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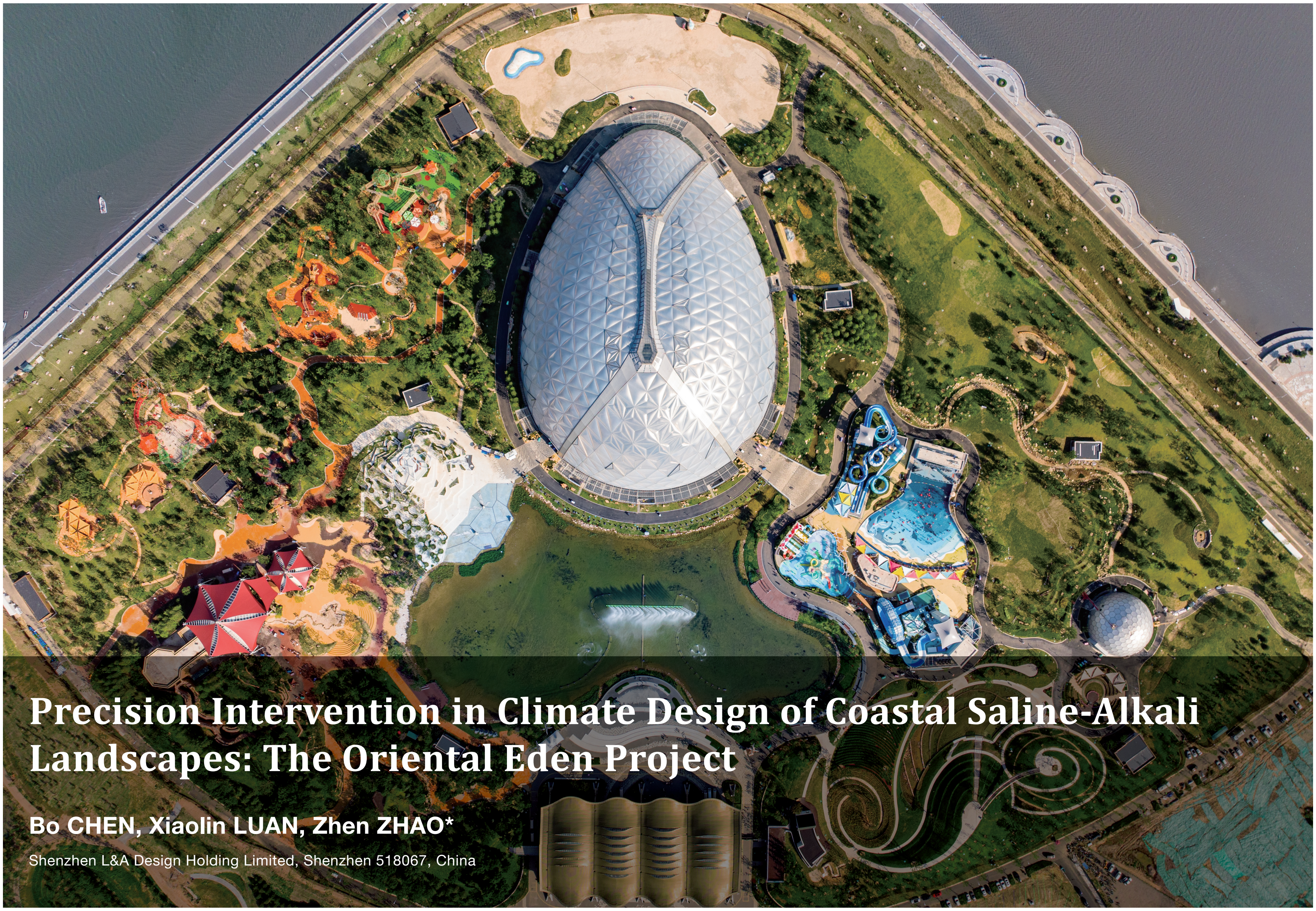

Precision Intervention in Climate Design of Coastal Saline-Alkali Landscapes: The Oriental Eden Project

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Fig. 1 The design features three thematic zones: Water-Extreme, Water-Quality, and Water-Abundant.

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FEATURES

Climate Design; Coastal Saline-Alkali Soil; Ecological Restoration; Precision Intervention; Interdisciplinary Collaboration; Water Cycle; Parametric Design

PRACTICE REFLECTIONS

- This project applies the climate design that targets salt migration and water imbalance, offering a mechanism-oriented strategy for saline-alkali landscape restoration
- By integrating hydrological regulation, soil remediation, and parametric habitat design, it links ecological performance with spatial and programmatic design
- This approach requires high initial investment and long-term adaptive management, which may limit its scalability in resource-constrained contexts

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Fig. 2 On the north coast of Jiaozhou Bay in Qingdao, a reclaimed saline-alkali wasteland is transformed into a hydrological science education park.
Fig. 3 A targeted saline-alkali drainage system integrating subsurface blind pipes and surface open ditches is established.

1 Introduction

In the context of rapid climate change and urbanization, coastal salt marshes have become a key concern in landscape architecture and climate design. Conventional engineering restoration is often cost-intensive and may further disrupt ecological processes, while passive conservation measures such as designating ecological reserves have limited effectiveness in enhancing land value.

The Oriental Eden project is located on the north coast of Jiaozhou Bay in Qingdao City of Shandong Province, China, where land reclamation has produced severely saline terrain with low ecological function and limited public use. In response, the project explores an integrated approach combining ecological restoration and spatial transformation. This article proposes an analytical framework of “precise diagnosis–targeted restoration–resilience construction–experience translation” to examine climate-responsive design under extreme conditions.

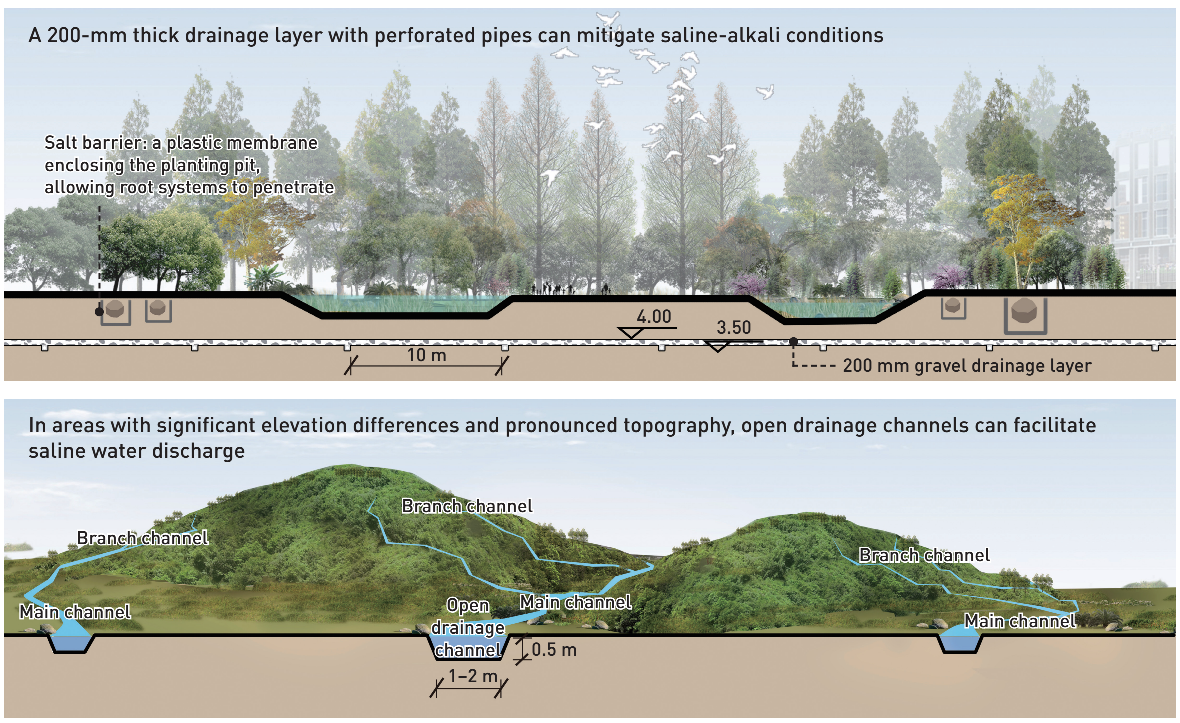
2 Precise Diagnosis: Core Ecosystem Challenges

The project is located on a 26.67 hm^2 reclaimed coastal salt marsh site with a fragile ecosystem characterized by high soil salinity, strong winds, limited freshwater availability, and a disrupted hydrological system. Field measurements indicate that the groundwater table averages 1.8 m in depth (maximum 3.5 m), enabling continuous upward transport of salts via capillary action. With an annual average wind speed of 5.3 m/s, strong coastal winds accelerate surface evaporation, intensifying salt accumulation as moisture dissipates. At the same time, freshwater supply is insufficient: the theoretical rainwater availability cannot meet landscape demand, resulting in a persistent hydrological imbalance.

3 Targeted Restoration: Technological Integration and Ecosystem Strategies

3.1 Systematic Ecological Restoration of Saline-Alkali Soil

The restoration strategy focuses on



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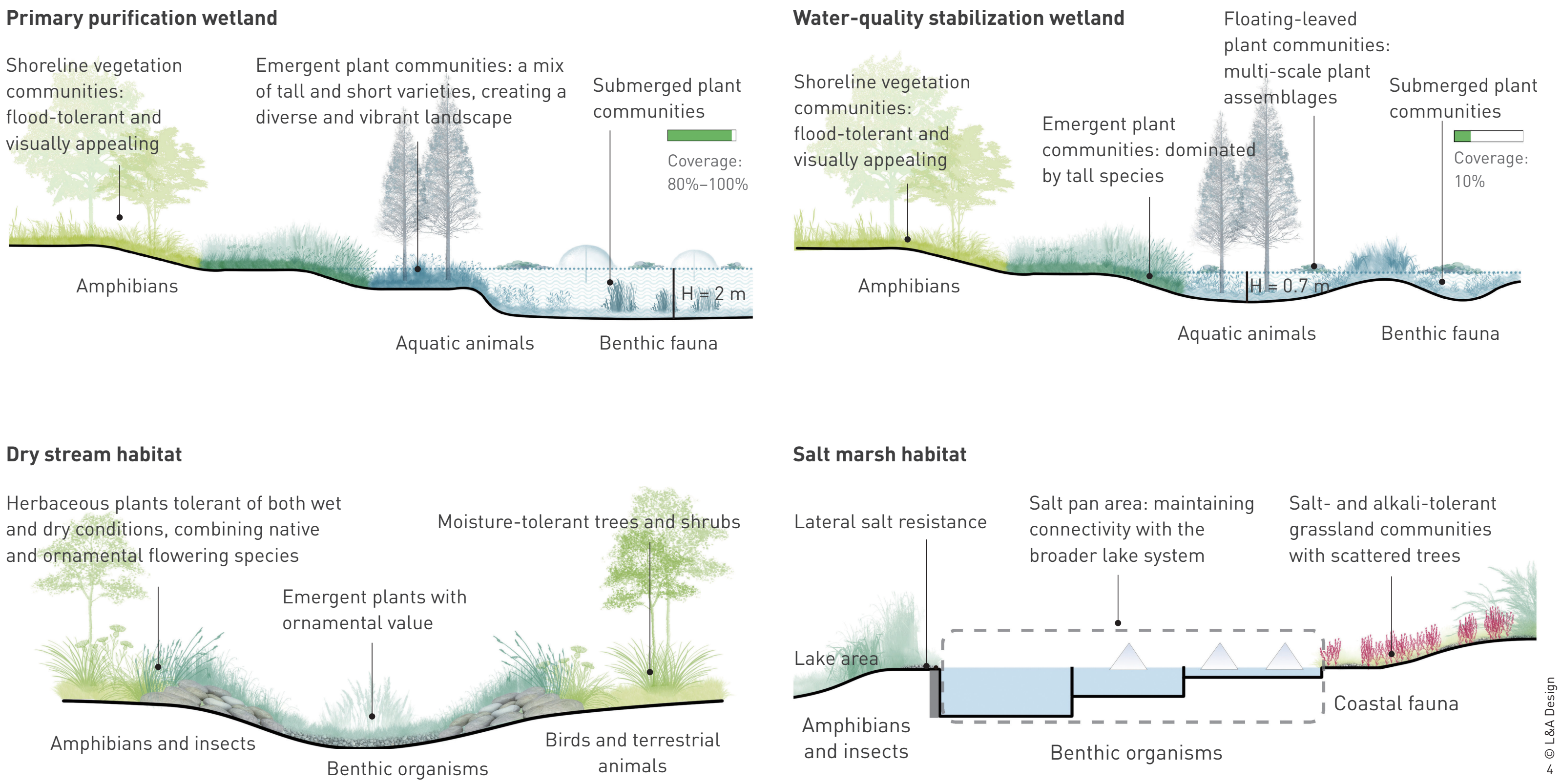

Fig. 4 The ecological water purification wetland system integrates ecological, landscape, and science education functions.

interrupting capillary salt migration by defining a critical elevation threshold. Based on the average groundwater level and its seasonal fluctuations, as well as the decrease in soil salinity with elevation, a minimum elevation of 3.8 m was established to exceed the critical capillary rise height and block upward salt transport.

This principle was implemented through a combined system of underground blind-pipe salt drainage, physical salt isolation layers, and salt-tolerant pioneer plants. A network of blind drains and open ditches was configured according to groundwater depth, with subsurface drainage applied in areas with shallow groundwater and surface drainage used where groundwater depth exceeds 3 m. The subsurface system consists of gravel filtration layers and drainage pipes arranged at regular intervals, forming a hierarchical network that connects to external drainage infrastructure. To further prevent lateral salt intrusion into planting areas, localized salt isolation measures were implemented around planting areas. Surface drainage was organized in response to site topography, combining main channels and branch ditches to facilitate runoff conveyance, supplemented by vegetated swales to enhance infiltration and ecological performance.

Through this integrated approach, soil conditions were substantially improved, with vegetation coverage reaching 78% and carbon sequestration increasing by 40%.

3.2 Closed-Loop Water Resource Management

A closed-loop water cycle system was established to integrate supply, circulation, and purification, thereby balancing the site's water budget. Based on hydrological analysis, the annual rainwater availability was estimated at 182,000 t, meeting approximately 65% of landscape demand. Harvested rainwater and reclaimed water were jointly used, reducing freshwater consumption by about 15,000 t per year. A circulation system centered on a central lake connects surrounding water bodies through gravity and mechanical pumping, while hydraulic structures such as weirs regulate water levels and maintain system stability.

Water quality has been improved through a multi-stage ecological purification system combining constructed wetlands and ecological revetments. Primary purification and water-quality stabilization wetlands were arranged in the lake and terraced areas, while a surface-flow wetland was applied in the western stream. Through sequential processes of filtration, sedimentation, and biological uptake, the system removed 1,250 kg of nitrogen and 175 kg of phosphorus annually, improving water quality from Class IV to Class III.

In parallel, sponge city strategies were integrated through terrain shaping and permeable landscape systems to enhance stormwater management. By combining water bodies, green spaces, and infiltration

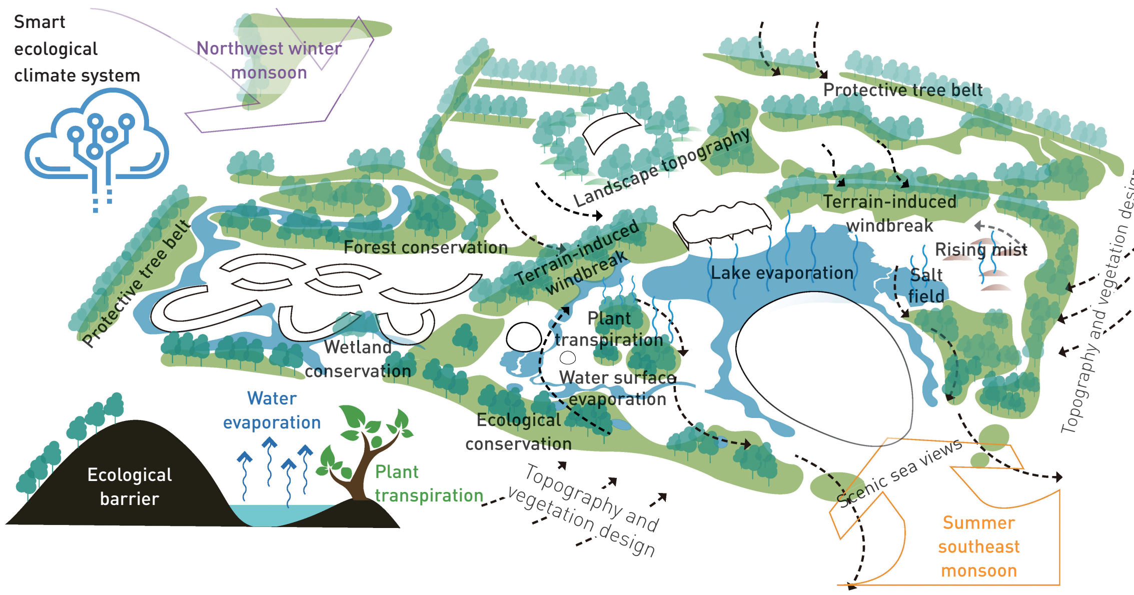

Fig. 5 The microclimate design through wind field simulation and analysis.
Fig. 6 The distinctive habitat in the Water-Extreme Zone is shaped by characteristic plant communities and native materials.

facilities, the design achieved an annual runoff control rate of 75% and a total suspended solids removal rate exceeding 60%.

3.3 Proactive Biodiversity Enhancement

Going beyond passive protection, parametric design was used to simulate and optimize biological corridors, proactively creating foraging and roosting habitats for regional flagship species based on simulations of their habitat preferences.

For representative migratory birds, such as *Platalea minor* and *Grus japonensis*, key habitat parameters—including foraging water depth (5–25 cm) and disturbance distance (200–300 m)—were incorporated into the design. These parameters informed the configuration of reed–Suaeda tidal flats and shrub–herb communities, providing shallow-water habitats (≤ 25 cm) suited to their ecological requirements. The introduction of diverse salt-tolerant plant species, predominantly native ones, further enhances ecosystem stability and connectivity for regional biodiversity.

4 Resilience Construction: Climate Adaptation Design

To address coastal climate constraints, including strong winds and heat accumulation, the project employed simulation-based design to guide spatial intervention.

Wind environment simulations based on Computational Fluid Dynamics (CFD) modeling were used to analyze seasonal conditions under prevailing summer and winter winds. Areas with low wind speed and poor ventilation were identified as heat-prone zones, where water bodies, vegetation, and mist systems were introduced to enhance evapotranspiration and mitigate the heat island effect. In contrast, high-wind-speed areas were mitigated through terrain modification and vegetation buffering. Rather than relying on uniform shelterbelt planting, the design adjusted spatial configurations based on simulation results, avoiding excessive wind blockage and local turbulence.

Climate adaptability is further supported through the use of corrosion-resistant materials and stress-tolerant plant species adapted to saline and coastal conditions. In addition, operational strategies such as seasonal programming and controlled indoor environments extend site usability and support long-term maintenance.

5 Experience Translation: Storytelling About Ecosystem Technologies

The design adopts “The Journey of a Drop of Water” as a narrative framework


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Fig. 7 Immersive educational space in the Water-Extreme Zone, demonstrating traditional hydrological wisdom.
Fig. 8 Underground river node revealing past water traces through stone paths, grooves, and fossils.
Fig. 9 Children can explore understory and shrub layers in the restored green space.
Fig. 10 Terraced platforms reinterpret remnants of the saline-alkali habitat.
Fig. 11 The Water-Quality Zone creates wetland habitats and improves water quality with aquatic vegetation.
Fig. 12 South of the Water-Abundant Zone, water-adaptive strategies are demonstrated through interactive features.

to translate ecological processes into spatial sequences. The Water-Extreme, Water-Quality, and Water-Abundant Zones correspond to different stages of the water cycle, structuring visitor movement and perception. Ecological infrastructures are selectively exposed and reinterpreted as spatial elements. Subsurface drainage systems and water purification processes are expressed through landscape installations, such as the "Salt Field Theater," while hydraulic mechanisms are incorporated into interactive facilities. This approach links technical systems with spatial experience design, making underlying ecological processes more perceptible to the public.

6 Practice Reflection

The project suggests that precision-based, mechanism-oriented intervention can provide a viable approach for ecological restoration in highly constrained saline-alkali environments, particularly when integrated with spatial and programmatic strategies. However, its applicability is conditioned by several practical constraints.

First, the project spanned nearly a decade of iterative processes, including soil amelioration, subsidence control, species introduction and acclimatization, prototype testing, and construction, indicating that such strategies may be difficult to replicate under limited financial or temporal resources. Second, although some ecological processes have been translated into spatial elements, key infrastructures remain largely invisible to the public, limiting the science communication of their operational logic. Third, it requires an adaptive management framework to ensure healthy ecosystem succession through continuous monitoring and fine-tuning. These limitations highlight that precision intervention is not a universally applicable solution, but a context-dependent strategy that relies on sustained technical, financial, and managerial support.

Competing interests | The authors declare that they have no competing interests.

Project Name: The Oriental Eden
Location: Qingdao, China
Size (area): 26.67 hm^2
Client: Qingdao Oriental Eden Cultural & Tourism Development Limited
Landscape Architecture: Shenzhen L&A Design Holding Limited
Principal: Baozhang Li
Project Team: Fangyue Li, Zhen Zhao, Yongzhen Ding, Xiaolin Luan, Hongkai Wei, Bo Chen, Jianyu Feng, Shengjiao Wang, Yanbo Li, Peng Jin, Tao Ding, Yanni Pan, Weiquan Wang, Wenchao Zhang, Kai Yao, Shuang Song, Yao Lu, Shuyan Zhang, Xintong Liu, Ning Wang, Chengqi Su, Zhongxiu Guo, Qing Wang, Yang Wang, Chensheng Zhang, Shihan Tao, Li Zhou
Collaborators: Grimshaw Architects LLP, Qingdao Jingge Landscape P and D Co., Ltd.
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