Article

Not peer-reviewed version

A Study of the Ecological Security Based on the DPSIR (Driver Pressure State Impact Response) Framework Fit for Marine Environmental Protection Evaluation Approach

Yi-Che Shih *

Posted Date: 3 October 2024

doi: 10.20944/preprints202410.0266.v1

Keywords: Ecological Security; DPSIR; Marine Environmental Protection; Driver-Pressure-State-Impact-Response; Evaluation Approach

 doi:10.20944/preprints202410.0266.v1

Article

A Study of the Ecological Security Based on the DPSIR (Driver Pressure State Impact Response) Framework Fit for Marine Environmental Protection Evaluation Approach

Yi-Che Shih

National Cheng Kung University; shih@gs.ncku.edu.tw

Abstract: This research uses the DPSIR framework to analyse and anticipate Taiwan's marine ecosystems' ecological security. The goal is to understand how human-induced pressures including pollution, overfishing, habitat loss, and climate change affect Taiwan's marine habitats. For Taiwanese maritime ecological security assessments, the DPSIR framework, case studies, and assessment models are used. The DPSIR model classifies human activities, environmental pressures, marine ecosystem states, effects, and reactions. Assessment models complement the DPSIR framework for systematic and quantitative evaluation, while case studies are practical. This systematic literature review follows PRISMA guidelines for thoroughness and organisation. The research shows the DPSIR framework's adaptability and efficacy in analysing Taiwan's complex marine biological processes. Human-induced stressors on marine states are revealed via a comprehensive examination of causes, pressures, states, consequences, and responses, contributing to ecological security discourse. The DPSIR model helps Taiwan identify environmental change sources, analyse pressures, and provide sustainable marine environmental management solutions. The research concludes that the DPSIR framework is crucial to Taiwan's maritime environmental preservation. Despite its strengths, the DPSIR framework has to be refined and customised to Taiwan's unique maritime environments. Taiwan's maritime protection policies are shaped by the study's evidence-based findings. The report also recommends combining the DPSIR framework with SWOT analysis to improve evaluation and decision-making in Taiwan's marine environmental protection setting.

Keywords: Ecological Security; DPSIR; Marine Environmental Protection; Driver-Pressure-State-Impact-Response; Evaluation Approach

1. Introduction

Taiwan’s marine ecosystems confront many difficulties, requiring adequate assessment frameworks to maintain their fragile balance and biodiversity. Furthermore, multiple threats make Taiwan’s maritime habitats vulnerable, in fact, Taiwan’s industrialization and urbanisation have polluted its oceans. Nevertheless, urban runoff, industrial discharges, and agriculture degrade water quality, hence, monitoring and reducing pollution impacts on marine ecosystems requires a strong assessment framework (Patrício et al. 2016). Notably, Taiwan’s maritime biodiversity is threatened by overfishing, where, unsustainable fishing depletes fish supplies, disrupts food webs, and harms coastal communities (Li & Wang 2013). Definitely, a good assessment system may assist determine fishing sustainability and guide conservation efforts, because, Taiwan’s maritime habitats are destroyed by coastal development and destructive fishing (Wang et al. 2022). Moreover, mangroves, coral reefs, and other ecosystems are threatened, hence, a thorough assessment approach may help identify habitat loss hotspots and drive conservation (Gari et al. 2015). Unquestionably, rising sea temperatures, ocean acidity, and climate-related severe weather contribute to the problem, thus, an assessment methodology can track climate change’s effects on Taiwan’s maritime ecosystems and guide adaptation. Therefore, Taiwan may benefit from a customised assessment framework, such as

 doi:10.20944/preprints202410.0266.v1

DPSIR, to address these issues, since, frameworks for systematic evaluation, monitoring, and policy creation would safeguard Taiwan's maritime ecosystems' sustainability and resilience.

Driver-Pressure-State-Impact-Response (DPSIR) is a demanding and systematic model created to untangle Taiwan's marine ecosystems' relationships. Nevertheless, this structured model examines driving factors, mostly human-induced stresses, and their diverse effects on marine ecosystems, therefore, the DPSIR model enables a deeper knowledge of Taiwan's maritime environment concerns (Atkins et al. 2011). Evidently, the DPSIR model helps Taiwan, a dynamic coastal environment with a significant dependency on marine resources, understand the interactions that endanger its marine ecosystems, for the same reason, industrial and urban pollution, unsustainable overfishing, coastal development-driven habitat degradation, and climate change are the main causes (Mukuvari et al. 2016). Indeed, these forces change Taiwan's maritime ecosystems, influencing biodiversity, water quality, and health. However, the DPSIR model naturally prioritises sustainable management strategies as it analyses driving factors and their effects, therefore, in Taiwan, these measures might include targeted conservation, pollution and habitat protection policies, and sustainable fishing (Dzoga et al. 2020). Thus, the DPSIR model is both an analytical instrument and a guide for developing strategic answers to Taiwan's maritime concerns, hence, the DPSIR model guides Taiwanese policymakers, academics, and environmentalists in understanding, addressing, and managing marine ecosystem complexity for long-term sustainability and environmental health.

This work in Taiwan is driven by a deep understanding of how ecological security protects marine biodiversity and marine ecosystem resilience. Notably, human-induced pressures including pollution, overfishing, habitat degradation, and climate change make it necessary to study marine state dynamics. Therefore, this study examines the interactions between human activities and marine habitats in Taiwan using the widely used DPSIR model. Furthermore, it uses the DPSIR model—Drivers, Pressures, States, Impacts, and Responses—to examine Taiwan's marine ecosystems' vulnerabilities and stressors, hence, this research aims to provide light on Taiwan's unique maritime environmental protection concerns. Unquestionably, it seeks diverse viewpoints that may guide strategic actions by carefully evaluating environmental changes, their pressures, marine ecosystems, their implications, and the measures taken to address them. Moreover, this research goes beyond science to inspire action, thus, it aims to promote Taiwan's marine resource conservation and management. In brief, this study calls for responsible care of Taiwan's marine ecosystems outside academia. It uses the DPSIR model and a comprehensive knowledge of ecological security to identify obstacles and offer informed measures to improve ecological security and sustainable marine management in Taiwan.

2. Literature Review

The adaptable and effective Driver-Pressure-State-Impact-Response (DPSIR) paradigm is used in marine ecology research to explain environmental system dynamics, where, this paradigm has been useful in Taiwan, especially in coastal zones like Qinzhou, for developing the SEEC model and ecological security assessments. According to Ji et al. (2023), Taiwan, with its rich marine biodiversity, has distinct human and environmental concerns, in fact, the DPSIR paradigm, customised to this environment, has helped segment these difficulties. Ideally, it provides a holistic understanding of the interaction between human activities and the marine environment by examining the drivers of environmental change, the pressures on marine ecosystems, their states, and their impacts. Evidently, the SEEC model, developed in Taiwan, uses the DPSIR framework to assess watershed ecological security, since, the DPSIR framework allows this model to analyse the interactions between driving factors, environmental pressures, watershed states, and effects, providing a comprehensive ecological security assessment method (Wang et al. 2015). Notably, the DPSIR framework in coastal zones, as seen in Qinzhou, illuminates Taiwan's coastal ecosystems' unique problems, because, it helps identify coastal environment-pressing factors including urbanisation, industry, and agriculture (Shao et al. 2014). Definitely, understanding the results and consequences helps policymakers and academics develop sustainable marine ecosystem management strategies in Taiwan, because, in

 doi:10.20944/preprints202410.0266.v1

Taiwan, the DPSIR framework is essential for comprehending marine ecosystems' complex issues. Thus, its versatility and efficacy make it essential in marine ecological research, allowing personalised and educated responses to preserve Taiwan's distinctive marine biodiversity and ecological balance.

The SEEC (Driving Force-Pressure-State-Impact-Response) model, based on the DPSIR framework, is useful for assessing watershed ecological security in Taiwan. Ideally, this model fits effortlessly into environmental assessment and has a sophisticated approach by incorporating several DPSIR indicators (Gao et al. 2022). Definitely, according to Zhou et al. (2022) the SEEC model evaluates Taiwanese watershed ecological security holistically by including population dynamics, socioeconomic conditions, and other relevant elements. Moreover, land use, urbanisation, and agriculture affect Taiwanese watershed ecosystems, therefore, the SEEC model helps explain these difficulties' causes. As well, it examines watershed stressors such pollution, deforestation, and land use changes, indeed, the SEEC model examines Taiwan's watersheds and their ecological balance, going beyond identification (NA & CA 2015). Furthermore, the model helps identify vulnerabilities and environmental deterioration by providing a picture of water quality and biodiversity. Importantly, Sobhani et al. (2023) states that, the SEEC model goes beyond research by examining current plans and initiatives to address the identified concerns. In essence, in Taiwan, SEEC model insights may be used to build adaptive management techniques, making this reaction critical (Bradley & Yee 2015). Therefore, the SEEC model is an environmental management tool that applies DPSIR theory to Taiwan's unique biological setting. Thus, its adaptability and comprehensiveness help Taiwan achieve sustainable watershed management and ecological security.

The DPSIR (Driving Force-Pressure-State-Impact-Response) paradigm has been used to analyse marine ecological security in Taiwan's Qinzhou coastal zone. Unquestionably, Li, Y., Liu & Liu (2023) study shows that the DPSIR model can explain marine environmental dynamics in the area, whereby, the Qinzhou coastal zone in Taiwan is a good example of marine ecological security changing. Evidently, the DPSIR framework, a powerful analytical tool, was used to carefully examine the driving forces behind coastal ecosystem changes, marine environment pressures, ecosystem states, impacts, and responses over the defined timeframe. Definitely, He & Shi (2023) quantified ecological security and qualitatively examined marine environment changes, since, the DPSIR model allowed researchers to identify ecological change drivers, assess pressures, and assess marine ecosystem impacts. Indeed, this detailed research revealed the region's environmental changes and provided a detailed picture of Taiwan's Qinzhou coastal zone's ecological security (Elliott & O'Higgins 2020). Therefore, the DPSIR framework's methodical methodology has helped identify difficulties and provide informed solutions for sustainable maritime environmental management in Taiwan.

In Taiwanese marine ecological research, the DPSIR (Driving Force-Pressure-State-Impact-Response) paradigm has helped evaluate marine ranching operations, whereby, this technique established an evaluation index system based on DPSIR's major components to organise the approach. Notably, Yang et al. (2023) investigated the ecological security of marine ranching, revealing the linkages between human activities, environmental stressors, ecosystem states, effects, and responses. Definitely, Taiwan's coastal regions, vital to marine ecosystems, have been assessed using DPSIR, because, the systematic study helps identify change drivers, assess ecological implications, and develop suitable solutions. Ideally, this integrative method advances marine ecosystem research and informs Taiwanese environmental management. In brief, the literature study shows that DPSIR is handy in Taiwan beyond marine ranching assessments. Again, Yussif et al. (2023) have developed SEEC (Socio-Economic and Ecological Criteria) models and conducted coastal zone evaluations using the framework. Hence, these applications demonstrate the DPSIR methodology's continuous relevance and influence in understanding and predicting environmental changes in Taiwan's maritime ecosystems. In brief, the DPSIR framework is a powerful and broadly applicable instrument in Taiwanese marine ecology, offering a solid platform for thorough assessments and educated environmental management decisions.

3. Methodology

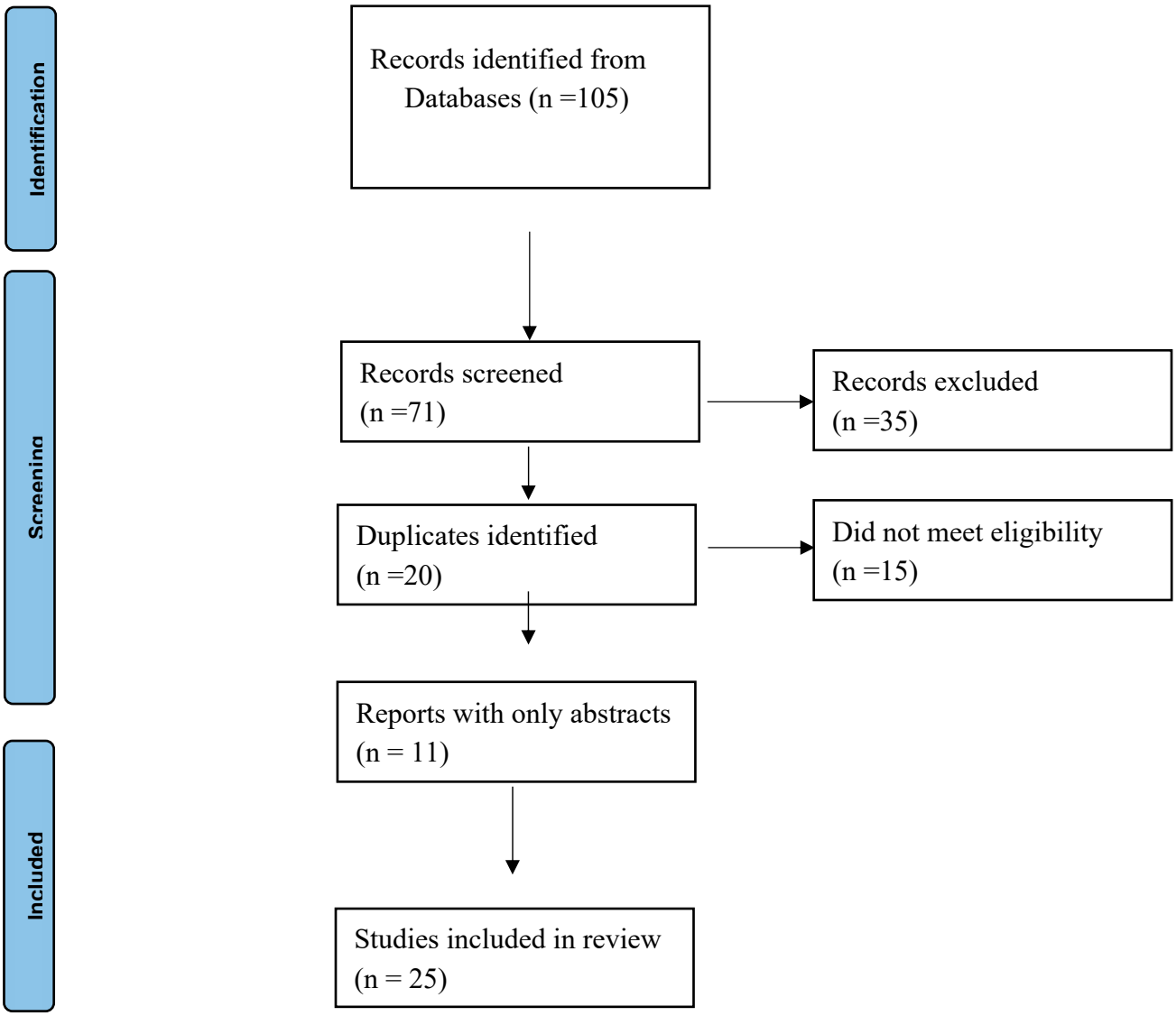
 doi:10.20944/preprints202410.0266.v1

The paper incorporates the DPSIR (Driver Pressure State Impact Response) framework, case studies, and evaluation models for marine ecological security assessments in Taiwan. Ideally, this comprehensive method evaluates and predicts marine habitats' ecological security, emphasizing the need of recognizing human-induced stresses on marine states for successful marine environmental protection (Gonçalves et al. 2020). Evidently the core DPSIR framework categorizes and analyses human activities (Drivers), environmental pressures, marine ecosystem states, effects, and environmental management solutions, therefore, this holistic approach evaluates ecological security in Taiwan and provides a framework to cross marine ecosystem complexity (Mahrad et al. 2020). Notably, case studies help explain how the DPSIR framework works in Taiwan's particular maritime situations, making the assessment more practical and relevant, hence, these real-world examples illuminate ecological security concerns and validate and improve the DPSIR framework's use in the Taiwanese maritime environment (Fan et al. 2023). In addition, the research uses assessment models to evaluate and anticipate ecological security in Taiwanese maritime habitats. Furthermore, these models, which supplement the DPSIR framework, use a systematic and quantitative evaluation procedure to improve ecological security forecasts. This integrated strategy acknowledges Taiwan's unique maritime ecological security considerations. Following PRISMA principles, the study's systematic literature review includes planning, conducting, and reporting. The thorough literature review guideline, created during preparation, includes inclusion and exclusion criteria and after a preliminary evaluation of linked literature, the search approach identifies potential research keywords based on title and abstract relevance to the study subject, notably Taiwan. Finally, data extraction and analysis are demanding, meeting AI, contemporary art, and interior design research aims, since, a consensus methodology handles extracted data inconsistencies to ensure a high-quality evaluation of included studies, taking into account information bias, selection bias, research design, and confounding correction of outcome measures. Again, tables summaries result and generate subgroups depending on research goals, hence, the DPSIR framework, case studies, and assessment models guarantee a comprehensive approach to evaluate ecological security in Taiwanese maritime settings.

4. Analysis

The DPSIR model (Driver Pressure State Impact Response) is used to analyse Taiwan's marine ecosystems' interactions, hence, to understand ecological security dynamics, the analysis uses a systematic approach to navigate the interaction between human activities, environmental pressures, and marine ecosystem impacts. Evidently, this investigation begins with driver identification, exploring human activities that cause ecological changes in Taiwan's maritime habitats. As well, this requires a thorough analysis of human causes including industrial operations, population expansion, and resource extraction that cause environmental changes in the area. Still, the study then evaluates environmental pressures from these human activities, since, this phase examines how these forces affect pollution, habitat loss, and climate change. Moreover, the research quantifies and evaluates these pressures to determine their impact on Taiwan's sensitive marine ecosystems. Next, the examination examines Taiwan's aquatic habitats, where, this requires a thorough evaluation of biodiversity, water quality, and ecosystem health. Unquestionably, understanding baseline conditions helps identify Taiwanese marine environment variations and vulnerabilities by comparing possible repercussions. For the same reason, the next step is assessing the pressures' effects on marine conditions, and this involves exploring biodiversity loss, ecological structural changes, and long-term effects. Definitely, these effects will be quantified and qualified to assess Taiwan's maritime habitats' ecological security, afterwards, synthesized drivers, pressures, states, and effects are used to investigate response solutions in the final step. In sum, these solutions may include legislative proposals, conservation efforts, or sustainable management techniques to reduce negative effects and improve Taiwan's maritime ecosystems. Therefore, the study's analytical portion uses the DPSIR model to analyse and synthesize these important components to give a comprehensive knowledge of Taiwan's maritime ecosystems' complex ecological security dynamics.

 doi:10.20944/preprints202410.0266.v1



5. Findings

The DPSIR (Drivers, Pressures, States, Impacts, Responses) paradigm in this research provided comprehensive insights on maritime ecological security, with an emphasis on Taiwan. Ideally, the research analyses factors, pressures, conditions, consequences, and responses, which shape Taiwan's maritime ecological security. Notably, the research analyses drivers to determine how human activity affects Taiwan's maritime ecosystems, furthermore, industrial operations, population increase, and resource extraction promote regional ecological changes. Therefore, human-caused environmental stresses in Taiwan are assessed in the study, since, the human influences affecting Taiwan's marine ecosystems, including pollution, habitat degradation, and climate change, are better understood and contribute to ecological security. Moreover, the state inspection phase examines Taiwan's aquatic habitats, where, this involves analysing biodiversity, water quality, and ecosystem health to provide a baseline for Taiwan's maritime ecosystems. Notably, impact assessment follows, analysing how identified pressures affect marine conditions in Taiwan, still, the level of biodiversity loss, ecosystem structural changes, and long-term effects on ecological security in Taiwan is assessed. Definitely, after identifying factors, pressures, and repercussions in Taiwan, the paper examines successful responses. Hence, these may include legislative proposals, conservation efforts, and sustainable management techniques to reduce negative effects and improve ecological security in Taiwan's maritime habitats. In brief, the thorough results improve knowledge of Taiwan's marine ecosystems' processes. Thus, the DPSIR framework provides a structured and insightful approach to unravelling ecological

 doi:10.20944/preprints202410.0266.v1

security in Taiwan, enabling informed decision-making and sustainable environmental management tailored to the region's unique challenges and opportunities.

No	*Author*	*Study and Participants Characteristics*					
		Year of Publication	*Type of Study*	*Focus of Study/ Type of Cancer of Focus*	*Study Methodology*	*Sample Size*	*Publishing Journal*
1	Patrício, J., Elliott, M., Mazik, K., Papadopoulou, K. N., & Smith, C. J.	2016	Review	Development of a unifying framework for marine environmental management	Not specified	Not specified	Frontiers in Marine Science
2	Li, K., & Wang, X.	2013	Research Article	Calculation methodology of marine environmental capacity for heavy metal in Jiaozhou Bay, China	Four-step calculation method	Not specified	Chinese Science Bulletin
3	Chatterjee, A.	2022	Review	Interaction of Art and Artificial Intelligence	Not specified	Not specified	*Frontiers in Psychology*
4	Wang, B., Yu, F., Teng, Y., Cao, G., Zhao, D., & Zhao, M.	2022	Research Article	SEEC model based on the DPSIR framework for watershed ecological security risk assessment in Northwest China	DPSIR model framework	Not specified	Publishing Journal: Water
5	Gari, S. R., Newton, A., & Icely, J. D.	2015	Review	Application and evolution of the DPSIR framework with an emphasis on coastal social-	Not specified	Not specified	Ocean & Coastal Management

 doi:10.20944/preprints202410.0266.v1

				ecological systems			
6	Atkins, J. P., Gregory, A. J., Burdon, D., & Elliott, M.	2011	Research Article	Managing the marine environment : Is the DPSIR framework holistic enough?	Not specified	Not specified	Systems Research and Behavioral Science
7	Mukuvari, I., Mafwila, S. K., & Chimuka, L.	2016	Research Article	Measuring the recovery of the Northern Benguela Current Large Marine Ecosystem (BCLME): An application of the DPSIR framework	Not specified	Not specified	Ocean & Coastal Management
8	Dzoga, M., Simatele, D. M., Munga, C., & Yonge, S.	2020	Research Article	Application of the DPSIR framework to coastal and marine fisheries management in Kenya	Not specified	Not specified	Ocean Science Journal
9	Ji, F., Luo, Z., Hu, X., Nan, Y., & Wei, A.	2023	Research Article	DPSIR Framework to Evaluate and Predict the Development of Prefabricated Buildings: A Case Study	Not specified	Not specified	Sustainability
10	Wang, Z., Zhou, J., Loaiciga, H., Guo, H., & Hong, S.	2015	Research Article	DPSIR model for ecological security assessment through indicator screening: A	Not specified	Not specified	PloS One

 doi:10.20944/preprints202410.0266.v1

				case study at Dianchi Lake in China			
11	Shao, C., Guan, Y., Chu, C., Shi, R., Ju, M., & Shi, J.	2014	Research Article	Trends analysis of ecological environment security based on DPSIR model in the coastal zone: a survey study in Tianjin, China	Not specified	Not specified	International Journal of Environmental Research
12	Gao, L. H., Ning, J., Yan, A., & Yin, Q. R.	2019	A Review	AI's Potential in Art and Creativity	Not specified	Not specified	Marine Pollution Bulletin
13	Zhou, J., Wang, X., Lu, D., Dan, S. F., Kang, Z., Xu, Y., ... & Wei, Z.	2022	Research Article	Ecological security assessment of Qinzhou coastal zone based on Driving forces-Pressure-State-Impact-Response (DPSIR) model	Not specified	Not specified	Frontiers in Marine Science
14	NA, S., & CA, K.	2015	Not specified	Evaluation and comparison of DPSIR framework and the combined SWOT–DPSIR analysis (CSDA) approach: Towards embracing complexity	Not specified	Not specified	Not specified
15	Sobhani, P., Esmaeilzadeh, H., Wolf,	2023	Research Article	Evaluating the ecological	Not specified	Not specified	Ecological Indicators

 doi:10.20944/preprints202410.0266.v1

	I. D., Deljouei, A., Marcu, M. V., & Sadeghi, S. M. M.			security of ecotourism in protected areas based on the DPSIR model			
16	Bradley, P., & Yee, S.	2015	Technical Support Document	Using the DPSIR framework to develop a conceptual model	Not specified	Not specified	US Environmental Protection Agency
17	Li, Y., Liu, Z., & Liu, G.	2023	Research Article	Evaluation of Tourism Ecological Security	Not specified	Not specified	Sustainability
18	He, X., Cai, C., & Shi, J.	2023	Research Article	Evaluation of tourism ecological security and its driving mechanism in the Yellow River basin, China	Not specified	Not specified	Systems
19	Elliott, M., & O'Higgins, T. G.	2020	Not specified	From DPSIR to the DAPSI (W) R (M) Emerges	Not specified	Not specified	Ecosystem-based Management, Ecosystem Services and Aquatic Biodiversity: Theory, Tools and Applications
20	Yang, G., Gui, Q., Liu, J., Chen, X., & Cheng, S.	2023	Research Article	Spatial-temporal evolution and driving factors of ecological security in China	DPSIR-DEA model	Not specified	Ecological Indicators
21	Yussif, K., Dompreh, E. B., & Gasparatos, A.	2023	Systematic Literature Review	Sustainability of urban expansion in Africa	Not specified	Not specified	Sustainability Science

 doi:10.20944/preprints202410.0266.v1

22	Gonçalves, L. R., Oliveira, M., & Turra, A.	2020	Research Article	Assessing the complexity of social-ecological systems	Not specified	Not specified	Sustainability
23	Mahrad, B. E., Newton, A., Icely, J. D., Kacimi, I., Abalansa, S., & Snoussi, M.	2020	Review	Contribution of remote sensing technologies to a holistic coastal and marine environmental management framework	Not specified	Not specified	Remote Sensing
24	Fan, J., Abudumanan, A., Wang, L., Zhou, D., Wang, Z., & Liu, H.	2023	Research Article	Dynamic Assessment and Sustainability Strategies of Ecological Security in the Irtysh River Basin of Xinjiang, China	Visual Features-based Evaluation	Not specified	Chinese Geographical Science
25	Qiu, M., Zuo, Q., Wu, Q., Yang, Z., & Zhang, J.	2022	Assessment	Water ecological security assessment and spatial autocorrelation analysis of prefectural regions in the Yellow River Basin	Assessment and spatial autocorrelation analysis	Not specified	*Scientific Reports*

6. Discussion

The research compares its findings to previous literature on environmental assessment systems, whereby, the DPSIR model is crucial in this situation. Unquestionably, this model is essential for environmental research because it provides a complete framework for assessing human-marine ecosystem interactions, hence, the report highlights the DPSIR framework's merits in Taiwan. In addition, the methodical methodology in DPSIR helps comprehend complicated marine interactions, therefore, by tracing the causal chain from causes to responses, DPSIR offers a systematic approach to analysing Taiwanese environmental changes (Qiu et al. 2022). Furthermore, this systematic approach is vital in an area with pollution, overfishing, and habitat loss, hence, the DPSIR model's systematic framework helps academics and environmental professionals understand the Taiwanese

 doi:10.20944/preprints202410.0266.v1

marine ecosystem's cause-and-effect interactions (Kosamu et al. 2022). Basically, this strategy supports academic research and practical actions and policy choices for sustained maritime environmental conservation in Taiwan. In brief, the study's comparative comparison with existing literature and deep investigation of the DPSIR framework's strengths demonstrate its relevance and usefulness in Taiwan's maritime environmental protection efforts.

7. Challenges and Limitations

While the DPSIR (Drivers, Pressures, States, Impacts, and Responses) architecture has virtues in Taiwan, it also has drawbacks. Nevertheless, the Taiwanese environmental landscape makes it difficult to determine and analyse the linkages between human pressures and state-changes in marine ecosystems, therefore, Taiwan's maritime ecosystems are complex, impacted by many elements including human activity, industrial processes, and socio-economic dynamics (Bruno et al. 2020). Definitely, the interconnections between these factors and their effects on marine conditions make DPSIR evaluation difficult, still, Taiwan’s coastal areas' distinctive terrain, biodiversity, and environmental dynamics make them complex, requiring a comprehensive approach to capture all aspects (Ogara et al. 2023). Notably, the discussion's limits also emphasise the necessity for Taiwan's maritime environment-specific refinement and development, because, in Taiwan, the DPSIR framework offers a methodical structure, but indicators, data collecting methods, and response tactics must be tailored to local environmental issues (Yang et al. 2023). Indeed, this suggests that the framework must be constantly updated to meet Taiwan's marine ecosystems' changing needs. Thus, the discussion's issues and limits emphasise the need for a context-specific DPSIR framework for Taiwan's maritime environmental assessment. This acknowledgment allows the framework to be refined, developed, and customised to Taiwan's various marine ecosystems' particular difficulties.

8. Role of DPSIR in Marine Protection Policies

The research applies the DPSIR (Drivers, Pressures, States, Impacts, and Responses) framework to Taiwanese marine preservation policies. Notably, research results are crucial to Taiwan's marine environment protection strategies, since, the research shows how the DPSIR framework may assist policymakers and decision-makers (Sobhani et al. 2023). Furthermore, Taiwan suffers pollution, overfishing, and climate change in its various maritime habitats, however, the DPSIR framework's methodical methodology helps Taiwanese decision-makers comprehend the interactions between human activities and the marine ecology (Dzoga et al. 2020). In addition, DPSIR provides a systematic framework for developing policies to address Taiwan's maritime environments' unique issues by identifying environmental change drivers, pressures, states, effects, and solutions, hence, policymakers in Taiwan, where marine conservation is crucial, benefit from the DPSIR model (Wang et al. 2022). Moreover, a clear causal chain helps policymakers identify crucial intervention sites for evidence-based decision-making, thus, enhancing ecological security in Taiwan's maritime habitats is the overall aim. Definitely, once translated into policy insights, the study's results help preserve Taiwan's marine resources, therefore, Taiwan may proactively manage environmental challenges, build resilience, and conserve its marine ecosystems by implementing the DPSIR framework into marine conservation legislation (Atkins et al. 2011). Thus, the report highlights DPSIR's influence on Taiwan's marine preservation regulations, providing a methodical approach to the island nation's varied maritime habitats.

In the Taiwan setting, the study's extensive discussion centres on DPSIR integration with other techniques. Notably, due to Taiwan's maritime environmental issues, possible integrations seek to improve assessment and decision-making. Again, the research emphasises the need of a holistic strategy by combining DPSIR with SWOT analysis and other complimentary frameworks (Shao et al. 2014). Ideally, Taiwan's various ecosystems and biological variety need a flexible environmental assessment technique, hence, DPSIR may be integrated with other frameworks to produce synergies (NA & CA 2015). Furthermore, Taiwan's maritime ecology is complicated, with overfishing, habitat deterioration, and pollution requiring a comprehensive approach, hence, the conversation goes beyond acknowledging future integration to emphasise the necessity for a purposeful and thoughtful

 doi:10.20944/preprints202410.0266.v1

merger. In fact, SWOT analysis might reveal Taiwan's maritime environmental protection activities' strengths, weaknesses, opportunities, and dangers (Bradley & Yee 2015). In essence, this integrated approach will provide a more detailed and solid framework for decision-making, ensuring that interventions are successful and customised to Taiwan's particular circumstances. In brief, the study's examination of the DPSIR framework's integration with other techniques in Taiwan's maritime environmental protection is contextually relevant, thus, it places the study in the context of environmental evaluations, noting the necessity for specific responses to Taiwan's maritime ecosystems' complex difficulties.

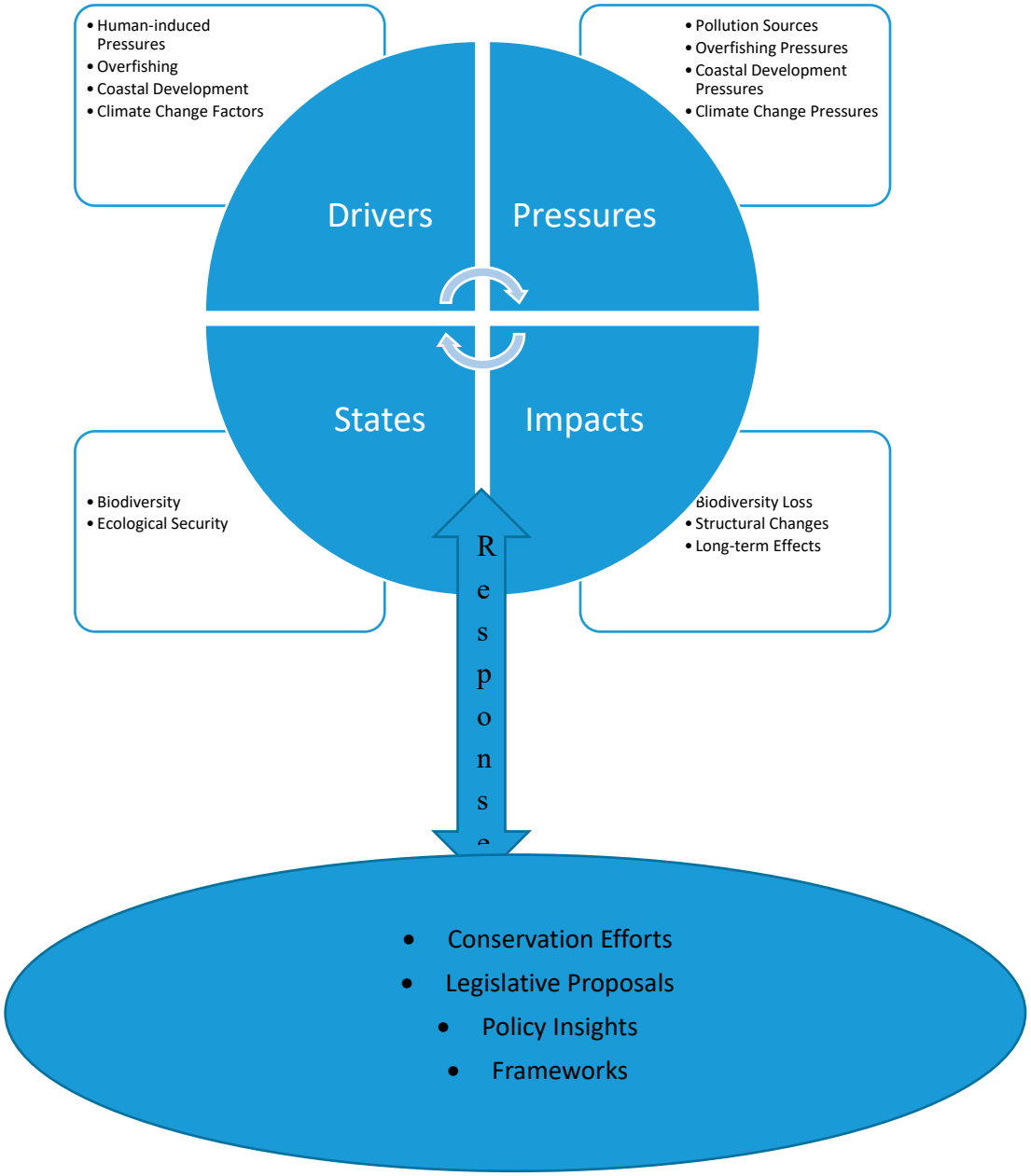


Figure 1. DPSIR Framework (Source:Created by this Research).

 doi:10.20944/preprints202410.0266.v1

9. Integration with Other Frameworks

In the Taiwan setting, the study's extensive discussion centres on DPSIR integration with other techniques. However, due to Taiwan's maritime environmental issues, possible integrations seek to improve assessment and decision-making. Therefore, the research emphasizes the need of a holistic strategy by combining DPSIR with SWOT analysis and other complimentary frameworks (Wang et al. 2022). Ideally, Taiwan's various ecosystems and biological variety need a flexible environmental assessment technique, hence, DPSIR may be integrated with other frameworks to produce synergies (Atkins et al. 2011). In fact, Taiwan's maritime ecology is complicated, with overfishing, habitat deterioration, and pollution requiring a comprehensive approach, nevertheless, the conversation goes beyond acknowledging future integration to emphasize the necessity for a purposeful and thoughtful merger. Ideally, SWOT analysis might reveal Taiwan's maritime environmental protection activities' strengths, weaknesses, opportunities, and dangers. Definitely, this integrated approach will provide a more detailed and solid framework for decision-making, ensuring that interventions are successful and customized to Taiwan's particular circumstances. Thus, the study's topic of integrating the DPSIR framework with other techniques in Taiwan's maritime environmental protection is sophisticated and contextually relevant. Therefore, it places the study in the context of environmental evaluations, noting the necessity for specific responses to Taiwan's maritime ecosystems' complex difficulties.

10. Conclusions

In conclusion, the study of Taiwan's marine ecosystems highlights the importance of the DPSIR framework in understanding, analysing, and controlling human-marine interactions. Ideally, Taiwan's marine ecosystems confront pollution, overfishing, habitat deterioration, and climate change, requiring a strong evaluation methodology for sustainable environmental management. Furthermore, the DPSIR model helps analyse Taiwan's maritime environmental changes by dissecting the causal chain from human-induced factors to ecosystem responses. Moreover, the study provides detailed insights into ecological security dynamics in Taiwan's unique environmental setting using case studies, assessment models, and the SEEC (Driving Force-Pressure-State-Impact-Response) model, based on the DPSIR framework. Indeed, the results demonstrate the DPSIR framework's ability to solve Taiwan's marine ecosystems' issues. Definitely, the approach helps politicians, scholars, and environmentalists make evidence-based choices and strategic actions for long-term sustainability and environmental health by methodically examining drivers, pressures, states, effects, and responses. Therefore, Taiwan's unique maritime environment presents constraints and hurdles; however, the research emphasises the need for context-specific DPSIR framework improvement. Nevertheless, this awareness enables the framework to adapt to Taiwan's various marine ecosystems' evolving demands, keeping it relevant and useful for environmental evaluations. In brief, this study advances Taiwan's marine ecology and promotes the use of the DPSIR framework with other methods like SWOT analysis. Conclusively, this comprehensive method improves evaluation and decision-making and provides a firm platform for addressing Taiwan's marine environment's issues therefore, the DPSIR framework becomes a key analytical tool and guidance for strategic responses, improving Taiwan's marine ecosystems' ecological security and sustainable management.

Acknowledgments: I thank the anonymous reviewers from this journal for their precious comments. I also thank all individuals who assisted in this study. This study was financed by grants from the Taiwan National Science and Technology Council (NSTC 112-2410-H-006-099, NSTC 112-2119-M-004-001).

References

1. Atkins, J. P., Gregory, A. J., Burdon, D., & Elliott, M. (2011). Managing the marine environment: is the DPSIR framework holistic enough?. *Systems Research and Behavioral Science*, *28*(5), 497-508.
2. Bradley, P., & Yee, S. (2015). Using the DPSIR framework to develop a conceptual model: technical support document. US Environmental Protection Agency, Washington, DC. EPA/600/R-15/154.

3. Bruno, M. F., Saponieri, A., Molfetta, M. G., & Damiani, L. (2020). The DPSIR approach for coastal risk assessment under climate change at regional scale: The case of apulian coast (Italy). *Journal of Marine Science and Engineering*, *8*(7), 531.
4. Dzoga, M., Simatele, D. M., Munga, C., & Yonge, S. (2020). Application of the DPSIR framework to coastal and marine fisheries management in Kenya. *Ocean Science Journal*, *55*, 193-201.
5. Elliott, M., & O'Higgins, T. G. (2020). From DPSIR the DAPSI (W) R (M) Emerges… a Butterfly–'protecting the natural stuff and delivering the human stuff'. *Ecosystem-based management, ecosystem services and aquatic biodiversity: Theory, tools and applications*, 61-86.
6. Fan, J., Abudumanan, A., Wang, L., Zhou, D., Wang, Z., & Liu, H. (2023). Dynamic Assessment and Sustainability Strategies of Ecological Security in the Irtysh River Basin of Xinjiang, China. *Chinese Geographical Science*, *33*(3), 393-409.
7. Gao, L. H., Ning, J., Yan, A., & Yin, Q. R. (2022). A study on the marine ecological security assessment of Guangdong-Hong Kong-Macao Great Bay Area. *Marine Pollution Bulletin*, *176*, 113416.
8. Gari, S. R., Newton, A., & Icely, J. D. (2015). A review of the application and evolution of the DPSIR framework with an emphasis on coastal social-ecological systems. *Ocean & Coastal Management*, *103*, 63-77.
9. Gonçalves, L. R., Oliveira, M., & Turra, A. (2020). Assessing the complexity of social-ecological systems: taking stock of the cross-scale dependence. *Sustainability*, *12*(15), 6236.
10. He, X., Cai, C., & Shi, J. (2023). Evaluation of tourism ecological security and its driving mechanism in the Yellow River basin, China: based on open systems theory and DPSIR model. *Systems*, *11*(7), 336.
11. Ji, F., Luo, Z., Hu, X., Nan, Y., & Wei, A. (2023). A DPSIR Framework to Evaluate and Predict the Development of Prefabricated Buildings: A Case Study. *Sustainability*, *15*(19), 14264.
12. Kosamu, I. B. M., Makwinja, R., Kaonga, C. C., Mengistou, S., Kaunda, E., Alamirew, T., & Njaya, F. (2022). Application of DPSIR and tobit models in assessing freshwater ecosystems: the case of Lake Malombe, Malawi. *Water*, *14*(4), 619.
13. Li, K., & Wang, X. (2013). Calculation methodology of marine environmental capacity for heavy metal: A case study in Jiaozhou Bay, China. *Chinese Science Bulletin*, *58*, 282-287.
14. Li, Y., Liu, Z., & Liu, G. (2023). Evaluation of Tourism Ecological Security Based on Driving Force–Pressure–State–Influence–Response Framework and Analysis of Its Dynamic Evolution Characteristics and Driving Factors in Chinese Province Territory. *Sustainability*, *15*(18), 13680.
15. Mahrad, B. E., Newton, A., Icely, J. D., Kacimi, I., Abalansa, S., & Snoussi, M. (2020). Contribution of remote sensing technologies to a holistic coastal and marine environmental management framework: a review. *Remote Sensing*, *12*(14), 2313.
16. Mukuvari, I., Mafwila, S. K., & Chimuka, L. (2016). Measuring the recovery of the Northern Benguela Current Large Marine Ecosystem (BCLME): An application of the DPSIR framework. *Ocean & Coastal Management*, *119*, 227-233.
17. NA, S., & CA, K. (2015). EVALUATION AND COMPARISON OF DPSIR FRAMEWORK AND THE COMBINED SWOT–DPSIR ANALYSIS (CSDA) APPROACH: TOWARDS EMBRACING COMPLEXITY.
18. Ogara, D. A., Morishita, J., Davies, P. J., Mbui, M., Gamoyo, M., Njoroge, N., ... & Ochieng, S. O. (2023). An indicator-based approach to assess sustainability of port-cities and marine management in the Global South. *Frontiers in Marine Science*, *10*, 1052128.
19. Patrício, J., Elliott, M., Mazik, K., Papadopoulou, K. N., & Smith, C. J. (2016). DPSIR—two decades of trying to develop a unifying framework for marine environmental management?. *Frontiers in Marine Science*, *3*, 177.
20. Qiu, M., Zuo, Q., Wu, Q., Yang, Z., & Zhang, J. (2022). Water ecological security assessment and spatial autocorrelation analysis of prefectural regions involved in the Yellow River Basin. *Scientific Reports*, *12*(1), 5105.
21. Shao, C., Guan, Y., Chu, C., Shi, R., Ju, M., & Shi, J. (2014). Trends analysis of ecological environment security based on DPSIR model in the coastal zone: a survey study in Tianjin, China. *International Journal of Environmental Research*, *8*(3), 765-778.
22. Sobhani, P., Esmaeilzadeh, H., Wolf, I. D., Deljouei, A., Marcu, M. V., & Sadeghi, S. M. M. (2023). Evaluating the ecological security of ecotourism in protected area based on the DPSIR model. *Ecological Indicators*, *155*, 110957.
23. Wang, B., Yu, F., Teng, Y., Cao, G., Zhao, D., & Zhao, M. (2022). A SEEC model based on the DPSIR framework approach for watershed ecological security risk assessment: a case study in Northwest China. *Water*, *14*(1), 106.
24. Wang, Z., Zhou, J., Loaiciga, H., Guo, H., & Hong, S. (2015). A DPSIR model for ecological security assessment through indicator screening: A case study at Dianchi Lake in China. *PloS one*, *10*(6), e0131732.
25. Yang, G., Gui, Q., Liu, J., Chen, X., & Cheng, S. (2023). Spatial-temporal evolution and driving factors of ecological security in China based on DPSIR-DEA model: A case study of the Three Gorges reservoir area. *Ecological Indicators*, *154*, 110777.

 doi:10.20944/preprints202410.0266.v1

26. Yussif, K., Dompreh, E. B., & Gasparatos, A. (2023). Sustainability of urban expansion in Africa: a systematic literature review using the Drivers–Pressures–State–Impact–Responses (DPSIR) framework. *Sustainability Science*, 1-21.
27. Zhou, J., Wang, X., Lu, D., Dan, S. F., Kang, Z., Xu, Y., ... & Wei, Z. (2022). Ecological security assessment of Qinzhou coastal zone based on Driving forces-Pressure-State-Impact-Response (DPSIR) model. *Frontiers in Marine Science*, *9*, 1009897.