Pak. J. Bot., 58(2): 395-402, February 2026.

ARTICLE DOI: http://dx.doi.org/10.30848/PJB2026-2(4)

TRAIL DESIGN FOR THE HIGH INTERTIDAL ZONE RESTORATION OF LANTIAN MANGROVE DESTRUCTION AREA IN HAINAN PROVINCE, CHINA

BINGYU LIU, SHANYU LIN, YOUHUA YE*, KETONG ZHANG, CHEN XIU, SHUXIAN HUO AND ZONGLONG WU

College of Horticulture and Landscape Architecture, Zhongkai University of Agriculture and Engineering, Guangzhou, Guangdong 510225

*Corresponding author's email: yeyouhua@zhku.edu.cn

Abstract

The restoration of mangrove wetland habitats involves designing trails that consider the sustainable use and value realization of mangroves. This study examines the damaged mangrove wetland in Lantian Village, Danzhou City, Hainan Province, using field surveys, spatial analysis, and landscape design. Three types of trails were selected, including ecological, recreational, and cultural. Trail planning considered directional layout and surrounding resource conditions, leading to the integration of key nodes such as photography platforms, bird-watching platforms, and volunteer service stations. These features support multiple functions, including coastal zone protection, eco-tourism, and nature education. The findings provide a valuable reference for restoring degraded high intertidal zones and inform similar restoration efforts elsewhere.

Keywords: Lantian mangroves; Ecological restoration; Trail design; Hainan Province

Introduction

In the past, mangrove ecosystems have undergone dynamic changes due to the dual impact of climate change and human activities (Ruan *et al*., 2022; Chang *et al*., 2024). Some areas of mangroves, particularly those outside nature reserves, have experienced varying degrees of degradation, leading to the loss of coastal ecosystem functions and biodiversity (Valiela *et al*., 2001; Liao & Zhang, 2014; Meng *et al*., 2016; Xin *et al*., 2016), which in turn threatens the sustainable development of human and nature in coastal zones (Polidoro *et al*., 2011; He *et al*., 2019; Gargaran *et al*., 2024). Promoting the ecological restoration of mangroves is related to the realization of global sustainable development goals (Sasmito *et al*., 2023). The protection and restoration of mangroves, as well as the realization of their ecological product values, are currently important practice areas in China. Trail design is one of the important ways to promote the ecological restoration and sustainable use of mangroves.

Trails serve as a link between humans and nature, connecting landscape nodes and guiding visitors for appreciation and tourism, providing spaces for leisure and rest (Xie, 2016). They are some types of recreational paths that merge aesthetic and ecological value, functioning as greenways and blueways while also serving as ecological corridors. They are flexible, diverse, and green linear ecological landscape spaces. Since the 1930s, countries such as France, England, and the United States have rapidly developed trail systems. In 1968, the American parliament passed a bill to establish the legal status of the national trail system, emphasizing that a trail is a system comprising four parts: national leisure trails, national scenic trails, national historical trails, and connecting (byways) trails (Johnson, 2008). In Asia, countries like Japan and regions in China have also initiated trail construction since the 1960s (Yu *et al*., 2013). In China, trails are commonly named paths, walkways or alleys in the early stages. In recent years, driven by sustainable development, the construction of corridors, greenways, and blueways has flourished (Ma *et al*., 2020; Zheng & Du, 2020; Hu *et al*., 2022). Research on specialized trail systems such as mangrove walkways has continued to expand to address environmental challenges, with studies highlighting the importance of aesthetic integration in coastal wetland design (Ma *et al*., 2020; Meadema *et al*., 2020; Yao & Chen, 2022). These studies and practices have effectively connected a large number of different types, levels, and locations of mountains, waters, forests, fields, lakes and grasslands, creating local characteristics and improving the regional ecological environment, and also providing essential support for the construction of the regional ecological security network.

In mangrove restoration, trails serve multiple critical functions in protection, restoration, and sustainable use. They provide residents with spaces for production, daily life, and social interaction, while acting as a key medium to showcase coastal rural landscapes (Xiao, 2023). Research on trail construction can focus on bird watching, ecological protection, and managementt (Meadema, 2020), aiming to enhance human-nature interaction, expand connections with production and living spaces, and establish a pathway for the sustainable use of coastal zones.

Up until 2021, the Lantian Mangrove wetland in Hainan Province, China, had been a neglected area. The high intertidal zone was previously developed for fishponds used for aquaculture, destroying mangrove plants. In recent years, efforts to protect the natural coastline have resulted in the

Received: 12-11-2024 | Revised: 04-06-2025 | Accepted: 20-06-2025 | Online: 12-10-2025

removal of these fishponds, creating an urgent need for ecological restoration. Ecological restoration of the site must consider at least two aspects: (1) According to the "Danzhou Xinyingwan Mangrove City level Nature Reserve Scope and Functional Area Identification Report," except for two narrow areas extended into the mangroves that were designated as the experimental area, the majority of the remaining area has not been included in the protection scope. How should the restoration of this site be planned and designed? (2) Previously, aquaculture was a significant source of income for the Lantian villagers. Integrating ecological restoration design with sustainable use and increasing village income are key points. Therefore, this study focuses on restoring the degraded Lantian Mangrove area into an ecological scenic spot site, aiming to revitalize the repair area through trail design.

Research Area and Methodology

Research area: The design area is located at Lantian Village, Xinzhou Town, Danzhou City, Hainan Province (E109°17′, N19°43′), about 0.3 kilometers away from Xinying Port, and adjacent to the Danzhou Xinyingwan Mangrove City level Nature Reserve（the two narrow extensions into the mangroves form the reserve's experimental zone), with a terrain extends from northwest to southeast. The northeast side connects with the Lantian Village, the southwest side with Danzhouwan and the southeast side is connected to Provincial Road 315 (Fig. 1). This region has a tropical marine monsoon climate. The high intertidal zone of Lantian coastal zone was designated as an illegal fishpond clearance area with a sparse distribution of mangrove plants before; the middle intertidal zone is mainly composed of *Kandelia candelabra-Aegiceras corniculatum* mangrove community and the low intertidal zone is mudflats. The Trail design area in this study primarily focuses on the high intertidal zone and the adjacent idle land on the east side of the village. The middle and low intertidal zones are largely included within the nature reserve.

Methodology: This study integrates field surveys, spatial analysis, landscape design, and drone photography, etc., to obtain basic information such as spatial distribution, and transportation conditions within the study area. Under the existing small-scale geographical conditions such as fishpond dikes and tidal channels, trail type selection, functional definition. Then, traditional landscape design methods and graphic technologies such as Auto CAD and Adobe Photoshop were applied to complete the trail design.

Condition of mangrove wetlands: The restoration site is located in a high intertidal zone and the adjacent idle land east of the village, covering approximately 17 hectares. Among them are 8 hectares of mudflats cleared after the demolition of illegal breeding ponds and 9 hectares of wasteland. The fishpond ridges of the cleared illegal fishponds are clearly visible (Fig. 2). Relevant planning and restoration efforts have not yet commenced. Relevant planning and restoration efforts have not yet commenced. To address development issues, villagers implemented a poverty alleviation project of "mudworm farming" on the mudflats after the demolition of the fishponds.

In addition to some remaining plants such as *Kandelia candel*, the mudflats after the removal of illegal aquaculture ponds are mainly scattered with young mangrove plants of various species, including *Aegiceras corniculatum*, *Avicennia marina*, *Excoecaria agallocha*, *Acrostichum aureum*, *Hibiscus tiliaceus*, *Sesuvium portulacastrum*, *Ipomoea pes-caprae*, *Opuntia dillenii*, etc. In addition, fishponds also located in this area which is connected with ocean via tidal channel. During the survey, a total of 28 little egrets Egretta garzetta were feeding and perching in the restoration area were observed. Overall, as most of this area is located outside designated nature reserves, and field surveys show that early land reclamation and aquaculture activities have significantly damaged the original mangrove ecosystem along the Lantian coastline. Therefore, most of the existing mangrove vegetation consists of young plants, while trees and shrubs in the wasteland are sparse and in a state of decline. The overall ecological quality of the restoration area remains poor.

Function and type analysis of trails

Overall positioning design: From the perspective of historical and natural characteristics, this area was mainly distributed with mangroves before being damaged. Hence mangrove restoration in this area aligns with its historical and natural characteristics. Although the damaged mangrove area is not currently within nature reserve boundaries, its close proximity to reserves and location in the high intertidal zone mean mangrove restoration here must urgently follow reserve protection standards. Previously, this area was used for aquaculture, generating economic income through fishpond operations. If considering aquaculture, it would only be ecological aquaculture, and controlling pollutant emissions would be challenging. Therefore, new methods of economic development must be explored. Based on the need for coastal zone protection and considering its natural and historical features, this area converting into a mangrove ecological tourism scenic spot is more appropriate. It can achieve both purposes, i.e., protection and restoration, as well as promote economic growth through ecological tourism. The design of trails provides a possibility for the tourism development within the mangrove ecological scenic area. Nodes and tourism models will also be created to achieve value preservation and appreciation on the basis of protection and restoration. Therefore, positioning the restored area as a "Mangrove restoration & ecological tourism area" is both ecologically and economically beneficial.

Selection of trail types: As the trail system evolves and improves, it has given rise to a diverse array of trail types, ranging from cultural and geological trails to mountain bike paths, equestrian trails, wetland boardwalks, rail-trails, and waterways. The construction types of trails will be set according to the needs of tourists and the ecological requirements (Liu & Jia, 2015). The Lantian mangrove trail belongs to the wetland trail type. Considering the natural environment of the Lantian mangrove wetland and the functional needs of coastal ecological protection, eco-tourism, cultural landscape, and nature education, three trail types are defined: ecological, recreational, and cultural (Table 1).

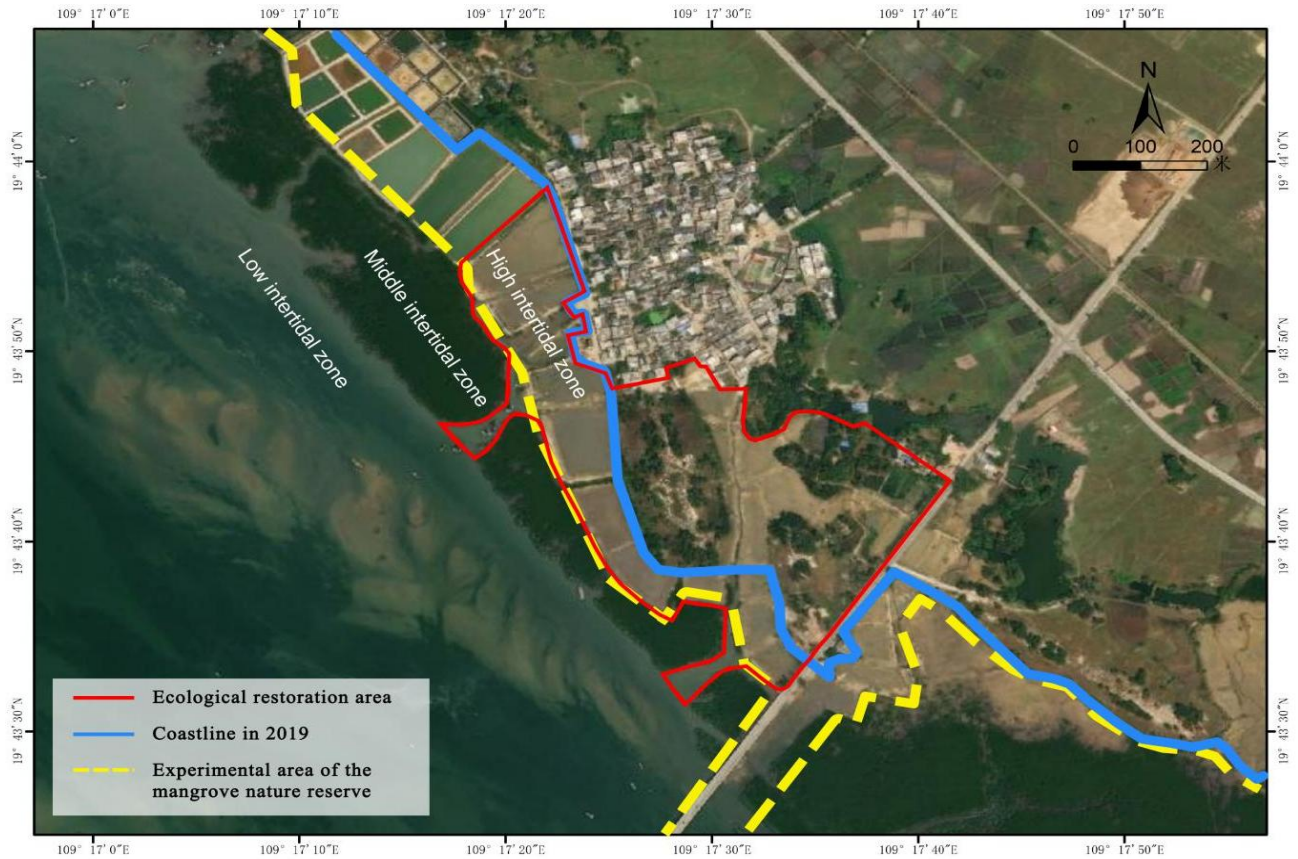

Fig. 1. Aerial view of Lantian Mangrove Wetland (The red line range is the ecological restoration area.)

Fig. 2. Situation of the high intertidal zone of Lantian coastal zone.

Table 1. Trail type and characteristics of the restoration area.

Trail type	Construction content	Composition elements	Effect
Ecological	●Building ecological trails ●Connecting fragmented ecological patches along the coastal zone ●Forming a coastal ecological network	●River systems ●Plant and fauna (birds) ●Mudflats ●Wooden or stone walkways	●Forming an ecological network to protect the biodiversity of mudflats and wetlands ●Maintaining the ecological security of wetlands
Recreational	●Connecting recreational resources within the coastal zone ●Constructing a coastal zone recreational system	●Bird watching points ●Photography spots ●Supply service point	●Adding tourism and recreation venues ●Connecting with the mangrove landscape outside the restoration area ●Enhancing the economic value of mudflats and wetlands
Cultural	●Connecting the village closely adjacent to the wetland ●Connecting other cultural resources	●Material cultural attractions ●Intangible cultural heritage	●Protecting historical and cultural heritage ●Inheriting historical culture ●Forming an ecological and cultural network

Trail function design

Protection function: The remaining mangroves in the restoration area are sparse, consisting primarily of young seedlings within a single habitat patch. Biodiversity, including both plant and animal resources, is limited. In this study, the trail design should focus on protecting the mudflats, wetlands and the mangrove plants. Engineering projects should be planned to minimize risks to existing mangroves. On this basis, the protection and utilization of the tidal channels should be strengthened.

Management function: Effective management, maintenance, and sustainable development must be integral to the trail design in the Lantian mangrove restoration area. Therefore, the trail design should be combined with the comprehensive management function, and the trail should provide patches and conveniences for management at least. While facilitating internal management within the restoration area, the trail design should connect with the Lantian coastal zone and its surrounding coastal zones, achieving systematic, comprehensive, and unified management.

The public is both the user and protector of the environment and resources of the Gulf. Several studies have shown that community participation plays an important role in the protection and sustainable development of mangrove reserves or mangrove ecosystems, and that the active participation and supervision of communities surrounding mangroves are conducive to promoting the sustainable development of ecotourism, environmental protection and social and economic progress (Arfan *et al*., 2024; Gargaran *et al*., 2024; Bachri *et al*., 2024; Srifitriani *et al*., 2025). Therefore, in the operation and later management of mangrove protection and restoration projects, it is necessary to strengthen cooperation between the reserve and surrounding communities, and between residents and the government. The degree of public participation is largely affected by their awareness of ecological protection. Therefore, in the process of trail design, the setting of key nodes and publicity signs can increase the intensity of publicity about mangrove protection and restoration to the public, providing a better public foundation for the protection and management of mangroves.

Ecotourism function: Balancing ecological conservation with cultural heritage and tourism is key to enhancing the value of the coastal zone. By integrating landscape elements, trail design can harmonize development and protection, highlighting both ecological aesthetics and economic potential. Therefore, trail design needs to incorporate landscape concepts, prioritize ecological protection, increase recreational functions, and construct a coastal zone recreational system. The design process should incorporate flexible and diverse trails with ecotourism functions to improve the ecological quality and economic value of the coastal zone.

Trail design

Trail selection: Trail layout should comprehensively consider production, living and ecological spaces (Fig. 3). Based on the perspective of land space, the interconnections between elements within the region should be fully considered. At the same time, the connections between the inside and its external surroundings must be carefully planned. From a value-realization perspective, the trail network should facilitate ecological value enhancement. The trail effectively connects production, living, and ecological spaces using linear space, facilitating the sustainable use of ecological assets. Based on the type and functional positioning, the Lantian trail is designed as three types including ecological trails, cultural trails, and recreational trails (Fig. 4). Ecological trails are mainly composed of natural tidal channels, natural mud dikes, and artificial dikes.

Cultural trails focus on village traditional culture, folk experiences, and popular science education. It helps to innovate rural culture, enhance the inheritance of village culture, and continue the cultural context of villages. Recreational trails are based on ecological protection, providing paths for relaxation and leisure through forms such as photography bases, bird watching, mangrove conservation experiences, and sea voyages by boat. In the process of trail selection design, the retained natural road network was basically preserved and supplemented, strengthening the connection between patches. Dredging tidal channels extended the river system, enriched the regional landscape, and improved ecological flows. The trail not only connects typical mangroves, tidal channels, bird habitats, and landscape flowering forests within the wetlands but also connects roads, villages, folk handicraft workshops, folk customs, cultural regions, as well as adjacent farmland, water and other types of ecosystems (Fig. 5).

How to balance the relationship between the protection of nature reserves and the development and utilization of resources is an inevitable problem in the process of common development between the reserves and the surrounding communities. The mangrove ecological protection and restoration area is adjacent to the experimental area of the mangrove nature reserve (Fig. 1). After a full investigation and assessment of the project area and the surrounding environment, an ecological trail and a leisure trail were designed at the location of two tidal gullies in the experimental area of the mangrove nature reserve (Fig. 5). Tidal trench are key ecological elements of the mangrove ecosystem, The two trails designed here can these trails well connect the experimental area of the reserve with the surrounding communities, and connect the ecological, production and living spaces. In addition, as a transitional area between the two areas, it is conducive to providing tourists with a better opportunity to get to know the mangroves and their ecosystems up close on the basis of protecting the mangroves, while improving the effective utilization of mangrove resources.

Trail width design: Width design has a significant impact on the realization of trail function value (Zhu *et al*., 2005). For example, ecological trails mainly based on tidal channels are important river corridors, and the mudflats on both sides of the tidal channels provide habitats for fish, shellfish, etc.

The width of the ecological trail should be determined based on the surrounding plants, main functions, and the size of the water inlets and outlets. In principle, the width should maintain the existing natural tidal channel width. If it does not affect the ecological function, the width of the ecological trail can be appropriately expanded.

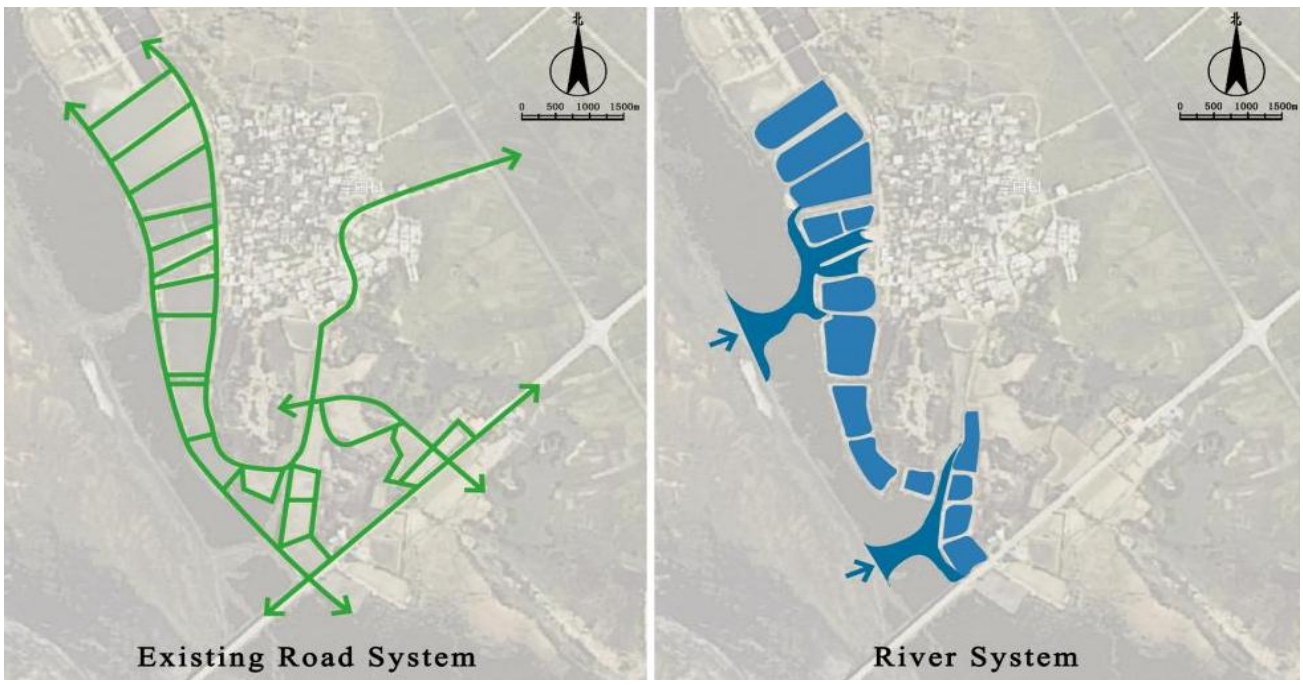

Fig. 3. Natural water system and road network in Lantian mangrove wetland.

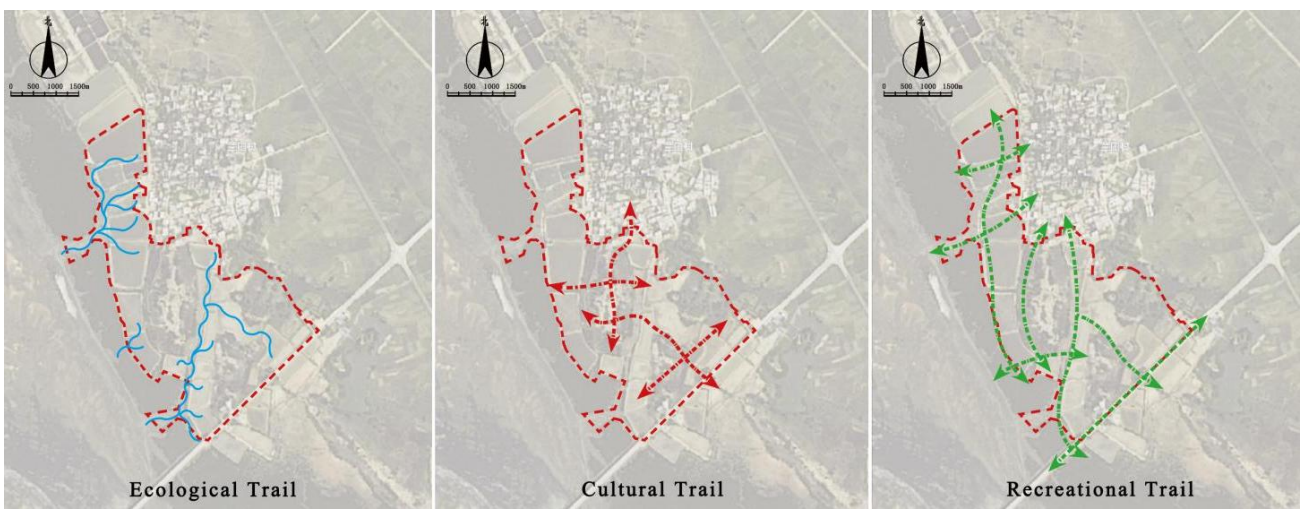

Fig. 4. Route design of different types of trails in Lantian Mangrove Wetland.

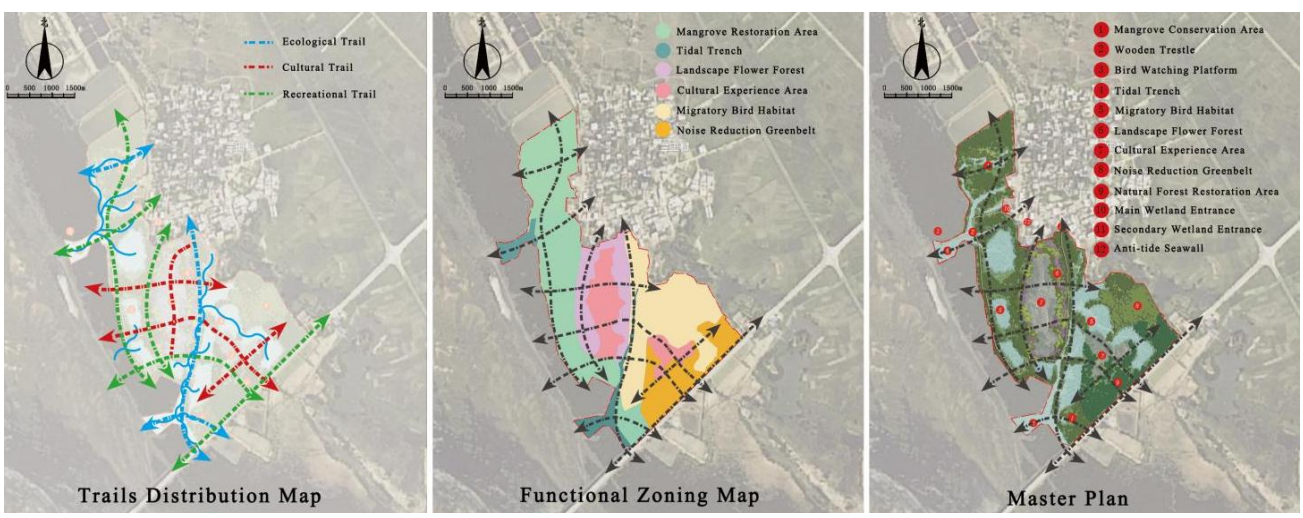

Fig. 5. Planning and design drawing map for Lantian Mangrove Wetland.

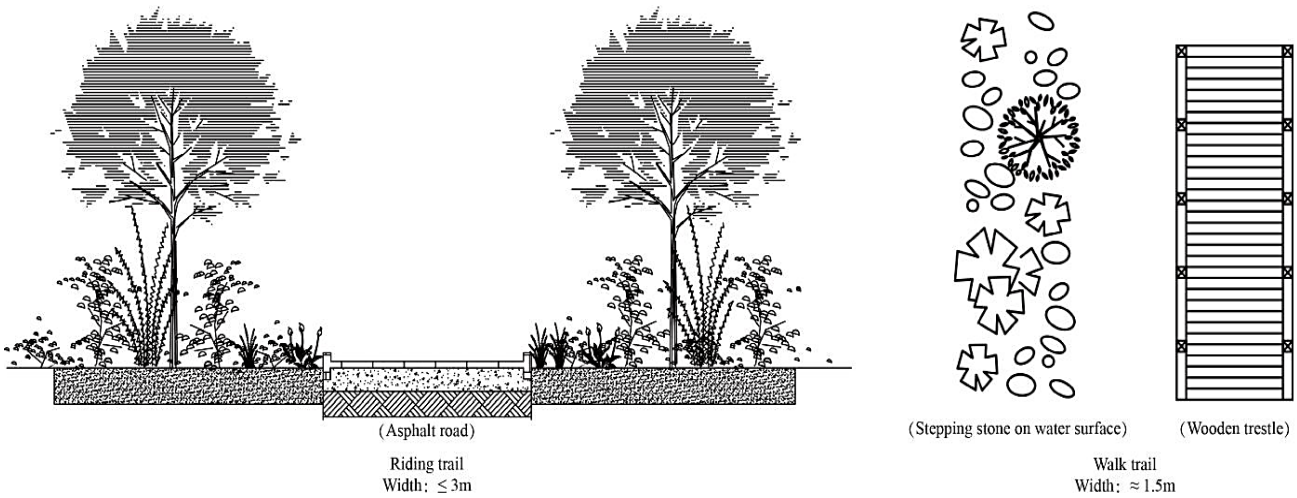

Fig. 6. Trail width design for Lantian Mangrove Wetland.

The width of the trail is set based on the surrounding plants, main functions, and the size of the entrance and exit water. In principle, the width should be maintained at the natural tidal channel width and may be appropriately widened without affecting ecological functions. Cultural trails are primarily designed for walking tours, with their width set to that of standard walkways. Recreational trails mainly provide services such as sightseeing, science education, bird watching, and flower viewing, and their width is primarily a combination of cycling lanes and walkways.

Referring to the greenway planning and design guidelines issued by the Ministry of Housing and Urban Rural Development of the People's Republic of China, the Lantian coastal zone trail is categorized into two levels: pedestrian trails and cycling trails. Based on the actual conditions of the Lantian coastal zone, the width of the pedestrian trail in this area is controlled to be around 1.5m and can be implemented using stone steps or wooden plank paths. The cycling trail is mainly distributed in the villages, as well as between various elements in the villages. The construction width should be controlled within 3m (Fig. 6).

Mangrove restoration design within the trail network: Guided by ecological restoration principles, mangrove rehabilitation within trail corridors should be implemented through approaches that respect, adapt to, and protect natural processes. For the mangrove wetlands within the Lantian coastal zone, the design of the trail should include the mangrove restoration design within the trail area. Mangrove restoration within trail corridors prioritizes areas along both sides of the trail and key nodes, with a specific emphasis on linear restoration of the corridor flanks. In the mangrove plant distribution area, the main focus should be on maintenance and protection, and a suspension wooden plank path should be used for paving. Tidal channels should primarily be deepened. In the migratory bird habitat, mangrove species including *Acanthus ilicifolius*, *Kandelia obovata* and *Terminalia catappa* should be planted at designated intervals to ensure sparse distribution. Within the village preservation area, newly constructed channel banks should be densely planted with *Avicennia marina* and other mangrove species to form a typical *Avicennia marina* community landscape belt and photography hotspot. In the landscape flower forest and within the village trails, plants like *Taliparitiliaceum* should be sparsely planted, interspersed with other flowering plants. The types of mangrove plants that can be planted in this area and their selection criteria are presented in (Table 2).

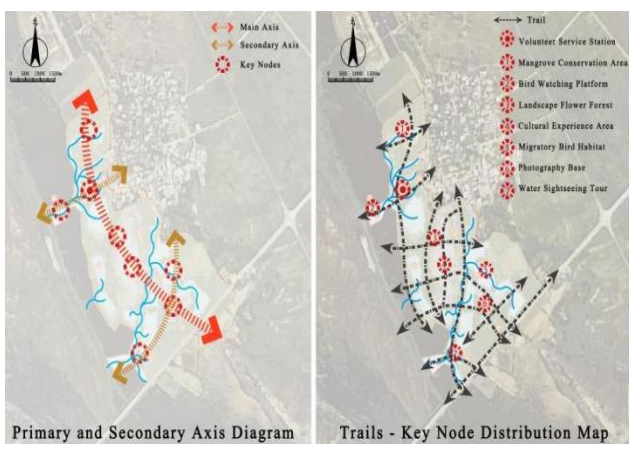

Fig. 7. Key nodes distribution in Lantian Mangrove Wetland.

Key node construction of the trail: Key trail nodes are designed by integrating trail alignment with the spatial distribution of adjacent resources, such as ecological patches and cultural landscapes. Combining scenic spots can showcase local characteristics and create a distinctive landscape pattern (Li *et al*., 2024). According to the above trail design and the existing resources of the Lantian coastal zone, attractive characteristic scenic spots are selected as key nodes on the trail (Fig. 7). Key trail nodes include mangrove conservation area, volunteer service station, landscape flower forest, photography base, village cultural experience area, folk experience area, folk workshop, water sightseeing, bird-watching platform, and migratory bird habitat, etc. Secondary nodes, as shown (Fig. 8) primarily denote small-scale spatial units characterized by superior surrounding landscapes and endowed with ecological or historical-cultural value.

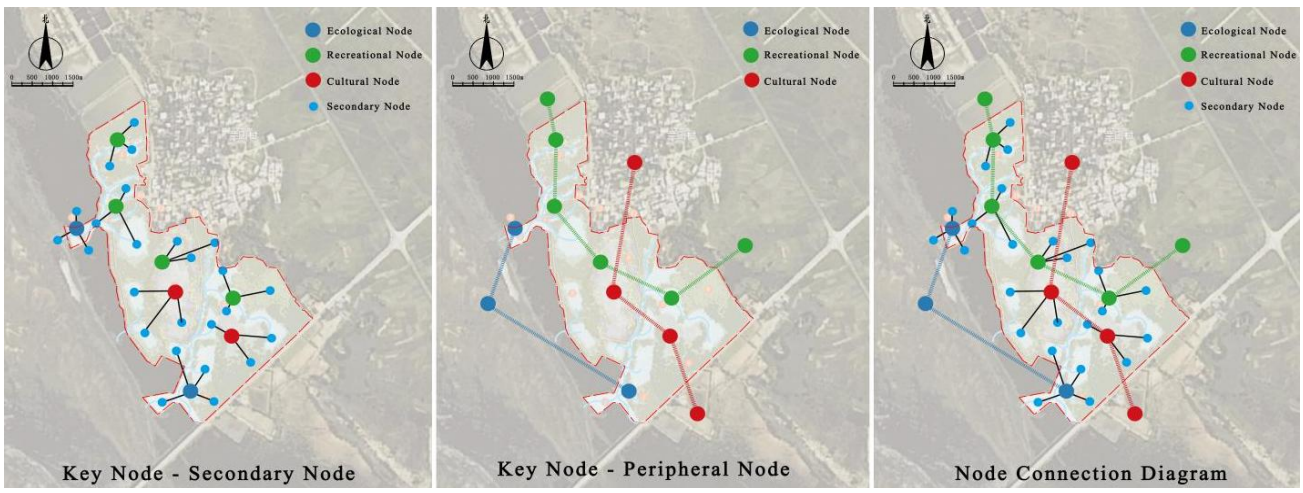

Fig. 8. Nodes contact diagram in Lantian Mangrove Wetland.

Discussion and Conclusion

As one of the important natural resources and ecosystems of the gulf environment, mangrove forests contain rich ecological products, including material ecological products and non-material ecological products such as regulatory services types, cultural services types, and ecological resource rights and interests types (Xie & Li, 2023). They can provide ecological products such as coastal protection, carbon fixation and oxygen release, leisure tourism, education and scientific research services, etc. In addition, in some areas permitted by law, they can also provide material ecological products such as wood. The key to realizing the value of ecological products lies in promoting the realization of the economic value, social value and ecological value of ecological products. At present, the main paths for realizing the value of ecological products include the government path, market path and government + market path, and gradually derived from market + public welfare path, government + public welfare path and other paths (Ye *et al*., 2022). There are more modes for realizing the value of ecological products, and ecological protection and restoration is one of them, the protection and restoration of mangrove ecosystems is conducive to the improvement of the quality and efficiency of mangrove ecological products. The design of trails in the mangrove ecosystem space is conducive to the protection and restoration of mangroves and can also promote the development of mangrove ecotourism and further promote the realization of the value of mangrove ecological products.

The Lantian mangrove ecosystem includes key ecological elements such as mangrove plants, birds, water bodies, mudflats, and tidal channels. How to connect these elements during the restoration process, and how to promote the maximization of value realization on the basis of the least resources is particularly important for the design, selection, and optimization of trail types and routes. This study tackles the challenge of severe fragmentation in the Lantian mangrove ecosystem by proposing a tripartite trail system-ecological, recreational, cultural-coupled with strategically designed key nodes (e.g., habitat connectors, cultural-educational hubs) to enhance ecological connectivity. These trails effectively connect the production, residential and ecological 'three-life spaces' using linear space, promoting the sustainable use of coastal zone ecological resources. For the repair area with relatively fragmented road systems (such as fishpond ridges) and the outer repair area with good growth potential mangrove communities at mean high tide, some original Trails were retained on the trail route, fully considering their width, height, and other spatial scales relative to the mangroves, minimizing interference with the ecosystem. Fully considering local development needs, elements of recreation and cultural education were integrated, enriching the function of the trail while meeting ecological protection needs.

Overseas research on trail design began earlier, focusing more on the impact of various factors on trail sustainability and optimal design of existing trails (Lukoseviciute, 2021; Marion, 2023). The Lantian mangrove trail design is a restoration planning and design oriented towards the protection and restoration of small and micro ecological environments and as part of the restoration process of wetland-type coastal zones, with trails as the main content. Compared to general restoration projects, this study emphasizes the spatial connectivity between trail distribution and key nodes, providing engineering insights for the protection and restoration of mangroves in small areas, emphasizing the promotion of dual goals of ecological protection and resource utilization through trail design, while also strengthening community participation and ecological education functions.

Trail design should follow the principle of preserving nature whenever possible and protecting it when necessary, strictly controlling the scale and type of construction, making the trail an important ecological channel and trail that promotes mangrove ecological protection and value realization. In addition, trail materials significantly influence the mudflat wetland ecosystem. Due to the variety of trail materials, further discussion is needed on more trail choices to ensure the long-term effectiveness and environmental friendliness of design. In practical application trail usage should be continuously monitored, complemented by periodic ecological impact assessments, to sustain the long-term health and stability of the mangrove ecosystem. This study represents an initial attempt to integrate trail design concepts into mangrove protection and sustainable use. The proposed trail routes and types for Lantian mangroves generally align with the site's ecological conditions and conservation needs. However, during the construction phase, the design plan and routes should be optimized based on real-time ecological monitoring data, translating design drawings into precise spatial arrangements and actionable

implementation plans. During implementation, it is also necessary to flexibly adjust the plan, maintaining sensitivity to ecological changes. Mangrove trails serve as bridges between human production-living spaces and natural habitats, mitigating direct human impacts on the wetland ecosystem and providing an important approach for its protection and sustainable use. The application of design results helps promote the transformation of the value of ecological products contained within the mangrove ecological space into 'mountain gold and silver', transforming ecological advantages into tangible public welfare benefits.

Acknowledgments

Thanks to the Danzhou Natural Resources Bureau and Shenzhen Zhongda Environmental Protection Science and Technology Innovation Engineering Center Co., Ltd. for their assistance during the investigation process. This paper also benefitted from the Hainan Province Ecological Restoration Special Fund (HNZY2020-033) and the Zhongkai Youth Startup Fund (KA180581314), Key Area Special Project of Science and Technology Service s for Rural Revitalization in Ordinary Higher Education Institutions of Guangdong Province (2023ZDZX4021) and Zhongkai Degree and Graduate Education Reform Research Project (YJSJY202401).

References

Arfan, A., W. Sanusi, M. Rakib, M.F. Juanda and I. Sukri. 2024. Mangrove ecosystem management strategy to support sustainable development goal 14. *Environ. Res., Engin. Manage.*, 80(1): 64-76.

Bachri, S., T. Mútia, Sholeha, A.W. Sholeha, P.I. Rahmasyah and R.P. Shrestha. 2024. Mangrove forest management strategy in Bedul, Banyuwangi: Collaboration between community and Alas Purwo National Park for sustainable ecotourism development. *Geo. J. Tour. Geosites*, 52(1): 85-97.

Chang, Y.L., J.J. Liao and L. Zhang. 2024. Spatio-temporal changes and trends of global mangroves. *Act. Ecol. Sin*., 44(9): 3830-3843.

Gargaran, J.P.S., R.D.Y. Capuno, V.F.P. Novicio, C.C. Petiluna, C.E.T. Catalba, D.A.P. Paras and J.J.C. Garces. 2024. Mangrove ecosystem in Asia: review and synthesis of ecosystem services and economic valuation methods. *Environ. Exp. Biol.*, 22(2): 59-70.

He, Y.H., D.S. Zhang, B.W. QIU, Y.T. Li, Y.S., Han and X.Z. Liu. 2019. Characteristics and common relationship between mangrove community and mangrove community in China. Chin. *J. Ecol*., 38(8): 2326-2336.

Hu, L., T.S. Chen, L.T. Gu and R.L. Wang. 2022. Study on the design of scenic greenway - a case study of the design of the second phase of Qingshan Lake Greenway. *Chin. Land. Arch.,* 38(S1): 59-64.

Johnson, S.L. 2008. An Overview of the National Trails System Act, *Taproot. A Journal of Outdoor Education*: 18(2): 7.

Li, Z., X.L. Li, Y. Jiang and M.X. Zhang. 2024. Combining scenery into a path: an indigenous concept of creating scenic trails. *City Plan. Rev.*, 48(03): 123-124.

Liao, B.W. and Q.M. Zhang. 2014. Area, distribution and species composition of mangroves in China. *Wet. Sci.*, 12(4): 435-440.

Liu, L.L. and Y.L. Jia. 2015. A research overview on trail system at home and abroad. *J. Guizhou Com. Col.*, 28(3): 37-40.

Lukoseviciute, G., L.N. Pereira and T. Panagopoulos. 2021. Sustainable recreational trail design from the recreational opportunity spectrum and trail user perception: A case study of the Seven Hanging Valleys. *J. Ecot.*, 1-22.

Ma, X.M., J.M. Wei, X.M. Hu, L. Shen and H.M. Yuan. 2020. New idea of national land and space ecological restoration: Guangdong greenway and blueway planning. *Planners*, 36(17): 26-34.

Marion, J.L. 2023. Trail sustainability: A state-of-knowledge review of trail impacts, influential factors, sustainability ratings, and planning and management guidance. *J. Environ. Manag.*, 340: 117868.

Meadema, F., J.L. Marion, J. Arredondo and J. Wimpey. 2020. The influence of layout on Appalachian Trail soil loss, widening, and muddiness: Implications for sustainable trail design and management. *J. Environ. Manag.*, 257: 109986.

Meng, X., P. Xia, Z. Li and D. Meng. 2016. Mangrove degradation and response to anthropogenic disturbance in Maowei Sea (SW China) since 1926 AD: Mangrove-derived OM and pollen. *Org. Geochem.*, 98: 166-175.

Polidoro, B.A., C.T. Elfes, J.C. Sanciangco, P. Helen and K.E. Carpenter. 2011. Conservation status of marine biodiversity in oceania: an Analysis of marine species on the IUCN red list of threatened species. *J. Mar. Biol.*, 1: 1093-1097.

Ruan, L.L., M. Yan, L. Zhang, X.S. Fan and H.X. 2022. Yang. Spatial-temporal NDVI patem of global mangroves: A growing trend during 2000-2018. *Sci. Total Environ.*, 844: 157075.

Sasmito, S.D., M. Basyuni, A. Kridalaksana, M.F. Saragi-Sasmito, C.E. Lovelock and D. Murdiyarso. 2023. Challenges and opportunities for achieving Sustainable Development Goals through restoration of lndonesia's mangroves. *Nat. Ecol. Evol.*, 7(1): 62-70.

Srifitriani, A., T.R. Soeprobowati and S. Puryono. 2025. Empowering communities in mangrove ecotourism: A pathway to sustainability and climate resilience in Bengkulu City. *E3S Web of Conf. EDP Sci.,* 605: 03039.

Valiela, I., J.L. Bowen and J.K. York. 2001. Mangrove Forests: One of the World's Threatened Major Tropical Environments: At least 35% of the area of mangrove forests has been lost in the past two decades, losses that exceed those for tropical rain forests and coral reefs, two other well-known threatened environments. *BioSci.*, 51(10): 807-815.

Xiao, Y. 2023. Design of coastal greenways under the background of rural revitalization: Taking the coastal greenway project of Cangnan Dayukou scenic area as an example. *Mod. Hort.*, 46(22): 187-189.

Xie, H.L. and Z.Y. Li. 2023. Multi-agent collaborative mechanism and path for realizing the value of ecological products in the field of natural resources. *J. Nat. Resour.*, 38(12): 2933-2949.

Xie, X.X. 2016. Research On Mao Lan He Kou National Wetland Park of Heilongjiang Province Trails System Design. *Chin. Acad. Forest., Beijing*, 1-80.

Xin, X., X.Q. Song, J.R. Lei, Z.S. Fang and Q.W. Meng. 2016. Mangrove plants resources and its conservation strategies on Hainan. *J. Trop. Biol.*, 7(4): 477-483.

Yao, J. and D.H. Chen. 2022. Research on the engineering design and aesthetic value evaluation of coastal wetlands-a case study of the mangrove wetland of Zhanjiang City's Sea Watch Promenade. *Acad. J. Environ. Earth. Sci*., 4(7): 42-48.

Ye, Y.H., B. Xiao, H.J. Feng, Y.L. He, P. Chen, X.Y. Chen, D.D. Wang, Z.X. Zeng and X. Guo. 2022. Researches on the pattern and route of ecological product value realization from the perspective of rural revitalization. *Ecol. Environ. Sci*., 31(02): 421-428.

Yu, Q., S.L. Lin and W.J. Mo. 2013. The development and management of national scenic trails for America: take Appalachian National Scenic Trail for example. *Urban Plan. Inter*., 28(4): 108-114.

Zheng, J. and Y. DU. 2020. A study on the Planning and Management of American Florida National Scenic Trail. *Chin. Land. Arch.*, 36(12): 123-128.

Zhu, Q., K.J. Yu and D.H. Li. 2005. The width of ecological corridor in landscape planning. *Acta. Ecol. Sin.*, 25(9): 2406-2412.