

**MANAGEMENT OF FLOOD RISK
WITH SPATIAL PLANNING**

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Degree of Doctor of Philosophy in Civil Engineering

Department of Civil Engineering

University of Moratuwa

Sri Lanka

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Thesis submitted in partial fulfillment of the requirements for the Degree
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DECLARATION OF CANDIDATE AND SUPERVISOR

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ABSTRACT

Management of Flood Risk with Spatial Planning

Flood risk has become a significant issue particularly in urban regions of Asia. Climate change will intensify existing flood vulnerability and further strengthen it due to socio-economic inequalities. A new set of problems are created by the traditional decision-making of flood management in the face of climate change and rapid urban development. The concept of the socio-ecological system suggests that resilience is the key to managing complex systems and reducing flood vulnerability. In addition, recognizing the significance of nonlinear and non-stationary interactions of flood risk in decision making has highlighted the transition of flood management towards Flood Risk Management (FRM). Acknowledging the uncertainty associated with flood risk has become a key aspect in decision-making. Decision-makers agree on the need for adaptive and integrated policies and strategies of FRM rather than modifying the flood and making it easier to cope with by eliminating the highest probability of floods. Flood resilience embeds the incorporation of spatially distributed land-use policies, strategies, and guidelines which are a must for the management of flood vulnerability. As a result, the characterization, assessment, and management of flood risk were subjected to a critical review during the past years. Risk-based flood management is yet in its early period of development. Though the theory has advanced over the years, there still are visible shortcomings in the operationalization of the concepts and methods, mainly due to the lack of a framework for clear recognition and understanding of the components of the FRM system.

The FRM and spatial planning domains have developed their knowledge bases separately over a long period. Recently, FRM and spatial planning have begun to share a similar perspective in the decision-making process. The role of spatial planning as an integrated planning tool has been emphasized in the decision-making of flood risk management. It is largely evident that as at present, the role of spatial planning in flood risk management remains inadequate mainly because of the absence of a common framework for stakeholders' integration. The main objective of this research is to identify the complete FRM system and its components with recommendations for its operationalization. This research has developed a solution model to structure the complexity of the planning process of FRM. The criteria and sub-criteria of the conceptual framework of the decision model have been identified based on the systematic literature review. Further, the criteria and sub-criteria of the conceptual framework have been selected and prioritized using the Delphi technique and Analytical Hierarchical Process (AHP). Forty-two experts have participated in this research and the established framework has been validated using a case study. Panadura urban area which is located in the coastal wet zone and Colombo Metropolitan Region has been selected as the case study area for application of the framework. This research has established a methodological framework for the operationalization of FRM. The main criteria which determine the practicing of FRM are the conceptualization of flood risk in the planning process, assessment of flood risk in the planning process, as well as the discourse of the governance structure, and the available participatory tools in the context. This study has identified and prioritized sixteen sub-criteria to manage the uncertainty in the planning process. The established framework can be used to identify the strengths and the weaknesses of the planning process in a given context and to guide the planning process to operate risk-based flood management objectives, strategies, and guidelines. The established framework can be used to evaluate the alternative options of flood risk management for achieving flood resilience. The case study has revealed that the existing decision-making process of FRM does not recognize the complex interdependencies between flood risk, spatial form, and spatial planning. As a result, the current practices of FRM are unable to achieve flood resilience. Therefore, this research recommends the integration of FRM with spatial planning. The developed framework is more sensitive to the governance structure of the context, therefore more case studies are needed to conduct in different governance contexts for further refine

Keywords: AHP, Delphi, Framework, Integration, Nonlinearity, Stakeholders, Uncertainty

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LIST OF ABBREVIATIONS

| Abbreviation | Description |
|---------------------|--|
| AHP | Analytic Hierarchy Process |
| CBA | Cost Benefit Analysis |
| EAD | Expected Annual Damage |
| EPL | Exceedance Probability-Loss |
| FPGAS | Flood Risk Governance Arrangements |
| FRM | Flood Risk Management |
| FRMS | Flood Risk Management Strategies |
| NWSDB | National Water Supply and Drainage Board |
| SER | Socio Ecological Resilience |
| USD | United States Dollar |