Investigating climate change-related factors that hinder stakeholders' willingness to protect ocean

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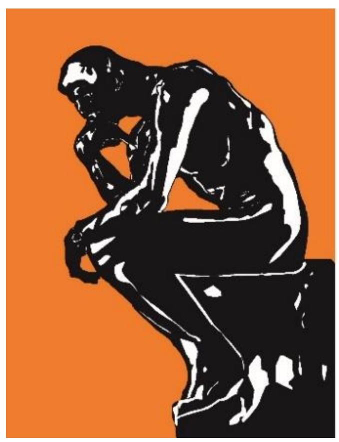

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"The age of technology has arrived, and Kingfisher has decided it's time for something new: Technological Innovation. Innovation can help Kingfisher conserve energy while maintaining a sense of tranquility, which is suitable for an increasingly advanced age with diminishing physical strength.

[…]

Pressing the buttons has gradually become somewhat of a new technological ritual."

—In "Innovation", *The Kingfisher Story Collection* (2022)

Abstract

Community and stakeholder support for marine and coastal ecosystem conservation policies is crucial. However, extant multinational studies on climate change-related factors that constrain stakeholders' willingness to protect the ocean are limited. Therefore, the dataset from 709 marine stakeholders across 42 countries, part of the MaCoBioS project funded by the European Commission, was analyzed using the Bayesian Mindsponge Framework (BMF) method to fill the knowledge gap. The findings reveal that for individuals who think society is doing too much to address climate change, new technologies can solve climate change. Responses to climate change can damage the country's economy and might not be productive in supporting actions protecting the ocean. Based on the study results, we recommend policymakers raise awareness among individuals engaged in marine and coastal ecosystems about the crucial role of marine protection in combating climate change, taking into account the limitations of technology in solving climate change problems and the inadequacy of current efforts. The findings also provide insights for enhancing the effectiveness of awareness and knowledge-raising campaigns, conservation programs, and eco-surplus culture-building agenda.

Keywords: marine and coastal ecosystem; exceptionalism; stakeholder support; environmental policy; Mindsponge Theory; BMF analysis framework.

1. Introduction

The unsustainable exploitation of marine resources, driven by population growth, has raised significant concerns about biodiversity and the overall health of marine ecosystems, which have played a pivotal role in human development throughout history. Millions of people rely on marine resources for their livelihoods, as the sea is considered a rich source of food and contributes significantly to global food security (Simeoni et al., 2023). However, overfishing, habitat loss, pollution, and the impacts of climate change are among the numerous challenges threatening the marine environment (Kusumawati & Huang, 2015). For instance, the disturbance caused by local human activities leading to the loss of seagrass beds can result in altered sediment surfaces and the degradation of biogeochemical environments, exacerbating the impacts of climate change on coastal areas (James et al., 2023). These impacts encompass ocean acidification, temperature fluctuations, and rising sea levels.

Acknowledging the significance of marine ecosystems and the need to combat climate change has led to substantial investments in research and technology for their protection and sustainability (Apostu et al., 2023). Researchers are innovating approaches focusing on scientific and technical solutions, including developing ocean conservation technologies like autonomous underwater vehicles, remote sensing, and satellite-based monitoring systems (Khaskheli et al., 2023). Simultaneously, implementing sustainable fisheries management practices and monitoring technologies ensures the long-term health of marine ecosystems (Korpinen et al., 2022).

While scientific and technical advancements offer promising tools, it is crucial to acknowledge that an exclusive reliance on them may inadvertently overshadow the broader socio-cultural, economic, and political factors shaping marine conservation attitudes (Zamzami et al., 2020). This is particularly relevant in the context of human exceptionalism, which views humans as independent of the ecosystems they are part of, potentially leading to an exclusive focus on technological innovations to address challenges in conservation practices, nature management, climate change adaptation, and environmental science (Kim et al., 2023).

Recognizing the exceptionalism issue within the context of technological solutions sheds light on the intricate nature of marine ecosystems, emphasizing the necessity for a better approach that includes not only technological solutions but also socio-cultural, economic, and political considerations (Bennett & Dearden, 2014; Hiriart-Bertrand et al., 2020; James et al., 2023; McNeill et al., 2018). Adopting a holistic approach that considers both technological and non-technological strategies is crucial to ensure sustainable practices in protecting marine ecosystems. Policies informed by this comprehensive perspective contribute to ecological equilibrium, acting as protective measures for vulnerable species and ecosystems and aligning with the overarching goal of ensuring the enduring sustainability of marine resources.

Recently, there has been a significant increase in research focusing on public support for coastal and marine conservation. Studies have emphasized the necessity of involving a variety of actors in these conservation efforts, including local communities, businesses, governments, NGOs, and scientists (Adams et al., 2023; Blackwatters et al., 2023). Additionally, the research aligns with the significance of understanding the attitudes, opinions, and willingness to participate in conservation initiatives of different communities when developing and implementing policies in a focused and effective manner (Agnello et al., 2022).

Studies also emphasize the importance of identifying factors influencing community awareness and consciousness, thereby shaping their support for marine and coastal conservation. Firstly, these factors include the perceived environmental impacts, benefits, or costs, as well as the effectiveness and efficiency of management and operating policies, institutions, and procedures (Bennett & Dearden, 2014; Diedrich et al., 2017; Kusumawati & Huang, 2015).

Furthermore, increasing community support and contributions to marine protection strategies is a multifaceted commitment, including educational, cultural, and social considerations (Christie et al., 2017; Rahman et al., 2022; Rifai et al., 2023). Public awareness and education campaigns, which have received widespread scholarly attention, are considered one of the essential aspects of this effort (Lucrezi, 2022; McKinley et al., 2023). Notably, these studies especially emphasize strengthening community support activities for the goals of environmental education, mitigating climate change, and promoting marine conservation policies, thereby creating the potential for a more robust and sustainable approach to conservation (Britton et al., 2021; Lucrezi et al., 2019).

Similarly, recent scholarly investigations have shown the complex relationship between cultural and social factors and the perspectives of communities. For example, when a community's interactions with marine ecosystems are embedded in long-standing cultural practices and traditions, they will have a stronger sense of marine resource management (Johnson et al., 2020; Wheaton et al., 2021). This complex relationship highlights the impact of cultural factors on public support for marine conservation efforts (Bennett et al., 2022).

Although there has been an increase in research on public support for marine protection policies, some major research gaps still require attention. The impact of contextual factors on public support for coastal and marine conservation varies significantly across countries (Guan et al., 2022; McNeill et al., 2018). Contextual differences encompass social, cultural, political, economic, and historical factors (Chính & Hoàng, 2009; Diedrich et al., 2017; Mahajan & Daw, 2016). If scientific results can be generalized to countries with different contexts, it could help make policies more effective and reduce research costs. Therefore, a cross-national study that identifies trends generalizable to countries with different contextual factors is needed (Hinds et al., 2011). Even when common trends cannot be found, multinational research efforts can assist in identifying contextual factors that may have differential effects across countries, thereby guiding future research efforts. By understanding these factors, policymakers and decision-makers can develop more effective and targeted strategies that resonate with different stakeholder groups, thereby increasing their support and fostering a stronger sense of connection and responsibility toward marine preservation. This strategy could reduce the resources needed compared to alternative strategies, such as strong regulatory enforcement (Diedrich et al., 2017).

Furthermore, although there have been many studies examining the perceptions of whole communities or concerned individuals about climate factors, weather, and climate change (Bennett et al., 2022; Britton et al., 2021; Johnson et al., 2020; Lucrezi et al., 2019; Wheaton et al., 2021), studies about climate change related factors that can undermine stakeholder’s willingness to protect the ocean still have many limitations.

Based on the Mindsponge Theory, which describes how people perceive and process information (Vuong, 2023; Vuong et al., 2022), this study aims to contribute new insights into the impact of cognitive climate change-related awareness of stakeholders on their support for marine protection policies in 42 countries. Therefore, we aim to address the following research questions:

Question 1: Do perceptions that mitigate climate change risk (e.g., developing technology to help address climate change) reduce stakeholders' willingness to protect the ocean?

Question 2: Do perceptions of the costs associated with combating climate change (e.g., the belief that responding to climate change will harm economies and societies already actively addressing the issue) reduce stakeholders' willingness to protect the ocean?

The research article is presented according to the following structure. First, the introduction clearly states the importance of the research problem in protecting ocean and coastal ecosystems and the research questions. Details of the Bayesian Mindsponge Framework (BMF) analysis method, statistical model, and data specifics for 42 countries are described in Section 2. The results and conclusions are then presented in Parts 3 and 4.

2. Methodology

2.1. Theoretical Basis and Hypotheses

The Mindsponge Theory is a psychological and social theory of the mind developed from mindsponge mechanisms and the most recent findings in biology, ecology, and neuroscience (Vuong, 2023; Vuong & Napier, 2015). This theory is based on an information-processing approach to studying the human mind. This approach views information as the foundation on which practice is constructed, allowing for investigating complex phenomena requiring multidisciplinary knowledge (Davies & Gregersen, 2014). Various studies have used this theory as a theoretical foundation to study social psychological phenomena, including environmental and conservation psychology (Kantabutra & Ketprapakorn, 2021; Kumar et al., 2022; Nguyen, Duong, et al., 2023; Nguyen & Jones, 2022a, 2022b; Raja et al., 2023; Santirocchi et al., 2023; Tanemura et al., 2022; Xu et al., 2023).

Mindsponge Theory (MT) was chosen as the theoretical framework for this study because it can clarify the interconnected components of our complex topic. MT provides a new information processing perspective that complements and clarifies existing theories and conceptual frameworks in psychology and sociology, e.g., The Theory of Planned Behavior (Ajzen, 1985, 1991; De Leeuw et al., 2015). In the context of this study, MT helps explain the factors that hinder stakeholder's willingness to protect the ocean.

Specifically, this theory views the mind and the environment as two main domains. The mind is considered an information-gathering and -processing system. At the same time, the environment is conceptually a larger and more encompassing information-processing system (e.g., Earth system, social system, etc.) that contains the human mind. The main goal of the mind is to prolong the system's existence in one way or another, such as through survival, growth, and reproduction. The mind consists of three main parts: mindset, a buffer zone (or comfort zone), and a multi-filtering system (see Figure 1). Mindset is defined as the collection of highly reliable information or core values in the human mind; the buffer zone is the conceptual space where information is temporarily stored before being reviewed and evaluated by the multi-filtering system.

Information integration and discrimination are two main functions of the multifilter system (Levy et al., 2007). When sensory systems absorb information from the environment into the mind, the information is processed in two different ways. Absorbed information will be synthesized and absorbed into the mindset if it is consistent with core values (or highly reliable information) contained in the recipient's thinking. However, suppose the new information differs significantly from the core values or trusted information. In that case, the new information must undergo a rigorous review and evaluation process to determine the costs and benefits of accepting or rejecting the emerging information (or replacing the existing information with new information).

In general, in cases where new information is considered potentially beneficial, it will be accepted into the core of the mind and influence thinking, thereby further influencing filtering processes, thoughts, and subsequent behavior. In cases where it is deemed inappropriate or costly, the information will be discarded. In cases where the perceived cost and benefit do not have a clear difference, it will be stored in a buffer and used for later evaluation when there is enough necessary information (Vuong et al., 2022).

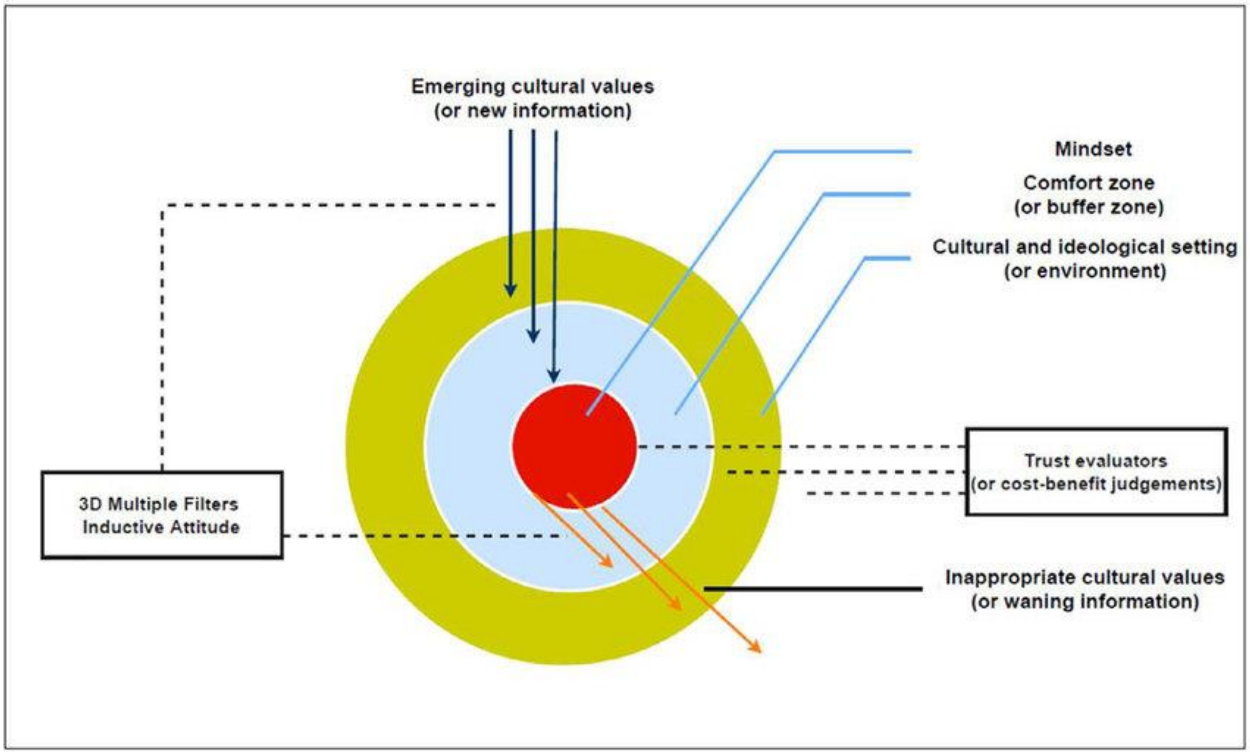

Figure 1: Conceptual diagram of the mindsponge mechanism. Retrieved from Nguyen et al. (2021) under CC BY-SA 3.0.

Based on the information processing principles of Mindsponge Theory, we assume that for individuals to be willing to protect the ocean, information related to marine protection must be absorbed into their mindset. However, for this information to be absorbed into the mindset, it must be evaluated by the mind as beneficial. If the mind, based on the information already present, deems the protection of the sea as costly, the relevant information may be limited in the absorption process or even eliminated from the mind.

To address the issue of climate change, nature conservation, including marine conservation, is considered one of the significant solutions, alongside technological development (e.g., clean energy, carbon capture technology, electrification, etc.). Therefore, if an individual's mind contains information that technological development will help solve the problem of climate change, they may be less inclined to seek and absorb information related to other solutions for climate change, including marine protection. Therefore, we made the first Hypothesis (H):

> **H1:** Individuals who think new technology can be developed to solve adverse environmental changes will be less willing to protect the ocean.

In addition, protecting the ocean demands a great amount of time, effort, and resources (including money), but an individual's time, effort, and resources are finite. Therefore, even if individuals know the importance of combating climate change, they can only allocate a portion of their time, effort, and resources to combat it. Suppose an individual's mind contains information that society is already making significant efforts to address the impacts of climate change. In that case, it will tend not to absorb and may eliminate information related to solutions to combat climate change, including marine protection, to save time, effort, and resources. Based on this, we made the second Hypothesis:

> **H2:** Individuals who believe that society is doing more to address the impacts of climate change will be less willing to protect the ocean.

Along with this logic, if individuals feel that actions to combat climate change require sacrificing or reducing current benefits (including economic benefits), their minds will tend to eliminate information related to solutions to combat climate change, including marine protection. Based on this, we made the third Hypothesis:

> **H3:** Individuals who believe that responses to climate change will harm the country's economy will be less willing to protect the ocean.

2.2. Model Building

2.2.1. Variable Selection and Theoretical Basis

The dataset used in the present study was a product of the MaCoBioS project (Biodiversity and Coastal Ecosystem Services in a Changing World), funded by the European Commission H2020. Data were collected through an online survey accessible on the Qualtrics internet platform from November 16, 2021, to February 16, 2022. The questionnaire is available in English, French, Spanish, and Italian. The survey interface was adapted to the device used. The final dataset has a total of 709 respondents and is stored on Mendeley Data as "Survey_Fonsecaetal_07122022.xlsx" (Fonseca et al., 2023).

The survey was designed for public stakeholders interested in marine and coastal ecosystems, climate change, and ecosystem management. The questionnaire included questions about attitudes, responses to climate change, socio-demographic information, and the importance of and threats to coasts, oceans, and animals. It was initially tested on a sample of 20 people. Most questions require a response, while demographic questions offer a "prefer not to answer" option. Participation was optional, and respondents were allowed to exit the survey and return later to complete it. Participant information is kept confidential, ensuring respondents' IP addresses, location data, or contact information are not recorded.

Snowball sampling was applied to find a suitable target group for the survey due to the difficulty of accessing population groups related to marine and coastal ecosystems, climate change, and ecosystem management (Szolnoki et al., 2013). Specifically, the survey was widely shared on MaCoBioS's social media pages (i.e., Twitter and Instagram). Furthermore, the surveyors also contacted 105 organizations involved in conservation, tourism/recreation, and fishing/seafood in multiple countries (e.g., UK, Norway, Ireland, France, Italy, Spain, Bonaire, Martinique, and Barbados) to ask them to share the survey with their members.

Furthermore, because the project aims to conduct a cross-national survey of coastal and marine communities' perceptions of climate change, human impacts, and the values and management of marine and coastal ecosystems, it is not feasible to conduct other types of sampling (e.g., stratified or random sampling) due to the high costs involved (Vuong, 2018). Therefore, the sample collected is not representative but only has a reference value.

In the present study, we used four variables to build the model (one outcome variable and three predictor variables). The outcome variable is *ProtectOceans*, representing respondents' willingness to protect the ocean. The three predictor variables represent factors that potentially hinder support for coastal and marine ecosystem conservation: *TooMuchSocialEffort*, *TechasEnvironSolution*, and *NegativeImpactonEconomy*. A detailed description of these variables is presented in Table 1.

Table 1: Variable Description

Variable	Description	Data type	Value
TooMuchSocialEffort	Society is doing too much to address the impacts of climate change	Numerical	1. Strongly disagree 2. Disagree 3. Average 4. Agree 5. Strongly agree
TechasEnvironSolution	People do not need to worry about climate change as new technologies will be developed to help address adverse environmental changes	Numerical	1. Strongly disagree 2. Disagree 3. Average 4. Agree 5. Strongly agree
NegativeImpactonEconomy	Actions to respond to climate change will damage my country's economy	Numerical	1. Strongly disagree 2. Disagree 3. Average 4. Agree 5. Strongly agree
ProtectOceans	I am willing to support actions to protect the ocean, even if it requires consuming less seafood and paying a higher price for it	Numerical	1. Strongly disagree 2. Disagree 3. Average 4. Agree 5. Strongly agree

2.2.2. Statistical Model

To test our hypotheses about social, technical, and economic factors constraining stakeholders' willingness to protect the ocean, we built the model as follows:

$$ProtectOceans \sim normal(\mu, \sigma) \quad (1.1)$$

$$\mu_i = \beta_0 + \beta_1 * TooMuchSocialEffort_i + \beta_2 * TechasEnvironSolution_i + \beta_3 * NegativeImpactonEconomy_i \quad (1.2)$$

$$\beta \sim normal(M, S) \quad (1.3)$$

The probability around the mean value μ is represented by a normal distribution, whose width is determined by the standard deviation σ. μ_i is the willingness level of stakeholder i to protect the ocean; $TooMuchSocialEffort_i$ is stakeholder i's agreement level that society is doing too much to address climate change; $TechasEnvironSolution_i$ is i's agreement level that new technologies will be developed to help address adverse environmental changes; $NegativeImpactonEconomy_i$ is stakeholder i's agreement level that taking action to respond to climate change will cause damage to the country's economy.

Model 1 has five parameters: the intercept β_0, the coefficients β_1-β_3, and the standard deviation of "noise", σ. The coefficients of the predictor variables are distributed as a normal distribution around the mean denoted M with the standard deviation denoted S. The logical network of Model 1 is shown in Figure 1.

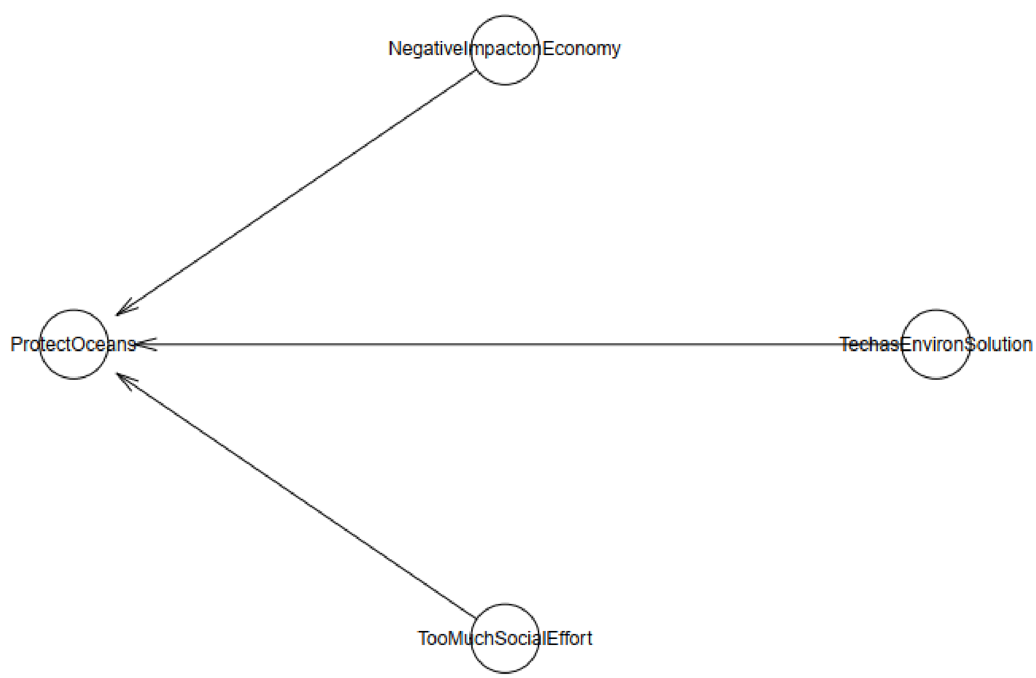

Figure 1: Logical Network of Model 1.

2.2.3. Analytical and Diagnostic Methods

This research paper uses the Bayesian Mindsponge Framework (BMF) method to analyze and test the proposed hypothesis based on the Mindsponge Theory (Nguyen et al., 2022; Vuong et al., 2022). The BMF method is used for several reasons.

First, the method combines the theoretical reasoning power of Mindsponge Theory and the inferential advantages of Bayesian analysis because both are highly compatible in nature (Nguyen et al., 2022). Second, Bayesian inference evaluates all values probabilistically, allowing for reliable predictions with parsimonious models (Csilléry et al., 2010; Gill, 2014). Third, Bayesian inference has several advantages over the frequentist approach; for example, it allows users to use credible intervals to interpret results instead of *p*-values. The reproducibility crisis is related to the variability of *p*-values (Halsey et al., 2015).

Due to the exploratory nature of this study, uninformative priors were used to provide as little information as possible before estimation (Diaconis & Ylvisaker, 1985). Once the model was estimated, we used the Pareto smoothed importance sampling leave-one-out (PSIS-LOO) diagnosis to test the model's fit to the data (Vehtari & Gabry, 2019; Vehtari et al., 2017). Specifically, the *k*-Pareto value in PSIS-LOO diagnosis is used to evaluate the model's fitness. Typically, a model is considered to fit the data when the *k* value is less than 0.5.

Before interpreting the estimated results, the convergence of the Markov chains must be checked. The convergence of the Markov chains can be tested using statistical values, such as the effective sample size (*n_eff*) and the Gelman–Rubin coefficient (*Rhat*), and diagnostic plots, such as the trace plots. The *n_eff* value represents the number of non-autocorrelated iterative samples generated during the stochastic simulation. If the *n_eff* value is greater than 1000, we can consider the Markov chain to be convergent, and the effective samples are enough to support reliable inference (McElreath, 2018). The *Rhat* value—often called the potential scale reduction factor or the Gelman–Rubin shrinkage factor—is used to evaluate the convergence of a Markov chain (Brooks & Gelman, 1998). If the *Rhat* value exceeds 1.1, the model does not converge. Typically, the model is considered convergent if *Rhat* = 1.

The Bayesian analysis in this study was performed using the bayesvl package on R software. This package is chosen for its user-friendly interface, ease of use, and capacity to generate visually appealing and intuitive graphics (La & Vuong, 2019; Vuong et al., 2022). For the sake of research transparency and reducing research and reproducibility costs, we have stored all data and computer code on OSF.

3. Results

First, we check the goodness of fit of Model 1 using the PSIS-LOO plot in Figure 2. It can be seen that all *k* values are less than 0.5, indicating a good fit between the model and the data.

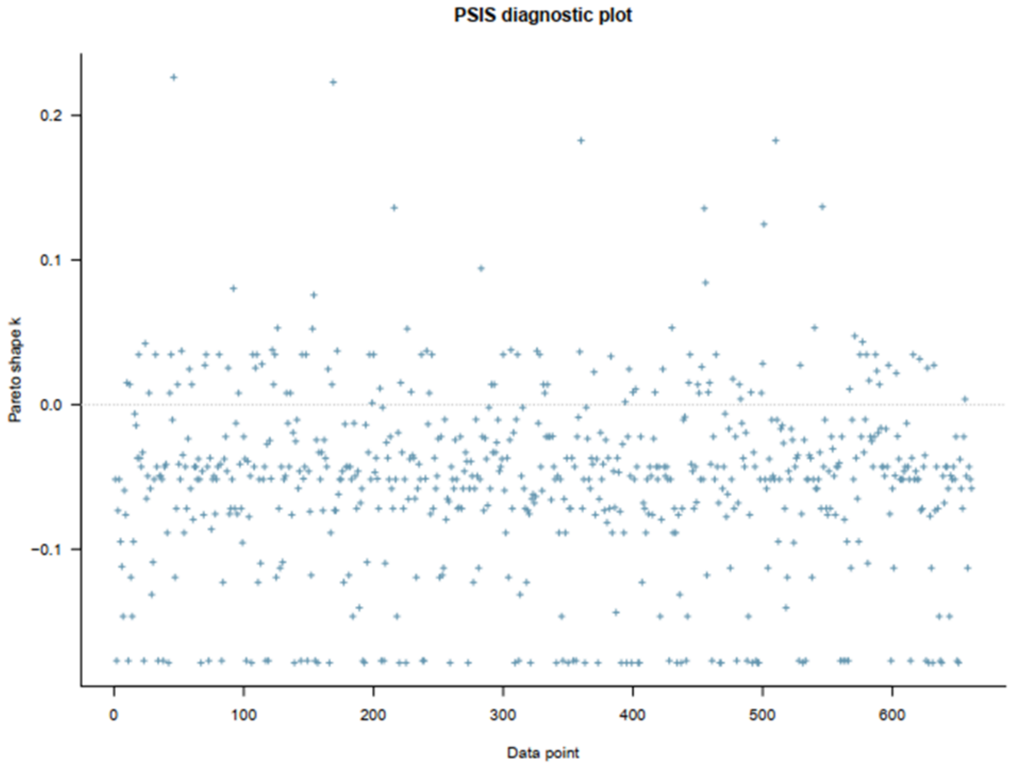

Figure 2: Model 1's PSIS-LOO test

The estimated results of Model 1 are shown in Table 2. The effective sample size (*n_eff* > 1000) and the Gelman-Rubin shrinkage factor (*Rhat* = 1) show that the Markov chain converges well, so we can continue interpreting the simulated posterior distributions of the model coefficients. The healthy mixing of the Markov chain around the central equilibrium point, as illustrated in Figure 3, also confirms the convergence.

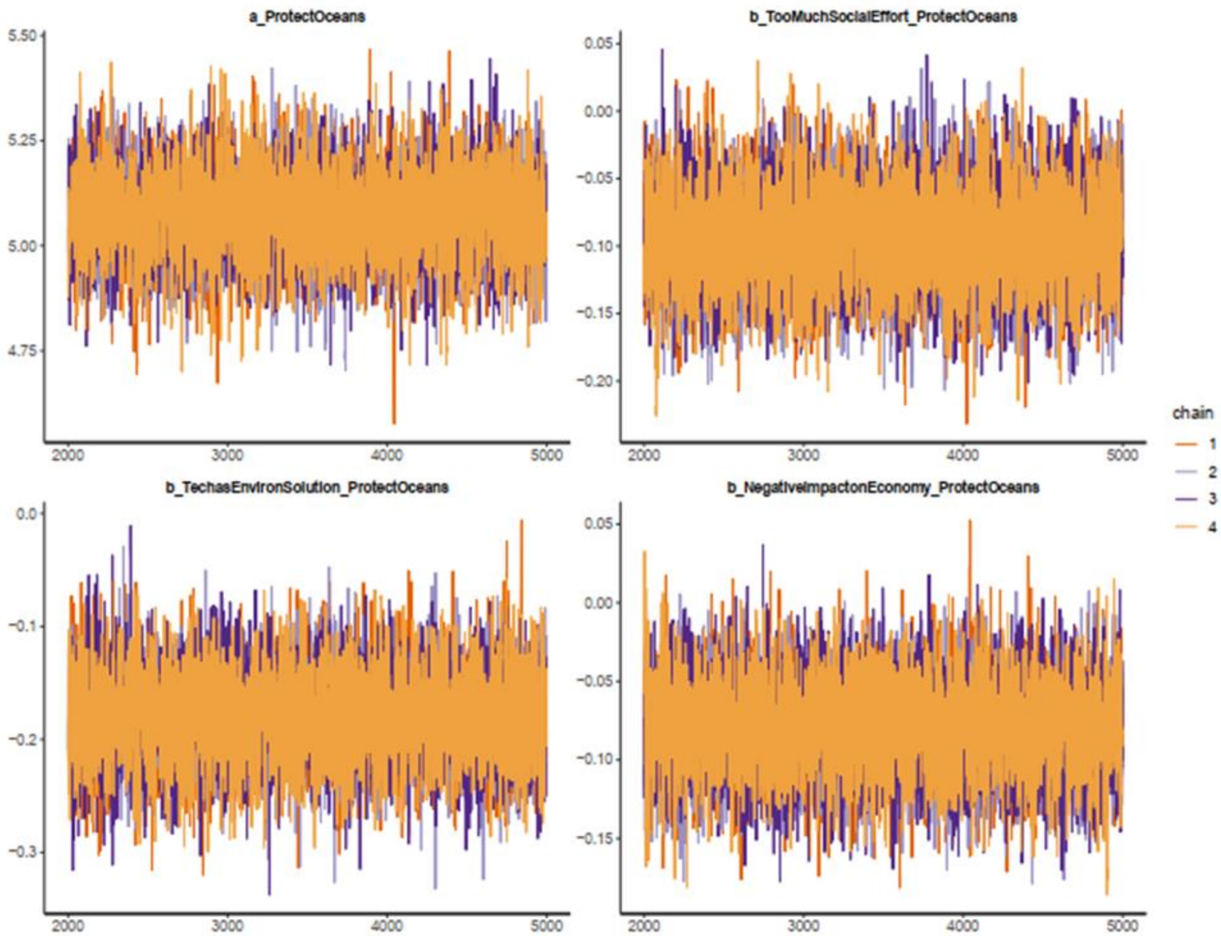

Figure 3: Model 1's trace plot

The posterior distribution of the coefficient implies that individuals who agree more with the statements "society is doing much to address the impacts of climate change", "new technologies will be developed to help address adverse environmental changes", and "taking action on climate change will damage my country's economy" are less willing to protect the ocean (see Table 2).

Table 2: Estimated Results of Model 1

Parameters	Mean	Standard deviation	*n_eff*	*Rhat*
Constant	5.07	0.10	6986	1
TooMuchSocialEffort	-0.09	0.04	7341	1
TechasEnvironSolution	-0.18	0.04	8639	1

NegativeImpactonEconomy	-0.08	0.03	8128	1

The illustration of the posterior distributions in Figure 4 shows that the impacts of *TooMuchSocialEffort*, *TechasEnvironSolution*, *NegativeImpactonEconomy* on *ProtectOceans* are highly reliable, as the dark blue lines of each coefficient (representing the 89% of the Highest Posterior Density Interval) lie entirely on the negative side of the horizontal axis of the coordinate axis.

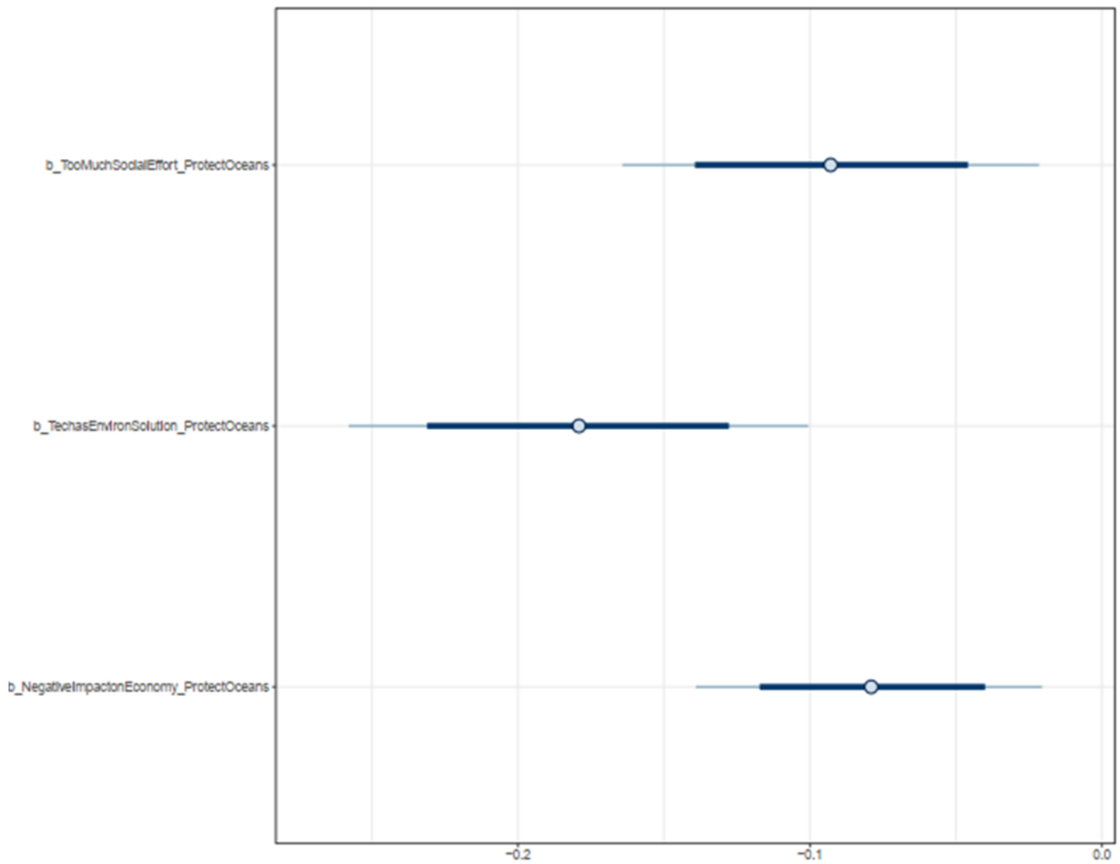

Figure 4: Posterior distributions of Model 1's coefficients

4. Discussion

By utilizing Mindsponge Theory and BMF analytics, this study delves into the relationships between perceptions of climate change-related attitudes and marine protection willingness. Its results contribute to the field of environmental psychology and marine conservation. By exploring these psychological dimensions, the study enhances our understanding of marine protection and enriches the broader comprehension of how individuals interact with and respond to environmental challenges. The implications of the findings extend beyond the specific context of marine protection, resonating with the broader field of pro-environmental behavior research (Bradley et al., 2020; Tian & Liu, 2022).

Our results confirm that individuals with different types of information in their minds will think differently, specifically their willingness to protect marine and coastal ecosystems. Individuals expressing beliefs that society is already doing too much to address climate change, new technologies will help solve adverse environmental changes, and climate actions that will harm the economy tend to be less supportive of marine protection efforts, validating our proposed hypotheses.

The confirmation of our hypotheses has far-reaching implications, particularly for policymakers dedicated to fostering pro-environmental behaviors that protect marine environments. Firstly, our study's findings highlight the critical relationship between effective marine conservation policies and their alignment with key economic sectors associated with marine ecosystems. Policymakers are encouraged to design measures that protect the environment and actively contribute to national economic goals, highlighting the crucial need for a balanced approach to prevent unintended hindrances to economic growth through conservation efforts.

Secondly, the emphasis on the risk of exceptionalism in this study underscores the necessity to acknowledge and understand the constraints of viewpoints isolating humans from the ecosystems integral to existing policies, programs, and campaigns (Vuong & Nguyen, 2023). Addressing these challenges requires the implementation of several key measures. One example is the promotion of multi-stakeholder collaboration, encouraging the establishment of partnerships among scientists, policymakers, local communities, and conservation organizations to enhance the decision-making process. This approach helps mitigate the narrow focus associated with an exceptionalist viewpoint that tends to isolate humans from ecosystems, fostering a more comprehensive and inclusive approach to environmental conservation (Bulmer & Yáñez-Araque, 2023). Additionally, recognizing and integrating indigenous knowledge will provide valuable insights into advancing sustainable living and cultivating harmonious coexistence with nature (Mazzocchi, 2020; Vuong & Nguyen, 2023).

Furthermore, it is important to advocate for ecocentrism, promoting a perspective that recognizes the value of every component within an ecosystem, thereby deepening our understanding of life's interconnectedness (Washington et al., 2017). This approach aligns with the significance of comprehensive environmental education, crucial in nurturing a society with ecological consciousness.

To reinforce this perspective, we also propose that to gain public support for marine and coastal protection, the content of disseminated environmental information should highlight the importance of marine and coastal ecosystems in improving human welfare, regulating climate and weather, and mitigating climate change (Nguyen, Duong, et al., 2023). At the same time, it is necessary to take advantage of different information transmission channels so that relevant parties can increase access to information about climate change, thereby raising awareness about protecting marine and coastal ecosystems and bringing long-term economic benefits to people (Vuong, 2020a; Q.-H. Vuong et al., 2021). In the long term, these perceptions will be the foundation for building an eco-surplus culture (Nguyen & Jones, 2022a; Nguyen, Le, et al., 2023; Vuong, 2021; Vuong & Nguyen, 2024; Q. H. Vuong et al., 2021). These proposals could contribute to achieving the EU's carbon neutrality target (e.g., European Green Deal).

Incorporating these suggestions into policymaking ensures that marine conservation interventions are globally informed, locally relevant, and impactful. By forming a robust framework that considers the intricate connections between environmental, cultural, economic, and technological factors, policymakers can enhance the effectiveness of their initiatives. This approach promotes a holistic understanding of marine conservation, fostering sustainable practices that benefit the environment and the economy.

The current study has several limitations, so we report them here for transparency and integrity (Vuong, 2020b). First, although the dataset includes people from 42 countries, most are from Europe, especially France and Italy. Therefore, this dataset is not representative of people from non-European regions. However, it can be seen as an exploratory attempt to bring non-European perspectives into the global approach. Second, a potential source of bias arises from the self-selection of respondents who chose to participate in the survey. Individuals who choose to participate in the survey might already have certain opinions or beliefs about environmental issues, potentially introducing a bias that could impact the generalizability of the findings. This inherent bias should be considered when interpreting the study's results and their applicability to a broader population.

5. Conclusion

Using BMF analysis, the present study delves into a dataset from the MaCoBioS research project, encompassing 709 populations engaged in marine and coastal ecosystems across 42 countries. The primary goal is to explore the factors linked to climate change that impede individuals' willingness to protect marine and coastal ecosystems.

The research findings provide valuable insights into the determinants influencing stakeholder endorsement for marine conservation efforts. Those who perceive already excessive societal responses to climate change, have faith in the development of environmentally friendly technology, and view climate actions as potentially detrimental to the economy are less willing to conduct marine protection. These results align with Mindsponge Theory predictions, emphasizing the pivotal role of cognitive processes in shaping attitudes and behaviors related to environmental conservation. Furthermore, the study underscores the necessity of avoiding an exclusive reliance on technological solutions. It highlights the importance of a holistic approach integrating socio-cultural, economic, and political considerations in marine conservation policies, programs, and campaigns.

This research contributes to the knowledge in the fields of environmental psychology and marine conservation by providing insights into human interactions with environmental challenges. Based on the study results, we recommend policymakers raise awareness among individuals engaged in marine and coastal ecosystems about the crucial role of marine protection in combating climate change, taking into account the limitations of technology in solving climate change problems and the inadequacy of current efforts.

References

Adams, A., Danylchuk, A. J., & Cooke, S. J. (2023). Conservation connections: incorporating connectivity into management and conservation of flats fishes and their habitats in a multi-stressor world. *Environmental Biology of Fishes*, *106*(2), 117-130. https://doi.org/10.1007/s10641-023-01391-4

Agnello, G., Vercammen, A., & Knight, A. T. (2022). Understanding citizen scientists' willingness to invest in, and advocate for, conservation. *Biological Conservation*, *265*, 109422. https://doi.org/10.1016/j.biocon.2021.109422

Ajzen, I. (1985). From Intentions to Actions: A Theory of Planned Behavior. In J. Kuhl & J. Beckmann (Eds.), *Action Control* (pp. 11-39). Springer Berlin Heidelberg. http://link.springer.com/10.1007/978-3-642-69746-3_2

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, *50*(2), 179-211.

Apostu, S. A., Nichita, E. M., Manea, C. L., Irimescu, A. M., & Vulpoi, M. (2023). Exploring the Influence of Innovation and Technology on Climate Change. *Energies*, *16*(17), 6408.

Bennett, N. J., & Dearden, P. (2014). Why local people do not support conservation: Community perceptions of marine protected area livelihood impacts, governance and management in Thailand. *Marine Policy*, *44*, 107-116. https://doi.org/10.1016/j.marpol.2013.08.017

Bennett, N. J., Le Billon, P., Belhabib, D., & Satizábal, P. (2022). Local marine stewardship and ocean defenders. *NPJ Ocean Sustainability*, *1*(1), 3. https://doi.org/10.1038/s44183-022-00002-6

Blackwatters, J. E., Betsill, M., Enrici, A., Le Cornu, E., Basurto, X., & Gruby, R. L. (2023). More than funders: The roles of philanthropic foundations in marine conservation governance. *Conservation Science and Practice*, *5*(5), e12829. https://doi.org/10.1111/csp2.12829

Bradley, G. L., Babutsidze, Z., Chai, A., & Reser, J. P. (2020). The role of climate change risk perception, response efficacy, and psychological adaptation in pro-environmental behavior: A two nation study. *Journal of Environmental Psychology*, *68*, 101410.

Britton, E., Domegan, C., & McHugh, P. (2021). Accelerating sustainable ocean policy: The dynamics of multiple stakeholder priorities and actions for oceans and human health. *Marine Policy*, *124*, 104333. https://doi.org/10.1016/j.marpol.2020.104333

Brooks, S. P., & Gelman, A. (1998). General methods for monitoring convergence of iterative simulations. *Journal of computational and graphical statistics*, *7*(4), 434-455.

Bulmer, E., & Yáñez-Araque, B. (2023). Tackling Climate Change through Multi-Stakeholder Partnerships: Promoting SDG 17 to Combat Climate Change. *Energies*, *16*(9), 3777.

Chính, P. M., & Hoàng, V. Q. (2009). *Kinh tế Việt Nam: Thăng trầm và đột phá*. Nxb Chính trị quốc gia-Sự thật.

Christie, P., Bennett, N. J., Gray, N. J., Wilhelm, T. A., Lewis, N. A., Parks, J., ... Day, J. (2017). Why people matter in ocean governance: Incorporating human dimensions into large-scale marine protected areas. *Marine Policy*, *84*, 273-284. https://doi.org/10.1016/j.marpol.2017.08.002

Csilléry, K., Blum, M. G., Gaggiotti, O. E., & François, O. (2010). Approximate Bayesian computation (ABC) in practice. *Trends in Ecology and Evolution*, *25*(7), 410-418. https://doi.org/10.1016/j.tree.2010.04.001

Davies, P., & Gregersen, N. H. (2014). *Information and the nature of reality: From physics to metaphysics*. Cambridge University Press. https://doi.org/10.1017/CBO9781107589056

De Leeuw, A., Valois, P., Ajzen, I., & Schmidt, P. (2015). Using the theory of planned behavior to identify key beliefs underlying pro-environmental behavior in high-school students: Implications for educational interventions. *Journal of Environmental Psychology*, *42*, 128-138.

Diaconis, P., & Ylvisaker, D. (1985). Quantifying prior opinion. In J. M. Bernardo, M. H. DeGroot, D. V. Lindley, & A. F. M. Smith (Eds.), *Bayesian Statistics* (Vol. 2, pp. 133-156). North Holland Press.

Diedrich, A., Stoeckl, N., Gurney, G. G., Esparon, M., & Pollnac, R. (2017). Social capital as a key determinant of perceived benefits of community-based marine protected areas. *Conservation Biology*, *31*(2), 311-321.

Fonseca, C., Wood, L. E., Andriamahefazafy, M., Casal, G., Chaigneau, T., Cornet, C. C., ... Furlan, E. (2023). Survey data of public awareness on climate change and the value of marine and coastal ecosystems. *Data in brief*, *47*, 108924. https://doi.org/10.1016/j.dib.2023.108924

Gill, J. (2014). *Bayesian methods: A social and behavioral sciences approach* (Vol. 20). CRC press.

Guan, Y., Bai, J., Tian, X., Wang, X., Wang, C., Zhang, Y., ... Liu, G. (2022). Social network analysis and application for ecosystem service perceptions by stakeholders for coastal wetland conservation. *Journal of cleaner production*, *371*, 133596. https://doi.org/10.1016/j.jclepro.2022.133596

Halsey, L. G., Curran-Everett, D., Vowler, S. L., & Drummond, G. B. (2015). The fickle P value generates irreproducible results. *Nature Methods*, *12*, 179-185. https://doi.org/10.1038/nmeth.3288
Hinds, P., Liu, L., & Lyon, J. (2011). Putting the global in global work: An intercultural lens on the practice of cross-national collaboration. *Academy of Management Annals*, *5*(1), 135-188. https://doi.org/10.5465/19416520.2011.586108
Hiriart-Bertrand, L., Silva, J. A., & Gelcich, S. (2020). Challenges and opportunities of implementing the marine and coastal areas for indigenous peoples policy in Chile. *Ocean and Coastal Management*, *193*, 105233. https://doi.org/10.1016/j.ocecoaman.2020.105233
James, R., Keyzer, L., van de Velde, S., Herman, P. M., van Katwijk, M., & Bouma, T. (2023). Climate change mitigation by coral reefs and seagrass beds at risk: How global change compromises coastal ecosystem services. *Science of the Total Environment*, *857*, 159576. https://doi.org/10.1016/j.scitotenv.2022.159576
Johnson, A. E., McClintock, W. J., Burton, O., Burton, W., Estep, A., Mengerink, K., ... Tate, S. (2020). Marine spatial planning in Barbuda: A social, ecological, geographic, and legal case study. *Marine Policy*, *113*, 103793. https://doi.org/10.1016/j.marpol.2019.103793
Kantabutra, S., & Ketprapakorn, N. (2021). Toward an Organizational Theory of Resilience: An Interim Struggle. *Sustainability*, *13*(23), 13137. https://doi.org/10.3390/su132313137
Khaskheli, M. B., Wang, S., Zhang, X., Shamsi, I. H., Shen, C., Rasheed, S., ... Baloch, D. M. (2023). Technology advancement and international law in marine policy, challenges, solutions and future prospective. *Frontiers in Marine Science*.
Kim, J. J., Betz, N., Helmuth, B., & Coley, J. D. (2023). Conceptualizing human–nature relationships: Implications of human exceptionalist thinking for sustainability and conservation. *Topics in Cognitive Science*.
Korpinen, S., Kahlert, M., Kuosa, H., Mack, L., Meissner, K., Pitkänen, H., ... Uusitalo, L. (2022). Marine monitoring in transition: On the verge of technological revolution? *Frontiers in Marine Science*, *9*, 1066769.
Kumar, M., Srivastava, S., Muhammad, T., & Saravanakumar, P. (2022). Examining the association between health status and subjective life expectancy among older Indian adults based on the mindsponge approach. *Humanities and Social Sciences Communications*, *9*(1), 1-10. https://doi.org/10.1057/s41599-022-01368-1
Kusumawati, I., & Huang, H.-W. (2015). Key factors for successful management of marine protected areas: A comparison of stakeholders′ perception of two MPAs in Weh island, Sabang, Aceh, Indonesia. *Marine Policy*, *51*, 465-475. https://doi.org/10.1016/j.marpol.2014.09.029
La, V.-P., & Vuong, Q.-H. (2019). bayesvl: Visually learning the graphical structure of Bayesian networks and performing MCMC with 'Stan'. *The Comprehensive R Archive Network (CRAN)*. https://cran.r-project.org/web/packages/bayesvl/index.html
Levy, O., Beechler, S., Taylor, S., & Boyacigiller, N. A. (2007). What we talk about when we talk about 'global mindset': Managerial cognition in multinational corporations. *Journal of International Business Studies*, *38*(2), 231-258. https://doi.org/10.1057/palgrave.jibs.8400265
Lucrezi, S. (2022). Public perceptions of marine environmental issues: A case study of coastal recreational users in Italy. *Journal of Coastal Conservation*, *26*(6), 52. https://doi.org/10.1007/s11852-022-00900-4
Lucrezi, S., Esfehani, M. H., Ferretti, E., & Cerrano, C. (2019). The effects of stakeholder education and capacity building in marine protected areas: A case study from southern Mozambique. *Marine Policy*, *108*, 103645. https://doi.org/10.1016/j.marpol.2019.103645
Mahajan, S. L., & Daw, T. (2016). Perceptions of ecosystem services and benefits to human well-being from community-based marine protected areas in Kenya. *Marine Policy*, *74*, 108-119. https://doi.org/10.1016/j.marpol.2016.09.005
Mazzocchi, F. (2020). A deeper meaning of sustainability: Insights from indigenous knowledge. *The Anthropocene Review*, *7*(1), 77-93.

McElreath, R. (2018). *Statistical rethinking: A Bayesian course with examples in R and Stan*. Chapman and Hall/CRC Press.
McKinley, E., Burdon, D., & Shellock, R. (2023). The evolution of ocean literacy: A new framework for the United Nations Ocean Decade and beyond. *Marine Pollution Bulletin*, *186*, 114467. https://doi.org/10.1016/j.marpolbul.2022.114467
McNeill, A., Clifton, J., & Harvey, E. S. (2018). Attitudes to a marine protected area are associated with perceived social impacts. *Marine Policy*, *94*, 106-118.
Nguyen, M.-H., Duong, M.-P. T., Nguyen, M.-C., Mutai, N., Jin, R., Nguyen, P.-T., ... Vuong, Q.-H. (2023). Promoting stakeholders' support for marine protection policies: Insights from a 42-country dataset. *Sustainability*, *15*(16), 12226. https://doi.org/10.3390/su151612226
Nguyen, M.-H., & Jones, T. E. (2022a). Building eco-surplus culture among urban residents as a novel strategy to improve finance for conservation in protected areas. *Humanities & Social Sciences Communications*, *9*, 426. https://doi.org/10.1057/s41599-022-01441-9
Nguyen, M.-H., & Jones, T. E. (2022b). Predictors of support for biodiversity loss countermeasures and bushmeat consumption among Vietnamese urban residents. *Conservation Science and Practice*, *4*(12), e12822. https://doi.org/10.1111/csp2.12822
Nguyen, M.-H., La, V.-P., Le, T.-T., & Vuong, Q.-H. (2022). Introduction to Bayesian Mindsponge Framework analytics: an innovative method for social and psychological research. *MethodsX*, *9*, 101808. https://doi.org/10.1016/j.mex.2022.101808
Nguyen, M.-H., Le, T.-T., & Vuong, Q.-H. (2023). Ecomindsponge: A novel perspective on human psychology and behavior in the ecosystem. *Urban Science*, *7*(1), 31. https://doi.org/10.3390/urbansci7010031
Nguyen, M.-H., Vuong, Q. H., Ho, M.-T., & Le, T.-T. (2021). Mindsponge mechanism. *Scholarly Community Encyclopedia*. https://encyclopedia.pub/7320
Rahman, M. K., Masud, M. M., Akhtar, R., & Hossain, M. M. (2022). Impact of community participation on sustainable development of marine protected areas: Assessment of ecotourism development. *International Journal of Tourism Research*, *24*(1), 33-43. https://doi.org/10.1002/jtr.2480
Raja, R., Ma, J., Zhang, M., Li, X. Y., Almutairi, N. S., & Almutairi, A. H. (2023). Social identity loss and reverse culture shock: Experiences of international students in China during the COVID-19 pandemic. *Frontiers in Psychology*, *14*, 994411. https://doi.org/10.3389/fpsyg.2023.994411
Rifai, H., Quevedo, J. M. D., Lukman, K. M., Hernawan, U. E., Alifatri, L. o., Risandi, J., ... Kohsaka, R. (2023). Understanding community awareness of seagrass ecosystem services for their blue carbon conservation in marine protected areas: A case study of Karimunjawa National Park. *Ecological Research*, *38*(4), 541-556. https://doi.org/10.1111/1440-1703.12391
Santirocchi, A., Spataro, P., Alessi, F., Rossi-Arnaud, C., & Cestari, V. (2023). Trust in science and belief in misinformation mediate the effects of political orientation on vaccine hesitancy and intention to be vaccinated. *Acta Psychologica*, *237*, 103945. https://doi.org/10.1016/j.actpsy.2023.103945
Simeoni, C., Furlan, E., Pham, H. V., Critto, A., de Juan, S., Trégarot, E., ... Botelho, A. Z. (2023). Evaluating the combined effect of climate and anthropogenic stressors on marine coastal ecosystems: Insights from a systematic review of cumulative impact assessment approaches. *Science of the Total Environment*, *861*, 160687. https://doi.org/10.1016/j.scitotenv.2022.160687
Szolnoki, G., Hoffmann, D. J. W. E., & Policy. (2013). Online, face-to-face and telephone surveys—Comparing different sampling methods in wine consumer research. *Wine Economics and Policy*, *2*(2), 57-66. https://doi.org/10.1016/j.wep.2013.10.001
Tanemura, N., Kakizaki, M., Kusumi, T., Onodera, R., & Chiba, T. (2022). Levels of trust in risk-only negative health messages issued by public agencies: a quantitative research-based

mindsponge framework. *Humanities and Social Sciences Communications*, *9*, 388. https://doi.org/10.1057/s41599-022-01415-x
Tian, H., & Liu, X. (2022). Pro-environmental behavior research: Theoretical progress and future directions. *International journal of environmental research and public health*, *19*(11), 6721.
Vehtari, A., & Gabry, J. (2019). *Bayesian Stacking and Pseudo-BMA weights using the loo package*. In (Version loo 2.2.0) https://mc-stan.org/loo/articles/loo2-weights.html
Vehtari, A., Gelman, A., & Gabry, J. (2017). Practical Bayesian model evaluation using leave-one-out cross-validation and WAIC. *Statistics Computing*, *27*(5), 1413-1432. https://doi.org/10.1007/s11222-016-9696-4
Vuong, Q.-H. (2018). The (ir)rational consideration of the cost of science in transition economies. *Nature Human Behaviour*, *2*, 5. https://doi.org/10.1038/s41562-017-0281-4
Vuong, Q.-H. (2020a). From children's literature to sustainability science, and young scientists for a more sustainable Earth. *Journal of Sustainability Education*, *24*(3), 1-12. http://www.susted.com/wordpress/content/from-childrens-literature-to-sustainability-science-and-young-scientists-for-a-more-sustainable-earth_2020_12/
Vuong, Q.-H. (2020b). Reform retractions to make them more transparent. *Nature*, *582*(7811), 149. https://doi.org/10.1038/d41586-020-01694-x
Vuong, Q.-H. (2021). The semiconducting principle of monetary and environmental values exchange. *Economics and Business Letters*, *10*(3), 284-290. https://doi.org/10.17811/ebl.10.3.2021.284-290
Vuong, Q.-H. (2022). *The kingfisher story collection*. https://www.amazon.com/dp/B0BG2NNHY6
Vuong, Q.-H. (2023). *Mindsponge Theory*. Walter de Gruyter GmbH. https://www.amazon.com/dp/B0C3WHZ2B3/
Vuong, Q.-H., Ho, M.-T., Nguyen, M.-H., Thang Hang, P., Vuong, T.-T., Khuc, Q., . . . La, V.-P. (2021). On the environment-destructive probabilistic trends: a perceptual and behavioral study on video game players. *Technology in Society*, *65*, 101530. https://doi.org/10.1016/j.techsoc.2021.101530
Vuong, Q.-H., & Napier, N. K. (2015). Acculturation and global mindsponge: An emerging market perspective. *International Journal of Intercultural Relations*, *49*, 354-367. https://doi.org/10.1016/j.ijintrel.2015.06.003
Vuong, Q.-H., & Nguyen, M.-H. (2023). Kingfisher: Contemplating the connection between nature and humans through science, art, literature, and lived experiences. *Pacific Conservation Biology*. https://doi.org/10.1071/PC23044
Vuong, Q.-H., & Nguyen, M.-H. (2024). Forests of gold: carbon credits could be game-changing for Vietnam. *Land & Climate Review*. https://www.landclimate.org/forests-of-gold-carbon-credits-could-be-game-changing-for-vietnam/
Vuong, Q.-H., Nguyen, M.-H., & La, V.-P. (2022). *The mindsponge and BMF analytics for innovative thinking in social sciences and humanities*. Walter de Gruyter GmbH. https://www.amazon.com/dp/B0C4ZK3M74/
Vuong, Q. H., La, V. P., Nguyen, H. K. T., Ho, M. T., Vuong, T. T., & Ho, M. T. (2021). Identifying the moral–practical gaps in corporate social responsibility missions of Vietnamese firms: An event-based analysis of sustainability feasibility. *Corporate Social Responsibility and Environmental Management*, *28*(1), 30-41. https://doi.org/10.1002/csr.2029
Washington, H., Taylor, B., Kopnina, H., Cryer, P., & Piccolo, J. J. (2017). Why ecocentrism is the key pathway to sustainability. *The Ecological Citizen*, *1*(1), 35-41.
Wheaton, B., Waiti, J. T. A., Olive, R., & Kearns, R. (2021). Coastal communities, leisure and wellbeing: Advancing a trans-disciplinary agenda for understanding ocean-human relationships in Aotearoa New Zealand. *International Journal of Environmental Research and Public Health*, *18*(2), 450. https://doi.org/10.3390/ijerph18020450

Xu, J., Wang, C., & Cui, Y. (2023). Multidimensional proximities and interorganizational coinnovation performance: The roles of intraorganizational collaboration network inefficiency. *Frontiers in Psychology*, *14*, 1121908. https://doi.org/10.3389/fpsyg.2023.1121908

Zamzami, L., Ermayanti, E., Hendrawati, H., & Miko, A. (2020). Socio-cultural impacts of marine conservation areas in Indonesian fishing communities. IOP Conference Series: Earth and Environmental Science,