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Modular integrated construction as a development strategy for post-COVID urban sustainability: the case of Hong Kong

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The UN Sustainable Development Goals (SDG) suggest a broader concept of health as the focus of development, i.e., economic growth to take into account of the health and wellbeing of a diversity of people included by age, gender, ability, ethnicity, economic status, region, and generation. With this understanding, a city's development strategy should aim for win-win solutions for the broadest inclusion of people. The global pandemic has caused world economic recession and rising geopolitical tensions, but also the opportunity of digitalization and economic restructuring for more sustainable solutions. This study aims to explore sustainability solutions for the Hong Kong government under this situation, with particular reference to strategic choices related to construction. The Hong Kong government initiated the modular integrated construction (MiC) project delivery model, embedded in a cross-border supply chain, as a major strategy for industrialisation of construction, enabled by an updated institutional infrastructure and growing digital capabilities. On this basis, MiC will gain more market share in construction project businesses, necessitating closer regional collaboration. The MiC model is set to create a pathway towards participation in the carbon market and a gateway connecting green construction project activities with the eligibility for green fund.

KEYWORDS

modular integrated construction (MiC), sustainability, digital capability, institutional infrastructure, green finance, carbon market

1 Introduction

The COVID-19 pandemic and the subsequent economic recession and geopolitical tensions have erased a significant portion of the progress made towards the United Nations (UN) Sustainable Development Goals (SDG) (UN, 2022). However, the crisis has also forced new ways of thinking, living and working. Many cities managed to seize the opportunity to re-establish a more sustainable and healthier 'normal' through digitalization and innovation (Kunzmann, 2020). In Hong Kong, the pandemic was preceded by a few years' social unrest, which caused a negative growth in GDP in 2019 and a further 6% contraction in 2020 (Chen, 2020). Towards the end of 2022, as society was stabilised and borders re-opened, Hong Kong is on its way to recovery, with an official return to normalcy declared on March 1, 2023, symbolised by the lifting of mask-wearing requirements and a closure ceremony of the largest community quarantine facilities in Penny's Bay (Hong Kong Government, 2023). The city took this opportunity to review its positioning in the global context and reset its development strategies towards a more equitable and low carbon economy and sustainable development.

Three challenges have come to the fore under this situation: high uncertainty of the global economy and geopolitics, persistent labor shortage, and the shortage of housing supply in the immediate future (Chief Executive, 2022, p. 28). This article states the Hong Kong Government which addressing these challenges and driving a green economic revival with new industry strategies and supply chain restructuring, updating existing institutional frameworks through digital transformation and industrialised construction. This study presents an institutional analysis on the post-COVID recovery strategies of Hong Kong government with a focus on the adoption of modular integrated construction (MiC) approach in achieving the SDGs in Hong Kong.

2 Review of literature

2.1 The UN sustainable development goals (SDGs)

In 2015, 191 UN Member States, upon agreement of the SDGs, pledged to achieve sustainable, equitable and inclusive development solutions by 2030 (UN, 2023). The SDGs involve 17 goals which are broad themes with overlapping scopes. The 17 themes are focused on the problems of (SDG1) poverty, (SDG2) hunger, (SDG3) health and wellbeing, (SDG4) education, (SDG5) gender equality, (SDG6) water, (SDG7) energy, (SDG8) decent work and economic growth, (SDG9) industry, innovation and infrastructure, (SDG10) regional inequalities, (SDG11) sustainable cities and community, (SDG12) responsible consumption and production, (SDG13) climate action, (SDG14) ocean, (SDG15) life on land (biodiversity), (SDG16) peace, justice and strong institutions, (SDG17) partnership for the Goals (UN, 2022). Dimitriou and Field (2020) changes in geopolitical context have a significant impact on the global infrastructure investment which affects global and local sustainable development goals. Sustainable urban development refers to the ability of cities to meet the needs of current residents without jeopardising the ability of future generations to meet their needs (Hassan and Lee, 2015). It emphasises the achievement of balance and coordination in the economic, social and environmental dimensions (Yigitcanlar and Teriman, 2015; Yan et al., 2018). It means that the sustainability of a city needs a holistic solution to environmental, social and economic sustainable development of the city, including a regional responsibility beyond the city. On this understanding, sustainable urban health needs to consider, firstly, not only the health of the people who use the built environment, but also who produce it; secondly, the health of all classes of people, especially a heathy living condition for the people of lower economic status; thirdly, mental health, which is closely associated with equal opportunities for participation. On the one hand, scholars have proposed a variety of evaluation indicators to assess the level of sustainable development of cities. These indicators usually include economic indicators (e.g., GDP per capita, industrial structure, etc.) (Yang et al., 2017), social indicators (e.g., education level, medical and health conditions, social equity, etc.) (Michalina et al., 2021) and environmental indicators (e.g., air quality, water quality, greening coverage, etc.) (Tasnim et al., 2022). On the other hand, scholars have proposed comprehensive index method, hierarchical analysis method (Ameen and Mourshed, 2019), fuzzy evaluation method (Robati and Rezaei, 2021) etc., to assess the level of sustainable urban development. Despite the progress made in sustainable urban development, it still faces many challenges. For example, environmental pollution, ecological damage and resource shortages in the process of urbanisation are becoming increasingly prominent (Bai et al., 2017); and social inequality and the gap between the rich and the poor within cities also need to be addressed (Chancel, 2020). Therefore, exploring ways to achieve sustainable urban development deserves attention.

2.2 Modular integrated construction (MiC)

A robust correlation exists between Modular Integrated Construction (MiC) and sustainable urban development (Tsz wai et al., 2023). Jin et al. (2021) reviewed building industrialisation, policy, and sustainability. They identified key areas of policy development on MiC development include regulations, standards, incentives, urban design and planning policies, technology policies, management and education policies, and sustainability policies. They suggested that upgrading infrastructure will improve the overall sustainability of the city. MiC fosters the green, efficient, and human-centric development of urban areas (Omotayo et al., 2024). Initially, MiC exhibits substantial benefits in terms of resource conservation and environmental stewardship. By employing precise calculations and prefabricated production methodologies, it enables the minimization of material waste and the reduction of construction debris (Hu et al., 2022). MiC can save time for identification of non-value-added activities and recycling, and improve energy efficiency (Xie et al., 2018). Modular building components possess the capacity for reuse, thereby mitigating the consumption of building materials and decreasing waste emissions. It means that higher reusability of waste in MiC compared with conventional construction method (Begum et al., 2010). Secondly, MiC improves the efficiency of construction. MiC can achieve faster site construction and ensure time certainty, improve financial benefits and cost certainty, better product quality and quality control, increase productivity and labour efficiency (Pan et al., 2019). Finally, MiC improves building quality and safety. Pan et al. (2019) found that MiC can improve environmental sustainability and reduce life-cycle CO2 emissions and health and safety risks. The quality and precision of the building components are assured through the prefabrication process conducted in the factory, which involves rigorous quality testing protocols to ensure compliance with high standards (Skrzypczak, 2023). In addition, Jin et al. (2022) did an empirical analysis on policy drivers of MiC while COVID-19 has been a key circumstance that drive mass implementation of MiC in quarantine facilities (Zhang et al., 2021).

2.3 Digital capability

Digital technologies played a crucial role in the recovery from COVID-19 (Zhang et al., 2023). Digital capability is indispensable for MiC to achieve its promised value for urban and regional sustainability. Bruno et al. (2023) suggested to build resilience by investing in sectoral digital capabilities and infrastructure. Digital technologies facilitate the precise simulation and optimization of building structures for designers, enabling a substantial reduction in design errors and costs. Consequently, this enhances design flexibility and adaptability, fostering more efficient and innovative architectural solutions

(Adeyemi et al., 2024). Digital technology has the capacity to effectuate automation and intelligence within the production process, thereby minimising manual intervention and reducing production costs (Ivanov et al., 2019; Mohamed et al., 2019). Consequently, it enhances production efficiency, leading to more streamlined and cost-effective manufacturing operations. By leveraging digital technology, project personnel are empowered to monitor the progress, quality, and safety conditions at the construction site in real-time, enabling them to promptly identify and address any issues with precision and efficiency (Rane, 2023). Through the application of digital technology, precise procurement and inventory management of construction materials can be achieved, thereby minimising material waste and mitigating environmental pollution (Ajayi et al., 2017). Furthermore, digital technology can be harnessed for the classification, recycling, and reuse of construction waste, thereby fostering the advancement of a circular economy within the construction industry. InvestHK recently published a report to review smart technologies for green buildings in Hong Kong (Arcadis, 2023). They envisioned for the next step of development is to integrate innovation and technology (e.g., BIM, AI) throughout building lifecycle, where green finance is highlighted for supporting the smart green buildings.

2.4 Government policies and measures

The ramifications of governmental policies and initiatives on modular integrated buildings and sustainable development are profound and beneficial. Modular integrated building, as an innovative construction methodology, exhibits substantial advantages in terms of resource conservation, environmental protection, and enhanced construction efficiency. These attributes align closely with the governmental objective of advancing sustainable development. The government can incentivize enterprises and research institutions to undertake research and development (R&D) and innovation in modular integrated building technology (Buravleva et al., 2021) by allocating research funding, offering tax incentives, and enacting other pertinent policies (Pan et al., 2023). By fostering technological innovation and refining the industrial structure, the government can steer the modular building industry towards a more efficient and environmentally sustainable trajectory. To guarantee the quality and safety of modular integrated buildings, the government will establish a comprehensive suite of standards and codes (Wuni and Shen, 2020). These standards will not only elevate the overall industry benchmark but also assure consumers of a safer selection option. The Hong Kong Government mandates the adoption of the Modular Integrated Construction (MiC) methodology for public housing projects, aiming to expedite construction timelines and enhance building quality (Khan et al., 2022). This policy will not only contribute to fulfilling the housing demands of the Hong Kong populace but also facilitate the broader application and sustainable progression of modular integrated buildings within Hong Kong. Concurrently, standardization will expedite the promotion and dissemination of modular buildings. The Hong Kong Buildings Department (BD) has established a pre-approval mechanism that, in principle, pre-approves "modularized" building methods/components. This initiative aims to facilitate the broader utilisation of "modularized" building methods in private building developments in Hong Kong, thereby promoting the widespread adoption and application of modularized and integrated buildings within the region. Through the promotion of demonstration projects, the government showcases the advantages of modular integrated buildings in terms of energy conservation, environmental protection, and enhanced efficiency. Such endeavours serve to elevate public awareness regarding modular integrated buildings and the principles of sustainable development.

3 Methodology

The research methodology employed in this study is centered on the interpretation and analytical examination of governmental report texts. It encompasses three distinct phases: the initial phase involves data collection and organization, followed by data visualisation and interpretive analysis, and culminating in a comprehensive assessment coupled with formulated recommendations. The research methodology for interpreting and analyzing the textual content of government reports constitutes a multifaceted and systematic process, encompassing numerous interconnected stages and procedures. The comprehensive application of this methodology facilitates an in-depth understanding and precise evaluation of the governmental reports content. Consequently, it furnishes a scientific rationale and foundational support for governmental decision-making processes.

In the section pertaining to data collection and organization, it is of paramount importance to ascertain the authority and precision of the data, necessitating the selection of credible data sources. Typically, governmental reports derive their information from official statistics, policy documentation, questionnaires, and third-party data providers, among others. For the purposes of this article, the governmental reports chosen have been sourced from the official website of the Government of Hong Kong, thereby ensuring their authenticity and reliability. Secondly, this paper identifies the initiatives pertaining to MiC based on the 2022 Policy Address issued by the current Hong Kong government (Chief Executive, 2022). Subsequently, it traces the pertinent stakeholders and elucidates their respective responsibilities. Following the identification of key players, an exhaustive search of additional governmental documents is conducted to achieve a comprehensive data organization. In the section devoted to data visualisation and interpretation, this study meticulously identifies the institutional and digital infrastructure associated with MiC within the framework of the policy context and economic environment. It further examines the connections between these infrastructures and the SDGs. An in-depth interpretation of the resultant data is provided, elucidating the underlying meanings, trends, and potential influencing factors that may shape these connections. Ultimately, in the section of comprehensive assessment and recommendations, the study formulates precise policy prescriptions and enhancement strategies, grounded in a rigorous evaluation of the assessment outcomes. These recommendations encompass considerations pertaining to policy efficacy, socio-economic circumstances, potential challenges, as well as other pertinent dimensions.

4 Results and discussion

4.1 Key challenges for a sustainable post-COVID economic recovery

Three challenges have come to the fore: high degree of uncertainty of the global economy and geopolitics, persistent labour shortage, and

the shortage of housing supply in the immediate future (Chief Executive, 2022, p. 28). The Hong Kong Government is addressing these challenges with new industry strategies and supply chain restructuring, updating existing institutional frameworks to drive a green economic revival through digital transformation and industrialised construction.

Over the past decade, Hong Kong's construction industry had around 8,000–15,000 unfilled vacancies every year, signalling a persistent labour shortage (HKCA, 2019). This situation was aggravated by ageing of the workforce. During the pandemic, the Construction Industry Council (CIC) initiated different funding schemes to support registered workers and Small and Medium Sized Enterprises (SMEs), e.g., the Construction Relief Fund (CIC, 2021), which helped to maintain an essential workforce level in the industry. The industry's recent experience of the construction of a large number of quarantine facilities within a short period has helped build up the delivery of MiC capability. The labour shortage has been partly solved by the supply chain restructuring caused by the adoption of MiC, which shifted much of the labour demand to factories located in the Mainland across the border.

4.2 Global positioning of Hong Kong

In this challenging global geopolitical and economic landscape, Hong Kong's economy is moving towards integration with the Mainland China economy, as a component part of the Greater Bay Area (GBA) (Figure 1). Historically, Hong Kong's development benefited from regional cooperation as part of the Asia-Pacific region. In 2020, the Regional Comprehensive Economic Partnership Agreement (RCEP) came into force (ASEAN, 2021). Over 70% of Hong Kong's total trade consists of bilateral trade with the 15 RCEP member nations. Hong Kong is rebuilding the supply chains in service trade and financial investment with these nations (Chief Executive, 2022).

Traditionally, the positioning of Hong Kong in the world economy is of an international trade centre, an international shipping centre and an international aviation hub. On this basis, Hong Kong is also an international financial centre, a global fundraising platform, the world's largest off-shore RMB business centre, and in the immediate future, developing into an international carbon market. Strategic development in the next 5 years and beyond is focused on two emerging industries, innovation and technology (I&T), and arts and culture (A&C), with a vision to become an international I&T centre, an East-meets-West Centre for International Cultural Exchange and a regional centre for arts conservation and restoration. Another strategic area of focus consists of Hong Kong's legal services for translation between the common law and civil law systems, with the vision of becoming a regional centre of disputes resolution, an international intellectual property trading centre, and a gateway connecting Mainland China to the rest of the world.

4.3 Initiatives undertaken by the construction industry

For economic revival, transition and growth, the Hong Kong Government's initiatives include two megaprojects, a series of ongoing

FIGURE 1
The Greater Bay Area: general figures in 2020 (Source: Chief Executive, 2021, p. 3–4).

infrastructure projects and the transformation of the construction industry towards industrialised construction, digitalisation and a greener economy. The two megaprojects are the Northern Metropolis adjacent to the Mainland border and the Lantau Tomorrow plan which involves the creation of three artificial islands off Lantau Island. The adoption of high productivity construction methods including Design for Manufacturing and Assembly (DfMA) and Modular Integrated Construction (MiC) is the chosen strategy for the construction industry, starting with housing industrialisation. The overall model is for green growth including four major decarbonisation strategies of Net-Zero electricity generation, energy saving, waste reduction and green finance based on a carbon market (CarbonNeutral@HK, 2021). Below, the specifics of these initiatives are introduced.

As for occupational health and safety, The Labour Department is piloting a Rehabilitation Programme to support injured workers with rehabilitation treatment for quick recovery (LD, 2022). For non-skilled workers, the government is currently conducting a review on their levels of remuneration under government outsourced service contracts to ensure equality and fairness (Chief Executive, 2022).

4.4 Megaprojects

The Northern Metropolis is a megaproject planned next to the border with Mainland China, budgeted for HK$100 billion (US$ 12.8 billion) as a new international Innovation & Technology (I&T) city in northern Hong Kong, which is planned to produce 165,000 to 186,000 units of housing and 84,000 jobs (Hong Kong Government, 2022). The project is planned to network with Shenzhen, Hong Kong's neighbouring city in the Mainland, and, geographically connected with the I&T cluster in Shenzhen to form an innovation centre in the Greater Bay Area (GBA), which is expected to be the new engine for Hong Kong's strategic development. A number of landmark developments have been planned, including a cluster of cultural facilities, a network of post-secondary education institutions, major sports facilities, hospital networks and a cluster of government offices (Chief Executive, 2022). The new city is designed to be the central business district of the whole GBA, as an ecosystem of business development and green living, conservation, culture and recreation activities.

The land preparation work has been going on for a decade in turning pieces of 'primitive land' into 'spade-ready sites' for major projects. Three building projects are now under construction; other projects are at site formation stage, aiming to commence land resumption procedures for all development projects within 5 years, and to form 40% of the new development land and complete 40% of the new flats within 10 years, which will provide additional 190,000 residential units and increase population from 1 million at the current level to as high as 2.5 million (Chief Executive, 2022).

The Tomorrow's Lantau plan, budgeted for HK$ 580 billion (US$73.8 billion), involves reclamation works for three artificial islands in Kau Yi Chau, totalling 1,000-hectares, as well as the construction of new transport networks, including rail links and a road transport network, and a new cross-harbour tunnel. The vision, is the development of Hong Kong's third central business district as a world finance centre (Ip et al., 2023). This project involves extensive environmental impact assessment for the reclamation processes and public consultation. To make this new piece of land green and liveable, policies specify a 10–20% higher average flat size for both public and private housing and higher ratios of land for open space and community facilities than those specified in existing regulations. The Steering Committee for Land and Housing Supply oversees the procedure relating to the resumption of private land for public use. The government has put forward proposals on the scope of reclamation, land use, transport infrastructure network and financing options in relation to the artificial islands. The Environmental Impact Assessment has already been made (Arup, 2021) and reclamation work is scheduled to start in 2025 (Chief Executive, 2022, p. 34–36).

4.5 Transition to industrialised construction

Off-site construction, including Modular Integrated Construction (MiC) and more generally, Design for Manufacturing and Assembling (DfMA), are strategized as the target approach for improving productivity, quality and the speed of housing supply, opening also to applications in hospitals and other types of projects. The Housing Authority (HKHA) as the government developer of public housing, in coordination with the NOG developer of the Housing Society (HKHS), is to mandate MiC as the delivery model for housing production. The government has recommended that all public housing projects in the next 5 years to adopt the Design for Manufacture and Assembly (DfMA) approach, with the rate of adoption of the MiC approach guided by a roadmap of gradual increase. In the following 5 years, at least 50% of projects must adopt the MiC approach and use the design-build delivery model. The modules are generally built in factories located in the GBA cities at a much lower costs due to the lower land and labour cost in Mainland China. The MiC method has shown itself to be 10–15% quicker in the overall speed of project delivery and a greatly reduced on-site construction time, with both site safety and sustainability measures showing significant improvements.

To tackle the housing crisis, the government has already introduced two new public housing development programmes to increase short-term housing supply: the Transitional Housing (TH) Scheme, targeted for 20,000 units, currently under delivery, and the 30,000 units Light Public Housing (LPH) Scheme, both using the MiC method with standardised simple design, to increase short-term housing supply. This housing will make use of government and private land where no immediate development plan exists, with de-constructable MiC design, to provide temporary public housing of good living quality at a lower rent than that of traditional public housing. When the hosting land is no long available, the THs/LPHs are de-constructed and relocated to a new piece of available land to serve a second lifecycle. The two schemes will increase public housing production by about 50% in the next 5 years. The TH scheme is delivered in partnership with NGOs. The LPH scheme will be solely funded by public funds. Based on the observations from the first MiC TH project, the Nam Cheong 220 Transitional Housing Project, in Hong Kong, Luk et al. (2023) found that MiC modules can be largely reused and relocated to a new location, enabling the achievement of sustainability and circular economy goals.

4.6 Major infrastructure projects

Recent strategic studies by the Government prioritised three major road projects and three strategic railway projects, including the Northern

Metropolis Highway, Shatin Bypass, TKO-Yau Tong Tunnel, Hong Kong-Shenzhen Western Rail Link, Central Rail Link, and the TKO Line Southern Extension project (Hong Kong Government, 2021). The plans of these six infrastructure projects are under public consultation. Meanwhile there are seven already ongoing railway projects, four road projects and two airport extension projects which will be completed in the next few years to improve the inter-connectivity and accessibility of Hong Kong's road network and rail system (Chief Executive, 2022, p. 34–36). These infrastructure projects are expected to improve internal and international connectivity, drive economic development and create jobs.

Apart from the transportation infrastructure projects, manufacturing industry is going through a digital transformation process in which the second Advanced Manufacturing Centre is under construction. Infrastructure for the A&C industry and the Asia World-Expo Phase 2 construction project is to commence in 2023, to be commissioned in 2027. Furthermore, I&T infrastructure projects include the Hong Kong and Shenzhen Innovation and Technology Park (HSITP) and Science Park/Pak Shek Kok Station of the East Rail Line, expansion works at the Science Park and Cyberport, and the ongoing development of San Tin Technopole in the Northern Metropolis, scheduled to be delivered within the next 10 years (Chief Executive, 2022, p. 16–17).

4.7 Developing the digital infrastructures

In 2020, Hong Kong updated its Smart City Blueprint (Innovation and Technology Bureau, 2020) which initiates development in digital payment systems, robots for environmental monitoring, a $40 million LawTech Fund to encourage digitalisation in the legal services sector, and Common Spatial Data Infrastructure.

With well-developed 5G networks, the key issue for a smart city is data. The HK Government is actively opening up multiple data sources and encouraging private and public sectors to share data, as well as liaising with the Mainland to arrange mainland data flow to HK, for fertilising innovation purposes and the coordinated development of smart cities in the GBA.

The MiC project delivery process particularly needs the support of a digital infrastructure, including logistics monitoring, quality control, early supplier involvement at the design stage and construction planning, etc. A digital twin model based on BIM will be needed for registering and responding to the multi-layers of information. Following Hong Kong's first Roadmap for BIM implementation (CIC, 2014) and nearly a decade of voluntary BIM practise in the construction industry, the Government is now developing a Roadmap requiring the mandatory use of BIM if a new project submission is to be granted approval. The government will launch an App in 2024 to automate some of the building regulation compliance checks (Chief Executive, 2022).

4.8 Green infrastructure

Hong Kong's Climate Action Plan 2050 (CarbonNeutral@HK, 2021) sets the vision for Hong Kong to halve total carbon emissions by 2035 and achieve carbon neutrality by 2050, taking the year 2005 as a baseline. Major initiatives include renewable energy, green buildings, green transport, waste management, and use green and sustainable finance products as financial incentives to support decarbonisation. Furthermore, an international carbon market, the 'Core Climate', has been set up by the Hong Kong Exchanges and Clearing Limited (HKEX, 2022, 2023) as an international carbon trading platform.

Green infrastructure has been systematically considered in the planning of the two new megaprojects. For the Northern Metropolis project, along with the I&T industry development, a green infrastructure system is planned, including a Wetland Conservation Parks System drawing from the private wetlands and fish ponds, and a country park based on the 500 hectares of Robin's Nest land. This green infrastructure system echoes with the Shenzhen Wutong Mountain Scenic Area to create a cross-border ecological corridor. Likewise, the planning of the Tomorrow's Lantau is coupled with the design of a green infrastructure system, including a higher than customary ratio for open space and application of the principles for a smart, green and resilient city. The new city is to be powered by green energies and a waste-to-energy system, meanwhile operationalising efficient energy saving and management systems to reduce everyday energy demand and overall carbon emissions.

4.9 Updating institutional infrastructures to enable development

Institutional infrastructure, i.e., the rules, regulations, organising structures and procedures, that embeds all activities in any society, needs to be updated to enable and incentivise the new economic and delivery models. This involves setting up new roles and accountabilities, updating rules and regulations, and streamlining and simplifying approval procedures. The megaprojects involve statutory processes to formulate new legislations and regulations, including, e.g., conservation policy and raised plot ratio limits to frame a higher density development in the Northern Metropolis. The project governance structure for the Northern Metropolis project has been set up, which includes a Steering Committee led by the Chief Executive to steer policy and for supervision purposes, an Advisory Committee chaired by the Financial Secretary involving experts and stakeholders, and a new Government Department to coordinate the whole project. Externally, the HKSAR Government liaises with the Guangdong Provincial Government on the Mainland (Chief Executive, 2022, p. 24–27).

A major obstacle to speeding up housing supply is the statutory procedures for land availability. The Hong Kong Government is streamlining and harmonising the statutory requirements of land production, administrative procedures, approval process, and procedures for land lease extension to make way for the new development. A bill has been discussed recently in the Legislative Council (LegCo) to harmonise six existing Ordinances on planning, environmental impact assessment, land resumption and infrastructure in order to speed up land production, in response to which LegCo set up a Committee to conduct relevant study (LegCo, 2023). The Task Force on Public Housing Projects is responsible for implementing the Pilot Scheme on Private Developer Participation in Subsidised Housing Development (Chief Executive, 2022, p. 65–66).

Adoption of MiC is now among the Key Performance Indicators (KPIs) of the Task Force on Public Housing Projects (Chief Executive, 2022, p. 65–66). Beyond housing projects, the Development Bureau, as the major government developer, is establishing a cross-departmental steering committee to coordinate MiC adoption to streamline related approval processes to enhance the MiC supply chain, including making available land for manufacturing and the storage of modules and fostering collaboration with the GBA.

As for development of the digital infrastructure, the Hong Kong Government has created the new role of Commissioner for Industry, who will co-ordinate and steer digitalisation of manufacturing at the strategic level. The Steering Committee on Land and Housing Supply (Chief Executive, 2022, p. 33, 65) is set to oversee the BIM implementation roadmap and development of the digital design approval system. A series of funding schemes are set up for supporting businesses and digitalisation, e.g., the Re-industrialisation Funding Scheme for subsidising the development of smart production lines.

As for the green economy, the Green and Sustainable Finance Cross-Agency Steering Group was established in 2020, led by the Hong Kong Monetary Authority and the Securities and Future Commission, to accelerate green and sustainable finance development. The construction industry has been an active player in green building standards development, but the system is incompatible with the green finance structure and remains an area open for future work (HKGFA, 2022). On green infrastructure design, the Secretary for Housing will chair a new Taskforce to develop the 'Design for Well-Being Guidelines' to improve community environment and the facilities provided in public housing projects. Five existing estates have been identified for pilot tests (Chief Executive, 2022).

4.10 Future directions

With the above introduced initiatives and strategies, future trends for the Hong Kong economy lie in developing the digital infrastructure across industries and the digital capabilities of both the public and the private sector organisations. BIM will be mandated within the building projects approval processes according to a roadmap. MiC will gain more market share in construction project businesses, necessitating closer supply chain collaboration with the GBA cities in the Mainland China. The existing regulations and procedures for project approval will continue to be harmonised and streamlined to make way for speedy land production and housing project delivery in the immediate future and to enable the new MiC integrated project delivery model. The carbon market as a new positioning strategy of Hong Kong is a promising area for development, in which the construction industry is yet to develop a pathway to participate, as is to establish a gate way to translate between green construction activities and the criteria of green loan and green bond.

5 Conclusion

In conclusion, the economic revival strategy of Hong Kong is to maintain its traditional positions as international aviation, shipping and finance hubs, and built on this foundation, to develop the emerging I&T and A&C industries and a green economy, including green and sustainable finance and an international carbon market. These strategies are materialised in the Hong Kong Government's initiatives of two megaprojects and a series of major infrastructure projects, as well as industrialised construction and BIM mandate in statutory process, enabled by reconfiguration of the institutional infrastructure to facilitate the new MiC project delivery model integrated with a cross-border supply chain. Overall, to mitigate the risks of geopolitical uncertainties and to take up opportunities for development, the direction of Hong Kong's economy is moving towards integration with the economy of Mainland China in becoming the 'capital' region of the GBA and a gateway of China to the rest of the world.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found here: https://www.policyaddress.gov.hk/2022/en/policy.html.

Author contributions

AJ: Conceptualization, Data curation, Formal analysis, Investigation, Visualization, Writing – original draft, Writing – review & editing. YZ: Data curation, Formal analysis, Writing – original draft. JS: Conceptualization, Funding acquisition, Project administration, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The author(s) declare that no Gen AI was used in the creation of this manuscript.

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References

Adeyemi, A. B., Ohakawa, T. C., Okwandu, A. C., Iwuanyanwu, O., and Ifechukwu, G. O. (2024). Integrating modular and prefabricated construction techniques in affordable housing: architectural design considerations and benefits. *J. Constr. Innov.* 18, 67–82. doi: 10.57219/crrst.2024.2.1.0030

Ajayi, S. O., Oyedele, L. O., Akinade, O. O., Bilal, M., Alaka, H. A., and Owolabi, H. A. (2017). Optimising material procurement for construction waste minimization: an exploration of success factors. *Sustain. Mater. Technol.* 11, 38–46. doi: 10.1016/j.susmat.2017.01.001

Ameen, R. F. M., and Mourshed, M. (2019). Urban sustainability assessment framework development: the ranking and weighting of sustainability indicators using analytic hierarchy process. *Sustain. Cities Soc.* 44, 356–366. doi: 10.1016/j.scs.2018.10.020

Arcadis (2023). The City of smart green buildings. Hong Kong, InvestHK: The Government of Hong Kong Special Administrative Region of the People's Republic of China.

Arup (2021). Reclamation for Kau Yi Chau Artificial Islands: Project profile. Hong Kong: Civil Engineering and Development Department.

ASEAN (2021). Regional comprehensive economic partnership (RCEP) agreement to enter into force on 1 January 2022. *Assoc. Southeast Asian Countries*.

Bai, X., McPhearson, T., Cleugh, H., Nagendra, H., Tong, X., Zhu, T., et al. (2017). Linking urbanization and the environment: conceptual and empirical advances. *Annu. Rev. Environ. Resour.* 42, 215–240. doi: 10.1146/annurev-environ-102016-061128

Begum, R. A., Satari, S. K., and Pereira, J. J. (2010). Waste generation and recycling: comparison of conventional and industrialized building systems. *Am. J. Environ. Sci.* 6, 383–388. doi: 10.3844/ajessp.2010.383.388

Bruno, R. L., Korosteleva, J., Osaulenko, K., and Radosevic, S. (2023). Sectoral digital capabilities and complementarities in shaping young firms' growth: evidence from Europe. *Entrep. Reg. Dev.* 36, 115–135. doi: 10.1080/08985626.2023.2218314

Buravleva, Y., Tang, D., and Bethel, B. J. (2021). Incentivizing innovation: the causal role of government subsidies on lithium-ion battery research and development. *Sustain. For.* 13:8309. doi: 10.3390/su13158309

CarbonNeutral@HK (2021). Hong Kong's Climate Action Plan 2050. Hong Kong: Hong Kong SAR Government of the People's Republic of China.

Chancel, L. (2020). Unsustainable inequalities: Social justice and the environment. Cambridge, Boston Metropolitan Area, Massachusetts, USA: Harvard University Press.

Chen, J. (2020). Recovery with challenges - 2021 Hong Kong economic outlook. *Econ. Rev.* 2020, 1–11.

Chief Executive (2021). The chief Executive's 2021 policy address: Northern Metropolis development strategy report. Hong Kong: Hong Kong SAR Government of The People's Republic of China.

Chief Executive (2022). The chief Executive's 2022 policy address: Charting a bright future for Hong Kong. Hong Kong: Hong Kong SAR Government, PRC.

CIC (2014). Roadmap for building information modelling strategic implementation in Hong Kong's construction industry (September 2014). Hong Kong: Construction Industry Council.

CIC (2021). Construction industry council relief fund. Hong Kong: Construction Business Support Scheme.

Dimitriou, H. T., and Field, B. G. (2020). Mega infrastructure projects as agents of change: new perspectives on 'the global infrastructure gap'. *J. Mega Infra. Sustain. Develop.* 1, 1–34. doi: 10.1080/24724718.2020.1786877

Hassan, A. M., and Lee, H. (2015). The paradox of the sustainable city: definitions and examples. *Environ. Dev. Sustain.* 17, 1267–1285. doi: 10.1007/s10668-014-9604-z

HKCA (2019). Advocacy and views. Hong Kong: Hong Kong Construction Association.

HKEX (2022). HKEX launches Core climate, Hong Kong's international carbon marketplace, supporting global transition to net zero. Hong Kong: HKEX News Release.

HKEX (2023). The growth of global carbon markets and opportunities for Hong Kong. Hong Kong: Hong Kong Exchange and Clearing Limited.

HKGFA (2022). Developing Hong Kong as a leading investment fund hub for green and sustainable infrastructure financing. Hong Kong: Hong Kong Green Finance Association.

Hong Kong Government. (2021). Transport Infrastructure for Our Future: Strategic Studies on Railways and Major Roads Beyond 2030, Hong Kong, Transport and Logistic Bureau, Highways Department, Transport Department. Hong Kong SAR Government of the People's Republic of China: Hong Kong goverment. Available at: https://rmr2030plus.hk.

Hong Kong Government. $100 billion for northern Metropolis, Hong Kong, information service department, the Hong Kong SAR government, P. R. China (2022). Available at: news.gov.hk, (Accessed on 13 March 2023).

Hong Kong Government (2023). Penny's bay community isolation facility closing ceremony the government Hong Kong special administrative region press release, 2023.

Hu, R., Chen, K., Fang, W., Zheng, L., and Xu, J. (2022). The technology-environment relationship revisited: evidence from the impact of prefabrication on reducing construction waste. *J. Clean. Prod.* 341:130883. doi: 10.1016/j.jclepro.2022.130883

Innovation and Technology Bureau (2020). Hong Kong Smart City blueprint 2.0, Hong Kong government. Hong Kong: Office of the Government Chief Information Officer.

Ip, R., Hui, J., and Chiu, A. (2023). Is the HK$580 billion cost of creating artificial islands off Lantau worth it? Guang Zhou, China: South China Morning Post.

Ivanov, D., Dolgui, A., and Sokolov, B. (2019). The impact of digital technology and industry 4.0 on the ripple effect and supply chain risk analytics. *Int. J. Prod. Res.* 57, 829–846. doi: 10.1080/00207543.2018.1488086

Jin, X., Ekanayake, and Shen, G. Q. P. (2022). Critical policy drivers for modular integrated construction projects in Hong Kong. *Build. Res. Inform.* 50, 467–484. doi: 10.1080/09613218.2021.2010030

Jin, X., Shen, G. G. P., Wang, Q. C., Ekanayake, E. M. A. C., and Fan, S. (2021). Promoting construction industrialisation with policy interventions: a holistic review of published policy literature. *Int. J. Environ. Res. Public Health* 18, 1–23. doi: 10.3390/ijerph182312619

Khan, A., Yu, R., Liu, T., Guan, H., and Oh, E. (2022). Drivers towards adopting modular integrated construction for affordable sustainable housing: a total interpretive structural modelling (TISM) method. *Buildings* 12:637. doi: 10.3390/buildings12050637

Kunzmann, K. R. (2020). Smart cities after COVID-19: ten narratives. *disP Plan. Rev.* 56, 20–31. doi: 10.1080/02513625.2020.1794120

LD (2022). Pilot rehabilitation Programme for employees injured at work (construction industry). Labour Department: The Government of the Hong kong Special Administrative Region of the People's Republic of China.

LegCo (2023). Bills committee on development (town planning, lands and works) (miscellaneous amendments) bill 2022: Background brief. LC paper no. CB63/2023(01). Hong Kong: Legislative Council.

Luk, C., Yang, Y., Chung, K., Jia, A., and Shen, J. (2023). Technical report on the deconstruction, relocation and reinstallation of MiC modules in the Nam Cheong 220 transitional housing project, technical report for Hong Kong construction industry council. university member.

Michalina, D., Mederly, P., Diefenbacher, H., and Held, B. (2021). Sustainable urban development: a review of urban sustainability indicator frameworks. *Sustain. For.* 13:9348. doi: 10.3390/su13169348

Mohamed, N., Al-Jaroodi, J., and Lazarova-Molnar, S. (2019). Leveraging the capabilities of industry 4.0 for improving energy efficiency in smart factories. *IEEE Access* 7, 18008–18020. doi: 10.1109/ACCESS.2019.2897045

Omotayo, T., Egbelakin, T., Ogunmakinde, O., and Sojobi, A. (2024). Innovations, disruptions and future trends in the global construction industry: Routledge.

Pan, W., Yang, Y., and Pan, M. (2023). Implementing modular integrated construction in high-rise high-density cities: perspectives in Hong Kong. *Build. Res. Inform.* 51, 354–368. doi: 10.1080/09613218.2022.2113024

Pan, W., Yang, Y., Zhang, Z., and Chan, S. (2019). Modularisation for modernisation, Hong Kong, Centre for Innovation in construction and infrastructure development (CICID). Hong Kong: The University of Hong Kong.

Rane, N. (2023). Integrating building information modelling (BIM) and artificial intelligence (AI) for smart construction schedule, cost, quality, and safety management: challenges and opportunities. Cost, quality, and safety management: challenges and opportunities (September 16, 2023).

Robati, M., and Rezaei, F. (2021). Evaluation and ranking of urban sustainability based on sustainability assessment by fuzzy evaluation model. *Int. J. Environ. Sci. Technol.* 19, 625–650. doi: 10.1007/s13762-021-03128-1

Skrzypczak, I. (2023). Statistical quality inspection methodology in production of precast concrete elements. *Materials* 16:431. doi: 10.3390/ma16010431

Tasnim, S., Mahbub, F., Biswas, G., and Haque, D. M. E. (2022). Spatial indices and SDG indicator-based urban environmental change detection of the major cities in Bangladesh. *J. Urban Manage.* 11, 519–529. doi: 10.1016/j.jum.2022.09.004

Tsz Wai, C., Wai Yi, P., Ibrahim Olanrewaju, O., Abdelmageed, S., Hussein, M., Tariq, S., et al. (2023). A critical analysis of benefits and challenges of implementing modular integrated construction. *Int. J. Constr. Manag.* 23, 656–668. doi: 10.1080/15623599.2021.1907525

UN (2022). The sustainable development goals report. New York: United Nations.

UN (2023). Progress towards the sustainable development goals: Towards a rescue plan for people and planet (SDG Progress report 2023). New York: United Nations General Assembly, Economic and Social Council.

Wuni, I. Y., and Shen, G. Q. (2020). Barriers to the adoption of modular integrated construction: systematic review and meta-analysis, integrated conceptual framework, and strategies. *J. Clean. Prod.* 249:119347. doi: 10.1016/j.jclepro.2019.119347

Xie, H., Chowdhury, M. M., Issa, R. R. A., and Shi, W. (2018). Simulation of dynamic energy consumption in modular construction manufacturing processes. *J. Archit. Eng.* 24:1. doi: 10.1061/(ASCE)AE.1943-5568.000028

Yan, Y., Wang, C., Quan, Y., Wu, G., and Zhao, J. (2018). Urban sustainable development efficiency towards the balance between nature and human well-being: connotation, measurement, and assessment. *J. Clean. Prod.* 178, 67–75. doi: 10.1016/j.jclepro.2018.01.013

Yang, B., Xu, T., and Shi, L. (2017). Analysis on sustainable urban development levels and trends in China's cities. *J. Clean. Prod.* 141, 868–880. doi: 10.1016/j.jclepro.2016.09.121

Yigitcanlar, T., and Teriman, S. (2015). Rethinking sustainable urban development: towards an integrated planning and development process. *Int. J. Environ. Sci. Technol.* 12, 341–352. doi: 10.1007/s13762-013-0491-x

Zhang, Y., Yu, Y., Fong, P. S. W., and Shen, J. (2023). Addressing unforeseen public health risks via the use of sustainable system and process management. *Front. Public Health* 11:1249277. doi: 10.3389/fpubh.2023.1249277

Zhang, Z., Zheng, Z., and Pan, W. (2021). Fighting Covid-19 through fast delivery of a modular quarantine camp with smart construction. *ICE Proc. Civil Eng.* 174, 89–96. doi: 10.1680/jcien.20.00025