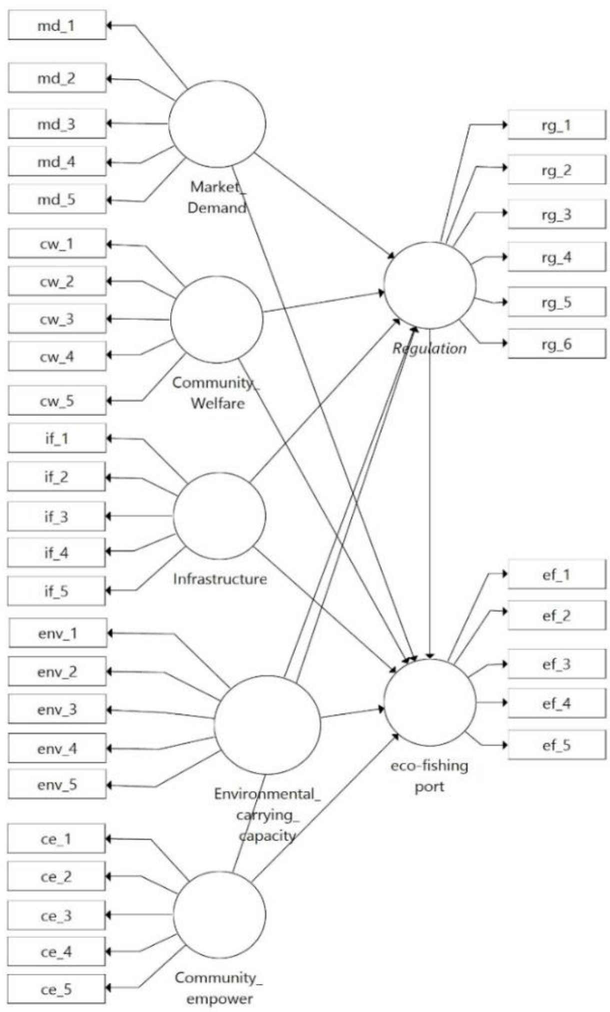

Figure 2. Conceptual framework

4. RESULTS

4.1 Respondent profile

The survey participants comprised a diverse group from the fishing sector, including individuals employed by the Ministry of Maritime Affairs and Fisheries, workers of fishing companies, and representatives of fishing communities. The majority, accounting for 65.3%, were from the Ministry of Maritime Affairs and Fisheries, while 10.3% were workers from various fishing companies, and 2.4% represented the fishing communities. This diverse representation provides a comprehensive overview of perspectives within the fishing sector.

In terms of experience, the participants had varying lengths of service in the fishing sector. A small percentage, 3.8%, had less than 5 years of experience, while 30.9% had worked for 5 to 10 years. The largest group, 52.9%, had extensive experience of 10 to 15 years, and 12.4% had been in the sector for over 15 years. This range of experience among respondents offers valuable insights into both the challenges and developments within the industry over time.

The respondents were also geographically dispersed across several key fishing ports. Specifically, 20.2% of the participants were from Brondong fishing port, 19.4% from Prigi fishing port, 13.3% from Mayangan fishing port, 17.7% from Pondok Dadap fishing port, 15.2% from Puger fishing port, and 14.2% from Tamperan fishing port. This wide distribution ensures that the survey captures the conditions and practices across different locations, providing a well-rounded understanding of the fishing sector's regional dynamics.

4.2 Measurement model analysis results

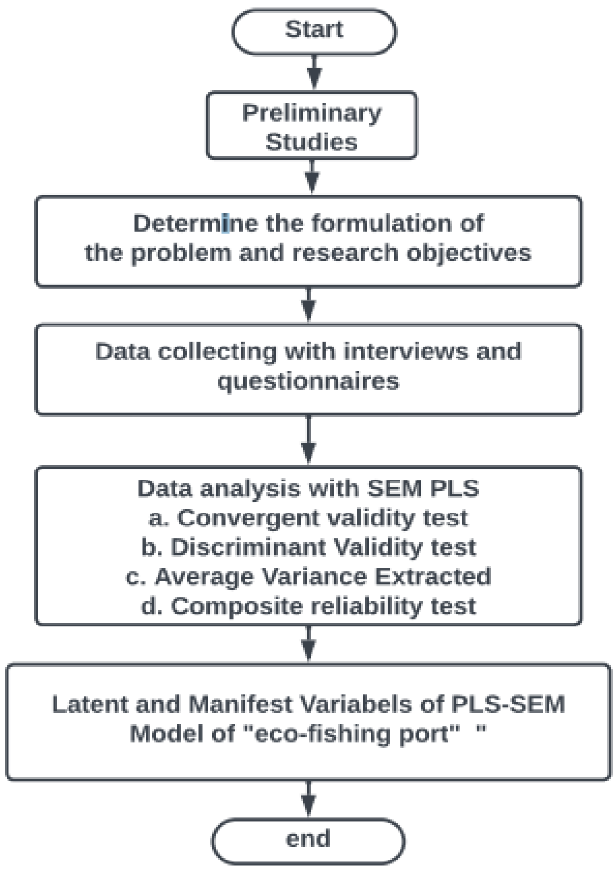

Figure 3. Research flow

The outer model, as indicated, is responsible for establishing the relationship between latent variables and their corresponding indicators or manifestations [58]. In addition, the assessment of the outer model involved a four-stage testing process, encompassing individual reliability, internal consistency reliability, average variance extracted (AVE), and discriminant validity. This evaluation was performed on 36 indicators variables as illustrated in Figure 2.

The indicators were assessed as measurement of outer model. The assessment of the research model through the PLS-SEM approach was conducted through the phases, as illustrated in Figure 3.

The first step in establishing the relationship between the latent variable and the indicator variable involves providing a comprehensive explanation of the overall relationship based on the eco-fishing port concept refer to Figure 4. Subsequently, the analysis focuses on assessing the strength of the connection between the latent variable and its corresponding indicator variable through individual reliability tests so that from the test, it can be seen several indicator variables that do not meet the requirements and are eliminated from the model. This stage is described in the individual reliability test sub-section and is depicted in Figure 5.

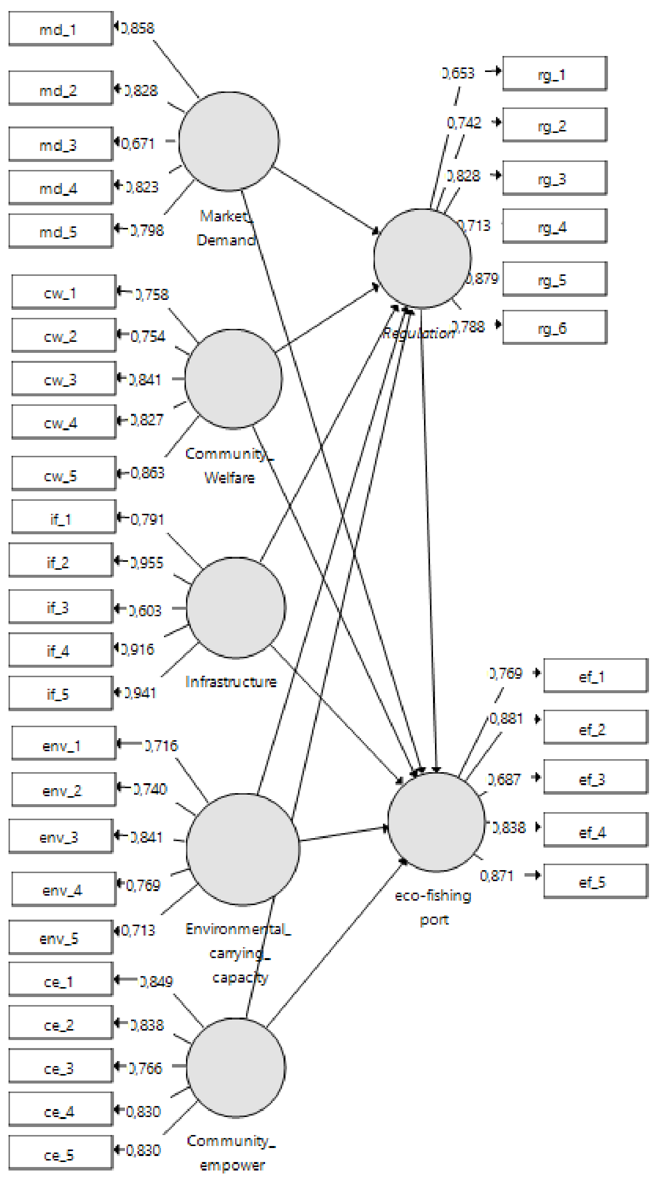

Figure 4. The eco-fishing port concept

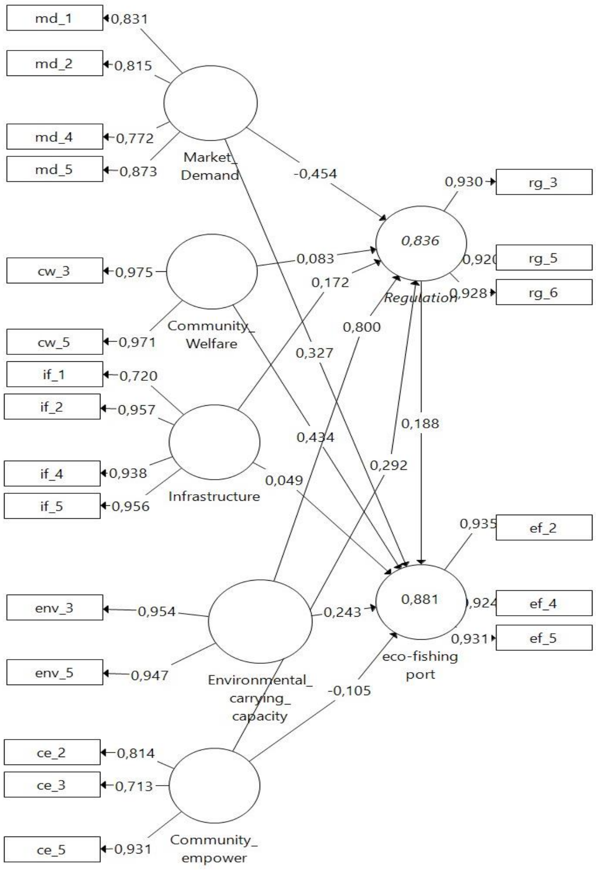

Figure 5. Tested loading factor values for the outer model outcomes

4.3 Reliability of individual items

The reliability of individual items was assessed by examining the loading factor value, indicating the strength of the connection between latent variables and the corresponding indicators. A loading factor exceeding 0.7 is considered favourable, indicating the ability to measure or elucidate the latent variable effectively. Once the loading factor is acquired, any indicators with a value below 0.7 were rejected from further consideration, 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. Figure 5 displays the final outcomes of the variable elimination process.

4.4 Reliability measurement

The test for consistency reliability (CR) utilized the composite reliability value, adhering to a threshold of 0.7 as recommended by Hair et al. [59]. Furthermore, because composite reliability does not presuppose a resemblance between all indicator variables, it assesses internal consistency reliability more accurately than Cronbach's alpha.

The test outcomes revealed a CR value exceeding 0.7, while Cronbach's alpha exceeding 0.6, indicating that the variable requirements have been fulfilled and the questionnaire data has undergone reliability testing. Detailed CR results can be found in Table 3.

4.5 Convergent validity

In the context of convergent validity, the Average Variances Extracted (AVE) statistic is used to assess the degree to which a latent variable captures the variance in its measured indicators relative to the measurement error. It reflects the extent to which a latent variable explains the variance among its observed indicators compared to measurement error. The latent variable is generally thought to be collecting more variance than measurement error when the AVE value is 0.5 or greater. The convergent validity of AVE used a minimum value of 0.5 denotes strong convergence, suggesting that a larger proportion of the variance in the latent variable is explained by its indicators rather than measurement error. The result shows the AVE values for variables md, cw, if, env, ce, rg, and ef all exceed the threshold of 0.5. It indicates that each latent variable has a valid measurement model as shown in Table 3. The loading factor in Table 3 also shown that all variables meet the criteria >0.3 or significant, and a visual representation is presented in Figure 5.

Table 3. Construct reliability, validity, and loading factor

Variable	Indicator	Cronbach's Alpha Coefficient	Composite Reliability	Average Variance Extracted (AVE)	Loading Factor	P-value	Information
Market Demand (md)	md1	0.855	0.972	0.946	0.831	<0.001	Fullfill
	md2				0.815	<0.001	Fullfill
	md4				0.772	<0.001	Fullfill
	md5				0.873	<0.001	Fullfill
Community Welfare (cw)	cw3	0.943	0.863	0.679	0.975	<0.001	Fullfill
	cw5				0.971	<0.001	Fullfill
Infrastructure (if)	if1	0.924	0.949	0.903	0.720	<0.001	Fullfill
	if2				0.957	<0.001	Fullfill
	if4				0.938	<0.001	Fullfill
	if5				0.956	<0.001	Fullfill
Environmental Carrying Capacity (env)	env3	0.893	0.943	0.807	0.954	<0.001	Fullfill
	env5				0.947	<0.001	Fullfill
Community Empower (ce)	ce2	0.789	0.894	0.678	0.814	<0.001	Fullfill
	ce3				0.713	<0.001	Fullfill
	ce5				0.931	<0.001	Fullfill
Regulation (rg)	rg3	0.917	0.948	0.858	0.930	<0.001	Fullfill
	rg5				0.920	<0.001	Fullfill
	rg6				0.928	<0.001	Fullfill
Eco-fishing port (ef)	ef2	0.922	0.951	0.865	0.935	<0.001	Fullfill
	ef4				0.924	<0.001	Fullfill
	ef5				0.931	<0.001	Fullfill

4.6 Discriminant validity testing

Discriminant validity testing aims to evaluate the relationship between latent variables, where the essence is that the square root of AVE should be greater than the specified correlation. The testing is conducted in two stages, namely the analysis of cross-loading among indicator variables and Fornell cross-loading. The cross-loading of this research shows that the correlation between indicator variables and their constructs is higher than the correlation with other constructs, indicating that the constructs in the block are better predicted than other constructs (Table 4).

Table 4. Cross loading

Indicator	Community Welfare	Community Empowers	Environmental Carrying Capacity	Infrastructure	Market Demand	Regulation	Eco-fishing Port	Type (As Defined)	P-value
md_1	0.530	0.685	0.129	0.405	0.831	0.048	0.453	Reflective	<0.001
md_2	0.521	0.745	0.241	0.267	0.815	0.118	0.497	Reflective	<0.001
md_4	0.433	0.626	0.110	0.277	0.772	-0.001	0.466	Reflective	<0.001
md_5	0.927	0.831	0.537	0.760	0.873	0.489	0.861	Reflective	<0.001
cw_3	0.975	0.824	0.514	0.806	0.777	0.510	0.875	Reflective	<0.001
cw_5	0.971	0.809	0.496	0.688	0.797	0.481	0.816	Reflective	<0.001
if_1	0.388	0.473	-0.038	0.720	0.443	-0.006	0.260	Reflective	<0.001
if_2	0.650	0.511	0.239	0.957	0.452	0.338	0.577	Reflective	<0.001
if_4	0.828	0.713	0.384	0.938	0.642	0.483	0.690	Reflective	<0.001
if_5	0.741	0.669	0.466	0.956	0.580	0.533	0.718	Reflective	<0.001
env_3	0.472	0.456	0.954	0.307	0.344	0.855	0.721	Reflective	<0.001
env_5	0.517	0.506	0.947	0.392	0.383	0.819	0.653	Reflective	<0.001
ce_2	0.496	0.814	0.333	0.335	0.767	0.234	0.501	Reflective	<0.001
ce_3	0.501	0.713	0.048	0.405	0.639	0.049	0.378	Reflective	<0.001
ce_5	0.910	0.931	0.612	0.760	0.814	0.615	0.881	Reflective	<0.001
rg_3	0.455	0.434	0.798	0.432	0.255	0.930	0.585	Reflective	<0.001
rg_5	0.402	0.426	0.802	0.333	0.217	0.920	0.624	Reflective	<0.001
rg_6	0.553	0.459	0.845	0.494	0.311	0.928	0.697	Reflective	<0.001
ef_2	0.781	0.742	0.696	0.597	0.695	0.680	0.935	Reflective	<0.001
ef_4	0.810	0.720	0.684	0.609	0.754	0.625	0.924	Reflective	<0.001
ef_5	0.838	0.765	0.639	0.700	0.668	0.615	0.931	Reflective	<0.001

5. DISCUSSION

The findings of this research are related to numerous references and best practice of sustainable fishing port worldwide. For instance, a methodology for transforming Egyptian ports into sustainable green ports by balancing environmental, social, and economic aspects [14]. The study highlights primary objectives such as managing resources responsibly, reducing environmental impacts, preventing pollution, and enhancing personal, community, and environmental health in fishing port. Another similar research is the port of Vigo in Spain, which is committed to enhancing its sustainability strategies by focusing on anticipating growth, staying abreast of sustainability legislation and contemporary trends, and exploring diversification opportunities. This approach acknowledges that the port has feasible options to broaden its business scope beyond conventional fishing activities [14]. The port of Valencia is another Spanish port that has made a strong commitment to transforming into a green port. It focused on reduce and monitor noise and air pollution generated by port activities by digitalizing and integrating information systems to enhance the management of road traffic at the port's entrances and exits.

Integrated with the previous studies and best practices, the strategy to develop eco-fishing ports in East Java involves a comprehensive analysis of several key variables. These include Market Demand (md), which ensures that the ports meet the economic needs of the fishing industry, Community Welfare (cw), which focuses on improving the quality of life for local community, Infrastructure (if), which ensures the ports have the necessary facilities and services to operate efficiently. Additionally, the strategy considers Environmental Carrying Capacity (env) to ensure that port activities do not exceed the ecological limits of the environment, and Community Empowerment (ce) to involve local communities in decision-making processes and boost their capacity to benefit from port activities. The Regulation (rg) is crucial for ensuring that the development and operation of the ports comply with relevant laws and policies, promoting long-term sustainability and resilience [14].

The strategy to meet the needs of the international market involves high-quality processes and the production of products that meet international standards, as well as obtaining product certification according to applicable standards [31]. The latent variable Market Demands (md) is significantly related to biosecurity (md_1), traceability (md_2), conservation of fish resources (md_4) and assurance of fish availability (md_5). Biosecurity, traceability, conservation of fish resources and assurance of fish availability is essential for ensuring the sustainability, safety, and quality of fish production to fulfill the international market demand [30].

Biosecurity measures in fisheries ensure the safety of fish products for human consumption by preventing the spread of pathogens and contaminants. Biosecurity contributes to producing safe and high-quality seafood, meeting the standards and expectations of consumers. The traceability serves the purpose of tracking and documenting the production and distribution of seafood throughout the supply chain. Its responsible ensuring environmentally friendly fishing practice, safeguarding food safety, supporting conservation of fish resources and sustainable and transparent seafood supply chains. The sustainability of fish stock in the fisheries system assures fish availability, thereby creating a stable supply in the fish market [10, 30, 31].

A fish market offering consistent assurance of fish availability tends to be more attractive to businesses and stakeholders in the supply chain, as they can plan production and distribution more effectively [5]. Hence, it is important to assess the potential sustainable yield of this commercially significant species to guarantee the long-term viability of the stock [10].

The social system variable is based on fishermen's welfare. The latent variable of Community Welfare (cw) has strong correlation to indicator of price protection (cw_3) and quality of life (cw_5). Price protection contributes to the stability of income in fishing communities by safeguarding fish prices [35]. The stability of fish prices can protect community income from price fluctuations, providing a sense of security for fishing communities in terms of both food and economic stability. Quality of life (cw_5) reflects an indicator or variable measuring the quality of life influenced by income, economic security, access to adequate education, access to infrastructure and public facilities, and the availability of sustainable fisheries resources. Therefore, the fisheries are able to provide for a household's basic need. Therefore, an improvement in quality of life is a key indicator of the increasing the Community Welfare [34].

The latent variable of Infrastructure (if) is significantly related to the indicator of port performance(if_1), fish handling infrastructure (if_2), transportation infrastructure (if_4), and communication infrastructure (if_5). The port performance reflects the overall efficiency, effectiveness, and general performance of a fisheries port, encompassing operational productivity, the speed of loading and unloading of catches, handling facilities, security, and logistical efficiency [5]. The adequate fish handling infrastructure (if_2) lead to efficient fish handling from capture to distribution, helping maintain product quality throughout the handling and storage processes [35].

The system and the effects of transportation on fishing communities are measured using sustainable transportation indicators [39]. The availability of transportation infrastructure (if_4) increased connectivity and enabled more efficient movement of fish production from fishing port to market or industry. Communication facilities (if_5) include information technology and communication networks. The communication facilities (if_5) involve tracking systems, communication between fishermen and processing centers, and information platforms supporting the exchange of crucial data. Good communication infrastructure can enhance the coordination and management of fisheries resources [40].

Environmental protection concern to a desire to protect and preserve the environment The fishing product qualities is influenced by the environment or support for environmental protection [8]. The analysis research found that the availability of water resources (env_3) and the potential for cultural and local wisdom (env_5) are closely related to Environmental Carrying Capacity [34]. A high level of environmental sustainability can create conditions that support the availability of good water resources (env_3). Meanwhile, local communities with a deep understanding of water ecosystems and the practice of local wisdom (env_5) in their management contribute to higher levels of environmental sustainability [60].

Empowering Communities related to education and training (ce_2), institution (ce_3), and business collaboration (ce_5). These three elements have positive impact to the economic and social sustainability of fishing communities [34].

The regulation for the protection of fishery resources (rg_3) aims to safe the fishery resources from overexploitation and ensure long-term sustainability. Therefore, regulation monitoring (rg_5) and enforcement of regulation (rg_6) requires a firm handling of violations in fishing port. Integrating regulations and effective enforcement against violations is crucial to ensure the sustainability of fishery resources and support the livelihoods of fishing communities. Therefore, a successful Eco-fishing port (ef) is the outcome of the effective integration of implementation of regulations (ef_2), long-term strategic plan (ef_4), protection of the local community (ef_5) and a commitment to sustainability principles throughout its operations [9].

One significant limitation of sustainable fishing port in East Java is the limited progress of implementation. Developing a diagnostic and planning tool to propose future scenarios could be beneficial. Government, private sectors, and local community through non governments organization should recognize the importance of this commitment, and fully collaborated on developing the sustainable fishing port in East Java.

6. CONCLUSION

This research aims to analyze the measurement models that affect the development of eco-fishing ports in East Java Province. This article delves into the fundamental concept of eco-fishing ports outer model and highlight the significant relationship of measurement variable which affecting the development of eco-fishing port.

This model comprehensively evaluates eco-fishing ports by considering 36 indicators of the seven latent variables: Market Demand (md), Community Welfare (cw), Infrastructure (if), Environmental Carrying Capacity (env), Community Empowerment (ce), Regulation (rg), and Eco-fishing port (ef). The analysis test found that the AVE and the Construct Reliability values of 21 indicators all exceed the threshold of 0.5 and 0.7, respectively. It indicates that each latent variable has a valid and reliable measurement model. The result revealed that the eco-fishing port development model's latent variable strongly correlated with 21 indicators.

The findings of the analysis show that that latent variable of Market Demands (md) is significantly related to biosecurity (md_1), traceability (md_2), conservation of fish (md_4) and assurance of fish availability (md_5). The latent variable of Community Welfare (cw) has strong correlation to indicator of price protection (cw_3) and quality of life (cw_5). The Environmental Carrying Capacity (env) is closely related to availability of water resources (env_3) and the potential for cultural and local wisdom (env_5). Community Empower (ce) is related to education and training (ce_2), institution (ce_3), and business collaboration (ce_5). The latent variable of regulation has strong connection to fish resources protection (rg_3), relation monitoring (rg_5), and enforcement of regulations (rg_6). The latent variable of eco-fishing port also related to implementation regulations (ef_2), long-term strategic plan (ef_4), and protection of local communities (ef_5).

In conclusion, the expanding fishing industry necessitates thoughtful attention to eco-friendly port development policies, ensuring sustainability in the sector. The development of eco-fishing ports is not only linked to meet market demands but also addresses environmental concerns. It plays a crucial role in ensuring the avalability of efficient infrastructure to support fishing activities, promoting social welfare, engaging in community empowerment, and implementing regulations as a vital support system for eco-fishing ports.

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