Development of a Conceptual Framework to Operationalize the Flood Risk Management

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Abstract. Policy makers have progressively recognized the limitations of traditional decision-making frameworks of Flood Risk Management (FRM). This is mainly due to their incapability to manage inherent uncertainty of flood risk. Accordingly, the method of flood risk assessment, method of flood risk management and methods of operationalizing flood risk management have been recognized to be improved over the past years. The theory related to FRM has advanced over the years. However, there are visible shortcomings in operationalization of this concept mainly due to the lack of a framework for clear recognition and understanding the components of flood risk management system. Therefore, the objective of this research is to identify the FRM system, its components and make appropriate recommendations for its operationalization. State of art review was conducted to recognize the present level of flood risk management systems with its components. Further, it has identified the critical components for successful operationalization and develop a solution model for critical elements of the system. A satisfactory solution has been identified with accepted criteria and proposed solution for a Flood risk management system and developed recommendations for sustainable management of flood impacts.

1. Introduction
Flooding has become a critical issue in the face of rapid urban development and climate change. The understanding of resilience in flood risk assessment and management has improved over the years. The notion of socio-ecological systems has highlighted the importance of dealing with stakeholders’ issues which incorporated with flood risk management. Therefore, the integrated and adaptive planning process is increasingly seen as a way to enhance flood resilience. Consequently, it has recognized that the method of assessment, method of management, methods of operationalization of flood risk management should be improved. However, there are visible shortcomings in operationalization of this concept. It is mainly due to the lack of a framework for clear recognition and understanding the components of the flood risk management system. Therefore, there is a knowledge gap with respect to the definitions, assessment and hence its operationalization of the planning process of FRM. As a result, the resilience notion in flood risk management is quite fragmented and the practitioners’ knowledge of ways to enhance flood resilience is also insufficient.

2. Objectives & methodology
In this context, there is a requirement for identifying the components of the flood risk management system and the weakness of the FRM system for its operationalization. The main objective of this research is to identify the FRM system with its components and make appropriate recommendations for its operationalization. State of the art review has been conducted to recognize the present level of flood risk management systems with its components. Accordingly, it has conceptualized and
developed a flood risk management system and identified the critical components for successful operationalization. Further, it has developed a solution model for critical elements of the system and conceptualize the requirements for operationalization. The satisfactory solution has identified with accepted criteria for sustainable management of flood risk.

3. Results

3.1 Identification of flood risk management system
A system is composed of many components which interact with each other. A framework usually denotes a structure, overview or an outline which explains the components of a system and their interactions [1]. The decision making frameworks of flood risk management systems can be broadly divided into as rationalist and constructivist [2]. However, these two paradigms are not always conflicting contexts for interpreting the flood risk management system. Moreover, the characterization of the components, interactions of components, relation between the components and output of the system and structuring the components in the system in the flood risk management system have been evolved during the past years [3]-[7]. This was mainly due to understanding the non-stationary and nonlinear interactions of flood risk. The decision-makers have progressively questioned the planning process for operationalization of flood risk management system of including the data collection and data checking, analysis of flood risk, evaluation of management options, goal & strategy development, designing of governance mechanism of flood management including the roles & responsibilities of the stakeholders and monitoring system.

3.2 Rationalist thinking of flood risk management system
Flood risk has characterized with mainly two components such as hazard & the consequences. Accordingly, the flood risk has characterized in a narrow sense and flood risk management was considered as a process of managing an existing flood risk situation [8]. The main concern of the flood risk management system is on the physical phenomenon of flood and considered flood risk as an entity independent of the social systems. Therefore, the infrastructural measures are designed to resist the flood consequences from specific flood events and they could not cope up with the extreme flood events [9], [10]. This narrow characterization of flood risk management system often fails to take account of complex and the dynamic nature of the flood risk [7]. It has been progressively recognized the limitations of the rationalist approach of flood risk management for providing resilient solutions [5], [11].

3.3 Vulnerability perspectives on flood risk management system
Subsequently, flood risk has been characterized as a function of the flood hazard and vulnerability. It has increasingly recognized that the flood risk cannot be managed by focusing solely on the hazards. It has also been recognized that the actual flood impacts can only occur to a vulnerable society or an area [3], [12], [13]. Vulnerability to flood risk has been considered as an inherent characteristic of the social system rather a characteristic of the hydrological and climatic systems [12], [14]. Policy makers have attempted to understand how the characteristics of social system contribute to changes in the impacts of flood [15]. It has been recognized that the vulnerability as an outcome of complex and dynamic interactions of social, economic, political, environmental and institutional systems of an area or a community [3], [16]. Further, vulnerability has been viewed as a local characteristic, which influenced by diverse socio ecological factors, implementing at global, national and regional scales [17]. The impacts of floods are varied spatially and socially depending on characteristics of the location and the magnitude of events [18]. The impacts of the extreme floods have large variety of social impacts that extend across space and time [19]-[21]. Therefore, it has been realized that the importance of understanding the socio spatial and temporal dynamics of flood risks in defining the flood risk management system [4]. In addition, this understanding has underlined that the need of adaptive planning process and increase the stakeholders’ participation in the planning process [22]-[24]. As a result, divergent stakeholders are involved in the planning process of flood risk management and has been highlighted the need of integrated flood risk management policies and
socio-ecological systems perspective on flood risk management system

Successively, the policy makers have begun to understand the flood risk management from the perspectives of socio-ecological systems [11], [27]-[29]. In contrast to linear rational models of flood risk management which were based on a more certain view, flood risk management has been considered as a social and continuous process [7]. As a result, the components of the FRM system, the interactions of these components and the arrangement of these components in the flood risk management system have questioned. The following figure 1 explains the changes of the configuration of components of the FRM system. The components of the FRM system are characterizations of flood risk, flood risk assessment, identification of the objectives, identification of flood risk management options, evaluation of the merits of flood risk management options, identification of the flood risk management strategies, evaluation of the merits strategies, implementation methods, guidelines, institutions, financing, evaluation of achievement of the long term objectives, change the guidelines, change the strategies and change the conceptualization of management objectives.

![Figure 1. Identification of flood risk management systems](image-url)

3.5 Current status of FRM system

3.5.1 Flood risk

The flood risk and vulnerability of a place or a community have been conceptualized as coevolution phenomena due to the complex and dynamic interactions between natural and human systems [30]-[32]. As a result, of this complexity, there is an irreducible uncertainty incorporated with the flood risk management system [33]. Socio ecological systems thinking has also explicitly emphasized the importance of understanding the tipping points, thresholds and recognizing the feedback mechanisms.
which cause the transformation of socio ecological systems for managing the flood resilience [34]-[36]. Accordingly, it has emphasized that when identification and characterization of flood risk, the consideration of whole complex interactions is needed to take into account [37]. As a result, it has realized that the flood risk management system includes not only the physical system, but also include the stakeholders that are impacted upon by flooding or responding to flooding, the rules which structure and regulate the associated [20].

The overall behavior of the interrelationships between these land, water and social systems over the floodplains usually cannot be explained merely as the sum of individual parts. Therefore, it has realized that the emergent properties of floodplains cannot be predicted by knowing the components alone. Moreover, there are different correct perspectives are with different stakeholders at different levels about the floodplain land uses due to the multi-scalar nature of the systems [38]. These different forms perceptions of stakeholders give external threat to others which is part of the flood vulnerability. Therefore, it has been highlighted the requirement of the precautionary measures and coordinated action in governance processes [4]. This new perspective demands a fundamental shift in perspectives, world views, and institutions [34]. Therefore, it necessary to carefully consider these interdependencies among stakeholders carefully in order to improve efficiency sustainability of floodplain land use development.

3.5.2 Flood risk management objectives
The objectives of the flood risk management system should select the options which optimize the multiple objectives of stakeholders [5], [42]. Further, it has been highlighted that the balancing of social, economic, and ecological goals of the stakeholders while at the same time satisfying the functions of social and ecological systems of each location [6]. It is highlighted the consideration of flood risk management in coherence with the objectives of other stakeholders related to floodplain development such as housing, recreational, nature conservation and heritage [43]. Therefore, the objectives of the flood risk management systems have different from the rationalist approach which focused more on the economic efficiency of floodplain [44].

3.5.3. Uncertainty assessment
Flood risk management process involves many stakeholders, each with their own perspectives, objectives and priorities. In addition, all the stakeholders operate in an environment and their interactions are closely interconnected with each other particularly in urban areas. It has well recognized that the future conditions of socio ecological systems as well as the interactions between the social, hydrological climatic systems, etc related to flood risk, may be significantly vary from those that exist today. Therefore, the presence of alterative interpretations of assumptions of the floodplain land uses of different stakeholders may have diverse implications over the resilience of floodplains. Moreover, the future is necessarily a combination of the known and the unknowable. In this situation, two types of uncertainty can arise; one is over the stakeholders expected outcome and the other is the expected output [39]. Further, it has been realized that not only the assess the damage due to floods caused by the current situation, but also the dynamics of future social, spatial and temporal interactions associated with flood risk should be taken into account [40]. In this context, flood risk assessment should focus upon stakeholder’s uncertainty rather taking decision which based the estimation of the probability of flood damages as in the past [41]. Further, there cannot be any single centralized control mechanism that governs system behaviour. This situation has questioned the need of adaptive and integrated decision making capacity of the decision-making system which can generate common knowledge among the stakeholders to appropriately evaluate flood hazards and then realistically determine the expected damage with a careful consideration of objectives of the all stakeholders with long term perspectives.

3.5.4. Flood risk management options
For that reason, the flood risk management system should provide diverse options of flood management to deal with hazard and vulnerability. In addition, the floodplain should be primarily arranged to reduce the flood vulnerability in different scenarios [45]. Therefore, the flood risk
management system should have ability to develop diverse strategies which aimed at (1) increasing the capacity to transform and adaptive, (2) increasing the capacity to absorb and recover and to (3) increasing the capacity to resist the flood risk [46].

3.5.5 Evaluation of flood risk management

The evaluation process of the flood risk management system should consider the spatial requirements of diverse stakeholders including the urban developers, communities, flood managers, hydrologists, etc, their interdependency of and the dynamics of the flood risk [47]-[49]. This means that the evaluation process needs to support the negotiation of diverse aspirations of stakeholders in order to lean towards the implementation of strategies which fulfill multiple objectives of the stakeholders [50]. Therefore, the evaluation process should be adaptive and integrated process. Moreover, selection of applicable flood management options is based on the stakeholders’ knowledge system for imagination the outcome over floodplains or the floodplain community at different scenarios and available resources, methods, tools, institutions and flexibility of the planning process [51], [52]. Therefore, the selection of management options of flood risk management system is depended on the adaptive and integrated capacities of its planning process. Therefore, integration of stakeholders’ knowledge systems, opportunities for social learning are underlined as the central methodological concern of the planning process for operationalization of food risk management [53]. Operationalization of flood risk management objectives has become a clearly an element of collective governance, which is beyond the government as a single actor [54].

3.6 Challenges for Integrated and adaptive planning system

The potentials for integrated and adaptive planning process depends on the aspirations of the stakeholders of each context [55]. There are plural views among the public as well as private stakeholders on flood risk, vulnerability and risk management. In addition, there is a fundamental difference in the perceptions of engineers and the spatial planners in characterizing the interactions of flood risk management [56]. Therefore, understanding the multiple perceptions among stakeholders based on the interdependencies between land and water has been recognized as one of the key challenges for operationalization of flood risk management. Adaptive perspective of stakeholders alone would not be sufficient to implement flood resilience strategies. It has been underlined that the worldviews of stakeholders and the flexibility of governance system are important aspects for defining the adaptability of planning process [57]. Stakeholder engagement and public participation in planning process are seen as one of the central aspect of flood risk management [58]. Contextual factors, such as defining the local social relations in planning process is also influenced to operationalization of flood risk management [59], [60]. However, the involvement of private stakeholders with the public sector is strongly dependent on the political and constitutional tradition of a state [61]. Operationalization of flood resilience is based on the level of political decentralization and the fashion for public consultation [62].

Public indifference to natural disasters is also another major challenge for operationalization of flood risk management. Many local officials, community and politicians have often given low priority to collaborative planning as a strategy to reduce flood risk [63]. Incorporation of hazard mitigation into the local planning is determined mainly by state planning policy context and hence the local community, their capacities and potentials are inhibited in the planning process [63]. Moreover, shared dilemmas are one of the challenges for the operationalization of the FRM system [64]. Lack of political support at the local level is also another major challenge for this [65]. An over-reliance on top-down expert-led planning, structural flood defences, and ‘hard’ engineering solutions is also inhibiting the socio ecological systems thinking of stakeholders. Implementation of a diversified set of flood risk management strategies in a certain area is only possible if these strategies and their coordination are seen as legitimate, effective and efficient in their physical and social context [66]. Another limitation is the absence of the government incentives for autonomous adaptation to the local community. Moreover, this will allow individual communities and the market forces to take land use decisions which has collectively lead for increasing the flood risk while leaving the costs of adaptation and land scarcity with governments [67]. Consequently, spatial planning, as a collaborative planning
tool has highlighted for e providing of opportunities to stakeholders to find out the integrated and adaptive strategies for operationalization 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 planning process [5].

3.7 Gaps of the current status of operationalization of flood risk management system

Operationalization of Flood risk management means the translation the core principles of flood risk management the planning process. This included how relevant information of flood risk is collected, analysed and communicated, and decisions within the complex web of actors, rules, conventions, processes, and mechanisms of governance [68]. Thus, adaptation of social system is understood as any modification in planning process in response to actual or expected impacts of flooding. Accordingly, the operationalization of Flood risk management is explaining the (1) arrangements of stakeholder including water managers, spatial planners, communities, local government, disaster managers, urban developers, etc in planning process, (2) their dominant discourses, (3) their networks of rules, resources and (4) multilevel coordination mechanisms [6], [20], [48], [57], [69]-[72]. Moreover, there is no criteria to evaluate the institutional arrangements, characteristics of stakeholders’ and their discourses, their coordination mechanisms to evaluate the potential for operationalization of flood risk management [73]. Currently, there is no guidelines to define the adaptive capacity of the planning system to operationalize the flood risk management.

4. Discussion and conclusions

The dimensions of the conceptual framework for operationalization of Flood risk management are described under four categories.

- Conceptualization of flood risk management in the planning process
- Assessment of flood risk in the planning process
- Potential for participatory decision making in the planning process
- Potential for flexible decision making in the planning process

4.1. Conceptualization of flood risk management system in the planning process

Planning process should realize that the flood risk is a characteristic of socio ecological system of any place. The flood risk management system is comprised with river subsystem, socio economic subsystem, institutional subsystem, etc. These social and natural subsystems are inextricably linked with each other and are influenced by multi-dimensional factors at different levels and different scales. In this context, the planning process must define the components of flood risk management system by considering these sub systems and their interactions. Stakeholders of the planning process should conceptualize the inherent uncertainty of flood risk management system which is due to the non-linear and non-stationary nature of socio ecological subsystems of flood risk. Conceptualization of flood risk means that, the stakeholders of the planning process recognize the nonlinear nature of flood risk and hence identify the impacts on tangible and intangible elements of the floodplain (assets, stakeholders, economy, living quality, etc.) which are both fixed and mobile, stakeholders, economy, living quality, socio-ecological & economic functions of the place using a scenario based approach. Further, it is necessary to understand which stakeholders’ objectives will be influenced due to flood risk and management options in the long run. Therefore, it is required to identify the stakeholders in the planning process by considering the ‘uncertainties’ and ‘adaptability’ as a potential solution for FRM. The objective of the planning process is to enhance the adaptive capacity of the FRM system. The adaptive capacity of the FRM system means, the understandings of planning process, the interdependencies among socio economic, hydrological and climatic subsystems of a place. Therefore, the planning process is required to recognize the co-evolutionary interactions of land, water and society, global change and the unavoidable uncertainties which are associated with it. Moreover, the adaptive capacity of the planning process is the ability to identify the variables to describe the feedback loops of the system which can cause vulnerability and hence leading to flood risk.
The planning process should be able to recognize how different socio-ecological changes can bring out different outcomes of the floodplain. Therefore, the scenario analysis should be able to recognize these uncertainties in an organized way. Further, it is required to legitimize the co-evolutionary interactions of land water and society by the planning process. Accordingly, the planning process has to have the ability to define a diverse range of management strategies in order to manage the vulnerability of the area. Therefore, the conceptualization of planning process indicates how the planning system is defining what is at risk, whose risk, what are the objectives, strategies and the actions of the FRM system, and who are the stakeholders who should be included in the FRM system.

4.2. Assessment of FR in the planning process
Flood vulnerability mainly occurs due to the ill recognition of socio-spatial interrelations of a location in the planning system. Therefore, it is needed to consider the territorial spatial link of ecological, hydrological and social elements related to the floodplain in order to reduce flood vulnerability. A planning process should have the ability to develop spatially heterogeneous policies and strategies. Stakeholders perceptions of socio-ecological interdependency may differ in different places even though the natural environmental conditions are similar. Therefore, the planning process should also recognize the social context and perceptions of different stakeholders at each location. Further, the planning process should be able to integrate different spatial demands of housing, recreational, infrastructure development and nature conservation, and flood management of those locations. Moreover, it is necessary to develop some shared focus on knowledge about cause-effect relationships. Designing of flood risk management strategies should consider the place uniqueness considering the territorial connectivity of social, hydrological and ecological subsystems. The objective of the planning process is to develop multifunctional strategies for all stakeholders on the floodplain considering the uncertainty incorporated with flood risk of each location of the watershed. Accordingly, there should be spatially heterogeneous policies, strategies, and guidelines. Therefore, the planning process should have the ability to develop place-based strategies that are tailored to the dynamic spatial demands of diverse stakeholders in the different scenarios of climate change. Increase of the flood vulnerability is the absence of recognition of the potential of resources and the capacities of the local community. Therefore, the planning process of the operationalization of flood risk management is required to empower local community-centred actions.

4.3. Participatory decision making
There should be an opportunity to integrate knowledge, power, and resources among the stakeholders during the process of flood management considering the interdependencies over space, time and society. Secondly, there should be legal and financial tools to stakeholders for designing the multifunctional and diverse strategies over the floodplain considering the location values and the climatic changes.

4.4. Flexibility in decision making
Implementation of flood risk management system requires an adaptive planning process that promotes learning to deal with uncertainties of flood risk. In this context, the presence of opportunities for social learning is recognized as a crucial element in policy and strategy making. The planning process should be a continuous process due to the dynamics of socio-ecological systems which focus on balance multiple forces within a complex social process that is prone to diverse interpretations. There should be an opportunity to share the information among all stakeholders to change the goals, objectives, and the guidelines considering the dynamics of the social and ecological processes. The notion of Socio-ecological systems thinking highlighted the inherent uncertainties to provide unconventional perspectives for coping with flood risk. Therefore, operationalization of flood risk management system means, the planning system provides opportunities for identifying the uncertainty of flood risk and manage it while providing opportunities for the development of integrated and adaptive objectives, strategies and guidelines. Therefore, the indicators which can be used to evaluate the operationalization of flood risk management system by the planning process can be identified. They are defining of (1) flood risk (2) flood risk management system (3) flood risk management
objectives (4) Flood risk management options (5) flood risk assessment (6) consideration factors of evaluation of flood risk management objectives strategies and guidelines (7) Designing of implementation options for strategies (8) Implementation options for guidelines including methods, financing tools, institutional tools (9) consideration factors in changing of management options, strategies, and the guidelines. Adaptive capacity of the planning process of FRM system is represented in four ways. First, how the planning process defines the FRM system by considering the complex & dynamic interactions of floodplains. Second, the planning process should have the ability to identify and manage the dynamics of socio spatial temporal interactions of floodplains. Third, the planning process should have the capacity (methods, financial & legal tools) to integrate spatial, temporal and social dynamics of flood risk in order to manage the uncertainty incorporated with flood risk. Fourth, the planning system should have the capacity (methods, financial & legal tools) to change spatial, temporal and social dynamics of flood risk in order to manage the uncertainty.

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