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Risk Analysis of the Development of Sustainable Dongtan

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Abstract: Dongtan is set to be developed as a sustainable urban-rural integration, aiming to attract a wide range of commercial and leisure investments. The Shanghai Industrial Investment Corporation (SIIC), the largest international investment group owned by the Shanghai municipal government, is leading the Dongtan project in partnership with Arup. The project's risks are categorized into eight major groups: (1) Force majeure, (2) people-related risks, (3) financial and economic risks, (4) political and country risks, (5) environmental risks, (6) completion-related risks, (7) design-related risks, and (8) technology risks. Among these, political risk is particularly notable for its high probability and significant impact. Effective project risk management is essential to foresee and address uncertainties that could jeopardize the project's objectives and timelines. Appropriate strategies must be implemented to manage and mitigate these risks.

Keywords: Major risks; Project risk management; Risk mitigation; Sustainable Dongtan

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1. Introduction

Dongtan is situated in a strategic position near Shanghai on China's third largest island, at the mouth of the Yangtze River. Dongtan is three-quarters the size of Manhattan and will be developed as a sustainable urban-rural integration to attract a whole range of commercial and leisure investments.

The Dongtan project (**Figures 1 & 2**) is being developed by the Shanghai Industrial Investment Corporation (SIIC), the largest international investment group owned by the Shanghai municipal government, in partnership with Arup. Arup, a global design, engineering, and business consultancy, is also the client for Dongtan and is responsible for the integrated master planning of the development.

Dongtan will be completed in phases, with future development up to around 2050, and is expected to accommodate up to 500,000 people on approximately 30 km^2 (3,000 hectares/7,415 acres). It will be the first ecological urban-rural integration in the 21st century, featuring a high-efficiency, small-footprint design based on sustainable development principles. It will be a livable, complete community that makes economic, environmental, and social sense locally while contributing to national and global sustainable development, serving as a compelling model for sustainable urban-rural integration worldwide.

Figure 1. Sustainable Dongtan

Concerns for the Dongtan project include risks that can influence project objectives of cost, time, and quality. Some risks in the development process are predictable or readily identifiable, while others may be unforeseen. Major risks are classified into eight categories: (1) Force majeure, (2) people-related risks, (3) financial and economic risks, (4) political and country risks, (5) environmental risks, (6) completion-related risks, (7) design-related risks, and (8) technology risks. Among these, political risk is particularly notable for its high probability and significant impact.

2. Materials and methods

2.1. Necessity of risk management

The whole point of undertaking a project is to achieve or establish something new, to venture, to take chances, to risk [1]. Risk is defined as a combination of the probability of a negative event and its consequences. Large engineering projects are notably complex, unique endeavors characterized by substantial irreversible commitments, skewed reward structures in the event of success, and high probabilities of failure. The complexity of these projects arises from two main sources: the interdependence of tasks and uncertainty.

Uncertainty in large engineering projects stems from four sources: (1) management's unfamiliarity with local resources and environment; (2) incomplete specifications for activities at the construction site; (3) lack of uniformity in materials, work, and teams with regard to time and place; and (4) the unpredictability of the environment. Once built, such projects have limited use beyond their original intended purpose. Potential returns can be significant, but they are often constrained. The journey to the period of revenue generation typically takes about 10 years, necessitating substantial front-end expenditures before committing large capital costs. [2].

Participants in large engineering projects face greater risk and uncertainty compared to other projects, many of which are beyond their direct control. The process of taking a project from initial investment appraisal to completion and eventual use is complex, generally customized, and involves time-consuming design and production stages. This process necessitates the involvement of numerous individuals with diverse skills and interests, and the coordination of a wide range of disparate, yet interrelated, activities. This complexity is further compounded by numerous uncontrollable external factors [3].

As a result, participants in large engineering projects often endure agonizing outcomes, such as unusual delays in project completion, cost overruns, and occasionally failing to meet quality standards and operational requirements. Therefore, effective analysis and management of construction-related risks remain a significant challenge for industry practitioners [4].

To ensure a successful project, it is essential that all participants implement methods to manage risks and mitigate the impact of any negative events.

2.2. Risk management process

2.2.1. Framework of risk management process

The framework of the risk management process is shown in **Figure 2.**

2.2.2. Risks identification and assessment

Risk management is fundamental to the success of a project. Understanding and managing risks, especially in large engineering initiatives, are challenging tasks. A comprehensive list of all possible risks should be identified at the beginning of the risk management process. For general projects, risks should be categorized into (1) market-related: demand, financial, and supply; (2) completion-related: technical, construction, and operational; and (3) institutional: regulatory, social acceptability, and sovereign. Strategies for addressing foreseeable risks can be developed using management science approaches, ensuring that the costs of controlling risks align with the expected benefits. Most risks and their control should be framed as managerial problems rather than technical issues. Some risks can be managed through direct allocation and mitigation, while others are best controlled by shifting them to co-specialized players with the necessary competencies, interests, and knowledge. These lists and categorizations are based on the assumption that risk is inherently negative and poses a threat to the project (**Table 1**) [5].

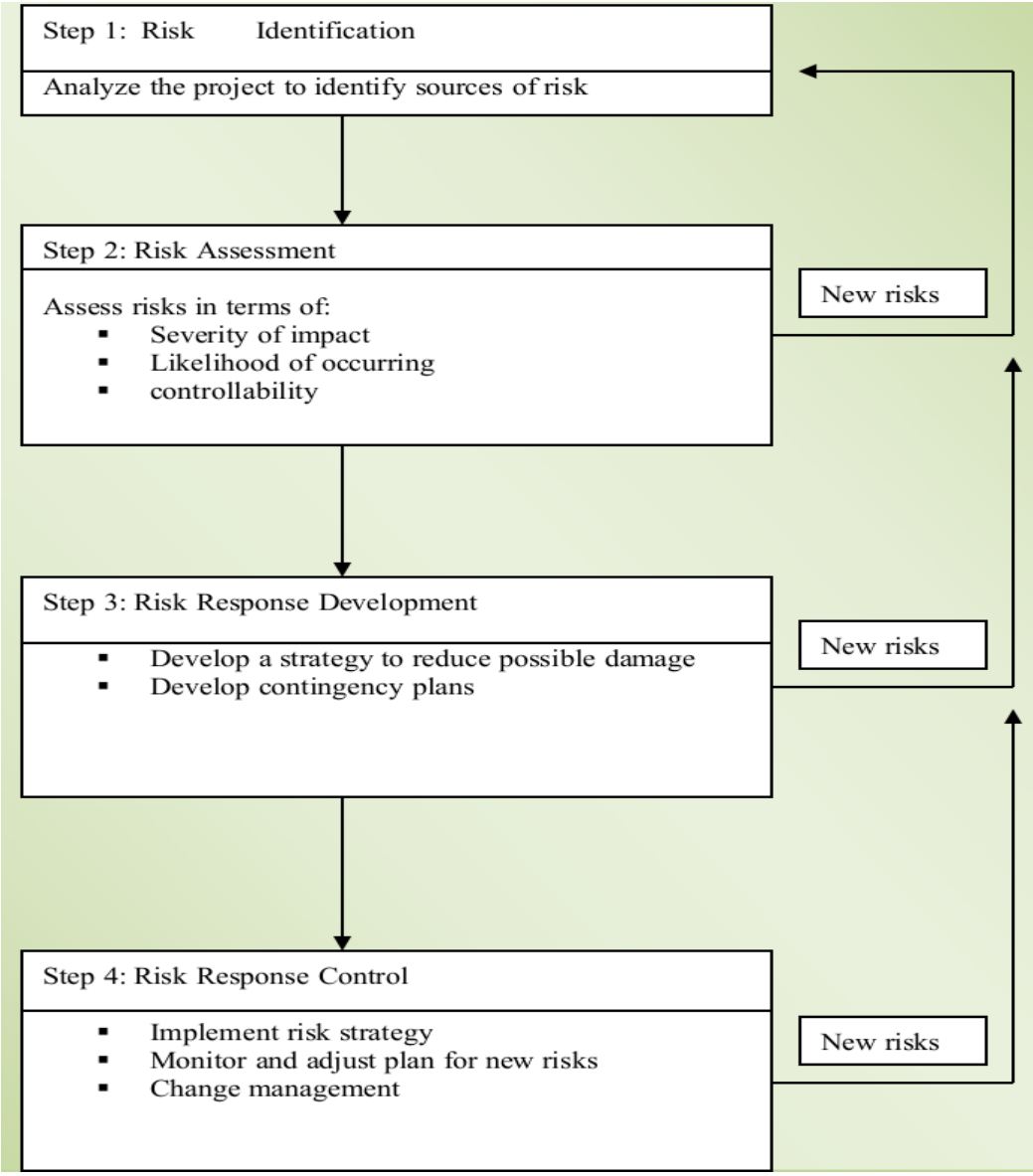

Figure 2. Framework of the risk management process

Table 1. Typical construction project risk categorization

Risk category	Risk
Market-related	Demand
	Financial
	Supply
Completion-related	Technical
	Construction
	Operational
Institutional-related	Regulatory
	Construction
	Operational

In project management terms, the most serious effects of risk can be summarized as follows:

(1) Failure to keep within the cost estimate

(2) Failure to achieve the required completion date

(3) Failure to achieve the required quality and operational requirements [6]

For the development of Dongtan, it's crucial to identify risks early on, during phases like feasibility and master planning. In the context of the Dongtan project, risks are events that impact project objectives of cost, time, and quality. Some risks associated with the development process are predictable or identifiable, while others may be unforeseen. These risks can be classified into eight categories (**Table 2**).

Table 2. Main risks identified in the development of Dongtan

Identified risks	Main characteristics
Force majeure	Floods, hurricanes
People-related risks	Labor education, experience, insufficient skilled staff
Financial and economic risks	Inflation, unavailability of funds
Political and country risks	Corruption, changes of law, political uncertainty
Environmental risks	Some constraints and changes in rules and regulations
Design-related risks	Defective design
Completion-related risks	Site acquisition and access, delay in completion, etc.
Technology risks	New technology use

2.2.3. Risk analysis and mitigation

The purpose of risk analysis and management is to help stakeholders avoid these failures. Risk analysis helps in estimating the potential impacts of risk and in making decisions regarding which risks to retain and which risks to transfer to other parties. Some quantitative and qualitative techniques are available for risk analysis. The quantitative methods rely on the probability distribution of risks and may give more accurate results than the qualitative methods if the available data is reliable. On the other hand, qualitative methods depend on the personal judgment and past experiences of the analyst and the results may vary from person to person. Hence the quantitative methods should be given precedence if both choices are available. The analysis is often used in estimating risk probability and impact on a simple scale (**Figure 3**).

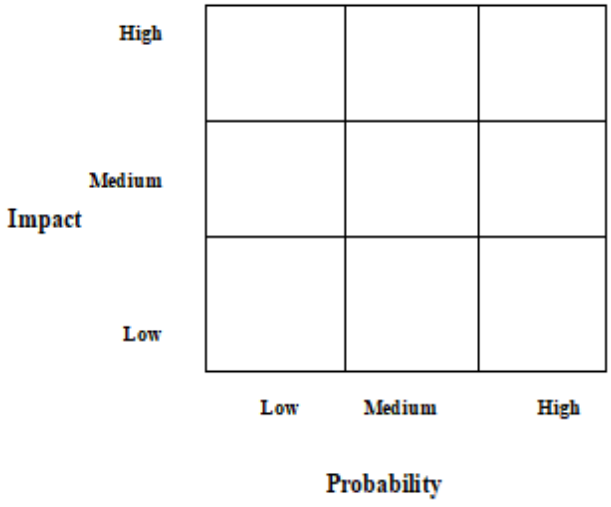

Figure 3. Probability-impact grid

2.2.3.1. Completion risk

Since the inception of Dongtan's development, completion has been fraught with risks. Foreign architects often find themselves losing control over their Chinese projects, facing the embarrassment of cost-cutting measures and spontaneous redesigns by developers. Many striking Shanghai towers, while impressive from the outside, often lack cohesion and functionality internally, resembling more of a Moscow aesthetic than Tokyo. Dongtan, too, faces the risk of devolving into a Potemkin eco-village, merely a superficial display of green technology that ultimately fails to deliver. Below are some primary causes of completion risks in Dongtan's development.

2.2.3.1.1. Permit

Lenders typically mandate the acquisition of construction permits before disbursing funds, ensuring that the lack of such permits does not impede project completion. Additionally, investment and financing permits must be secured before financing can take effect.

Furthermore, the ultimate completion of the project may hinge on obtaining operating permits that validate compliance with emissions or safety regulations. A government support agreement can help reduce the risk of problems with permits. Although it may not eliminate the need for permits, it can provide a basis for the cooperation of the government in obtaining permits from ministries and other agencies.

Arup signed a broad contract with Shanghai Industrial Investment (Holdings) Co. (SIIC) to design, master plan, and manage the Dongtan development project. With strong government support, this arrangement helps to mitigate the risks associated with obtaining permits (**Figure 4**).

Figure 4. Arup signing the Dongtan contract with SIIC- Shanghai Industrial

2.2.3.1.2. Construction cost overturn

There may be insufficient funding available to complete the project, potentially forcing the sponsors to invest funds for which they have not committed. This situation aims to avoid the loss of their investment or putting them at a severe disadvantage by necessitating requests for further funds from lenders or agreeing to new financing arrangements.

Even if additional funding is available, the project's cost base, and hence debt service costs, have been increased, with no corresponding increase in revenue. In the worst case, it could lead to the sponsors abandoning the project because the increased costs destroy the viability.

To build Dongtan, a substantial amount of money is required, amounting to billions of dollars in the first phase. Funding for the construction will be sourced from the global financial system. Therefore, risk analysis

should concentrate on examining the main cost headings in the Dongtan project budget and addressing how costs and budgets are managed.

To control construction costs, a budget is agreed upon, and any actual or projected excesses beyond the amounts specified in the major cost categories of the Dongtan project must be identified and typically require approval.

2.2.3.1.3. Delay in completion

A delay in the Dongtan sustainable city completion may be caused by several reasons.

(1) Failure of the contractor to perform under the contract

(2) Failure of third parties such as the government to provide necessary connections to the project

(3) Force majeure and relayed risks

To mitigate this risk, some measures can be taken in the process of construction:

(1) Allocation of the construction risk, as far as possible, to the contractors by negotiating a turnkey (ideally fixed price) construction contract. Such contracts will be carefully analyzed to see who bears the risk of non-completion, late completion, or the possibility of cost over-run.

(2) The lender will require the sponsors to commit equity (or potentially secured assets) so that the sponsor has a serious interest in successfully completing the project.

(3) The developer is obliged to provide specified levels of support until satisfactory operational completion has been certified.

The diagram of the completion risk analysis is shown in **Figure 4**.

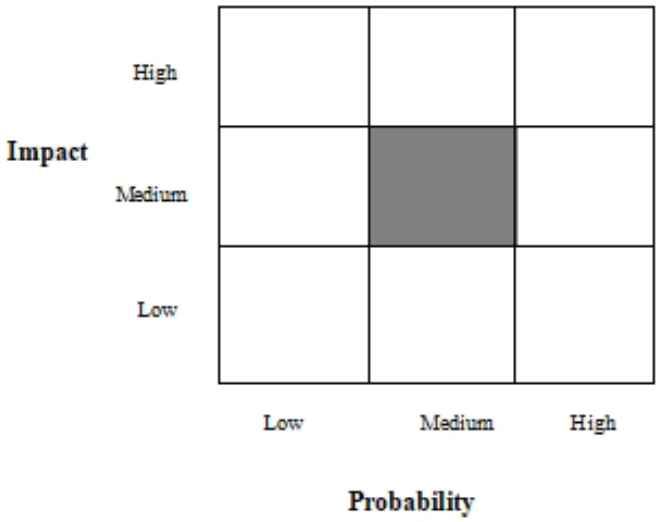

Figure 4. Completion risk analysis

2.2.3.2. Economic risk

Economic risks are linked to ensuring sufficient cash flow to cover project overruns, operations and maintenance (O&M) costs, debt servicing, and achieving a reasonable return on equity. These risks also include inflationary pressures and sectoral challenges, such as competition, as well as regulatory risks.

The economic risk, or economic viability, serves as an initial benchmark for evaluating a project. Lenders conduct financial modeling exercises to assess this risk and ensure that project revenues will adequately cover operating costs and loan obligations. They scrutinize all project assumptions, evaluating the reasonableness of projections and the likelihood that the project can sustain sufficient cash flow to meet its commitments. The

cost of this process, which encompasses due diligence aspects, is one of the factors contributing to the high fixed costs associated with loans.

Economic risks are typically analyzed based on the net of inflation. However, the assumption that inflation effects can be managed separately does not always hold true. For instance, if project expenditures, receipts, and loans all use the same currency, there is a relatively low inflation risk. Yet, if different elements of the project are subject to varying inflationary escalators (e.g., disparities between input and output prices), project economics can be jeopardized. Moreover, additional risk arises in cross-border transactions where each country may have a different inflation rate. Sponsors often commit to supporting debt servicing obligations until the project achieves certified operational completion or for the entire debt servicing period, contingent on the outcome of risk assessments. To hedge against fluctuations in interest rates and currency exchange rates, lenders may require sponsors to engage in hedging contracts. These financial instruments are employed to mitigate losses stemming from future price movements.

China's significant inflation rate increase and unstable currency exchange rates pose a high economic risk to the Dongtan project. To safeguard participants involved in the Dongtan project from fluctuations in interest rates and currency exchange rates, it is essential to utilize financial instruments to mitigate potential losses stemming from future price movements. The diagram of the economic risk analysis is shown in **Figure 5**

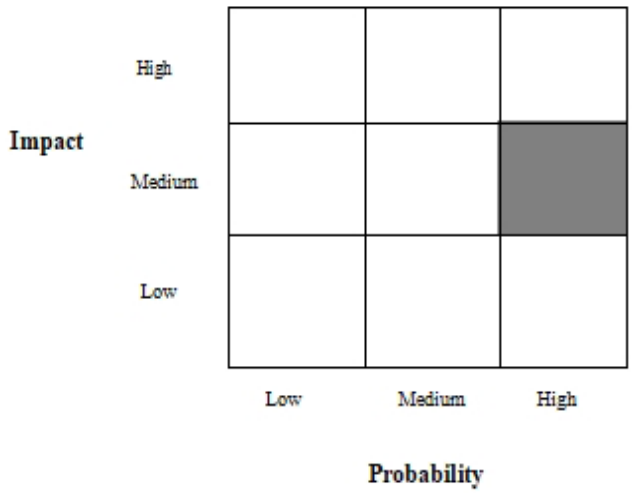

Figure 5. Economic risk analysis

2.2.3.3. People-related risk

People-related risks pertain to individual activity, attitudes, and capabilities. Lack of experience can manifest as a deficiency in risk management knowledge, but it also extends to talent and education. Varying levels of talent and education among project participants directly impact work quality and productivity. A lack of shared education and personal qualities that contribute to performance levels make it challenging to accurately assess time spent on tasks and adequately prepare for potential issues or the workload required for guiding crews. Evaluating the professional capabilities of employees is crucial; their skills must align with the tasks they are assigned.

Moreover, the persistent prevalence of corruption in construction projects poses a significant people-related risk. Governments, funders, and project owners must implement preventive measures to curb corruption on a project-by-project basis.

Dongtan project is a large-scale and very complicated project that involves different companies from

different countries, educational backgrounds, skills, and experience. Among the people-related risks in the Dongtan project is the tendency for developers to default to conventional construction and infrastructure practices once they are in place, rather than making the radical changes required to implement the sustainability strategy.

People-related risks can be mitigated by providing both formal and informal training for general contractors and construction managers. Additionally, implementing a reward-penalty system is crucial. These measures will help improve project quality, ensuring completion on time and within budget. The diagram for people-related risk analysis is shown in **Figure 6**.

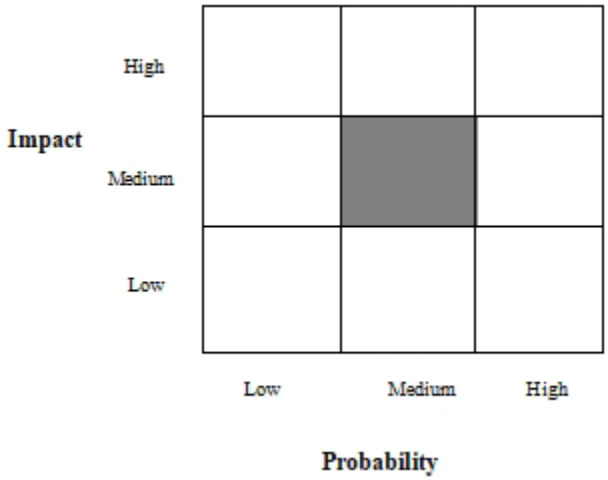

Figure 6. People-related risk analysis

2.2.3.4. Technology risk

Technology risk can be a significant concern, particularly for new technologies. Lenders are primarily worried that underperformance in technology might negatively impact operations, hindering the project's success. They view technology risk as a sponsor risk, and therefore, they are hesitant to lend to projects involving new or unproven technologies. Lenders typically prefer tried and tested technologies that have a track record of successful financing in the past. Even new applications of conventional technology can raise concerns among lenders. Generally, lenders feel more comfortable when there have been 3–6 previous projects utilizing the same technology, each with at least 5 years of reliable operation.

In the Dongtan project, a variety of technologies are being applied to realize sustainability, encompassing fields such as energy, waste management, land use, and water management. While most of these technologies are well-understood and have been tested in past projects, there are exceptions for some new technologies.

To mitigate technology risks, participants in the Dongtan project should seek additional support and guarantees from sponsors. Sponsors typically are not willing to assume full risk themselves and will require guarantees and warranties from manufacturers of renewable equipment, and consequently, from component suppliers as well. If manufacturers are not large, creditworthy entities, they may need to provide private insurance or bank bonds to cover these risks. Some effective risk mitigation methods are listed below.

(1) Utilization of independent engineering assessment, for example, as part of the due diligence process.
(2) The application of tried and tested technology (i.e. one that has been shown to operate in broadly similar contexts).
(3) Strong, experienced sponsor with a significant track record (and ideally an equity stake).
(4) Arrangement that ties the key parties into the project at least until the debt has been cleared.

(5) Provision of long-term performance guarantees and warranties.

The diagram for technology risk analysis is shown in **Figure 7**.

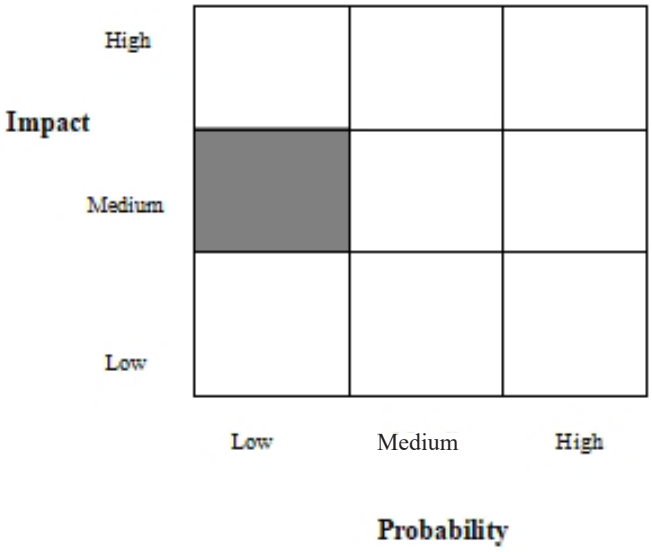

Figure 7. Technology risk analysis

2.2.3.5. Environment risk

It is crucial to anticipate potential changes in future environmental regulations. Environmental concerns are paramount to the participants of the Dongtan project, and they are becoming more vigilant about safeguarding themselves against environmental liabilities. Participants will demand assurance that all necessary planning, environmental, and other consents and approvals have been secured.

Large-scale projects like Dongtan can significantly influence the physical, social, cultural, economic, and political environment of their surroundings. As public awareness grows, scrutiny of how project participants manage these environmental impacts intensifies. The diagram for environment risk analysis is shown in **Figure 8**.

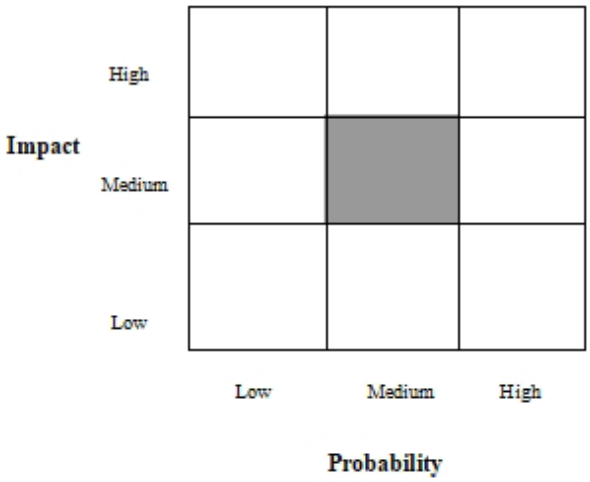

Figure 8. Environment risk analysis

2.2.3.6. Political risk

The government plays a pivotal role in project finance, particularly in endeavors like the Dongtan project, which requires substantial long-term investments. Political will and sustained governmental support are imperative, as

these projects may align with government policies, or their failure could carry significant political ramifications.

Few major projects can proceed without political backing. Support from high-level officials is often essential for successful project completion. Additionally, continued political support is necessary once the project is operational. If the project becomes a political battleground, it risks weakening as it provides an opportunity for opposition to criticize the government.

Key political risks in the Dongtan project are described below.

2.2.3.6.1. Investments risks

The developer of the Dongtan project may seek to transfer the risk to the host government, specifically the Shanghai local government, through the project or government support agreement. However, there is a possibility that when the need arises, the local government may be unwilling or unable to meet this obligation. This situation may necessitate some form of political risk coverage to mitigate the potential financial impact on the developer [7].

2.2.3.6.2. Change of law risks

Changes in laws, whether due to new legislation or modifications in regulations under existing laws, can significantly impact the viability of a project such as Dongtan. These events may necessitate adjustments to construction and development rules and regulations. Uncertainty exists regarding whether the government will adhere to the same rules and laws pertaining to the development of Dongtan. To mitigate political risks, political risk insurance or guarantees are available from various bilateral and multilateral entities, as well as private-sector insurers. The diagram for political risk analysis is shown in **Figure 9**.

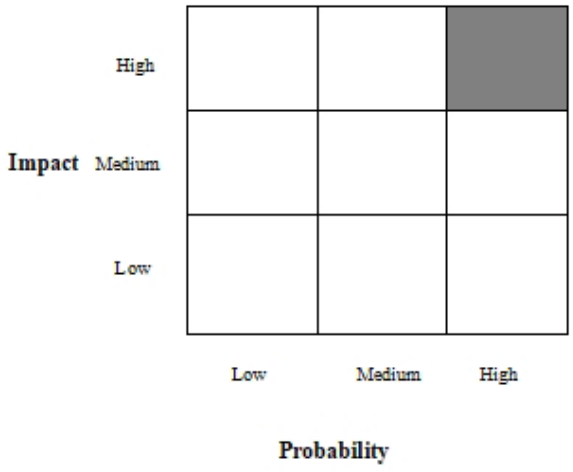

Figure 9. Political risk analysis

2.2.3.7. Force majeure

Force majeure risk encompasses events that are beyond the control of project participants, such as natural disasters, severe weather, and sometimes industrial disputes. A force majeure clause is often included in contracts to excuse non-performance in such circumstances.

Given Dongtan's location, flooding is a significant force majeure risk that needs to be carefully managed.

2.2.3.7.1. Flood risk management

Given the projected rise in sea levels over the next century, coupled with the risk of increased periods of high tides and heavier rainfall, it is crucial to further explore and test solutions to adapt to climate change when managing flood risk. This may involve strategies like lowering open space levels, expanding flood cells to increase pluvial storage, installing pumping systems, and altering the use of ground-floor buildings.

While the best practice is to avoid constructing urban developments in flood-prone areas, this can be challenging in reality. Therefore, specific design targets have been established for Dongtan to ensure sustainable flood management solutions are implemented.

(1) Establishing high-quality coastal flood defenses to withstand a 0.1% flood level (equivalent to a 1 in 1,000-year event).

(2) Providing adequate storage capacity for a 1% pluvial event (equivalent to a 1 in 100-year event).

(3) Creating buffer zones behind flood defenses to mitigate the impact of extreme events and allow for adjustments in response to climate and geomorphological changes, such as coastal erosion.

(4) Designing three distinct flood cells from the outset to minimize the risk of catastrophic failure to individual villages and the city as a whole, with an additional flood cell designated for critical infrastructure like wastewater treatment facilities.

(5) Developing a flood risk zone map for the master plan layout, strategically locating essential emergency infrastructure such as hospitals and fire stations in lower-risk areas, and incorporating green spaces and water features in higher-risk zones.

The diagram for force majeure risk analysis is shown in **Figure 10**.

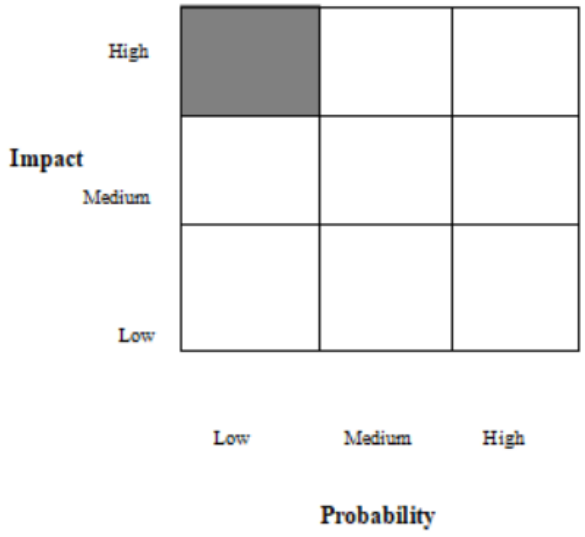

Figure 10. Force majeure risk analysis

3. Conclusion

Dongtan is a large-scale engineering project developed by the SIIC, aiming to become the world's first sustainable community and spanning nearly four decades. It will have a profound impact on the physical, social, cultural, economic, and political landscape of its surroundings. The construction process involves numerous participants, both domestic and international, making it susceptible to unforeseen events such as government interference, contractor inexperience, poor planning, and environmental instability. Therefore, effective risk management is crucial throughout the construction of Dongtan.

Project risk management is essential for anticipating and addressing uncertainties that could jeopardize project goals and timelines. These uncertainties may involve issues like material quality, delays in material delivery, budgetary changes, personnel turnover, and incomplete knowledge or research. Failure to manage these risks can result in delays and budget overruns, eroding confidence in the project and its management. However, by employing regular and rigorous risk analysis and management techniques, potential problems can be identified and addressed before they escalate, increasing the likelihood of project success.

Disclosure statement

The author declares no conflict of interest.

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