Urban Metabolism and Spontaneous Architectural Growth: A Sustainable Strategy Featuring Participatory Co-Construction by Multiple Stakeholders

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Abstract: Several studies have linked urban metabolism with sustainable development goals, but few studies have addressed how architectural design could contribute to the linkage. Japanese Architectural Metabolism promotes the empowering of individuals and encourages spontaneous growth through urban metabolism. However, Architectural Metabolism has lacked (1) links with sustainable urban development goals, (2) realistic and powerful strategies, and (3) the ability to keep up with information technology. Whether and how architectural design can contribute to sustainable and spontaneous urban growth remains unclear. This paper presents case studies of the growth and renewal of formal and informal urban organisms in East Asia. The cases reveal that sustainable spontaneous urban growth should be linked with a strong governance system as well as adaptive architectural and construction technology that is easy to master by users. This paper argues that the conditional basis of contemporary Chinese urban development can support the spontaneous growth of architecture. Finally, a design strategy is proposed that reconstructs participatory co-construction among the government, social investors, and users with information and adaptive construction technology. Its purpose is to realize the orderly metabolism and spontaneous growth of buildings and achieve economically, socially, and ecologically sustainable development.

Keywords: urban metabolism; sustainable spontaneous growth; information technology; participatory co-construction; adaptive construction technology

1. Introduction

With respect to the global urban system and urban life in the context of environmental, social, economic, and other challenges for sustainable development, “urban metabolism” is often used from the perspectives of biophysics and socioeconomic entities [1] (p. 851). It aims to explain how the interaction among various factors forms a phenomenon of a city and shapes its development [1–3]. Several studies have linked urban metabolism with sustainable development [4,5]. However, few research has addressed how architectural design affects the link between metabolism and sustainability.

In the area of architecture, Architectural Metabolism that rose in Japan during the 1960s and 1970s conceptualized cities as flexible systems that accommodate continual changes and metabolism. Architectural Metabolism emphasizes the participation and freedom of individual users and considers the spontaneous growth of urban settlements. The principles of Architectural Metabolism, such as “the participatory strategy of design, building adaptability, impermanence of urban structures, and concept of the city as a process” [6] (p. 246), are suitable for inclusion in discussions of urban renewal in the context of high-density and compact cities in contemporary developing countries. However, the principles of Metabolist Architecture are difficult to realize in practice and had been withdrawn from the architectural historical arena temporarily due to various shortages...
and real-world conditions. Metabolist Architecture lacks connection with sustainable development goals and has not yet incorporated developments of information technology. That is, how architectural elements can be arranged to organically link spontaneous urban growth and sustainable urban development remains unclear in the contemporary age of rapid urban development. Therefore, this paper offers an integrative analysis of whether Chinese urban development has conditions suitable for sustainable urban metabolism from the perspective of architectural design.

This paper first summarizes Japanese Architectural Metabolism, explaining how the movement started to empower users of the architectural system, but lacked effective architectural strategies that could be linked with sustainability goals. The paper analyses the architectural design factors that lead to sustainable and unsustainable development on the basis of two comparative case studies of formal and informal urban/architectural growth in East Asia. The paper then explores whether contemporary Chinese urban development can supply the factors leading to sustainable development. The research results are incorporated into a low-carbon architectural design strategy proposal in the contemporary urban development stage of China and lot-scale as the module scale. The paper proceeds this architectural growth model from social, ecological, and economic perspectives to explore the possibility of realizing more balanced, sustainable, and intensive land development. The growth model involves the co-participation of the government, social investors, and community. Herein, design is also used as a research method to realize sustainable metabolism in similar quickly urbanizing regions of the world.

2. Literature Review: How Can Spontaneous Architectural Growth Contribute to Sustainable Urban Metabolism?

2.1. Linking Urban Metabolism with Sustainable Development Goals

Urban metabolism refers to “the exchange processes that produce the urban environment” [1] (p. 851). Inspired by biological science and ecology, urban metabolism views cities as ecosystems. Since the 2010s, urban metabolism has been placed in dialogue with other such approaches as urban ecology, ecological economics, and political ecology [1] (p. 851) [2] (p. 562). Spontaneous urban growth has become a phenomenon and development mode of contemporary cities, and its extensive occurrence in global cities and megalopolises, planned and unplanned cities, and formal and informal cities has been widely explored [2] (p. 562) [8] (p. 147). Urban metabolism is also a new lens for considering how to make cities ecologically, socially, and economically sustainable [1] (p. 851) and to manage environmental, social, and economic interactions [4]. However, few studies have addressed how architectural design can contribute to sustainable urban metabolism goals.

2.2. Spontaneous Urban Growth and Renewal from an Architectural Perspective: Enlightenment of Metabolism in Japan

After World War II, a chaotic but energetic social environment appeared in Japan, accompanied by rapid urban development and the emergence of electrification and other advanced technologies. Proponents of the Architectural Metabolism approach in the 1960s made the utopian proposal [9] that planners should not focus on the final urban form, but should understand that the city was growing “in a manner like the evolution and metamorphosis of an organism” [6] (p. 1). Such proponents also discussed megastructures, group modeling, assemblies, cabins, and other spatial construction models, as well as the “spine–limb” construction logic based on living organisms.

Studies have interpreted Architectural Metabolism from various perspectives [10,11] (p. 291). This paper focuses on an interpretation of urban architecture as a process of evolutionary development and compares features of biological organisms to the key features of urban renewal [12] (p. 110) [13]. It aims to promote sustainable and resilient urban development to cope with urban crises [14]. Certain Metabolist schemes (e.g., the competition schemes for the Sakaide mass housing project in Kagawa and the low-income group mass housing project in Lima, Peru) have had the goal of linking society and the community. Metabolism encourages planners or architects to “build an overall urban devel-
opment framework,” “set the development mechanism,” and guide people to build their own houses, thereby “creating more changes” [6] (p. 94). This means that Architectural Metabolism also aims to reorganize the relations between society and individuals and empower individual users of urban development [11] (p. 284). From another perspective, Architectural Metabolism promotes urban self-organization [15], but this is not the main aim of the architects. Metabolism also helps to fully realize an intrinsically complex and flexible system to effect rich and continuous changes through artificial active control and bottom-up regulation. Metabolists champion modularization, cabin style, and other concepts that encourage people to participate in the design and customization process, which “provides a clue for the future trend of participatory building” and promotes an adaptive building model and prefabricated module units [6] (pp. 207, 246).

With the rapid advances in science and technology in the 1960s, Metabolists foresaw the immense potential of applying information technology to urban metabolism. However, they could not thoroughly understand the trends of information technology development and thus failed to provide applicable measures to utilize information technology [16] (p. 51). The rapid development of Internet technology has provided a new understanding of participatory design and collective wisdom and brought about direct, rather than hierarchical, communication methods. Internet technologies are worthy of further in-depth linkages with social participation in Architectural Metabolism.

2.3. Why Study Spontaneous Architectural Growth?

The spontaneity of urban (and architectural) growth has demonstrated several benefits. First, considering the synergy of the urban population, economy, environment, and space, a good dialogue and bottom-up mode of urban development encourages and increases individual enthusiasm and participation from individuals in an open and egalitarian manner. It reduces unnecessary consumption and waste in funds and energy, and fully guarantees sustainable environmental development while satisfying the needs of city residents.

As a continuous evolutionary mechanism, urban planning cannot be effective without bottom-up cooperation. Urban planning has gradually become a technocratic procedure and urban intervention [17], and a spontaneous participation process of public fill-in is sometimes ignored in planning. Linking urban planning directly to ambitious plans is often difficult [18]. Spontaneous urban growth has become a kind of development mode of modern cities; as Roy (2005) argued, “In fact, most cities (even the great capitals) have the spontaneous cities”.

Concepts associated with spontaneous architectural growth, such as self-organization, in which bottom-up “collective and coordinated decisions produce social outcomes” [19] (p. 2303), have been developed. Urban self-organization can occur when the planning professionals, designers, and politicians are empowered and play important roles in shaping cities [20] (p. 1152). Recently, scholars have recognized that “the development of technologies for distributed communication has reinvigorated hopes that people can coordinate and cooperate,” for example, as they do on the online platform Wikipedia [19] (p. 2301). However, how to realize spontaneous urban development that works toward sustainable goals in architectural design remains uncertain.

3. Materials and Methods: The Possibility of Realizing Sustainable Metabolism in the Contemporary Urban Development Stage of China

Enlightened by the Metabolism way of thinking, future generations should seek a more distinct method “appropriate” for contemporary urban conditions and closely linked with sustainable development goals. The following research will search for the key conditions for sustainable architectural space growth through the analysis of two typical self-growing cities in East Asia. Then, the research will try to elucidate whether there is a conditional basis in the current situation of China’s urban development. An architectural design strategy will follow for further research and exploration. Hence, my research is an
integrative understanding of the potential of realizing sustainable metabolism in Chinese cities.

3.1. A Framework to Analyze Issues Related to Architectural Design, Urban Metabolism and Sustainability

The ever-changing organic urban system is a potentially effective way to shorten the gap between the planning and actual usage of the “ghost city” and “high-density city” coexisting cities phenomenon [21], but its relationship with sustainable development in terms of architectural design is still unclear. Specific case studies will be explored with respect to the conditions for coordinating with the sustainable growth of East Asian cities and the existence of these conditions for the current development of Chinese cities.

The following will analyze how the development model of the urban growth case (Figure 1) arranged architectural elements to create conditions for spontaneous urban growth in a sustainable and orderly manner in East Asia. The research system was set up from several perspectives related to architectural and construction design. It started from tracing their history and discussing the site resources, policy and supervision, industrial structure, space and function system, and neighborhood relationship, as well as the horizontal or vertical transportation and the mode of construction.

![Figure 1. Case study framework of architectural growth (Source: author).](image)

3.2. Research Methods and Selection of Spontaneous Growth Cases in East Asian Megacities

As Roy (2005) stated, there are spontaneous growth phenomena in most cities (even metropolises) [8] (p. 149), especially in Asian cities, such as Tokyo, Shanghai, Hong Kong, and Mumbai. Some general analyses of urban self-organization and spontaneous urban growth have been used in cities around the world, such as Amsterdam and Dharavi [20]. In this research, two typical cases of high-density settlement, the formal urban growth in Tokyo during 1945–1960s and the informal urban growth in Kowloon Walled City, Hong Kong, were selected to form a comparison. The relevant literature, documentation, and media reports related to the spontaneous urban growth of the two cases were analyzed. Some research has referenced the two cases, but little has linked them with sustainable goals. The case research was analyzed using the above framework to find the relationship between the elements for urban growth. The research then understood and found the
potential conditions for realizing sustainable urban metabolism in Chinese cities through reviewing relevant documents and data published by the government and research institutes. The research is largely qualitative, instead of quantitative. Finally, the research employs architectural design as the research method [22] of inquiry “by the development of a project and also exploring the different materials by which a design is carried out” [7] (p. 3). The design is used to explore how the above understandings could be further developed in practice.

3.3. Case Analysis and Comparison Results

3.3.1. Introduction to the Cases

Tokyo (Figure 2) has a custom of growing without planning and autonomous construction by the neighborhoods themselves [23]. During World War II, Tokyo’s built-up areas were almost completely burned, and 750,000 houses were destroyed; the urban economy was weak, and building materials and industrial capacity were in short supply [24] (p. 159). Tokyo’s municipal government found it hard to “launch a citywide reconstruction effort”. Additionally, from 1945 to 1960, Tokyo saw an enormous level of population inflow [24] (p. 174), and the population increased from 3.5 million to 9.5 million [25]. The government made one thing clear facing the rigorous challenges: the citizens were endowed with rights to reconstruct their homeland [23]. The public had enough rights to build their houses one by one, and they then combined these neighborhoods into an over-large-scale urban system [23]. Before 1960, Tokyo was still an “agricultural” city, with more than half of the population living in rural areas. In the 1960s, the government could still provide basic facilities to many rural residents who migrated to cities. However, in 1968, the City Planning Law was re-examined to control the expansion of the urban fringe so as to promote urban conditions [26].

With the subdivision of land ownership, buildings that were easy to metabolize on each land lot emerged, which is the reason why Tokyo (regular urban growth) could maintain continuous change and development, like an organism [27]. To a large extent, the citizens were approved to rebuild their homes on the basis of family-owned enterprises with a “weak planning” and spontaneous growth-oriented strategy [26] (p. 18). Driven by a sustainable economic pattern of family-owned businesses [23] under the strong support of the government both in attitude and facilities, cooperation was formed among the government, private sectors, and community, which contributed to the fast development of the city into a prosperous metropolis. Moreover, the adaptive mode of construction that was easy to be imitated by residents was also an important reason for the spontaneous growth of Tokyo.

In contrast, the Kowloon Walled City (KWC) was regarded as a labyrinth of crime for a long time [28], and was full of historical, political, and architectural meaning. The KWC is located in the heart of Hong Kong and was built in the Qing Dynasty, before the period of colony, as an “important vantage point from which to monitor [Manchu invasion of south China]” [29] (p. 26). The KWC was then “a forbidden place” of the Chinese government, British government, and local department, and became a place that was not “under the
control of the lands and building policy in Hong Kong” [30] (p. 7). In the late 1980s, the KWC was home to 35,000 people [31]. The KWC was demolished in 1993 before Hong Kong became a special administrative region (SAR) of China, and KWC had been a permanent city in Hong Kong. Until that time, the KWC contained spontaneous communities as a “surrealistic extreme of the living environment of mankind” [28].

As a mature community (informal urban growth) beyond the governance of the government [30], KWC (Figures 3 and 4) presented a picture of spontaneous growth with high density (13,000 people/hectare), while that of New York was only about 91 people/hectare [28]. Startlingly, there were 8800 apartments and 1045 business organizations [32] (cited in [28], p. 29). There were also numerous shortcomings in the housing structure, quality, and associated infrastructures. The basic power supply in the city was often overloaded, and there was also a lack of water supply [31]. These conditions imply that the city had a serious deficiency in the management system and social co-construction consciousness. However, in terms of functional adaptability and intensive mixing, the city is a good example of how to develop a high-density comprehensive city into an organism satisfying various living needs [31] (p. 13) with around 12–14 stories [29] (p. 27). Furthermore, the self-sustaining industrial mode, the intensive and mixed use of functions, and the uneven spaces made for a more usable and equal neighborhood relationship, and 3D transportation (in random forms) greatly eased the vertical pressure [29] (p. 29). On the other hand, even if bottom-up spontaneous growth is allowed in a city, governmental supervision and cooperation between formal and informal forces are still necessary with respect to the growth operation strategy and associated infrastructures. This was also the main cause of the city’s unsustainable development.

Figure 3. A map of the Hong Kong Island and Kowloon region in 1915; the KWC is in the upper-right corner of the map (marked “Chinese Town”) (https://commons.wikimedia.org/wiki/File:Victoria_City_and_Kowloon_1915.jpg, public domain, accessed 11 March 2022).
3.3.2. Case Comparison Result

As one of the most prosperous cities in the world, Tokyo has had a spontaneous growth experience that has had a strong impact on the current urban layout and high urban energy. The spontaneous growth, assisted by the sustainable family economy industrial mode and the positive attitude and strong infrastructure support from the government, form strong cooperation between the government, private sector, and community, contributing to the rapid development and prosperity of Tokyo after the Second World War [23]. Meanwhile, the “vernacular” adaptive construction methods are easier for residents to learn, which is also the reason why Tokyo could rapidly grow spontaneously.

As one mature community that is isolated from the government’s regulation, the KWC presented an informal growth image of a high-density city. Even though there were a lot of deficiencies in the building structure, the quality of houses, and basic infrastructure completely caused by no engineering guidance, there is no denying that the KWC provided a good case for an introverted, high-density, comprehensive city with spatial compatibility and functionary intensity. Additionally, it constantly met the residents’ basic requirements as a growing organism [29] (p. 27) [33] (p. 13). Furthermore, the irregular space brought about more even neighborhood relations, and the three-dimensional traffic mode better relieved the pressure from vertical transport. Additionally, we can come to another conclusion that, while spontaneous growth from bottom to top is allowed in contemporary cities, basic regulations from the government on growth strategies and infrastructure support are still necessary.

Through case analysis (Table 1), it can be concluded that the advantages of Tokyo are its strong support from the government, the transparent cooperation relationship among the government, private sectors, and the community, and the adaptive space system, while those of KWC are the intensive and changeable functions; the lack of an effective management system and the overloaded use of land are the disadvantages of KWC. In urban development design, it is necessary to use the advantages and avoid disadvantages so as to realize the sustainable growth of urban buildings at each level, and further investigate
whether the Chinese urban development level, especially the governance level, the ability to set up a strong governance platform, and the adaptative architectural construction ability that could be easily mastered by the individual users, could satisfy the underlying conditions of the goal.

Table 1. Case analysis and comparison of the growth models of Tokyo after the war and Kowloon Walled City in Hong Kong, China (Source: author).

<table>
<thead>
<tr>
<th></th>
<th>Post-War Development of Tokyo (1945–1960s)</th>
<th>Kowloon Walled City, Hong Kong, China (Demolished in 1993)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formal and informal cities</td>
<td>Formal urban growth</td>
<td>Informal urban growth</td>
</tr>
<tr>
<td>Historical relationship</td>
<td>After the war, the population expanded and the government was on the verge of bankruptcy, which made it unable to reconstruct the city.</td>
<td>Neither the authorities of China nor Britain would govern this region at that time</td>
</tr>
<tr>
<td>Density</td>
<td>High</td>
<td>High; 13,000 people/hectare</td>
</tr>
<tr>
<td>Distribution of site resources</td>
<td>Buildings that were easy to metabolize on each land lot emerged due to the subdivision of land ownership.</td>
<td>Three-dimensional barbaric growth within a limited space</td>
</tr>
<tr>
<td>Policy and supervision</td>
<td>Close cooperation was established between the government, private sectors, and community.</td>
<td>Being absolutely beyond the control of policies for special offer estate and buildings and seriously lacking a management system and social consciousness.</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>The government provided infrastructure support and cared about the necessary utility demands of the entire city, such as the establishment of a sewage treatment system, hydropower system, and road system for the city.</td>
<td>The basic power supply in the city was often overloaded; there was also a lack of a water supply.</td>
</tr>
<tr>
<td>Industrial structure</td>
<td>Sustainable family workshop-styled economic industry and local commercial model based on family-owned enterprises; mutual help among the neighborhood</td>
<td>Self-sustaining industrial mode</td>
</tr>
<tr>
<td>Space and function system</td>
<td>Adaptive space system</td>
<td></td>
</tr>
<tr>
<td>Internal transportation patterns</td>
<td>2D pattern</td>
<td>3D pattern</td>
</tr>
<tr>
<td>The mode of construction</td>
<td>Residents were empowered to construct individually, and the mode of construction was easy to be imitated by other residents</td>
<td>Illegal informal construction</td>
</tr>
</tbody>
</table>

3.4. Lessons Learnt from the Case Study and the Missing Point in Sustainable Metabolism

Spontaneous urban growth requires certain necessary constraints under the cooperation of various conditions so as to integrate the urban population, economy, environment, and space, and have citizens or users participate in the development of the city and buildings. Such a “bottom-up” urban development model with an open and equal attitude encourages individuals’ active participation to reduce unnecessary capital and energy consumption, and restricts and balances the development direction of the city and build-
ings while fully guaranteeing the sustainable development of the environment. From the two-case comparison, we can see that it is important to set up a regulation mechanism that supplies strong monitoring/infrastructure support, as well as an adaptive construction system (Figure 5). A good governance system for managing architectural growth has the potential for better satisfying user demand in architecture.

![Image](image.png)

**Figure 5.** The elements of spontaneous architectural growth clarified by case analysis from the perspective of sustainability (Source: author).

Several studies have discussed urban metabolism from the governance perspective [34,35]. However, discussion on the combination of effective governance and adaptive construction in architectural design is lacking. A future study will determine the potential conditional basis in Chinese urban development today and examine how they could link with an architectural growth strategy to achieve sustainable development goals.

3.5. Conditions (Recognized) for Realizing Urban Metabolism in the Context of Contemporary Urban Development in China

To date, many factors, such as social system development, values, participatory design strategies, construction, and management technologies, in Chinese cities have provided the potential conditions for realizing urban metabolism (Figure 6) and assisting in the co-construction of urban growth and renewal.

3.5.1. Multi-Governance-Oriented Development of Community Management

In 2018, Tsinghua University, one of the best universities in China, and other units jointly held the first Community Planning and Social Governance Forum and observed the emergence of community planning practices in some metropolises in recent years [36]. Since 2014, the governments of Beijing, Shanghai, Shenzhen, and other cities have gradually delegated urban management and design power to communities, which enhanced the empowerment of communities and improved the governance ability of Chinese cities. This also enhanced the levels of system modernization, community management, and multi-stakeholders’ participatory social construction (such as [https://www.shqp.gov.cn/housing/zcfg_wygl/20180822/269495.html](https://www.shqp.gov.cn/housing/zcfg_wygl/20180822/269495.html) accessed on 11 March 2022). After tracing the history of reform and opening up, Xiang and Hua (2019) [37] believed that, in the current stage, community construction had begun to add multi-stakeholders’ consultation and co-governance to city management, and the contemporary social development of China provided good social civilization and institutional conditions for the participatory management of architectural space.
3.5.2. Evolution of Information Technology

The vigorous promotion of 5G mobile technology in Chinese cities will accelerate the deep integration of communication technology and sustainable urban development (Please see [link](http://www.gov.cn/xinwen/2019-11/29/content_5456970.htm) accessed on 11 March 2022). Supported by BIM technology, big data, the Internet, and other technologies, it will be available to allow all parts of the building sector to be linked up to share information in real time, access and update databases, promote the transparency of information, and provide a powerful means for multi-stakeholders’ participatory project construction supervision and real-time building management. The information age has truly changed the characteristics of the mechanical age and begun to establish a new state of life, providing potential opportunities for users to participate in the organic growth and metabolism of buildings.

3.5.3. Mature Prefabricated Construction Technology

China’s prefabricated frame structure, shear wall structure, and other technologies are maturing day by day. Since 2013, the central government and local governments have continuously issued policies to greatly support the promotion of relevant technologies and the upgrading of the industry. In 2019, the area of China’s newly commenced prefabricated building projects reached 418 million square meters at an increase rate of 44.6% from that in 2018 (Please see [link](https://www.qianzhan.com/analyst/detail/220/200804-c9c05290.html) accessed on 11 March 2022). Hence, the goal of adaptive space construction can be achieved absolutely.

4. Research Design Results: A Design Strategy Encouraging Users to Participate in Community-Level Low-Carbon Building Construction

4.1. How to Respond to the Research Results with a Strategy Proposal

Based on the above discussion of the importance of governance systems and adaptive construction technology, and the urban development conditions in contemporary China, this paper puts forward a strategy for natural orderly growth (Figure 5) and the sustainable development of the economy, society, and ecology. It involves further research and production of knowledge to understand how urban metabolism could be realized through architectural design. The design proposal learns from the Japanese Metabolism ideologies that divided architectural elements into a hierarchy of two parts, a permanent element and a transient element, where the former refers to a large invariable system or framework and the latter refers to a small variable unit or module [38]. The two elements have different structural hierarchies and metabolic cycles. The combination of the two

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**Figure 6.** The one-to-one correspondence between the conditions for realizing urban metabolism in the context of urban development in contemporary China and the sustainable spontaneous elements for architectural growth (Source: author).
elements can be regarded as “an urbanism of large, technical and institutional infrastructures and the freedom of the individual” [11] (p. 280). The spatial structure growth system designed by the author (Figure 7) was inspired by the “theory of different metabolic cycles” and the advantages of Tokyo’s adaptive structural system that is easy to popularize among users, as well as the central administrative system proposed by Metabolists,

“The Metabolists believed that the city is a process and changeable, thus it is formless and ‘non-plan’ [39]. However, architects paradoxically need to make a plan for the city. Although they embraced people’s autonomy and freedom in the future society, their major concept, megastructure, was accompanied by the idea of a central administrative system where professional architects could play a key role in designing and controlling urban life” [40] (p. 214)

![Figure 7. The process of community and building growth proposed in the author’s proposal. Here is the proposed growth process of building structure and function.](image)

1. Early-stage platform construction: transportation core plus the basic column network system
2. Low-carbon companies are introduced during the incubation period, and the construction space is in its infancy
3. The growth of low-carbon enterprises is during the incubation period, and there are emergence of supporting facilities, such as residences and offices, and the formation of architectural space
4. Low-carbon enterprises in the growth period will further be developed, and supporting facilities, such as residences and offices, will grow proportionally
5. Low-carbon companies in the mature period will expand further, and the building functional space will continue to grow and gradually improve
6. Low-carbon enterprises continue to operate during the stable period, the building function ratio is balanced, and the spatial shape is stable (Source: drawn by the author).

Due to the importance of administrative systems, as mentioned in the KWC and Tokyo’s urban growth, and the development of information technology, the administrative power in our strategy will be changed from the architects to the co-construction information platform. In this strategy, users are involved in the low-carbon development planning and multi-stakeholders’ co-construction management at the community level in the productive relationship of buildings; information technology platforms are used as a means
of management, as well as to bring equality into the three-dimensional spatial growth’s structure; adaptive technology is used as the method for construction and lots (unit) are used as the scale of discussion. Further, various supports are considered to put this strategy into practice. The following will start from scientific land planning, and we will then discuss this strategy in detail from three perspectives: multi-stakeholders’ participatory joint co-construction, an information technology-based management platform, and an adaptive building space configuration.

4.2. Architectural Strategy Proposal

4.2.1. Venue Introduction and Dynamic Conception of Plan Operation

For the convenience of discussion, this strategic plan uses the site of a Shenzhen low-carbon building strategy design competition proposed by the authors as an example to discuss a model that can be promoted in other fast-urbanization cities. The project was designed to be located in two lots in the center of the economic circle (Figure 8) covering the one-hour living circle of Shenzhen, with low-carbon industry and cooperation as the main development model.

![Figure 8. The location of the design plan (Source: author).](image)

4.2.2. Dynamic Conception for Project Operation

The project is a “growing” building born from the concept of “sharing low carbon and letting it be”. The key point of design is how to use information technology to grant buildings the characteristics of organic life and then achieve more effective building management. It can be described as the rethinking of the Japanese metabolism movement in the information era and introspection on the cases of urban growth. Today, as the diversified production relations of buildings continue to develop day by day, the author hopes that the building user is not only the “buyer” of the system of design-construction-building-construction, but also an “intelligent participant” of the building’s construction process. Every construction activity in the field relies on every user (Figure 9), and their indicators vary along with the dynamic conditions, i.e., the building’s self-growth and low-
carbon life, and the production development of the user within the local district is realized by the involvement of the user, which responds to the idea of Architectural Metabolism movement, namely “spatial urbanism”. Such a “crowdfunding” strategy grants more initiatives to construction and development, making the whole local district become more cohesive, competitive, attractive, and popular externally to push the development of urban construction and the realization of the public’s individual interests. It upgrades the community-based economic industry and develops the social economy, and finally drives the community-based economic industry to form a sustainable cyclic development pattern.

Figure 9. Schematic diagram for the building development strategy: circular relationship among users’ involvement, design, construction, and neighborhood operations (Source: author).

4.2.3. Planning the Land Development Strategy and the Industrial Capacity Scientifically

After considering the spatial demands of low-carbon industry and its related populations, the author proposes a spatial strategy compatible with low-carbon technology innovation, industrial incubation cultivation, and international technical exchange/cooperation. The author, by referring to the industrial investment intensity and output intensity as specified in the industrial land-use guide of Shanghai (by comparing the Guide of Shanghai for Industrial Land Use 2012 and the Guide of Guangzhou for Industrial Land Use, Shanghai is the city adopting the relative higher standard), and by comparing with international reference values, determined the industrial access criterion, and the industrial selection principles, access criterion, and demand types of production and living spaces (Figures 10–12).

Based on the research results of Industrial Planning for Projects of Low-Carbon Towns, the author found that the most possible industrial scale of enterprises within the startup area was 0.4–1, where that of the leading enterprises was approximately 15–20%. According to the land function divisions as specified in the Study on Shenzhen International Low-Carbon Startup Area, the enterprises on the two land lots in the future will be approximately one-quarter to one-third of all enterprises within the startup area. According to the aforementioned industrial scale, structural characteristics, and land function requirements, we can estimate the scale and quantity of the enterprises on the two land lots in the future.
Figure 10. Industrial operation principle and industrial access criterion (Source: author).

Figure 11. Output value estimation results of two land lots (Source: author).
Figure 12. Schematic diagram for forecasting the employed population, architectural scale, and spatial characteristics within the proposed community. It is named the “Smart Cube” (Source: author).

The calculation formula is as follows:

\[
\text{Expected production value} = \text{unit annual average production value (mean value)} \times \text{quantity of stationed enterprise (whichever is higher)} \times 1.5
\]

\[
\text{Employed population} = \frac{\text{expected production value}}{\text{per-capita production value}}
\]

4.2.4. Growth of “Building Community” by Joint-Construction Involvement

In the internet era, to remove the characteristics of the mechanical age, the author expects that scientific and technological achievements and information technology will be applied to the community growth process to show the life status of a building. This is to guarantee the possibility of realizing the idea of joint-construction involvement in urban metabolism. The author proposes building a comprehensive strategy of benign work and a life system to optimize the overall management of buildings. In this process, every user can rent or buy an “energy module” (i.e., solar panels, windmill generators, green plants, and energy tiles) from the developer to produce clean energy, and then convert the clean energy into “energy value” to exchange the “building space combination modules” (that is, building beams, slabs, columns, doors, windows, connectors, etc.) with build site spaces to meet their basic needs, or convert them into “virtual low-carbon coins” to consume production and living needs. Additionally, under the condition that there is a surplus of energy output, it is connected to the surrounding area for further external output.

4.2.5. Information Technology Management Platform Construction

If we establish an application platform, i.e., an app–client terminal allowing for real-time monitoring and community interaction, we can use it as a regulator of building development and operation to realize interactive relations between people and building development, and thereby improve people’s initiatives and persistence in involvement (Figure 13). An app platform is specially designed for the building developer, the designer, the constructor, the manager, and the user, and it is also the carrier of the user for all development and operations in the course of production and life (Figure 14). As the app platform holder, the government or the developer is responsible for formulating a comprehensive, relatively fair agreement benefiting all parties in development, and also for the development and maintenance of the app platform. After setting up the app platform, the user, being the independent individual, the group (government, enterprise and public
institutions, and other social public service agencies), and the manager (property holder) will sign an agreement and register to use the app client terminal. Through the app platform, every user can comprehend their role and development in the building at any time, conduct operations related to energy upgrading, spatial use conversion, participate in virtual trading, and receive and send real-time messages related to production and life activity in real society. The app client terminal will record and monitor the real-time data of the user involved in the spatial use, waste, energy production, and consumption, and help the owner and user of the building property to analyze and evaluate the development direction of the building and the risks those might incur.

Figure 13. Schematic diagram for how the application platform supervises and operates the spontaneous growth of a community by information technology (Source: author).

In the whole building, the development signifies the change in the dynamic balance between energy upgrading, consumption reduction, and building space volume. The value of the energy and resources generated and saved by the user by the existing “energy module” can accumulate automatically, and an automatic upgrade will be conducted when the value accumulates and reaches a given number. After upgrading, the user can acquire more energy modules and the building’s used space, and then expand their life and production scale. On the contrary, if the user consumes excessive energy continuously, they will find it difficult to survive in the building and will be passively phased out. Such a reward and punishment system will benefit the user to maintain space and guarantee that the building will develop in a benign and fair manner.

Once the building space cannot meet the benign development demand of a user anymore, the “low-carbon fortune” held by the user, such as “energy value”, “energy module”, “virtual low-carbon currency”, and “building space composite module” (Figure 15), can be returned to the platform, and the platform will return the user substantial currency higher than or equal to that paid before occupation according to the corresponding conversion ratio. Such an architectural growth pattern will generate a novel and sustainable building development pattern to improve people’s initiatives and participation, and form a dynamic
force that can achieve self-directed development and lead building growth. Information technology, as a medium showing building vigor, will effectively improve the management efficiency of the government and developers.

![Image](https://example.com/image1)

**Figure 14.** The operating platform of the app on the user’s mobile phone. The meanings of each stage are: Register/login: users will be in the status of real-time registration in the Smart Cube; Personal center: users could inquiry about their status at any time; My energy: calculate personal consumption among all energy consumption; My community: Users could mutually trade with other users in the Smart Cube (only limited by carbon currency); My bulletin: platform will send messages to the users and play a role of supervision and guidance; My module: users can use the energy exchange space module and use carbon currency to exchange life necessities (Source: author).

![Image](https://example.com/image2)

**Figure 15.** Spatial relationships between greening facilities and buildings (Source: author).

4.2.6. Adaptive Construction Space Configuration

As they are a type of building that allows for organic growth, industrialized prefabricated buildings can realize complete and free assembly and disassembly for space modules. A single (individual) building can be assembled and constructed by using uniform standardized building components on the site according to the unified modulus, making the free composite building capable of meeting the personalized space demand of contemporary people (Figure 16). The project has been specially designed from the component library.
and the construction scale criterion, and all integral buildings are formed by assembling standardized single components (Figure 17); in addition, the sustainable building materials are used to realize their cyclical use and thereby provide a possibility to give the user their own personalized space identity.

Figure 16. Schematic diagram for the adaptive structure system and architectural space module (Source: author).

Figure 17. Schematic diagram for the installation of standardized architectural components (Source: author).
5. Discussion and Conclusions

Vicente Guallart (2014), a planner from Barcelona, proposed a sustainable urban pattern capable of realizing a self-sufficient urban economy and urban ecology in his work titled the Self-Sufficient City [41], which could be viewed as a kind of metabolism today. This paper firstly reviewed the literature on the Japanese Architectural Metabolism. It then conducted a two-case study of related spontaneous urban growth in Asia through comparison. The research analyzed relevant studies, documents, and media reports at this stage. The research then explored the present context of policy conditions, community development, and rapid advancement of information technology in China through reviewing relevant policies and data from the government and research institutes. The paper finally researched a sustainable spontaneous architectural growth strategy through design and proposed a relatively fair and open “crowdfunding” joint-construction involvement pattern based on the lot-scale, aiming at activating urban vitality. The whole design research result showed that it is possible to realize sustainable spontaneous development goals via architectural design strategies combining information technology.

The author set the urban spontaneous growth mechanism based on maintaining the current production and life quality and reducing energy consumption, and encouraged joint-construction involvement in building low-carbon communities, exporting energy outwards as much as possible, and finally forming a sustainable development pattern. In the process of the current study and practice, the author re-defined the role of the government, social investors, and the community’s joint construction party, re-organized their relations, and re-assigned their interests, thereby making it eager to solve the problems of blind and imbalanced urban development in developing cities.

Under such a development strategy, this strategy hopes that city managers, project developers, designer organizations (including planning analysis, industrial study, risk evaluation, planning and design, and technical support), construction organizations, future users, and property departments will serve as the participants and beneficiaries of the full life–cycle of a building, realize scientific planning and design, industrialize standard production, personalize on-site assembly, recycle building materials, improve users’ joint-construction involvement and conscious maintenance, and then make every community realize sustainable social, economic, and life development. The proposal improves the freedom and benefits of the individual users when reaching the overall sustainable goals.

The research further supplies enlightenment for the cities in other developing countries with similar unbalanced development. The “Utopia” and rational proposal is very possible to realize in the present urban environment. Additionally, this strategy is explored to be a mode of construction that can be copied in other cities under similar conditions. The development pattern proposed by the author embraced two further directions. One is introducing economic/industrial calculation and simulation methods to calculate the ecological and economical effect of this model in real construction. The second is studying how to better improve the social and community-level cohesion in this spontaneous architectural growth model.

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