

## Flood management assessment in Iran: Problems and Solutions

\*<sup>1</sup>Meisam Badfar and <sup>2</sup>Emrah Doğan

\*<sup>1</sup> Ph.D. candidate, Faculty of Engineering, Department of Civil Engineering, Sakarya University, Turkey

<sup>2</sup>Professor, Faculty of Engineering, Department of Civil Engineering, Sakarya University, Turkey

### Abstract

According to the United Nations statistics, floods and storms are the most damaging to human societies. Worldwide, in the last decade between 2005-2015, the caused damages were estimated by about 21 billion USD and about 18 billion USD by earthquakes for flooding and earthquake respectively. Iran is one of the areas that face many natural disasters mostly flooding, earthquake, and storms. The Iranian governorates seriously face huge damages from the occurrence of flooding events. In this regard, each financial year, the Iranian Ministry of Energy adopts about 70% of the annual budget to reduce the hazard impacts of these natural disasters by improving the construction methods and applying the regulations of structural safety against the dangers of flood. However, the process of application for these mitigation measures and regulations of safety is still weak where the increase in damages from flooding in the past five decades was surveyed by about 250 %. Therefore, the planned and suggested mitigation measures to prevent and reduce flood damage in the form of research and development projects are essential for achieving the goals of sustainable development.

**Key words:** Flood management, Iran, damage, Solutions, sustainable development.

## 1. Introduction

Based on the wide variety of damages caused by natural events, Iran is classified as one of the top 10 countries in the world. Annually large part of Gross Domestic Product (GDP) per capita is spent on reconstruction and rehabilitation of damages caused by these events [1].

One of the most risky natural events faces the country is the flooding. The geographical location and conditions of many regions of Iran continuously suffer from flooding events specially these areas that locate along the rivers and streams' basins. In addition, the earthquakes are characterized as the largest damaging natural disaster in Iran, about 410 of the Iran's cities are frequently subject to earthquake and nearly 350 cities are subject to floods [3]. Recently, due to the development in the structural works and the efficient application of safety regulations the coming damages from earthquakes decreased to about 8% of the total caused damages by natural disasters However, the Iranian governorates still suffer from the frequently occurrences of flooding events, in the light of global warming and climate change, the trend goes toward increasing the occurrence of flooding events [2]. In General, the urban development highly contributes as a main player in the flooding occurrence where the paved streets and other infrastructures prevent the infiltration of rainfall waters into the groundwater and huge runoff could be flooded around. In the light of climate changes threats, the United Nations reports that, among the natural disasters, floods and storms have huge potential to cause the most casualties and losses to human societies [4].

This article concerns in reviewing by literature the flooding concepts, types, events, damages and other considerations in Iran.

## 2. Flood classifications in Iran

**Flash Flood:** Flash flood is caused by extreme precipitation occurs in usually small areas. Such as the flood of Golabdareh area (1987), Masouleh (1998) and Golestan (2001 and 2002).

The occurrence of these types of floods is usually due to the rapid reaction of the area to severe precipitation in the spring and summer and due to the surprising nature of this type of flood, leads to considerable damage and waste.

**River Flood:** Caused by fairly severe and intense precipitation in areas of high or continuous rainfall exceeding permeability capacity such as the floods of the southern provinces of Iran in 1998 (Sistan and Baluchestan, Bushehr, Hormozgan, Khuzestan).

**Sea Flood:** Due to rising sea levels or lakes such as the rise of Caspian Sea water in the years 1996 and 1991.

**Snow Flood:** Due to the melting of the upstream snowfall due to the sudden increase in the degree of heat that can be associated with rainfall, such as the Karun River flood in April, 1998.

### 3. Flood damage in Iran

Flood damage is divided into two categories of tangible (direct and indirect) and intangible damages. The tangible losses are quantitative and measurable and are included in the economic justification calculations and include all losses incurred by human casualties and losses, destruction of public buildings, residential, commercial and industrial buildings, damages to arable lands and gardens and livestock, destruction of infrastructure such as buildings and bridges, communication networks and transmission lines (gas, electricity, water, telecommunications), etc. The intangible losses are these social and economic losses that cannot be quantified and measured due to its very long consequences.

**Table 1.** Flood Damage Estimate

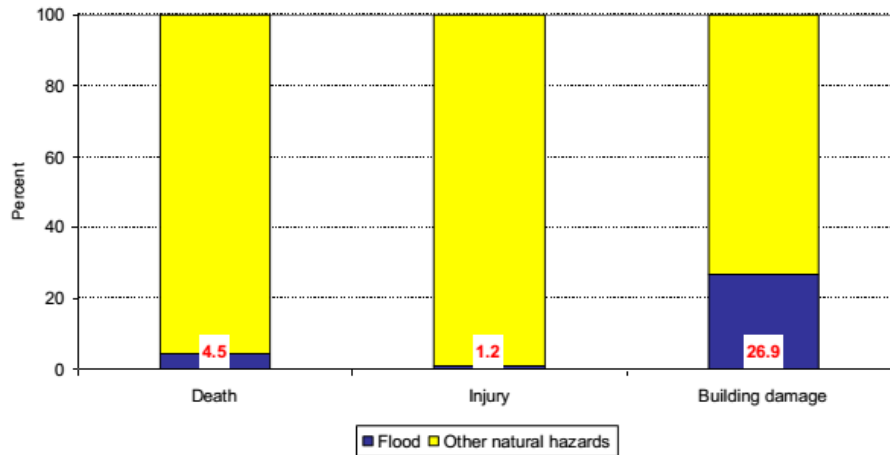
damaged part	Tangible damages		Intangible losses
	Direct damage	Indirect damage	
Residential areas	Temporary Housing Costs Clearing residential areas and rebuilding System recovery and vital arteries		Feeling insecure creating social turmoil
Agriculture	complete destruction of the land Loss of crops and gardening	The cost of rehabilitation of land and roads The cost of not producing or delaying production Damages of industry and related services Destruction of pastures and natural resources	
Agricultural facilities	destruction of rivers and irrigation and drainage network destruction of aqueducts - water storage pools Pumping station damage Damage to ponds, deviations and dams	Dredging costs Delay in supplying and irrigation of land and reducing production	Sedimentation in reservoirs
Animal husbandry	Livestock losses	Outbreak of contagious and non-communicable diseases Reduce the productivity of livestock products	Job insecurity Emergency in the environmental cycle
Industrial	- Industrial and workshops	- Reduce production	- Environmental waste

	- Damage to the utilities (utilities) - Wastes related to raw materials		
Infrastructure (Service)	Damage to the network of roads, buildings and bridges - Damages to public utilities - losses of transmission lines, water, telephone and ..	- Disturbing transportation and clearing roads - Creating temporary and vital networks in vital arteries	- Make terror and horror
Sanitary	- Damage to health units - Treatment and relief costs	- Human casualties -Healthy environment	- mental health problems - Losses and long-term health needs
Environmental	- Changes in the physical conditions of the basin - Outbreaks of diseases - Create new marshes	- Soil erosion - Land reclamation - Changes in biological and aquatic conditions	-Increase next flush peak value -Immigration of villagers -The destruction of wetlands

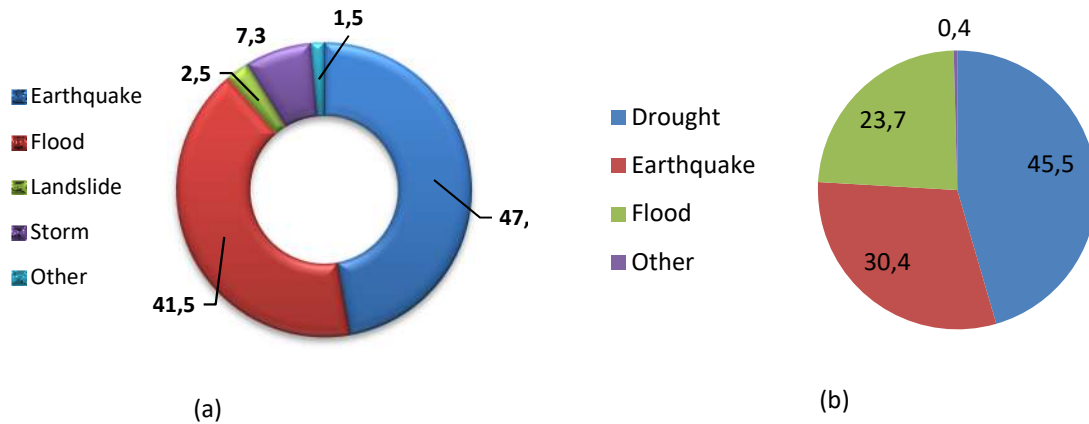
**Table 2.** Ten largest floods sorted by numbers of people killed, I.R.Iran, 1986-2007

Year	Province	City	Killed	Injured	damaged and destroyed Buildings
Sorted by killed					
1991	Lorestan	Kuhdasht	308	0	0
1987	Tehran	Tehran	300	0	0
2001	Golestan	Kalaleh	217	0	570
1993	Kerman	Kerman	211	0	120
1987	Tehran	Shemiranat	179	650	490
1991	Sistan va Baluchestan	Zabol	139	0	0
1986	Bushehr	Dashti	126	0	0
1988	Tehran	Tehran	107	18	100
1998	Fars	Mamasani	100	0	0
1991	Yazd	Tabas	81	5	0
Sorted by damaged or destroyed buildings					
1998	Esfahan	Fereydun Shahr	0	0	6,992
1993	Khuzestan	Dezful	0	0	6,200
1992	Golestan	Gorgan	0	0	4,600
1992	Kerman	Baft	0	0	4,000
1998	Khuzestan	Ramhormoz	2	0	3,467
2005	Esfahan	Fereydun Shahr	0	0	3,430
1989	Kohgiluyeh	Dehdasht	0	0	2,977
1992	Kerman	Sirjan	0	0	2,960
1989	Baluchestan	Zahedan	0	0	2,500
2006	Ardebil	Moghan	1	3	2,175

In Iran, in ten years between 1986-2007, nearly 150 people were killed, 79 were injured, and 6,212 buildings were totally or partially damaged by floods. The flooding contributes, **Fig.1**, other natural disasters by about 4.5% of mortality, 1.2% of injuries and approximately 26.9% of totally or partially damaged buildings. Numerically, the number of totally destroyed buildings to partially destroyed buildings ratio was calculated as 1.2%. As well, the death to injury ratio (DIR) due to flooding was  $8.56 \pm 32.3\%$  with median of 2.0 (range 0-308), given assuming at least one injury for the events with at least one death.



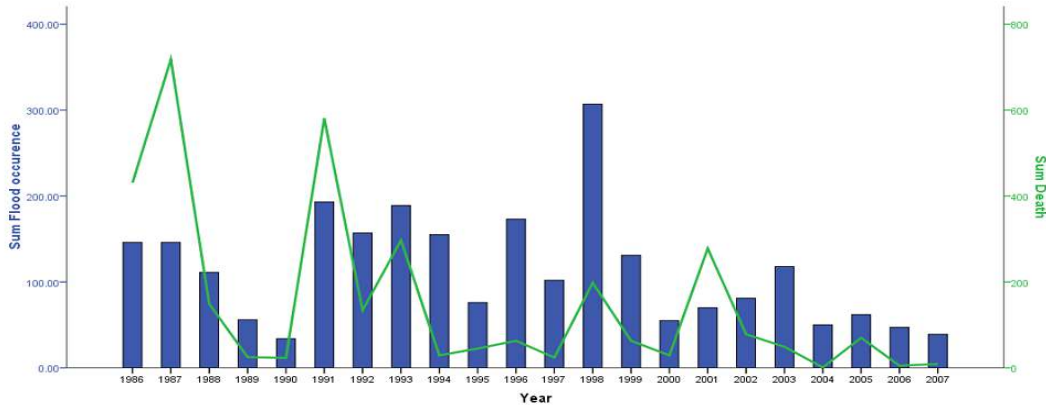
**Figure 1.** Comparison of death, injury and building damage caused by floods and other natural hazards, I.R.Iran, 1986-2007 [5]



**Figure 2.** (a) Frequency of disasters; (b) Combined economic losses caused by events in Iran [7]

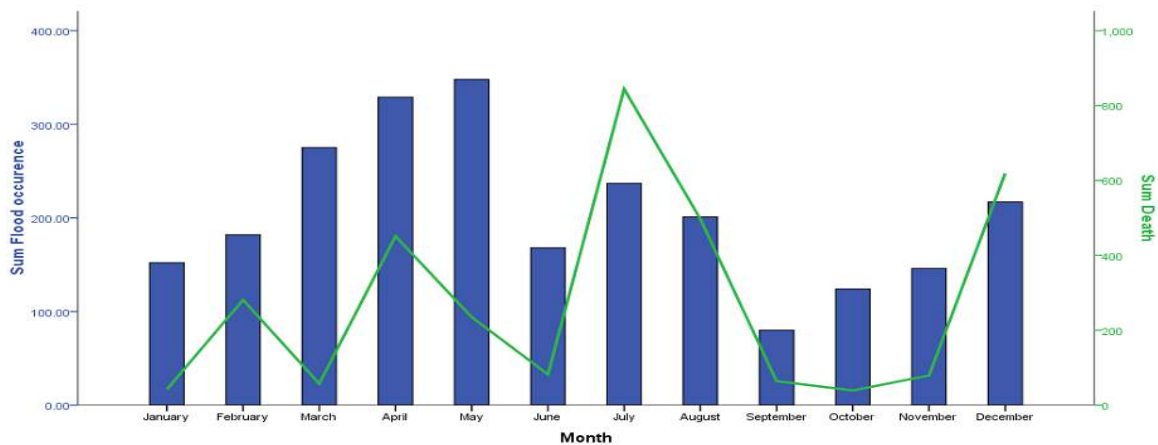
During 1986-2007, in average, 113.6 floods occurred per year. The years of 1986 and 1987 were the most hit years by floods. Comparison of 1997-2007 with 1986-1996 periods reveals 26% decrease in flooding occurrence, but 27% decrease in mortality.

The highest death toll occurred in the years of 1987 (mainly due to Tehran and Shemiranat floods) and 1991 (mainly due to Kuhdasht and Zabol floods).



**Figure 4.** Annual trend of flood occurrence and related death, I.R.Iran, 1986-2007 [8]

Spring and summer were the most hit seasons by flooding. July and May were the most hit months, accordingly. The country experienced the highest death toll in month of July, mainly due to floods in Tehran (1987), Shemiranat (1987), Salmas (1992), Fuman (1998), Behshahr (1999), Meshkinshahr (2001).



**Figure 5.** Monthly trend of flood occurrence and related death, I.R.Iran, 1986-2007 [8]

Geographical distribution of flood occurrence, death, injury and buildings damage or destruction are shown in Figures 4 and 5 at Ostan and Shahrestan levels, respectively. The most

flood hit provinces were Khuzestan (9.13%), Kerman (8.85%) and Razavi Khorasan (7,85%). The most affected provinces by floods in term of death per 10,000 inhabitants were: Bushehr (0.204), Kerman (0.076), Golestan (0.073), Ilam (0.073), Charmahal va Bakhtiari (0.073) and Khuzestan (0.070). Nobody was killed by flood in East Azerbaijan, Ghom, Kermanshah and Zanjan provinces.

The highest numbers of buildings damage or destruction were observed in Kerman (16.64%), Khuzestan (11.96%), Esfahan (10.43%) and Golestan (10.31%).

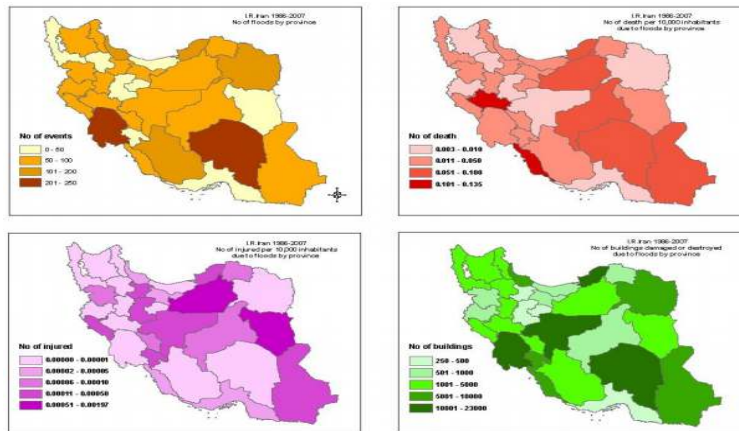


Figure 6. No of death, injury and building damaged and destroyed by floods at Ostan level, I.R.Iran, 1986-2007

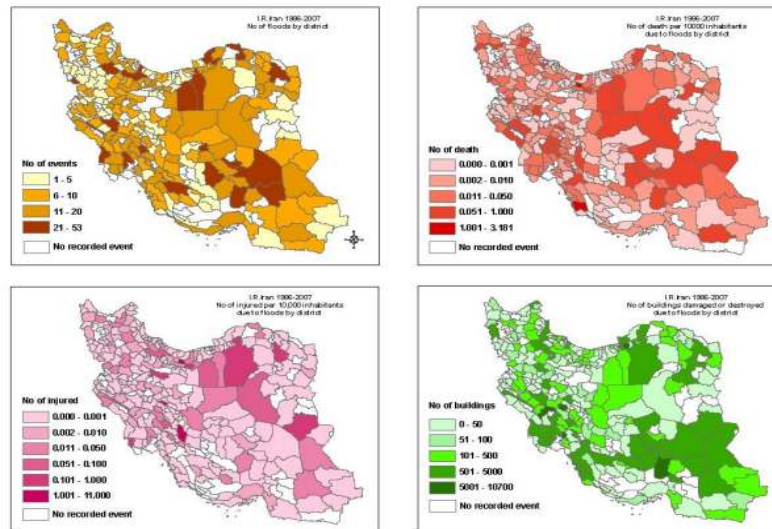


Figure 7. Frequency, death and injury per 10,000 inhabitants and building damaged and destroyed by floods at Shahrestan level, I.R.Iran, 1986-2007

**Table 3.** Provincial distribution of occurrence, death, injury and building damaged and destroyed caused by floods, I.R.Iran, 1986-2007

Province	Frequency	%	No of Death	%	No of injury	%	No of building damage	%
Ardebil	64	2.56	53	1.60	3	0.17	4770	3.49
West Azarbayjan	47	1.88	65	1.97	3	0.17	1606	1.17
East Azarbayjan	71	2.84	70	2.12	34	1.96	1154	0.84
Bushehr	63	2.52	182	5.51	3	0.17	6989	5.11
Chaharmahal va Bakhtiyari	75	3.00	41	1.24	10	0.57	2132	1.56
Esfahan	89	3.56	70	2.12	372	21.46	14257	10.43
Fars	158	6.33	136	4.12	3	0.17	2868	2.09
Ghazvin	81	3.24	39	1.18	105	6.05	418	0.30
Gilan	112	4.48	59	1.78	26	1.50	5143	3.76
Golestan	165	6.61	338	10.24	57	3.28	14100	10.31
Hamedan	72	2.88	41	1.24	3	0.17	1942	1.42
Hormozgan	48	1.92	8	0.24	5	0.28	254	0.18
Ilam	58	2.32	32	0.96	13	0.75	1911	1.39
Kerman	221	8.85	311	9.42	7	0.40	22752	16.64
Kermanshah	52	2.08	11	0.33			574	0.42
South Khoransan	33	1.32	31	0.93	73	4.21	3241	2.37
Khorasan-e-Razavi	196	7.85	93	2.81	40	2.30	5810	4.25
North Khorasan	72	2.88	22	0.66	12	0.69	572	0.41
Khuzestan	228	9.13	146	4.42	27	1.55	16353	11.96
Kohgiluyeh va Boyerahmad	41	1.64	37	1.12	4	0.23	7895	5.77
Kurdestan	66	2.64	42	1.27	17	0.98	624	0.45
Lorestan	57	2.28	344	10.42	4	0.23	4403	3.22
Markazi	36	1.44	11	0.33	45	2.59	330	0.24
Mazandaran	33	1.32	85	2.57	0	0	540	0.39
Ghom	0	0	0	0	0	0	0	0
Semnan	91	3.64	52	1.57	80	4.61	1006	0.73
Sistan va Baluchestan	63	2.52	201	6.09	56	3.23	9552	6.98
Tehran	67	2.68	666	20.18	719	41.48	957	0.70
Yazd	92	3.68	98	2.97	12	0.69	817	0.59
Zanjan	47	1.88	15	0.45	.	.	3694	2.70
<b>Total</b>	<b>2498</b>	<b>100</b>	<b>3299</b>	<b>100</b>	<b>1733</b>	<b>100</b>	<b>136664</b>	<b>100</b>



**Table 4.** Annual distribution of occurrence, death, injury and building damaged and destroyed caused by floods, I.R.Iran, 1986-2007

Year	Occurrence	%	Death	%	Injury	%	Destroyed building	%
1986	146	5.84	431	13.06	213	12.29	8419	6.16
1987	146	5.84	718	21.76	1022	58.97	5889	4.31
1988	111	4.44	149	4.52	21	1.21	4221	3.09
1989	56	2.24	25	0.76	0	0.00	9425	6.90
1990	34	1.36	23	0.70	0	0.00	360	0.26
1991	193	7.73	581	17.61	78	4.50	13295	9.73
1992	157	6.29	134	4.06	35	2.02	16355	11.97
1993	189	7.57	297	9.00	22	1.27	22816	16.69
1994	155	6.20	29	0.88	27	1.56	8252	6.04
1995	76	3.04	45	1.36	15	0.87	2074	1.52
1996	173	6.93	63	1.91	63	3.64	3623	2.65
1997	102	4.08	24	0.73	5	0.29	1412	1.03
1998	307	12.29	198	6.00	19	1.10	16901	12.37
1999	131	5.24	63	1.91	15	0.87	1400	1.02
2000	55	2.20	29	0.88	127	7.33	1072	0.78
2001	70	2.80	278	8.43	4	0.23	1411	1.03
2002	81	3.24	78	2.36	13	0.75	2526	1.85
2003	118	4.72	49	1.49	6	0.35	3213	2.35
2004	50	2.00	1	0.03	0	0.00	1395	1.02
2005	62	2.48	70	2.12	45	2.60	7358	5.38
2006	47	1.88	5	0.15	3	0.17	4593	3.36
2007	39	1.56	9	0.27	0	0.00	654	0.48
<b>Total</b>	<b>2,498</b>	<b>100</b>	<b>3299</b>	<b>100</b>	<b>1733</b>	<b>100</b>	<b>136664</b>	<b>100</b>

**Table 5.** Legislation and Responsible Organizations

Time	
Before 1989	only a limited group, related to the Ministry of Interior, was responsible to allocate compensational payments to flood victims and reconstruction of flood damages
1991	the law of "National Committee on Natural Disaster Reduction" and "Flood Prevention Committee" was approved by parliament
1995	"River Engineering and Flood Control Bureau " was established at the national level in the Ministry of Energy
1998	relevant provincial offices were established all over the country
2003	The law of "Disaster Management" was passed
2009	"Disaster Management Organization" was established

**Table 6.** Flood Control Measures

Time	
Before 1992	Flood control measures were limited to Construction of flood protection walls. Limited funds were allocated only for casualties and reconstruction of damaged structures.
1995	Later, guidelines and manuals provided standards for river engineering projects, and different structures (Dikes, Groins,) along with dredging were applied for river channel improvement, protection and control of erosion or sedimentation.
2000	Non- structural measures such as Flood Warning Systems, and floodplain delineation and flood zoning maps, were introduced in order to cover the shortcomings and disadvantages of structural measures.

#### 4. Current Situation of Flood Management in IRAN

##### Organizational Structure of Flood Management in IRAN

- National Disaster Management Organization (NDMO) is responsible for control and management of all natural disasters and crises in the country
- All other related organizations work with NDMO under 14 working groups, including Working group of Flood, Marine Hazards, Electricity, Water and Waste water
- NDMO supervises, coordinates and finances all committees.
- Secretary of Flood prevention working group is at the Ministry of Energy.
- Provincial subcommittees of Flood, Marine Hazards, Electricity, Water and Waste water manage and control floods in their criteria and under supervision of NDMO and Ministry of Interior

##### References

1. NOAA/NWS. 2009. Flood losses: complication of flood loss statistics [Online]. NOAA gov climate research Centre. Available: [http://www.weather.gov/oh/hic/flood\\_stats/Flood\\_Loss\\_time\\_series.shtml](http://www.weather.gov/oh/hic/flood_stats/Flood_Loss_time_series.shtml) [Accessed 25.08.2009].
2. Saghafian B., Farzjoo Hassan, Bozorgy Babak and Yazdandoost Farhad. 2008. Flood intensification due to changes in land use. Water Resource Management. 22, pp. 1051-1067. [In Persian]
3. Yamani M., Enayati M. 2005. The relation between basins geomorphologic characteristics and flooding potential (analyzing of the flood data by geomorphologic compare of the Fashand and Behjatabad Basins). Geographical Researches 54: 47-57. [In Persian].
4. Framji, K. K. 1976. Flood control in the World: A Global Review. Vol.1.International Commission on Irrigation & Drainage. New Delhe.
5. GAR 2009 Iran's Draft Report: Hazard Profile Section 30 Aug 2008.
6. USDA, Natural Resources Conservation Service, 1998. Water Resources Handbook for Economics.
7. Iran, Islamic Rep of Disaster & Risk Profile (<https://www.preventionweb.net/countries/irn/data/>)
8. EM-DAT | The international disasters database (<https://www.emdat.be>).