9.1 Reflection

Introduction

The main intent of this chapter is to reflect upon the methods used within the thesis while outlining constraints, limitations, and how the process could be improved. The chapter concludes with a discussion on the ethical considerations and societal and scientific relevance.

STAGES TO REFLECT UPON

Application of Methodology

- Can the methodology be applied to other cases or contexts?
- What conditions need to be met? What methods are transferable?

ANALYZING EXISTING IMPACTED SYSTEMS

Through different scales and understanding externalities and uncertainties

Critical Infrastructure

Spatial
- Flood exposure
- Flood hazard
- Flood risks

Governance
- Policies
- Regional Plans
- Evacuation Plans

EVALUATING THE EXISTING SYSTEM

Through the lens of resilience & response phase

Resilience Indicators & GIS

- Rationale
- Limitations/Constraints
- Benefits

IDENTIFYING AREAS OF INTERVENTION

Vulnerable Systems

- Network Analysis: accessibility & serviceability

SPATIAL CONTINGENCY PLAN

Design Interventions

- Scenario planning
- Open spaces, land-use configurations and critical infrastructure
- Critique on dynamic adaptive pathways

EVALUATING THE PROPOSED SYSTEM

Resilience Indicators & Iterations

- Rationale
- Limitations/Constraints
- Benefits

REFLECTING ON NEXT STEPS

Risk Cycle, Planning and Design

Can the methodology be applied to other cases or contexts?

Based on the motivation of the thesis, the future intent was to test the transferability of the methods and lessons learned to a case study back in Canada. Over the years, there has been significant climatic issues and geohazards Canada has faced from coast to coast. If the process had to be replicated to another context, a series of steps that need to be fulfilled.

1. ***Analysis of Exogenous factors (drivers of change):*** uncertainties and trends in climate change

2. ***Spatial Analysis:***
   - Flood hazards: probability and extent of damages
   - Flood exposure
   - Flood vulnerability: populations and infrastructure exposed

3. ***Collection of data:***
   - Site specific data related to hydrology, climatology, geology, local history on flooding, landscape ecology
   - Inventory of critical infrastructure systems exposed to flood risk
   - Land-use, spatial morphology and building age of selected areas
   - Traffic model
   - Census tracts

4. ***Contexts would need to have similar attributes in:***
   - Governance: willing to invest in areas that are of high value (economic, political and social)
   - Political awareness and investments in flood risk management
   - Strong set of involved stakeholders
   - Available resources to accumulate and share data
   - Critical infrastructure protection programs
   - Economic state to develop, plan and execute large scale interventions
   - Strong urban planning regulations

The transferability of the project requires having available resources to model and identify weak vulnerable points in the system. The methods and recommendations proposed in the thesis are restricted to developed nations such as those in the EU, United States, Canada or Australia is due to these governing bodies already having regional critical infrastructure programs. In addition, these nations have access to various resources that would enable them to model and inventory physical vulnerable systems. The pitfall on using spatial analysis through GIS is placing investments over a long period of time in developing a database. While working on the Thames Estuary, the amount of open source data was abundant from the Environment Agency. Due to flood risk being a high priority in the UK and the Thames Estuary, a significant number of previous investments and models have been made privately and publicly available. In contrast to other areas around the world, this may prove difficult as the available amount of resources (from a top down perspective) is not available or is not placed at a high priority.

Other considerations would include debating about how much of the developed set of strategies and policies can be implemented to other countries based on regulations, governance, economic conditions and cultural norms. In addition, there may be limitations on the upscaling and applicability of some of the solutions. These may be restrictive to only addressing specific local contexts.

Process and Methodology: The Choice of Using Resilience Indicators

The process of selecting resilience indicators was to have variables to quantify and compare changes to urban systems. Currently, there is no existing framework set in place within the UK or for the Thames Estuary to evaluate how resilient critical infrastructure is to externalities. To limit the number of indicators, each variable had to correspond with the response cycle which translates to transportation infrastructure systems and emergency relief.

From analyzing travel times to access to services, this would impact the evaluation of the current and future system. In addition, it became a requirement in the design to consider isolation components from:

- The provision of electricity: backup generators, self-sufficient energy supply
- Provision of clean water
- Temporary refuge
- Safe access and egress to safe areas
- Sacrificing developed land

There is a constant feedback loop in understanding and addressing the displacement of specific infrastructure (such as residential units). This would require other areas outside the floodplain to cope with the change in capacity. In addition, the design intent would also need to consider the immediate demographics that would be affected.

From here, a set of parameters were needed to be made in order to understand the extent of the scenarios.

- Priority of elements and what is crucial to be maintained/require extra protection
- Number and placement of connections, services and of shelters
- Program of urban life and direction of development
- The states of isolation and how it is relieved

However, there are two key considerations and limitations in using resilience to evaluate the current and proposed system. First, the term resilience has been heavily debated upon. Resilience is seen to be more reactive and tries to restore the system to its previous state before any incident. Regarding this issue, this could eventually lead to short-sighted thinking and leading to the same perpetual risks and vulnerabilities in an existing system. Moreover, there is a gap in existing research on the spatial application of evolutionary resilience into existing and newly proposed critical infrastructure systems.

The second major limitation is the scope that the chosen resilience indicators can cover. In the process of trying to reduce risks, there was a clear intention finding weaknesses and gaps in the existing system. Using the indicators framed the context of the components of the system that needed to be improved. However, through the selective process of narrowing down the resilience indicators, there are several missed aspects. A future consideration on implementing this project in other contexts is that the indicators should be interchangeable and modifiable in other contexts.

Identifying Areas of Intervention
The process of identifying areas utilized the conclusions made from the methods in identifying the most vulnerable critical infrastructure systems exposed to flood risks. The process of designing and using scales was vital in creating spatial iterations of the project. Working between multiple scales also provided a comprehensive overview of how the system functions, is governed and risks in the system. This process is also essential in the iterative process of analyzing and designing a contingency plan. However, there are a series of limitations and trade-offs per scale which is listed in Figure 116.

Urban Analytics: Network Analysis and GIS
The project heavily relied on GIS as a primary platform and tool to visualize and synthesize spatial conclusions. With the defined resilience indicators, an accessibility and serviceability network analysis were performed to determine distances and availability of refuge. The intent would to build a system to compare the performance of the existing and proposed interventions.

Constraints and Evaluations

- There is a lack of comparative economic values for the interventions
- Weighing the direct benefits of the interventions would need to be further explored. Other models that would assist in developing a more robust process are:
    - Pedestrian and vehicle accessibility flows with a weighted factor:
    - Involving different demographics
    - Understanding the detours that may occur
    - Thresholds and speeds that the system can accommodate
    - Traffic analysis and the capacity that the system can take in an event of an emergency.
- Modeling catchment areas
    - Understanding the infiltration and water flows in the system
- Weighing the added benefits to the system that could impact social vulnerabilities

Scale	Limitations	Trade-offs
Territorial: UK	• Proposing site specific interventions are extremely difficult due to having limited detail of each context • Replications of the same design in each area would disregard the fluctuations in physical and social vulnerabilities • Level of risk impacts areas unevenly	• There is limited detail of the exact conditions of each location, but general conclusions can be put forth. For example, concentrations of vulnerabilities could be determined. A standard minimum resilience guideline for critical infrastructure could be made. This would enable smaller scales to interpret and execute a set of policies and regulations in a more flexible manner while raising safety standards.
Regional: Thames Estuary	• General outline given through a broad TE2100 framework	• Takes into consideration a regional network of affected cities and neighbourhoods. Physical and social vulnerabilities can be distinguished from the defined flood zones. However, the execution and responsibility of flood mitigation is reliant on the smaller scales.
Urban: City of London	• There is a certain level of detail made in strategizing the placement of designated elevated roads, priority safe shelters and connection to open spaces	• This scale enables the user to visualize a wider set of connections proposed from the smallest scale but exact interventions are not ideal to be made at this scale.
Neighbourhoods: Isle of Dogs, Wandsworth to Deptford and Royal Docks	• Ideal locations were informed by larger scales • Location specific strategies were limited by the series of resilience metrics developed to evaluate the system • Limited to small-scale interventions	• Decisions can be made at the local scale, but the scale cannot provide an overview of the grander scheme of things or a holistic perspective • The design, planning and implementation is site specific, and any intervention needs to be modified to the existing context. Interventions at this scale would feed back into the larger scales in order to evaluate changes to the system.

Figure 116 Matrix outlining the limitations and trade-offs in each scale

Developing the Spatial Contingency Plan: Scenario Planning and Lessons Learned

Scenario planning was used as a leverage to see how different interventions could meet a series of goals and objectives set for the response framework. Due to the uncertainties of the future, the scenarios offered a different way of thinking, ways of manipulating spaces and assemblages while working within the mindset to increase safety parameters. Three main elements were considered in each design iteration which includes: how critical infrastructure systems would be modified, changes in land-use and open space strategies. Through this process, the importance of iterative design thinking became apparent.

While investigating the impacts of a large-scale managed retreat, there was a question of how to execute and the practicalities of managed retreat. It is typically treated as a long-term option and is only considered effective when the costs of flood risk management exceed the value of the property that it protects. Often at times, this is seen in cases with low-density areas. Typically, this also involves a buy-out programme that relies on the full participation from the community which can also be politically sensitive. It is noted in some documents that in highly urbanized areas, this option would not be viable unless it was part of a post-disaster rebuilding strategy. However, this strategy allows for the proactive change in land use to open space, recreation of nature to avoid future developments in flood risk areas. However, if a contingency plan is not embedded in the urban fabric or is not considered, there will be a higher risk for future urban developments. The interdependencies within the existing system will continue to grow and there will be higher chances of cascading risks from not only future possible floods but other climate related issues.

Altering Interventions Based on Scenarios and Local Contexts

In outlining the opportunity areas within the designated focus units, there was a necessity in changing the initial 'catalogue' of spatial actions based on location. Modifications in the design and size requirements were restricted on the available land use. Opportunity areas that could be modified were identified in a systematic manner with the focus starting at priority resilience areas (most impacted by residual risks from a breach). Intervening in existing and highly developed urbanized areas posed as a challenge. Two proposals were conducted in the thesis where one envisioned a more radical and expensive perspective. In the managed retreat scenario, the main intention was to remove large swaths of infrastructure to create larger capacity of water and green zones to reduce risks. The second option is to connect fragmented spaces and to use these to direct water flow and capacity. Once these networks were identified, interventions could be made on how to strengthen these areas. This would also align with improving areas of deprivation and were lacking public amenities. New developments should have synergetic benefits that would not only improve the response phase but to also improve the urban landscape. In addition, there could be possibilities where incentives can be given from the government if private gardens or spaces can provide further infiltration or provide means of support.

Strategic and Spatial Interventions: Adjustments to the Utilized Interventions and Deliverables

In the research-by-design phase of the project, it was evident that the initial catalogue of strategies was insufficient to represent the full intent of the project. Several of the proposed interventions required another set of analysis. This included an investigation of what was readily available in the existing urban fabric and within the defined priority resilience areas. The implementation of the strategies differed per context even with the parameter of selecting designated safety areas for permanent public access. For example, the neighborhoods within the Isle of Dogs had an extreme disadvantage for finding room to expand public spaces. Due to the highly developed and dense neighbourhood structure, the interventions relied on life cycle-based planning and the period of retrofitting as the window of opportunity to expand. In contrast, the other two policy units already had shelters adjacent to large open parks alongside designated safety corridors.

Design Intentions: Using Public Spaces as Temporary Emergency Relief

The challenge of having the intent of working in built-up areas is that there are a series of societal, spatial, economic conflicts due to the lack of available space. In addition, there could be a struggle in financing or valuing the trade-offs in investments and interventions could foster disagreements with local residents. The proposed interventions could also result in a series of conflicts due to the multiple stakeholders affected. Each set of stakeholders have their own agenda within a set time frame, so it would be vital to find potential synergies and mutual benefits.

Benefits and Consequences of Recommendations

The idea of increasing and elevating public spaces was under the assumption that it would be beneficial towards nearby communities. In addition, it would improve the deprivation index of communities by increasing accessibility to open spaces. In a practical standpoint, the actual process and execution of the smaller scale projects would require public consultations.

As the thesis strove to find synergetic benefits while trying to meet the objectives of integrating an earlier response and recovery framework. One example of this is done through design iterations of reintegrating water storage and re-organizing the water system to be more visible and cohesive. Rather than concealing the process of the water system, this could enable a stronger relationship between carrying capacity of water, land use and risk management.

Additional Limitations in Proposed Spatial Interventions

An important element to consider when designing for vulnerability-focused adaptation is when an 'islanding effect' occurs. This would severely impact and limit the performance of systems related but not limited to: power, heat, sewers, and electrical infrastructure recovery capacity. Due to the limited scope of the thesis, it would be difficult to quantify the exact performance of these systems during and after a flood. The design will take into consideration on how temporary failure of power systems or reduced accessibility would occur in certain locations, but the cascading effects of the flooding would not be measured. At most, the project tries to explore the best methods to minimize large scale cascading effects that would reduce the recovery time if an extreme scenario would occur.

While developing spatial strategies, the thesis will also not be able to comprehensively describe all the hydrological, ecological systems or traffic conditions that would be impacted when configurations of land use or portions of flood walls are removed. This would be difficult to model in addition to quantifying residual risks that would impact the system.

During the process of analyzing infrastructure vulnerabilities, social vulnerabilities have also been analyzed as it is a key component in an integrative approach to risk mitigation. Due to the scope of the project, the underlying factors and conditions that perpetuate vulnerabilities cannot be fully addressed or solved. There are too many variables to account for to program the design to solve or address the core issues of why and how these areas are vulnerable. However, the scope of the design should also account for, assist and reduce flood risks on vulnerable populations. This is to be accounted for in the analysis using the deprivation index and SOVI to also address these areas.

Is Dynamic Adaptive Pathways (DAP) an effective means to evaluate, address deep uncertainty and create future plans?

Dynamic adaptive pathways is an example of a model that can plan or anticipate for future deep uncertainties. There should be multiple and diverse set of options that clearly outline the roles of stakeholders alongside constraints, impediments and benefits. However, in the research component of analyzing the TE2100 and Thames Gateway Project, it was important to be critical on the existing frameworks and policies that are currently hailed upon as successful. For example, the Thames Barrier is classified as one of the best-known movable storm surge barrier systems set to protect large urbanized areas from high tides similar to the Maeslantkering in Rotterdam. Interdependencies between higher level of flood protection and local level flood protection systems create complex governance arrangements which may lead to conflicting expectations and interest among several layers of authority. In addition, as storm surge barriers are known to generate a sense of security leading to a reduction of flood awareness and precaution and consequently to increased accumulation of assets in the protected hinterland. This has resulted in the paradoxical situation in which flood losses continue to increase even when more investments in flood protection are made. Evident in the Thames Estuary, further investments in storm surge barriers may create an irreversible situation that reduces flexibility and adaptability of local level systems. The TE2100 plan continues to propose proactive spatial planning to keep flood risk in the greater London area low, but the city continues to expand into floodplains.

Another concern is that there is a general critique of the DAP concept is it remains very conceptual and the application and execution of the adaptive planning can be challenging. For the success of the implementation of the project, there are many presumptions made. One of the key aspects is that decision-makers have the power and agency to make decisions and influence the system to be driven towards the most optimal pathway. This would also require a political and social consensus towards this decision.

Based on several case studies and reports, local adaptation strategies have encountered various difficulties in where the goals of adaptation have not been clearly defined. In addition, the level of resilience that the local government wants to achieve is also ill defined. Also, for the project, how does one define when something has reached an adequate level of resilience for an uncertain future?

As per the design, it needs to be recognized that not all critical infrastructure systems can be protected but parts of the system can be strategically maintained. One can speculate on how to design energy infrastructure so that these systems can be designed to be flexible. However, the modeling and testing of if the actual speculation could work would be too complicated. The other dilemma is the question of whether the design proposal compromises other cycles of risk management.

How to integrate the contingency plan and response phase into dynamic adaptive planning?

One of the main methods that was not fully executed was creating a DAP plan. However, after the creation of the spatial strategies and re-evaluating the existing TE2100 plan, it became evident that an addendum would be needed to address the uncertainty component and the practicalities in the execution of the project. Currently, there is no existing DAP modeled to address contingencies. In addition, with DAP, a series of dynamic policies would need to be created in order for the system to be fully functional. The time component would also need to be considered in the new addendum and understanding the conflicts of interest between environmental or economical risks. Also, due to the limited time constraint, the governance structure in which stakeholders would be involved in the execution of the project was not fully explored.

To satisfy the creation of dynamic and adaptive strategies, the thesis also proposes a model that would integrate iterations throughout the design and planning process which would enable the system to perform better with future uncertainties. The capacity to learn, re-assemblages of spaces would be able to unfold different if externalities continue to change. In addition, future conditions are unpredictable and there may be changes in the needs and demands of society or a change in political powers and interests. By having a contingency plan and iterative processes, this can accommodate for flexibility in the system.

The series of proposals in the thesis that allows built in flexibility and a certain extent of contingencies would be:

- Elevation changes to critical infrastructure systems (safety corridors, shelters and open spaces)
- Expansion of green and blue networks
- Decentralizing and redundancy in back-up systems
- Land-use modifications
- Ground plane modifications

Limiting the Scope to Critical Infrastructure Systems and Flood Risk Management

At the start of the thesis, the ambition was to look at how to make all critical infrastructure systems resilient to flood risks. However, it was recognized at a very early stage that researching and intervening in every component defined as critical infrastructure would be extremely difficult due to the limited time-frame of the thesis. To narrow the scope, it was important to determine which critical infrastructure systems should be placed as a priority. The rationale was based on understanding the risk cycle and choosing to further investigate the response phase. Due to the Thames Estuary having strong mitigation policies and spatial flood defences, it became more apparent to investigate if a spatial contingency plan exists. Recognizing a gap within policies, governance, planning and design of the urban structure regarding the state of ‘plan b’, the focus was directed towards the response phase. Within this phase, the critical infrastructure systems impacted were transportation systems, emergency services and shelters. All attention was then directed on how to improve the safety parameters of the system based on maintaining these services.

Another major point to highlight was the design interventions were restricted to adapting to flood risks. It is important to note that areas do not experience only one form of risk. In fact, there are multiple risks and uncertainties in every area of the world. Therefore, the design intent is not meant to accommodate or combat all forms of risk and is restricted to floods. However, the safety parameters and flexibility in the proposed interventions could alleviate other risks in the system. For example, London is experiencing higher water demands, droughts and urban heat island effect. But through the creation of multi-purpose spaces that allow for water infiltration and storage, and off-grid services, these could help in alleviating pressures in the existing system.

Reflecting on the Emphasis Placed on Systematic Thinking

During the time-frame of the thesis, there was a conscious effort in developing a systematic process from the initial stages of the analysis to the conclusion. Gathering an understanding of the overall scope of the project was a personal choice in amassing knowledge of the existing systems and theories that were defined within the scope. This included having a strong comprehension of existing risk management performed at all scales, governance, and policies and practices.

Referring to the road map made in the methodology chapter, each step was rationalized in order to move forward throughout different phases of the project. This was seen from determining the areas for interventions to the tools to used. However, this also put a huge time constraint on developing design strategies. Notably, when designing spaces, there was a lot more hesitation in intervening with the existing system due to the concern of negatively impacting areas or understanding the practicality of implementing the plans. By holding back or shooting down designs due to the mindset of practicalities, limits the process of iterating different designs. Instead, it would have been more beneficial to be more radical and take lessons learned through manipulating spaces. From there, aspects of the design could have been pushed further to really emphasize the need to change urban environments from how they are currently designed. Thus, the quality of spaces developed were not fully explored as well as the full extent of relationships and impacts made from the interventions.

The Future of Planned Developments: How Can Design Inform Governance and Planning?

Design should be used as a platform to challenge the existing norm and deliver a series of options that should advise current governance practices, policies and planning. One model of advancing this change is using GIS and Big Data to visualize flood risks, exposures and vulnerabilities which can further inform other disciplines. Due to rising complexities and dynamism of cities, research and design could be used as a method to streamline a better understanding of socio-economic data, land use, infrastructure networks and other correlations needed to inform long-term plans. Rather than relying on the static nature of urban plans, design speculates plausible futures and potential synergies that could benefit society, increase livability, and satisfy political and economic agendas. However, the field of design requires multidisciplinary collaboration, perseverance and exploratory approaches from all disciplines.

Can synergies within the risk cycle be used as the starting point for new development?
The primary intent of the risk cycle is to control, avoid or transfer risks. Figure 117 outlines the relationships found within the risk cycle and when there are synergies, these could be the new window of opportunities.

Practicalities in Implementing the Project
It is important to comprehend when and how the windows of opportunity are used to integrate resiliency into the system. Life cycle-based planning can be used as a factor in creating allowances to retrofit existing infrastructure, ground floor usages and land use. However, with the proposals made from the thesis, current governmental planning and design practices need to consider:

- A comprehensive overview of water, environment, social and critical infrastructure systems is required in the planning and design processes
- A need to integrate a more long-term trans-scalar design method to avoid the existing ad-hoc decision-making processes
- A proposal on determining which critical infrastructure should be maintained along with changing the model of spatial planning through series of iterations
- Negotiating between private and public stakeholders in land-use transitions
- Developing a range of adaptive capacities in the system

	Mitigation	Preparedness	Response	Recovery
Mitigation		*Synergy:* • Public education, awareness and training	*Synergy:* • Assessment to strengthen and improve infrastructure/services	*Synergy:* • Spatial planning • Long-term planning • Retrofitting to alter spaces • Future reconstruction areas
Preparedness	*Conflict:* Investments in prevention vs. capacity to respond to an event		*Synergy:* • Time component • Short-term emergency management • Early warning systems	*Synergy:* • Faster recovery with population having a stronger awareness to emergency relief, housing and services
Response	*Conflict:* Mitigation tries to prevent risks to maintain all services. Whereas response maintains only essential services	*Conflict:* Readiness and training vs. incident stabilization and mass care		*Synergy:* • Faster recovery rate if response is efficient at organization (mass care) and maintains essential services
Recovery	*Conflict:* Investments in protecting economies vs. economic recovery and restoration	*Conflict:* Short-term vs. long-term objective	*Conflict:* • Time conflicts and infrastructure priorities • Recovery focuses more on reducing economic risks and restoration	

Figure 117 Table outlining synergies and conflicts within the risk cycle