

Introducing Sustainable Intervention Strategies of Operation Planning and Environment Design to Activate Void Areas on the Urban Fringe

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Abstract. Vacant and abandoned spaces were increasingly recognised as a major obstacle to urban revitalisation. How to intervene sustainably in urban void areas became a challenge. This paper presented a new theoretical framework for sustainable operation and design by reflecting and innovating on existing studies through a literature review and classification. The framework for sustainable operation planning included operational theme and promotion, management and maintenance, effective resource utilisation and sustainable digital technology. The framework for sustainable environment design included function and layout, ecosystem management, construction material and art design aesthetic. In the context of the sustainability framework, one urban void area in the northern part of the 19th Middle School in Wuhan was selected as the case study area. This case was based on secondary data collection, field research, virtual 3D modelling and computer rendering. The aim was to achieve sustainable and synergistic economic, social and environmental development by activating urban void areas. The results found that the theoretical framework of sustainability had positive implications for operation and design. The scientific and practical value of the planning and design could be enhanced by fully considering the logic of sustainable operation. In addition, the innovative concepts of the sustainable framework provided a theoretical and practical basis for filling the research gap of interventions in the urban void area.

1 Introduction

The definition of the void area in the urban fringe region was unused, underused, abandoned and misused space, including vacant land, remnants, derelict land, extinct land, dead ends and brownfield in the urban area [1]. A lack of presence, ambiguity and emptiness characterised the urban void area. Urban vacant and abandoned spaces were increasingly considered a major obstacle to revitalising local urban areas but implied it could be reused as a potential urban land resource [2]. As a sphere of discussion for professionals such as urban- rural planners, urban designers and landscape architects, its focus mainly included causes of spatial vacancy, optimisation of management methods and spatial waste [3]. In the context of favourable policies, some scholars explored using the creative city concept to provide a form of cultural marketing

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expression for developing void areas in Berlin, Germany [4]. Within the background of human-natural wilderness symbiosis, some scholars focused on whether post-modern wilderness concepts were possible in woodlands, abandoned lands, river corridors and brownfields in void areas [5]. Some scholars explored how to improve the public value optimisation and alternative strategies in the urban void area, suggesting that interventionists needed to use resources wisely with an open attitude and improve residents' quality of life from the perspective of health and ecological integration [6].

In general, this paper found that the urban fringe region's void area was a potentially valuable resource with little research in the academic field. Scholars were mainly concerned with the urban void area from the landscape, environment, social and aesthetic perspectives, and almost no scholars intervened on the issue from the perspective of sustainable operation and design. However, the urban void area has become an essential part of the urban fabric as a common sight in most urban areas nowadays. Therefore, this paper proposed a framework of sustainable strategies based on the current research gap to intervene in the urban void area from both operation planning and environment design perspectives. It considered the possibility of integrating sustainability theories and used an urban void area as a case study in Wuhan, Hubei Province, China. Computer modelling and rendering were used to simulate future sustainable urban void area practices.

2 Methodology

Although different types of literature reviews vary in the procedure, all reviews could follow the following eight common steps: formulating the research question, developing and validating the review protocol, reviewing the literature, screening for inclusion, assessing quality, extracting data, analysing and synthesising the data, and reporting findings [7]. Computer 3D modelling was distinguished from traditional manual sketch modelling, computer-aided architectural design systems were designed to assist the architect in sorting out and monitoring the architect's design thinking and behaviour in the early stages of planning and design [8]. Computer modelling systems differed significantly from the use of paper in planning and design by manipulating the control elements of the interface window rather than single graphical elements [9]. Using computer tools for the design process facilitated the full use of its capabilities to improve efficiency. The computer could provide an essential role in generating solutions, evaluating and resolving measures when the object of study was identified as a planning and design objective [10]. Computer-aided modelling generated design alternatives faster and in larger quantities, providing more sources of inspiration than traditional design methods resulting in more satisfactory and higher quality designs, helping architects to make more informed design decisions [11]. In order to simulate the actual effects of the scene after computer modelling, computer rendering portrayed and synthesised authentic images of the architectural scene through colours and materials to realistically visualise the results of the planning and design [12].

Among the methodological techniques used for the literature review, this study opted for a scoping research approach to map the key concepts and main sources of evidence underpinning the research area by including a wide range of studies in the review process [13]. Based on a comprehensive review of the literature on the void area of the urban fringe regions, the existing research was reflected and innovated through a literature review and categorisation based on the research results of past scholars. A new theoretical framework for interventions in sustainable operation planning and environment design was proposed

using logical reasoning and inductive methods to better understand the practical value of urban void areas in ecological, economic and social terms. In the context of the theoretical framework of sustainable operation planning and environment design, this paper selected an urban void area published by the Wuhan Municipal Bureau of Natural Resources and Planning in the past for a case study and intervention practice (<http://zrzyhgh.wuhan.gov.cn/>). By collecting secondary data on geographical, environmental, demographic, cultural, social and economic characteristics and combining the field survey results, the case study proposed a sustainable operation and design strategy for this urban void area. The effects of the interventions were visualised through computerised virtual 3D modelling and rendering to simulate the real-life application of the theoretical framework.

3 Results and Discussions

Through a general review of the literature, this paper found a common consensus that the urban void area had a high potential for development as a valuable resource. Traditional planning and design focused on providing a singular function that resulted in the loss of space in the urban area. Promoting multifunctionality through Green Infrastructure Planning (GIP) is an appropriate solution [14]. GIP could help reduce the local heat island effect in dense urban areas by influencing the void area, but an unreasonable GIP could damage the urban environment [15]. Therefore, this paper established a perspective of integrating sustainable ecology and other functions, taking the void area of the urban as an entry point. A strategic framework for intervention in the urban void area was discussed regarding sustainable spatial operation planning and environmental design.

3.1 Sustainable Operation Planning for Urban Void Area

People's well-being in space was correlated with operation planning, as well-being derived from the ability of space to provide the interaction and enjoyment that people need to enjoy [6]. Therefore, this paper developed a sustainable operation planning strategy in the urban void area. The framework consists of four sustainable strategies: operation theme and promotion, management and maintenance, effective resource utilisation and sustainable digital technology (Figure 1).

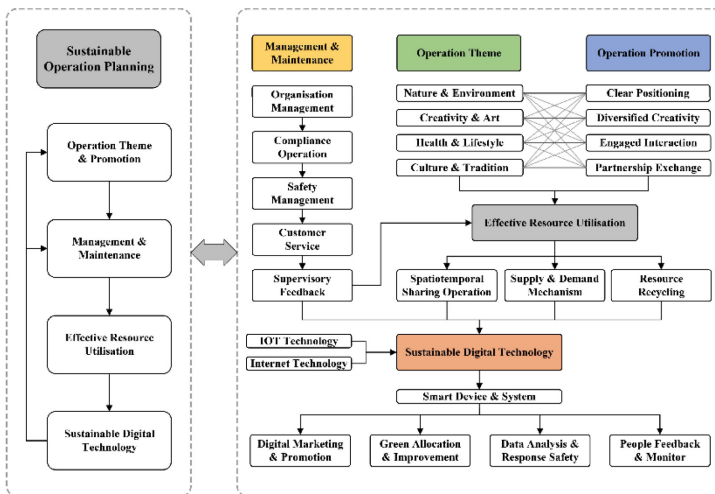


Fig. 1. Strategic Framework for Sustainable Operation Planning of Urban Void Area Space.

3.1.1 Sustainable Operation Theme and Promotion Strategy for Urban Void Area

In the aspect of sustainable operation, the focus was on the natural environment and creating innovative and creative art spaces that could provide sustainable operation services to people. Encouraging green mobility and healthy lifestyles contributed to developing a sustainable urban environment [16]. In addition, the local cultural traditions allowed residents and visitors to experience the interactivity of local flavours through theme events. In the aspect of sustainable promotion, precise operational positioning helped to find the target group and deliver effective messages, ensuring the theme promotion's effectiveness and reducing wasted resources [17]. Using different channels and creative ideas to expand the campaign's impact and reach as many people as possible. Focusing on engagement and interaction with the target audience further enhanced the campaign's attention and user stickiness. Collaboration with relevant campaign organisations helped to promote sustainable ideas.

3.1.2 Sustainable Management and Maintenance Strategy for Urban Void Area

Establishing an excellent organisational management system and a clear division of responsibilities ensured that all management and maintenance were carried out in an orderly manner. Compliance with local laws and regulations was required regarding access to operations, and the provision of business licences and permits demonstrated compliance. Sustainable safety management included periodic maintenance checks and preventive maintenance planning for the operating facilities, as well as meeting local safety regulations and fire safety requirements to prevent safety hazards [18]. The different needs of the target groups were met through quality customer service and operational attitude, which facilitated good communication and interaction with customers. In addition, regular monitoring and evaluation of the operation strategy in response to market demand and customer feedback helped ensure the operation's sustainability and effectiveness.

3.1.3 Sustainable Effective Resource Utilisation Strategy for Urban Void Area

The optimal operation time strategy was determined according to the target audience and market demand by maximising the efficiency of operations through time-sharing operations. For example, by adjusting to the different demand characteristics of weather, holidays and specific events, the aim was to improve the effectiveness of the operation and increase user traffic. A rational supply and demand system was established to enhance the interaction between buyers and sellers and optimise allocation efficiency between demanders and suppliers [19]. In addition, recycling and efficient use of resources were critical issues in the SDGs and reduced environmental pollution, and the waste of resources were important objectives of sustainable management [20].

3.1.4 Sustainable Digital Technology Strategy for Urban Void Area

Against the background of the renewal of IoT and Internet technologies, the introduction of intelligent devices and systems to assist in the planning and management of sustainable operations allowed for real-time monitoring and remote control, thereby increasing the effectiveness of functions [21]. Data analysis and personalised recommendations based on computerised internet technology could facilitate digital marketing and channel promotion, improving marketing effectiveness and user satisfaction. Green and sustainable allocation and improvement solutions were an essential trend in technological market innovation and re-source utilisation tendencies, promoting innovative and improved operation models,

operation efficiency and customer experience to adapt to emerging market needs [22]. Computer analysis and optimisation algorithms were used to understand target groups' behavioural preferences and improve operations' effectiveness [23]. In addition, establishing intelligent sensors and monitoring systems for the surrounding environment facilitated real-time data analysis and rapid response to emergency security. By collecting and analysing user feedback and survey data from monitors in the context of privacy protection, the shortcomings of operation service were captured and responded to quickly.

3.2 Sustainable Environment Design for Urban Void Area

In the context of urban regeneration, the relevant literature indicated a discrepancy between the studies and practices of infill urban development. The planning and design of some areas neglected user participation and experience, such as interactivity, joy and fun [24], and place-making approaches were constructed as design strategies based on the person's recreational needs to participate in spatial interaction [25]. Therefore, this paper developed a sustainable environment design strategy for void areas by considering four sustainable aspects: function and layout, ecosystem management, construction materials and art and design aesthetics (Figure 2).

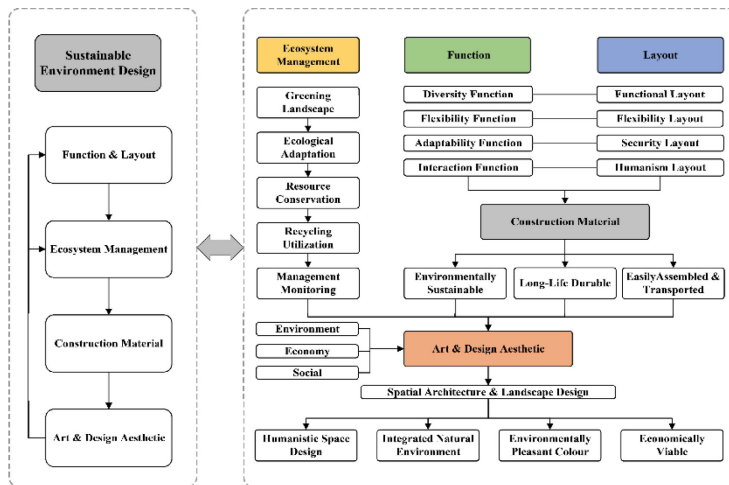


Fig. 2. Strategic Framework for Sustainable Environment Design of Urban Void Area Space.

3.2.1 Sustainable Function and Layout Strategy for Urban Void Area

By considering the diversity of spatial functions to maximise the use of spatial resources and increase the efficiency of spatial service. In the event of future variations and new spatial needs, spatial functions could be adapted and replaced according to different spatial requirements. The emphasis was on adapting the space to meet the required spatial functions. To better meet the needs of users, interactive, joyful and fun spatial engagement could be achieved through placemaking. A rational functional layout and zoning enabled the various functional areas to be coordinated with each other, and a flexible layout facilitated a quick response following adjustments to the space's function, aiming to maximise the efficiency of the design and use of the area [26]. In addition, the safety layout required full consideration of aspects such as space safety standards and safety elements.

3.2.2 Sustainable Ecosystem Management Strategy for Urban Void Area

Greening and ecological landscaping enhanced the ecosystem's diversity and stability and created a pleasant and liveable ecological environment [27]. Ecological adaptation required that the design respected the surrounding natural ecosystems, was well-informed about the local climate and vegetation, and integrated and maintained the natural ecosystems. Planning and design interventions should not hurt the surrounding ecological environment, and measures needed be taken to protect the surrounding ecological landscape as much as possible. An effective waste separation and recycling system was established to encourage people to participate in waste separation and minimise the negative impact on the environment [28]. In addition, an ecological monitoring system was established to assess and manage the ecological environment around design areas regularly. Based on the data analysis and assessment, problems were taken to respond in a timely manner.

3.2.3 Sustainable Construction Material Strategy for Urban Void Area

Reducing resource consumption and carbon emissions was facilitated using recycled or recyclable and sustainable materials [29]. Long-life and high-durability materials helped to reduce material consumption and waste, minimise the use of environmentally harmful materials and thus reduce emissions. In addition, long-life and durable materials were used to reduce the need for maintenance and replacement, thereby reducing consumption. Materials with high transport efficiency and easy packaging could reduce consumption during transport and use [30].

3.2.4 Sustainable Art and Design Aesthetic Strategy for Urban Void Area

By considering the environmental and economic benefits, sustainable architectural and green landscape spaces were created to integrate aesthetics. The human-centred design approach focused on using people in the area, which helped stimulate user participation and communication, leading to interaction and cohesion. A design that integrated the natural environment emphasised the harmony between the local and the whole, contributing to sustainable art and design aesthetic [31]. The pleasant environment colours created a sustainable and comfortable environment by combining the aesthetics of natural materials and organic forms. In addition, a balance was sought between environmental and economic benefits so that the planning and design plan met both environmental and economic possibilities, creating an urban void area that combined sustainable ecological art and economic operation concepts [32].

3.3 Sustainable Exploration of Urban Void Area: Spatial Design Practice

3.3.1 Geographical Environment Analysis for Urban Void Area

The urban void area was located southwest of the intersection between Machang Road and Machang Yi Road in Jianghan District of Wuhan, covering an area of approximately 2,000 square metres (Figure 3), adjacent to the north entrance of the 19th Middle School in Wuhan, Hubei Province (Figure 4). It was used by the Wuhan Municipal Bureau of Natural Resources and Planning as one of the study areas for the Urban Pocket Park proposal call (Figure 5).



Fig. 3. Surroundings Environment of the Void Area in Wuhan, Hubei Province, China.



Fig. 4. Vicinity Map of the Void Area in Wuhan, Hubei Province, China.



Fig. 5. Urban Void Area in Wuhan, Hubei, China (Source: <http://zrzyhgh.wuhan.gov.cn/>)

3.3.2 Sustainable Operation Planning and Environment Design Strategy for Urban Void Area

The sustainable operation management strategy for the void area was achieved by considering four aspects: sustainable operation theme and promotion, sustainable management and maintenance, effective sustainable resource utilisation and sustainable digital technology. This paper proposed an operation theme strategy of "pocket landscape + market stall economy". Dividing into pockets of landscape theme as the main operation and market stalls on holidays as the supplemented operation through the sustainable time-sharing operation. The sustainable operation of landscape architectural facilities was guaranteed

through cyclical and preventive maintenance. Using the integration of IoT and Internet technologies, the issue of sustainable operation was regulated access system and compliance of market stall, coordination mechanism of interaction between buyers and sellers, efficient organisation management and monitoring feedback.

The sustainable environment planning and design strategy for the void area was achieved by considering four aspects: sustainable function and layout, sustainable ecosystem management, sustainable construction materials and sustainable art and design aesthetics. The space's interactive, joyful and exciting nature is enhanced through rational functional division, di-verse functional implantation and living spatial form changes. The landscape aesthetics and ecological beauty of the space were enhanced through the operation and design of the green pocket landscape. Through the rainwater collection system under the lawn, the rainwater was directed to the water collector for filtration and storage. After passing through the piping system, it was reintroduced to the lawn through the pump for recycling and watering. The local area ecology was monitored with the urban development concept of sustainability, focusing on organic forms, artistic aesthetics and environmentally friendly materials to make the area development sustainable.

By achieving sustainable operational planning and environment design in urban void areas, the aim was to achieve synergistic economic, social and environmental development based on activating urban void regions. The economic level included improving resource efficiency, recycling to reduce costs and technological innovation. The social level included social responsibility, creating human well-being and designing healthy and comfortable urban environments. The environmental level included reducing damage to biodiversity, using low-carbon technologies to reduce energy carbon emissions and reducing carbon footprints to combat climate change.

3.3.3 Sources of Sustainable Spatial Design Morphology for Urban Void Area

The generation of models was based on the mathematical arrangement of geometry. By considering the morphology of the geometric symbols and cutting the forms, it was found that a regular and neat geometric composition facilitated the arrangement of space and management. The geometric variation was based on articulating the surrounding area, creating a variety of geometry within the space. For example, the external sides of the square contained two sizes, 2.5m and 2m (Figure 6), facilitating the different needs of each market stall unit. The patterned layout of the space had a variety of colours in black, white and grey to add a sense of reality to the area, and local cultural icons were added to make the space more culturally specific.

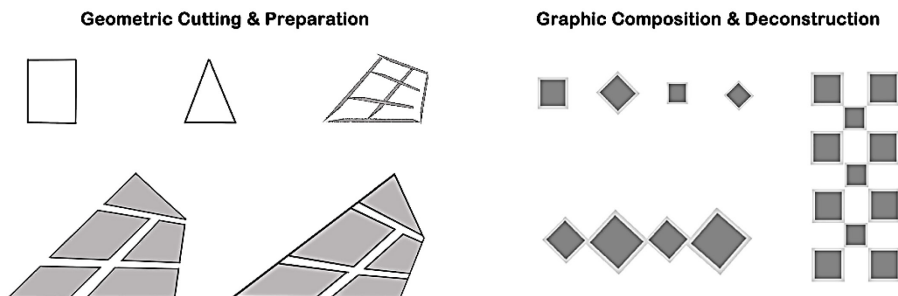


Fig. 6. Formative Diagram of Design for Urban Void Area

3.3.4 Sources of Sustainable Spatial Design Morphology for Urban Void Area

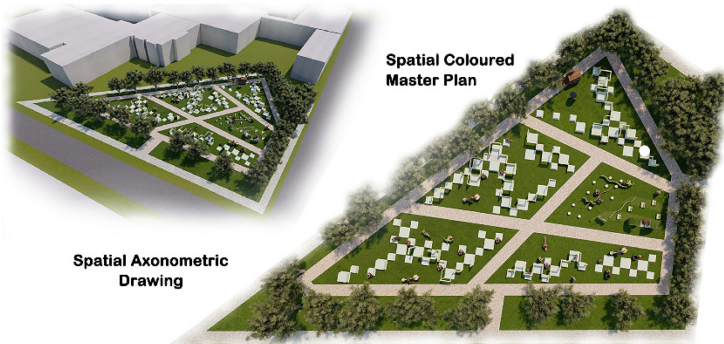


Fig. 7. Design Master Plan and Axonometric Drawing for Urban Void Area

3.3.5 Elevation of Sustainable Space for Urban Void Area



Fig. 8. Elevation of Environment Design for Urban Void Area

3.3.6 Rendering of Sustainable Space for Urban Void Area



Fig. 9. Computer Rendering of Design for Urban Void Area

4 Conclusion

Through a comprehensive review of the literature on the void area of the urban fringe region, a literature review and categorisation were used to reflect on and innovate existing research based on past scholarly findings. Using a logical reasoning approach, a new theoretical framework for sustainable operation planning and environment design was proposed. The spatially sustainable operation planning framework included four aspects: operational theme and promotion, management and maintenance, effective resource utilisation and sustainable digital technology. The spatially sustainable environment design framework included four aspects: function and layout, ecosystem management, construction material and art design aesthetic.

In the context of the theoretical framework for sustainable operation planning and environment design, this paper selected an urban void area in the northern part of the 19th Middle School as a case study area in Wuhan, Hubei Province, China. By collecting secondary data on geographical, environmental, demographic, cultural, social and economic characteristics and the results of field research to propose a sustainable operation and design strategy for this urban void area. The results of the intervention were visualised through three-dimensional computer modelling and rendering. By achieving sustainable operational planning and environmental design in urban void areas, the aim was to achieve sustainable and synergistic development on economic, social and ecological levels based on activating the functions of urban void areas. The study results revealed that the theoretical framework of sustainability had positive implications for sustainable design and was conducive to enhancing the design's practical value and scientific validity with full consideration of the sustainable operation logic. In addition, sustainable operation and design consideration in harmony with the environment, economy and society filled a certain theoretical and practical basis for the research gap of sustainable interventions in the urban void area.

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