

# Design of an environmental management model for the efficient use of urban floods using the DPSIR model (Case study: Tehran city)

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## Original Research

## Abstract:

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This research aims to design a model for managing urban floods in Tehran. For this purpose, DSPIR model and Delphi panel (consensus of 18 experts) were used. In order to achieve effective criteria and indices, a researcher-made questionnaire was used, and to determine the validity and reliability of the questionnaire, Cronbach's alpha method was used by SPSS, Version 21 software. Fuzzy AHP (Analytic Hierarchy Process) method was used to determine the weights of criteria as well as classes of each criterion, and PLS (Partial Least Squares) method to fit the model. The results indicated that the model in connection with flood driving force in Tehran comprises 5 components and 16 dimensions. Evaluation of goodness for model fit shows that GFI is equal to 0.954, which is within the acceptable range. RMR is equal to 0.011, which is within the acceptable range. TLI, CFI and IFI are 0.931, 0.987 and 0.986, respectively, all of which are within acceptable ranges. CMIN/DF is equal to 4.255, and RMSEA is equal to 0.065, therefore, they are within acceptable ranges. In general, the results of model analysis and evaluation showed that the model has the accuracy needed to simulate urban runoff and this model can be used for urban flood management plans and design of urban flood drainage network in the studied area.

**Keywords:** Urban flood; Environmental management; DPSIE model; Tehran city

## 1. Introduction

Flood is among the known natural disasters, ranking the highest in terms of financial and life damage, alongside earthquakes and droughts, according to the International Hazard Database on Natural Disasters (International Hazards Database 2015). Flood risk is the most common natural hazard, accounting for almost half of all natural disasters worldwide (Sodhi and Tang, 2014). According to recent United Nations statistics, 157,000 people passed away as a result of the floods between the years 1995 to 2015 (Wahlstrom and Guha-Sapir, 2015). During the same period, 2.3 billion people were affected by floods, and 56% of all those damaged by weather-related disasters were af-

ected by floods (Ngang et al., 2017). At least one-third of all losses due to natural forces can be attributed to flood (Abebe et al., 2018). Therefore, knowledge of the degree of vulnerability of different areas of the city and attention to the issue of urban flood management as one of the important axes of attention to urban issues, with emphasis on urban environmental preservation, is of importance (Amoako et al., 2019). Today, disproportionate expansion of cities has caused drastic changes in the morphology of watershed basin. In addition, leveling of the lands, encroaching on the boundaries of rivers and streams, changes the natural drainage pattern and runoff on the surfaces of cities. With the rapid growth of urban development and creation and development of infrastructures, flood in urban areas has be-

come more and more severe (Babaei et al., 2018). Therefore, due to the expansion of urbanization and climate change, it is necessary to establish an effective flood control system and efficient drainage mechanism in cities (Luan et al., 2019). Flood-induced instability is variable and complex, and flooding in a watershed basin depends on several criteria such as characteristics of watershed basin, rainfall intensity, soil permeability, and antecedent conditions (Waghwalwa et al., 2019). Collecting and disposing of rain-induced runoff in river channels is actually considered as measures for safety, health and welfare (Zhao et al., 2019). Urbanization leads to an increase in unstable areas and construction of stormwater drainage networks, reducing the time needed for concentration and increase in direct runoff, consequently accelerating flow rates and decreasing water table levels (Mohammadi et al., 2023). Additionally, natural water bodies such as lakes, wetlands, and rivers, which can contain a significant amount of floodwater have been largely reduced or overfilled, therefore, rate of flood occurrence has been increased. Increasing frequency of urban flood disasters threatens human living and infrastructures and result in greater economic losses. Hydrological events are estimated to account for 51.7% of all natural disasters occurred in 2016. In addition, the total cost resulting from hydrological disasters in 2016 has increased more than annual average by 74% (Disaster Risk Reduction (UNISDR), 2015)<sup>1</sup>.

This research aims to achieve an environmental management model for the efficient use of urban floods in Tehran. For this purpose, DPSIR model was used. Basically, the researcher seeks to find the answer to this question: What are the effective components of urban flood management? Urban flood generally occurs when intense rainfall is immediately followed by limited drainage system capacity (Manjusree and Surwase, 2019). Depending on the drainage system, specific characteristics of the drainage design, and specific local constraints, runoff in the urban basin may occur in various stages of hydraulic redundancy (Rabori and Ghazavi, 2018). Urban flood can damage structures, affect people's daily living environments and in extreme cases, can be catastrophic. Consequently, for this reason, global authorities are interested in flood prevention and mitigation of its devastating effect (Samsuri et al., 2018). Although urban areas serve as economic and population centers, they have negative environmental impacts both in city and suburbs. In the 21<sup>st</sup> century, most climate models and empirical evidence indicate that warm weather increases atmospheric water vapor, leading to more intense and frequent precipitation (Berndtsson et al., 2019).

Although some cities in different countries still follow old, linear and traditional approaches, many others are shifting from traditional approaches to using an integrated, consistent, coordinated and collaborative approach required by sustainable urban water management (Sahoo and Sreeja, 2018). New approaches attempt to consider urban water resource management as a "water cycle" to reflect the complexities and interconnections between different sectors and aspects of urban water management. Traditional and linear approaches in urban management are mainly charac-

terized by a coordinated institutional framework (Jalilov et al., 2018). Increase in damages and human vulnerability has compelled local decision-makers and governments to think about solutions for investing on control of short-term and long-term flood. Accordingly, they adopted appropriate strategies based on structural and non-structural measures to mitigate the effects of natural events (Asghariazim, 2023). According to experts, one of the main causes of generation of flood is inefficient urban management (Amoako et al., 2019). Changes in land usage model are largely responsible for floods and result in damages and casualties (Karimi et al., 2015). Failure to manage flood water in urban areas, in turn, will lead to an increase in severe casualties in cities (Waghwalwa et al., 2019). Flood risk effects in terms of flood depth and waterlogged area are considered as mandatory parameters for proper flood management and planning.

Flood risk assessment is necessary to reduce or eliminate disaster risks in all areas of flood-prone countries. Effectiveness of adaptation measures depends on the role of water managers, and execution of an appropriate water management system can minimize the impact of flood and optimize access to drinking water and wastewater treatment (Jalilov et al., 2018).

In the past, flood management approaches were based on collection, transfer, and discharge of urban floods. While modern approaches in urban flood management emphasize methods that have maximum compliance with the natural cycle processes of surface water. The goal of modern approaches in urban flood management is to control and reduce flood and transfer pollution that have been arisen (Badeiizadeh et al., 2015). These approaches, which focus on maximum compliance with processes of the natural cycle of surface water, are technically referred to as "less effective development" methods. The less effective method aims to maintain and restore the natural hydrological conditions of the watershed basin and improve the environmental conditions in it. This method practically includes a set of land planning and engineering design methods being applied and is a tool for managing surface runoff and urban flood in the watershed basin (Ahmadian, 2017). This method emphasizes the protection of natural appearance of the basin to preserve the quantity and quality of water and make maximum use of environmental opportunities in the management of surface runoff in order to restore the natural water cycle (Chen et al., 2009).

The study and management experiences from different countries indicate that the first step towards reducing the damaging effects of flood is to know floodgate areas and zoning these areas in terms of flood risk. By identifying floodgate areas in the cities, the damaging effects of urban floods can be prevented as much as possible through an integrated management as well as comprehensive urban planning (James et al., 2011).

The comprehensive environmental assessment process should be presented in the form of a conceptual model so that the collected data and analyses meet the fundamental questions of research. Different models are used to perform this assessment. DPSIR<sup>2</sup> is one such model (Yazdi

1. United Nations Office for Disaster Risk Reduction

2. Driving Force, Pressure, State, Impact, Response

et al., 2019). DPSIR model is composed of the initials of five words “Driving Force”, “Pressure”, “State”, “Impact” and “Response”, which respectively express the cause-and-effect chain about each of the environmental components. This model attempts to define and relate a set of criteria that determine the influential characteristics on the environment at each geographical level (local, regional, national, global). Therefore, this model is recognized as an analytical framework. The DPSIR model seeks to establish a logical correlation between factors. It evaluates the state (S) of environment and its process and identifies and introduces the direct (Pressure) and indirect (Driving Force) criteria that caused this situation to occur. It also identifies and introduces responses (R) that improved state or should be addressed (Luan et al., 2019).

Tehran bears 22 regions and 123 districts. Although, all 123 urban districts of Tehran are not involved in the flood debate, in the northern regions, the risks of flood from the upstream basin and change in lands usage in that regions can increase the probability of flood. In central areas, especially south of Tehran city, due to socio-economic challenges, high population density and non-compliance with some urban management guidelines by some citizens can increase the flood risk of these areas. Tehran, the capital of Iran, is 200 years old. Its transformation from a small village in the current central area (market or business district) to the metropolitan area of today Tehran has not been gradual. A large part of the urban growth in the area and population has occurred in the last 50 years. This city, with an area of 2064 km<sup>2</sup>, is located in the center of Tehran basin (Sadeghinia et al., 2012).

The main causes of flood in Tehran are physical progress up to height of 2200m, steep slopes in the northern areas, height difference of about 700m between the northern and southern areas, extensive construction, disregard to ecosystem state, reduced soil absorption, incompatibility of sewage network and construction in rivers’ buffer zones. This has also lowered the rainfall threshold for flood generation (Banari et al., 2016). Examination of past floods in Tehran and

rainfall in these floods shows that floods in Tehran occurred at rainfall threshold ranging from 35 mm to 50 mm. According to studies, the number of floods in Tehran city has been increasing over the last four decades (1981 to 2021) (Behtash et al., 2021).

Evidently, some parts of the north of Tehran have a high flood potential due to influence of the upstream basins (Behrouzi et al., 2015). Therefore, it is necessary to pay more attention to the downstream areas of this city because the canals do not have the necessary ability to pass through and repel urban flood (Emam et al., 2016). The effect of surface and subsurface infrastructure on flood collection is another important criterion in generation of urban floods (Ahmadisharaf et al., 2017) although rainfall distribution models can also facilitate urban flood.

## 2. Materials and methods

### 2.1 Introduction to the studied area

The metropolis of Tehran is located in the southern domain of the Central Alborz Mountain range. The minimum elevation of the area is 1032 m at the southernmost point of the basin, and the maximum elevation reaches 3903 m in the northern part of the basin. The annual rainfall in Tehran city limits is mainly influenced by the elevation changes in the city limits and ranges from maximum 422 mm in the north of Tehran to minimum 145 mm in the southeast of Tehran (Darabi et al., 2019). The physical development of Tehran up to an elevation of 1133 m, leveling of the land, occupation of waterways and canals have caused an increase in occurrence of urban flood. So that the thresholds for the amount of precipitation in generation of flood in Tehran have been decreased (Tehran-Municipality, 2023). Figure 1 illustrates the map of drainage system in Tehran city. The inner-city basins of Tehran are divided into three main basins, namely East and Northeast flood diversion canal (220 km<sup>2</sup>), West and Northwest flood diversion canal (147 km<sup>2</sup>), and Central flood diversion canal (165 km<sup>2</sup>) (Figure 2).

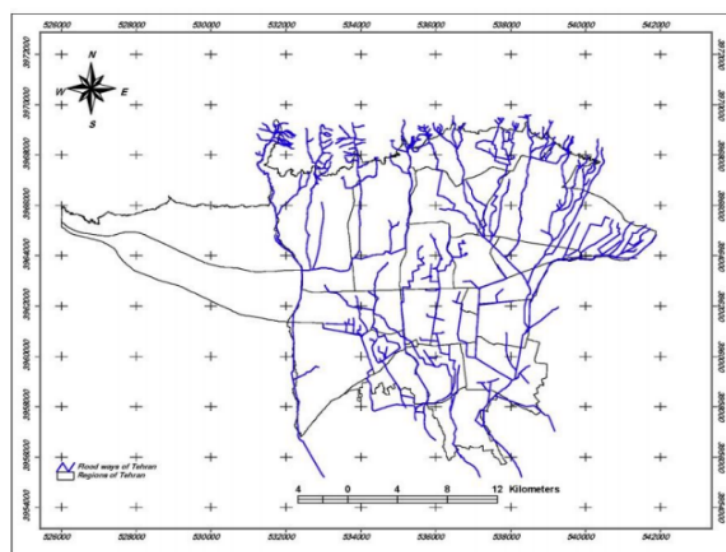


Figure 1. Map of drainage system in Tehran city (Tehran-Municipality, 2023).

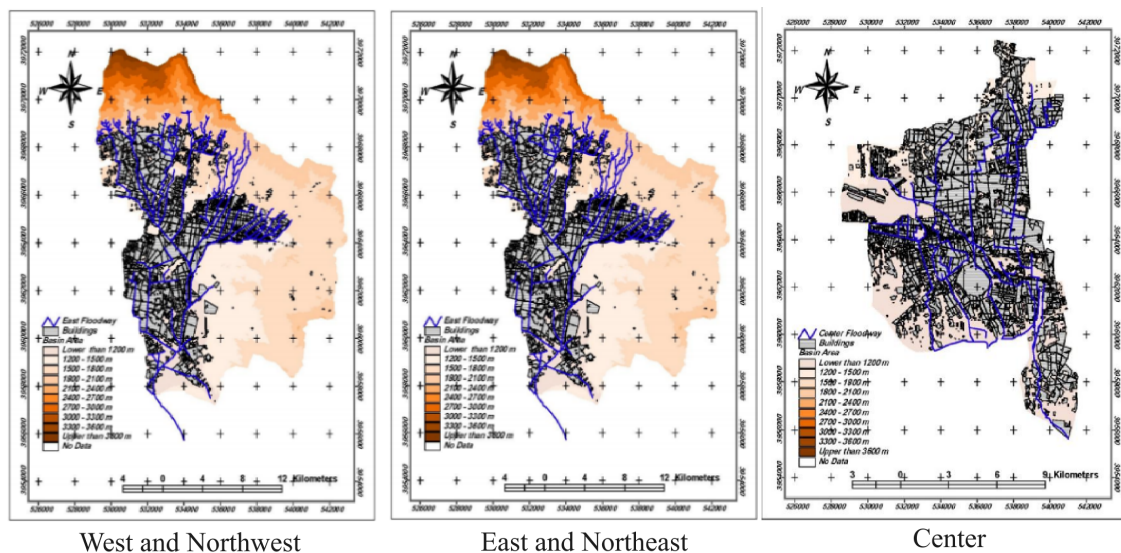


Figure 2. Map of drainage system in the areas of Tehran (Tehran-Municipality, 2023).

### 2.2 Methodology

This research is of applied type, which has been conducted using a combined method (qualitative and quantitative) in a mixed form (library and field). All basic data (meteorological, climatic, geological, land usage, required maps, etc.) were obtained from specialized organizations. In order to achieve effective criteria on urban flood in Tehran, the study of Karimpour et al. was referred to. In the field section, in order to identify the causes of floods and predict the range of damages caused by floods in different conditions, economic and social justification and flood control plans, analysis of the criteria affecting floods in the area was carried out with the DPSIR conceptual model. For this purpose, a researcher-made questionnaire was used. To determine the validity and reliability of the questionnaire, Cronbach’s alpha method was used by SPSS, Version 21 software. Delphi panel (consensus of 18 experts) was also used for the final conclusion. All the experts who participated in the Delphi panel had extensive knowledge and experience (more than 20 years) regarding flood management. These people were selected from university professors and high-level managers in the country. Next, by mapping the driving forces identified by the DSPIR model, and zoning the area, the risk level of different areas of Tehran in connection with flood, is determined. The process of identifying flood-sensitive areas should be divided into several stages. The first stage involves preparing a map of criteria affecting on urban flood

using Geographic Information System (GIS) data (Darabi et al., 2019). The second stage should be done by calculating the percentage of some weights of criteria using Analytic Hierarchy Process (AHP) algorithms (Rahmati et al., 2016). The third stage includes a transformation process of criteria affecting on flood from number 0 to 1 using fuzzy membership algorithm (linear functions) (Qiang et al., 2018). In addition, the fourth stage includes multiplying fuzzy criteria with AHP criteria and finally preparing a map of criteria affecting on flood using Fuzzy AHP (FAHP) method. Fuzzy AHP method was used to determine the weights of the criteria as well as the classes of each criterion. Although the FAHP method requires uniform computations when analyzing complex decision-making problems, it is able to yield judgments of human uncertainties (Darabi et al., 2019; Kling et al., n.d.; Yang et al., 2013). After calculating the factor weight for each criterion and fuzzification of each flood factor, the fuzzy logic output must be combined with the AHP weight output using Eq. 1. After that, the output maps should be combined using overlaying them, until finally the map of the criteria affecting on Tehran flood to be received.

$$MODEL_{FAHP} = \sum_i^n W_i \times F_i \tag{1}$$

where  $W_i$  is the weight of each effective factor and  $F_i$  is the fuzzy map of each flood. In this regard, in order to evaluate the significance of the criteria, linguistic variables are trans-

Table 1. Linguistic terminology and the relevant triangular fuzzy scale (Yang et al., 2013).

Hourly Scale	Linguistic Terminology	Triangular Fuzzy Number (TFN)
1	Equal importance	(1, 1, 1)
3	Average importance of one over the other	(2, 3, 4)
5	Strong or essential importance	(4, 5, 6)
7	Obvious importance	(6, 7, 8)
9	Extreme importance	(9, 9, 9)
2, 4, 6, 8	Average values between two close judgments	(7,8,9) (5,6,7) (3,4,5) (1,2,3)

**Table 2.** Comprehensive list of urban flood's driving forces in Tehran.

<b>Model Components</b>	<b>Dimensions</b>	<b>Index</b>
Driving Force	Economic-social-cultural	<ul style="list-style-type: none"> <li>• Increase in population</li> <li>• Rapid urban development</li> <li>• Weak citizenship commitment (Disposal of sewage and household waste from homes and public places in channels and waterways)</li> </ul>
	Physical	<ul style="list-style-type: none"> <li>• Change in land usage</li> <li>• Land leveling</li> <li>• Urban construction (encroachment to boundaries of canals)</li> </ul>
	Ecological	<ul style="list-style-type: none"> <li>• Climate change</li> <li>• Presence of steep mountainous terrain in the north and east</li> <li>• Geological conditions</li> <li>• Hydrological and geomorphological state (Hydraulic parameters)</li> <li>• Topographic conditions</li> <li>• Destruction of vegetation coverage</li> <li>• Soil type and texture state</li> </ul>
	Infrastructural-institutional-urban architecture	<ul style="list-style-type: none"> <li>• Lack of proper management of urban runoff</li> <li>• Lack of detailed pavements and infrastructures</li> <li>• Deterioration of the bed and walls of Tehran's urban channels</li> <li>• Insufficient number of trash and sediment excluders in Tehran's urban facilities (rivers)</li> <li>• Inadequate inspection valves of rivers</li> <li>• Inappropriate dimensions (width and depth of urban rivers and streams)</li> <li>• Inappropriate sloping of Tehran's urban channels and waterways (insufficient slope - reverse slope)</li> </ul>
Pressure	Enviromental	<ul style="list-style-type: none"> <li>• Increased exploitation of urban resources</li> <li>• Increased impermeable surfaces</li> <li>• Increased volume of runoff</li> <li>• Increased soil erosion</li> <li>• Increased velocity of urban runoff</li> <li>• Emission of various pollutants</li> <li>• Change in drainage system</li> <li>• Occurrence of heavy rainfall</li> <li>• Climate changes</li> <li>• Reduction in groundwater recharge</li> </ul>
	Economic-social	<ul style="list-style-type: none"> <li>• Increase in urban construction in inappropriate locations</li> <li>• Decrease in the volume of runoff passing through runoff collection facilities</li> <li>• Increase in society's demand for house</li> </ul>
State	Infrastructural-institutional	<ul style="list-style-type: none"> <li>• Sediment deposition in channels, waterways, streams, and rivers</li> <li>• Physical damage to urban runoff conveyance and transmission facilities</li> <li>• Weakness in execution of connections in urban canals</li> <li>• Inadequate quality of materials used in urban runoff management facilities</li> </ul>
	Environmental	<ul style="list-style-type: none"> <li>• Risk of flood occurrence</li> </ul>

Continue of Table 2.

Model Components	Dimensions	Index
Impacts	Ecological	<ul style="list-style-type: none"> <li>• Change in quality of runoff in the city</li> <li>• Soil pollution in urban areas</li> <li>• Destruction of ecosystems existing in the city</li> <li>• Decrease and loss of vegetation and animal coverages</li> </ul>
	Physical	<ul style="list-style-type: none"> <li>• Destruction and change in land usage</li> <li>• Inundation of streets</li> <li>• Threat of beautification in urban design</li> <li>• Loss of optimal use of space around waterways</li> </ul>
	Infrastructure urban architecture	<ul style="list-style-type: none"> <li>• Loss of efficiency of absorption wells for disposal of sewage</li> <li>• Collapse of adjacent installations and properties leading to the destruction of channels</li> <li>• Filling of waterways with concrete and soil</li> <li>• Blockage of bridges</li> </ul>
	Socio economic	<ul style="list-style-type: none"> <li>• Spread of diseases and damage to community health and hygiene</li> <li>• Harassment and annoyance of citizens by emitting a foul odor.</li> <li>• Shortage of drinking water due to reduced groundwater recharge</li> <li>• Fatalities resulting from flood</li> <li>• Financial damages to homes and vehicles</li> <li>• Mental and psychological damages to citizens as a result of flood</li> </ul>
Responses	Infrastructural-institutional	<ul style="list-style-type: none"> <li>• Planning for reconstruction of damaged channels</li> <li>• Repairing the flooring of waterways or walls of Tehran's urban channels</li> <li>• Principled design of urban runoff collection and management systems</li> <li>• Flood control by building structures, waterways and channels</li> <li>• Construction of sediment excluders basins</li> <li>• Regular dredging of waterways</li> </ul>
	Ecological	<ul style="list-style-type: none"> <li>• Protection of soil, water resources and vegetation coverage</li> <li>• Revitalization of rivers in the north of the city</li> <li>• Preservation and restoration of vegetation coverage</li> </ul>
	Environmental	<ul style="list-style-type: none"> <li>• Control of pollutions (chemical and biological pollution of water, soil, air)</li> </ul>
	Physical	<ul style="list-style-type: none"> <li>• Land usage planning and management</li> <li>• Compliance with regulations prohibiting construction within boundaries of waterways</li> <li>• Supervision on urban construction</li> </ul>

formed into triangular fuzzy numbers. A weight higher than 1 means high importance of that parameter (Table 1). To fit the measurement model in Partial Least Squares (PLS) method, three criteria are initially evaluated: 1) Cronbach's alpha, 2) Composite reliability, 3) Factor loads coefficients and subsequently convergent and divergent validity.

### 3. Results

#### 3.1 Introduction of model components

To determine and select the influential driving forces on urban flood, after reviewing scientific and valid documents and considering regional conditions, the Delphi method survey was conducted with 18 executive experts and university scholars. The results indicated that this model consists of 5 components and 16 dimensions. Table 2 presents a com-

prehensive list of urban flood's driving forces in Tehran together with indices and model components.

#### 3.2 Model fit

##### 3.2.1 Indices fit

In scientific literature, limit for Cronbach's alpha coefficient has been defined as 0.6. Additionally, if the composite reliability value for each component exceeds 0.7, it indicates an intrinsic suitable stability for the measurement model. The results of the research show that all criteria have confirmed Cronbach's alpha coefficient and composite reliability value. Therefore, convergent validity is also confirmed (Table 3). Another criterion used to check the reliability of the tool is the amount of factor loads, which are calculated by determining the correlation value of the indices of a structure

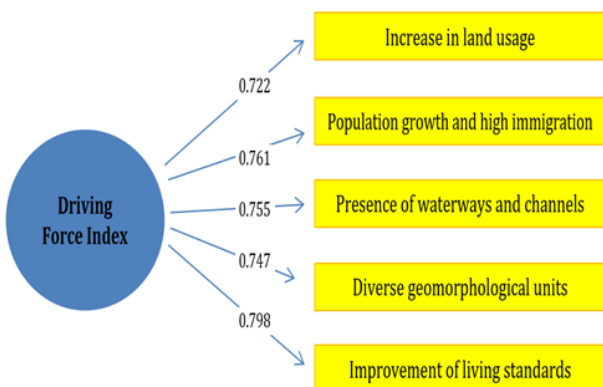
**Table 3.** Examination of the reliability coefficients of the driving force index.

Criteria	Cronbach's alpha Coefficient ( $\alpha$ )	Composite Reliability (CR)	Average Variance Extracted (AVE)
<b>Investigation of the reliability coefficients of the driving force index</b>			
Increase in land usage	0.765	0.813	0.813
Population growth and high immigration	0.866	0.867	0.844
Presence of waterways, channels at entrance of the valleys	0.843	0.745	0.869
Diverse geomorphological units	0.911	0.898	0.809
Improvement of living standards	0.897	0.877	0.831
<b>Examination of the reliability coefficients of pressure index</b>			
Increase in impermeable surfaces	0.607	0.642	0.642
Increase in runoff and erosion	0.735	0.696	0.677
Constructions	0.781	0.776	0.608
Increase in pollution	0.815	0.709	0.717
Improvement of drainage system	0.611	0.713	0.766
<b>Examination of the reliability coefficients of state index</b>			
Reduction in area and size of vegetation coverage	0.666	0.878	0.714
Inappropriate distribution and land usage changes	0.811	0.870	0.621
Dominance of human corridors in the city	0.749	0.812	0.778
Land flooding and their destruction	0.891	0.833	0.790
Increase in built-up areas	0.876	0.856	0.747

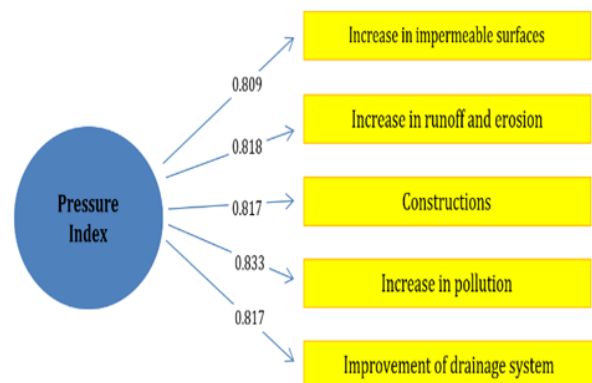
with that structure. Holland (1999) believes that if this value (factor load) is equal to or higher than 0.4, the reliability of that model is acceptable. According to the results obtained from this study, all indices had acceptable factor loads, and values of the significant coefficients (T) for all questions were greater than 1.96, therefore, they are significant at the confidence level of 0.95 (Figures 3 to 7).

**3.2.2 Measurement model fit**

To fit the measurement model, three criteria are used: reliability, convergent validity and divergent validity. As indicated in Table 4, Cronbach's alpha values and composite reliability for all variables in the structural model of the research exceed 0.7, demonstrating adequate internal consistency and stability of the measurement model. Given that the average variance extracted (AVE) values, whose



**Figure 3.** Factor load values of criteria related to driving force index.



**Figure 4.** Factor load values of criteria related to pressure index.

square root represents the values of divergent validity or the Fornell-Larcker criterion are greater than 0.4, adequacy of convergent validity is also confirmed.

**3.2.3 Structural model fit**

To decide on confirmation or rejection of the final management model, indices of final model fit have been used (Table 5). For evaluation of goodness of the model fit, indices such as Goodness of Fit Index (GFI), Root Mean Square Residual (RMR), Tucker-Lewis Index (TLI), Comparative Fit Index (CFI), Incremental Fit Index (IFI), Chi-Square to Degrees of Freedom Ratio (CMIN/DF), and Root Mean Square Error of Approximation (RMSEA) have been employed.

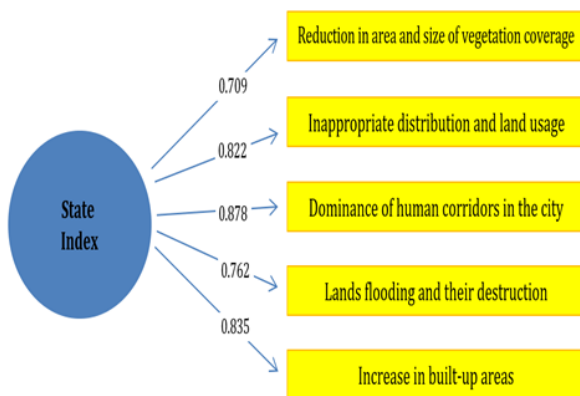
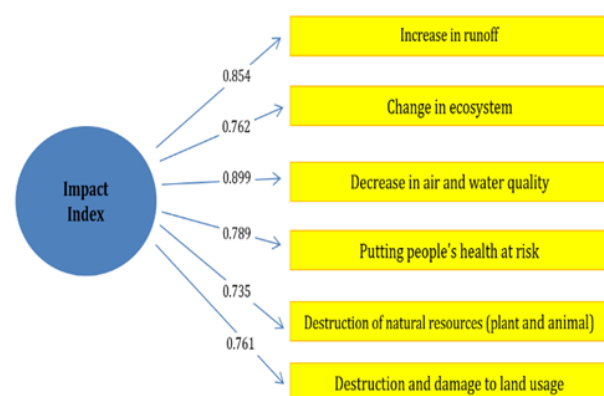
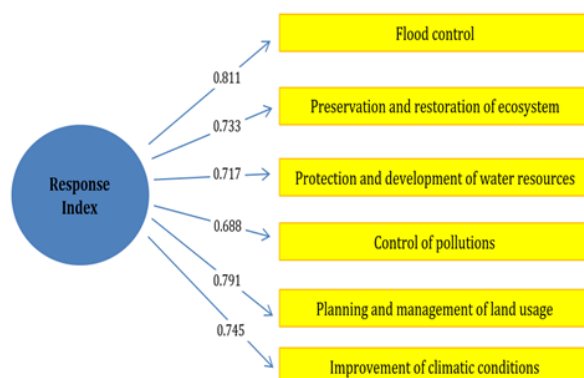
The results arising from evaluation of goodness of the model fit indicate that GFI is equal to 0.954, which exceeds 0.90,

**Table 4.** Examination of reliability coefficients of the research model

Component	Cronbach's alpha Coefficient ( $\alpha$ )	Composite Reliability (CR)	Average Variance Extracted (AVE)
Driving force index	0.824	0.812	0.906
Pressure index	0.855	0.817	0.911
State index	0.838	0.819	0.817
Response index	0.859	0.857	0.725
Impact index	0.862	0.888	0.891

**Table 5.** Indices for the final model fit of the research

Index type	Absolute Fit Indices		Comparative Fit Indices			Parsimonious Fit Indices	
	RMR	GFI	TLI	CFI	IFI	RMSEA	CMIN/DF
Standard value	Less than 0.08	More than 0.9	More than 0.9	More than 0.9	More than 0.9	Less than 0.08	Between 1 to 5
Research model	0.011	0.954	0.931	0.987	0.986	0.065	4.255

**Figure 5.** Factor load values of criteria related to state index.**Figure 7.** Factor load values of criteria related to impact index.**Figure 6.** Factor load values of criteria related to response index.

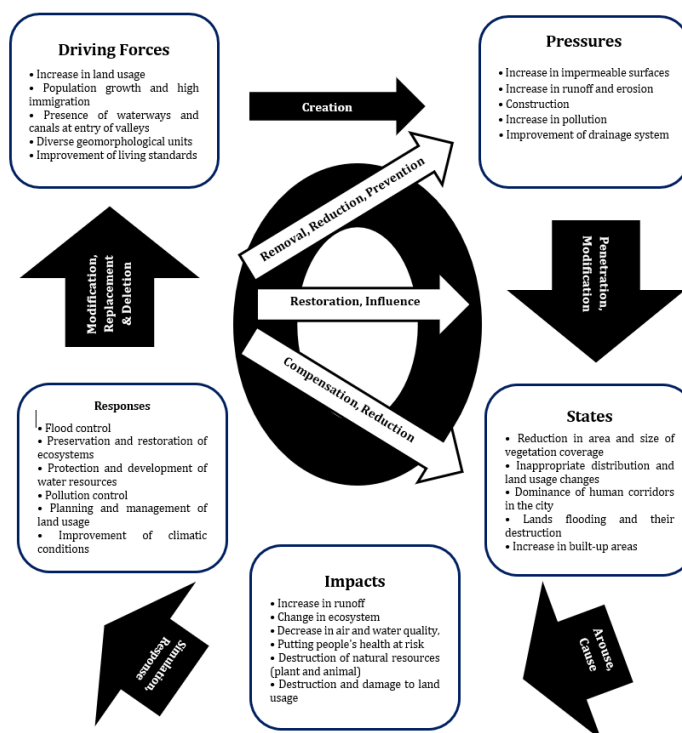
therefore, it is within an acceptable range. RMR is equal to 0.011, which is less than 0.08, therefore, it is within an acceptable range. TLI, CFI and IFI were 0.931, 0.987 and 0.986, respectively, all of which are within acceptable

ranges. CMIN/DF is equal to 4.255 and given the fact that it ranges from 1 to 5, therefore, it is within an acceptable range. RMSEA is equal to 0.065, which is less than 0.08, therefore, it is within an acceptable range.

#### 4. Discussion

Due to the rapid growth of cities in Iran, problems such as urban waterlogged passageways and emission of environmental pollution due to the lack of suitable drainage systems and mismanagement of channels and waterways are considered as fundamental issues in many urban areas. Because of the complexity of hydrological and hydraulic processes of urban flood, the use of computer models will play an effective role (Shahbazi et al., 2013).

The results of this study indicate that the aforementioned model is capable of simulating flood, which is consistent with the findings of the study conducted by Bazidi et al. (2017), who used aforementioned model to simulate surface runoff in Gorgan city. Their research shows that SWMM model has the required accuracy for simulating surface runoff. It also corresponds to the findings of the study



**Figure 8.** The final model of flood management in Tehran city based on the DPSIR model.

conducted by Karimi et al. (2017) on simulating rainfall-induced flood in some parts of Babolsar urban area, as well as the study conducted by Gigovic et al. (2017). The results arising from evaluation of goodness of the model fit indicate that GFI is equal to 0.954, which exceeds 0.90, therefore, it is within an acceptable range. RMR is equal to 0.011, which is less than 0.08, therefore, it is within an acceptable range. TLI, CFI and IFI were 0.931, 0.987 and 0.986, respectively, all of which are within acceptable ranges. CMIN/DF is equal to 4.255 and given the fact that it ranges from 1 to 5, therefore, it is within an acceptable range. RMSEA is equal to 0.065, which is less than 0.08, therefore, it is within an acceptable range. Figure 8 depicts the final model of the current study. As it is clear in the figure, driving forces cause pressures that also affect the states. This causes impacts that are followed by responses. Of course, the answers can transform the driving forces.

## 5. Conclusion

The model used in this research, due to its comprehensiveness and the use of multiple components, can be used in urban flood management in Tehran. This model has been used in other countries and has yielded good results. In general, the results obtained from validation and evaluation of the model demonstrate that the model has the required accuracy for simulating urban runoff and this model can be used for urban flood management projects and design of urban flood drainage networks in the studied area. The proposed solutions are as follows:

For optimal and efficient planning in terms of environmental management, given all conducted studies and evaluations, some practical recommendations are presented as follows:

- Since, most of the research conducted in the country are

currently based on academic methods, the introduced model in this study has enough potential to serve as a tool to assist decision-making and formulate flood risk management programs. In fact, this method identifies and examines the causes leading to the phenomenon, as well as the adopted and even required actions and policies. Therefore, it is recommended that this model be used for other flood-prone regions of the country.

- Basic pixel methods should be used for studies conducted on flood risk assessment and zoning.

### Authors Contributions

All authors have contributed equally to prepare the paper.

### Availability of Data and Materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

### Conflict of Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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