

Original Research Paper

## Assessment and Evaluation of the Status of Vulnerable Urban Fabrics in Babol Neighborhoods against Flood Hazards

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### Abstract

Adaptation and regeneration of vulnerable urban fabrics in Babol appear essential to prevent further damage. The aim of this study is to regenerate vulnerable urban fabrics in Babol in the face of flood crises. To achieve the research objectives, key indicators affecting the regeneration of vulnerable urban areas will be identified using a combination of library research, field surveys, and theoretical studies. In fact, these indicators, including relevant criteria and sub-indicators, will be recognized and analyzed. Subsequently, to prioritize the influential indicators for the regeneration of vulnerable urban fabrics against natural hazards—with an emphasis on floods in Babol—the Friedman test will be applied using SPSS software. The findings indicate that each component of urban regeneration contributes differently to the neighborhoods with vulnerable urban fabrics exposed to flood hazards. The results show that various factors, such as poor water resource management, deteriorating infrastructure, and neglect of crisis management planning, play a significant role in increasing the vulnerability of Babol's urban areas to floods. Furthermore, empowering the local community and establishing green infrastructure have been identified as effective strategies in mitigating damages. The study highlights that the regeneration of vulnerable urban fabrics in Babol must adopt a comprehensive and multidimensional approach. The use of modern technologies, community participation, and enhancement of the resilience of natural resources are among the essential strategies in this regard. Therefore, it can be concluded that the implementation of these measures can significantly improve the city's capacity to cope with floods and other natural hazards.

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## Introduction

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In the face of today's escalating global risks and tensions, it is no longer feasible to respond reactively to sudden changes. In a world confronted by a complex set of evolving pressures, strategic thinking and adaptation are not only necessary but should also be viewed as an opportunity. For societies, the lack of such strategic adaptability can jeopardize public health, social cohesion, stability, and overall success (Pelling, 2013: 32).

The present study focuses on Babol, where the researcher aims to explore the regeneration of vulnerable urban fabrics in response to floods—one of the most persistent natural hazards threatening urban areas. The flooding of the Babolrud River is a major environmental threat in Babol. In its mountainous section, the river flows through a steep valley, but as it enters the Caspian coastal plain, the terrain slope drops significantly, transforming the river into a meandering stream. The land slope within Babol city ranges from 1.5 to 2 per thousand. As the river flows through the center of Babol, it passes near numerous urban neighborhoods. The minimal gradient of the coastal plain contributes to the river's meandering nature.

When embankments are constructed without adequate geological understanding or adherence to hydrological principles, they are quickly destroyed by the first flood event. An example is the Janbazan Bridge in the Chak-Sar neighborhood, a non-standard structure that sustains damage in every flood. A flood barrier has been built 30 kilometers from Babol to protect agricultural lands. The oldest significant flood event in recent memory occurred in 1976 (1355), when water levels reached five meters and overflowed the Mohammad Hassan Khan Bridge. The floodwaters penetrated up to 500 meters into the city, severely damaging citrus orchards and rice paddies. In the 1996 (1375) flood, nearly all buildings in the Mollakola neighborhood were destroyed. In the 2000 (1379) flood, the Vozdehkola Bridge was damaged, and concrete river walls suffered heavy destruction. In the 2005 (1384) flood, the Kamangar dirt road (2 km southeast of Amol) was seriously damaged. The high-risk flood zone of the Babolrud River begins 1.8 kilometers south of Babol and ends 800 meters north of the city. The flood-prone section of the river extends from the coastal road to Hamzeh-

Kola, encompassing neighborhoods such as Oshib, Qazi-Kati, Darzi-Kati, and Sad Dastgah. Additionally, urban neighborhoods in Babol are more vulnerable to flooding due to changes in ground permeability and increasing residential density. The city's geographical position—located along multiple watershed pathways—further emphasizes the necessity of predictive flood planning. Urban planners, geologists, and geographers must thoroughly assess the causes of such natural disasters and develop strategies to mitigate their effects. Consequently, addressing urban regeneration in response to natural hazards such as urban flooding is both vital and unavoidable.

Moreover, due to inadequate urban construction standards for natural disaster resilience, the urban system often lacks the dynamism and recoverability necessary during a crisis. Following the Islamic Revolution, population growth and rural-to-urban migration from surrounding villages to Babol have created numerous challenges. Limited urban expansion capacity, along with the proliferation of residential and commercial complexes and an inclination toward high-rise development, has led to environmental issues such as flooding, river pollution, rising temperatures, and unmanaged waste disposal. Socially, the city faces increased migration, settlement by non-native populations, and the spread of second homes. These conditions cast doubt on the effectiveness of Babol's most recent urban development plan in addressing such complex and multifaceted issues. Furthermore, many of the crises experienced in daily life are often intangible, leading to a lack of urgency in urban decision-making. As a result, these problems often remain at the level of damage assessment without progressing to actionable solutions.

This study seeks to explore the theoretical background of urban regeneration and its practical application in urban planning, specifically focusing on the concept of regeneration as a response to flood hazards. The study examines the role of urban regeneration components in addressing flooding and their transformative potential. The importance of regeneration lies in its ability to manage and organize urban spaces—especially rivers—and to revitalize and repurpose these areas under various conditions. In other words, this approach not only preserves the environmental, ecological, and structural conditions of urban

rivers but also strengthens their resilience to diverse disturbances.

Accordingly, this dissertation proposes a theoretical framework for urban regeneration in response to natural hazards, particularly flooding. The findings of this research will be

significant for urban planners and designers in applying its recommendations to city development projects, as well as for urban policymakers and decision-makers in shaping strategic urban regeneration policies.

**Table 1.** Number of Floods in the Province over a Five-Year Period

Statistical Period	Number of Years	Number of Floods in the Province	Average Annual Occurrence
2011–2016 (1390–1395)	5	56	11.2

Source: Authors, 2025

**Table 2.** Recent Flood Events in Mazandaran Province

Flood Name	Cause	Casualties	Damages
October 2018	Heavy rainfall for approximately one day	6 dead and several injured	Destruction of several bridges and urban infrastructure; disruption of telecommunication networks in some areas
Late March 2019	Continuous rainfall, temperature drop, and soil erosion due to deforestation	Several dead and injured; large loss of livestock and poultry	Submergence of several villages, evacuation of others, disruption of drinking water supply, and railway damage
July 2020		2 dead and several injured	Damage to wheat fields close to harvest, as well as potato and orchard crops

Source: Authors, 2025

**Table 3.** Dimensions, Components, and Sub-Indicators of Urban Resilience

Dimension	Component	Indicators
Socio-Cultural	Awareness	Citizens' awareness of disaster risk – awareness of potential damages – awareness of building safety and resistance
	Knowledge	Citizens' knowledge of disaster causes – knowledge of appropriate behavior during disasters
	Skills	Skills of authorities in providing relief – citizens' psychological resilience during disasters
	Attitude	Household attitudes toward disasters – attention to building resistance
	Social Capital	Level of citizen interaction – trust in urban authorities – trust in public communications – crisis management effectiveness – volunteer cooperation in vulnerability reduction
Economic	Damage Severity	Safety of urban assets (homes, shops, etc.) against hazards – vulnerability and potential loss of jobs due to disasters
	Compensation Capacity	Potential for support from government and local institutions in compensating for damages
	Recovery Capacity	Ability to return to previous job and income conditions – citizens' professional and occupational skills

Institutional– Managerial	Institutional Infrastructure	Citizens’ awareness of disaster management organizations – presence of volunteers and relief groups – adherence to preventive regulations – citizen participation in planning
	Institutional Relations	Communication with urban management institutions – preparedness of service organizations – training sessions held by institutions
	Institutional Performance	Citizens’ satisfaction with the performance of crisis management institutions
Physical– Infrastructural	Building Resistance and Age	Quality of construction materials – structural condition of buildings
	Incompatible Land Uses	Distance from man-made hazard zones (e.g., fuel stations, high-voltage power lines)
	Accessibility	Access to medical centers – access to main road networks
	Density	Building and population density
	Open Spaces	Access to parks and green spaces
Environmental	Site Characteristics	Distance from natural hazard-prone areas – geographical features
	Pollution	Water, air, and soil pollution
	Diversity and Sustainability	Environmental diversity – environmental sustainability
	Environmental Health	Quality and health of water, air, and soil

Source: (Rezaei, 2009); (Salehi et al, 2011); (Mohammadi & Pashazadeh, 2017)

## Literature Review

### The Concept of Urban Regeneration

In its literal sense, regeneration refers to the natural reproduction (or restoration) of a part of a living whole that has been subjected to deterioration or decay. Initially, the term urban regeneration was not distinct from urban renewal; however, over time, and in response to the negative consequences of urban renewal, it emerged as an independent concept. In other words, this transformation reflects a dual perspective of metamorphosis and sustainability, encompassing urban restoration and conservation, which collectively represent a form of “soft urbanism” (Tan et al., 2014, p. 248). From this viewpoint, the restoration of urban heritage and the preservation of the physical structure of the old city are aligned with preparations to accommodate new urban functions (Latifi, 2013).

Urban regeneration refers to a comprehensive and integrated approach and practice aimed at resolving urban issues in targeted areas. Ultimately, it leads to sustainable economic,

physical, social, and environmental advancement (Boyle et al., 2018).

### Dimensions of Urban Regeneration

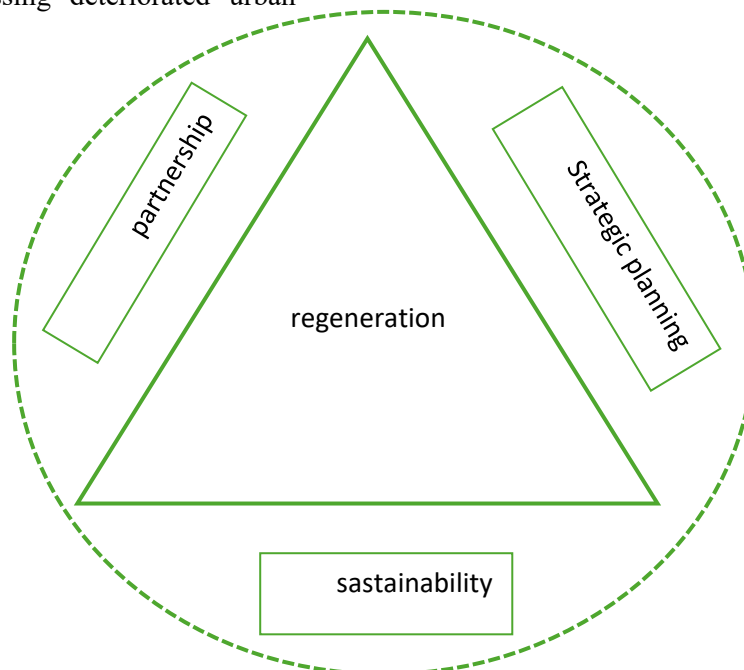
Urban regeneration occurs across multiple dimensions—social, economic, physical, and environmental—each emphasizing specific objectives:

- Physical regeneration involves assessing the structural elements of urban fabric, identifying limitations and latent potentials, and aligning the physical city with rapid economic and social transformations.
- Economic regeneration generally includes strategies such as attracting domestic investments, encouraging self-employment, creating temporary and part-time jobs, enhancing education, increasing professional skills, and reducing living costs.
- Social and cultural regeneration focuses on minimizing crime and violence, providing adequate healthcare services, reducing cultural

deviance, strengthening micro-communities, empowering local groups, and addressing the needs of diverse population segments.

A key dimension of urban regeneration is sustainability. The approach known as sustainable urban regeneration represents one of the most recent and widely accepted global strategies for addressing deteriorated urban

areas. It aims to establish a continuous and sustainable process of urban development. On one hand, it seeks to make optimal use of internal urban potentials to meet new needs; on the other hand, it prioritizes the revitalization of old urban fabrics and the restoration of social life and economic vibrancy.



**Figure1.** illustrates the main components of urban regeneration  
Source: (rasouli et al., 2021: 89)

## Review of Key Perspectives in Urban Regeneration

Urban regeneration, in its general definition, emerged after numerous reforms to the urban renewal process. It is now considered an integrated approach encompassing both physical and functional considerations, reflected through several sub-approaches and

narratives. Therefore, urban regeneration can be defined as a comprehensive and integrated view, along with a set of actions that lead to solving urban problems and ensuring continuous improvement in the economic, physical, social, and environmental conditions of a changing area.

**Table 4.** Perspectives Influencing Urban Regeneration

Perspective	Key Considerations	Source
Culturalism	<ul style="list-style-type: none"> <li>- Emphasis on cultural heritage and prevention of historical loss.</li> <li>- Consideration of national culture and traditional values in urban development, rehabilitation, and restoration.</li> <li>- Completion of buildings in historical style, museum-like use, and restoration of urban fabric.</li> </ul>	Habibi, 1996, p. 1

Humanism	<ul style="list-style-type: none"> <li>- Focus on nature and culture.</li> <li>- Attention to human movement within urban spaces.</li> <li>- Drawing inspiration from hidden structures and highlighting them in urban renewal.</li> <li>- Improving urban environments and residents' quality of life with citizen participation.</li> <li>- Integration of restoration projects with spatial planning and geographic studies.</li> <li>- Conducting regeneration based on the organic fabric and functional hierarchy of historic cities, considering spatial-temporal alignment with urban planning studies</li> </ul>	Hall, 1995, p. 229
Intermediate/Realist	<ul style="list-style-type: none"> <li>- Views the historic urban fabric as a heterogeneous and uneven whole, ranging from highly valuable heritage sites to severely deteriorated zones, some of which may lack preservation value altogether</li> </ul>	Arman Shahr, 2007, p. 14

Source: Zangiabadi & Moeidfar, 2012: 316

### Natural Hazards

- Natural hazards refer to sudden events that cause harm to humans and the environment. These events include earthquakes, floods, volcanic eruptions, storms, locust infestations, and the like (Crisis Management Organization, 2016).
- Natural disasters are defined as incidents that impact the lives and security of people and cannot be managed through ordinary resources. Disasters can be categorized into:
  - Climatic hazards (e.g., floods, droughts, frost, lightning, sandstorms, avalanches, cold spells, forest fires)
  - Geotectonic hazards (e.g., earthquakes, landslides, rockfalls)
  - Human-induced hazards (e.g., incidents caused by human activity)

### Different Definitions of Natural Disasters:

- Manitoba Emergency Measures Organization (2006): Any actual or anticipated event that threatens the life, safety, welfare, or health of a group or entire population and cannot be managed through regular governmental services.
- Fritz (1961): An event occurring in a specific time and place that affects a portion of society, causing damage to the physical environment and disrupting social functioning.
- Burton & Kates (1964): A component of the physical environment that is harmful to humans and caused by

external forces (Ramazanzadeh Lasbouei & Badri, 2014, p. 113).

### Urban Vulnerability Factors:

Rapid population growth and high density in hazard-prone areas  
 Lack of local resources and capacities  
 Weak local governance and poor participatory planning  
 Inadequate water management and poor drainage infrastructure  
 Ecosystem degradation due to human activity (e.g., road construction, pollution, wetland reclamation)  
 Aging infrastructure and unsafe building materials  
 Poorly coordinated emergency services  
 Climate change affecting the frequency, intensity, and location of floods and other natural disasters  
 (Hyogo Framework for Action, UNISDR, 2012)

### Floods

Floods are the result of hydrological and topographical conditions in flood-prone areas, wherein river discharge exceeds the river channel capacity and spills over into the floodplain. A flood occurs when the river channel cannot contain the excessive flow. Technically, a flood involves the rise of water levels in rivers and channels, causing overflow into adjacent plains, which can damage infrastructure, public facilities, and cause loss of life and livestock.

Flooding can also result from rising water levels in lakes or seas, where strong winds



exacerbate the situation (Zand-Moghaddam et al., 2019, p. 84).

During rainfall or snowmelt, a portion of water is absorbed by soil and vegetation, some evaporates, and the rest becomes surface runoff. Flooding occurs when the soil and vegetation cannot absorb the precipitation, and the natural channel lacks the capacity to carry the runoff. On average, about 30% of rainfall becomes runoff—a rate that increases with snowmelt.

Flood events create an area known as a \*floodplain\* around the river. River floods are mostly caused by intense rainfall, sometimes accompanied by snowmelt. A \*flash flood\* refers to a sudden flood with little or no warning, typically in small catchments, often resulting in higher fatalities compared to larger river floods (Dorfesh et al., 2020: 169).

Motevalli et al. (2022), in their article titled “Analysis of Urban Resilience to Floods (Case Study: District 2 of Sari City)”, concluded that factors such as the formation of deteriorated urban fabric, impervious surfaces, weak management, unemployment, underutilized critical areas, and a large number of vulnerable individuals have contributed to the low level of resilience in this area. The study emphasizes the necessity of solutions such as increasing public participation in regional management and enhancing coordination and integration in local governance under the guidance of urban management to address these issues and improve resilience.

### Research Background

Motavalli et al. (2021), in their study entitled “Identifying the Components of Resilience in Coastal Border Cities to Natural Hazards: Case Study of Behshahr”, found that the overall resilience status of Behshahr, a coastal border city, was unsatisfactory. The empirical mean obtained for overall urban resilience and its dimensions was below the medium threshold value of 3. Among the six studied zones, Zone 3 showed relatively better conditions compared to others, while Zone 4 had the poorest status with an average score of

2.43. Another key finding of the study was that among the urban resilience components, the “physical component” had the greatest path coefficient (0.376) and the most significant impact, whereas the institutional-managerial component had the lowest path coefficient (0.168), indicating the least influence on urban resilience.

Prawira et al. (2024), in their article “Community Empowerment in Sustainable Outdoor Tourism in the Pangandaran Tourism Destination”, applied a qualitative approach to investigate various forms of local community participation in the tourism industry of Pangandaran, Indonesia. The results show that Pangandaran features 270 tourist attractions—64% natural, 27% cultural, and 9% man-made. The highest concentration of these attractions was observed in the Parigi area, indicating the region’s strong potential for tourism development. Notable growth in restaurants (a 34.1% increase in 2023 compared to the previous year) and small businesses (over 700% growth between 2020 and 2021) reflects economic dynamism and the close connection between the local economy and the tourism industry. The active engagement of the community in professional tourism associations (e.g., a cycling association with 310 members and a boating group with 150 members) demonstrates a robust network and the crucial role of local stakeholders in the sustainable development of tourism. Despite these strengths, the study identified challenges such as infrastructure strain during peak tourist seasons, insufficient awareness of sustainable tourism practices among residents, and limited access to education and financial resources. Moreover, the conflict between environmental conservation and local livelihoods remains a key barrier to sustainable development. The authors highlight the importance of improving public education on environmentally friendly practices and establishing collaborative frameworks among stakeholders to foster a sustainable tourism ecosystem. Proposed strategies include infrastructure upgrades, educational programs, and facilitating financial

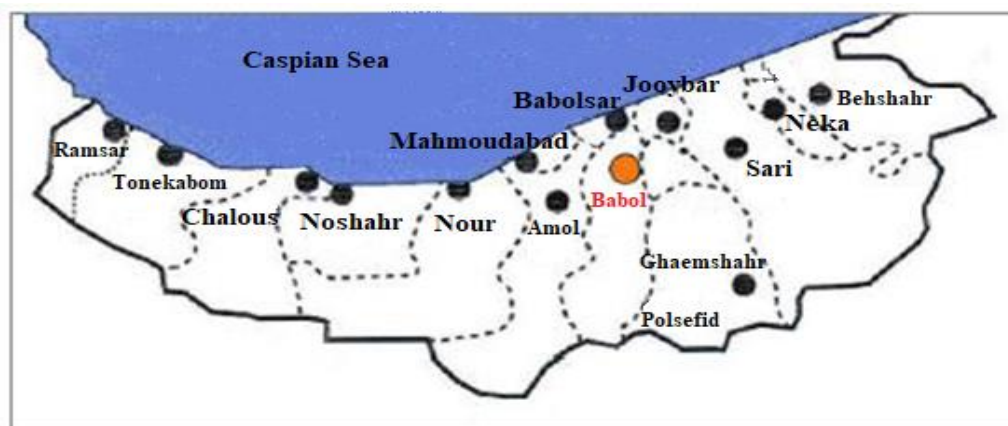
access to enhance the role of the local community in the tourism sector. Ultimately, the study concludes that by addressing these challenges and leveraging local capacities, Pangandaran can serve as a successful model for balanced and sustainable tourism development across economic, cultural, and environmental dimensions.

Risfandini (2024), in her article "Implementing Sustainable Tourism in Indonesia: Emphasizing Green Tourism, Community-Based Tourism, and Local Empowerment", explores the key concepts of sustainable tourism development in Indonesia. Using a systematic literature review method, the study analyzes previous research in the field of sustainable tourism. Three core concepts—green tourism, community-based tourism, and local empowerment—are identified as essential pillars of sustainable development. The findings indicate that green tourism requires the active involvement of all stakeholders, including the government, local communities, and tourists. Success in this area depends on appropriate policymaking, environmental

certifications, and related education. Community-based tourism contributes to the preservation of natural and cultural resources while enhancing the economic and social well-being of host communities. Local empowerment—particularly through the penta helix model (collaboration among government, industry, academia, community, and facilitators)—is considered a fundamental driver of sustainable tourism. The study also recommends further quantitative research to evaluate the effectiveness of these strategies and calls for empirical testing of step-by-step models for empowering local communities.

### The Area under Study

Babol is one of the central cities of Mazandaran Province, located 217 kilometers northeast of Tehran and 48 kilometers from the provincial capital, Sari. It is bordered by Amol to the west, Babolsar and the Caspian Sea to the north, Qaemshahr to the east, and the Alborz mountain range to the south. Geographically, Babol is situated at approximately 36°34'N latitude and 52°44'E longitude.



**Figure2.** The Area under Study

Source: Haft Shahr Arya Consulting Engineers, 2009

### Methodology

The present study is descriptive–analytical in nature and applied–developmental in terms of its objectives. The main goal is to regenerate vulnerable urban fabrics in the city of Babol in the face of flood risk. To achieve this goal, effective indicators for the regeneration of vulnerable urban areas were first identified through a combination of library research and field studies. Specifically, theoretical foundations were reviewed, and relevant indicators and sub-indicators were recognized.

To prioritize the identified indicators affecting the regeneration of vulnerable urban areas in the context of natural hazards, particularly flooding in Babol, the Friedman test was employed using SPSS software. To assess the degree of impact of each indicator, a single-sample t-test was conducted using expert questionnaire responses. Additionally, multiple linear regression was applied to analyze the current condition of vulnerable urban fabrics in Babol against flood threats. Finally, practical strategies for improving the situation were proposed.



The reliability of the questionnaire was confirmed through Cronbach's alpha coefficient, which yielded an acceptable value indicating high internal consistency of the research instrument. The validity of the questionnaire was ensured through expert reviews and academic feedback.

### Results and Discussion

To achieve the main objective—analyzing the regeneration of vulnerable urban fabrics in

Babol in the face of flood risks—various methods and techniques were utilized.

### Main Hypothesis Test

$H_0$ : Regeneration of vulnerable urban fabrics in Babol is not adequate against flood risks.

To examine whether the regeneration of vulnerable urban fabrics in Babol is adequate or not—based on the views of both citizens and experts—a one-sample t-test was conducted. The results are presented in Table 5.

**Table 5.** Assessment of the adequacy of regeneration of vulnerable urban fabrics in Babol against flood risk

Variable	Sample	N	Mean	SD	t-value	df	Sig. (p-value)
Regeneration	Citizens	384	3.735	0.696	20.709	383	0.000
	Experts	30	2.918	0.221	-2.027	29	0.052
Combined		-	3.327	0.459	9.341	-	0.026

Source: research findings, 2025

Based on Table 5, citizens reported a mean score of 3.735 with a t-value of 20.709 and a significance level of 0.000, indicating that regeneration efforts are perceived as adequate. However, experts reported a lower mean of 2.918 (below the theoretical average of 3), and a negative t-value of -2.027 with a borderline significance level of 0.052, suggesting that, from their perspective, regeneration is insufficient.

Considering the aggregated responses from both groups, the overall mean was 3.327, with a t-value of 9.341 and a significance level of 0.026. Therefore, the null hypothesis is rejected, and it can be concluded that

regeneration of vulnerable urban fabrics in Babol is considered adequate against flood risk.

### First Sub-Hypothesis Test

$H_{11}$ : Physical–infrastructural–environmental components contribute to the regeneration of vulnerable urban fabrics in the face of flood risks.

To evaluate whether physical, infrastructural, and environmental components play a role in the regeneration process, a one-sample t-test was conducted using responses from both citizens and experts. The results are presented in Table 6.

**Table 6.** Role of physical–infrastructural–environmental components in the regeneration of vulnerable urban fabrics against flood risk

Variable	Sample	N	Mean	SD	t-value	df	Sig. (p-value)
Physical–Infrastructural–Environmental	Citizens	384	3.766	0.826	18.187	383	0.000
	Experts	30	3.069	0.277	1.371	29	0.181
Combined		-	3.418	0.552	9.779	-	0.091

Source: research findings, 2025

According to Table 6, the overall mean for this variable was 3.418, which is above the theoretical average of 3. The t-value of 9.779 confirms the positive and statistically significant influence of these components. Hence, the first sub-hypothesis is confirmed: physical, infrastructural, and environmental components play a key role in the regeneration of vulnerable urban fabrics against flood risk.

### Testing the Second Sub-Hypothesis

#### Second Sub-Hypothesis:

Socio-economic components can contribute to the regeneration of vulnerable urban fabrics in response to flood hazards.

To analyze whether socio-cultural and economic components can support the regeneration of vulnerable urban areas in Babol against flood hazards, the one-sample t-test was employed, based on responses from citizens and experts. The results are presented in Table 7.

**Table 7.** Effects of Socio-Cultural and Economic Components on the Regeneration of Vulnerable Urban Fabrics against Flood Hazards

Variable	Sample	N	Mean	SD	t-value	df	Sig. Level
Socio-Cultural	Citizens	384	3/522	0/593	17/277	383	0.000
	Experts	30	3/394	0/268	8/054	29	0.000
Economic	Citizens	384	3/787	0/736	20/96	383	0.000
	Experts	30	2/560	0/199	-12.092	29	0.000
Combined		-	3/316	0/449	8/538	-	0.000

Source: research findings, 2025

Based on Table 7 and the perspectives of citizens and experts, the overall mean of the socio-cultural and economic variables was calculated as 3.316, which is higher than the theoretical median. With a significance level of 0.000, the overall t-value of 8.538 indicates a statistically significant positive impact. This confirms that socio-cultural and economic components play an important role in the regeneration of vulnerable urban fabrics in response to flood hazards. Hence, the second sub-hypothesis is supported.

### Testing the Third Sub-Hypothesis

#### Third Sub-Hypothesis

Institutional components influence the regeneration of vulnerable urban fabrics in response to flood hazards.

To assess whether institutional components contribute to the regeneration of vulnerable urban areas in Babol against flood hazards, the one-sample t-test was employed using responses from citizens and experts. The findings are summarized in Table 8.

**Table 8.** Effects of Institutional Components on the Regeneration of Vulnerable Urban Fabrics against Flood Hazards

Variable	Sample	N	Mean	SD	t-value	df	Sig. Level
Institutional	Citizens	384	3/866	0/804	21/110	383	0.000
	Experts	30	2/650	0/637	-3/011	29	0/005
Combined		-	3/258	0/721	9/0495	-	0/0025

Source: research findings, 2025

According to Table 8, the mean score for the institutional variable was 3.258, exceeding the theoretical median. The positive t-value (9.0495) with a significance level of 0.0025 indicates that institutional (i.e., governance and management) components have a significant and positive effect on the regeneration of

vulnerable urban fabrics in the face of flood hazards. Thus, the third sub-hypothesis is confirmed.

### Testing the Fourth Sub-Hypothesis

#### Fourth Sub-Hypothesis:

Each component of urban regeneration has a different level of contribution to the

regeneration of vulnerable neighborhoods in response to flood hazards.

To evaluate the relative contribution and impact of each urban regeneration component in vulnerable neighborhoods of Babol when

facing natural hazards such as floods, separate analyses of citizen and expert opinions were conducted using one-sample t-tests. The results from citizens' responses are shown in Table 9.

**Table 9:** Effects of Urban Regeneration Components on Vulnerable Urban Fabrics in Babol (Citizen Perspectives)

Variable	N	Mean	SD	t-value	df	Sig. Level
Socio-Cultural	384	3/522	0/593	17/277	383	0/000
Economic	384	3/787	0/736	20/964	383	0/000
Institutional	384	3/866	0/804	21/110	383	0/000
Physical– Infrastructure– Environmental	384	3/766	0/826	18/187	383	0/000

Source: research findings, 2025

Based on the data in Table 9 and citizen responses, institutional components exhibit the highest mean score, indicating they have the most significant effect on the regeneration of vulnerable urban fabrics in Babol against flood

hazards. This highlights the varying degrees of influence that each regeneration component exerts on flood risk mitigation in vulnerable neighborhoods.

**Table 10.** Effects of Urban Regeneration Components on Vulnerable Urban Fabrics in Babol against Flood Hazards (Expert Perspectives)

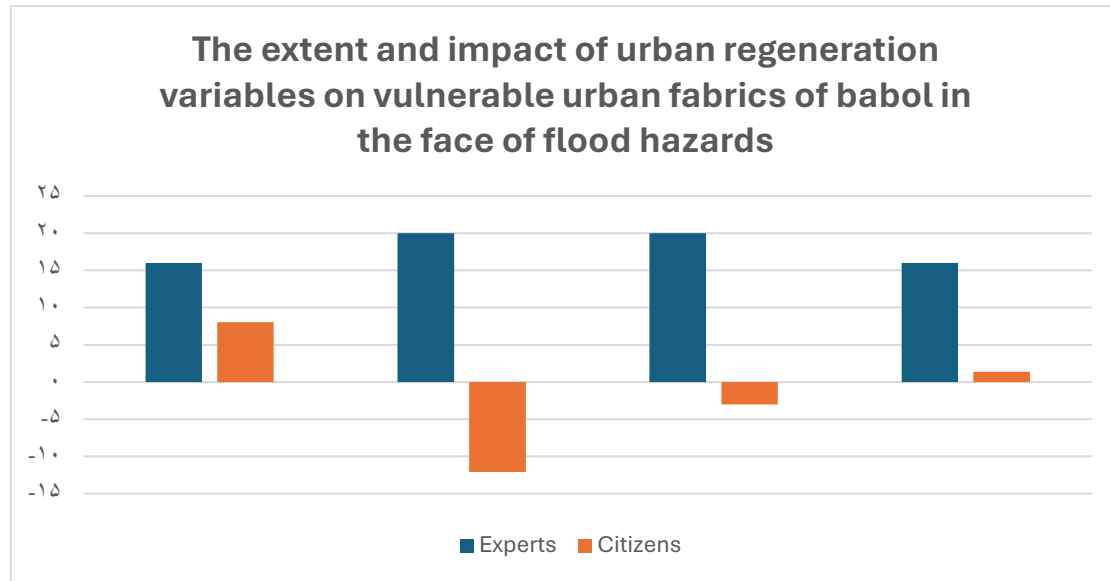
Variable	N	Mean	SD	t-value	df	Sig. Level
Socio-Cultural		3/394	0/268	8/054	383	0/000
Economic	30	2/560	0/199	-12/092	383	0/000
Institutional	30	2/650	0/637	-3/011	383	0/005
Physical–Infrastructure– Environmental	30	3/069	0/277	1/371	383	0/181

Source: research findings, 2025

According to Table 10 and the views of experts, the socio-cultural component had the highest effect on the regeneration of vulnerable urban fabrics in Babol against flood hazards, compared to other variables. As shown, each component of urban regeneration exhibits a

different level of impact, emphasizing the varied contribution of each dimension.

To further illustrate this difference, Chart 1 displays the comparative influence and contribution of each urban regeneration component on vulnerable urban areas from the perspectives of both citizens and experts.



**Chart 1:** Comparative Effects and Contributions of Urban Regeneration Components on Vulnerable Urban Fabrics in Babol (Citizens vs. Experts)

Source: research findings, 2025

Based on the above analysis, it can be concluded that each urban regeneration component contributes differently to the regeneration of vulnerable neighborhoods against flood hazards. Therefore, the fourth sub-hypothesis of this study is confirmed. Qualitative Data Analysis: Thematic Analysis of Urban Regeneration Dimensions

In the qualitative part of the study, a thematic analysis was conducted to identify the key dimensions and indicators of urban regeneration in vulnerable urban fabrics of Babol in the context of flood risk. The findings, based on expert interviews, are presented in Table 11.

**Table 11.** Thematic Analysis Results Based on Expert Interviews

Dimension	Indicator	Dimension	Indicator
Socio-Cultural Regeneration	Education and Awareness	Economic Regeneration	Financial Crises
	Participation and Cooperation		Economic Sustainability
	Community Empowerment		Employment Conditions
	Population Density	Physical–Infrastructure–Environmental	Land Use Buffers
	Social Sustainability		Accessibility
	Emergency Response Groups		Structural Resilience
Institutional Regeneration	New Technologies		Infrastructure
	Water Resource Management		Green and Open Spaces
	Urban Planning Research		Environmental Pollution
	Protective Structures		
	Crisis Management		
	Sustainable Development Planning		

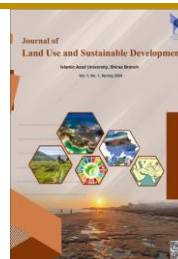


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	Natural Resource Conservation		
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Source: research findings, 2025

## Conclusion

The evaluation of the socio-cultural regeneration status from the citizens' perspective revealed that they believe there are favorable conditions in terms of education and awareness-raising, cooperation and participation, social sustainability, and emergency response groups. However, the indicators of community empowerment and population density require improvement. These insights can serve as a guide for future planning and interventions in these areas.

In assessing the economic regeneration status, the citizens rated the indicators of "financial crises," "economic sustainability," and "employment situation" above the theoretical mean (value = 3), indicating their relative satisfaction with the current state of financial and economic conditions in the city.

Regarding institutional regeneration, citizens expressed satisfaction with the status of modern technologies, water resource management, urban planning research, protective structures, crisis management, sustainable development plans, and the management and conservation of natural resources in their locality. These results suggest that urban management and related authorities have performed relatively well in these areas, contributing positively to the city's development trajectory.

The assessment of the physical–infrastructural–environmental dimension also showed that citizens are generally satisfied with the current state of this domain. Indicators such as zoning regulations, accessibility, structural retrofitting, infrastructure, green and open spaces, and environmental pollution were rated positively, forming a solid basis for further improvement and development.

The prioritization of urban regeneration indicators for vulnerable urban fabrics in Babol against flood risks, from the citizens' perspective, revealed that "natural resource management and conservation" ranked first,

"sustainable development plans" ranked second, while "community empowerment" and "population density" ranked twenty-first and twenty-second, respectively.

From the experts' point of view, the socio-cultural regeneration status in Babol is generally favorable. However, they emphasized the need for more attention to community empowerment and emergency response groups to further improve this dimension. The indicators of cooperation and participation, as well as population density, were below the theoretical average, indicating deficiencies that require targeted planning and intervention.

In the economic dimension, experts found the employment situation to be weaker compared to economic sustainability, suggesting that employment issues and potential labor market crises in Babol require more focused support and policy measures.

With respect to the institutional dimension, experts assessed modern technologies and sustainable development plans positively. However, indicators such as water resource management, urban planning research, protective structures, crisis management, and natural resource conservation were deemed unsatisfactory, highlighting critical gaps in key pillars of urban resilience that require strategic development.

In terms of physical–infrastructural–environmental regeneration, experts viewed the overall status as relatively favorable, especially for indicators such as accessibility, retrofitting, green/open spaces, and environmental pollution. Nevertheless, they identified weaknesses in zoning regulations and infrastructure, emphasizing the need for targeted development in these areas.

The results of evaluating the effects of socio-cultural indicators on the regeneration of Babol's vulnerable urban fabrics in the face of natural hazards, particularly floods, showed that education and awareness, community



empowerment, social sustainability, and emergency response groups play highly significant roles. These indicators recorded above-average means with statistically significant positive impacts. Conversely, cooperation and participation, as well as population density, had means below the theoretical average and statistically insignificant or negative impacts, indicating minimal contribution to flood-related urban regeneration.

In the economic domain, “financial crisis management” had a strong positive effect on post-disaster regeneration, with a mean above the theoretical average and significant impact. In contrast, “economic sustainability” and “employment situation” were rated lower and showed minimal influence on regeneration efforts, underscoring the need to consider broader dimensions of crisis management and resilience building.

The institutional dimension analysis showed that modern technologies and sustainable development plans significantly impacted the regeneration of vulnerable areas, with above-average ratings and positive statistical significance. In contrast, indicators such as water resource management, urban research, protective structures, crisis management, and natural resource conservation showed low means and insignificant or negative effects, highlighting the need for increased attention to these institutional mechanisms.

Finally, the physical–infrastructural–environmental indicators of accessibility, retrofitting, green/open spaces, and pollution control demonstrated strong influence on regeneration, with above-average means and statistically significant impacts. Conversely, zoning regulations and infrastructure were found to have low influence and remain key priorities for future planning and investment

### Research Recommendations

- Investigate the effects of climate change on flood generation and regeneration of vulnerable urban fabrics.
- Explore innovative urban flood management approaches.
- Assess the socio-economic impacts of other natural hazards (e.g., earthquakes, storms) on urban populations.
- Conduct comparative studies of international best practices in urban regeneration.
- Evaluate the role of emerging technologies in regenerating vulnerable urban fabrics.
- Develop comprehensive natural hazard risk management plans for vulnerable urban areas.

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