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Climate Risk, Nature-Based Solutions, and Livelihood Resilience in Small-Scale Fisheries: Correlation Evidence from the Lease Islands, Indonesia

Adhitya Nugroho[1*], Muhammad Usman Islachudin[2], Margaretha Arnita Wuri[3], Yofita Anaktototy[1]

[1]Fisheries Agrobusiness, Faculty of Fisheries and Marine Science, Pattimura University, Ambon, Indonesia
[2]Agribusiness, Faculty of Agriculture, Pattimura University, Ambon, Indonesia
[3]Environmental science, Faculty of Agriculture, Pattimura University, Ambon, Indonesia

*Corresponding author email: Adhitya.nugroho@lecturer.unpatti.ac.id

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ABSTRACT

Small-scale fisheries in the Lease Islands, Central Maluku, Indonesia, face interconnected challenges involving climate-related risks, livelihood vulnerability, and sustainable resource management. This study examined associations among six constructs: Climate Risk Exposure (CRE), Livelihood Vulnerability (LV), Perceived Nature-based Solutions (NbS) Effectiveness (PNbSE), Support for Sasi (SfS), Support for NbS Implementation (SNbSI), and Livelihood Resilience (LR). Data were obtained through structured interviews with 186 small-scale fishers from Saparua and Haruku. Composite scores were calculated from 44 questionnaire items, and Spearman's rank correlation was used to assess 15 pairs of constructs, with p-values adjusted using the Holm procedure. All pairwise correlations were positive and statistically significant after adjustment (adjusted $p < 0.001$). The strongest associations were found between CRE and LV ($\rho = 0.754$) and between PNbSE and SNbSI ($\rho = 0.744$). The positive association between SNbSI and LR ($\rho = 0.699$) also highlighted the relationship between support for ecosystem-based interventions and perceived livelihood resilience. These patterns suggest that climate-related concerns, customary governance, and perceptions of NbS are interconnected in the surveyed communities. However, the positive LV–LR correlation ($\rho = 0.635$) requires further examination of construct scoring and definitions. The findings provide a descriptive basis for integrated coastal fisheries management but do not establish causal relationships.

Keywords: *Climate risk exposure; Livelihood resilience; Livelihood vulnerability; Nature-based solutions; Sasi*

INTRODUCTION

Small-scale fisheries are embedded in social–ecological systems in which fishing livelihoods depend on environmental conditions, access to marine resources, and the capacity of households and communities to respond to change. Climate variability, extreme weather, and ecological degradation can disrupt fishing operations, affect catch availability, and increase uncertainty in household income. These pressures are particularly consequential for coastal communities with limited livelihood alternatives and a high dependence on fisheries. Recent empirical studies in Indonesia and the Philippines document the vulnerability of small-scale fishing households to climate-related and socioeconomic pressures, while also showing that vulnerability and resilience are shaped by the resources, strategies, and institutional arrangements available to fishers (Macusi *et al.,* 2025; Riantini *et al.,* 2024). Consequently, understanding small-scale fisheries requires attention not only to climate-related exposure, but also to how different dimensions of vulnerability, adaptation, and livelihood resilience are related within fishing communities.

Research on climate adaptation in small-scale fisheries has employed diverse conceptual and methodological approaches. A systematic review by de Carvalho et al. (2023) identified local knowledge, vulnerability, and resilience as three prominent conceptual groupings in the literature, highlighting the diversity of ways in which fisheries–climate interactions are investigated. More recent research further indicates that the implications of environmental change depend partly on fisheries governance

and the strategies available to resource users. For example, Frawley et al. (2024) showed that different self-governance arrangements among small-scale fishing enterprises were associated with differences in fishing strategies, vulnerability, and responses to environmental change. These findings suggest that climate-related pressures, livelihood conditions, and governance cannot always be understood in isolation. Examining the associations among these dimensions may therefore provide a useful empirical profile of how fishers' perceptions and reported livelihood conditions co-vary in a particular social–ecological context.

Nature-Based Solutions (NbS) have gained attention as approaches that use the protection, restoration, or sustainable management of ecosystems to address societal and environmental challenges. Nevertheless, the potential ecological benefits of NbS do not automatically translate into community acceptance or implementation support. A review of NbS for flood-risk reduction found that small coastal communities remain comparatively underrepresented in the literature and frequently face institutional, financial, and technical constraints, despite the potential importance of local knowledge and locally appropriate interventions (Mortensen *et al.,* 2024). Empirical evidence also shows that public preferences, perceived effectiveness, and support for coastal interventions do not necessarily align. In the United Kingdom, Seenath et al. (2025) found differences between public preferences for nature-based coastal solutions and perceptions of the effectiveness of conventional coastal defences. Similarly, Apine and Stojanovic (2026) identified trust, knowledge, and perceived effectiveness as important considerations in community acceptance of nature-based solutions for coastal flood-risk management. These studies reinforce the value of examining perceived NbS effectiveness and support for implementation as related but distinct dimensions rather than treating them as interchangeable measures.

Small-scale fisheries are an important component of coastal livelihoods in Maluku, where fishing activities are influenced by environmental conditions, access to marine resources, and operational constraints. In the Ambon–Lease Islands cluster, small-scale handline tuna fisheries contribute to regional tuna production, although fishers face challenges related to investment, operating costs, and fishing effort (Tauda *et al.,* 2021). These livelihood conditions intersect with customary resource-management institutions, particularly *sasi laut*, which regulates the use of natural resources through locally established rules. Research in Central Maluku has documented variations in the presence, performance, and institutional resilience of sasi, highlighting the importance of institutional legitimacy, rules, and enforcement (Harkes & Novaczek, 2002). In Haruku, *sasi lompa* provides a prominent example of customary fisheries governance (Gazali & Ruban, 2021; Lopulalan & Abrahamsz, 2023). More broadly, governance arrangements can shape how small-scale fisheries respond to environmental change, although their implications may differ according to institutional form and fishing strategy (Frawley *et al.,* 2024). Within this context, support for sasi and support for Nature-Based Solutions (NbS) implementation represent conceptually distinct dimensions: the former concerns a customary institution, whereas the latter concerns support for ecosystem-based approaches. Examining their associations with perceived NbS effectiveness and livelihood resilience can help characterize how customary governance, environmental perceptions, and livelihood conditions are related among small-scale fishers. However, these associations should not be interpreted as evidence of causal relationships.

Despite these advances, a clearer empirical description is still needed of how climate-risk exposure, livelihood vulnerability, perceived NbS effectiveness, support for customary resource governance, implementation support, and livelihood resilience are associated within small-island fishing communities. Much of the existing literature has examined selected dimensions through vulnerability indices, qualitative assessments of adaptation, or focused investigations of public perceptions and acceptance of coastal interventions. A complementary approach is to examine the pairwise association profile of these dimensions in a single fishing-community setting, without imposing a causal sequence among them. Such an approach is particularly relevant where climate-related experiences, livelihood assessments, perceptions of ecological interventions, and customary institutions may be interconnected but are not necessarily linked in a uniform way.

Against this background, this study examines the pairwise associations among six research constructs—Climate Risk Exposure (CRE), Livelihood Vulnerability (LV), Perceived NbS

Effectiveness (PNbSE), Support for Sasi (SfS), Support for NbS Implementation (SNbSI), and Livelihood Resilience (LR)—among small-scale fishers in Saparua and Haruku, the Lease Islands, Central Maluku, Indonesia. Using questionnaire data from 186 fishers, the study applies Spearman's rank correlation to describe the direction and strength of associations among the six constructs. Specifically, it identifies the strongest and weakest associations and examines the patterns linking climate-related conditions, perceptions of NbS, customary governance support, implementation support, and livelihood resilience. By focusing on the overall correlation profile rather than direct and indirect structural pathways, this study aims to provide a descriptive basis for understanding the co-occurrence of these dimensions in an Indonesian small-island fisheries context. The findings are interpreted as associations rather than causal effects.

MATERIALS AND METHODS

Study Design and Study Area

This study employed a quantitative correlational design to examine the pairwise associations among six research constructs related to climate-risk exposure, livelihood vulnerability, perceived Nature-Based Solutions (NbS) effectiveness, customary resource governance, support for NbS implementation, and livelihood resilience. The study was conducted in the Lease Islands, Central Maluku, Indonesia **Figure 1**, focusing on small-scale fishing communities in Saparua and Haruku. The individual fisher served as the unit of analysis.

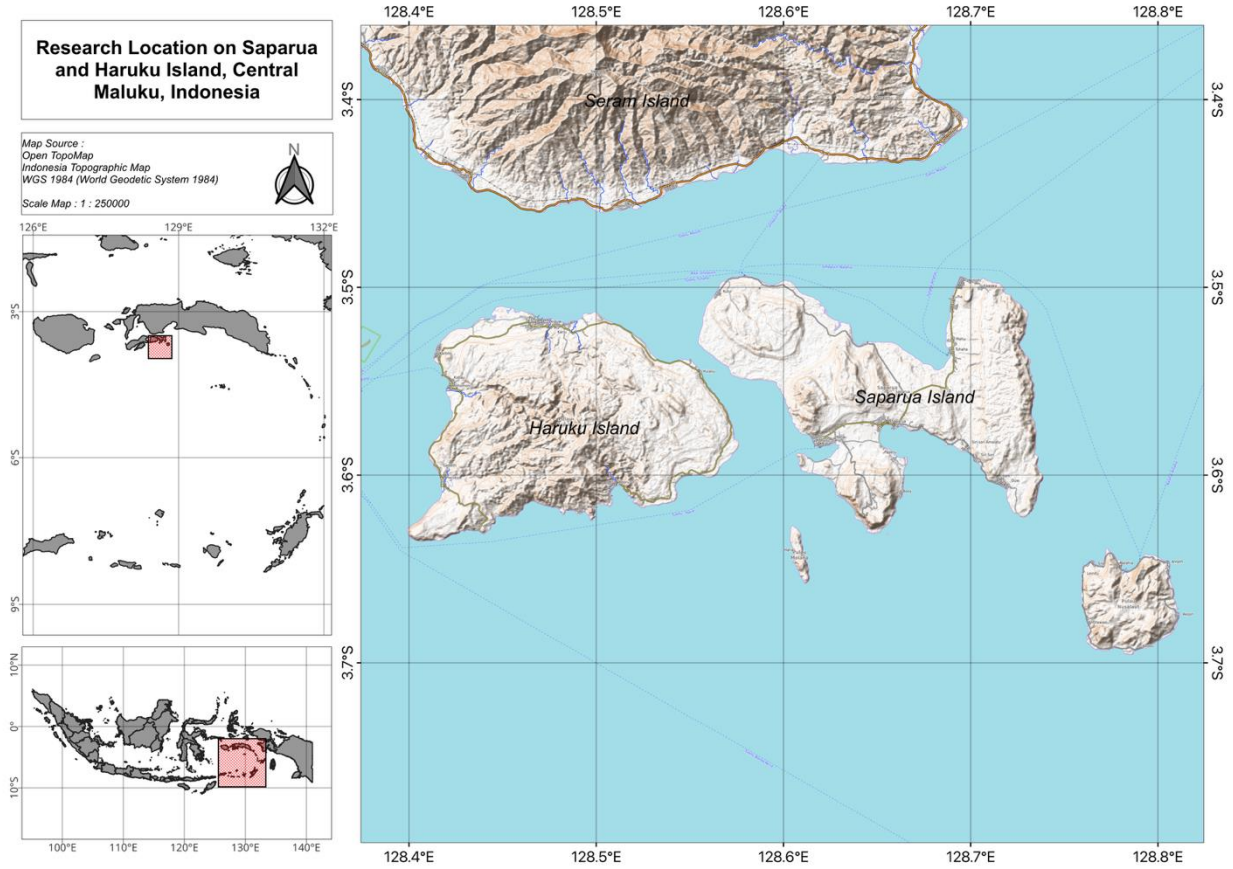


Figure 1. Map of the study area showing Saparua Island and Haruku Island, Central Maluku, Indonesia.

The analysis focused on describing the direction and magnitude of monotonic associations among six respondent-level composite scores. Rather than estimating structural paths or indirect effects, the study used Spearman's rank correlation coefficient to examine how the constructs varied together. Accordingly, the findings were interpreted as statistical associations rather than evidence of causal relationships.

Respondents and Data Collection

The study involved small-scale fishers in Saparua and Haruku, Lease Islands, Indonesia, operationally defined as individuals actively engaged in small-scale fishing

activities and with direct experience of local fishing and livelihood conditions. Respondents were recruited using purposive sampling, with village heads serving as local informants to identify households where fishers resided. The final analytical sample comprised 186 respondents, including 131 from Saparua (70.4%) and 55 from Haruku (29.6%). This represented the number of eligible respondents successfully recruited during fieldwork with complete data for all six research constructs. The distribution across locations reflected recruitment outcomes rather than proportional allocation based on the fisher population.

A complete register of eligible fishers was unavailable, preventing the establishment of a formal sampling frame and an exact estimate of the target population. Furthermore, because the numbers of individuals approached, unavailable, or declining participation were not systematically recorded, the response rate could not be calculated. As a non-probability sample, the findings should therefore be interpreted in relation to the participating respondents rather than as statistically representative estimates of the entire fisher population. Primary data were collected through face-to-face interviews in Haruku in June 2026 and Saparua in August 2026 using a structured questionnaire comprising 44 items covering six research constructs. Responses were measured on a four-point Likert scale, ranging from 1 (strongly disagree) to 4 (strongly agree). The dataset was screened for valid response values, complete composite scores, and consistency between questionnaire items and their assigned constructs, resulting in 186 complete respondent records for analysis.

To ensure that respondents understood the concept of Nature-Based Solutions (NbS), the term was explained during face-to-face interviews using mangrove restoration and coral reef restoration as examples of ecosystem-based approaches to addressing coastal and marine environmental challenges. This explanation was provided before respondents answered the questionnaire items concerning perceived NbS effectiveness and support for NbS implementation, thereby helping respondents interpret the questions in a common conceptual context.

Research Constructs and Composite-Score Calculation

Six constructs were included in the analysis: Climate Risk Exposure (CRE), Livelihood Vulnerability (LV), Perceived NbS Effectiveness (PNbSE), Support for Sasi (SfS), Support for NbS Implementation (SNbSI), and Livelihood Resilience (LR). The number of items used to calculate each composite score and their respective measurement focuses are presented in **Table 1**.

Table 1. Research constructs and composite-score composition

Construt	Number of items	Measurement focus
Climate Risk Exposure (CRE)	6	Perceived exposure to extreme weather, high waves, strong winds, changing marine conditions, declining catches, and increasing fishing costs.
Livelihood Vulnerability (LV)	8	Perceived susceptibility of fishing-based livelihoods to disruption, including fisheries dependence, income pressures, adverse weather, and limited financial or productive assets.
Perceived NbS Effectiveness (PNbSE)	8	Perceived ecological, protective, and fisheries-supporting benefits of coastal ecosystems and ecosystem-based interventions.
Support for Sasi (SfS)	9	Support for customary resource governance, compliance with customary rules, community monitoring, resource sustainability, and continuity of sasi.
Support for NbS Implementation (SNbSI)	8	Support for ecosystem-based actions, including mangrove and coral reef restoration, conservation, community participation, and environmental monitoring.
Livelihood Resilience (LR)	5	Perceived capacity to improve skills, adopt innovations, prepare for uncertainty, learn, and adapt to environmental and climate-related changes.

For each respondent, a composite score was calculated as the unweighted arithmetic mean of the questionnaire items assigned to the corresponding construct. Mean-based composite scoring is an established approach for summarizing multiple item responses into a single score when the items are intended to represent the same construct (Boateng *et al.,* 2018).

The composite score was calculated using Equation :

$$C_{ik} = \frac{1}{m_k}\sum_{j=1}^{m_k} x_{ijk} \quad \text{..... (1)}$$

where C_{ik} denotes the composite score of respondent i for construct k, m_k represents the number of items assigned to that construct, and x_{ijk} represents respondent $i's$ response to item j within construct k.

Each item received equal weight, and the resulting composite score remained on the original 1–4 scale. Item coding was checked against the substantive definition of each construct before interpreting the scores. Higher CRE scores represented greater perceived climate-risk exposure, higher LV scores represented greater perceived livelihood vulnerability, and higher LR scores represented greater perceived livelihood resilience. The six composite scores were treated as observed measures in the subsequent correlational analysis. No latent-variable measurement model or structural paths were estimated.

Statistical Analysis

Descriptive statistics were used to summarize the distribution of respondents across the two study locations and the six composite scores. Frequencies and percentages were used to describe respondents' island of residence, while medians, interquartile ranges (IQRs), minimums, and maximums were used to summarize the composite scores.

Spearman's rank correlation coefficient ρ_s was used to examine the direction and magnitude of monotonic associations among CRE, LV, PNbSE, SfS, SNbSI, and LR. Spearman's coefficient measures monotonic association by calculating the Pearson correlation between the ranked values of two variables. It is suitable for assessing associations involving ordinal or ranked data and does not require the relationship between the original scores to be linear (Spearman, 1904; Schober *et al.,* 2018).

The coefficient was calculated using Equation :

$$\rho_s = \frac{\sum_{i=1}^{n}(R_i-\bar{R})(S_i-\bar{S})}{\sqrt{[\sum_{i=1}^{n}(R_i-\bar{R})^2][\sum_{i=1}^{n}(S_i-\bar{S})^2]}} \quad \text{..... (2)}$$

where ρ_s denotes Spearman's rank correlation coefficient, n is the number of paired observations, R_i and S_i represent the ranks of the two construct scores for respondent i, and $\bar{R}$ and $\bar{S}$ represent their respective mean ranks. When identical composite scores occurred, average ranks were assigned to tied observations before calculating Spearman's rank correlation coefficient (Thomas, 1989; Zar, 2005). Spearman's rank correlation coefficients were calculated for the 15 unique pairs among the six constructs. Tied observations were assigned average ranks before calculating the correlations. Two-sided tests were conducted at a nominal significance level of .05. Where applied, the Holm (1979) procedure was used to adjust p-values for multiple comparisons. The coefficients were interpreted according to their direction and magnitude, with positive values indicating positive monotonic associations and negative values indicating inverse monotonic associations. The results were presented in a correlation matrix and heatmap. All findings were interpreted as associations rather than causal relationships.

For descriptive interpretation, the absolute magnitude of Spearman's rank correlation coefficient ρ_s was classified as negligible (0.00–0.29), low (0.30–0.49), moderate (0.50–0.69), high (0.70–0.89), or very high (0.90–1.00), following Mukaka (2012). These categories were treated as heuristic guidelines rather than universal thresholds, and the interpretation of association strength also considered the context of the study (Schober *et al.,* 2018).

RESULTS AND DISCUSSION

Respondent Characteristics

The study involved 186 small-scale fishers from the Lease Islands, Central Maluku, Indonesia, comprising 131 respondents from Saparua (70.4%) and 55 from Haruku (29.6%). Small-scale fishers were defined as individuals actively engaged in fishing activities within the study area and with direct experience of local fishing and livelihood conditions. The fishing methods used by respondents included pole-and-line, purse-seine, and longline fishing. Their fishing activities in the surrounding coastal and marine waters provided the empirical context for examining the relationships among climate-risk exposure, livelihood vulnerability, perceptions of Nature-Based Solutions (NbS), customary resource governance, and livelihood resilience.

The respondent data were analyzed as a pooled sample to examine the overall patterns of association among Climate Risk Exposure (CRE), Livelihood Vulnerability (LV), Perceived NbS Effectiveness (PNbSE), Support for Sasi (SfS), Support for NbS Implementation (SNbSI), and Livelihood Resilience (LR). This analytical focus allowed the study to

characterize how perceptions of environmental risk, livelihood conditions, customary resource governance, and nature-based interventions co-varied among traditional fishers across the two island communities. The findings therefore represent the correlation patterns observed in the surveyed respondents and should be interpreted within the geographical and livelihood context of the Lease Islands.

Descriptive Statistics of Research Constructs

Responses across the six research constructs were predominantly concentrated in the "Agree" (S) and "Strongly Agree" (SS) categories. The proportion of "Agree" responses ranged from 53.2% to 71.5%, while "Strongly Agree" responses ranged from 25.8% to 44.6%. In comparison, "Disagree" (TS) responses accounted for 0.0%–5.9%, and "Strongly Disagree" (STS) responses were absent from most indicators. The distributions of responses across the individual indicators are presented in **Figure 2**.

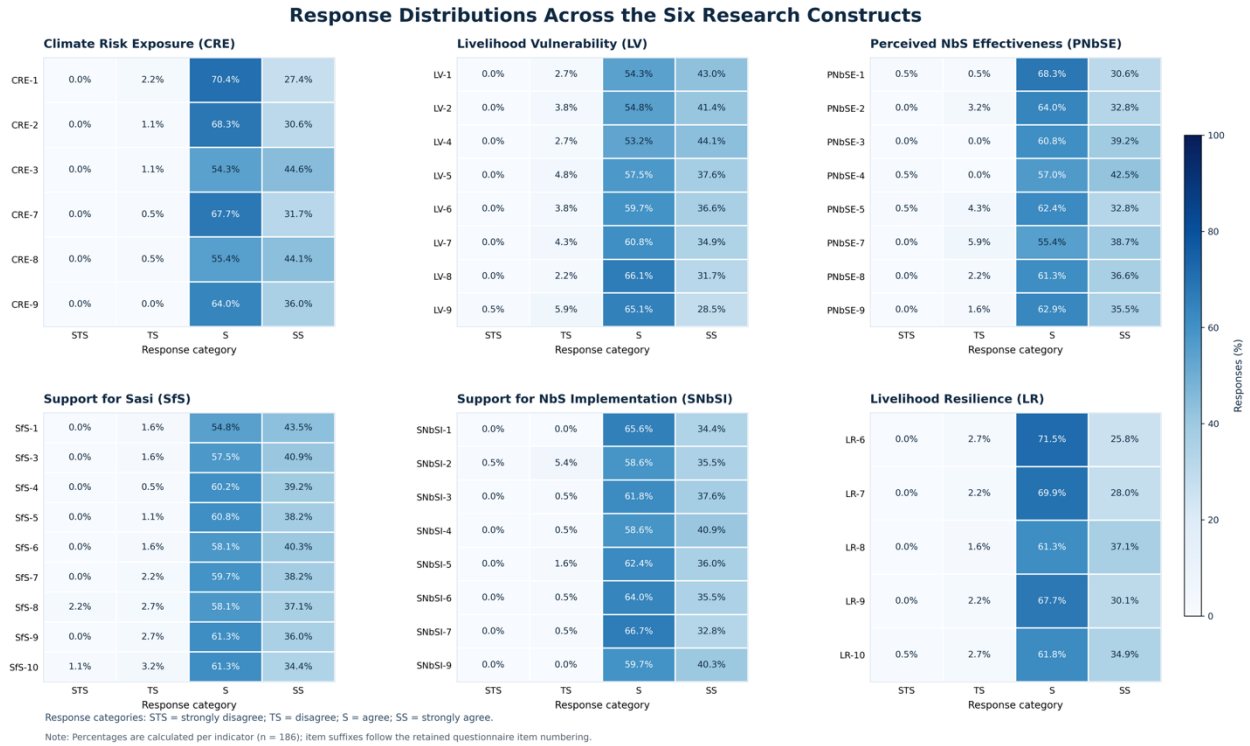


Figure 2. Response distributions across the six research constructs

Within the Climate Risk Exposure (CRE) construct, "Agree" responses ranged from 54.3% to 70.4%, while "Strongly Agree" responses ranged from 27.4% to 44.6%. CRE-3, concerning the disruption of fishing activities by strong winds, recorded the highest proportion of "Strongly Agree" responses (44.6%), followed by CRE-8, concerning declining catches associated with changing climate conditions (44.1%). The response distribution for Livelihood Vulnerability (LV) showed that "Agree" responses ranged from 53.2% to 66.1%, while "Strongly Agree" responses ranged from 28.5% to 44.1%. LV-4 recorded the highest proportion of strong agreement within this construct (44.1%), whereas LV-9 recorded the lowest (28.5%).

Responses to the Perceived NbS Effectiveness (PNbSE) indicators showed that "Agree" responses ranged from 55.4% to 68.3%, while "Strongly Agree" responses ranged from 30.6% to 42.5%. PNbSE-4 recorded the highest proportion of strong agreement (42.5%). A relatively consistent pattern was observed for Support for Sasi (SfS), where "Agree" responses ranged from 54.8% to 61.3% and "Strongly Agree" responses ranged from 34.4% to 43.5%. SfS-1 had the highest proportion of strong agreement (43.5%), whereas SfS-10 had the lowest (34.4%).

For Support for NbS Implementation (SNbSI), "Agree" responses ranged from 58.6% to 66.7%, while "Strongly Agree" responses ranged from 32.8% to 40.9%. SNbSI-4 recorded the highest proportion of strong agreement (40.9%). Regarding Livelihood Resilience (LR), "Agree" responses ranged from 61.3% to 71.5%, while "Strongly Agree" responses ranged from 25.8% to 37.1%. LR-6 recorded the highest proportion of "Agree"

responses (71.5%) and the lowest proportion of "Strongly Agree" responses (25.8%) within this construct. In contrast, LR-8 recorded the highest proportion of strong agreement for LR (37.1%).

Overall, "Agree" was the most prevalent response category across the retained indicators, although the relative proportions of "Agree" and "Strongly Agree" varied among constructs and individual items. These distributions provide a descriptive overview of the responses used to calculate the six composite scores and establish the empirical context for the subsequent Spearman correlation analysis.

The descriptive statistics showed that mean composite scores ranged from 3.29 for Livelihood Resilience (LR) to 3.36 for Support for Sasi (SfS). Standard deviations ranged from 0.40 to 0.46, indicating variation in respondents' scores across the six constructs. The median scores ranged from 3.10 to 3.33, while the interquartile ranges varied across constructs (**Table 2**). These descriptive results summarize the composite scores used in the subsequent Spearman's rank correlation analysis.

Table 2. Descriptive statistics of research constructs

Construct	N	Mean	SD	Median	Q1–Q3
CRE	186	3.349	0.400	3.333	3.000–3.667
LV	186	3.333	0.464	3.125	3.000–3.875
PNbSE	186	3.335	0.418	3.125	3.000–3.750
SfS	186	3.360	0.434	3.222	3.000–3.889
SNbSI	186	3.353	0.420	3.125	3.000–3.875
LR	186	3.287	0.432	3.100	3.000–3.600

Spearman's Rank Correlation Results

Spearman's rank correlation analysis was conducted to examine the associations among the six research constructs. The analysis identified 15 pairwise correlations, all of which were positive and statistically significant ($p < 0.001$). The correlation coefficients and their statistical significance are summarized in **Figure 3**.

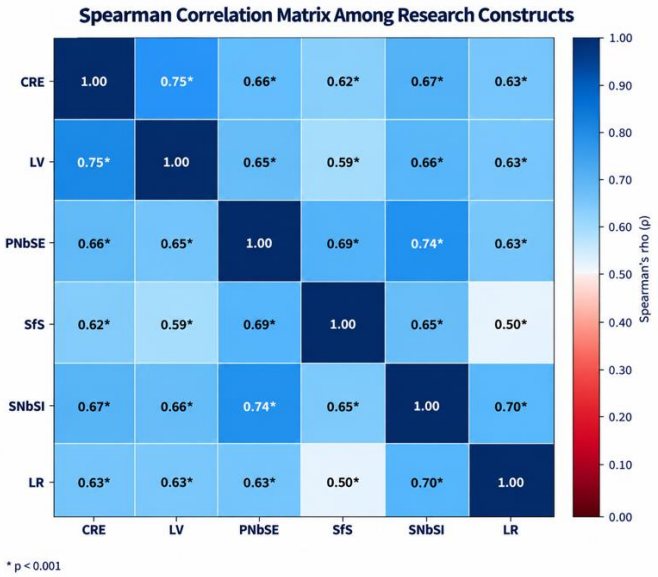


Figure 3. Spearman's rank correlation matrix among the six research constructs.

The strongest correlation was observed between Climate Risk Exposure (CRE) and Livelihood Vulnerability (LV) ($\rho = 0.754$), followed by Perceived NbS Effectiveness (PNbSE) and Support for NbS Implementation (SNbSI) ($\rho = 0.744$). A positive association was also identified between SNbSI and Livelihood Resilience (LR) ($\rho = 0.699$). These results indicate that higher scores on these constructs tended to occur alongside higher scores on their respective paired constructs.

The weakest correlation was found between Support for Sasi (SfS) and LR ($\rho = 0.496$), although the association remained statistically significant. Notably, LV was positively correlated with LR ($\rho = 0.635$). This relationship warrants careful consideration because vulnerability and resilience represent

conceptually distinct dimensions of livelihood conditions. Overall, the correlation analysis revealed positive associations across all six constructs. However, these relationships should be interpreted as statistical associations rather than evidence of causal effects.

Discussion

The strongest correlation in this study was observed between Climate Risk Exposure (CRE) and Livelihood Vulnerability (LV) (ρ = 0.754), indicating that respondents reporting greater exposure to climate-related risks also tended to report higher livelihood vulnerability. This pattern is consistent with research on Indonesian small-scale fisheries, which identifies climate variability, dependence on fishing income, and limited livelihood resources as important dimensions of livelihood vulnerability (Badjeck *et al.,* 2010; Riantini *et al.,* 2024). From a social–ecological perspective, vulnerability reflects not only exposure to environmental pressures but also the socioeconomic conditions that shape the capacity to respond to disturbances (Adger, 2006). For fishers in the Lease Islands, the observed association highlights the importance of considering environmental risks and livelihood conditions together. However, the correlation describes co-variation between reported experiences and does not establish that climate risk exposure causes livelihood vulnerability.

The positive correlation between Perceived NbS Effectiveness (PNbSE) and Support for NbS Implementation (SNbSI) (ρ = 0.744) was the second strongest association identified. This finding indicates that respondents with more favourable perceptions of NbS effectiveness also tended to express stronger implementation support. Recent research has highlighted the importance of perceived effectiveness, local knowledge, trust, and community participation in the acceptance of coastal NbS (Apine & Stojanovic, 2026; Seenath *et al.,* 2025). However, community support alone does not demonstrate ecological effectiveness. NbS should be designed according to local ecological and social conditions, with meaningful participation by local communities and measurable biodiversity benefits (Seddon *et al.,* 2021). For the Lease Islands, the observed association provides a basis for considering community perceptions in NbS planning while recognising the need for ecological assessment and participatory implementation.

Support for Sasi (SfS) was positively correlated with Perceived NbS Effectiveness (PNbSE) (ρ = 0.689) and Support for NbS Implementation (SNbSI) (ρ = 0.649). These relationships indicate that support for customary resource governance tended to occur alongside favourable perceptions of NbS and stronger implementation support. Research in Central Maluku has documented the importance of customary rules and institutional arrangements in the functioning of Sasi, while more recent work highlights the interaction between customary institutions and formal governance in Maluku (Harkes & Novaczek, 2002; Soselisa *et al.,* 2024). These studies provide a relevant institutional context for interpreting the correlations. Nevertheless, the measured construct represents respondents' support for Sasi, not direct evidence of institutional performance. The results therefore identify an association between governance perceptions and NbS-related perceptions without demonstrating that Sasi directly improves NbS effectiveness or implementation. Thorburn (2000), for example, documented how sasi lola in the Kei Islands was embedded in customary marine resource management and how interactions between local institutions and government regulation shaped its implementation. This regional context provides a useful basis for understanding why customary institutions may be relevant to community support for coastal resource management.

Support for NbS Implementation (SNbSI) was positively correlated with Livelihood Resilience (LR) (ρ = 0.699), while Perceived NbS Effectiveness (PNbSE) was also positively correlated with LR (ρ = 0.634). These findings place NbS-related perceptions among the constructs closely associated with reported livelihood resilience. Research on coastal communities emphasises that resilience depends on multiple dimensions, including livelihood resources, adaptive capacity, collective action, and institutional support (Cinner *et al.,* 2018). Recent studies of small-scale fisheries in Indonesia also demonstrate that vulnerability and adaptive responses need to be understood through the socioeconomic resources available to fishing households (Riantini *et al.,* 2024). In the Lease Islands, the observed correlations provide an empirical basis for examining NbS perceptions alongside livelihood resilience. However, they do not establish whether stronger implementation support contributes to resilience or whether other factors account for both.

The positive correlation between Livelihood Vulnerability (LV) and Livelihood Resilience (LR) (ρ = 0.635) warrants particular attention because the constructs represent distinct dimensions of livelihood conditions. Vulnerability concerns susceptibility to harm, whereas resilience concerns the capacity to cope with, adapt to, and respond to disturbances (Adger, 2006; Smit & Wandel, 2006). Their positive association does not necessarily mean that vulnerability strengthens resilience. Fishers may recognise substantial livelihood challenges while also reporting capacities to respond, but this remains a possible interpretation rather than a demonstrated explanation. The indicator wording, scoring direction, potential reverse coding, and conceptual overlap between LV and LR should therefore be examined before drawing stronger conclusions. The generally positive pattern across all 15 correlations also warrants consideration of shared response tendencies and similarities in item content.

Overall, the correlation profile shows that climate risk exposure, livelihood vulnerability, NbS perceptions, support for Sasi, implementation support, and livelihood resilience were positively associated within the surveyed sample. The strongest associations—CRE–LV, PNbSE–SNbSI, and SNbSI–LR—identify relationships that deserve particular attention in future research and coastal fisheries planning. For the Lease Islands, management initiatives could combine climate adaptation, participatory NbS planning, recognition of customary governance, and livelihood-support measures. These priorities are consistent with guidance on sustainable small-scale fisheries that emphasises community participation and livelihood considerations (FAO, 2015). Nevertheless, the present study provides a descriptive map of associations rather than evidence of causal pathways or intervention effectiveness. Further research using ecological observations, livelihood indicators, and longitudinal or comparative island-level data would help clarify how these dimensions relate to actual management and livelihood outcomes.

CONCLUSIONS AND SUGGESTION

This study identified positive and statistically significant associations among climate risk exposure, livelihood vulnerability, perceived Nature-based Solutions (NbS) effectiveness, support for Sasi, support for NbS implementation, and livelihood resilience among small-scale fishers in the Lease Islands, Indonesia. The strongest correlation was observed between Climate Risk Exposure and Livelihood Vulnerability (ρ = 0.754), followed by Perceived NbS Effectiveness and Support for NbS Implementation (ρ = 0.744). Support for NbS Implementation was also positively correlated with Livelihood Resilience (ρ = 0.699). Furthermore, support for Sasi was associated with both perceived NbS effectiveness and implementation support, highlighting the relevance of customary governance in understanding community perspectives on coastal resource management. However, the positive association between Livelihood Vulnerability and Livelihood Resilience (ρ = 0.635) requires further examination of construct definitions and indicator scoring. Overall, the findings demonstrate interconnected patterns among environmental risks, livelihood conditions, customary governance, and perceptions of ecosystem-based interventions, without establishing causal relationships.

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REFERENCE

Adger, W. N. (2006). Vulnerability. *Global Environmental Change*, 16(3), 268–281. https://doi.org/10.1016/j.gloenvcha.2006.02.006

Apine, E., & Stojanovic, T. (2026). Community acceptance of nature-based solutions for coastal flood risk management. *People and Nature*, 8(1), 21–36. https://doi.org/10.1002/pan3.70182

Badjeck, M.-C., Allison, E. H., Halls, A. S., & Dulvy, N. K. (2010). Impacts of climate variability and change on fishery-based livelihoods. *Marine Policy*, 34(3), 375–383. https://doi.org/10.1016/j.marpol.2009.08.007

Boateng, G. O., Neilands, T. B., Frongillo, E. A., Melgar-Quiñonez, H. R., & Young, S. L. (2018). Best practices for developing and validating scales for health, social, and

behavioral research: A primer. *Frontiers in Public Health*, 6, Article 149. https://doi.org/10.3389/fpubh.2018.00149

Cinner, J. E., Adger, W. N., Allison, E. H., Barnes, M. L., Brown, K., Cohen, P. J., Gelcich, S., Hicks, C. C., Hughes, T. P., Lau, J., Marshall, N. A., & Morrison, T. H. (2018). Building adaptive capacity to climate change in tropical coastal communities. *Nature Climate Change*, 8, 117–123. https://doi.org/10.1038/s41558-017-0065-x

de Carvalho, D. A., Amaral, S., & Alves, L. M. (2023). Climate change adaptation frameworks in fishing communities: A systematic review. *Ocean & Coastal Management*, 243, Article 106754. https://doi.org/10.1016/j.ocecoaman.2023.106754

Food and Agriculture Organization of the United Nations. (2015). Voluntary guidelines for securing sustainable small-scale fisheries in the context of food security and poverty eradication.

Frawley, T. H., González-Mon, B., Nenadovic, M., Gladstone, F., Nomura, K., Zepeda-Domínguez, J. A., Rodriguez-Van Dyck, S., Ferrer, E. M., Torre, J., Micheli, F., Leslie, H. M., & Basurto, X. (2024). Self-governance mediates small-scale fishing strategies, vulnerability and adaptive response. *Global Environmental Change*, 84, Article 102805. https://doi.org/10.1016/j.gloenvcha.2024.102805

Gazali, S., & Ruban, A. (2021). Coastal and marine resources management based local wisdom at the Haruku Village in Central Maluku District. Jurnal IPTEKS Pemanfaatan Sumberdaya Perikanan, 8(2), 70–81. https://doi.org/10.20956/jipsp.v8i2.18464

Harkes, I., & Novaczek, I. (2002). Presence, performance, and institutional resilience of sasi, a traditional management institution in Central Maluku, Indonesia. *Ocean & Coastal Management*, 45(4–5), 237–260. https://doi.org/10.1016/S0964-5691(02)00057-1

Holm, S. (1979). A simple sequentially rejective multiple test procedure. *Scandinavian Journal of Statistics*, 6(2), 65–70.

International Union for Conservation of Nature. (2020). Global standard for nature-based solutions: A user-friendly framework for the verification, design and scaling up of NbS (1st ed.). https://doi.org/10.2305/IUCN.CH.2020.08.en

Lopulalan, Y., & Abrahamsz, J. (2023). Kelembagaan sasi lompa dan implikasinya (studi kasus di Negeri Haruku Kabupaten Maluku Tengah). TRITON: Jurnal Manajemen Sumberdaya Perairan, 19(1), 52–63. https://doi.org/10.30598/TRITONvol19issue1page52-63

Macusi, E. D., Diampona, D. O., & Macusia, E. S. (2025). Understanding vulnerability and building resilience in small-scale fisheries: The case of Davao Gulf, Philippines. *Climate Policy*, 25(1), 1–14. https://doi.org/10.1080/14693062.2023.2261889

Mortensen, E., Tiggeloven, T., Kiesel, J., & Ward, P. J. (2024). For resilient rural shorelines: Reviewing nature-based solutions for flood risk reduction in small coastal communities. *Nature-Based Solutions*, 6, Article 100189. https://doi.org/10.1016/j.nbsj.2024.100189

Mukaka, M. M. (2012). Statistics corner: A guide to appropriate use of correlation coefficient in medical research. Malawi Medical Journal, 24(3), 69–71.

Riantini, M., Mardiharini, M., Saptana, Sudjarmoko, B., Kasymir, E., Nur'aini, L. G., Anindita, S. H., Syukur, M., Zulham, A., Wardono, B., Ardana, I. K., Indrawanto, C., & Wahyudi, A. (2024). Livelihood vulnerability household fishermen household due to climate change in Lampung Province, Indonesia. *PLOS ONE*, 19(12), Article e0315051. https://doi.org/10.1371/journal.pone.0315051

Schober, P., Boer, C., & Schwarte, L. A. (2018). Correlation coefficients: Appropriate use and interpretation. *Anesthesia & Analgesia*, 126(5), 1763–1768. https://doi.org/10.1213/ANE.0000000000002864

Seddon, N., Smith, A., Smith, P., Key, I., Chausson, A., Girardin, C. A. J., House, J. I., Srivastava, S., & Turner, B. (2021). Getting the message right on nature-based solutions to climate change. *Global Change Biology*, 27(8), 1518–1546. https://doi.org/10.1111/gcb.15513

Seenath, A., Mahadeo, S. M. R., & Catterson, J. (2025). Public perceptions of nature-based coastal solutions in the UK. *Journal of Environmental Management*, 373, Article 123413. https://doi.org/10.1016/j.jenvman.2024.123413

Smit, B., & Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. *Global Environmental Change*, 16(3), 282–292. https://doi.org/10.1016/j.gloenvcha.2006.03.008

Soselisa, P. S., Alhamid, R., & Rahanra, I. Y. (2024). Integration of local wisdom and modern policies: The role of traditional village government in the implementation of Sasi in Maluku. Baileo: Jurnal Sosial Humaniora, 2(1), 63–75. https://doi.org/10.30598/baileofisipvol2iss1pp63-75

Spearman, C. (1904). The proof and measurement of association between two things. *The American Journal of Psychology*, 15(1), 72–101. https://doi.org/10.2307/1412159

Tauda, I., Hiariey, J., Lopulalan, Y., & Bawole, D. (2021). Efisiensi perikanan pancing ulur tuna-skala kecil di Gugus Pulau 7 Maluku. Jurnal Kebijakan Perikanan Indonesia, 13(1), 31–42. http://dx.doi.org/10.15578/jkpi.13.1.2021.31-42

Thomas, G. E. (1989). A note on correcting for ties with Spearman's ρ. *Journal of Statistical Computation and Simulation*, 31(1), 37–40. https://doi.org/10.1080/00949658908811109

Thorburn, C. C. (2000). Changing customary marine resource management practice and institutions: The case of sasi lola in the Kei Islands, Indonesia. *World Development*, 28(8), 1461–1479. https://doi.org/10.1016/S0305-750X(00)00039-5

Zar, J. H. (2005). Spearman rank correlation. In P. Armitage and T. Colton (Eds.), Encyclopedia of biostatistics. *John Wiley & Sons*. https://doi.org/10.1002/0470011815.b2a15150