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Application of Constructed Wetlands to Treat Sewage by the Government in China

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Abstract: This study examines the deployment of constructed wetlands in China, focusing on their efficacy in water purification and ecological restoration, with a case study on the city of Wuxi. Constructed wetlands, which utilize natural processes to treat wastewater, represent a sustainable alternative to conventional methods. Despite their benefits in enhancing water quality and local biodiversity, these systems pose significant challenges, notably in land use and socio-economic impacts. The research highlights the conflict between environmental initiatives and urban development, exacerbated by land scarcity and housing affordability issues. This paper proposes strategies for optimizing wetland design and suggests policy adjustments to balance ecological benefits with urban development needs, aiming for sustainable urban planning.

Keywords: Constructed wetlands; Water purification; Ecological restoration; Urban development; Socio-economic impact; Land use; Housing affordability; Sustainable urban planning; Wuxi

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1. Introduction

In recent years, hundreds of wetlands have been constructed in China. Their main purpose is to purify the polluted water. However, many people doubt whether it is useful for the governments to spend so much money on constructing wetlands. To answer their question, we need to understand what constructed wetlands are, and their development history in China, and then analyze their advantages and drawbacks.

Constructed wetlands are treatment systems that use natural processes involving wetland vegetation, soils, and their associated microbial assemblages to improve water quality. Compared with Western countries, the application of artificial wetlands started later in China. In 1990, China's first artificial wetland was constructed in Bai Ni Kong, Shenzhen, for sewage treatment, and it was used as a base to carry out a series of studies and research [1]. There was a rapid development of artificial wetlands from 2000 to 2009. With the implementation of major projects on water pollution control and management, the research and application of constructed wetlands in China have been developed very fast. The number of papers increased rapidly, the artificial wetland is widely used in the treatment of many types of wastewater, and the deep treatment of tailwater of sewage treatment plants,

ecological restoration of lakes and rivers, and comprehensive remediation of small watersheds [2]. Since 2009, artificial wetlands have been widely used in various types of water treatment in China, and those constructed for water treatment have been combined with landscape and ecological environment protection and restoration to emphasize the effect of water treatment as well as the landscape and ecological effects.

A preliminary review indicates that previous studies primarily emphasize the advantage of constructed wetlands. For instance, water purified by artificial wetlands exhibits a more stable quality compared to those purified by machines. Additionally, artificial wetlands require low investment, energy consumption, and operating costs [3].

Some papers mentioned this technology's disadvantages. For example, constructed wetlands have encountered blockage problems, so an optimal solution is still being searched [4]. Moreover, they can be significantly affected by temperature fluctuations. For instance, the removal of ammonia and nitrate is adversely affected at low temperatures [5].

In conclusion, artificial wetlands are treatment systems that use natural processes to purify water. They have been widely used in China in recent years. Despite papers focused on their superiority and weaknesses, studies aimed at comparing their strengths and weaknesses are almost non-existent. This study's goal is to find out if it is worth it for the Chinese government to construct so many artificial wetlands by comparing the advantages and disadvantages of the artificial wetlands.

2. Case study

The primary research method for this study is a case study and secondary data analysis. This study will first introduce the current status of artificial wetlands in Wuxi. In the second stage of this study, existing problems faced by constructed wetlands technology in Wuxi and its positive effects will be identified based on a comprehensive review of current industry practices and academic research. Finally, once the problems and benefits of constructed wetlands technology are identified, the study can then conclude whether it is worthy to construct so many artificial wetlands. Moreover, some suggestions and thoughts about the improvement of this technology will be outlined, aiming to guide future development and application in similar contexts.

Wuxi is a city located adjacent to Taihu Lake. The latest data from the Wuxi Natural Resources and Planning Bureau shows that the city has 107,500 hectares of wetland retention, which accounts for 22.5% of its jurisdiction. Wuxi's wetlands are dominated by rivers, lakes, marshes, and artificial wetlands. Lake wetlands make up the majority at 61.5%, followed by artificial wetlands at 26.1%. Since 2007, Wuxi's agricultural department has steadily increased the number of artificial wetlands. They have built 28 wetland projects above the provincial level, with a total investment of 3.6 billion yuan, resulting in approximately 6,000 hectares of new wetlands.

The addition of these artificial wetlands has improved the local ecology. According to Lu Xiaohe, deputy director of the Wuxi Municipal Agriculture Committee and the Forestry Bureau, there were 163 bird species in Wuxi in 2007, and 22 of them have increased in number in recent years. Out of the 185 bird species, white egrets, mandarin ducks, crows, cuckoos, falcons, and eagles are classified as national second-class protected animals. Additionally, white frigatebirds, mandarin ducks, ospreys, black-winged kites, crows, and cuckoos are included in the Red Book of Endangered Animals in China. The rise in bird population in Wuxi is primarily attributed to the enhancement of the ecological environment and water quality through the construction of wetlands. The author's observations can also demonstrate the improvement in the local environment brought by artificial wetlands. The author lived in a community that previously had few birds, but recently she can see sparrows walking on the lawn, tits constructing nests on the trees, and crows flying in the sky. This may

be attributed to the construction of Daxigang Wetland Park, an artificial wetland which located near the community.

The development of artificial wetlands, while beneficial for ecological restoration, has also precipitated notable spatial and socio-economic challenges. Huang elucidates that the operational process of artificial wetlands, particularly those of the horizontal flow type, necessitates extensive land due to their low hydraulic loads. This expansive land requirement can impede further wetland development in areas with limited available land. Moreover, the absorption capacity of the substrates used in these wetlands is inherently restricted; they rapidly reach saturation, requiring the implementation of parallel wetlands operating alternately to maintain functionality and treatment efficacy.

This extensive land utilization has exacerbated land scarcity, directly impacting housing affordability in urban areas. For instance, the Daxigang Wetland Park in Wuxi's Xinwu District, which spans 3.8 million square meters, has been implicated in a sharp increase in local property prices — from 6,841 yuan/m^2 in 2010 to approximately 13,000 yuan/m^2 in 2023. The resultant housing market inflation has placed significant financial strain on many residents, pushing some to relocate to more affordable regions and thereby depleting the local labor force.

This situation has ignited considerable public discontent, as citizens attribute these socio-economic issues to the disproportionate land consumption by what they perceive as "insignificant" environmental projects. However, in response to the rising discontent and the adverse effects on urban dwellers, the city government has enacted policies aimed at mitigating these impacts. Notably, the introduction of enhanced housing subsidies for undergraduates from top global universities represents a strategic approach to alleviating the financial burdens imposed by the sprawl of artificial wetlands. This policy initiative indicates a move towards more balanced urban planning that considers both environmental sustainability and the socio-economic well-being of the community.

3. Conclusion and discussion

The widespread construction of artificial wetlands in China, notably in cities such as Wuxi, has significantly advanced ecological restoration and water quality enhancement. These wetlands utilize natural processes to treat wastewater, presenting a sustainable alternative to mechanical purification methods. The findings of this research underscore the benefits of constructed wetlands, including improving water quality and enhancing local biodiversity, especially bird populations.

However, this approach is not devoid of challenges. The primary concerns are centered around the extensive land requirements and the resulting socio-economic impact, particularly in terms of housing affordability. The study highlights how the expansion of wetland areas in Wuxi has led to an increase in property prices, exacerbating social issues such as diminished housing affordability for lower-income families. Although measures have been implemented by the government to mitigate these issues, the tension between environmental initiatives and urban development needs remains evident.

Moreover, the efficacy of wetlands in water purification can be variable due to external factors such as temperature, which impacts the biochemical processes essential for the treatment capabilities of wetlands. This variability emphasizes the need for ongoing research and adaptation of wetland management practices to ensure their effectiveness under various environmental conditions.

In summary, while constructed wetlands offer significant environmental and ecological benefits, their implementation must be judiciously managed to balance these advantages with the socio-economic realities

of urban development. Future research should focus on optimizing wetland designs to minimize land use and enhance treatment efficiency, as well as on policies that equitably address the socio-economic impacts of environmental conservation efforts. This balance is crucial for the sustainable integration of such ecological solutions within rapidly urbanizing areas.

This study calls for a nuanced appreciation of the intricate interplay between ecological technology and urban planning, urging a pathway forward that harmonizes environmental sustainability with social equity and urban development.

Disclosure statement

The author declares no conflict of interest.

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