Journal of Infrastructure, Policy and Development 2024, 8(4), 3424.
https://doi.org/10.24294/jipd.v8i4.3424

Case Report

Exploring the feasibility of using modular technology for construction projects in island areas

Zhenquan Zhou[1,2], Deprizon Syamsunur[2,*], Lanxin Wang[3], Ang Chun Kit[4]

[1] School of Architecture and Engineering, Tianfu College of SWUFE, Mianyang 621050, China
[2] Department of Civil Engineering, Faculty of Engineering, Technology and Built Environment, UCSI University, Kuala Lumpur 56000, Malaysia
[3] School of Electronical and Information Engineering, Chengdu Aeronautic Polytechnic, Chengdu 610100, China
[4] Faculty of Engineering, Technology and Built Environment, UCSI university, Kuala Lumpur 56000, Malaysia
*** Corresponding author:** Deprizon Syamsunur, deprizon@ucsiuniversity.edu.my

CITATION

Zhou Z, Syamsunur D, Wang L, Kit AC. (2024). Exploring the feasibility of using modular technology for construction projects in island areas. Journal of Infrastructure, Policy and Development. 8(4): 3424. https://doi.org/10.24294/jipd.v8i4.3424

ARTICLE INFO

Received: 23 November 2023
Accepted: 4 February 2024
Available online: 22 March 2024

COPYRIGHT

Copyright © 2024 by author(s). *Journal of Infrastructure, Policy and Development* is published by EnPress Publisher, LLC. This work is licensed under the Creative Commons Attribution (CC BY) license. https://creativecommons.org/licenses/by/4.0/

Abstract: Scholars widely agree that modular technologies can significantly improve environmental sustainability compared to traditional building methods. There has been considerable debate about the viability of replacing traditional cast-in-place structures with modular construction projects. The primary purpose of this study is to determine the feasibility of using modular technology for construction projects in island areas. Thus, it is necessary to investigate the potential problems and suitable solutions associated with modular building project implementation. This study is accomplished through the use of qualitative and quantitative methods. It systematically examines desk research based on the wide academic literature and real case studies, collating secondary data from government files, news articles, professional blogs, and interviews. This research identifies several important barriers to the use of modular construction projects. Among the issues are the complexity of stakeholder engagement, limited practical skills and construction methodologies, and a scarcity of manufacturing capacity specialised for modular components. Fortunately, these unresolved challenges can be mitigated through fiscal incentives and governmental regulations, induction training programmes, efficient management strategies, and adaptive governance approaches. As a result, the findings support the feasibility of starting and advancing modular building initiatives in island areas. Project developers will likely be more willing to embrace and commit resources to initiate modular building projects. Additional studies can be undertaken to acquire the most recent first-hand data for detailed validation.

Keywords: prefabricated building; coastal regions; project management; barriers and solutions; sustainability; infrastructure and policy; stakeholder engagement

1. Introduction

There has been a notable surge in public consciousness regarding the adverse consequences of climate change, particularly the component associated with global warming, in recent years (Thaker, 2020). The systemic peril of global warming is widely recognised for its propensity to induce severe weather phenomena, facilitate disease transmission, and reduce biodiversity (Haque et al., 2019). This detrimental phenomenon is primarily attributable to excessive human activity, including the emission of greenhouse gases and the combustion of fossil fuels, according to Bian (2020). Annual European Union (EU) estimates indicate that the construction sector contributes over 25% of worldwide waste generation and approximately 30% of overall energy usage (Wu et al., 2019). The construction industry needs to advance sustainable building technologies and energy solutions in order to halt the progression

of global warming (Zhang and Dincer, 2017). Consequently, in the contemporary global construction industry, the principal objective is to discern a viable project category that functions as an alternative construction method with a particular emphasis on sustainability.

Lachimpadi et al. (2012) posit that the modular building project offers environmental advantages and applies to various construction categories. An expanding cohort of scholars and industry frontrunners are advocating for modular building projects to emerge as the prevailing method in the worldwide construction sector during the forthcoming decade based on an extensive collection of experiments and surveys (Cao et al., 2015; Jiang et al., 2018; Xie et al., 2020; Zhai et al., 2014). In most situations, modular construction should be defined as an offsite building approach, which can decrease construction waste and pollutants effectively (Pan et al., 2021). Although modular construction projects are a viable alternative, it is imperative to emphasise that conventional cast-in-place building projects remain the prevailing force in the construction industry (Xu and Huang, 2015). Substantial obstacles may impede the successful implementation of modular construction projects, potentially leading to substantial financial setbacks for investors and project developers (Jiang et al., 2018; Qin, 2020). Many island areas have been experiencing urban development worldwide, and the huge number of buildings and infrastructure constructions in these regions will likely cause negative impacts on the ecological environment system. Therefore, this study will investigate the impeding factors and solutions of implementing modular building projects on large islands as its major research problem. It is crucial to conduct additional studies evaluating modular projects' promotion and efficient development.

China has a lot of islands, such as the Hainan Province, which currently demands many building and infrastructure constructions. Under sustainable development concepts, the wide application of modular constructions in such large island areas can improve the building sustainability for various project stakeholders, such as the environment, economy, culture and technology. Thus, this article aims to assess the viability of initiating and expanding modular construction initiatives in island areas. The stated research objective is accomplished by completing three specific duties. The first objective is ascertaining the precise advantages of modular construction projects. The analysis results emphasise the significance of employing this sustainable project type compared to conventional cast-in-place projects. Another objective of this study is to ascertain prevalent obstacles encountered during the implementation of modular construction projects. Thirdly, this research seeks to develop suitable solutions to these challenges. These objectives' responses have the potential to generate convincing research results that contribute to the exhaustive completion of a feasibility study. In project management, the preliminary investigation is crucial for academic research and construction practises. It is possible to demonstrate that modular construction projects are a practical implementation method. Consequently, extensive adoption of this particular project category can substantially enhance the ecological sustainability of buildings and infrastructure, thereby mitigating the release of detrimental substances and the detrimental impacts on the health of inhabitants (Cao et al., 2015; Lachimpadi et al., 2012).

2. Review of literature

Hainan Province is a sizable island located in the southern region of China. According to the annual statistics report released by the National Bureau of Statistics of China (NBSC 2019), Hainan's population growth rate remains consistently stable at about 6%. Additional fundamental information about Hainan is also presented in **Table 1**. China has begun the process of urbanising Hainan Province, positioning it as a potential economic hub in the future. This expansive island has a captivating tourism sector and intends to develop into a free commerce port before the year 2050 (Li, 2020; Ma and Liu, 2018). The increasing requirements of residential and commercial structures will likely persist for the next few decades.

Table 1. The basic conditions regarding the Hainan Province of China (NBSC, 2019).

Province	Hainan of China
Capital city	Haikou
Geographical location	South of China
Coordinates	19.5664° N, 109.9497° E
Population	Around 9.5 million
Land total area	35,400 square kilometers
Demographics	83% Han Chinese and other ethnic minority groups
Natural disaster	Tropical cyclones, typhoons, and rainstorms
Geographical features	A typical continental island
Natural growth rate	6.76%

Mao et al. (2015) assert that cast-in-place construction is widely acknowledged as the prevalent type of construction endeavour on a global scale. Many construction developers in developing nations are willing to employ conventional methods (Hamzeh et al., 2017; Wuni et al., 2019). As Khalfan and Maqsood (2014) state, this project category involves finalising all construction activities at the site. Additionally, Lee and Kim (2017) underscore that many construction professionals are acquainted with and favour this traditional project format. However, a considerable proportion of participants in the construction industry are cognizant of the intrinsic drawbacks. Concerns such as excessive construction refuse and pollutants, high energy consumption, variable project budgets and deadlines, and unanticipated on-site hazards are among these drawbacks (Cao et al., 2015; Dong et al., 2015). Scholars have recently supported substituting cast-in-place construction projects with alternative sustainable projects (Gan et al., 2018).

The necessity of Sustainable 'evelopment Goals (S'Gs) is underscored by the United Nations (UN, 2016) in light of the climate change crisis. SDGs influence the construction industry in many aspects, especially focusing on sustainable cities and communities. Additionally, several non-governmental organisations (NGOs) endorse this approach to development. A consensus exists among developed nations, such as Australia, Singapore, and the United States, regarding the superior sustainability of modular construction projects over traditional cast-in-place building projects (Fard et

al., 2017; Haque et al., 2022; Khalfan and Maqsood, 2014; Lawson et al., 2012). An increasing number of developing countries have been directing their efforts towards promoting modular construction initiatives as part of their urbanisation strategy. Although the relevant departments provide backing for modular building initiatives (Jiang et al., 2018), the practical execution of these projects could encounter a few obstacles. Wu et al. (2019) state that the proportion of large-scale building projects incorporating modular construction is comparatively minor in some regional areas. This situation suggests that further development is required regarding implementing modular construction initiatives.

Concerning the budget and schedule of a project, implementing modular construction methods may enable improved management performance. Knaack et al. (2012) delineate the modular project construction process comprising four fundamental phases: Design, prefabrication, transportation, and assembly. This particular project type diverges from the conventional on-site construction approach by requiring the assembly of prefabricated building components. Effectively reducing on-site activities and uncertainties can enhance control over project costs and schedules, as Mao et al. (2015) stated. In addition, substantial distinctions can be observed between the implementation phase of a modular building project and a conventional cast-in-place project. The Modular Building Institute (MBI, 2020) research indicates that the processes of both project types are comparable, including engineering design, planning, and approval. In contrast to conventional building techniques, the modular building project exhibits enhanced time efficiency, reducing the overall construction period by approximately 40%. The Project Management Institute (PMI, 2017) states that time is a critical financial asset for construction initiatives. Consequently, the execution of a modular construction project could potentially yield a more succinct and manageable schedule, thereby facilitating enhanced cost control and reduction.

Because of additional advantages such as time-efficient construction methods and predictable project budgets (Jiang et al., 2018; Xie et al., 2020), modular construction is currently regarded as a sustainable building form in the construction industry. Cao et al. (2015) conducted a comparative experiment to determine the sustainability of modular construction versus conventional building methods for a project. The research findings indicate that modular construction offers comprehensive advantages concerning the sustainability of projects, such as enhancing environmental sustainability. This particular construction methodology has successfully reduced a minimum of 20% of overall building material consumption and 5% of contaminants and waste generated throughout the construction process (Cao et al., 2015; MBI, 2020). Moreover, a subset of construction experts believes that modular construction, in both its in-factory prefabrication and on-site assembly phases, may give rise to the potential fatalities of on-site workers (Jin et al., 2019). Fortunately, employing appropriate procedures can effectively reduce risks while enhancing modular construction projects' sustainability and safety. Fard et al. (2017) document a significant decline in incidents within the modular construction industry over five years when the frequency falls from 21.6% to 3.2%. The extensive utilisation of personal protective equipment (PPE) and the manufacturing expertise gained by construction workers contribute to this advancement (Chunling and Wangjinwa, 2020; Fard et al., 2017). Consequently, in

terms of sustainability, it can be concluded that modular construction projects outperform other building projects.

3. Methodology

This study utilises a comprehensive research technique integrating quantitative and qualitative methodologies, as seen in **Figure 1**. The supporting evidence includes desk research, non-academic secondary data collection, a case study, and a comprehensive literature evaluation (Maria and Andrew, 2009). In the context of quantitative techniques, a wide array of non-academic secondary data is collected. The key data sources include laboratory reports that have been accredited, online publications connected to the building, news articles available online, and a government database. Nevertheless, it is imperative to acknowledge the significance of qualitative techniques for the abovementioned objectives in this scholarly discourse. The compilation encompasses expert comments derived from several sources, including technical publications, construction industry reports, news commentary, and recorded interviews and films obtained indirectly. In essence, the process of data collecting depends on reliable web sources, expert perspectives, and governmental publications, all of which are widely acknowledged as valid sources of information. Furthermore, it is important to note that the public can access all the collated information above and the data gathered. In the following sections, referred data (RD) refers to the collated figures from reputable news reports or technical reports. The Appendix compiles this study's non-academic data and information sources from reputable news reports. Analytical tools encompass a range of instruments, such as Word document chart tools, Excel spreadsheet ranking tables, and SWOT analysis procedures, among others. The SWOT analysis should consider the advantages, disadvantages, opportunities and threats of the object of study (Jiang et al., 2018), which can provide a comprehensive analysis for this research. The collected data is systematically examined and transformed into visually improved representations such as tables, charts, and figures, enabling more effective responses to the relevant sub-queries. By studying other research projects (Jiang et al., 2018), the collected data may be visually represented in a SWOT map, illustrating their correlation with the final analytical results. Moreover, the present study relies on publicly accessible secondary sources and data for citation and analysis. The research findings are elaborated upon extensively in the subsequent paragraphs.

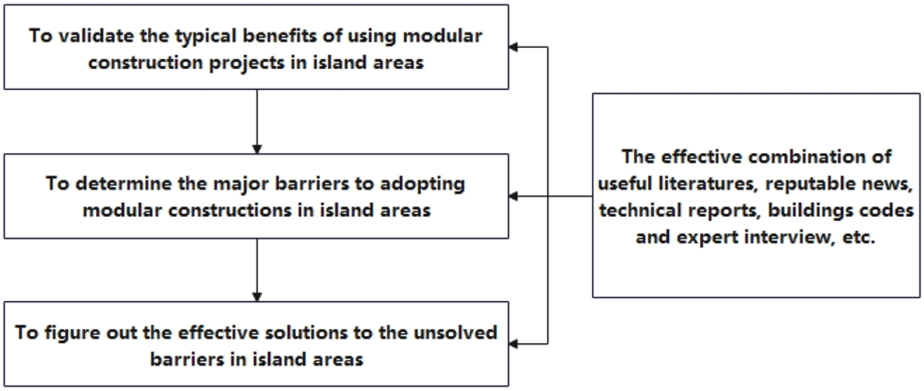

Figure 1. The proposed investigation approach and flow.

4. Findings

4.1. The established advantages of implementing modular construction projects

Hainan Province is a large island in China. The implementation of modular construction projects in Hainan has the potential to enhance and ensure the project's schedule, budget, and quality, as perceived by the project's creators. Compared to traditional on-site building methods, this specific form of project can optimise the timeline and decrease the entire duration. According to the Senior construction developer of the China Construction First Division Group, it is estimated that implementing modular building projects in Hainan may potentially reduce on-site construction time by around 30% (RD1). According to another credible construction source, this specific project can decrease the typical building timeframe by 30% to 50% (RD2). Furthermore, modular projects exhibit a notable cost reduction compared to traditional on-site buildings. According to the spokesperson from the Hainan Construction Group, it is suggested that their modular building projects in the local area have the potential to see a significant decrease of 60% in the requirement for construction labourers (RD3). According to an experienced site engineer employed by the Hainan Construction Industrialisation Company, the total site areas for a modular construction project are around 80% greater than those necessary for a traditional project (RD1). The possibility for lowered building expenditures arises from reduced personnel and site areas. This situation happens because many project expenses are directed towards employing construction workers and acquiring construction sites (Wu et al., 2019). The in-factory prefabrication technique serves as an extra regulatory mechanism for ensuring the quality of a modular building project. The Hainan Housing and Building Department also reports the remarkable calibre of their regional modular building projects (RD4). Many construction elements employed in modular projects are fabricated in controlled factory environments before being transported to the project site, ensuring the project quality (RD2).

The utilisation of modular construction in project implementation has the potential to enhance local environmental sustainability and project safety, in addition to the inherent benefits it offers in terms of project management. One notable benefit of modular projects is their capacity to alleviate the detrimental environmental effects commonly connected with traditional constructions. For instance, there are multiple clusters of modular construction initiatives in Chengmai County, located in Hainan Province. These initiatives indicate that this specific category of projects can reduce building material usage, water consumption, and energy usage by approximately 70%, 80%, and 20%, respectively (RD1; RD4). Furthermore, a construction magazine of high credibility confirms that implementing this ecologically conscious architectural design holds promise in efficiently reducing carbon emissions and pollutant output (RD2). On the other hand, implementing modular construction projects may effectively address possible safety concerns, which are crucial for developers (RD5). The Hainan Province Information Office has provided guidelines stating that prefabricated steel constructions (RD6) can be employed in building high-rise modular structures in areas with a seismic activity of six degrees. The recently introduced

building strategy can potentially safeguard the structures in Hainan from future earthquake calamities, thereby guaranteeing the overall safety of the population (RD2). Implementing this specific project type can potentially decrease the on-site construction casualty probability for construction professionals by 60% (RD7; RD1). In alignment with the conclusions drawn from scholarly research, expert viewpoints, and non-academic secondary sources, an extensive online investigation yields significant evidence and backing for the benefits above. The utilisation of modular building projects presents a range of advantages, encompassing but not limited to the following: expedited construction timelines, decreased land requirements, reduced on-site labour needs, improved energy conservation practises, anticipated cost savings during construction, preservation of development opportunities and quality, and promotion of environmental sustainability.

4.2. The difficulties associated with the use of modular building projects

In the worldwide range, the lack of practical experience and inherent flaws in the building processes used in modular construction projects may cause some challenges to project stakeholders. Compared to more modernised places, Hainan, an expanding metropolitan city in China, could face a few technological obstacles and challenges regarding project safety and quality while attempting to implement this specific project type (RD7; RD8). According to research by the Institute of Earthquake Track, Hainan is an earthquake-prone area in China. Over the last five decades, Hainan has had over ten seismic occurrences with magnitudes of 4.0 or greater (RD9–RD11). Hence, developers have substantial challenges in ensuring the safety performance of modular building projects in Hainan (RD6). It is well known that using skilled building technologies is critical in maintaining the quality and safety of modular buildings. However, many developing regions around the world may present a pool of construction talent that is insufficient. Besides, there is a potential need to improve local building enterprises' modular technologies. Some underdeveloped areas are confronted with difficulty preserving the quality of prefabricated components due to their low capability for offsite building (RD10). A scarcity of skilled modular construction professionals may result in inferior projects prone to collapse, easily posing a hazard to public safety and inflicting injury on persons. This situation is because inexperienced construction workers lack the expertise to install prefabricated building panels effectively in line with recognised building codes (Jiang et al., 2018).

Supply chain management issues can occasionally stymie modular building projects. Suppliers participating in modular building projects usually confront the requirement of providing raw materials to manufacturers on time, followed by delivery of prefabricated panels to the designated construction site on time (RD1). If the transportation step is delayed, this modular project will likely face financial and scheduling issues. Furthermore, dependence on conventional cast-in-situ construction technologies may face opposition from certain construction stakeholders, such as conservative cast-in-place building corporations and local construction workers. Conflicts among stakeholder groups may pose a significant barrier and systematical risks to the progress and expansion of modular building projects in regional areas.

Furthermore, the Hainan Province Housing Department agrees that resolving the

insufficient manufacturing capacity of modular components is a precondition for the wider implementation of modular building projects in Hainan. Furthermore, the China Construction Research Institute predicts a rise in demand for modular construction components in Hainan in 2022. The specific numbers of steel members and precast concrete required are 472,000 tones and 1.66 million square meters, respectively (RD12). According to the statistics, there is a high need for modular building components in the Hainan region. Given the conditions, Wanning City's municipal secretary claims an urgent need for the number of modular manufacturing enterprises in Hainan to increase within the next five years (RD3). As a result, inadequate local industrial capability may cause a substantial hindrance to executing modular building plans. The prior study highlights three major impediments: insufficient practical expertise, acceptance level to modular construction (complexity of engaging project stakeholders), and restricted manufacturing capacity for modular components.

4.3. Solutions to facilitate the adoption of modular building projects

China has made tremendous efforts over the last five years to strengthen the supervision of modular construction projects and the accompanying building codes. The barrier above may be overcome using suitable strategies, including efficient information communication and effective supervision. As a preliminary measure, the Hainan Province Housing Department released the Hainan Province Prefabricated Building Information Platform (RD13) in 2019. The fundamental goal of this endeavour is to effectively convey and expound on the most recent regulations regarding the promotion and execution of modular construction efforts in the Hainan area. This trustworthy web platform, for example, provides a full examination of modular buildings in a broader context and displays a selection of successful modular construction projects completed in the Hainan region. This information site also details forthcoming academic conferences focusing on important research areas, such as the sustainable progress of modular constructions in Hainan. By employing this platform, stakeholders participating in academic and non-academic building projects may improve their understanding of these sustainable construction initiatives. Another digital application for this case could be Building Information Modeling (BIM), which can improve the communication effectiveness and efficiency among different stakeholder groups. This situation can mitigate the complexity during the lifecycle of a modular construction project, such as the supply chain management.

In addition to conducting detailed market analyses, the Hainan local government is constantly revising the modular building standards. Continuous assessments and adjustments can ensure the long-term viability and inclusiveness of present construction schemes. Furthermore, the implementation of their new regulations for the construction industry is overseen by experienced researchers. In 2019, the local government established the Hainan Prefabricated Building Expert Database, which included hiring 35 highly experienced modular building professionals to oversee modular construction projects (RD14). Besides, many building codes and technical standards have been issued, such as technical standards for producing and installing prefabricated concrete precast members in Hainan Province (DBJ46-058-2021). These professionals must ensure that working modular structures adhere to updated building

guidelines. Consequently, Hainan's effective modular building projects are expected to reach three times the land area in 2020 compared to the previous year (RD5). So far, no severe safety concerns have been documented concerning local modular building projects (RD15). Hence, the role of local government is critical in properly addressing this situation. Similarly, it has been seen that effective government assistance can help overcome the remaining challenges of the modular construction market. The Chinese government is encouraging many state-owned construction companies to establish headquarters in Hainan, improving building practices and modifying a lack of practical expertise (RD16). This programme permits state-owned construction companies to supply experienced construction teams and modern modular building technologies to Hainan. Resilient organisations can begin and successfully execute complicated modular building projects that facilitate the progress of local construction firms. Since December 2018, the China Railway, China Railway building, and China Communications Construction firms have monitored substantial and experimental modular building activities in Hainan (RD17). The registered capital of state-owned construction companies is expected to reach 47 billion RMB (RD18). Assisting by state-owned enterprises can effectively overcome the present technological constraints impeding the growth of modular building efforts.

On the other hand, in 2018, construction companies began implementing training programmes for new construction workers. These courses are designed to improve their skills in the construction of modular structures (RD19). For example, in 2019, the company Precast Consultants took the initiative to hold the Hainan Province Prefabricated Building Training Course. The course taught specialists how to execute effective quality and safety control in modular construction projects (RD20). The Hainan Construction Training and Qualification Registration Centre officially authorised three courses with both theoretical and practical components in 2019 (RD21). These courses have been approved as mandatory training for modular building specialists. Given the thorough assessments, the challenges posed by a lack of innovative construction technology and an inexperienced labour force must be solved to support the effective implementation and extension of modular building projects. Furthermore, insufficient modular component manufacturing capability may be mitigated and eventually addressed by introducing effective government aid and incentives. The local government has issued a series of financial incentives aimed at manufacturers to support the establishment of prefabricated factories in Hainan (RD12). By adopting these approaches and corresponding improvements, the demand gap between the required modular panels and available manufacturing capacity may be steadily minimised. For example, in 2017, the Ministry of Housing and Urban-Rural Development allowed the creation of 195 industrial bases. However, 133 industrial sites explicitly designated for in-factory prefabrication have gained formal certification for 2020 (RD1; RD3). The growing number of modular factories can address the issue of insufficient modular component manufacturing capacity by using a logical strategy and establishing efficient operations.

The potential solutions for mitigating the barriers to advancing modular construction initiatives in Hainan are evident and useful, as seen in **Figure 2**. These challenges can be effectively addressed by suitable solutions, whether in the immediate or extended timeframe. Based on the results of these assessments and

feasibility discussions, the developers believe implementing and advancing modular building projects in Hainan is viable. As a result of this phenomenon, project developers possess the capacity to bolster their assurance through investment in and cultivation of the modular construction project category. Such sustainable development offers a range of tangible and intangible advantages to many stakeholders on this large island.

Figure 2. The effective solutions to the three major barriers in the targeted region.

As shown in **Figure 3**, the collated information may be categorised using a SWOT analysis framework. For starters, introducing modular building project typologies has the potential to improve overall project management efficacy and enhance sustainability in construction projects. Using this specific project in Hainan provides different advantages, which may be linked to two important advantages. The key opportunities for utilising and developing modular building projects in Hanan are related to the SDGs under the worldwide collaboration and the Master Plan for the Construction of the Hainan Free Trade Port released by China. As previously indicated, more particular representations can be used to widen the reach of these assets and possibilities. Although the use of modular construction projects provides several benefits and prospects, certain obstacles impede the present progress of this project type. This study identifies and highlights the top five challenges that impede the effective execution of modular building projects through a detailed examination of scientific journal publications and reputable non-academic public sources. Identifying these barriers is based on a comprehensive review of the relevant subject literature. The obstacles may be divided into internal barriers (weaknesses inside the organisation) and external barriers (threats from outside the group). By scrutinising relevant secondary sources, it becomes possible to validate and refine the fundamental impediments into three distinct specific barriers. Island areas like Hainan face challenges in the modular building industry due to project complexity, inadequate technologies, and insufficient production capacity for modular components.

Figure 3. A SWOT analysis of initiating modular projects for the proposed case.

The unique SWOT analysis map presents compelling strengths and prospects for potential construction developers and Hainan investors. This condition can be attributed to the likelihood that doing such a project would yield sufficient benefits and motivation. As presented in **Figure 4**, promoting modular construction in island areas can be regarded as a complex system to a large extent (Gorod and Astapov, 2015). Specifically, the mitigation and resolution of the inherent vulnerabilities and risks associated with implementing modular construction projects can be achieved by strictly monitoring the managerial issues and flexible responses to unpredictable emergencies during the project lifecycle (Gorod and Astapov, 2015). Consequently, the research findings indicate and illustrate that viable solutions have the potential to mitigate the primary obstacles associated with initiating and expanding modular building initiatives in Hainan and other coastal regions under similar conditions. By collating some viewpoints from previous interviews, executing and promoting modular building projects is plausible from the developers' perspective (e.g. an interview with Yahui Shui, an experienced property developer in China). The threats and opportunities can be divided into external factors and managing bodies in this complex system, providing the focused points with project principles. The governing strategies, tools, and methodologies will likely improve the success of developing modular building projects, and their effectiveness can be validated in further investigations. This research is useful and can contribute to many aspects. First, this research outlines the barriers and possible solutions to using modular constructions in the researched regions, which can promote this offsite technology in island areas. This situation can better the sustainability of the local environment, economy, culture and technology development, which aligns with SDGs. It can also enhance the confidence of project investors, bringing more prefabricated building projects to targeted areas and causing a positive systematic influence on promoting this eco-friendly technology. Additionally, this paper can provide a research pattern for other researchers who tend

to conduct similar studies for other regions worldwide. This research can also be cited as a case study for project management discipline.

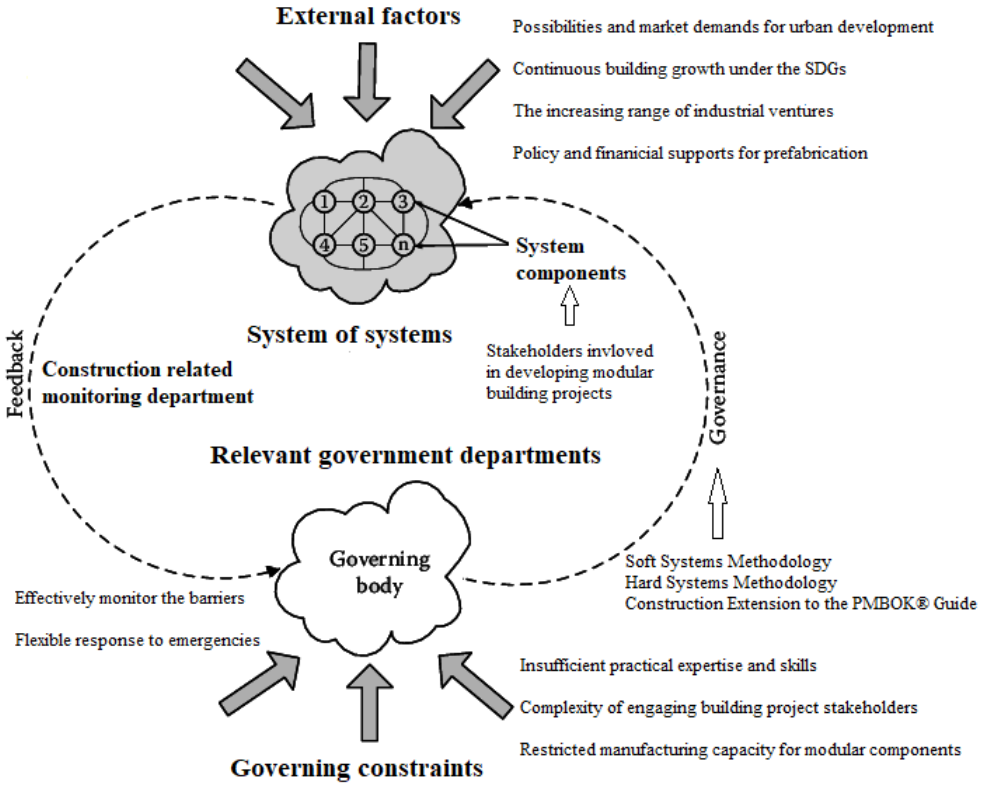

Figure 4. Analysis of the promotion of using modular constructions under system thinking (Gorod and Astapov, 2015).

5. Discussion

This paper employs the SWOT analysis approach and system thinking to assess the feasibility and effective way of implementing modular building project types in island areas. The analytical findings comprehensively consider academic and non-academic sources based on reputable publications, which can ensure accuracy to a large extent. It extrapolates the findings from secondary data sources and establishes a correlation between them and previous scholarly works. Including substantial support can enhance the validity and persuasiveness of the assessment and interpretation findings, thus bolstering the overall credibility of the research. Besides, the investigation results are represented through data conversion into visualised formats. The utilisation of data visualisation may enhance the understanding and interpretation of analytical discovery, hence facilitating a more comprehensive explanation of the findings of research. The research considers three major obstacles to developing prefabricated building projects in island areas: insufficient practical expertise, the complexity of engaging project stakeholders, and restricted manufacturing capacity for modular components. All these issues can be addressed or mitigated by effective governing strategies. The results of the investigation reveal the huge potential and bright future of developing modular constructions in island areas. These analytical findings can enhance the confidence of significant internal stakeholders (e.g., project investors), continually promoting the use of prefabricated

technology in construction. Adopting modular constructions can improve the project sustainability for the long-term development of island areas. The situation also satisfies the SDGs, considering positive environmental, economic, social, cultural and technological benefits.

Nevertheless, this study has several limitations. This study needs to reduce the influence of the subjective viewpoints from different stakeholder groups, which could be modified by using multi-criteria decision analysis in further research. Besides, verifying and revising the research findings based on bigger data collection is advisable, ensuring timeliness and accuracy. Further investigation can also consider more cases of coastal regions instead of the geographically isolated island areas. This modification can provide similar regions with accurate and effective solutions, facilitating modular constructions in developing areas. Consequently, the investigation might be conducted to gather up-to-date empirical evidence and assess the validity of previous assertions. Further investigations can improve collected and collated data accuracy, applying analytical results for more extensive research regions.

6. Conclusion

An increasing number of construction stakeholders see the bright future of implementing modular building projects, such as enhanced project management efficiency and greater environmental sustainability. This research assesses the viability of combining modular construction projects in island areas. The study employs qualitative and quantitative methodologies to evaluate the advantages, obstacles, and pertinent solutions for implementing modular building projects in Hainan. According to the analytical findings, the three major obstacles to developing prefabricated building projects in island areas are insufficient practical expertise, complexity of engaging project stakeholders (e.g., acceptance level to modular construction), and restricted manufacturing capacity for modular components. Fortunately, realistic methods for overcoming the obstacles above exist, including industrial collaboration among different corporates, policy backing and government incentives, support for supply chain efficiency and manufacturing capacity of modular constructions, and suitable governing strategies (e.g., strictly monitoring the managerial issues and flexible response to unpredictable emergencies). This research demonstrates that starting and advancing modular building projects in Hainan is possible and positive, as evidenced by the analytical findings. This case shows that project developers are more confident implementing and funding modular building activities in Hainan and other areas under similar conditions. On the other hand, further investigation is required to complete the bigger data collection to validate and improve the accuracy of previous research claims. To appropriately estimate the potential impediments and solutions, obtaining sufficient data first-hand from a designed questionnaire survey and face-to-face interviews is recommended, and employing calculation models can reduce the subjectiveness of collated figures effectively. Based on a comprehensive and objective feasibility study, modular constructions in island areas and related regions can be smoothly promoted to the building and infrastructure projects. The successful development of prefabrication projects can bring about increasing benefits for internal and external stakeholders, bettering the project sustainability on the

environment, finance and culture to a large extent.

Author contributions: Conceptualization, ZZ and DS; methodology, ZZ; software, ZZ and LW; validation, DS, LW and ZZ; formal analysis, ZZ; investigation, ZZ; resources, ZZ; data curation, DS; writing—original draft preparation, ZZ; writing—review and editing, ACK; visualization, DS; supervision, DS; project administration, ZZ; funding acquisition, ZZ and DS. All authors have read and agreed to the published version of the manuscript.

Acknowledgments: The authors thank the Department of Civil Engineering in the Faculty of Engineering, Technology and Built Environment at UCSI University for their invaluable help in completing this research. They also show appreciation for the support of Tianfu College of SWUFE.

Conflict of interest: The authors declare no conflict of interest.

References

A guide to the project management body of knowledge (PMBOK guide), 6th ed. Project Management Institute, Newtown Square, Pennsylvania; 2017.

Bian, Q. (2020). Waste heat: the dominating root cause of current global warming. Environmental Systems Research, 9(1). https://doi.org/10.1186/s40068-020-00169-2

Cao, X., Li, X., Zhu, Y., & Zhang, Z. (2015). A comparative study of environmental performance between prefabricated and traditional residential buildings in China. Journal of Cleaner Production, 109, 131–143. https://doi.org/10.1016/j.jclepro.2015.04.120

Chunling, Z., & Wangjinwa, Z. (2020). Quality Management and Safety Evaluation for Prefabricated Buildings. International Journal of Performability Engineering, 16(5), 811. https://doi.org/10.23940/ijpe.20.05.p15.811820

Dong, Y. H., Jaillon, L., Chu, P., & Poon, C. S. (2015). Comparing carbon emissions of precast and cast-in-situ construction methods – A case study of high-rise private building. Construction and Building Materials, 99, 39–53. https://doi.org/10.1016/j.conbuildmat.2015.08.145

Fard, M. M., Terouhid, S. A., Kibert, C. J., & Hakim, H. (2015). Safety concerns related to modular/prefabricated building construction. International Journal of Injury Control and Safety Promotion, 24(1), 10–23. https://doi.org/10.1080/17457300.2015.1047865

Gan, X., Chang, R., & Wen, T. (2018). Overcoming barriers to off-site construction through engaging stakeholders: A two-mode social network analysis. Journal of Cleaner Production, 201, 735–747. https://doi.org/10.1016/j.jclepro.2018.07.299

Gorod, A & Astapov, S. (2015). Case Studies in System of Systems, Enterprise Systems, and Complex Systems Engineering. CRC Press. https://doi.org/10.1201/b17139

Hamzeh, F., Abdul Ghani, O., Saleh Bacha, M. B., & Abbas, Y. (2017). Modular concrete construction. Engineering, Construction and Architectural Management, 24(6), 935–949. https://doi.org/10.1108/ecam-11-2014-0148

Haque, Md. O., Aman, J., & Mohammad, F. (2022). Construction sustainability of container-modular-housing in coastal regions towards resilient community. Built Environment Project and Asset Management, 12(3), 467–485. https://doi.org/10.1108/bepam-01-2021-0011

Haque, U., da Silva, P. F., Devoli, G., et al. (2019). The human cost of global warming: Deadly landslides and their triggers (1995–2014). Science of The Total Environment, 682, 673–684. https://doi.org/10.1016/j.scitotenv.2019.03.415

Jiang, R., Mao, C., Hou, L., Wu, C., & Tan, J. (2018). A SWOT analysis for promoting off-site construction under the backdrop of China's new urbanisation. Journal of Cleaner Production, 173, 225–234. https://doi.org/10.1016/j.jclepro.2017.06.147

Jin, Y., Zhang, J., & Sun, L. (2019). Safety Risk Assessment of Prefabricated Building Construction Based on Bayesian Network. IOP Conference Series: Earth and Environmental Science, 371(3), 032052. https://doi.org/10.1088/1755-1315/371/3/032052

Khalfan, M. M. A., & Maqsood, T. (2014). Current State of Off-Site Manufacturing in Australian and Chinese Residential Construction. Journal of Construction Engineering, 2014, 1–5. https://doi.org/10.1155/2014/164863

Knaack, U., Chung-Klatte, S., & Hasselbach, R. (2012). Prefabricated Systems. https://doi.org/10.1515/9783034611404

Lachimpadi, S. K., Pereira, J. J., Taha, M. R., & Mokhtar, M. (2012). Construction waste minimisation comparing conventional and precast construction (Mixed System and IBS) methods in high-rise buildings: A Malaysia case study. Resources, Conservation and Recycling, 68, 96–103. https://doi.org/10.1016/j.resconrec.2012.08.011

Lawson, R. M., Ogden, R. G., & Bergin, R. (2012). Application of Modular Construction in High-Rise Buildings. Journal of Architectural Engineering, 18(2), 148–154. https://doi.org/10.1061/(asce)ae.1943-5568.0000057

Lee, J.-S., & Kim, Y.-S. (2017). Analysis of cost-increasing risk factors in modular construction in Korea using FMEA. KSCE Journal of Civil Engineering, 21(6), 1999–2010. https://doi.org/10.1007/s12205-016-0194-1

Li, Q. (2020). China's Development Under a Differential Urbanisation Model, 1st ed. Springer Singapore.

Ma Zhiping & Liu Xiaoli (2018). Hainan tourism options blossom. China Daily.

Mao, C., Shen, Q., Pan, W., & Ye, K. (2015). Major Barriers to Off-Site Construction: The Developer's Perspective in China. Journal of Management in Engineering, 31(3). https://doi.org/10.1061/(asce)me.1943-5479.0000246

Maria J. Grant & Andrew Booth (2009). A typology of reviews: an analysis of 14 review types and associated methodologies. Health Information & Libraries Journal, 26(2), 91–108. Portico. https://doi.org/10.1111/j.1471-1842.2009.00848.x

MBI (2020). The environmental impact of traditional vs modular construction. Available online: https://www.modular.org/HtmlPage.aspx?name=why_modular (accessed on 2 November 2023).

National Bureau of Statistics of China (2019). China Statistical Yearbook 2019. China Statistics Press.

Pan, W., Wang, Z., & Zhang, Y. (2021). Module equivalent frame method for structural design of concrete high-rise modular buildings. Journal of Building Engineering, 44, 103214. https://doi.org/10.1016/j.jobe.2021.103214

Qin, L., Xu, W., Zhao, X., & Ma, Y. (2020). Typhoon track change–based emergency shelter location–allocation model: a case study of Wenchang in Hainan province, China. Injury Prevention, 26(3), 196–203. https://doi.org/10.1136/injuryprev-2018-043081

Thaker, J., Smith, N., & Leiserowitz, A. (2020). Global Warming Risk Perceptions in India. Risk Analysis, 40(12), 2481–2497. Portico. https://doi.org/10.1111/risa.13574

The United Nations (2016). THE 17 GOALS, The Department of Economic and Social Affairs. Available online: https://sdgs.un.org/goals (accessed on 2 November 2023).

Wu, G., Yang, R., Li, L., Bi, X., Liu, B., Li, S., & Zhou, S. (2019). Factors influencing the application of prefabricated construction in China: From perspectives of technology promotion and cleaner production. Journal of Cleaner Production, 219, 753–762. https://doi.org/10.1016/j.jclepro.2019.02.110

Wuni, IY, Shen, GQP & Mahmud, AT (2019). Critical risk factors in the application of modular integrated construction: a systematic review. International Journal of Construction Management.

Xie, L., Chen, Y., Xia, B., & Hua, C. (2020). Importance-Performance Analysis of Prefabricated Building Sustainability: A Case Study of Guangzhou. Advances in Civil Engineering, 2020, 1–17. https://doi.org/10.1155/2020/8839118

Xu, W. & Huang, Y. (2015). Island infrastructure drive set to make waves. China Daily.

Zhai, X., Reed, R., & Mills, A. (2014). Factors impeding the offsite production of housing construction in China: an investigation of current practice. Construction Management and Economics, 32(1–2), 40–52. https://doi.org/10.1080/01446193.2013.787491

Zhang, X & Dincer, I. (2017). Energy Solutions to Combat Global Warming, 1st ed. Springer International Publishing.

Appendix

RD1-https://m.thepaper.cn/baijiahao_10835534
RD2-https://www.sohu.com/a/199884720_497266
RD3-https://m.thepaper.cn/newsDetail_forward_10996957?from=
RD4-https://i.ifeng.com/c/81SK089yEGu
RD5-https://hainan.sina.cn/news/hnyw/2020-05-27/detail-iirczymk3748417.d.html?cre=tianyi&mod=wpage&loc=14&r=32&rfunc=49&tj=none&tr=32&wm=wo?vt1&wm=wo?vt1
RD6-https://www.sohu.com/a/706850218_121687414
RD7-http://zjt.hainan.gov.cn/szjt/zpcnbj/zpsjztjcnbj.shtml
RD8-https://news.cgtn.com/news/2020-09-14/S-China-s-Hainan-free-trade-port-begins-construction-on-151-projects-TLQxb09WjC/index.html
RD9-http://www.gysfdcyxh.com/h-nd-1550.html
RD10-https://www.gov.cn/xinwen/2018-06/28/content_5301769.htm
RD11-https://earthquaketrack.com/p/china/hainan/recent
RD12-http://zjt.hainan.gov.cn/attachment/cmsfile/szjt/zpzcwj/201805/daofile/3956990e663f72e9c44e19e96844ecaa4bc01.pdf
RD13-http://zjt.hainan.gov.cn/szjt/zpsjz/zpsjztj.shtml
RD14-http://hainan.cnpbi.com/cycj/1168.html
RD15-https://finance.sina.com.cn/tech/2021-02-07/doc-ikftpnny5551527.shtml
RD16-http://www.sasac.gov.cn/n2588025/n2588139/c16872606/content.html
RD17-https://www.hinews.cn/news/system/2018/12/25/032003699.shtml
RD18-https://www.thepaper.cn/newsDetail_forward_8239277
RD19-http://zjt.hainan.gov.cn/szjt/zjkhpx/zjxw.shtml
RD20-https://www.sohu.com/a/326208776_303572
RD21-http://zjt.hainan.gov.cn/szjt/dejgjs/dezjgjs.shtml