Research Paper

Resilience strategies for ecological restoration of the industrial shoreline of Dongting Lake: a case study of Yueyang Hualing Port shoreline

Yini ZHU, College of Landscape Architecture, Beijing Forestry University, CHINA

Chi LI, College of Landscape Architecture, Beijing Forestry University, CHINA

Abstract

Dongting Lake is a crucial regulation and storage lake in the Yangtze River basin and a significant ecological security barrier in China. Yueyang Hualing Port wharf is close to the intersection of Dongting Lake and the Yangtze River, which has undertaken diversified ecological, social and economic functions since ancient times. However, due to industrial invasion and shoreline solidification, the natural shoreline of its natural rocky-bay shape was destroyed, flooded constantly, and the surrounding city, environment, and industry declined.

By using a literature review, field study, GIS analysis, and other techniques, the historical photographs, satellite photos, and data on the current terrain, water system, and vegetation were acquired for this article. Analyzing the historical evolution traits and ecological fragility issues first on the basis of this. Then, to investigate, historical shoreline morphology, and environmental texture structure, the natural plant community structure of Yueyang Hualing Port shoreline. Finding the resilient components of the natural shoreline.

Finally, four primary shoreline spatial resilience strategies are proposed in this paper which are 1) Reshaping the site topography to restore the natural rocky-bay shoreline and reproduce the ancient natural geographical characteristics of the shoreline. 2) Building hidden a dike to resist flood disasters and improve the landscape. 3) Selecting plants in the water-level fluctuation zone with significant elevation differences creates flexible space. 4) Updating the service function of the site and continuing the cultural characteristics to provide a public space for the surrounding communities, maintain physical and mental health, and prevent disasters from achieving the harmonious coexistence of man and nature and healthy and sustainable development in the future. Furthermore, it provides a reference for the ecological restoration of the industrial shoreline in the Dongting Lake area.

Keywords

Resilience strategy, Ecological restoration of industrial shoreline, Dongting Lake

1. Introduction

1.1. Dongting Lake shoreline

A natural shoreline is a unique and irreplaceable resource. It cannot be repaired after being destroyed. It serves as the cornerstone for preserving ecological security and planetary stability. One of the factors

contributing to the artificial degradation of natural shorelines is an industrial invasion. Industrial invasion causes wetland resource encroachment and degradation, riparian ecosystem contamination, and the destruction of biological habitats. The natural shoreline now occupies the same significant place as grassland, marsh, and forest in terms of ecological space and natural resources in the overall design of the national ecological civilization.

Dongting Lake is a significant regulating and storing lake with a significant potential to store floodwater in the Yangtze River Basin. The natural shoreline of Dongting Lake has recently suffered damage due to land reclamation, climate change, and human encroachment. The dwindling of the lakefront wetland, the decline in biodiversity, and the major environmental contamination are just a few of the difficulties brought on by industry's erosion of the lakeshore line. The protection is crucial right now and is about to happen. Improving the coastal environment has increased importance in investigating Dongting Lake's ecological protection.

1.2. Resilience concept and shoreline resilience strategy

Canadian ecologist Holling put forth the resilience method in his 1973 publication, "Resilience and stability of ecosystems." Initially, the term "resilience" was used in engineering to define a system's capacity to bounce back after a disruption. Resilience method has been popular in recent years in environmental study and practice. The concept of resilience has currently been steadily integrated in the ongoing research on coastline restoration, and some results have been attained. Using Brooklyn Bridge Park as an example, Lu Feng et al. (2016) outlined the adaptable waterfront park's development method in New York in response to climate change. They also discussed the waterfront park's design principles. Xueyuan Deng , et al (2018) proposed the concept of resilient revetment. And she proposing that under the premise of satisfying the function of revetment and flood protection, resilient revetment has the function of engineering, ecological and cultural services. Luoqi Chen , et al (2018) created an elastic landscape system in the low-lying coastal areas of Boston. In order to achieve sustainable development in the real sense, a complete waterfront community development system that can respond to disasters, save ecological energy, and protect economy and environment is established. Zhou Manni , et al (2021) proposed the resilience design strategy of Huaihe River main stream shoreline in Huainan City in three aspects of flood safety, ecological health and public health. It not only improves the landscape effect of urban flood embankment water conservancy projects, but also designs a variety of ecological landscape corridors with additional functions. However, there is little research on the resilience strategy to realize the ecological restoration of industrial shoreline after the comprehensive analysis of history, culture, space and format.

2. Study area, analytical framework, and data

2.1. Study area: Yueyang Hualing Port shoreline

The study area is the Yueyang Hualing Port dock shoreline which belongs to one of the industrial dock shorelines in the Dongting Lake area, Hunan Province. East of this area is South Dongting Road, West Dongting Lake, North Baling Plaza, and South Hanjiawan Street, with the 1.2 km Dongting Lake shoreline. The study area is divided into two parts, including 18.3 hectares of the western dock area and 13.5 hectares of the eastern historic district, a total area of about 31.80 hectares (Figure I).

With a natural rocky-bay shoreline, Yueyang Hualing Port Wharf was the city's first trading wharf in ancient times. It had a sizable population and a thriving economy. The neighborhood had deteriorated as the metropolis had moved east. Later, due to industrial invasion, the natural scenery of the old wharf was

lost, and the lake shoreline was hardened. The natural lakeshore region was converted into a place of the industrial industry. Overall, the industrial invasion caused several ecological and environmental issues, and this area became a specific brownfield industrial area that had been abandoned. Now, Yueyang Hualing Port is surrounded by residential areas, commercial and trade areas, squares, historical gardens, etc. It is a significant component of the urban landscape axis and has excellent development potential. An important route to improving Yueyang City's ecological civilization construction system and the surrounding ecological environment is to address the environmental drawbacks of the plot in order to make the lake shoreline self-repairable and rejuvenate the area.

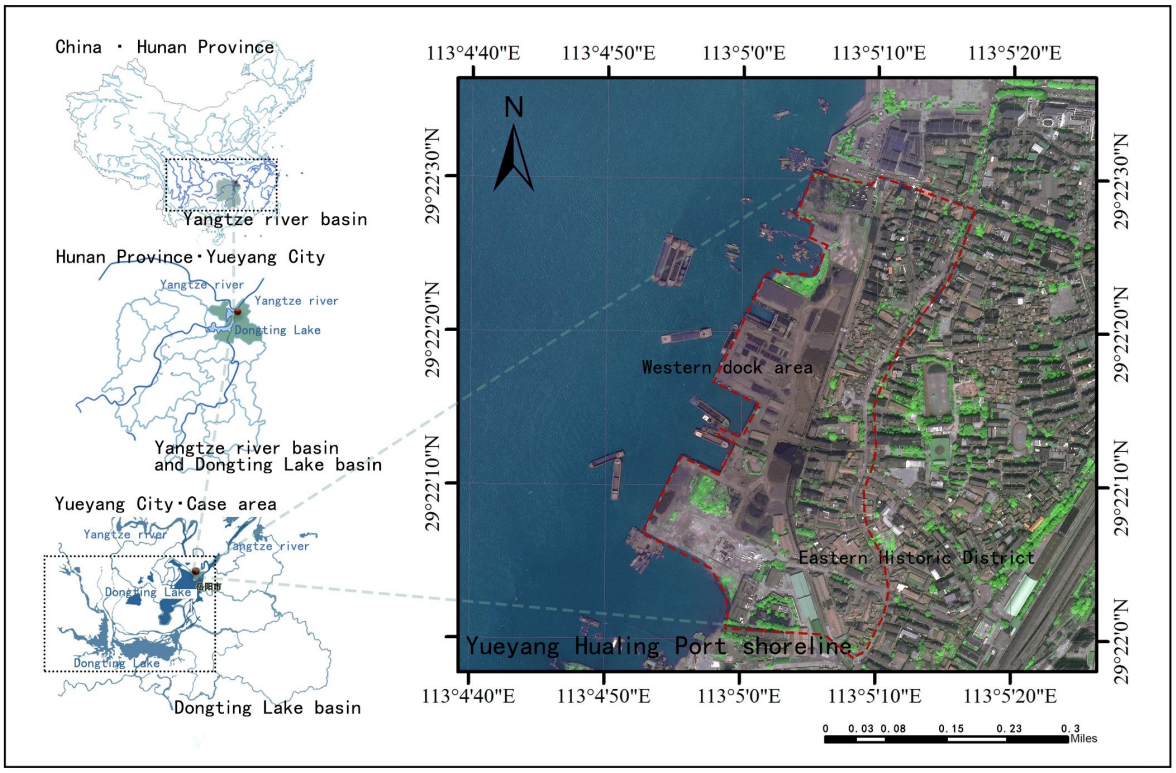


Figure 1. Study area: Yueyang Hualing Port shoreline. Source: Author self-painted.

2.2. Analytical framework

First, this study collects, organizes, and analyzes the data using a literature review, field investigation, GIS analysis, and other research techniques. The site's historical resilience traits, planning needs, and current unresolved issues were then examined. Afterward, considering how to apply the site's historical resilience elements and the new requirements of the new era planning to the site problem solving and exploration, and deriving the resilience strategy of the site ecological recovery.

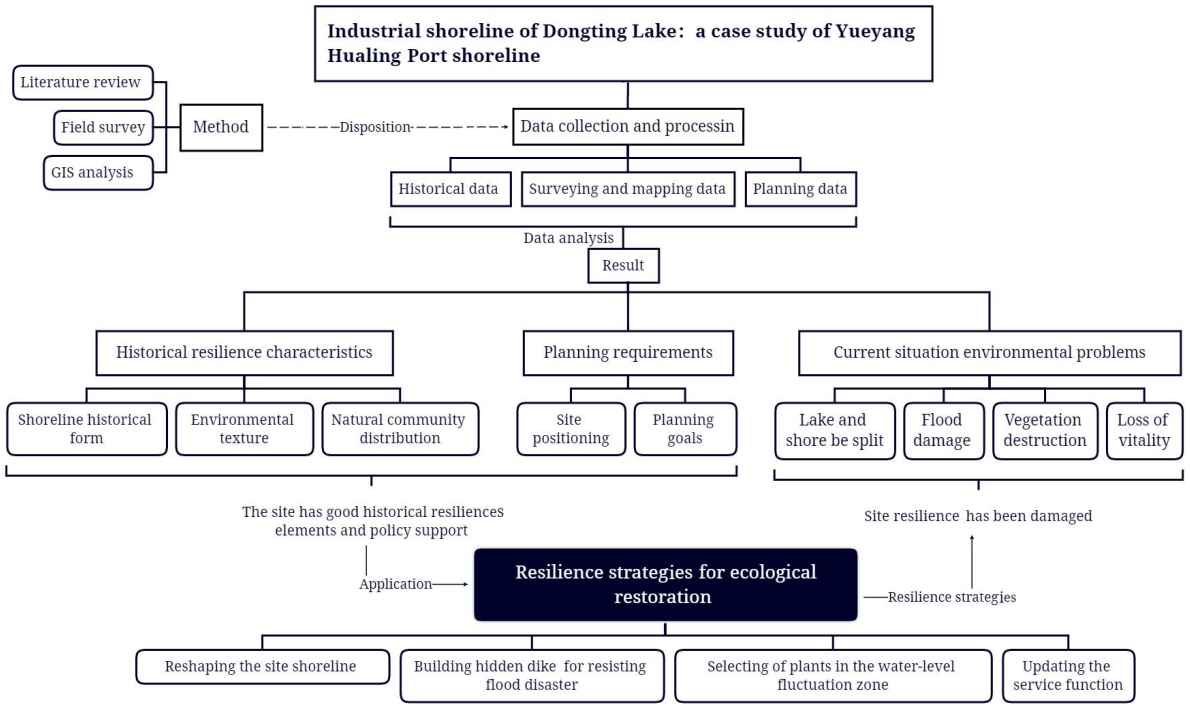


Figure 2. Research technology roadmaps. Source: Author self-painted.

2.3. Data

This study's primary sources of data include elevation, slope, vegetation, hydrology, pictures from old books of history, and upper planning diagrams. The data comes from the Yueyang city landscape remote sensing test report, yueyang Tower scenic area CAD topographic map, ASTER GDEM 30M resolution digital elevation data, meteorological data, yueyang hydrological center records Dongting lake hydrological data(Table 1).

Table 1: Data and Data sources. Source: Author self-painted.

	Data	Data Source
historical data	Historical and ancient images	Yuezhou Prefecture Records, Fangyu SummaryDongting Lake Records, Historical Images
Surveying and mapping data	Elevation	Yueyang Hualing Port Terminal CAD topographic map, ASTER GDEM 30M resolution digital elevation data,Site survey for supplementation
	Slope	Analysis based on DEM data
	Vegetation	Yueyang city landscape remote sensing test report
	Hydrology	Yueyang Hydrology Center
Planning data	Flood prevention regulations	Yueyang City Master Plan Flood Control Plan
	Nature of land use	Yueyang City Master Plan (2008-2030), Yueyang City Master Plan (2008-2030), Dongting South Road Historical and Cultural District Protection Plan (2013-2030), Yueyanglou Dongting Lake Scenic Spot Master Plan (Revised)

2.4. Data processing

This study mainly uses the methods of literature review, field investigation and GIS analysis to grasp the historical and cultural characteristics of the site, the problems existing in the current situation, and the positioning and development goals of the site.

(1) Historical data

Reading and Analyzing the images of ancient historical books such as ' Yuezhou Prefecture Records ' Fangyu Summary ' Dongting Lake Records ' and so on by using the literature review method to master the historical development context, ancient shoreline morphology, historical and cultural characteristics of the site.

(2) Surveying and mapping data

First, the SRTMDEM 30m resolution digital elevation data is adjusted according to the CAD topographic map of the Yueyang Hualing Port Terminal. Additionally, using ArcGIS analysis to acquire the elevation, slope, and aspect data. The vegetation type, road grade, water distribution, and other data in the research region were preliminarily determined through the analysis of the satellite remote sensing photos in conjunction with the topographic map and the field survey. The terrain, water system, vegetation, and historical buildings inside the site are also mapped and recorded using the field investigation approach, which is also utilized to augment and improve the current data.

(3) Planning data

The upper planning of Yueyang City Master Plan (2008-2030), Dongting South Road Historical and Cultural Block Protection Plan (2013-2030), and Yueyang Tower Dongting Lake Scenic Area Master Plan (revision) (2012-2025) were studied by literature review. Moreover, the analysis of site flood control regulations, historical building distribution, cultural relics protection, and other characteristics; the superposition method is used to overlay the positioning requirements of the site in the upper planning to obtain the future land use nature of the site.

3.Results

3.1. Historical resilience characteristics

Yueyang is built beside Dongting Lake, with a long history, and rich historical and cultural resources. Yueyang had no country fair until the Song Dynasty. In the Ming Dynasty, the county government schools were moved to the research area, and the regional country fair continued to develop. Then the overall pattern of regional streets and alleys began to form in the Qing Dynasty, and three major trading terminals caused busy markets. After 1938, the region steadily deteriorated due to a change in the emphasis on urban development and conflict. Even worse, when Industrial Wharf was built in 1956, the industry took over the area's natural shoreline, significantly harming the ecological ecosystem.

Restoring the shoreline of Hualing Port in Yueyang City requires insight into history and culture, innovation, and the continuation of context. The site's distinctive shoreline shape, street texture, and natural community are the consequence of long-term adaptation to nature, practicality for life, and resilient growth of the site. This is due to long-term historical evolution and cultural inheritance.

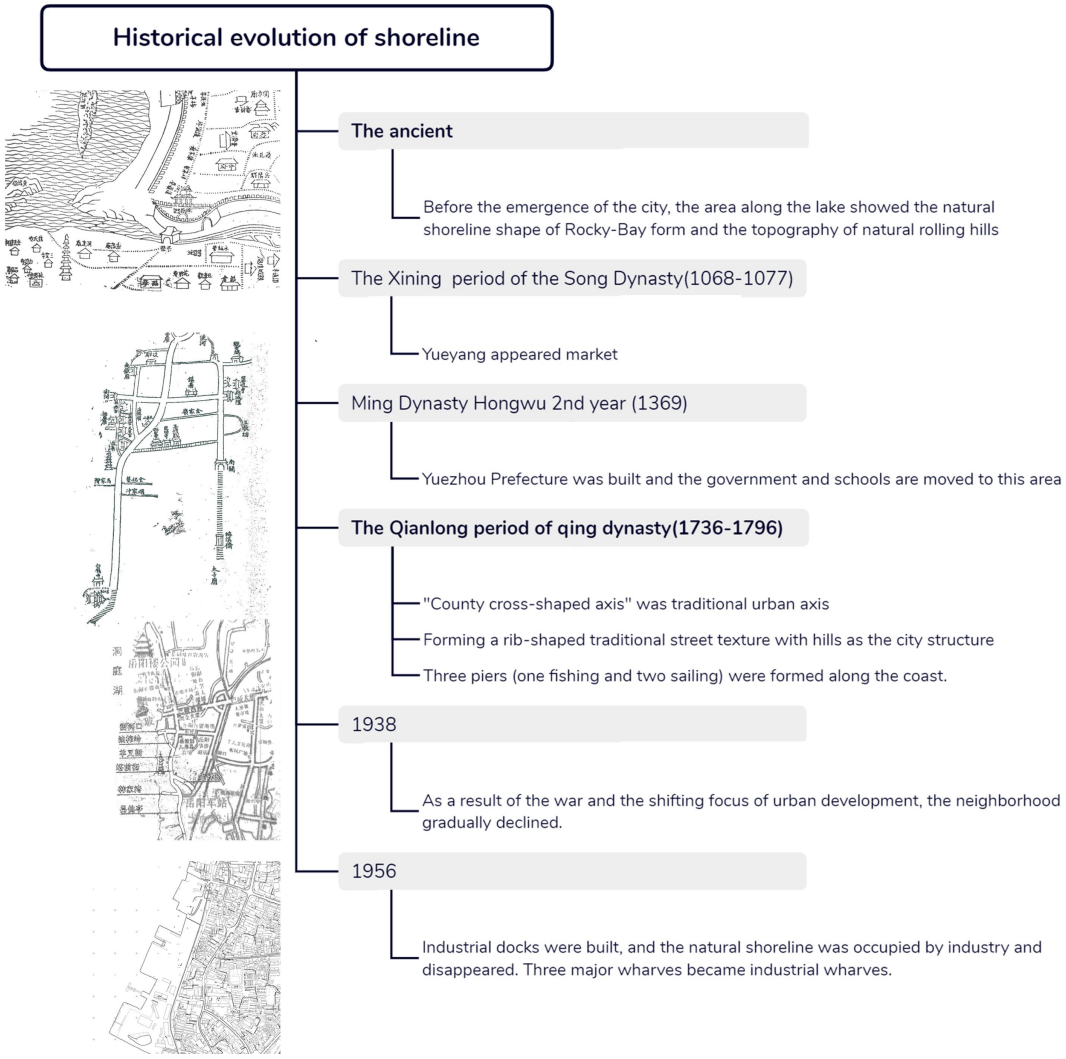


Figure 3. Historical timeline analysis graph. Source: Author self-painted.

(1) The evolution of the shoreline historical form

The literature review collected the schematic diagram and old photos of the site before 1956. It was found that the site had preserved the natural water shoreline before the industrial invasion (1956), showing the shape of the 'rocky-bay ' water bank. 'rocky-bay 'was rock projecting over water. The site was composed of three rocky areas, and the bay linked the rocky areas to form a concave and convex lake shoreline. Three rocks developed into a fishing dock and two sailing docks, which bear the surrounding residents' trade, transportation place, and commercial prosperity.

Dongting Lake's natural surroundings have historically taken the form of rolling hills. The topography of rolling hills on the edge of Dongting Lake was recorded in "Chu Ci-Tian Wen." Rolling hills mean small hills stuck together, which are naturally undulating. Rolling hills terrain and the shoreline of the 'rocky-bay ' shoreline have been the stable geomorphic features of the shoreline for a long time.

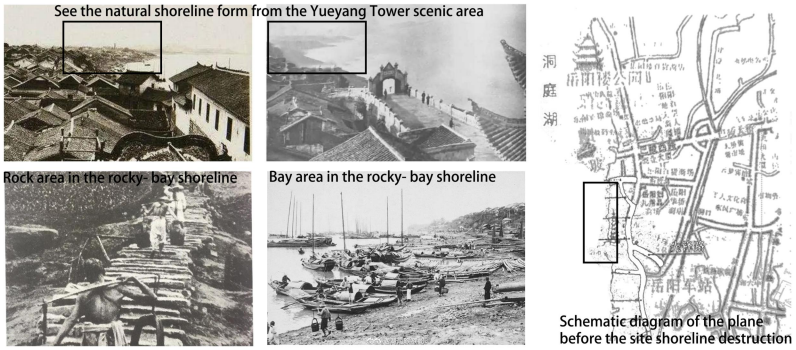


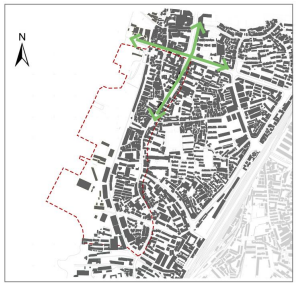
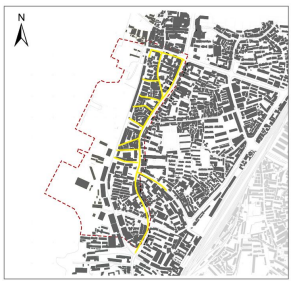
Figure 4. Historical photos. Source: Internet.

(2) Environmental texture structure

With a nearly 900-year history, the street texture culture of Yueyang City's Hualing Port shoreline area began in the Song Dynasty, developed in the Ming Dynasty, and was stereotyped in the Qing Dynasty. There was a stable overall pattern of the cross axis in the Qing Dynasty, namely the north-south axis composed of the original Diaoqiao Street, Tumen, and Cishi Tower near Baling Square, and the east-west axis composed of Tumen, town hall, and county god temple at the street's estuary. The population multiplied, resulting in a more prosperous business downtown.

The overall pattern forms the rib-shaped traditional street texture, which includes many historical streets. Different types of buildings have emerged in the region to meet the needs of the public as the street pattern has formed and developed. According to the current visit and literature review, there are 46 existing historical buildings in the region from various periods. Furthermore, the site's surrounding historical building resources are abundant, including Yueyang Tower, LvXian pavilion, and others. The selection of long-term environmental resilience resulted in the site's traditional environmental texture.

Table 2: Environmental texture structure. Source: Author self-painted.

The overall pattern	Street pattern	Historical building
County Cross Axis	The ribbed traditional street texture and historical streets include Shangci's Lane, Guerilla Lane, River Lane, Yuzhaling Street, Jiehekou, Shangda Lane, Wanshougong Lane, Nanyue Lane (Fish Lane), Changgun Lane, Dongting South Road, Fish Lane, Zhuyin Street, Majiawan Street	46 existing historical buildings of different ages
		

(3) Natural community distribution

The distribution of natural shoreline communities before the industrial invasion was explored from the ancient poetry describing shoreline, the natural shoreline that has not been destroyed in the Dongting Lake area, and the existing research papers on the community of Dongting Lake area. The natural plant communities on the shoreline of Dongting Lake show prominent zonal hierarchical distribution characteristics. In the state of natural growth, the most typical characteristic community species are Digitaria, Carex, Polygonum hydropiper, and so on (Hou, Z.Y. etal., 2016).

3.2. Situation environmental problems

Industrial and living docks, stacks, and freight yards were scattered around the lake shore of the Valin Port wharf region of Yueyang City following the industrial invasion of the site in 1956. The natural shoreline was all gone. There were five significant issues with the waterfront industrial shoreline, including shore separation, flood disaster, vegetation destruction, vitality loss, and site loss of resilience.

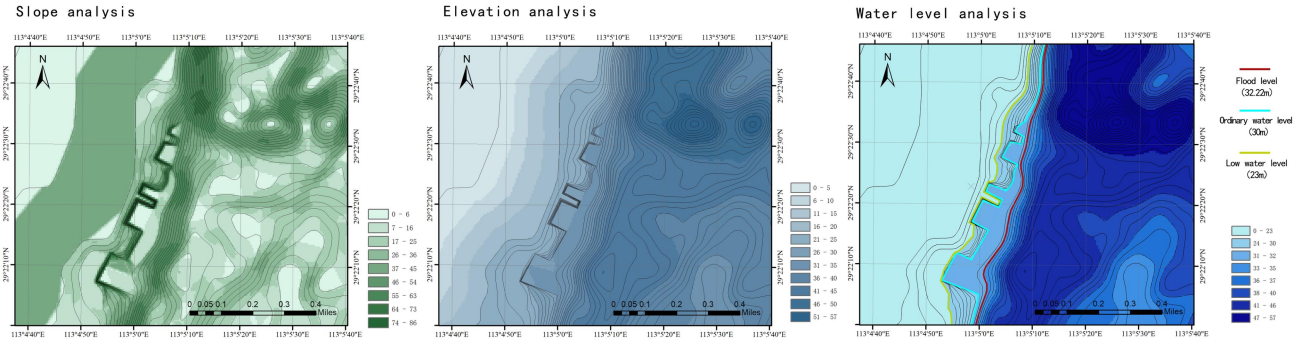


Figure 5. Slope, terrain, water level analysis map. Source: Author self-painted.

(1) Lake and shore be split

By Gis and other software to analyze the site topography, Yueyang City Hualing port wharf area elevation distribution in 23m-57m, including waterfront wharf area 23m-34m. The height disparity results in a fault state. The original natural slope of the rocky bay has also been transformed into a vertical hard revetment. Furthermore, Dongting Lake's water surface and shoreline height differ by roughly 10m, with a slope of close to 90°. Following the industrial invasion, the hard revetment caused the biological habitat in the lakeshore area to vanish, and the site's natural environment was severely harmed.

(2) Flood damage

According to the statistical data of Yueyang Hydrology Center, the flood level of Yueyang Hualing Port Wharf is 33.22 m, the normal water level is 30.0 m, and the dry water level is 23.0 m. Based on the topography, the west of the region, except for the southeast along the lake, are all below flood level and significantly impact the eastern historical block. Following the planning standards, the land is protected to the Yellow Sea elevation standard of 35.22 m. Currently, the site's flood control is far from standard, and the waterlogging interferes with the block's normal operation.

(3) Vegetation destruction

The construction of a wharf and industrial production sites led to the disappearance of the natural shoreline of the site, and the natural vegetation community in the original riparian zone of Hualing Port in Yueyang City was destroyed. There are only industrial relics and scattered green space in the western lakeside site, including abandoned rails, gantry cranes, concrete mixers, and so on. Although industrial

construction on the site is currently suspended, the vegetation in the area is challenging to recover naturally due to pollution. There are just 33 tall trees in the western historical block along South Dongting Road. There is no sheet of green space along the street, and the amount of green space in the area is woefully inadequate, so the ecological landscape design of the scenic area cannot be reflected.

(4) Loss of vitality

Although the street texture still exists, due to the lack of unified planning for the status quo of the shoreline area of Hualing Port in Yueyang City, new buildings inside the site deviate from the traditional ductile buildings resulting in the fuzzy texture of the site. In addition, this phenomenon causes chaotic architectural style, disorderly spatial organization, and chaotic overall style. Furthermore, the site's public facilities function old, with poor visual effect, which affects the lake landscape. Visitors can not be close to the lake because of the lack of open and public activity space. Those problems led this area to lose its vitality.

3.3. Planning requirements

The site planning requirements in the future are obtained by analyzing the existing site planning. On the one hand, in the west of the site, the area will be determined of the first-class protected areas, scenic spots, folk customs, and tourist areas by analyzing upper planning ' Yueyang City Master Plan ' (2008-2030), ' Dongting South Road Historical and Cultural Block Protection Plan ' (2013-2030), ' Yueyang Tower Dongting Lake Scenic Area Master Plan (revision) '. On the other hand, the ' South Dongting Road Protection Plan ' defines the eastern part of the site as commercial, residential, religious, and wide-field land. The superposition method is used to analyze the upper planning, and it is concluded that the future goal of the near-water bank part of the west of the site will be to design the future urban park with the ecological restoration as the core and the scenic sightseeing function to meet the needs of different groups. The west will be a historical protection block. Although the site has been destroyed, the site has good historical resilience elements and policy support, laying the foundation for ecological restoration.

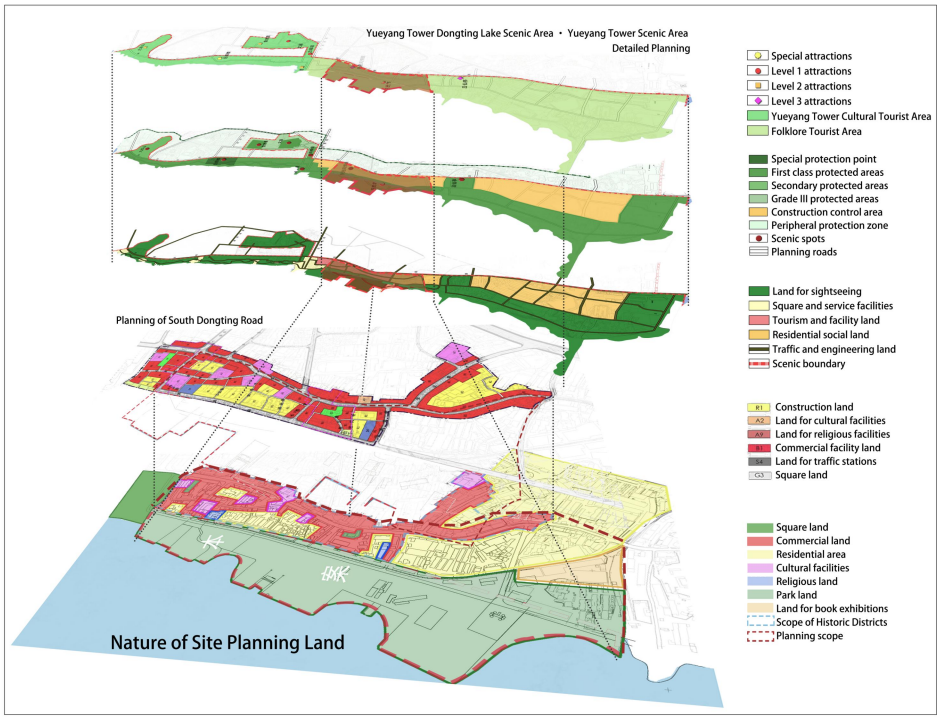


Figure 6. Topplan overlay analysis diagram. Source: Author self-painted.

4. Resilience strategies

From the analysis of environmental history toughness characteristics, it is concluded that the site has a deep historical and cultural heritage, and rich historical landscape resources around and inside. However, there are some problems in this area. In order to solve the current environmental problems and restore the regional ecology and vitality, the ecological restoration resilience strategy is extracted from the historical resilience factors of the site and the planning requirements of the new period from four aspects of the shoreline of Hualing Port Terminal.

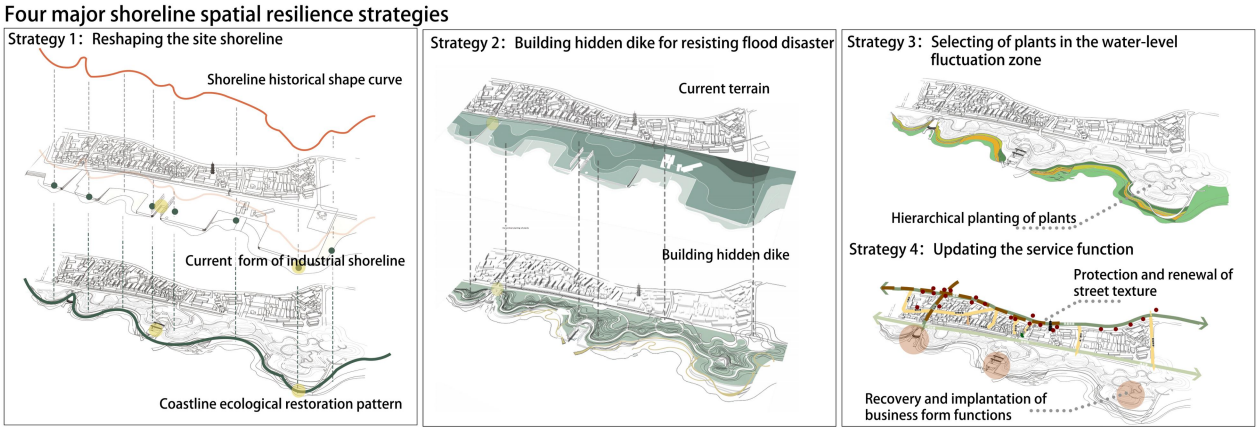


Figure 7. Schematic of four major resilience strategies. Source: Author self-painted.

4.1. Reshaping the site shoreline

In order to solve the problem of the waterfront separation of Hualing Port shoreline, the resilience strategy adopted is to restore the natural trend of the water system, transform the rigid revetment of the wharf, and shape the new 'rocky-bay 'ecological shoreline pattern.

For the rock area, it is suggested to transform the vertical rigid revetment facade of the wharf according to the natural rocky form so that it is more suitable to the historical form and restore the toughness ability. Furthermore, the border-to-bank ratio was determined to be 1: 2-1: 3 based on the site status characteristics and the natural rocky landform of the Yangtze River. Moreover, the height difference of 6 m was stratified and eliminated by a three-stage stone box withdrawal above 26 m (the distribution boundary of Dongting Lake wetland community). Then 23-26m natural slope into the lake.

For the bay area, based on protecting the natural form of the bay, appropriate artificial intervention is carried out to make the bay area and the rocky natural transition. Based on the reconstruction of the new 'rocky-bay ' shoreline, a series of measures are taken to promote the natural restoration of the shoreline habitat and biological resources, such as repairing the bottom of the lake, natural sediment silting, allowing lake floodplains, and providing habitat for organisms. Finally, wetland plant planning and habitat environment optimization restore the complete natural water ecosystem.

4.2. Building a hidden dike for resisting flood disaster

The problem of flood disaster can be solved by shaping an artistically hidden dike and scientific rainwater management. On the one hand, according to the water level elevation of 35.22 m planning requirements control, imitating Yueyang natural rolling hills terrain, setting up continuous ' micro hills ' and form the art of hidden embankment to solve the flood problem. This measure avoids the secondary damage to the

site caused by the hard levee. On the other hand, the methods are applied in the low-lying area to the east of the hidden dike, combining rainwater discharge with micro-topography and adopting surface ecological facilities such as shallow ditches and hollow green spaces, and rain ponds. Based on sufficient infiltration and retention of rainwater, the amount of outflow rainwater is reduced, the effective management of rainwater is realized, and the landscape is improved on the basis of ensuring no waterlogging in the site.

4.3. Selecting of plants in the water-level fluctuation zone

According to the characteristics of the zonal distribution of vegetation types in Dongting Lake wetland, shoreline plants are arranged to let shoreline have the function of elasticity and self-healing to solve the problem of vegetation destruction in the fluctuating zone, choose different plant communities to plant, through natural work gradually restore its natural habitat. The different elevations of natural plant communities in the graded retreat and gentle slope wetland, such as 26-30m selection of Salixs triandra L., Miscanthus sacchariflorus, reed community, 23-26m selection of Carex, Polygonum community, 23m below is no vegetation area. At the same time, a multi-stage artificial wetland can purify rainwater into Dongting Lake.

4.4. Updating the service function

Relying on streets and industrial sites to rebuild the site so that the site to regain vitality and attract people. Also, the business format is introduced in the region so that the site is connected with the surrounding Yueyang Tower scenic spot, Baling Square, and Dongting South Road Historical and cultural block into an organic whole to solve the problem of the loss of vitality of the shoreline.

(1) Protection and renewal of historical street texture in the east

First, according to the "Plan of Dongting South Road Protection", protect the 12 historical streets of Dongting South Road, such as fish Lane, Nanyue Lane, Street, and estuary, and protect the historical buildings in the site. The specific protection measures shall protect the main features and overall features of the traditional dwellings in the block, such as building height and traditional style, and protect the urban texture pattern composed of the streets and traditional dwellings.

The second is demolishing the buildings without value and affecting the overall spatial structure. The buildings with good structure and poor style and not affect the overall spatial structure will be transformed and updated according to the style of residential houses in northern Hunan.

Third, updating the traditional functions of buildings into a place for cultural display, catering, and accommodation.

(2) Shaping and Operation of the West Urban Park Scene

First, in order to ensure the safety of tourists, commercial format and park service facilities are arranged east of the hidden dike, and to the west of the hidden dike, some non-polluting industrial sites retain the industrial memory of the site and reproduce the cultural characteristics of the fishing yardstick by using the water surface.

The second is to create various park scenes, interpret history, inherit culture, and reproduce the life scenes such as downtowns in the Ming and Qing dynasties. Moreover, providing places for residents and tourists to enjoy and achieve the restoration of site formats and the sustainable development of the site.

Figure 8. The west Park shoreline part of the scene is illustrated. Source: Author self-painted.

5. Conclusions

This study uses the Yueyang Hualing Port shoreline in the Dongting Lake area as an example to explore the resilience strategy of industrial shoreline ecological restoration. It aims to protect and restore the unique resources of the natural lake shoreline and provide a reference model for the ecological restoration of the industrial shoreline in the Dongting Lake area.

Hualing Port in Yueyang is a typical area of Dongting Lake industrial shoreline. By analyzing its historical resilience characteristics, this study puts forward three major resilience factors, namely, the shoreline shape of 'rolling hill + rocky bay', the street environment texture of 'cross axis + rib pattern', and the natural plant community of 'band + stratification'. Combined with the planning requirements, this study proposes four spatial resilience strategies of shoreline to solve the problems of water shore separation, flood disaster, vegetation destruction, and loss of vitality. With the intention of reversing the disadvantage of the site, to regain the beautiful vision of harmonious coexistence between man and nature, and healthy and sustainable development in the future.

The innovation of the research is reflected in the recovery strategy of the industrial shoreline proposed in this paper, which is based on the comprehensive analysis of the resilience elements contained in the historical natural shoreline and the current ecological and environmental problems. It is proposed to consider more ecological, economic, cultural, social, and other resilience factors rather than directly use modern high-tech technologies for indiscriminate restoration. The proposed strategy is more targeted. It reflects the site's uniqueness, contributes to the natural restoration of the site ecology, continues the site's historical context, and activates the site's vitality as a catalyst.

It should be noted that this study still has much room for improvement in data analysis. However, the research ideas and methods can provide a reference for the recovery of ecological resilience of Dongting Lake shoreline. In future research, we hope to further focus on more macro environment of Dongting Lake shoreline.

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