Study on the Ecological Landscape Design of Yawei Creek Wetland Based on LID

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Abstract. In recent years, many cities in China have built sponge cities to cope with the flood disaster faced, and Hainan province has taken the lead in carrying out the "ecological restoration and urban repair" urban double repair pilot work. Based on the LID strategy, take the wetland landscape design of Yawei Creek in Haikou city as an example, wetland landscape ecological design strategies are introduced, including landscape design for water transmission, river channel design, plant planting design and road system design. This paper analyses methods and discusses the urban rain flood management approach, to improve the management level of urban rainwater and provide a good reference for the construction of ecological landscape with regional characteristics in Hainan province.

1. Introduction.
With the acceleration of the urbanization process, the urban area continues to expand, and the original green land and farmland are covered by buildings or roads and other hard pavement, and the natural ecological system of the city has undergone great changes. In terms of hydrologic process, excessive urbanization leads to an increase in the probability of sudden heavy rain in urban areas, a decrease in the infiltration area of rainwater, an increase in the confluence rate, and the failure of timely discharge of rainwater, making urban waterlogging a common occurrence [1]. Hainan province has also carried out wetland protection by establishing various wetland reserves and parks. How to construct the ecological wetland landscape to deal with the urban rain flood problem and highlight the regional characteristics of Haikou city so as to give full play to the role of wetland park should be considered in the design.

2. Overview of the research area.
Yawei Creek, a tributary of the Nandu River, flows through Haidian island in Haikou city, Hainan province. The construction area of Yawei Creek Wetland is located in the north of Haikou People's hospital, which is connected to the Haidian Wuzhong road of in the north, and to the east of Renmin Avenue and Heping Avenue in the west. The total length is 0.9km, the river is about 60m wide, and the planning and design scope is 6.7ha2 (Figure 1).
3. Low impact development design theory.

Low impact development (LID) technology stressed by adjusting the development mode, integrated into the landscape planning and design method, from the source of urban rainfall runoff process controls. Low environmental interference basic maintain site hydrology condition before and after the development of consistent, thereby weakening the fast urbanization and impervious ground surge produced negative effects. Compared with traditional storm management and design methods, the core features of LID measures are source control, decentralized treatment and landscape integration\(^2\). LID mainly includes: ecological grass swale, sunken green space, rain garden, green roof, underground seepage storage and permeable pavement\(^3\). LID is suitable for both new city development and old city reconstruction. LID can effectively control the pollution of the receiving water body by the pollutants brought by the rain wash. The infiltration of rainwater can also provide certain groundwater recharge for the rivers and lakes, which plays an important role and significance in improving the ecological environment of the city\(^4\).

LID technology originated in the United States. It has a short development history in China and is still in the initial stage of exploration and attempt. The relevant theoretical system has not been fully established. The relevant researches and practices in China are limited to the scale of urban districts, and mainly focus on the discussion of engineering facilities. There is a relative lack of macro-scale rain-flood management planning aiming at rain flood management, water quality protection and landscape comprehensive effect\(^5\). However, practical experience shows that LID measures can be well integrated with urban infrastructure, which not only reduces the impact and damage of rainstorm on urban ecological environment, but also has economic, environmental and social benefits such as low construction cost and good landscape effect\(^6\). The idea of dispersion and convergence provides a
good indication for urban rain flood management and will further promote the construction of sustainable rain water management system in line with China’s national conditions. At present, with the continuous deepening of LID concept over the years, its concept has been extended to various fields of urban construction, becoming a new urban development model of harmonious coexistence between city and nature\(^7\).

4. Ecological landscape design of Yawei Creek Wetland.
As a safe sponge body of urban rain flood, Yawei Creek wetland is an important part of urban green infrastructure in Haikou city. In order to set up the ecological water collection and purification system as the target, according to the LID criteria, the paper puts forward that under the premise of site conditions, the permeable paving, grass swale and green space area should be used to effectively reduce the surface runoff from the source. Specifically, its ecological landscape design mainly includes four parts: first, the landscape design of water transmission. Second, river channel design. Third, plant planting design. Fourth, road traffic system design.

![Figure 4. Yawei Creek wetland site plan.](image)

4.1. Hydrological design.

4.1.1. Rainstorm Intensity. The designed rainstorm intensity is calculated by using the rainstorm intensity formula newly compiled by Haikou city. The formula is as follows:

\[
q = \frac{2272.659 \times (1 + 0.555 \log P)}{(t_1 + t_2 + 17.246)^{0.616}}
\]

- \(P\) - Year return period, \(P = 1\).
- \(t_1\) - The ground water catchment time.
- \(t_2\) - Flow time of rainfall in canal.

The time of collecting water on the ground is affected by factors such as topographic slope, ground paving, ground planting, flow distance, longitudinal slope of road, etc. These factors directly determine the velocity of water flow along the ground or the side ditch. According to the Design Specification for Outdoor Drainage (GB50014-2006, 2016 edition), the time of surface water collection mainly depends on the length of distance, topographic slope and ground covering, etc. Generally, 5-15min is adopted, and 10min is taken for the river channel after comprehensive consideration.

The circulation time of rainwater in the canal refers to the circulation time when rainwater enters the pipeline from the rainwater mouth and finally drains into the river channel. It is related to pipe length, slope, flow rate and pipe properties. According to the general runoff time of stormwater pipes
in the urban area of Haikou city is close to 1h, so \( t = 60 \text{ min} \) in this project, the calculation results show that the rainstorm intensity in 1 year is \( 144.89 \left( \text{s} \cdot \text{hm}^2 \right) \).

4.1.2. Runoff Coefficient \( \psi \). The runoff coefficient is determined according to the ground cover of catchment area, ground slope, geomorphology, distribution of building density and pavement paving. According to the Design Specification for Outdoor Drainage (GB50014-2006, 2016 edition), the drainage design integrated flood runoff coefficient value is 0.65.

4.2. Landscape design for water transmission.
As the main water conveyance landscape, grass swale is a landscape surface ditch drainage system for planting vegetation \(^7\), mainly including standard transmission grass planting gully, dry grass swale and wet grass swale \(^8\), which can effectively slow down the rate of rainwater runoff, purify water body and achieve good landscape effect. The area between Haidian Wuzhong Road in the north and Heping Avenue in the east is set as the catchment area of planting grass gully. According to the actual topography and traffic routes, the catchment area of planting grass gully is divided into three parts (Figure 4). The proportion of each catchment area is shown in table 1.

| Grass Swale | Length (m) | A: Catchment area \( (\text{m}^2) \) | Proportion (%) |
|-------------|------------|-------------------------------|---------------|
| -1          | 180        | 3560                          | 7%            |
| -2          | 200        | 9770                          | 19%           |
| -3          | 400        | 36820                         | 74%           |

The design flow rate \( (Q) \) is calculated as follows:
\[
Q = \psi q A \times 10^{-7}
\]
Calculated according to the above formula, the design flow of three planting and grass furrows in the 1 year recurrence period can be obtained, which are 0.034 m\(^3\)/s, 0.092 m\(^3\)/s and 0.347 m\(^3\)/s respectively, where the maximum value is 0.347 m\(^3\)/s.

The longitudinal slope of standard transmission grass ditch should be 1%~5%, while the maximum vertical slope of dry grass swale should not be more than 2.5%. This project combines the climatic conditions of frequent and large rainfall in Haikou city, and the design flow value under the 1-year recurrence period is small, so it is advisable to choose the dry planting grass swale, and choose the small longitudinal slope of 1%. In this project, the grass planting ditch will be set on the Haidian Wuzhong Road and beside the plank road (below the road elevation) measured by Yawei Creek, so the slope coefficient is 1/3.

Coarse gravel was selected as the material for planting grass swale, and its manning coefficient \( n_0 = 0.024 \). The Manning’s Roughness Coefficient of the regular grass ditch was \( n_1 = 0.005 \). The Manning’s Roughness Coefficient \( n_2 = 0.000 \) in the furrow with small changes. The Manning’s Roughness Coefficient \( n_3 = 0.000 \) is not set for grass swale weir. In order not to affect the landscape effect, the Manning’s Roughness Coefficient \( n_4 = 0.025 \) was selected for the vegetation of grass swale with medium height. According to the designed path of the walkway, some sections of the grass swale are curved, and its Manning’s Roughness Coefficient \( m_5 = 1.150 \).

The formula of Manning’s Roughness Coefficient \( (n) \) is as follows:
\[
n = (n_0 + n_1 + n_2 + n_3 + n_4) \times m_5, \quad n = 0.062
\]
The formula for calculating the sectional size of the planting gully is as follows:
\[
Q = A_s R^{2/3} S^{1/2} / n
\]
\( Q \)—Design Discharge \( (\text{m}^3/\text{s}) \)
\( A_s \)—Discharge section area \( (\text{m}^2) \)
\( R \)—Hydraulic radius \( (\text{m}) \)
\( S \)—Canal bottom slope.
According to the above formula, the size of the water-flowing section of the herbage ditch can be calculated. Combined with slope slope, horizontal width at the top and other values, such as depth and horizontal width at the bottom can be obtained (Figure 5).

![Cross sectional parameters of grass swale.](image)

**Figure 5. Cross sectional parameters of grass swale.**

### 4.3. River channel design.

#### 4.3.1. Slope protection design.

The frontier is an area for landscape architects that can be changed, rebuilt and reshaped. The duality of border landscape is its main characteristic [9]. Yawei Creek with an average of 0.52 m of water, revetment border with the water tide has brought the rich landscape changes. The existing site boundary is cut off by the hard revetment, and the new design connects the boundary with the gentle ecological free gentle slope. When Yawei Creek is at low tide of 0.73m (1985 national elevation benchmarks), the gentle slope of wetland boundary is covered by rich and luxuriant waterfront plants. Walk on hydrophilic plank road, side is rapid urbanization brings the motor vehicle driving fast, on the other side is low impact development under the quiet wetland landscape. When the high water level comes, the area below 1.25m is submerged by the water, leaving only the standing plants and some bushes on the slope protection. Residents can still walk through the wetland park through the water-wet boardwalk. Compared with the rich plant landscape community at low water level, the wetland park at high water level has a broader landscape view, bringing different spatial feelings.

#### 4.3.2. Revetment design.

Due to lack of treatment and the discharge of surrounding sewage, the Yawei Creek channel is in poor water condition, which further leads to the deposition of a large number of silt along the riverbank, resulting in a single water flow pattern and poor regional hydrodynamic force. Therefore, the design adjusts the shoreline structure according to the channel hydrodynamic model, and constructs several ecological islands in combination with the landscape effect. The spindle-shaped shape of the ecological islands are able to dredge the water body, and the island is densely planted with mangrove plants to further purify the water, while providing a habitat for birds.
4.4. Plant planting design

Wetland plant in purifying water quality, and beautify the environment, especially the mangrove tree species play an enormous role in the provide habitats for animals, Yawei Creek wetland plant design fully consider the status quo and the existing vegetation ecological demand, ecological priority, graceful landscape around two aspects to carry on the design. Specifically, it is divided into three categories: first, mangrove trees, as the main plant type of ecological purification; Secondly, common tropical trees and shrubs are the main landscape plants in wetlands. Thirdly, aquatic plants of the ground cover can increase the types of plant species in the wetland, enrich the landscape level of the wetland, and improve the spatial heterogeneity of the wetland.

4.4.1. Mangrove trees. Mangrove trees mangrove trees are mainly planted between the river and the boardwalk, with a total planting area of about 1.3hm². Based on the analysis of the growth status and adaptability of mangrove plants in the site, six kinds of mangrove plants were finally selected, which can effectively adapt to the water quality of Yawei Creek and form a stable plant community. Including Aegiceras corniculatum (Linn.) Blanco, Kandelia candel (L.) Druse, Rhizophora stylosa Griff, Bruguiera sexangula (Lour.) Poir, Acrostichum aureum, Bruguiera gymnorhiza (L.) Lam. Among them, the Kandelia candel (L.) Druce can not only promote the formation of soil sediments, filter organic matter and pollutants, and purify water quality, but also can resist the impact of tides and floods, slow down the waves, regulate the flow of water and protect the embankment, almost year-round flowering also has a good landscape effect.

4.4.2. Common tropical trees and shrubs. There are a large number of tropical plants on both sides of the river road. Design in the field to grow in good condition, landscape trees survived with better effect, also planted some new trees, enrich the wetland landscape. Ceiba speciosa, Roystoea regia (HBK.) O.F. Cook with Barringtonia racemosa (L.) Spreng, Hibiscus tiliaceus Linn, Pandanus tectorius Parkinson var. sinensis Warb. in form scattered plant landscape.

4.4.3. Aquatic plant. River slope protection on both sides of the planting of Pennisetum alopecuroides (L.) Spreng, Axonopus compressus (Sw.) P. Beauv, ground cover plants can effectively prevent soil erosion and play a certain aesthetic role. Ruellia simplex C.Wright and Cyperus alternifolius has strong ability to resist drought, barren soil and salt-alkali soil.
4.5. Road system design
The traffic planning of Yawei Creek wetland needs to meet the commuting and recreation needs of residents in the north bank and staff in Haikou People’s hospital in the south bank, including ecological trestles on both sides of the river and pedestrian roads on the bank. The main traffic roads in the park are made of ecological permeable concrete, permeable brick and other materials, which can effectively promote rainwater infiltration. Infiltration can not only reduce the flow of surface runoff, but also replenish groundwater, which is of great significance to alleviate the shortage of groundwater resources and prevent seawater intrusion in coastal areas [5].

The river traffic is given priority to with the original tour river road network, connection on both sides, meet the demand of residents daily commuting and sports. Permeable bricks are laid on the road surface to facilitate the rapid infiltration of rainwater into the drainage network and river channels. There are ecological trestle bridges in the river, which form a winding recreation space along both sides of the river, and shuttle between the ecological island and mangrove plants to achieve the purpose of education and popularization of science. Considering the human flow and ecological needs, the trestle adopts pervious concrete material to meet the ecological requirements while ensuring the support strength.

![Permeable paving](image)

Figure 7. Permeable paving.

5. Conclusion.
Guided by the concept of LID, this paper discusses Yawei Creek wetland in Haikou city, which plays a very important role in urban rain flood management, water purification and regional water balance. In the design process, the original site environment is well protected, and ecological management and restoration are carried out to the greatest extent, while providing a more friendly and beautiful living environment for the surrounding residents. Generally speaking, rain and flood management with LID is mainly reflected in the following three aspects:

5.1. Dredging river to collect rainwater and constructing the revetment rainwater chain. The grass swale on the north bank of Yawei Creek forms an ecological rain water chain in the north of the site. The rainwater is collected and managed by planting gully and then reabsorbed into the municipal sewer, which effectively solves the problem of rainwater and sewage merging. According to the cross section size calculated by Haikou city precipitation, it can scientifically and effectively meet the requirements of local rainstorm and reduce the construction cost at the same time.

5.2. Reshaping the shoreline and improving the hydrodynamics of the river. Yawei Creek flow regime is single, and the existing local hydrodynamic condition is poor, which is prone to fill. Through the construction of ecological island, the river shoreline is well combed, and the hydrodynamic force of Yawei Creek is improved, creating a comfortable natural environment and providing a good habitat for nearby plants and animals.

5.3. Uniting people and nature and strengthening the dual water cycle. Ecological grass swale and other green infrastructure purify the area around the water effectively and reduce water pollution, the exogenous promoted social water circulation and the connection between the natural circulation,
exogenously promoting social water circulation and the connection between the natural circulation. The entire construction process always follows LID concept, effectively improves the Yawei Creek water conditions and shows the regional features of Haikou city, to promote the construction of the city of sponge.

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