A Comparative Case Study on Eco-Cities Among Chinese Failures/Cases and International Experiences

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Abstract. Creating an ecological environment is one of the sustainable paths along with burgeoning significance. Ecological cities (eco-cities) are prevailing to be embodied with the potential to transform urban landscapes into sustainable, human-centered, and ecological environments. However, the significant failures of Chinese eco-city development are barely compared with Western cases within a holistic system. By comparing the social, economic, and environmental factors between Chinese eco-city construction and successful cases, this paper aims to decode advantageous experiences, innovative paths, and insightful policies through a global lens. In detail, from the perspectives of society and institution, economy, environment, and the key performance indicator (KPI), this paper identifies the strengths of international cases and the weaknesses of Chinese cases, providing valuable references for policy-making and planning of eco-city development in China. The results show that China could learn to encourage bottom-up and active public participation, empower market involvement, emphasize ecological technology, and improve the KPI system. The findings will help failed ecological cities in China to foster their development.

Keywords: Eco-city, Comparative research, International case study, Chinese failure.

1 Introduction

Ecological city (Eco-city) is one of the most sustainable and prevailing urban development models. It is widely undertaken across the globe, especially in developing countries such as China. Since eco-city is a mongrel of diverse notions such as sustainable urban development, social ecology, and green cities (see Figure 1), the common definition is not explicit. Eco-city is a constellation of sustainable terms, hereby it is vital to learn from successful cases in different dimensions of society, institution, economy, environmental perspectives, and the key performance indicators (KPI). Nowadays, the Chinese Ministry of Environmental Protection approved 27 eco-cities, 42 eco-districts, and 34 eco-counties [1], with the goal of achieving a 'harmonious society' and coping with climate changes under a framework of 17 sustainable development goals of United Nations [2].

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Chinese eco-city development path is borrowed and learnt from the Western world. Nevertheless, the construction of an eco-city is full of political will and economic benefits in China, while ignoring the coordinated and integrated considerations of social cohesion and environmental impacts. There are also no rigorous norms and standards such as KPI, making the quality of development blurring. It is worth noting that lessons from China's failed eco-city development and inspiration from Western successful eco-city development can shed light on Chinese and even global future eco-city evolvement. Hence, this paper conducts a comparative study on Chinese and international eco-city cases from social and institutional, economic, environmental, and KPI perspectives.

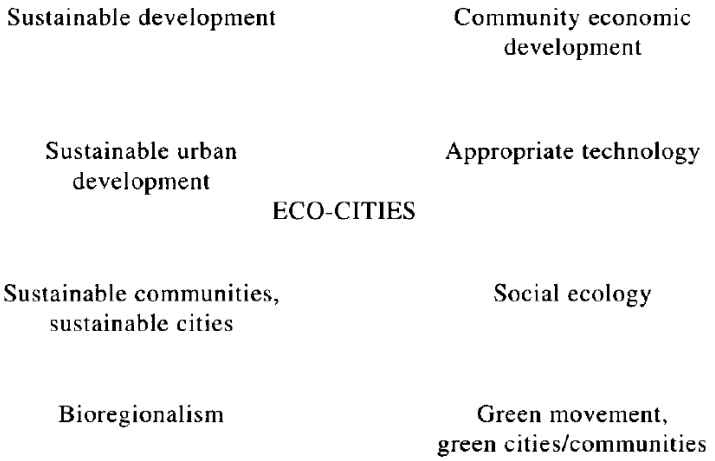

Fig. 1. The eco-city themes [3].

2 Social and Institutional Perspective

2.1 Successful Experiences

Emphasis on Sustainability and Environmental Awareness. It is important to raise great emphasis on urban sustainability and environmental-friendly awareness. The general awareness and concerns about environmental issues initially shape the development of the overall configuration of the eco-city.

For instance, Freiburg in Germany, which is renowned for its solar city and successful eco-city development model, has been raising public awareness of environmental protection since the 1970s [4]. Residents living there played an active role in opposing the project of a nuclear power station nearby, along with support from the local city administration. Instead, they succeed in changing a nuclear station scheme to a low-carbon lifestyle such as green transportation and solar energy development.

Top-Down Support and Bottom-Up Public Participation. It is essential to attach importance to social cohesion and community involvement, and thus to encourage public participation. It involves diverse stakeholders in the decision-making process and promotes a sense of cooperation to bring more socially and institutionally eco-city initiatives.

As mentioned in the Freiburg case, the main enabler of eco-city success is the support from central and local governments to largely invest in the solar energy industry. Moreover, the city benefits from public participation among sectors such as banks, local firms, universities, and residents (see Figure 2).

Similarly, Samso Island in Denmark is aware that top-down support and bottom-up participation are cores to complete the construction of a successful eco-city such as Freiburg. In detail, the actors are comprised of the Environmental Ministry in Denmark (1993-2001), Samso Municipality, a teacher in Samso, local investors, a local cooperative, and all citizens to become shareholders (see Figure 3) in wind turbines and solar powers projects, to finally boost the community into a fossil-free eco-city development.

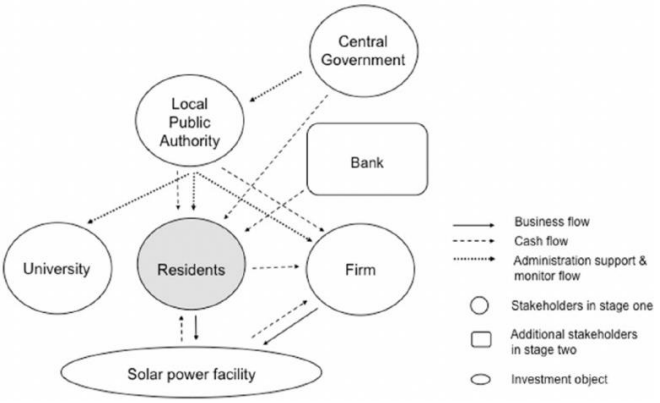

Fig. 2. The development model and stakeholders for solar energy in Freiburg [4].

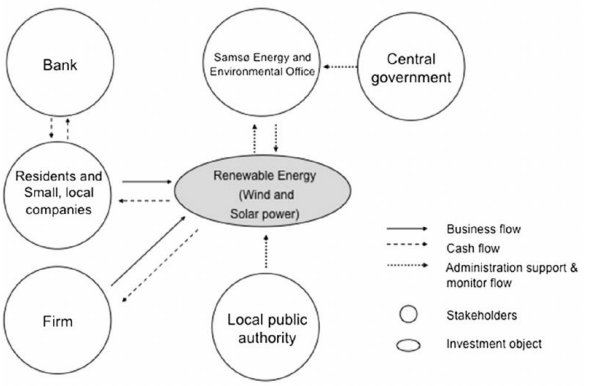

Fig. 3. The development model and stakeholders in Samso Island [4].

Respect for Heritage and Architectural Excellence. The UK has a rich cultural heritage and a deep appreciation for architectural excellence. Incorporating eco-friendly features into traditional buildings and heritage sites and utilizing them in sustainable design principles will enhance the cultural value of eco-cities while protecting historical and cultural assets.

2.2 Weaknesses of Chinese Eco-City Construction

Top-Down Planning System. Due to the hierarchical political system of China, the central and local governments have the direct decision power on most planning projects including eco-city construction [5]. The top-down approach of planning and funding from the government is well recognized as a Chinese characteristic notion.

On the one hand, the strong Chinese government power can lead to an ease of the start of a project. On the other hand, it puts a long-term project at risk. For example, the Dongtan eco-city project in Shanghai was acknowledged as a failure and infinitely postponed in 2008 [6,7]. Although there is no official recognition to connect the project's suspension to political corruption, it is commonly believed that this project lost its political priority both nationally and locally as the signature project of the former jailed Shanghai Mayor [8]. Undoubtedly, the Dongtan eco-city project indicated a negative impact on the top-down planning system role in China.

Limited Public Engagement. The Chinese eco-city system may place limited emphasis on stakeholder engagement and public engagement compared to Germany and Denmark. The opportunities for public participation are limited. The local residents cannot express and well solve their urgent needs, which disconnects between the development direction of the eco-city and the actual needs and preferences of residents.

In Dongtan, without abundant consideration of the geography and the local farmers, this project failed. The construction of the Dongtan eco-city is aimed at helping Shanghai to reduce carbon dioxide emissions, however, the distance from Dongtan to Shanghai is about 60 kilometers with the envisioned construction of transportation infrastructure such as bridges, highways, and undersea tunnels. This remains the question of why Dongtan was designated from a remote distance to build an eco-city without any concerns for local residents or farmers.

3 Economic Perspective

3.1 Successful Experiences

Strong Market Targeted. Eco-city has a strong market orientation that encourages private sector participation and investment in the development of the Eco-city. It promotes competition, innovation, and efficiency, allowing market forces to drive economic growth and sustainable development in eco-cities. Market orientation and commercial activities are crucial for maintaining public awareness and promoting and adopting local economic activities during the process of urban transformation into an

eco-city. However, this does not imply that the eco-city performs poorly in economic aspects; rather, it underscores the vital importance of market orientation and commercial activities for the sustainable development of the eco-city [4].

Campinas, located in the State of São Paulo, exemplifies effective market orientation achieved through strategic regulatory measures within the framework of its environmental plan. By fostering private sector involvement and investment, the city's eco-friendly agenda was advanced, nurturing competition, innovation, and efficiency. This approach harnessed market forces to propel the eco-city's economic growth and sustainable development, concurrently reshaping the perspectives of its populace and bolstering community unity.

A notable illustration of this strategy's success is evident in the establishment of the greenway. Initiated in 1998 with collaboration from neighboring businesses, the project's first phase received support from local enterprises, ensuring its initial utilization and continued upkeep. Presently, these entities persist in offering financial backing for the ongoing maintenance of the greenway. This synergy continued into the subsequent phase, where community collaboration became a mitigating factor. This phase witnessed the completion of three additional sections, the planting of nearly 26,000 indigenous trees, and the creation of a substantial 370,000-square-meter shopping center. By reviving riparian zones and incorporating recreational amenities, including sports facilities, bike paths, and trails, the initiative not only safeguarded habitats and resources but also regulated flooding and erosion. Remarkably, this transformative sequence of interventions reshaped the local perception of the waterway's open spaces [9].

Encouraged Innovation Technology. Encouraging the integration of innovative technologies, sustainable construction practices, and energy-efficient solutions not only opens up avenues for business opportunities but also nurtures the growth of eco-friendly sectors, thereby fostering economic expansion and enhancing competitive prowess. Furthermore, Egypt's regulatory framework has become a staunch advocate for unceasing innovation and technological advancement within the realm of eco-city development.

In the context of Egypt, the regulatory framework has played a crucial role in creating an environment conducive to continuous innovation and technological progress in the field of eco-city development. Moreover, by advocating for the adoption of novel technologies, sustainable construction methodologies, and energy-efficient solutions, a fertile ground is created for entrepreneurial ventures. At the same time, this approach cultivates the emergence of environmentally conscious industries that bolster economic growth and enhance competitive edge.

A notable example of this approach can be seen in the extensive utilisation of urban green spaces within the El-Sadat metropolis in Egypt. By applying landscape ecological threshold technology, a detailed calculation was carried out to determine the required green area to achieve critical thresholds such as population carrying capacity, carbon-oxygen balance, and water supply-demand equilibrium by the year 2020. Employing the principles of landscape ecology, green spaces are strategically used as corridors, cleverly introducing nature into urban landscapes at regional, urban, and community scales. This strategy not only nurtures the growth of green industries but also unlocks

avenues for enterprises to spur economic prosperity. Moreover, it plays a pivotal role in enhancing people's engagement with the natural world, as aptly demonstrated through the proposed green building initiatives [10].

3.2 Weaknesses of Chinese Eco-City Construction

More Emphasis on Quantity over Quality. China's intensified emphasis on rapid urbanisation and the attainment of developmental milestones may foster a rushed proliferation of eco-cities. Nevertheless, this precipitous trajectory might come at the expense of economic feasibility, enduring sustainability, and sustained economic profitability.

Moreover, within this context, various local authorities and real estate entities in China have independently embarked on their distinct eco-city endeavours. However, this unilateral approach conspicuously results in a void of effective policy synchronization and harmonious regional collaboration. In contrast, the Caofeidian Eco-City initiative, championed by the Tangshan Municipal Government, serves as an exception. It is distinguished by its meticulously tailored eco-city indicator system, showcasing a deliberate focus on uniqueness. Conversely, within the bounds of Hebei Province, approximately seven ostensibly unrelated eco-city projects are concurrently underway. Strikingly, these initiatives lack consistent entreaties for public involvement and consultation. This divergent developmental trajectory has accelerated the construction of eco-cities, inadvertently neglecting the pivotal significance of strategic coordination and transparent communication [11].

Unbalanced Regional Development. Diverse regional capabilities and variances in infrastructure development, coupled with disparities in economic resources and governance competencies, can potentially hinder the effective execution of eco-city endeavors and curtail their economic reverberations.

The expansion of China's Caofeidian—a development initially planned across a modest 30 square kilometers—has evolved into an ambitious expanse spanning 2,000 square kilometers, accompanied by a substantial investment amounting to 300 billion yuan. However, the high frequency of personnel rotations within a five-year cycle has precipitated shifts in perspectives across different temporal epochs. This administrative volatility has, in turn, engendered divergent viewpoints, thereby introducing complexities in coordination between officials temporarily stationed in Caofeidian and their counterparts in Tangshan.

Caofeidian's pivotal role as Hebei Province's flagship initiative is evident in its designation as the "No. 1 Project", prominently featured in the "Three-Year Great Transformation Project" for urban reinvigoration. Remarkably, Hebei Province's infusion of a staggering 713.1 billion yuan into urban infrastructure development within the past three years is more than double Caofeidian's cumulative investment over the preceding decade. Unfortunately, this substantial financial commitment, compounded by the burdens of debt servicing, has pushed Caofeidian's financial equilibrium perilously close to the precipice. As a result, the incongruities in governance capacities among various

regions have significantly impeded the seamless realization of eco-city initiatives, while concurrently exacerbating the scarcity of funds for project implementation [12].

4 Environmental Changes

4.1 Successful Experiences

Emphasis on a Balanced Ecological System. Eminent in numerous undertakings is the incorporation of verdant expanses, leisure-centric parks, and indigenous components—endeavors that collectively nurture biodiversity and elevate the ecological import of urban realms. This synergistic fusion of constructed landscapes and inherent natural systems harmoniously culminates in an eco-city that resonates with visual allure while maintaining a commendable degree of sustainable equilibrium**.**

The City of Rio de Janeiro, ensconced in the southeastern province of Brazil, stands as a poignant illustration of this intricate interplay. In this context, where a mere 15% of the land is still graced with vestiges of the Atlantic Forest, the need for a cohesive ecological integration strategy becomes glaringly evident. Responding with astuteness, designers have astutely conceptualised an integrated ecosystem within pasturelands and deforested zones, strategically contiguous to the remnants of the forest. This laudable endeavour transcends the bounds of rustic territories, its influence extending palpably to the expansive fringes of the Rio de Janeiro metropolitan landscape. Notably, this ambitious initiative, besides serving as a protective haven for the preservation of standing trees, allocates paramount priority to identified reforestation sites. These assiduous efforts will not only fortify the city's environmental resilience but also strategically redirect its trajectory towards a sustainable state of ecological congruence [9].

Consideration on Conservation of Historical and Cultural Sites. Many eco-city undertakings consciously weave together heritage sites, traditional architectural marvels, and iconic cultural landmarks, thereby orchestrating an eloquent synthesis of modern attributes and historical importance. This judicious amalgamation not only perpetuates the cultural essence of the locale but also imparts a distinctive and evocative sense of identity within the tapestry of the eco-city.

A pertinent exemplar of this artful convergence manifests itself in Italy—a nation punctuated by a labyrinthine maze of regulations strategically crafted at pivotal historical and cultural crossroads. These legislative pillars have, over time, assumed a palpable prominence that harmonizes with Italy's ingrained tradition of urbanization. Remarkably, across an expansive chronological spectrum, Italy's urban development ethos was characteristically imbued with humanistic aesthetics. This prevailing paradigm facilitated a graceful interplay between modernity and historical resonance, masterfully achieved through the harmonious fusion of traditional architectural motifs and deeply entrenched cultural narratives [13].

Focus on Human-Centered Design and Wellbeing. Human-centered design in eco-cities focuses on creating a human-friendly environment and promoting walkability. Pedestrian-friendly streets, well-designed public spaces, and an interconnected network of footpaths and cycle paths are key features of eco-city projects. Emphasizing walkability improves quality of life, encourages social interaction, and reduces reliance on private cars, thus creating more sustainable and livable urban environments.

Portland, Oregon, in the United States, serves as an exemplary model of sustainable planning, renowned for its robust green infrastructure including bike lanes, LEED-certified buildings, bio-swamps, and a light rail system. Effective municipal policies that enhance neighborhood walkability and decrease greenhouse gas emissions have earned the city accolades in sustainability and livability rankings. Portland's local food system further enhances its reputation as a vibrant, sustainable hub. Home gardens are gradually being integrated into municipal resilience strategies, including growing and preserving food to mitigate against natural disasters, economic instability, extreme weather events, or energy shocks. This collaborative approach contributes to creating sustainable and livable urban environments with a people-centric focus [14].

4.2 Weaknesses of Chinese Eco-City Construction

Overlook on Ecological Protection. Despite the earnest commitment to extensive green expanses embedded within China's Eco-City endeavors, the attendant challenge is the preservation of ecological harmony and the safeguarding of environmental robustness. The velocity of urbanization and developmental momentum engenders a cascade of repercussions, encompassing the disintegration of habitats, the accentuation of biodiversity decline, and the incremental erosion of ecological integrity.

An incisive panorama into this narrative is encapsulated within the annals of China's recent urbanization odyssey—characterized by an unprecedently brisk tempo and an audacious scale. Specifically, within the geographical confines of Caofeidian in Hebei province, the landscape is etched with the contours of unfinished infrastructure and embryonic transportation networks. This tapestry nurtures an environment where inspections proliferate, authentic investments remain modest, speculative industrial initiatives predominate, and substantive settlements remain scarce. Notably, this dynamic backdrop begets an array of adverse consequences. The intensifying interplay of city-based competition engenders the replication of infrastructures and industries, underscored by an inherent deficit in policy coordination coherence. In parallel, these multifarious factors compound the strain on urban infrastructures, service provisioning, agricultural expanses, and the ambient natural habitat. Consequently, this confluence accentuates the abatement of biodiversity and underscores the tangible contribution to the dilapidation of ecological equilibrium [11].

Conventional Landscape Design. The landscape architecture exhibited within select Chinese eco-cities has unfurled an observable proclivity towards uniformity and recurring motifs. Likewise, the inordinate reliance on standardised design blueprints and

methodologies has engendered a conspicuous deficit within the sphere of diversity and individuality intrinsic to the ambit of eco-city initiatives.

When delving into this narrative, it becomes evident that the bulk of eco-city endeavors in China have been spearheaded as top-down initiatives, orchestrated by governmental bodies at the state or municipal level. This strategic orientation, underscored by a prioritization of political accolades and economic growth, materializes through the stewardship of state-regulated developers intricately linked to provincial or local governance structures. This approach, regrettably, stifles the avenues for comparative exploration and scrutiny vis-à-vis the design attributes permeating diverse eco-city projects. This trend is accentuated further by an unwavering inclination towards expediting the establishment of multiple eco-cities by reducing temporal costs through standardized design templates and methodologies. This trajectory, however, unveils a conspicuous lacuna—a predilection towards design homogeneity characterized by recurrence and uniformity, at the expense of embracing a diverse and unique design ethos [15].

5 Key Performance Indicator (KPI)

5.1 Successful Experiences

Holistic KPI System. Within the realm of eco-city endeavors, the integration of Key Performance Indicator (KPI) frameworks stands as an indispensable imperative. These frameworks encapsulate specific parameters, characterized by a dynamic interplay of quantitative metrics and qualitative aspirations. Eminent illustrations include the illustrious LEED-ND certification originating from the United States and the pervasive CASBEE-UD schema inherent in Japan [15].

It is imperative to underscore the inherent significance within the Chinese landscape, as epitomized by the Sino-Singapore Tianjin Eco-city project. This endeavor is marked by an intricately orchestrated KPI construct, systematically calibrated to align with elevated national benchmarks. Notably, this architecture underwent a rigorous revision in 2018, extending its purview to encompass ambitious targets across the spectrum of social, environmental, and smart-city dimensions [16]. Emanating from this robust configuration are 30 quantitative KPIs and 6 qualitative KPIs, thereby adhering steadfastly to globally recognized benchmarks while remaining intrinsically attuned to the cutting-edge developmental priorities underpinning China's eco-city trajectory. This revision marks an enhancement from its predecessor—a composition comprising 22 quantitative KPIs and 4 qualitative KPIs, as lucidly depicted in Table 1. A tangible manifestation of these standards encompasses pursuits such as the realization of 100% green buildings, the mitigation of natural wetland diminution, a recycling quotient surpassing 60%, the facilitation of more than 90% green trips, the attainment of renewable utilization exceeding 20%, a quotient surpassing 50% for R&D scientists & engineers relative to the labor force, the advocacy of a secure and healthful ecosystem, the assimilation of pioneering policies, the safeguarding of historical and cultural heritage, and the impetus to foster regional development [16].

Table 1. The Sino-Singapore Tianjin Eco-City's 26 KPIs.

SINO-SINGAPORE TIANJIN ECO-CITY'S 26 KPIS				
Healthy Ecological Environment		Social Harmony & Progress		Dynamic & Efficient Economy
100% potable water	Zero loss of natural wetlands	≥60% recycling rate	100% barrier-free access	≥20% renewable energy utilisation
Carbon emission/unit GDP≤150 ton-C/U5$1million	Noise levels 100% meet environmental noise standards in urban areas	≤120L water consumption/person/day	≤0.8kg domestic waste generation/person/day	≥50 R&D scientists & engineers/10,000 labour force
Grade II ambient air quality	Grade IV water standards	≥20% public housing	Free recreation & sports amenities within 500m	≥50% non-traditional water source
≥70% native vegetation	≥12 sqm/person in public green space	100% non-toxic waste treatment	100% services network connectivity	≥50% employment-housing equilibrium index
100% green buildings		≥90% green trips		
Integrated Regional Cooperation				
▪ Promote a safe & healthy ecology to encourage green consumption & law carbon operations.				
▪ Adopt innovative policies to ensure the improvement of surrounding areas.				
▪ Preserve history & culture to give prominence to the river estuarine cultural character.				
▪ Promote regional development through sound economic and administrative policies.				

5.2 Weaknesses of Chinese Eco-City

Lack of Scientific KPI Evaluation. In the context of eco-cities such as Dongtan and Caofeidian in China, it is imperative to discern, delineate, and establish a comprehensive and robust Key Performance Indicator (KPI) framework. Within this framework, an amalgamation of detailed, integrated, and coherent metrics should be identified and solidified. This pivotal step is fundamental to charting the course towards an eco-city characterized by sustainability and efficacy.

6 Conclusion

In summary, the discourse surrounding ecological cities has assumed a significant stance within the discourse of sustainability, gaining prominence in contemporary urbanisation. The potential of ecological cities to reshape urban landscapes into sustainable, human-centric, and ecologically balanced environments underscores their growing importance.

However, the current comparative analysis of the challenges and drawbacks faced by Chinese eco-city development in relation to their Western counterparts remains relatively limited. This study aimed to bridge this gap by conducting a comprehensive analysis that encompassed the intricate interplay of social, economic, and environmental dimensions. Through this analytical prism, the paper aimed to unravel not only the

limitations within the Chinese eco-city paradigm but also the effective trajectories witnessed in successful international cases.

This investigation revealed a series of crucial insights. From a social and institutional perspective, the promotion of bottom-up participatory approaches and the cultivation of active public involvement emerge as catalysts for success. This is bolstered by the engagement of market forces, underscoring the pivotal role of private sector involvement in propelling eco-city development. Furthermore, the emphasis on ecological technologies signifies an imperative that extends beyond geographical boundaries. Concurrently, the meticulous evaluation of Key Performance Indicators (KPIs) delineates a pathway towards effective measurement and assessment.

By identifying these areas of divergence and convergence, this study provides a pragmatic roadmap for the enhancement of eco-city development within China. As the nation navigates the intricate terrain of urbanisation, the lessons gleaned from both triumphs and challenges in global eco-city endeavours stand to inform and shape the trajectory of policy formulation and planning. Consequently, the transformative potential of eco-cities can be harnessed more effectively, ushering in an era of holistic sustainability and balanced urban landscapes. The implications of these findings extend beyond the confines of China, resonating with other contexts grappling with the nuances of eco-city implementation. Essentially, this study enriches the knowledge base, paving the way for a more evolved approach towards eco-city development – one that is imbued with adaptability, innovation, and responsiveness to the intricate dynamics of contemporary urbanisation.

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