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Policies and governance impact maps of floods on metropolitan Shiraz (the first step toward resilience modeling of the city)

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ABSTRACT

Climatic conditions are changing and flood occurrences are increasing in frequency and intensity. The world's population is also becoming increasingly urban, meaning a flood could cause more damage than before. Mitigation and adaptation measures are prioritized by disaster planners and policymakers. This paper is the first step in quantitative assessment and modeling in a project aimed at resilience against flooding in metropolitan Shiraz. The paper also presents an approach for providing temporal and spatial information on flood policy and governance impacts for use in the resilience simulator. Basic population data, city expansion, changes in river width, the river's hydraulic behavior, and topography (which are indices of social, organizational, and physical conditions) for 2006, 2011, and 2016 are integrated to develop a composite policy and governance impact map. The final maps indicate that regions near the river and some parts in city's 1st, 6th, 7th, and 8th districts are more impacted by the floods compared to other municipalities. The product can be used as a single map to evaluate policies and governance in this city and as an input for city resilience modeling.

1. Introduction

Hazards (e.g., earthquakes, storms, flooding, and sea level rise) and vulnerabilities (e.g., rapid urbanization, rigid and unsuitable governance structures and policies, improper land use) combine to increase disaster risk in cities [1]. The flood, vulnerability, and exposure are the main elements in evaluating flood risk management (FRM) frameworks and resilience attributes [2].

Floods that occur in urban areas are governed by increased frequency and may cause more damage than before. A solution is to find the balance between land use and urbanization through adaptation, mitigation, prevention, response, and recovery strategies [2]. When managing flood risk in urban areas, the priority is to minimize flood damage. The new comprehensive approach is based on a resilience concept. Adding resilience to flood risk management is the first step. A resilient city is a sustainable network of physical systems and human communities that possess the capacity to survive, cope, recover, learn, and transform from a disturbance by: (a) decreasing damage probabilities; (b) reducing consequences; (c) decreasing the time of recovery; and (d) creating opportunity from adverse impacts [3].

When a system is subjected to any external shocks (usually called impacts) such as flood or earthquake, it has a limited capacity to resist, absorb, and recover from the shock, depending on the shock intensity, system vulnerability, exposure, and adaptation. For example, in the case of natural hazards like flooding in a city, Simonovic and Peck [4] identify five major possible impact sectors that include physical, economic, social, health, and organizational changes of city systems [3]. Direct health impacts of extreme weather events generally consist of immediate deaths and physical injuries. Secondary health effects are due to communicable diseases (types and varieties dependent on geographic location), compromised healthcare access for individuals suffering from non-communicable chronic diseases, and mental health conditions [5]. The time frames and magnitude of each health impact are also time dependent. Infectious complications, in general, occur early after the event. The effects on non-communicable diseases and mental illnesses occur later and can turn into long-term health issues.

The capacity to handle the shocks or impacts is termed the adaptive capacity (AC) of the system. In developing countries, the term 'adaptation' in the context of adaptive capacity is linked to climate change [6]. Adaptive capacity is an integrated behavior of several components within the system that changes with time and space and can be measured using four performance indicators: robustness, redundancy, resourcefulness, and rapidity. Known as the four R's, they were first introduced by Bruneau et al. [7] and Bruneau and Reinhorn [8]. Such indicators should be specified and identified for each case. A mathematical function should be chosen to combine the effects or indicators.

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It is important to study the urban master plans of each case study to understand local authorities' policies and planning for the city's future. Urban master plans in Iran were first prepared in 1966 or some time before. By that time, urbanization had increased in Iran's cities and authorities decided to manage this growing trend and reduce the related issues. Urban master plans were prepared in Western (developed) countries and then exported to developing countries.

In his book, "Models of Urban & Regional Systems in Developing Countries," Chadwick [9] examines the structure and behavior of urban and regional systems in developing countries. He considers how such systems change and how they might be changed by some form of manipulation. Using his experience in Bahrain, Hong Kong, Korea, and Saudi Arabia, he discusses that developed countries' planning patterns are improper for developing countries. Developing countries should study about social anthropology before planning. Andalib [10] presents principals and concepts of past measures in Iran, shows that urban master and detailed plans are inefficient in renovating deteriorated urban areas of Iran, and emphasizes the necessity of preparing a special plan for these areas using citizen participation. Shafie Dastjerdi [11] wrote "Renovation of deteriorated areas and the necessity of reorientation in preparation and execution of master and detailed plans; A case study: The master and detailed plan of Isfahan City." This paper suggests that the master plan and consequently the detailed plan of Isfahan have been unsuccessful regarding the proposed per capita services. Moreover, the plans have not been efficient in renovating the deteriorated areas of this city. The plans have been useful only to identify and stabilize the existing situation at best.

The UNIDSR (United Nations Office for Risk Reduction), launched the "Making Cities Resilient" campaign in 2010. UNISDR seeks to create global awareness of disaster risk reduction benefits and empower people to reduce their vulnerability to hazards. UNISDR's preferred approach is advocating and laying the foundation for action, developing and providing the necessary tools, and mobilizing partners to take ownership and drive disaster risk reduction initiatives forward, with UNISDR supporting as needed. The campaign focuses on resilient cities. Through the campaign, at least 850 municipalities in 62 countries have a dedicated institutional point of responsibility for disaster risk reduction, supported by budget allocations. Cities in India, Indonesia, Jordan, and the Philippines have set up special disaster risk reduction units [12,13]. Metropolitan Shiraz is a member of this campaign.

Simonovic et al. (2011–2016) have implemented the Coastal Cities at Risk (CCaR) project, a multidisciplinary team project involving four large coastal cities: Manila (The Philippines), Bangkok (Thailand), Lagos (Nigeria), and Vancouver (Canada). They are attempting to develop a City Resilience Simulator (CRS) to integrate various impacts and adaptive capacity measures to better assess the dynamics of community resilience in the presence of climate change-caused disasters. The CRS combines time and space simulation to gain real-world dynamic behaviors [14,3,4]. Batica's [2] Ph.D. thesis is "Methodology for flood resilience assessment in urban environments and mitigation strategy development." She expresses that the (i) flood, (ii) vulnerability, and (iii) exposure are the main elements in evaluating flood risk management (FRM) frameworks and resilience attributes. She studied case studies in Europe and Asia for differences between urban systems, beginning with the institutional organization. The priority of the existing FRM frameworks differs in Europe and Asia. The level of urbanization and available assets in the analyzed cities is not the same, contributing to different levels of disturbances during and after floods. She defines five dimensions (natural, social, physical, economic, and institutional) for resilience as well as some indicators, proposes an approach to evaluate flood resilience, and defines the Flood Resilience Index (FRI) as a unique approach for evaluating flood resilience in urban systems with a priority on system structure.

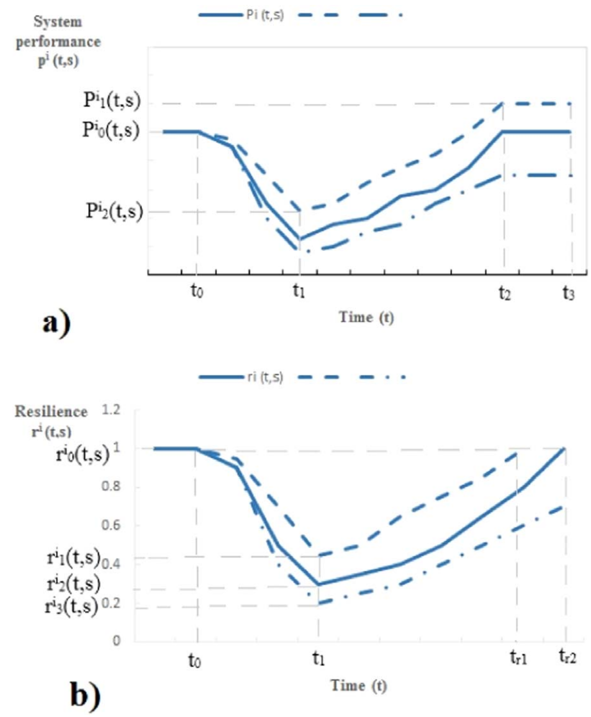

Fig. 1. Illustration of a) System performance, b) System resilience, subject to disturbance (Adapted from [4]).

The study of metropolitan Shiraz investigated 10 municipal regions. The physical, social, and organizational impacts of floods on urban areas and the effect of each of these impacts and their interdependencies were studied. Appropriate indices identified effects of the impacts. Policies and governance to enhance urban resilience were investigated, and impacts of floods on metropolitan Shiraz resilience were studied. This part of the study was descriptive-analytical and based on library research, documentation, and field surveys. A flood frequency analysis was conducted based on past floods, and flood discharges with different return periods were determined using Stormwater Management and Design Aid (SMADA) software. The Hydrologic Engineering Center's River Analysis System (HEC-RAS) software modeled the hydraulic behavior of the Khoshk River. This is the first step in modeling city resilience against floods.

Resiliency is known as a function of time and space. To assess urban resilience, impacts of both time and space must be investigated. This paper is a part of a comprehensive project on metropolitan Shiraz resilience. Shiraz's urban resilience was investigated using: 1) the city master plans, 2) information about urban stormwater systems, 3) metropolitan Shiraz maps, 4) digital elevation models, 5) water features, 6) population statistics, 7) population characteristics, 8) past flood data, and 9) past to present policies and governance (Data gathered from public and private local organizations, 1966–2016).

This research studied the policies and governance in metropolitan Shiraz that refer to its resilience against floods, which are defined as part of the organizational impacts. Urban master plans, past to present, were studied and their limits and shortcomings discussed. Population growth, city changes, policies, management, and proceedings related to urban resilience in flood events were studied, and the hydraulic behavior of the Khoshk River was modeled. In this research, the risk is defined as the inundation of the urban area (around the river) with various possible floods by three different social and organizational (policy