

# Analyzing the structural impact of key factors on the fishermen group productivity in North Minahasa, Indonesia

<sup>1</sup>Paulo G. I. Kawatu, <sup>2</sup>Rene C. Kepel, <sup>2</sup>Jardie A. Andaki, <sup>3</sup>Vecky A. J. Masinambow, <sup>2</sup>Carolus P. Paruntu, <sup>2</sup>Revol D. C. Pamikiran, <sup>2</sup>Desy M. H. Mantiri

<sup>1</sup> Doctoral Program in Marine Science, Postgraduate Program, Sam Ratulangi University, 95115 Manado, Indonesia; <sup>2</sup> Faculty of Fisheries and Marine Science, Sam Ratulangi University, 95115 Manado, Indonesia; <sup>3</sup> Faculty of Economics and Business, Sam Ratulangi University, 95115 Manado, Indonesia. Corresponding author: R. C. Kepel, renecharleskepel65@gmail.com

**Abstract.** This research was conducted from June to August 2024 with fishermen as respondents in North Minahasa Regency, Province of North Sulawesi. The respondents were fishermen who owned motorboats (KM) ranging in size from 26 to 64 gross tonnage (GT). The population used in this study was all fishermen who own a KM in North Minahasa Regency. Sample collection was carried out using a non-probability sampling method with a purposive sampling approach. The selection of respondents was based on the criteria of owners or direct managers of motorboats. The sample consisted of 50 respondents. The research variables were ecological, economic, social, and institutional aspects, while the dependent variable was the productivity of the fishermen groups. This study aims to analyze the structural relationship between factors on fishermen's productivity. The results showed that all outer loadings were valid, except for the organizational indicator of the institutional variable. All variables from the Discriminant Validity Average Variance Extracted (AVE) method were valid. All variables from Composite Reliability (CR) were reliable. Only the productivity of fishermen and social factors from Cronbach's Alpha were reliable. Multicollinearity analysis on ecological, economic, institutional, and social variables on fishermen's productivity displayed no multicollinearity. Inner model evaluation was carried out using the Coefficient of Determination (R<sup>2</sup>), Goodness of Fit (GoF) Test, and Hypothesis Test (Direct Effect and Indirect Effect). The R<sup>2</sup> showed that Fisherman's Productivity had a moderate value. The GoF Test of the model showed that this model was very good (strong fit). The results of the Hypothesis Test using the Path Coefficient Bootstrapping Technique showed that the effect of ecological and economic variables on fishermen's productivity was positive but not significant. Meanwhile, institutional and social variables effect on fishermen's productivity was positive and significant.

**Key Words:** Fishermen, ecology aspect, economic aspect, social aspect, institutional aspect.

**Introduction.** The fisheries sector is one of the key pillars for economic and food security development in Indonesia, particularly in coastal areas such as North Minahasa Regency. As an area rich in marine resources, North Minahasa possesses great potential for the development of fisheries. However, the productivity of fishermen's groups in this area still faces various complex and multidimensional challenges. The productivity of fishermen is affected not only by technical factors but also by ecological, economic, social, and institutional aspects. Ecological aspects include the condition of fish resources and the health of marine ecosystems. The decline in marine environmental quality due to human activities can reduce the availability of fish and disrupt the ecosystem stability. Schadow (2018) found that the management of the mangrove ecosystem in Nain Island, North Minahasa, showed that the sustainability of coastal ecosystems is highly dependent on human intervention. In terms of the economic perspective, fishermen's income is highly influenced by access to capital, infrastructure, and markets. Klara et al (2019) reported that fishermen's income levels in general fluctuate daily. Fishermen's income is greatly affected by various factors, such as climate or weather, namely, west and east

winds, the use of different fishing gear, the type of boat/vessel used, and the abilities of fishermen themselves. However, limited access to capital and infrastructure remains a major constraint in improving the fishermen's productivity. Stacey et al (2021) showed the development of sustainable small-scale fisheries livelihoods in Indonesia related to factors supporting positive program outcomes, including the application of inclusive and holistic approaches to sustainable livelihoods, implemented and supported over appropriate time frames; use of participatory capacity development methodologies and locally; and collaborative engagement with local government, non-government organizations, and private-sector actors. Saksono et al (2023) explained that small-scale fishers are particularly exposed to pressures from the weather, gear bans, rising fuel prices, low levels of education, and overfishing. Small-scale fishing households adapt by reorganizing household tasks, utilizing various technologies, and developing group organizations to avoid problems like territory disputes. The fishers also do this by requesting support and subsidies and actively participating in religious activities. Local customs that forbid fishing on particular days are said to aid in the replenishment of fish stocks, making sea alms a safety net for fisher communities. Pangemanan et al (2025) concluded that the structure and status of sustainability of fishermen's livelihoods in North Minahasa Regency, with a location-specific approach and focusing on the capital dimension, is very important to ensure sustainable livelihood strategies for fishermen.

Variables of gross tonnage (GT), age, and fishing trip significantly influence fishermen's income. In addition, social aspects also play an important role in fishermen's productivity (Jafar et al 2021). Education level, skills, and participation in fishermen groups can influence the ability of fishermen to adapt to changes and the implementation of new technologies. According to Longdong et al (2020) and Mustaruddin et al (2024), sustainable fisheries management in the socio-institutional aspect includes efforts to create a management system that is not only concerned with fish resource sustainability but also involves and empowers fishing communities and supports institutions involved in fisheries management. This includes strengthening local institutions, increasing participation of the community, and utilizing local wisdom in fisheries resource management. However, in many regions, including North Minahasa, fisheries institutions are still facing various challenges, such as inter-institutional coordination and limited resources.

To analyze the effect of these four aspects simultaneously and entirely, it is required an analytical approach capable of handling the relationships between latent variables is required. Structural Equation Modeling (SEM) with the Partial Least Squares (PLS) approach is an accurate method for this purpose. Hair et al (2017) stated that PLS-SEM is suitable for use in exploratory research with complex models and data that do not meet the assumption of normal distribution. The use of SmartPLS 4 software allows researchers to examine the structural models and identify causal relationships between the variables studied.

This study aims to analyze the structural relationship between factors on fishermen's productivity using a quantitative SEM approach, by measuring ecological (waves, rainfall, wind), economic (investment, fishermen's income, labor, technology), social (profession, education, health, culture, public perception), and institutional (regulations, organizations) aspects to fishermen's productivity (catch, fishing frequency, business efficiency). The results of this study are expected to contribute to the formulation of policies and strategies for improving sustainable fishermen's productivity based on a multidimensional approach.

## **Material and Method**

**Study area.** The research was conducted in one of the main fisheries areas in North Sulawesi Province, namely at Fish Landing Base in Kema, North Minahasa Regency (Figure 1), where the fishermen typically own motorboats (KM) ranging from 26 to 64 GT.

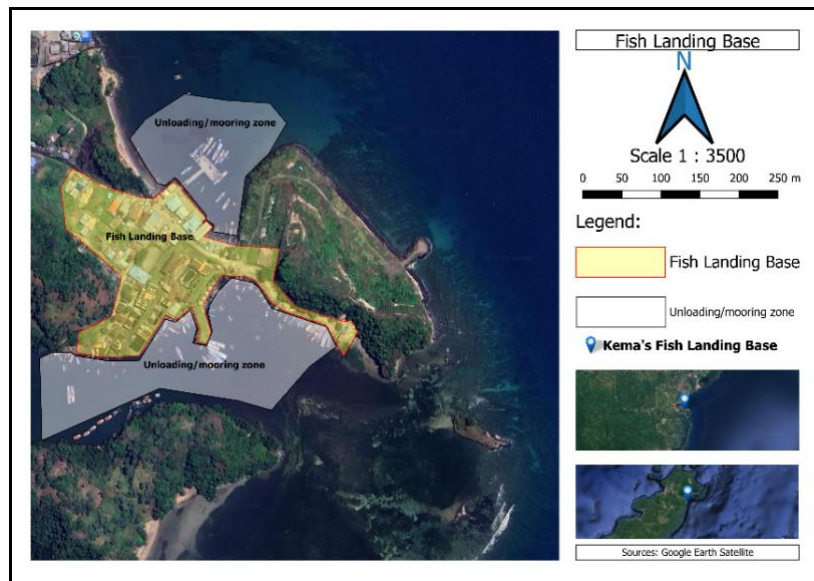


Figure 1. Fish Landing Base in Kema, North Minahasa Regency.

**Data collection.** The population used in this study was all fishing business owners in North Minahasa Regency who own motor boats. Sampling was carried out using a non-probability, purposive sampling approach in which the selection of respondents was based on the criteria of being the owner or direct manager of a motorboat. The number of samples was 50.

Primary data were collected using a questionnaire based on ecological, economic, social, institutional, and group productivity indicators, as well as direct interviews to obtain deeper perceptions and experiences of the fishing business.

The instrument used a Likert scale of 1-4, with the following criteria:

- 1 = strongly disagree,
- 2 = disagree,
- 3 = agree,
- 4 = strongly agree.

**Research variables.** Two main variables were used in this study: independent and dependent variables.

Independent variables (X) include:

- X1: Ecological aspects (waves, rainfall, wind)
- X2: Economic aspects (investment, fishermen's income, labor, technology)
- X3: Social aspects (profession, education, health, culture, public perception)
- X4: Institutional aspects (regulations, organizations)

Dependent variables (Y) include:

- Productivity of the fishermen group (catch, fishing frequency, market access).

**Data analysis.** The instrument test used was validity and reliability tests using a sample of 50 KM with different GT located in North Minahasa Regency. The results of validity and reliability tests were used to obtain data for further analysis. The effect of ecology, economy, social, and institutional factors on fishermen's productivity was examined using SmartPLS 4.

## Results

**Partial least squares (PLS) Scheme Model.** In this study, the hypothesis was examined through the PLS analysis technique with the SmartPLS 4 program. Figure 2 shows the schematic of the PLS program model proposed for North Minahasa Regency.

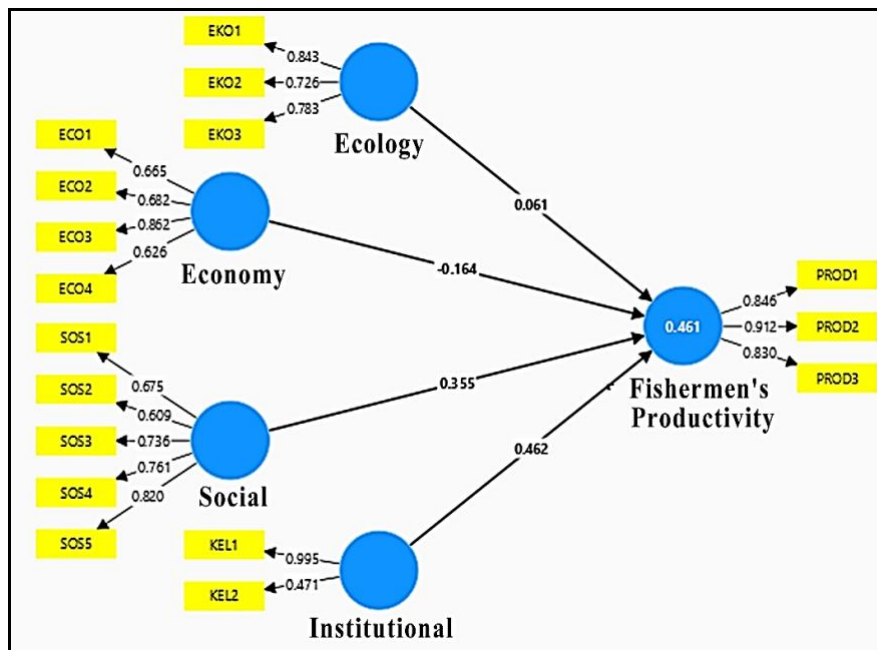


Figure 2. Partial Least Squares model scheme for North Minahasa Regency.  
(Source: primary data, 2024).

### Description:

Ecological aspects: waves (EKO1), rainfall (EKO2), wind (EKO3); Economic aspects: investment (ECO1), fishermen's income (ECO2), labor (ECO3), technology (ECO4); Social aspects: professions (SOS1), education (SOS2), health (SOS3), culture (SOS4), public perception (SOS5); Institutional aspects: regulations (KEL1), organizations (KEL2); Fishermen's Productivity: number of fish catches (PROD 1), frequency of sea trips (PROD 2), market access (PROD 3).

**Evaluation of the outer model or measurement model.** Evaluation of the outcome of this study generated economic variables reflected by four indicators, ecological variables by three indicators, social variables by five indicators, institutional variables by two indicators, and fishermen's productivity by three indicators. The steps in SmartPLS 4 analysis to evaluate the Outer Model reflect the use of four criteria, consisting of validity and reliability testing of variables by examining Cronbach's Alpha, CR, and Average Variance Extracted (AVE) for each variable. The four testing criteria were as follows:

- 1) Convergent validity: An indicator is considered valid if the coefficient value is  $> 0.70$  (Hair et al 2017) or  $0.60$  (Chin 1998). The loading factor for all indicator variables in this study had a value of  $> 0.70$ . This means that the indicator can be considered valid.
- 2) Discriminant Validity: A variable is considered valid if the AVE from each variable is  $> 0.50$ .
- 3) CR: A variable is considered reliable if the CR of each variable is  $> 0.70$ .

Cronbach's Alpha: A variable is considered reliable if the Cronbach's Alpha of each variable is  $> 0.70$ .

**Convergent validity.** Convergent validity was examined using the outer loading or loading factor value. An indicator is considered to meet the convergent validity in the good category if the outer loadings are  $> 0.70$ . The outer loading values for each indicator in the research variables were presented in Table 1.

Table 1

## Outer loadings of North Minahasa Regency

Variable	Indicator	North Minahasa Regency	
		Outer Loadings	Description
Ecology (EKO)	EKO 1	0.843	Valid
	EKO 2	0.726	Valid
	EKO 3	0.783	Valid
Economy (ECO)	ECO 1	0.665	Valid
	ECO 2	0.682	Valid
	ECO 3	0.862	Valid
	ECO 4	0.626	Valid
Social (SOS)	SOS 1	0.675	Valid
	SOS 2	0.609	Valid
	SOS 3	0.736	Valid
	SOS 4	0.761	Valid
	SOS 5	0.820	Valid
Institution (KEL)	KEL 1	0.995	Valid
	KEL 2	0.471	Invalid
Fishermen's productivity (PROD)	PROD 1	0.846	Valid
	PROD 2	0.912	Valid
	PROD 3	0.830	Valid

Source: Primary Data, 2025.

The results using SmartPLS 4 were shown in Table 1, where the outer model value or correlation between constructs and variables had one institutional indicator, namely the organization having a value of  $< 0.7$ . The value was close to the threshold for loading factors; therefore, it was considered valid.

**Discriminant validity.** Discriminant Validity was determined using the AVE method. Each indicator having a criterion of  $> 0.5$  was considered valid (Table 2).

Table 2

## Discriminant validity using the Average Variance Extracted method

Variable	North Minahasa Regency	
	AVE	Description
Ecology	0.617	Valid
Economy	0.510	Valid
Social	0.524	Valid
Institution	0.605	Valid
Fishermen's productivity	0.746	Valid

Source: Primary Data, 2025.

Table 2 showed that the AVE value in North Minahasa Regency for the ecological variable was  $> 0.5$  with a value of 0.617, the economic variable was  $> 0.5$  with a value of 0.510, the social variable was  $> 0.5$  with a value of 0.524, institutional variable was  $> 0.5$  with a value of 0.605, and fisherman's productivity variable was  $> 0.5$  with a value of 0.746. This indicated that each variable had good discriminant validity.

**Composite reliability (CR).** CR was used to examine the reliability of variable indicators. A variable is considered to meet CR if the CR value for each variable is  $> 0.70$ . In CR, two approaches were used: Rho\_a and Rho\_c. Rho\_c evaluates the reliability of the latent construct based on the estimated measurement model, while Rho\_a evaluates the maximum potential reliability of the latent construct. If the Rho\_c and Rho\_a values are consistent and above 0.7, the model is considered to have good reliability. The CR values for each variable are presented in Table 3.

Table 3

## Composite reliability

Variable	North Minahasa Regency		Description
	Composite reliability		
	(rho_a)	(rho_c)	
Ecology	0.714	0.828	Reliable
Economy	0.769	0.804	Reliable
Institution	2.956	0.731	Reliable
Fishermen's productivity	0.833	0.898	Reliable
Social	0.780	0.845	Reliable

Source: Primary Data, 2025.

Table 3 displayed the CR value of North Minahasa Regency. For economic variables, the value of CR was  $> 0.7$  with a value of 0.769 (Rho\_a) and 0.804 (Rho\_c), institutional variables was  $> 0.7$ , namely 2.956 (Rho\_a) and 0.731 (Rho\_c), the fishermen's productivity variable was  $> 0.7$ , namely 0.833 (Rho\_a) and 0.898 (Rho\_c), and social variables had a value greater than 0.7, 0.780 (Rho\_a) and 0.845 (Rho\_c). This showed that each variable had a CR of  $>0.70$ , indicating that the four variables are reliable.

**Cronbach's alpha.** The CR test above could be strengthened by using Cronbach's Alpha value. A variable is said to be reliable if it has a Cronbach's Alpha  $> 0.70$ . The Cronbach's Alpha values for each variable are shown in Table 4.

Table 4

## Cronbach's Alpha

Variable	North Minahasa Regency	
	Cronbach's alpha	Description
Ecology	0.695	Unreliable
Economy	0.686	Unreliable
Institution	0.547	Unreliable
Fishermen's productivity	0.828	Reliable
Social	0.770	Reliable

Source: Primary Data, 2025.

The data in the Table 4 above showed that the Cronbach's Alpha value of North Minahasa Regency for ecological variables was  $< 0.7$  with a value of 0.695, economic variables was  $< 0.7$  which was 0.686, institutional variables was  $< 0.7$  which was 0.547. These three variables were not reliable, while the fishermen's productivity variable had a value  $> 0.7$ , which was 0.828, and the social variable was  $> 0.7$ , which was 0.770. These results showed that ecological, economic, and institutional variables had a Cronbach's Alpha  $< 0.70$  each, indicating that these three variables are not reliable, while fishermen's productivity and social variables had a Cronbach's Alpha  $> 0.70$ , indicating that both variables are reliable.

**Multicollinearity test.** The purpose of the Multicollinearity test was to determine multicollinearity between variables by assessing the correlation between the independent variables. In general, this test is used to detect whether there is a very strong linear relationship between the independent variables in the structural model (Inner Model) that could influence the analysis results. The results of the multicollinearity test were presented in Table 5.

Multicollinearity test

Inner VIF Values	North Minahasa Regency	
	VIF	Description
Ecology -> Fishermen's productivity	2.354	Non multicollinearity
Economy -> Fishermen's productivity	1.944	Non multicollinearity
Institution -> Fishermen's productivity	1.789	Non multicollinearity
Social -> Fishermen's productivity	1.908	Non multicollinearity

Source: Primary Data, 2025.

Table 5 showed the results of Collinearity Statistics (VIF) to evaluate the multicollinearity test with the outer result of the ecology variable on Fisherman's Productivity was 2.354. The value of the economic variable on Fisherman's Productivity was 1.944. The value of the institutional variable on Fisherman's Productivity was 1.789. The value of the social variable on Fisherman's Productivity was 1.908. Variable VIF with a value of <5 does not interrupt the multicollinearity test.

**Inner model evaluation.** Evaluation of this model was carried out using the Coefficient of Determination (R2), GoF Test, and Hypothesis Test (Direct Effect and Indirect Effect). The schematic of the proposed PLS program model was presented in Figure 3.

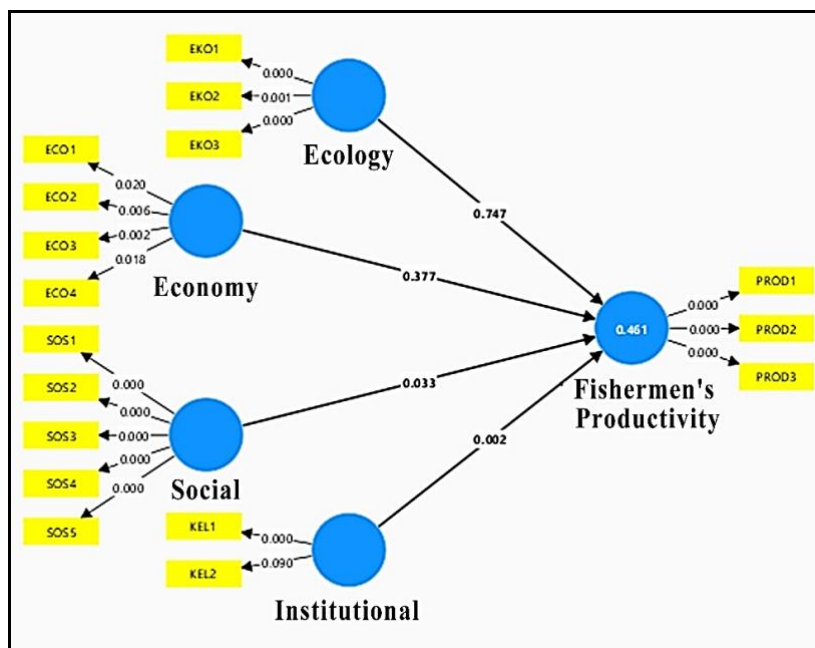


Figure 3. Inner Model Evaluation of North Minahasa Regency. (Source: Primary Data, 2025).

**Coefficient of determination (R2).** The R2 is used to measure how much a dependent variable is influenced by other variables. Chin (1998) stated that the value of R2 higher than 0.67 for a dependent latent variable in a structural model indicates that the independent variable (which influences) influences the dependent variable (which is influenced), designated as a good category. A value of 0.33-0.67 designates a moderate value, and a value of 0.19-0.33 indicates a weak value. The R-square value was obtained using SmartPLS 4 (Table 6).

Table 6

## Coefficient of determination

Variable	North Minahasa Regency	
	R-square	R Square Adjusted
Fishermen's productivity	0.512	0.469

Source: Primary Data, 2025.

The R-Square table is used to determine how much the effect of ecological, economic, social, and institutional variables on the Fishermen's productivity in North Minahasa Regency. The R-Square was 0.512, which was categorized as a moderate value.

**Goodness of fit (GoF).** GoF combines the  $R^2$  of the dependent variable and the AVE (Average Variance Extracted) of the reflective latent variables to assess how far the tested model can explain the data as a whole. GoF is calculated using the following formula:

$$GOF = \sqrt{AVE \times R^2}$$

Description:

AVE = mean value of the variance of all latent constructs.

$R^2$  (R-Square) = determination value of a structural model that measures how great the independent variable explains the dependent variable.

Table 7

## Category of GoF values

GoF value	Model quality
GoF $\geq$ 0.36	Strong Fit
$0.25 \leq$ GoF < 0.36	Moderate Fit
$0.10 \leq$ GoF < 0.25	Weak Fit
GoF < 0.10	Very Weak Fit

Source: Tenenhaus et al 2005.

Table 8

## Calculation of GoF values

Construct Latent	AVE	$R^2$
Fishermen's productivity	0.600	0.512

$$GoF \text{ Minut} = \sqrt{0.600 \times 0.512} = \sqrt{0.3072} = 0.554$$

GoF Minut value of 0.629 indicates that the model used is very good (strong fit). Thus, this research model has good goodness of fit.

**Hypothesis test.** The hypothesis in this study was proved by examining the r-statistics and P-values. The hypothesis is accepted if the P-value is < 0.05. In this study, there were direct and indirect influences due to the presence of independent and dependent variables, and mediating variables. In the SmartPLS 4 program, the results of the hypothesis test were shown through the Path Coefficient Bootstrapping Technique (Table 9).

This research proposed four hypotheses to analyze the direct effect. Analysis of the hypothesis was conducted using bootstrapping analysis techniques. Using the t-statistic, it was found that the level of significance effect between the independent and the dependent variable. If the t-statistic value is > 1.967 = TINV (0.05), then the effect is significant.

Table 9

The results of the hypothesis test using the Path Coefficient Bootstrapping Technique in North Minahasa Regency

<i>Variable</i>	<i>Original sample (O)</i>	<i>Sample mean (M)</i>	<i>Standard deviation (STDEV)</i>	<i>T statistics ( O/STDEV )</i>	<i>P values</i>	<i>Description</i>
Ecology -> Fishermen's productivity	0.061	0.045	0.189	0.322	0.747	Positive and not significant
Economy -> Fishermen's productivity	-0.164	-0.095	0.186	0.883	0.377	Negative and not significant
Institution -> Fishermen's productivity	0.462	0.420	0.150	3.091	0.002	Positive and significant
Social -> Fishermen's productivity	0.355	0.355	0.166	2.134	0.033	Positive and significant

Source: Primary Data, 2025.

Furthermore, if the p-value for each variable is < 0.05, then H0 is rejected. The positive effect was displayed through the Original Sample. The summary results of the direct effect analysis were presented in Table 10.

Table 10

Direct effect analysis

<i>Effect</i>	<i>Description</i>
Ecology on Fishermen's productivity	<ul style="list-style-type: none"> <li>➤ Path Coefficient (O): 0.061</li> <li>➤ T-Statistic: 0.322</li> <li>➤ P-Value: 0.747</li> <li>➤ note: Positive, not Significant</li> </ul> <p>Ecological factors had a positive effect but not significant on fishermen's productivity. This indicates that ecological conditions are not yet a major factor directly influencing fishermen's productivity. Therefore, ecological aspects have a positive effect on fishermen's productivity, thus H1 is rejected.</p>
Economy on Fishermen's productivity	<ul style="list-style-type: none"> <li>➤ Path Coefficient (O): -0.164</li> <li>➤ T-Statistic: 0.883</li> <li>➤ P-Value: 0.377</li> <li>➤ note: Negative, not Significant</li> </ul> <p>Economic factors had a negative effect and not significant on fishermen's productivity. This indicates that economic conditions are not strong enough to directly influence fishermen's productivity. Therefore, economic aspects have a negative effect on fishermen's productivity, thus H2 is rejected.</p>
Institution -> Fishermen's productivity	<ul style="list-style-type: none"> <li>➤ Path Coefficient (O): 0.355</li> <li>➤ T-Statistic: 2.134</li> <li>➤ P-Value: 0.033</li> <li>➤ note: Positive, Significant</li> </ul> <p>Social factors had a positive and significant effect on fishermen's productivity. This indicates that social aspects such as cooperation among fishermen, community support, and social networks can increase their productivity. Therefore, social aspects have a positive effect on fishermen's productivity, thus H3 is accepted.</p>
Institution on Fishermen's productivity	<ul style="list-style-type: none"> <li>➤ Path Coefficient (O): 0.462</li> <li>➤ T-Statistic: 3.091</li> <li>➤ P-Value: 0.002</li> <li>➤ Note: Positive, Significant</li> </ul> <p>Institutional factors had a positive and significant effect on fishermen's productivity. This indicates that good institutions (such as regulations, policies, or fishermen organizations) play an important role in increasing fishermen's productivity. Therefore, institutional aspects have a positive effect on fisher productivity, thus H4 is accepted.</p>

**Discussion.** Convergent validity is measured from the outer loading value. The ideal value is  $> 0.70$ . In this research, most indicators fulfilled this criterion, showing that the indicators consistently measure their latent constructs. Hair et al (2017) stated that a high outer loading value indicates good measurement quality. Even though the institutional indicator (KEL2) had a value of 0.471, it was acceptable in terms of exploratory. Chin (1998) stated that a value between 0.4-0.7 can still be considered if it increases the overall construct validity.

Discriminant validity is indicated by an AVE value  $> 0.50$ . Research results showed that all variables met this criterion. Fornell & Larcker (1981) stated that a higher AVE than the correlation between constructs indicates good discriminant validity. This is in line with the study by Hia et al (2023) in the context of fisheries institutions, who found similar results, supporting the clarity of construct measurement.

The CR is considered good if the CR value is  $> 0.70$ . This research found that all constructs met this threshold, meaning that the indicators within the construct have high internal consistency (Hair et al 2017). This result was consistent with the study by Prasetyono et al (2017) that analyzed farmer group empowerment, in which factors based on social and institutional capital were used as indicators of the reliability of survey instruments.

Cronbach's alpha was used to assess internal reliability. Only the social and fishermen's productivity variables had a value over 0.70. This implied that there were weaknesses in other variables, such as ecology and economics. Nunnally & Bernstein (1994) suggest a minimum value of 0.70, but in exploratory research, a limit of 0.60 is still acceptable. A study by Hermawan et al (2006) on fishermen institutions also noted several constructs with low alpha values, but still used for further exploration.

The VIF values of all variables were below 5, indicating the absence of multicollinearity between constructs. According to Kock & Lynn (2012), a VIF value  $< 5$  indicates that the model is free from multiple correlation bias between independent variables. This is in line with the research results by Noviyanti & Nuhasanah (2019), who also used PLS-SEM to study factors influencing fishermen's competence.

The R-square ( $R^2$ ) value of 0.512 indicates that the model has moderate predictive ability (Chin 1998). A GoF of 0.629 indicates excellent model compatibility (Tenenhaus et al 2005).

Hypothesis analysis results showed that social and institutional variables had a significant influence on fishermen's productivity. This is consistent with research by Primantika & Adi (2023), who found that institutional support and social dynamics of fishing groups significantly influence the catch yields and business sustainability. Conversely, ecological and economic variables were not significant. This is consistent with the findings by Oktopura et al (2020), who explained that ecological conditions only have a significant effect on productivity if accompanied by technological adaptation and effective fisheries management.

**Conclusions.** Based on the analysis using SmartPLS 4, it was found that the productivity of fishermen groups in North Minahasa Regency was significantly influenced by institutional and social aspects. Ecological and economic aspects did not show a significant direct influence on productivity. The research model has good validity, reliability, and goodness of fit, making it applicable for formulating strategies to improve productivity based on a multidimensional approach.

**Conflict of interest.** The authors declare that there is no conflict of interest.

## References

- Chin W. W., 1998 The partial least squares approach to structural equation modeling. In Modern methods for business research. Modern Methods for Business Research, Mahwah, Erlbaum, pp 295-336.
- Fornell C., Larcker D. F., 1981 Structural equation models with unobservable variables and measurement error: Algebra and statistics. *Journal of Marketing Research* 18(3):382-388.
- Hair J. F., Hult G. T. M., Ringle C. M., Sarstedt M., 2017 A primer on partial least squares structural equation modeling (PLS-SEM). 2nd Edition, Sage Publications Inc., Thousand Oaks, CA., 384 p.
- Hermawan M., Sondita M. F. A., Fauzi A., Monintja D. R., 2006 Sustainability status of small scale capture fisheries. *Buletin PSP* 15(2):1-19.
- Hia F., Telussa R. F., Patanda M., 2023 [Development of the capture fisheries sector in West Nias District]. *Jurnal Ilmiah Satya Minabahari* 9(1):48-57. [in Indonesian]
- Jafar M. S. R., Djafar S., Kasmawati, 2021 [Analysis of fisherman activity from social and economic aspects in Binanga Karaeng Village, Pinrang Regency]. *Journal of Indonesian Tropical Fisheries* 4(2):154-166. [in Indonesian]
- Klara A., Ratang S. A., Hutajulu H., 2019. [Analysis of fishermen's income and distribution of skipjack fish marketing in Jayapura City]. *Jurnal Manajemen & Bisnis (JUMABIS)* 3(1):25-33. [in Indonesian]
- Kock N., Lynn G. S., 2012 Lateral collinearity and misleading results in variance-based SEM: An illustration and recommendations. *Journal of the Association for Information Systems* 13(7):546-580.
- Longdong F. V., Mantjoro E., Kepel R. C., Budiman J., 2020 Adaptation strategy of Bitung fishermen to the impact of fisheries Moratorium policy in Indonesia. *AAFL Bioflux* 13(5):2477-2496.
- Mustaruddin, Puspito G., Baskoro M. S., Wisudo S. H., 2024 [Sustainable fisheries management and development of partnership institutions in Citemu Village, Cirebon]. *ALBACORE*, 8(2):121-129. [in Indonesian]
- Noviyanti R., Nuhasanah, 2019 Factors Influencing to the fisherman's competency in Banten Bay Using Partial Least Square-Structural Equation Modeling (PLS-SEM). *Marine Fisheries* 10(1): 33-44. [in Indonesian]
- Nunnally J. C., Bernstein I. H., 1994 *Psychometric theory* (3rd ed.). McGraw-Hill., 752 p.
- Oktopura A. A. D., Fauzi A., Sugama K., Mulyati H., 2020 [National aquaculture development: The performance and perspective of improving efficiency and productivity based on ecosystem]. *Buletin Ilmiah MARINA* 6(1):11-24. [in Indonesian]
- Pangemanan L. R. J., Kepel R. C., Rimper J. R. T. S. L., Rengkung L. R., Suhaeni S., Luasunaung A., Mantiri D. M. H., 2025 Structure and sustainability status of fishermen's livelihood in North Minahasa Regency, Indonesia. *AAFL Bioflux* 18(2):1011-1022.
- Prasetyono D. W., Astuti S. J. W., Supriyanto, Syahrial R., 2017 [Empowerment of farmers based on social and institutional capital]. *Asian Journal of Innovation and Entrepreneurship* 2(3):231-238. [in Indonesian]
- Primantika D. W., Adi I. R., 2023 [The effect of social support and resilience on the subjective quality of life of fishermen registered in the target data for the acceleration of extreme poverty elimination (P3KE) in Pangandaran Regency]. *Jurnal Ilmiah Perlindungan dan Pemberdayaan Sosial* 5(1):81-91. [in Indonesian]
- Saksono H., Nissa Z. N. A., Suadi S., 2023 Small-scale fisher's livelihood strategies: findings from case studies in several Indonesian coastal areas. *Jurnal Perikanan Universitas Gadjah Mada* 25(1):9-18.
- Schaduw J. N. W., 2018 [Community structure and sustainability of mangrove ecosystem management of small islands (Case on Nain Island, North Minahasa Regency, North Sulawesi Province)]. *Jurnal Ilmu Lingkungan* 16(2):120-129. [in Indonesian]
- Stacey N., Gibson E., Loneragan N. R., Warren C., Wiryawan B., Adhuri D. S., Steenbergen D. J., Fitriana R., 2021 Developing sustainable small-scale fisheries

livelihoods in Indonesia: Trends, enabling and constraining factors, and future opportunities. *Marine Policy* 132:104654.  
Tenenhaus M., Esposito Vinzi V., Chatelin Y. M., Lauro C., 2005 PLS path modeling. *Computational Statistics and Data Analysis* 48(1):159-205.

Received: 18 August 2025. Accepted: 16 September 2025. Published online: 24 October 2025.

Authors:

Paulo Grasiano Izaak Kawatu, Doctoral Program in Marine Science Postgraduate Program, Sam Ratulangi University, Kampus Bahu Street, 95115 Manado, Indonesia, e-mail: paulokawatu12@gmail.com

Rene Charles Kepel, Faculty of Fisheries and Marine Science, Sam Ratulangi University, Kampus Bahu Street, 95115 Manado, Indonesia, e-mail: renecharleskepel65@gmail.com

Jardie Androkles Andaki, Faculty of Fisheries and Marine Science, Sam Ratulangi University, Kampus Bahu Street, 95115 Manado, Indonesia, e-mail: jardieandaki@unsrat.ac.id

Vecky Apollos Junius Masinambow, Faculty of Economics and Business, Sam Ratulangi University, Kampus Bahu Street, 95115 Manado, Indonesia, e-mail: veckymasinambow@yahoo.com

Carolus Paulus Paruntu, Faculty of Fisheries and Marine Science, Sam Ratulangi University, Kampus Bahu Street, 95115 Manado, Indonesia, e-mail: carolusparuntu@unsrat.ac.id

Revol Dolfi Christian Pamikiran, Faculty of Fisheries and Marine Science, Sam Ratulangi University, Kampus Bahu Street, 95115 Manado, Indonesia, e-mail: revolspamikiran@gmail.com

Desy Maria Helena Mantiri, Faculty of Fisheries and Marine Science, Sam Ratulangi University, Kampus Bahu Street, 95115 Manado, Indonesia, e-mail: dmh\_mantiri@unsrat.ac.id

This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

How to cite this article:

Kawatu P. G. I., Kepel R. C., Andaki J. A., Masinambow V. A. J., Paruntu C. P., Pamikiran R. D. C., Mantiri D. M. H., 2025 Analyzing the structural impact of key factors on the fishermen group productivity in North Minahasa, Indonesia. *AAFL Bioflux* 18(5):2351-2362.