

The evaluation of susceptibility of Abadan city to natural disaster and immunization strategies

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Abstract: Natural disasters are a series of damaging events that have no human origin and immunization against them is one of the main issues that have always been considered in all communities. The present study deals with the susceptibility evaluation of Abadan city at the time of natural disasters and presents strategies for improvement of immunization status of this city against these phenomena. Abadan is one of the most important cities of Khuzestan province. The statistical and historical investigations show that this city has so far experienced many natural disasters such as flooding, lightning, severe raining and drought that have led to damages to this city. This is a descriptive-analytical study that has been done through investigation of the documents and data and interview with informed people. The results of this study show that the risk potential of this city is high in flooding and waterlogging and dust and requires special considerations. Furthermore, the resistance and ability of this city responsiveness to natural disasters is evaluated as being average.

Key words: Natural disasters; Safety; Waterlogging; Dust; Susceptibility; Abadan city

1. Introduction

Natural disasters are usually unpredictable or at least their occurrence cannot be predicted from long time before their occurrence. Although most natural disasters are beyond human control; their due damages and losses can be significantly controlled. This issue has direct relation with preventive operations by human being. For example, retrofitting of buildings against horizontal loads for reduction of earthquake induced losses or vegetation and construction of dams for reduction of damages due to flooding are among preventive actions. Furthermore, correct and appropriate reaction can be effective in reduction of the losses and damages due to natural disasters. For example, principled debris removal after earthquake occurrence can help in reduction of damages and losses.

Thus, at the time of natural catastrophes, necessary measures should be considered to prevent the probability of expansion of the range of catastrophe and its destruction. Thus, it is required to take actions for prediction and identification of the effects of events and various damages and make some regulations for neutralization or minimization of these effects (Hasani et al, 2007).

To achieve maximum environmental comfort, identity values and maximum safety and protection against natural and human risks in biological centers, human being has always seek to find principles and strategies to form and design his environment (Kohderq et al, 2010). Since the

occurrence of some events is imminent, correct and on time confrontation with them can minimize the damages and losses (Golabi et al, 2008).

Iran is disaster prone country and one of the most susceptible countries of the world at the time of natural disasters' occurrence. 31 out of 40 natural hazards and disasters in the world are present in Iran that made it to be considered among the first 10 most susceptible countries of the world and the 4th country in Asia (Amanpour and Zarifi, 2012). Iran has allocated 6% of the damages due to natural losses of the world to itself, while, it only contains 1% of the population of the world (Khastar, 2013).

In recent years, increasing urban population of Iran without consideration of the principles of city expansion and inattention to environmental hazards and factors in this regard has led to asymmetric and unsustainable development of Iran cities. Incidence of natural disasters such as flooding, drought, air pollution and etc. are just some of its unpleasant outcomes (Mahdavi Adeli et al, 2013).

There are 31 natural catastrophes in Iran, 21 of which are presented in Khuzestan province. Thus, this province can be considered one of the most disaster prone provinces that is always involved in natural hazards such as flooding, earthquake, drought, thunderbolt etc. that create much human and financial losses. The presence of long and waterful rives has made the cities of the province exposed to the risk of flooding whose resulting damages constitute 80% of total damages due to natural disasters. Moreover, in 2002-2006, thunderbolt has taken the life of 22 people in Khuzestan province (Amanpour and Zarifi, 2012).

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The review of past events in this province indicates much damages and losses in the cities of this province including Abadan. Thus, the necessity to take certain strategy in immunization of these areas and reduce its susceptibility against natural disaster becomes an unavoidable necessity. This issue had been rarely considered by the urban planning authorities in this province as well as other areas of the country. To reduce the susceptibility of urban areas, first the susceptible areas in this region should be identified and then actions should be taken to reduce this risk by planning, decision making and performing technical and managerial activities. In addition to identification of risks and its threatening ranges in urban areas and investigation of the current confrontation status, the prerequisite to achieve this objective is to perform precise and comprehensive studies to introduce the risk factors, confrontation facilities and optimum managerial strategies proportionate to the risk area in urban regions and present a comprehensive plan to immunize the urban community.

In this study, Abadan city has been studied to achieve this objective. Abadan is one of the borderline cities of Khuzestan province in southwest of the province. The area of this city is 2059.5 km² and constitutes 3.2% of the area of the province. Statistical and historical studies of Abadan show that this city has experienced various natural events including flooding, storm, thunderbolt, severe rainfalls and drought that have imposed various losses to this city. The present study deals with the evaluation of the susceptibility of Abadan in occurrence of natural events and presents improvement strategies for safety status of this city against these phenomena.

2. The specification of Abadan

Abadan is one of the borderline cities of Khuzestan province in southwest area of this province that is in neighborhood to Shadegan and Khoramshahr on the north, Iraq country on the west and Persian Gulf on other directions. This city is located in 48° and 12" to 48° and 57" east longitude of Greenwich and 29° and 55" to 30° and 31" north latitude of the equator. The area of this city is 2059.5 km² that constitutes 3.2% of the area of the province. This city, as an island, is located between Bahmanshir and Arvand rivers in a little distance from Khoramshahr. The presence of big refinery and port facilities are the main features of this city. The communication of this city is done through asphalt road and accessibility to the main railway of the country is done through Khoramshahr and also international airport of this city has facilitated the wide communication of this city with other areas of Iran and foreign countries. Abadan is a coastal city and its height from sea level is 6 meter. The population of this city in 2010 has estimated as 290006 individuals. Figure 1 presents the satellite image of Abadan city

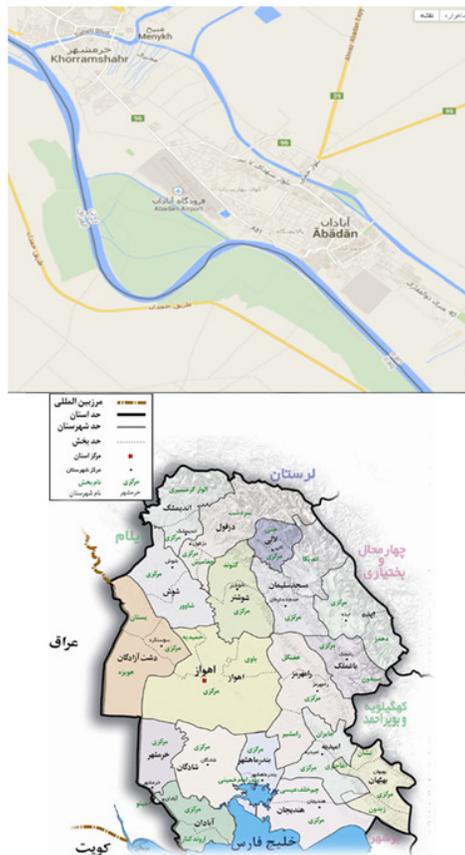


Fig. 1: Geographical maps of Abadan

Abadan city has been formed from deltaic sediments of Karoon and Arvand Rivers in estuary during Pleistocene. This delta is one of the flat and low-height areas of Khuzestan plain whose maximum height from sea level is 3 to 5 meter. The slope of the fields of this city is less than 5cm.km² and due to low level of land, most areas of the city are formed from retrogression of Karoon and Arvand rivers and the vegetation of this areas is canebrake.

This city is located in dry area with thermal period of 8-9 months in year. Due to being located close to Arvand, Bahmanshir, Karoon rivers and Persian Gulf, it has very hot summer and moderate winter. Moreover, due to the big deserts such as Arabia and Iraq desert, it has warm and hot desert climate. From September to April, the seasonal raining and sometimes severe raining leads to flooding. The peak of raining is in October, November and December. Raining in January, February and March is effective in climate variation. Furthermore, according to the statistics of June, July and August, there is no raining at all. In overall, Abadan is located in a moisture region (Abadan Outlook Document Studies in 1404, 2013).

3. Climate of Abadan

In Khuzestan province, most human losses are due to thunderbolt and lightning and most damages are due to flooding. The main origin of natural

catastrophes is due to climate and atmospheric interactions. Thus, knowledge of various parametric variations greatly helps in control of events. The first main parameter is raining. In Abadan, this raining is distributed in October to April. The second main parameter is temperature. July is the hottest month with 36.6° and January with average temperature of

12.7° is the coolest month of the year. December and January are the most humid months of the year. Thunderbolt and lightening are due to electrical load discharge of air masses that happens in some seasons (usually later winter or spring). The statistic of Abadan city is in Table 1.



Fig. 2: Satellite images of Abadan

Table 1: The number of storming days with lightening in synoptic station of Abadan in one year

Station	Parameter	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	Aug	Sep	Annual
Abadan	Max	5	12	8	8	5	8	7	8	1	1	1	1	39
	Average	1	2	2	1	1	2	2	2	0	0	0	0	13

The average warm and dust days in time range of 40 years (to 2010) in Abadan is 81.51 days. Furthermore, the number of days with dust phenomenon in 2013 is 93 days with maximum 20.3 times more than permitted limit and in the first six months of 2014 is 49 days with maximum 14.4 times more than permitted limit (Weather bureau of Abadan, 2014).

The occurrence of dust phenomenon began from 2001 in Khuzestan from Abadan, Khoramshar and Shadegan. This phenomenon included all cities of Khuzestan after four years and now it has included all cities of Khuzestan province and now it has involved 20 cities of the province. The reports of general office of environment protection of Khuzestan province indicate that the dust of this province has different specifications; the size of these particles is 2.5 micron and less, the pollution is 50 times more than standard level and with continuity of 3 to 10 days. The occurrence of dust phenomenon has been registered up to 80 days in 2009 and the average of once in 15 days. Furthermore, the occurrence of dust phenomenon is from northwest to southeast and in the wind direction, which has aggregated its negative effects.



Figure 3: The entrance of dust mass to Khuzestan province

This statistic shows the necessity for taking required safety considerations to minimize the damages and reduce the hygiene and respiratory harms to the inhabitants of this area. Moreover, concerning the presence of refinery and petrochemical company in Abadan, the pollution due

to dusts has aggregated and threaten the individuals' health.

According to an informed source in Abadan refinery, in estimation of the pollutions of Abadan, it suffices to say that daily 15 tons of catalyzer that is one of the toxic and carcinogenic materials of Refinery Company covers Abadan city center (public relations of health and medical care system of Abadan, 2011).

4. The history of natural events

The statistical and historical studies of Abadan show that this city has experienced many natural events so far. Jahangiri et al (2010) in their study entitled, "The study of people participation in dealing with natural catastrophes of Khuzestan province", presented the viewpoints of authorities on the ranking of Khuzestan province in terms of damages due to natural catastrophes as table2.

Table 2: Ranking of the cities of Khuzestan province in terms of damages due to natural catastrophes

City	Rank
Ahvaz	1
Shoushtar	2
Shoush	3
Izeh	4
Lali	5
Ramhormoz	6
Andimeshk	7
Dasht Azadegan	8
Dezful	9

Table 3: The history of flooding

The number of floods in 45-year period	Human losses	Building destruction	Agricultural damages (Ha)	Animal losses	Facilities destruction
14	7	10	10	160	1

The last incidence of flooding was in 1995-1996; then, after construction of various dams in the path of Karoon River, no flooding has occurred and the waterlogging due to severe raining and overflow of Arvand and Bahmanshir rives has occurred. The waterlogging of November 2013 and December 2014 are samples of waterlogging of passages and city in wide scale. Most waterlogging is related to Zolfaqari, Karegar, Sadeh, Tayeb square and Helal Braime.

4.1.2. Dam failures of the province and influence on Abadan

The geographical, topographical and weather condition of Khuzestan province is such that the biggest reservoir dams of the country have been constructed in this area. Although all dams are designed and constructed with high safety coefficient, the probability of dam failure due to various reasons including natural events such as flooding, earthquake and landslide should always be considered by the related authorities.

The identification of cities in downstream of dams due to this phenomenon is the first step for required decision makings for future planning.

Mahshahr port	10
Shadegan	11
Masjed Soleiman	12
Behbahan	13
Abadan	14
Baqmalek	15
Gotvand	16
Khoramsahr	17
Omidieh	18

In this ranking, Abadan is in rank 14 in terms of damages due to natural catastrophes among cities of Khuzestan province. In this section, the most important events happened in this city have been studied and the results have been presented based on existing data and according to the type of event in following tables.

4.1. Flooding

From natural events, the risk of flooding occurrence has always threatened this city such that in the existing documents, various floods have happened that imposed damages to this city.

4.1.1. The history of flooding occurrence

The last flooding occurrence in Abadan and its resulting damages have been presented in Table 3.

Abadan city is also affected by failure of Karoon 3, Karoon 1, Masjed Soleiman, Gotvand and Karkhe dams.

4.2. Storm and thunderbolt

One of the other natural disasters in this city that has imposed great damages to this city is storm. Furthermore, storm and thunderbolt are other natural disasters whose probability of occurrence has been presented in table 4.

Table 4: The history of thunderbolt and storm

The number of storms in recent 53 years	The number of thunderbolt in recent 53 years
683	4441

Sometimes the storms occurring in this city damage electricity facilities, tress and etc. In some cases, these damages are huge and require preventive considerations for reduction or removing of these damages.

4.3. Drought

The studies show that three drought periods and two wet periods have happened in Abadan, drought periods have been weak and moderate but with high continuity; while wet periods have been severe and extremely severe but with low continuity (Radmanesh et al, 2011).

The most severe drought in Abadan is related to 1988- 1989 that lasted for two years. In table5, the data related to drought and wet periods of Abadan has been presented.

Table 5: Drought and wet periods

First wet period	First drought period	Second wet period	Second drought period
1971- 1980	1980-1991	1991-1997	1997- 2004

4.4. Damages due to natural disasters in Abadan

In Table 6, the financial losses due to natural disasters in Abadan in a 9-year statistical period have been presented. Furthermore, the damages of natural disasters to various urban sections have also

been expressed. Concerning the mentioned table, the infrastructural facilities of the city have incurred the highest losses due to natural disasters that indicate the problem in this sector.

Table 6: The total damages of catastrophes during recent years

The total damage in 9-year period (million IRR)	Annual mean of losses due to disasters (million IRR)	The percentage of damages due to natural disasters					
		Infrastructural facilities	Agricultural lands	residential	Roads and bridges	Animal	Governmental buildings
232769.106	25863.234	35.67	10.81	28.63	14.66	6.51	3.72

5. The geological status of Abadan from crisis approach

One of the geological issues that are required to be preserved in expansion of Abadan city is the barriers and constrains that constitute nature. One of

these barriers is the presence of loose lands, erosion of riverside and the soil layers that are susceptible to liquefaction usually surrounding the expansion site of the city. It is required to study and consider these issues in expansion of Abadan.

Table 7: The effective factors on susceptibility of Abadan with geological origin

Loose areas	Erosion	Liquefaction	Tracks
There are loose areas in depths of 3 or 4 meters	Erosion occurs on the sides of Bahmanshir and Arvandrood Rivers	Its probability of occurrence exists	Don't exist

6. The summary of city status and presentation of strategies for reduction of the effects of natural disaster's occurrence in city surrounding

The susceptibility potential of Abadan in respect to disaster can be explain according to table8.

Table 8: The susceptibility potential of Abadan according to the type of catastrophe

Disaster occurrence status																				
Earthquake			Landslide			Flooding			Dust		Thunder bolt		Waterlogging			Drought				
Low	moderate	High	Low	moderate	High	Low	moderate	High	Low	moderate	High	Low	moderate	High	Low	moderate	High	Low	moderate	High

Concerning the construction of various dams on Karoon river path, the flooding risk has decreased in recent years. However, due to severe rainfalls, waterlogging of passages still leads to some problems in the city. In overall, concerning the obtained data the susceptibility status of Abadan can

be introduced and evaluated the same as table9. For this city, every three items of exposed to disaster, resistance and responding ability and susceptibility are in average.

Table 9: The susceptibility status of the city in natural disaster

Exposed to disaster			Resistance and responsiveness ability			Susceptibility		
low	Moderate	High	Low	Moderate	High	Low	Moderate	High
	✓			✓			✓	

In figure 4, the map of Khuzestan province and the situation of Abadan in terms of natural disaster

occurrence and its ability to confront with crisis have been shown.

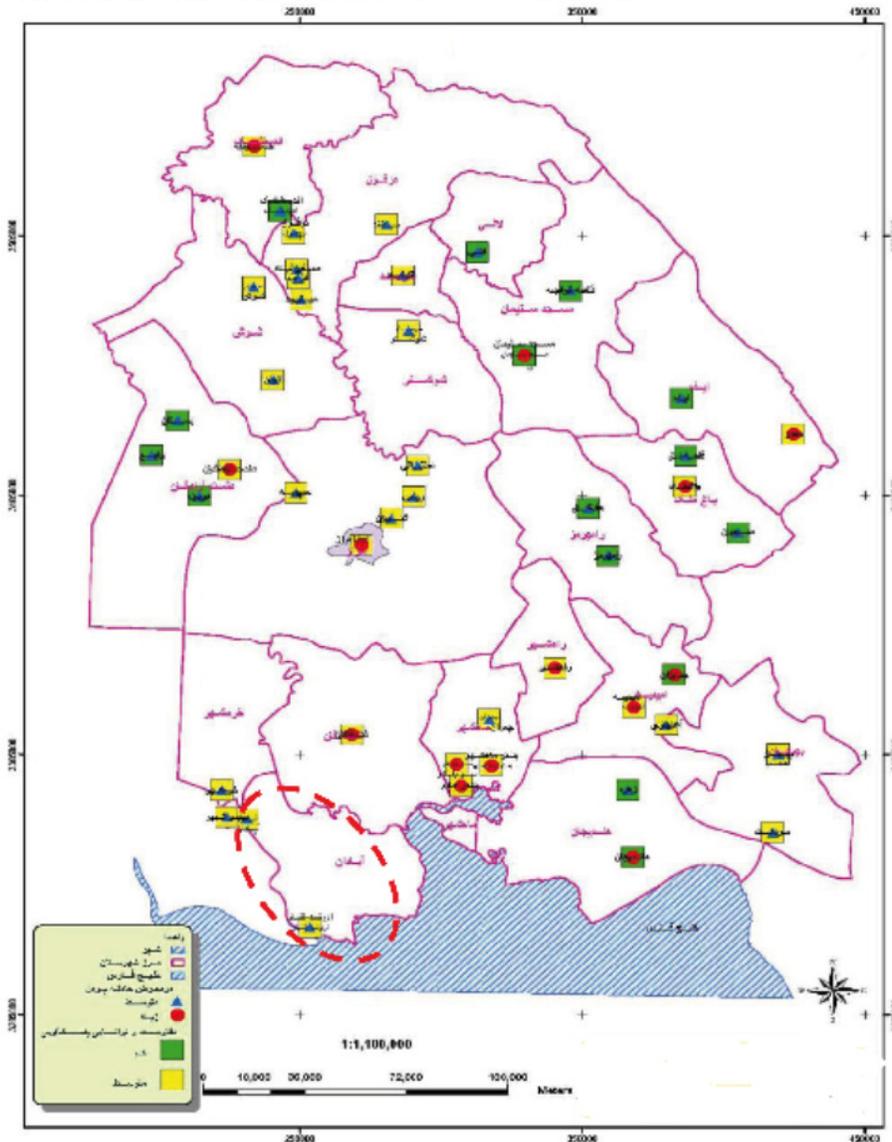


Fig. 4: Natural disaster occurrence and confrontation ability of Abadan

7. Safe areas for city expansion

To determine the safe areas for expansion of Abadan, it is required to pay special attention to the rivers' passing situation that has the waterlogging ability and also to the active faults of neighboring cities. Furthermore, it is required to preserve the vicinity of river in regional expansion. According to government's approvals, it is emphasized that no construction should be done in vicinity of rivers and mainly green lands should be created in this territory. Concerning the abovementioned points and other issues such as the susceptibility status of the city in respect to its geological origin, it is possible to propose the safe areas for expansion of Abadan city according to table 10.

Table 10: The situation of the safe areas for expansion of Abadan

Fault	Fault situation	Recommended safe areas for expansion of cities
Ahvaz	115 km on the north of city	City expansion toward east, west and north

8. Conclusion

- Concerning the geological and morphological situation of natural barriers in urban areas, it is recommended that in city to be expanded toward east, west and north directions and avoid construction of critical and main facilities in other areas.

- 2) Hydrological studies of the city show that in 30-year period, Abadan city has experienced 7 droughts and 5 extreme drought periods. Thus, it is required to consider required planning and preparation for drought periods in urban management, including the following:
 - Prevention of city over-expansion and overpopulation
 - Culture making and informing people of water deficiency and practical trainings of its optimum use
 - Use of urban wastewater by respecting environmental aspects in irrigation of green urban lands
 - Reconstruction of urban water distribution systems
 - Preparation of water and food deficiency programs at the time of drought
- 3) Bahmanshir and Arvandrood rivers are the best place for disposal of run offs of city.
- 4) Abadan city is in relatively low status among cities of Khuzestan province in terms of maximum probable raining with rainfall of 317.1 mm. However, the urban runoffs and the flooding due to focused raining in urban area in this city should be considered in urban planning.
- 5) The status of surface water collection and disposal was evaluated critical concerning inappropriate probable raining until 2013 and was not responsive to abovementioned raining. The investigations show that basic studies have been carried out for designing and building surface water disposal facilities based on the need to install and construct network systems all over the city; that will remove the problem of waterlogging of recent years if done at appropriate time.
- 6) Those areas of Abadan city that have waterlogging problem at the time of severe rainfalls are Zolfaqari, Karegar, Sade, Tayyeb square and Helal Braim that should be prioritized and planned.
- 7) No appropriate measure has been taken for reduction of severity and duration of dust phenomenon and its occurrence in 40-year period with mean of 81.51 days; although it requires taking actions in international and regional aspects. Furthermore, it is possible to build green belt around the city and in borderline areas that is national and governmental action. To reduce the pollutions due to refinery and petrochemical companies that leads to increased risk of dust at the time of dust phenomenon, it is possible to recommend installation of environmental catalysts in related units and improve facilities and machineries. Public training for confrontation with dust is another effective measure on this phenomenon that can be hold in form of training workshops in health centers. Moreover, short-term plans such as purchase of mask, hygiene instruments, equipping of emergency units and hospitals can

decrease the number of patients referring to these centers due to respiratory problems, allergy, skin allergies and heart diseases as a consequence of dust phenomenon in addition to improving the performance of related centers.

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