JOURNAL OF ARCHITECTURAL RESEARCH AND DESIGN STUDIES
DOI: 10.20885/jars.vol8.iss2.art6

# Exploring the Application of Restorative Environment Design in Coastal Area

**Syahnas Nevysilia Kirana[1], Wendy Sunarya[2]**

[1,2] Department of Architecture, Universitas Pembangunan Nasional "Veteran" Jawa Timur, Surabaya

Article History

| | | |
|---|---|---|
| Received | : | July 05, 2024 |
| Accepted | : | November 8, 2024 |
| Published | : | November 29, 2024 |

## Abstract

The coastal ecosystem provides biodiversity that is attractive for exploration and essential to support global life systems. However, these areas have become increasingly vulnerable due to climate change and human activities. Therefore, infrastructure development in coastal regions must prioritize sustainable practices to protect these ecosystems. This paper explores the potential of Restorative Environment Design (RED) in coastal zones, synthesizing fundamental principles from Attention Restoration Theory (ART), sustainable coastal infrastructure management, and multisensory human experiences in coastal environments. The study develops a design framework integrating three dimensions: (1) Identifying coastal management strategies, including habitat restoration, soft engineering, and eco-engineering; (2) Assessing multisensory properties and experiences of coastal zones; and (3) Applying the core components of restorative environments, including being away, fascination, extent, and compatibility. This study also presents a conceptual model for RED implementation in coastal zones based on the proposed design framework. The conceptual model illustrates how zoning strategies, guided by fundamental principles, can address ecological restoration while enhancing human well-being through restorative design. The results of this study ultimately provide insights for designing coastal spaces that promote mental recovery, community engagement, and long-term ecological sustainability.

**Keywords:** *Attention Restoration Theory (ART); Coastal Zoning Strategies; Ecological Restoration; Restorative Environment Design; Sustainable Coastal Development.*

## Introduction

The convergence of land and sea in coastal areas creates dynamic environments that support a variety of habitats with important ecological and economic value. According to Law No. 1 of 2014 Indonesia, coastal areas should be utilized to support the people's welfare, considering the preservation of ecosystems, local communities, traditional fishermen, as well as national interests. Effective management of these regions requires coordination between the government and various stakeholders to balance economic benefits with environmental protection.

Known as an archipelagic nation, Indonesia has rich and diverse coastal regions, such as mangrove forests, white-sand shores, and small island beaches (Hutomo & Kasim Moosa, 2005). These regions have a high potential for coastal and marine tourism development, attracting investments for tourism infrastructure development, creating job opportunities, and stimulating economic

Correspondence: Syahnas Nevysilia Kirana
Department of Architecture, Universitas Pembangunan Nasional "Veteran" Jawa Timur
E-mail: 20051010095@student.upnjatim.ac.id

growth in the local community (Hermawan et al., 2023). However, they have an important role in global ecosystems. For example, mangroves act as natural buffers, protecting shorelines from erosion, serving as pollutant filtration, and providing habitats for diverse marine organisms (Horstman et al., 2022). Coral reefs, another vital ecosystem, support complex species interactions for marine life while serving as coastal protection, food resources, and tourism attractions (Hoek & Bayoumi, 2017). Thus, coastal zones leverage immense potential for tourism, and ecological services are essential for sustaining both local and global environments.

In recent years, coastal and marine tourism in Indonesia has seen significant growth (Dewa & Atmadja, 2022; Hampton et al., 2024). The development of infrastructure, including tourist facilities, accessibility, and ancillary services, is essential to sustain this growth (Talib & Sunarti, 2020). Given the vulnerability of coastal zones to infrastructure development and human activities (Lins-de-Barros, 2017), it is essential that such projects not only minimize environmental harm but also contribute to ecological regeneration. This can be achieved through well-planned infrastructure prioritizing sustainability and promoting the connection between humans and nature. Several studies (Mustaqim & Setyawati, 2022; Perkol-Finkel et al., 2018) have emphasized the importance of ecologically sensitive design in addressing these challenges.

A further important question is how an ecological design principle can truly benefit local communities while offering meaningful experiences for visitors. While the ecological design may indeed mitigate environmental damage in coastal areas, it is important to ask how this approach can be sustained over the long term and contribute to both local welfare and the well-being of visitors. The Restorative Environment Design (RED) approach seems promising to address these challenges as it emphasizes a harmonic connection between humans and nature, fostering a sense of responsibility for well-being and environmental preservation (Nousiainen et al., 2016). Additionally (Sunarya et al., 2024) highlighted that the natural environments offer spaces conducive to health and socialization, which can be optimized as a strategic branding tool for rural tourism development.

Restorative Environment Design (RED) is grounded in Attention Restoration Theory (ART) (R. Kaplan & Kaplan, 1989; S. Kaplan, 1995), which suggests that exposure to natural environments can reduce cognitive fatigue and improve mental recovery. It incorporates biophilic design principles, aiming to create restorative environments that enhance both physiological and psychological health (Melchionni, 2021; Peters & D'Penna, 2020). As a result, restorative environments can motivate people to engage in environmentally friendly actions (Giusti & Samuelsson, 2020; Hartig et al., 2007).

This paper aims to explore the application of Restorative Environment Design (RED) in coastal infrastructure, particularly for supporting eco-tourism development. It examines key features of RED that are crucial for coastal areas and how these can be effectively implemented through architectural design strategies in the Indonesian context. The goal is to show how RED can minimize environmental impact while promoting sustainable behavior and well-being in coastal development.

## State of Art

Some studies on Restorative Environment Design (RED) have primarily focused on healthcare facilities, urban landscapes, and learning environments, discussing the potential of the restorative environment in these settings (Abdelaal & Soebarto, 2019; Derr Victoria, 2013; Jakob Lindal, 2013; Liu et al., 2024; Nousiainen et al., 2016; Peters & D'Penna, 2020). These studies have centered around built environments with controlled and curated natural elements, leaving a gap in applying

RED to more natural settings like coastal zones.

Coastal areas are rich in natural sensory experiences, such as the sound of waves, the ocean breeze, and views of the horizon. These elements provide an ideal setting for implementing RED to enhance human well-being through stronger connections with nature. Some studies have indicated the potential of the restorative environment in coastal areas to improve psychological health and healthy behaviors (Hipp & Ogunseitan, 2011; Nicolosi et al., 2021; Roe et al., 2019; Wang et al., 2022; White et al., 2013). To fully harness this potential, future research should explore a design framework integrating RED with the specific features of coastal environments. This approach is expected to promote long-term ecological sustainability, which would benefit coastal communities by attracting visitors in seeking restorative experiences.

## Literature Review

The literature review explores the key theories and frameworks that shape RED, including Attention Restoration Theory (ART) and biophilic design principles. Moreover, it examines ecologically sensitive design practices to aid sustainable coastal infrastructure. These perspectives provide valuable insights into understanding how RED principles can be applied to coastal areas, promoting environmental and human well-being.

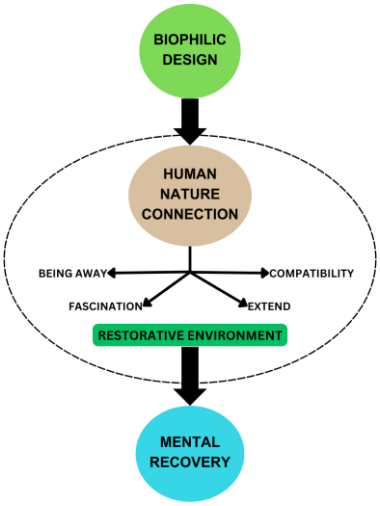
### 1. What is a Restorative Environment?

Restorative Environments can be defined as those that aid mental healing by alleviating cognitive stress and fostering emotional balance (R. Kaplan & Kaplan, 1989). According to ART, natural environments, such as greeneries and open spaces, draw attention in a way that improves cognitive functioning and directed attention. Some studies have shown the role of natural environments in enhancing cognitive functions and reducing stress (Bratman et al., 2012; Tyrväinen et al., 2014).

(S. Kaplan, 1995) suggests that restorative environments consist of four key components that encourage mental healing. The first is "Being Away", where individuals feel a sense of mental escape from daily routines, allowing them to be 'away" from usual pressures. The second is "Fascination," which refers to the effortless attention captured with natural environments, such as watching flowing water or swaying trees, allowing the mind to rest and recover. "Extent" involves a sense of immersion, where people can wander and discover things such as winding paths, forests, and water bodies. Lastly, "Compatibility" means that the environment aligns with the people's needs or desires, supporting personal well-being naturally and intuitively.

Restorative environments share a similar value ground with biophilic design as they emphasize the importance of nature in promoting human well-being. However, while Restorative Environment Design (RED) focuses on creating spaces specifically for mental recovery, the biophilic design integrates natural elements into built environments to foster a stronger human-nature connection. Biophilic design is grounded in a theory of Biophilia Hypothesis (Wilson, 1986) and plays a crucial role in shaping the design principles of restorative environments (Nousiainen et al., 2016).

Figure 1. The Relationship between Biophilic Design and Restorative Design
Source: Author, 2024



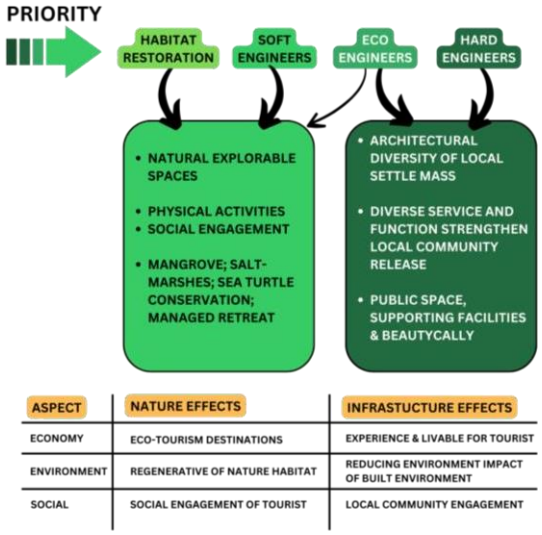
## 2. Sustainable Coastal Infrastructures

A fundamental principle of sustainable coastal development is the preservation and restoration of natural coastal ecosystems. This can be achieved by integrating ecological principles with engineering approaches, including Hard Engineering, Eco-engineering, Soft Engineering, and Habitat Restoration (Dafforn et al., 2015). Among these, habitat restoration is the most sustainable approach as it enhances natural defenses against climate impacts and storms while supporting biodiversity, particularly through the conservation of mangroves and salt marshes. Soft-engineering is better than eco-engineering since it manipulates natural habitats rather than relies on artificial structures such as beach nourishment and managed retreats. Soft engineering requires ongoing human intervention, making it a temporary solution, while eco-engineering blends engineering and ecological principles to minimize the environmental impact of built structures.

Meanwhile, (Wojtowicz-Jankowska & Kalfouni, 2022) shows the importance of a reclamation strategy to achieve sustainable coastal development based on case studies. They highlighted that shore reclamation could support ecological restoration by transforming degraded beaches into healthy and aesthetically attractive landscapes that benefit both locals and tourists. For example, beach reclamation integrated with green spaces and boardwalks can restore dune landscapes while providing active spaces for community engagement. A winding boardwalk, designed using eco-friendly techniques, also helps to prevent erosion while maintaining natural beauty.

Wojtowicz-Jankowska & Kalfouni (2022) also highlighted the role of spatial developments regarding coastal informal settlements. In this case, sustainable coastal development in informal settlements can be seen as a form of architectural biodiversity, providing a diverse range of services and functions that strengthen community resilience. By incorporating various architectural and urban design elements – such as schools, civic centers, public spaces, and health clinics – coastal developments can offer social, economic, and environmental benefits. For example, public spaces foster social interaction while preserved cultural heritage sites raise awareness of local history.

Figure 2. Priority Zone setting in infrastructure implementation in coastal areas and the impact on several aspects
Source: Author, 2024




## 3. Restorative Elements in Blue Space

Coastal zones offer a unique combination of tangible and intangible components that make them highly effective in restoring mental health. Tangible elements like ocean breezes and views, sound waves, and sandy beaches create multisensory spaces with restful and relaxing elements (Nousiainen et al., 2016).

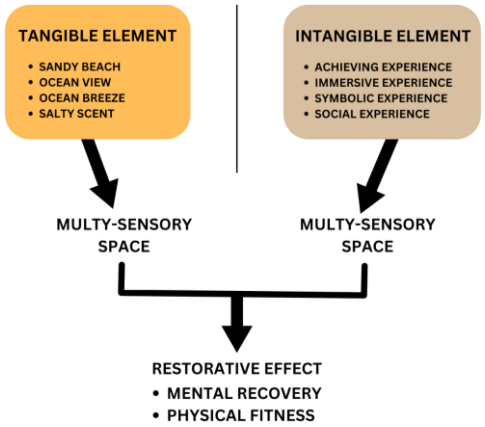
Studies have shown that natural water bodies, particularly, have a calming effect on the mind, often referred to as "blue space" therapy, linked to improved mental well-being and relaxation (White et al., 2013, 2020).

Moreover, engaging in simple activities at the beach, such as walking, swimming, or sunbathing, can help people to recover from daily stressors. According to (Roe et al., 2019), walking around urban waterfront environments enhances psychological and physiological health as well as social interaction. Design

interventions on the waterfront, such as providing shade, seating, and engaging features, can boost a sense of "being away" and "fascination," encouraging people to spend more time in these spaces.

In addition to these tangible components, coastal zones offer rich intangible benefits in the form of diverse experiences that contribute to well-being. (Bell et al., 2015) categorized these coastal interactions into four main types of experiences. First, "achieving experiences" are associated with physical fitness and the pursuit of meaningful goals, such as engaging in activities/ hobbies like surfing or kayaking, providing a sense of accomplishment. Second, "immersive experiences" involve multisensory engagement with the environment, offering relaxation or exploration opportunities, such as walking along the shore, sunbathing, or simply taking in the natural surroundings. Third, "symbolic experiences" are related to the cultural and historical significance of coastal spaces, which can evoke a sense of belonging, identity, and connection to the local customs and specific iconic sites. Finally, "social experiences" focus on the social atmosphere of coastal areas, where people find comfort in shared spaces like harbors, beaches, and public spaces.

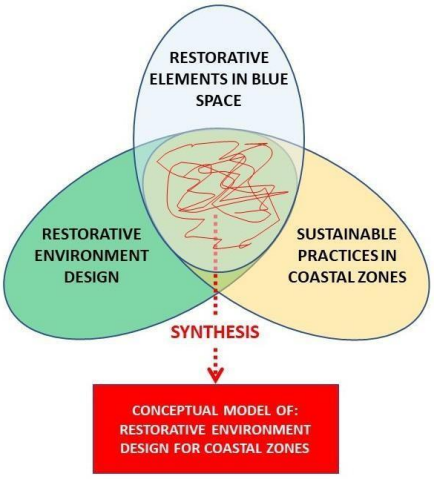
Figure 3. Tangible and Intangible components as multi-sensory tools of restoration effect
Source: Author, 2024




## Methodology

This study conducts a qualitative design synthesis approach to develop a conceptual model for restorative environments in coastal zones. The study synthesizes key concepts related to restorative environments, sustainable coastal infrastructure, and restorative properties in coastal zones from findings from the literature review. This qualitative method focuses on interpreting and applying theoretical insights to create practical design solutions, emphasizing how these elements can be incorporated into real-world coastal settings to foster both environmental sustainability and human recovery.

Figure 4. Schematic of Research Methods.
Source: Author, 2024

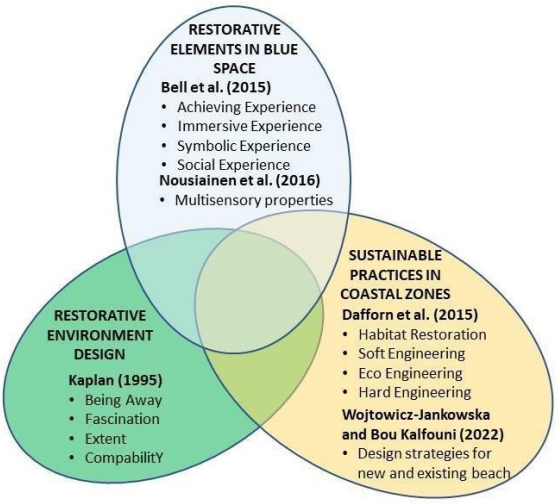



## Result and Discussion

The key findings of the literature review were extracted and synthesized, which are based on three core dimensions: (1) restorative environment components, (2) sustainable coastal infrastructure strategies, and (3) restorative elements in coastal zones. First, Attention Restoration Theory (S. Kaplan, 1995) identifies four components of restorative environments—Being Away, Fascination, Extent, and Compatibility—which contribute to mental healing. Second, sustainable coastal management strategies, including Habitat Restoration, Soft Engineering, Eco-Engineering, and Hard Engineering, are

presented by (Dafforn et al., 2015), while (Wojtowicz- Jankowska & Kalfouni, 2022) contribute insights into design strategies for new and existing beaches considering local settlements. Finally, the third dimension focuses on human interactions and experiences with coastal environments, as presented by (Bell et al., 2015). Moreover, (Nousiainen et al., 2016) provides key insights into restorative environments, emphasizing the importance of multisensory experiences that can be translated into the physical and ambient conditions of coastal zones.

Figure 5. Finding Point of Research Methods.
Source: Author, 2024




The synthesis results in a systematic design framework for Restorative Environment Design (RED) in coastal zones. The framework can support the design process of coastal zones in achieving ecological sustainability and improving human well-being.

The first phase is to create a zoning strategy based on relevant management strategies, considering the physical characteristics of each zone. In this case, the first priority is to determine which areas require habitat restoration and soft engineering interventions, such as restoring mangroves and wetlands to strengthen the natural defense system and enhance local biodiversity. Then, it is important to establish zones that require new infrastructures for incorporating eco-engineering to ensure the future built environment works in harmony with the natural ecosystem. Lastly, for areas with existing hard infrastructure, such as local settlements, the design will integrate eco-engineering can be integrated with its hard structures to enhance resilience and minimize their environmental impact.

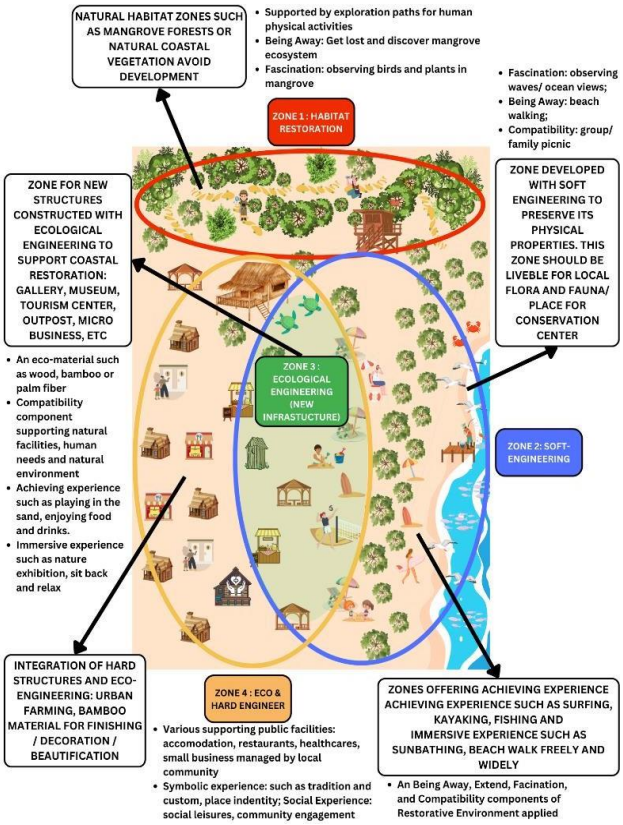
Figure 6. The Design Framework
Source: Author, 2024


The second phase of the framework is identifying the possible multisensory properties and experiences associated with each zone. For instance, sensory features, such as ocean breezes, views, and sandy beaches, can define a multisensory space that can aid mental healing. The possible types of experiences in each zone should be envisioned, such as achieving experience (e.g. surfing or fishing), immersive (e.g., relaxing walks or sunbathing), symbolic (e.g., connecting with local culture), or social experiences (e.g., recreational spaces).
In the third phase, the restorative potential of each zone is assessed by analyzing how the identified sensory properties and experiences

match in the core components of restorative environments —Being Away, Fascination, Extent, and Compatibility. This ensures that each zone will be designed to promote mental recovery and be aligned with the natural environment as well as the visitor's needs.

The final phase is to decide and program services and activities that each zone can offer based on the identification and analysis of each phase of the framework. This can ensure that the designed facilities and infrastructures can be interconnected to support economic, social, and environmental sustainability.

Figure 7. The design concept of restorative environmental design
Source: Author, 2024




The figure presents a conceptual model that envisions the implementation of Restorative Environment Design (RED) in a coastal zone. This model applies the zoning strategy outlined in the framework, showcasing distinct zones designated for habitat restoration, soft engineering interventions, and eco-engineering integrations. Each zone reflects its unique management strategy, with areas for habitat restoration incorporating mangroves and wetlands, while zones requiring new infrastructure are designed with ecological engineering techniques. Additionally, zones with existing hard structures, such as local settlements, are enhanced with eco-engineering to improve resilience and minimize environmental impact. The model also provides multisensory properties—like ocean views, breezes, and iconic natural features—and considers the types of experiences each zone can offer. Together, these components can inform designers to envision the implementation of restorative environment design in coastal environments.

## Conclusion

This paper examines the potential of Restorative Environment Design (RED) in coastal zones by synthesizing key principles from restorative environments, sustainable coastal infrastructure, and restorative qualities of coastal landscapes. It integrates concepts from Attention Restoration Theory (ART), coastal management strategies, and human experiences based on therapeutic coastal interactions to develop a systematic design framework. This framework can serve as a guide for zoning and assessing and analyzing the implementation of RED in coastal areas.

Besides, this study also presents a conceptual model envisioning how these principles can be practically applied, bridging ecological sustainability with human well-being. Finally, it gives insights into how coastal zones can be transformed into spaces that support mental restoration, foster community engagement, and ensure long-term environmental resilience.

## References

Abdelaal, M. S., & Soebarto, V. (2019). Biophilia and Salutogenesis as restorative design approaches in healthcare architecture. *Architectural Science Review*, 62(3), 195–205.

https://doi.org/10.1080/00038628.2019.16 04313

Bell, S. L., Phoenix, C., Lovell, R., & Wheeler, B. W. (2015). Seeking everyday wellbeing: The coast as a therapeutic landscape. *Social Science and Medicine*, 142, 56–67. https://doi.org/10.1016/j.socscimed.2015.0 8.011

Bratman, G. N., Hamilton, J. P., & Daily, G. C. (2012). The impacts of nature experience on human cognitive function and mental health. *Annals of the New York Academy of Sciences,* 1249(1), 118–136. https://doi.org/10.1111/j.1749-6632.2011.06400.x

Dafforn, K. A., Mayer-Pinto, M., Morris, R. L., & Waltham, N. J. (2015). Application of management tools to integrate ecological principles with the design of marine infrastructure. In *Journal of Environmental Management* (Vol. 158, pp. 61–73). Academic Press. https://doi.org/10.1016/j.jenvman.2015.05. 001

Derr Victoria. (2013). *Making Children's Environments "R.E.D.": Restorative Environmental Design and Its Relationship to Sustainable Design.* EDRA44: Healthy + Healing Places. Providence, RI.

Dewa, I., & Atmadja, G. (2022). Indonesian Marine Resources Law Perspective of Marine Tourism Development. In *Journal Equity of Law and Governance* (Vol. 2, Issue 2). https://www.ejournal.warmadewa.ac.id/ind ex.php/elg

Giusti, M., & Samuelsson, K. (2020). The regenerative compatibility: A synergy between healthy ecosystems, environmental attitudes, and restorative experiences. *PLoS ONE*, 15(1). https://doi.org/10.1371/journal.pone.02273 11

Hampton, M. P., Bianchi, R., & Jeyacheya, J. (2024). Dynamics of coastal tourism: drivers of spatial change in South-East Asia. *Singapore Journal of Tropical Geography*, 45(1), 54–69. https://doi.org/10.1111/sjtg.12512

Hartig, T., Kaiser, F. G., & Strumse, E. (2007). Psychological restoration in nature as a source of motivation for ecological behaviour. *Environmental Conservation*, 34(4), 291–299. https://doi.org/10.1017/S037689290700 42 50

Hermawan, S., Mihardja, E., Pambudi, D. A., & Jason, J. (2023). Hydrodynamic Model Optimization for Marine Tourism Development Suitability in Vicinity of Poso Regency Coastal Area, Central Sulawesi, Indonesia. *Sustainability* (Switzerland),15(4). https://doi.org/10.3390/su15043150

Hipp, J. A., & Ogunseitan, O. A. (2011). Effect of environmental conditions on perceived psychological restorativeness of coastal parks. *Journal of Environmental Psychology*, 31(4), 421–429. https://doi.org/10.1016/j.jenvp.2011.08.00 8

Hoek, L. S. van den, & Bayoumi, E. K. (2017). Importance, Destruction and Recovery of Coral Reefs. *IOSR Journal of Pharmacy and Biological Sciences*, 12(02), 59–63. https://doi.org/10.9790/3008-1202025963

Horstman, E., Gijsman, R., van Zee, R., Engel, S., Johnson, J., van der Wal, D., & Wijnberg, K. (2022). Creek restoration effects on tidal dynamics in mangroves. *Coastal Engineering Proceedings*, 37, 126.

Hutomo, M., & Kasim Moosa, M. (2005). Indonesian marine and coastal biodiversity: Present status. In *Indian Journal of Marine Sciences* (Vol. 34, Issue 1).

Jakob Lindal, P. (2013). Restorative Environmental Design for Densifying Cities Faculty of Architecture, Design & Planning.

Kaplan, R., & Kaplan, S. (1989). *The experience of nature: A psychological*

*perspective*. Cambridge university press.

Kaplan, S. (1995). The Restorative Benefits Of Nature: Toward An Integrative Framework. *Journal of Environmental Psychology*, 15(3), 169–182. https://doi.org/https://doi.org/10.1016/0272-4944(95)90001-2

Lins-de-Barros, F. M. (2017). Integrated coastal vulnerability assessment: A methodology for coastal cities management integrating socioeconomic, physical and environmental dimensions - Case study of Região dos Lagos, Rio de Janeiro, Brazil. *Ocean and Coastal Management*, 149, 1–11. https://doi.org/10.1016/j.ocecoaman.2017. 09.007

Liu, Y., Zhang, J., Liu, C., & Yang, Y. (2024). A Review of Attention Restoration Theory: Implications for Designing Restorative Environments. In *Sustainability (Switzerland)* (Vol. 16, Issue 9). Multidisciplinary Digital Publishing Institute (MDPI). https://doi.org/10.3390/su16093639

Melchionni, B. (2021). *Integrating Ecological and Human Health: Restorative Environmental Design In Therapeutic Landscapes* [Master's thesis]. University of Georgia.

Mustaqim, R. A., & Setyawati, E. (2022). Implementation Of Architectural Ecological Concepts In Cultural Resort Design In Coastal Area A Case Study Of Kubu Beach, Pangkalanbun, Kotawaringin District, West Kalimantan. In *International Journal of Engineering* (Vol. 4, Issue 1). https://aminjaya.desa.id/NEWS/detail/-List-nama-kecamatan-

Nicolosi, V., Wilson, J., Yoshino, A., & Viren, P. (2021). The restorative potential of coastal walks and implications of sound. *Journal of Leisure Research*, 52(1), 41–61. https://doi.org/10.1080/00222216.2020.17 41329

Nousiainen, M., Lindroos, H., Heino, P., Valta, M., & Häkkinen, J. (2016). Restorative Environment Design. *Kymenlaakso University of Applied Sciences*.

Perkol-Finkel, S., Hadary, T., Rella, A. Shirazi, R., & Sella, I. (2018). Seascape architecture – incorporating ecological considerations in design of coastal and marine infrastructure. *Ecological Engineering*, *120*, 645–654. https://doi.org/10.1016/j.ecoleng.2017.06. 051

Peters, T., & D'Penna, K. (2020). Biophilic design for restorative university learning environments: A critical review of literature and design recommendations. *Sustainability (Switzerland)*, 12(17). https://doi.org/10.3390/su12177064

Roe, J., Barnes, L., Napoli, N. J., & Thibodeaux, J. (2019). The restorative health benefits of a tactical urban intervention: An urban waterfront study. *Frontiers in Built Environment*, 5. https://doi.org/10.3389/fbuil.2019.00071

Sunarya, W., Avenzoar, A., & Utomo, H. P. (2024). Defining Wellness-Focused Design for Rural Tourism: Study Case of Penanggungan Village. *IOP Conference Series: Earth and Environmental Science*, 1351(1). https://doi.org/10.1088/1755-1315/1351/1/012007

Talib, D., & Sunarti, S. (2020). *Strategi Pengembagan Destinasi Wisata Pantai (Sebuah Analisis Teoritis).* https://doi.org/10.272098/tulip.3.2.73-82.2020

Tyrväinen, L., Ojala, A., Korpela, K., Lanki, T., Tsunetsugu, Y., & Kagawa, T. (2014). The influence of urban green environments on stress relief measures: A field experiment. *Journal of Environmental Psychology*, 38, 1–9. https://doi.org/10.1016/j.jenvp.2013.12.00 5

Wang, H., Zou, Z., & Tsai, S.-C. (2022). Exploring Environmental Restoration and Psychological Healing from Perspective of Resilience: A Case Study of Xinglin Bay Landscape Belt in Xiamen, China. *International Journal of Environmental Sustainability and Protection*, 2(4), 44–54. https://doi.org/10.35745/ijesp2022v02.04. 0005

White, M. P., Elliott, L. R., Gascon, M., Roberts, B., & Fleming, L. E. (2020). Blue space,

health and well-being: A narrative overview and synthesis of potential benefits. In *Environmental Research* (Vol. 191). Academic Press Inc. https://doi.org/10.1016/j.envres.2020.11 01 69

Wilson, E. O. (1986). Biophilia. Harvard university press.

Wojtowicz-Jankowska, D., & Kalfouni, B. B. (2022). A Vision of Sustainable Design Concepts for Upgrading Vulnerable Coastal Areas in Light of Climate Change Impacts: A Case Study from Beirut, Lebanon. *Sustainability (Switzerland)*,14(7). https://doi.org/10.3390/su14073986