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Societal and economic impacts of flood hazards in Turkey – an overview

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Abstract. Turkey has been severely affected by many natural hazards, in particular earthquakes and floods. Although there is a large body of literature on earthquake hazards and risks in Turkey, comparatively little is known about flood hazards and risks. Therefore, with this study it is aimed to investigate flood patterns, societal and economic impacts of flood hazards in Turkey, as well as providing a comparative overview of the temporal and spatial distribution of flood losses by analysing EM-DAT (Emergency Events Database) and TABB (Turkey Disaster Data Base) databases on disaster losses throughout Turkey for the years 1960-2014. The comparison of these two databases reveals big mismatches of the flood data, e.g. the reported number of events, number of affected people and economic loss, differ dramatically. With this paper, it has been explored reasons for mismatches. Biases and fallacies for loss data in the two databases has been discussed as well. Since loss data collection is gaining more and more attention, e.g. in the Sendai Framework for Disaster Risk Reduction 2015-2030 (SFDRR), the study could offer a base-work for developing guidelines and procedures on how to standardize loss databases and implement across the other hazard events, as well as substantial insights for flood risk mitigation and adaptation studies in Turkey and will offer valuable insights for other (European) countries.

1 Introduction

Even if natural events are a part of the Earth's system, extreme events can have destructive power and cause tremendously impact human society. Especially over the last two decades, natural hazards have caused enormous human and economic losses in Turkey that occasionally amounted to 3 to 4% of the gross national product [1]. Turkey is severely affected by many perils owing to its climatic, tectonic, topographic and seismic properties. Although disasters such as floods, landslides and wildfires are common in Turkey, earthquakes take the first place when evaluated in terms of their devastating effects.

While there are numerous studies and a large body of literature on earthquake hazards and risks in Turkey, relatively little is known about flood hazards and risks.

Between the years 1955 and 2009, 2089 flood disasters have been listed, and for the years 1960 to 2009, 1919 events are reported which caused 1050 fatalities, 3.1 billion US\$ economic loss and 1.9 million ha flooded area [2]. It has been indicated that 52 % of all flood events occurred in Black Sea, Mediterranean and Marmara region [3]. Other studies about flood events in Turkey show that Black Sea, Eastern Anatolia and Mediterranean region respectively had higher flood risk [2] and the most of the human deaths due to floods occurred in Black Sea and Eastern Black Sea basin [4]. The areal distribution of flood events shows that Black Sea Region, Eastern Anatolia and Mediterranean Sea Region had higher frequency of flood events. However, although the Eastern Black Sea Region had a comparatively little number of flood events, these events had more destructive effects than in the other regions [2]. To provide an overview of the spatial and temporal distribution of floods events in 2007 in Turkey, 237 principle climatological stations records had been used and between 1940 and 2005 it has been reported 1768 flood events by which 1344 people

died [5]. According to information of 1768 flood events, seventeen major flood events and losses have been listed. The spatial distribution of flood events shows that, the occurrence of events does not distribute uniformly. Congruently, valleys in Black Sea, the Marmara and Aegean Region are under threat in particular ([3, 5, 6, 7, 8, 9]). For the western part of the Turkey, heavy rainfall with combination of geomorphological features plays a main role for flood events. And for the flood events in Central Anatolia Region and eastern part of the Turkey, snow accumulation and sudden snowmelt is the main reason [5]. Another similar study for an overview relevant the flood events had been approached to natural hazards considering number of damaged buildings and number of affected provinces in the period 1960 to 1975. Although the total number of events is not mentioned, it is reported that 945 provinces and 24582 buildings were damaged between 1960 and 1975 [10]. These literature examples show that flood damage data differ from source to source based on institutions and each organization enrolls different indicators according to their requirements or areas of interest. Therefore, this paper focusses on providing an overview of flood hazards in Turkey while reflecting on the suitability of different disaster data bases to fulfil this task.

In general, data on disaster events and their impacts are scarce in comparison to other scientific fields in natural hazard research, although the lack of reliable, consistent and comparable data is seen as a major obstacle for effective and long-term loss prevention. To improve the comparability of current loss databases, hazards must be standardized by a common classification [11]. Currently, only a few data sets, in particular the emergency events database EM-DAT [12] hosted and maintained by the Centre for Research on the Epidemiology of Disasters (CRED) since 1988, are publicly accessible and have become widely used to

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describe trends in disaster losses. However, loss data are subjected to various biases. To eliminate these biases and to provide high quality loss data to decision makers, the public, the planners, the scientists or the other end users, it is recommended to standardize some key areas related to loss data collection [13]. Since Turkey is in the favourable position of having a distinct national disaster database since 2009, i.e. the Turkey Disaster Data Base (TABB), there is the unique opportunity to investigate flood impacts in Turkey in more detail as well as to identify biases and underlying reasons for mismatches with EM-DAT. Therefore, Turkey was selected as study area to provide an overview of flood patterns, spatial & temporal distribution of flood events, societal and economic impacts of flood hazards by comparison of two databases. It is aimed to discuss how to standardize and develop loss databases for flood hazards in Turkey by discussing mismatches between EM-DAT and TABB as well. Since loss data collection is gaining more and more attention, e.g. in the Sendai Framework for Disaster Risk Reduction 2015-2030 (SFDRR) [28] and the loss and damage program of the UNFCCC (United Nations Framework Convention on Climate Change), the study could offer a base-work for developing guidelines and procedures on how to standardize loss databases and implement across the other hazard events, in order to monitor developments in event frequencies as well as (flood) risk mitigation and adaptation studies in Turkey.

2 Databases

2.1 EM-DAT (Emergency Events Database)

EM-DAT (Emergency Events Database) is one the most frequently used global and publicly accessible database on both technological and natural disasters in the world. Initially supported by WHO (World Health Organization) and the Belgian Government, EM-DAT has been maintained and hosted since 1988 by the Centre for Research on the Epidemiology of Disasters (CRED). EM-DAT's main objective is to provide information relevant for humanitarian aid at national and international levels. It is further aimed to rationalise decision making for disaster preparedness and to provide data for vulnerability assessments. EM-DAT contains essential data on the occurrence and impacts of more than 21000 damaging events from all over the world from 1900 to present. Various sources, including UN agencies, non-governmental organisations, insurance companies, research institutes and press agencies are used to fill the database [12]. EM-DAT classifies disasters based on the IRDR peril classification and hazard glossary [11]. It describes an event by five levels of peril classifications (*disaster group, disaster sub-group, disaster type, and disaster sub-type and disaster sub-sub-type*). In EM-DAT, it is possible to retrieve data by selection criteria (e.g. time period, location, disaster classification). However, an event is only included in EM-DAT if it fulfils one of the EM-DAT criteria (Table 1). Information on total deaths, number of injured people, number of

affected people, number of homeless people, total affected and total damage in '000 US\$ are provided by EM-DAT as well.

2.2 TABB (Turkey Disaster Data Base)

In 1999, Turkey experienced a serious damaging event in the Marmara region. Because of the big Marmara earthquake, 18373 people lost their lives [14], 43953 people had been affected [15] and up to \$6.5 billion economic loss [16] occurred. After the Marmara earthquake, the collection of disaster losses for reducing the impacts of the disasters and for risk management studies became an important issue in Turkey. Therefore, the National Earthquake Investing Program (UDAP) was developed by the Republic of Turkey Prime Ministry Disaster and Emergency Management Authority (AFAD) in 2011 [17]. Turkey Disaster Database (TABB) has been developed within the UDAP project in order to supply all corresponding documents and sources (e.g. dissertations, reports, books, photos, videos) about both natural and anthropogenic disasters experienced so far. With this project, it is aimed to support the disaster preparedness and risk mitigation studies by presenting all documents and data that have been prepared by universities, local administrations, state institutions and organizations and non-governmental organisations. Using of the concept of UNDP (United Nations Development Programme) DesInventar database concept, TABB was set-up in 2009 and is now hosted and maintained by AFAD [18].

Initially, a contract with a newsagent ensured that all newspapers between 1900 and 2014 could be used to extract disaster loss information that was also geocoded. An interview with AFAD-representatives in May 2015 revealed that TABB was fundamentally updated in March 2015 and now contains reliable data from 1923 to 2015. TABB was developed into two modules, which are called as "Document Module" and "Analysis Module" [19]. When users access electronic documents and their sources about disasters by using "Document Module", they can perform statistical analyses. Data download as.doc, .xls or .pdf formats is possible by using the "Analysis Module". All events, for which an "AFAD information card" that is used in the Turkish emergency management exists, are included in TABB. TABB is also publicly accessible like EM-DAT. But in contrast to EM-DAT, there are no thresholds or entry criteria such as a certain number of dead or affected people (Table 1).

2.3 A Comparative Overview: EM-DAT vs. TABB

2.3.1 Pre-processing of TABB

Since most of the studies focus on the economic and societal impacts in a region based on global databases (e.g. EM-DAT) [20], it is comparatively easy to reach economic and societal loss data. However, global databases do not always reflect the spatial-temporal dynamics of events. Regional databases could have more detailed information and could be useful for regional studies on damage assessment.

| | EMDAT | TABB |
|----------------------------|---|--|
| Spatial coverage | Global | National |
| Spatial resolution | Country | Regional |
| Parameters | Injuries, fatalities, affected, homeless, insured damages, reconstruction costs, total damages | *Please see Annex 1 |
| Time interval | 1900–present | 1923–present |
| Update interval | Every 3 months | Irregular intervals |
| Thresholds | ≥10 fatalities ≥100 affected Declaration of state of emergency Call for international assistance | No thresholds |
| Data Accessibility | Downloadable (.xls) | Downloadable(.xls, .doc, .pdf), (singly for each hazard type) |
| User Access | Public | Public |
| Sources | United Nations, National Governments, US Governments, NGO's, Inter-Governmental Organizations, Reinsurance Companies, Press, etc. | Universities, local administrations, state institutions & organizations, non-governmental organizations, news agencies |
| Priority Source | UN agencies | News agencies |
| Host institution(s) | Center for Research on the Epidemiology of Disaster, Catholic University of Louvain | Republic of Turkey Prime Ministry Disaster & Emergency Management Authority |
| Web-page: | www.emdat.be | tabb.afad.gov.tr |

Table 1. Comparative summary of EMDAT & TABB

TABB is the only regional and publicly accessible disaster database for Turkey. Though, due to a lack of standardization and classification, all information about the disasters in database is unsorted. To make TABB more organized and comparable with EM-DAT, the events were reclassified. For natural disasters, the IRDR peril classification system [11] that was proposed by a workgroup within the Integrated Research on Disaster Risk (IRDR) was used. For anthropogenic disasters, a combined classification system has been created (Figure

1) by adapting both EM-DAT technological disaster classification and literature sources [21].

All disasters in TABB were assigned to a disaster generic group, a disaster sub-group, a main disaster type, a sub-disaster type and a sub-sub disaster type name by using a united disaster classification system. After the reclassification, TABB has become comparable with EM-DAT in terms of structure. For the analyses, the period from 1960 to 2014 was selected to procure a minimum timeframe of 50 years. For the concurred time slot,

accessibility of the hydro-meteorological data for the further studies was considered as well.

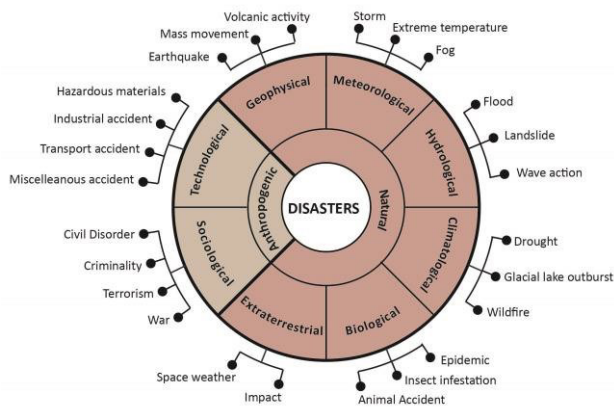


Figure 1. United disaster classification system

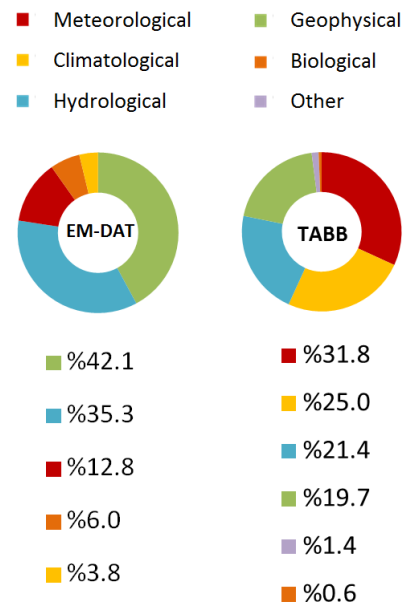


Figure 2. Percentile of natural disaster sub-groups in Turkey (1960-2014)

2.3.2 Overview of hazards in Turkey

In the last fifty years, Turkey has experienced numerous natural hazards. Between 1960 and 2014, EM-DAT (as at June 2015) reports 269 hazards -136 anthropogenic hazards and 133 natural hazards- in total. According to EM-DAT, geophysical hazards take the first place in the list with 42.1 % of those natural hazards and hydrological hazards are the second most frequent hazards with 35.3 % quantile. For the same time interval, TABB (as at June 2015) has listed 18208^a hazards in consisting of 5219 anthropogenic hazards and 12988 natural hazards. In contradiction to EM-DAT, meteorological hazards are the most frequent hazards in the database (31.8 % of all hazards) and hydrological hazards are the third frequent hazard type in the list (21.4 %) on the basis of the number of events (Figure 2). In the TABB database, 181 erosion and two geo-medical events were also listed. Since these sub-sub disaster types do not exist in the IRDR peril classification system, they were listed under the category “Other”.

When analysing event frequencies based on the disaster main types, wildfire is the most frequent hazard (2586 wildfire events, 19.9 % of all natural hazards) in Turkey according to TABB (Figure 3). Flood hazards (1076 flood hazards, 8.3 % of all natural hazards) take the sixth place in the list after storms (2364 storm event), earthquakes (2004 earthquake events), landslides (1702 landslide events) and extreme temperature (1647 extreme temperature events). When fatalities are considered in the TABB database, earthquakes are the most destructive hazards in Turkey that caused 75904 fatalities between the years 1960-2014. Flood hazards are the third destructive hazards -by which 795 people died- after extreme temperature hazards (with 60222^b fatalities).

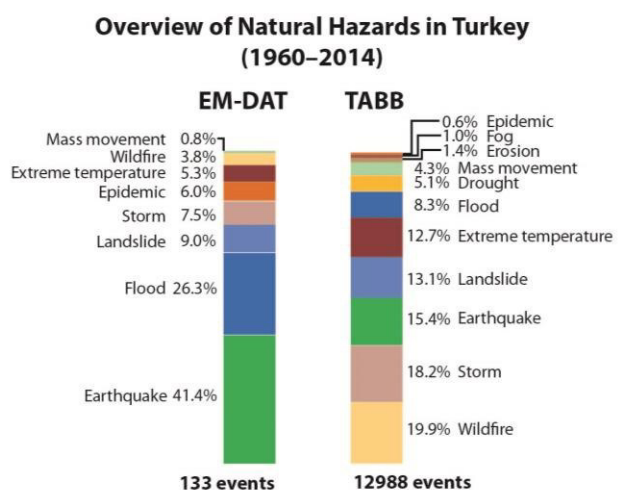


Figure 3. Overview of natural hazards in Turkey based on disaster main types (1960-2014)

^a In TABB database there is also one *Famine* event has been listed. But since there is not detailed information in explanations part related to reason (anthropogenic; e.g. war or natural; e.g. extreme temperature, drought) of *Famine*, this event has not been included in classification.

^b The detailed information and data conflicts in number of events with the current version of TABB have been discussed in *Conclusion & Implications* part.

As the EM-DAT database applies thresholds (Table 1), the number of events differs greatly from the data given by TABB. EM-DAT contains substantially fewer records for Turkey. For the period from 1960 to 2014, EM-DAT reports 55 earthquake events (41.4 % of all natural hazards) which are here the most frequent hazard type in Turkey, while flood events takes the second place in the list with 35 events (26.3 % of all natural hazards). In line with number of events, earthquakes have been reported as most destructive hazard types in Turkey by which caused 32256 fatalities and the floods are the second destructive hazard with a death toll of 773.

Figure 5 and Figure 6 show the cumulative distribution of natural hazards' occurrences by years for the databases EM-DAT and TABB from 1960 to 2014. Although their scales differ considerably, the temporal trends of the number of natural hazards are similar. Evolution of information systems in the early 1980s [22] and in parallel with this, the development of loss data collection and storage technologies are regarded as a major source for this effect. Moreover, the spatial distribution of natural hazards has importance to identify disaster-prone regions that are in need of support by disaster management and risk mitigation. While the TABB platform allows users to view the locations of each event on the map as point, unfortunately there is no more information about their impacts. And so, all disasters in TABB have been digitized, geo-referenced, mapped and linked with the TABB loss data as attribute table to make easier to display characteristics of the events as well (Figure 4). Such maps help users to have a general overview of spatial distribution of natural hazards in Turkey based on the number of events.

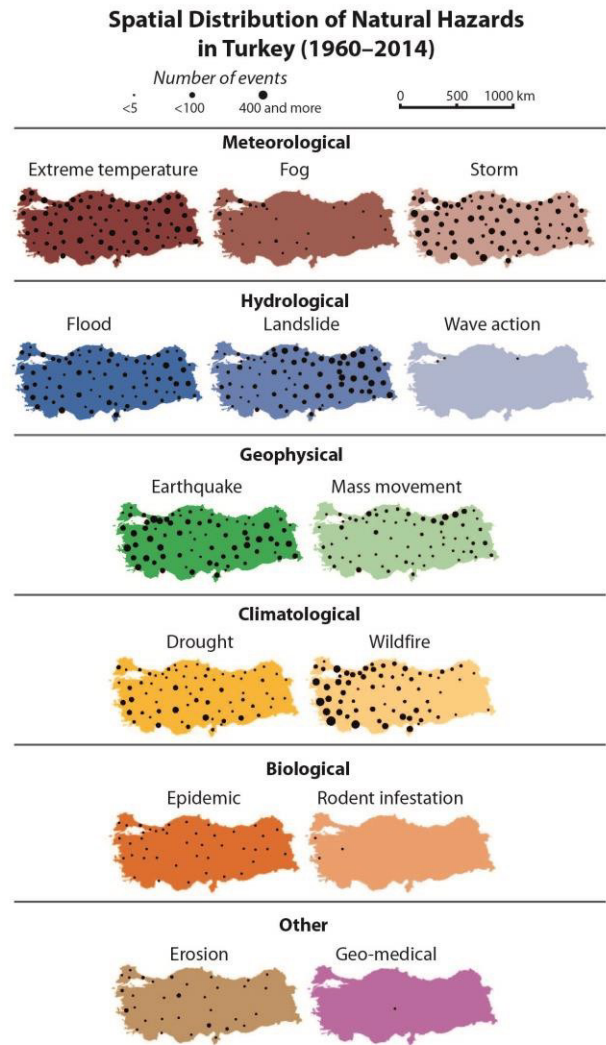


Figure 4. Spatial distribution of natural hazards in Turkey (TABB, 1960-2014)

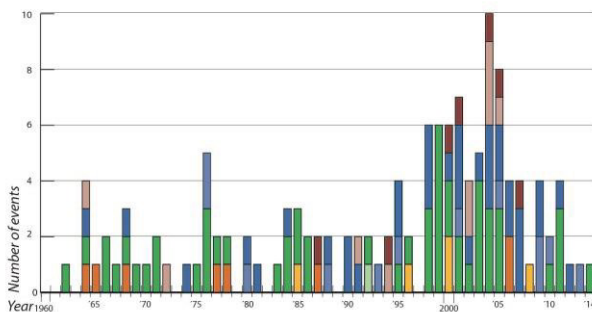


Figure 5. Cumulative distribution of natural hazards' occurrences by years (EM-DAT, 1960-2014)

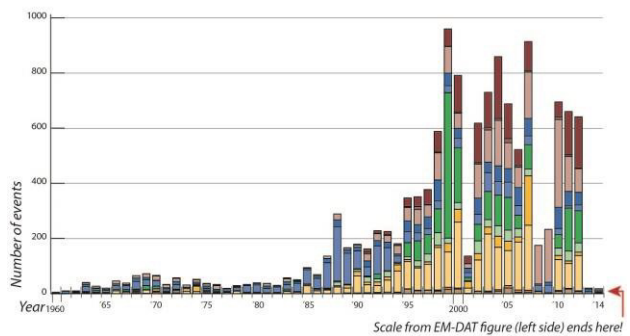


Figure 6. Cumulative distribution of natural hazards' occurrences by years (TABB, 1960-2014)

3 Flood Hazards in Turkey

As outlined above, flood hazards take the third place in natural disasters human loss list in Turkey according to TABB. Floods are due to heavy rainfall on the coastal areas of the western and southern parts of Turkey or to a sudden increase in air temperature, resulting in snow melt in eastern, mountainous part of southeast Turkey, especially Eastern Black Sea region [23].

According to the analysis of the TABB database, Erzurum province -which is located Eastern part of Turkey-, has the most flood events (64 flood events) in Turkey between the years 1960-2014 (see also Fig. 4). Antalya province, that is located in the Mediterranean region, keeps up with Erzurum with 55 flood events and takes the second place in the list. The number of flood events does, however, not imply any human or economic losses. When TABB was analysed with regard to fatalities, it reveals that flood hazards are more destructive in Eastern Black Sea region (Figure 7). Trabzon province has the most fatalities (145 death tolls) due to flood events between 1960 and 2014. Similarly, when TABB was analysed with respect to economic losses, it could be reported that the Black Sea and Mediterranean regions suffered from the highest economic losses. The biggest economic loss due to flood hazards in the 1960-2014 period occurred in Giresun province, which belongs to the Eastern Black Sea region, with US\$ 7.2 trillion (Figure 8). In view of TABB analyses results, it is possible to interpret that Black Sea and Mediterranean regions are comparatively more prone to flood hazards and risks.

3.1 Societal and Economic Impacts of Catastrophic Flood events (1960-2014)

The comparative overview using TABB and EM-DAT shows that global or regional databases do not include the same severe events. To better understand the flood regime and pattern, the analysis of catastrophic flood events is a next step. Therefore, a list with the most severe flood events was compiled that serves as a basis for a detailed analysis of flood hazards in Turkey. Catastrophic flood hazards between 1960 and 2014 have been identified using all the data and information that was available in TABB and EM-DAT. In addition, scientific literature, news archives and the Global Active Archive of Large Flood Events - Dartmouth Flood Observatory [29] were used to complement the databases. With this part of the study, it is also aimed to show mismatches in different data sources. For the 1960-2014 time periods, 25 most catastrophic flood events have been listed (Annex 2). To make an overview for societal and economic impacts of these 25 most catastrophic flood events, human loss, economic loss and number of affected people were considered.

Economic losses have been calculated in US\$ by using event days' exchange rates of the Central Bank of the Republic of Turkey (CBRT) ([24, 25]). For this calculation, explanatory notes in TABB, in literature and the information that was obtained from the AFAD representatives during an interview was considered. Considering and comparing all sources of information, it becomes apparent that fatalities, the number of affected people and economic losses differ dramatically. For example, although the Mersin- Adana flood event of December 1968 is the most destructive event in Turkey with 147 fatalities reported in EM-DAT, there is no information neither in TABB, nor in the Dartmouth archive or in the scientific literature. Similarly, the Isparta (Senirkent) flood event of July 1995 is reported as one of the most destructive flood events in terms of fatalities (74 fatalities) in TABB as well as in case studies in the literature. Surprisingly, this event neither exists in EM-DAT nor in the Dartmouth archive. On the other hand, information for some of the flood events is very similar with regard to the number of reported fatalities, the number of affected people or the economic losses - even in different data sources. A flood that hit the Western Black Sea region (Zonguldak, Karabuk, Bartın, Sakarya) in May 1998 was identified as the most devastating event with regard to economic losses. EM-DAT reported 10 fatalities, 1240047 affected people and US\$ 1.0 billion economic loss. Dartmouth reported 19 fatalities and US\$ 2.0 billion economic losses and TABB reported 5 fatalities, 43547 affected people for the same flood event. Case studies about the same flood event mention differing numbers for human and economic losses. Human losses vary from 10 to 27 fatalities and affected people vary 1.2 million to 2.2 million. Finally, the maximum economic loss is given as US\$ 2.0 billion for this flood event.

To see the spatial distribution of most severe flood hazards in Turkey, all events have been digitized; geo-referenced and mapped (Figure 9). To make a relation with most severe flood events list (Annex 2, Ref. Nr.), reference numbers have been given to each event and these numbers are displayed in the map (Figure 9). The provinces that were mainly affected by the flood events are also illustrated. According to Figure 9, it is possible to see that most of the catastrophic flood events take place in Eastern Black Sea and the East-southeast Anatolian Mediterranean region.

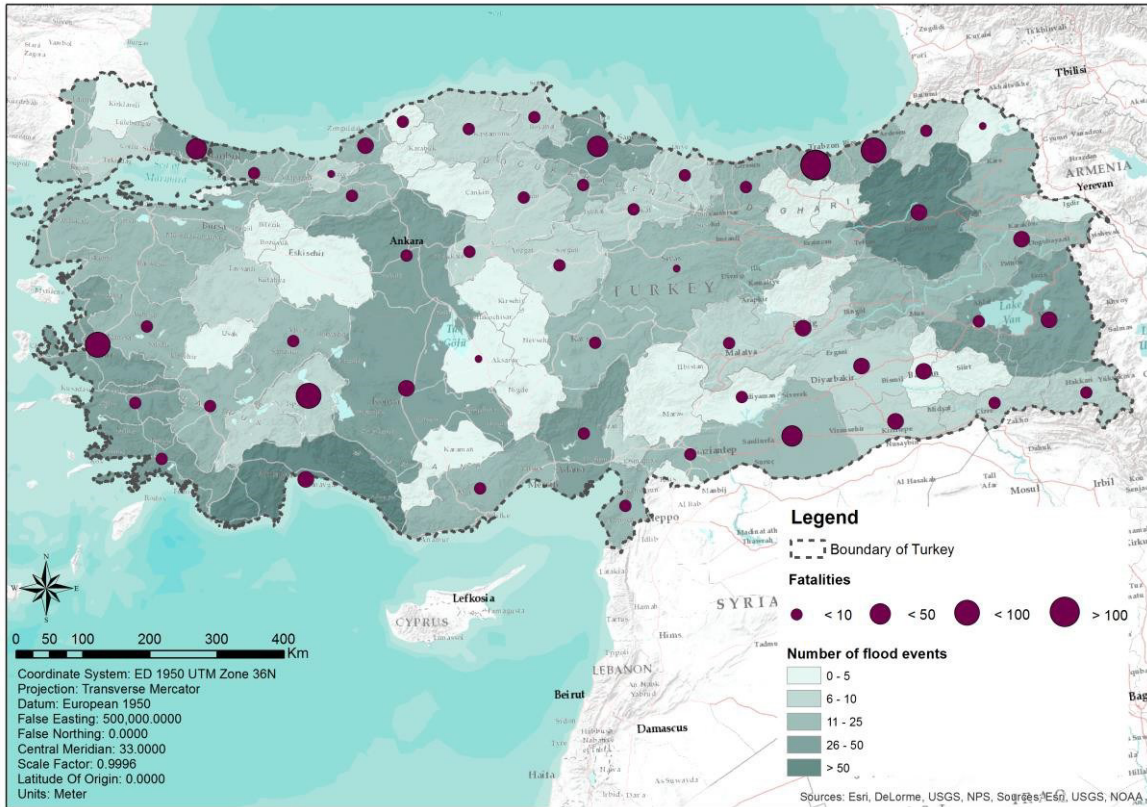


Figure 7. Fatalities due to flood hazards in Turkey (TABB, 1960-2014)

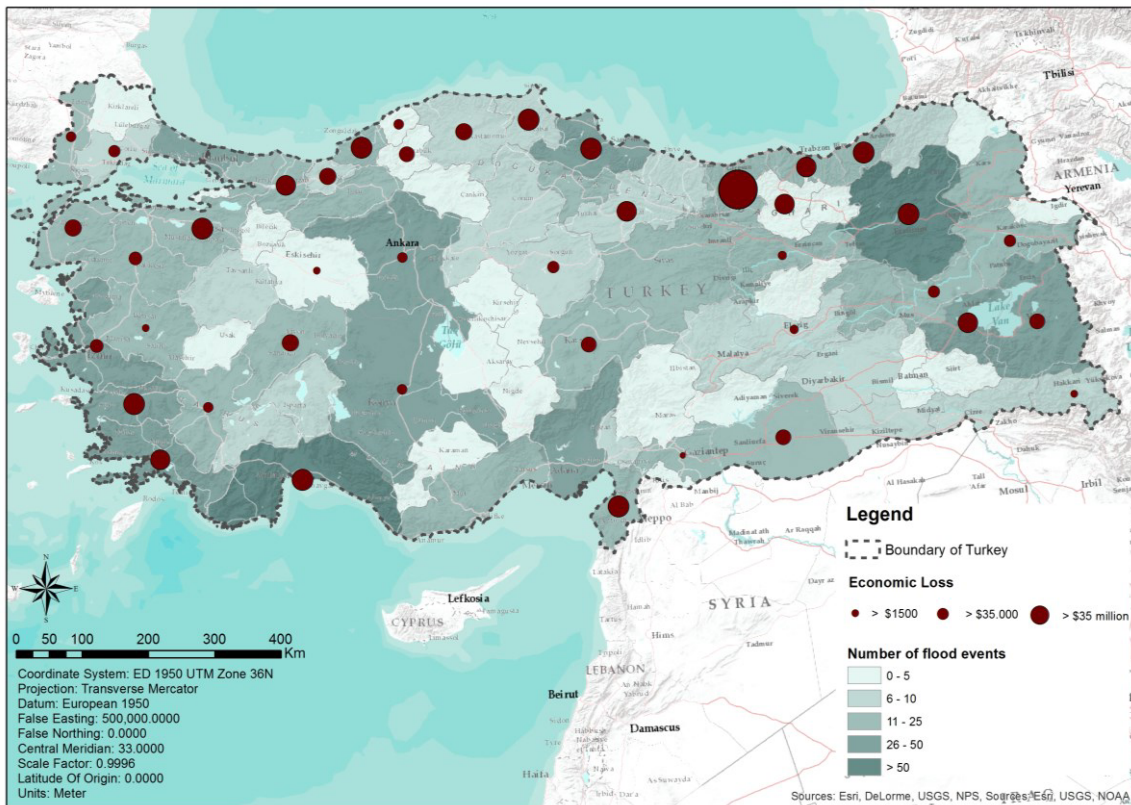


Figure 8. Economic losses due to flood hazards in Turkey (TABB, 1960-2014)

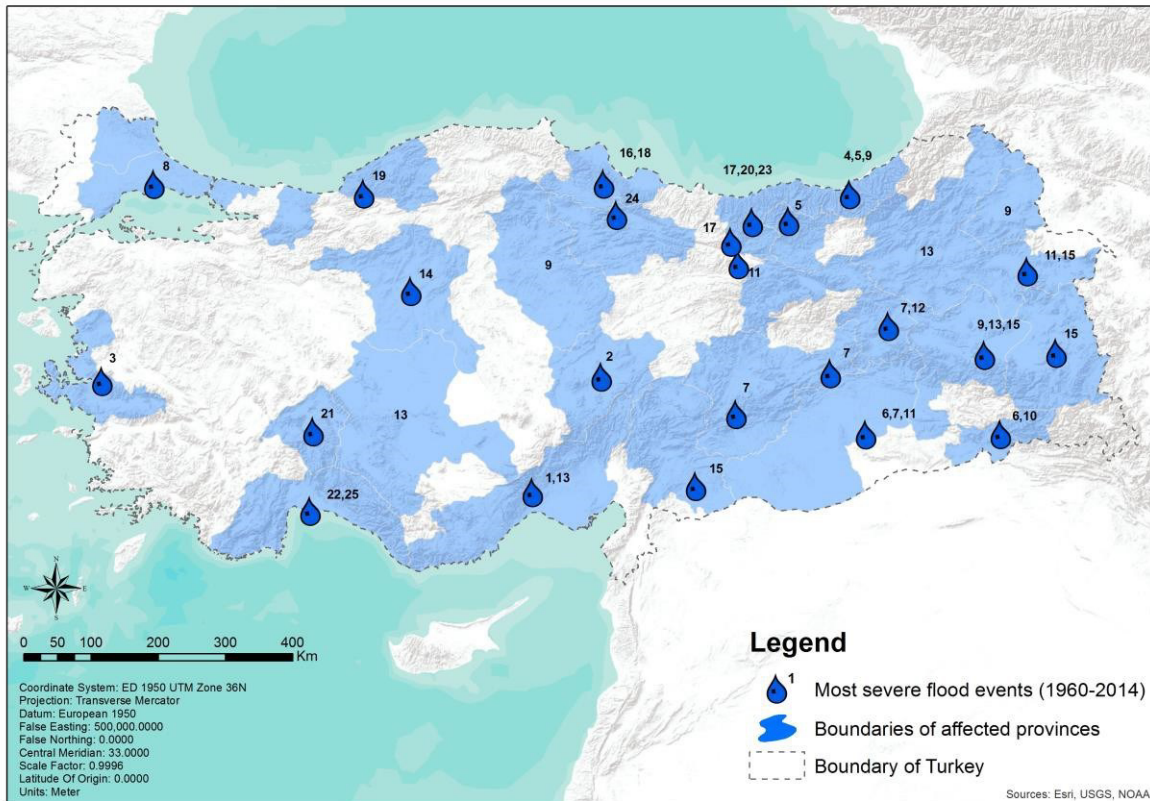


Figure 9. Most severe flood hazards in Turkey (1960-2014)

4 Conclusion & Implications

In this study, an overview of the spatial and temporal distribution of natural hazards, particularly flooding, has been presented for Turkey. Therefore, the TABB database was reclassified and the databases EM-DAT and TABB were compared with regard to the number of events, as well as economic and human losses. Finally, the most severe flood events in Turkey were retrieved and interpreted for the years 1960-2014. These events will be used for further studies about the flood triggering processes and risk drivers.

The comparison of the two databases shows that large mismatches between a global and a national database might occur. Current global and national databases for monitoring losses from natural hazards suffer from a number of limitations, which in turn could lead to misinterpretations of loss data. These biases include a hazard bias, a temporal bias, a threshold bias, an accounting bias, a geographic bias and a systematic bias [13]. According to comparison of the EM-DAT and TABB, it is possible to see these major biases in loss information. This comparative overview is a good example for temporal bias, threshold bias and accounting bias in particular. Temporal bias infers that, losses are comparable over time [13]. Changes in monetary value in time directly affect the economic losses. In TABB, all economic losses are given in Turkish Lira (TL)

denominated and since the changes the monetary value in TL and US\$ are different, it is a fallacy to compare losses over time. Especially, currency unit changes of TL in 2005, caused confuse the comparing the economic losses.

Another issue about the economic losses given in TABB is missing or untrusted data. When the list of the most severe flood events is interpreted, it seems that there are some non-realistic loss data in TABB (Annex 2, e.g. US\$ 0.004, US\$ 21.4 ...). These numbers could be commented as faulty data input or mistake. And at that case, these data shows the lack of data quality and accuracy control in TABB. ^(b)Similarly, when fatalities were analysed for all natural hazards, extreme temperature hazards caused 60222 fatalities according to TABB and 60000 fatalities had occurred in one event (08.10.1996, extreme temperature (cold wave), Kars-Sarikamis province, Glide Nr: S-24505f5e-1985, TABB June, 2015). The number of fatalities is not realistic and equal with the then-current population of Sarikamis region [26]. When the current version of TABB is checked (February, 2016), it is possible to see that this extreme temperature event was removed from the database. This case is another example for importance of standardization, accuracy and quality control studies in loss databases.

Another bias in these databases is threshold bias. Threshold bias infers that, all losses, regardless of size are counted [13]. An event is only included in EM-DAT if one of the following criteria is fulfilled: 1)10 or more

people died in the event; 2)100 or more people were affected by the event; 3) a state emergency was declared or 4) there was a call for international assistance. In contrast with EM-DAT, TABB contains all hazard events without any thresholds (Table 1). Threshold bias has caused fallacy to compare the two different-scaled databases. For instance, Figure 5 and Figure 6 illustrate well how the thresholds affect the content of the databases in term of number of events. Another conspicuous bias in this study is the systematic bias. Systematic bias infers that losses are the same regardless of the database used. Systematic bias starts from initial data collection methods to computing data [13]. EM-DAT and TABB obtain the data from various sources (Table 1) and the lack of standardization during data collection and computing processes, fallacies become during database comparison. With this implication, it is aimed to show the current situation of loss data in TABB and EM-DAT with a comparative overview and this study could help the further studies to overcome these problems and biases and to help the development of high quality, reliable and standardized databases for natural hazards.

Accurate accounting for disaster impacts is an important perspective for improving disaster risk management [22]. In disaster management studies, damage assessment of natural hazards play an important role. Especially, the estimation of economic damage of flood hazards is gaining more important in Europe [27]. And historical data allow analysts to search for disaster trends and causal factors over time and regions [22]. Therefore, to supply a useful database for historical severe flood events in Turkey, catastrophic flood events list has been retrieved (Annex 2) and mapped (Figure 9). Furthermore, to show the biases in the flood database, a comparative data list has been presented and data gaps has been fulfilled by benefiting from other data sources (e.g. Dartmouth, literature...).

In conclusion, suggestions and implication for non-standardized national databases, TABB could be sum up as;

- As a government office and only publicly accessible disaster data source for Turkey, TABB and AFAD could collect high quality data and produce related publications regularly.
- During computing processes of disaster data, attention should be paid on accuracy of data and data quality controls.
- Disaster database should be presented as classified according to a globally accepted disaster classification system. In terms of standardization, methodology and definitions should explain clearly.
- Most of the loss parameters in TABB (e.g. number of damaged building, total missing, displaced, total damage...) are incomplete.
- To make TABB more useful and sharable, inter-language version should be developed as well.

Loss data collection is gaining more and more attention, e.g. in the Sendai Framework for Disaster Risk Reduction 2015-2030 (SFDRR) [28] and the loss and damage program of the UNFCCC (United Nations Framework Convention on Climate Change). Correspondingly, the study could offer a base-work for developing guidelines and procedures on how to standardize loss databases and implement across the other hazard events to monitor progress of (flood) risk mitigation and adaptation in Turkey.

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ANNEX 1

TURKEY DISASTER DATABASE (TABB) LOSS PARAMETERS

| | |
|----------------------------------|--------------------------------------|
| Effectuated Areas | Injured (child 0-18) |
| Total Death | Injured (adult +18) |
| Total Injured | Injured (female) |
| Total Missing | Injured (male) |
| Number of Destroyed Building | Non-damaged public buildings |
| Number of Damaged Building | Light damaged public buildings |
| Affected | Moderate damaged public buildings |
| Displaced | Heavy damaged public buildings |
| Evacuated | Run-downed public buildings |
| Total Damage (\$) | Non-damaged residence buildings |
| Total Damage (TL) | Light damaged residence buildings |
| Destroyed Agricultural Area (Ha) | Moderate damaged residence buildings |
| Cattle Loss | Heavy damaged residence buildings |
| GLIDE NO | Run-downed residence buildings |
| Condition | Non-damaged workplace buildings |
| Deaths (child 0-18) | Light damaged workplace buildings |
| Deaths (adult +18) | Moderate damaged workplace buildings |
| Deaths (female) | Heavy damaged workplace buildings |
| Deaths (male) | Run-downed workplace buildings |

ANNEX 2

MOST SEVERE FLOOD EVENTS IN TURKEY

| Flood Events | | | EMDAT | | | Dartmouth | | | TABB | | | Literature | | |
|--------------|------------|---|------------|----------|---------------------------|------------|----------|---------------------------|------------|----------|--------------|---------------------|-----------------------|---------------------------|
| Ref. Nr. | Date | Location | Fatalities | Affected | Total Damage (in Mio. \$) | Fatalities | Affected | Total Damage (in Mio. \$) | Fatalities | Affected | Total Damage | Fatalities | Affected | Total Damage (in Mio. \$) |
| 1 | 12/1968 | Mersin (Icel), Adana | 147 | 0 | 0 | - | - | - | 0 | 0 | 0 | - | - | - |
| 2 | 03/1980 | Anatolia (Kayseri) | 75 | 60,000 | 15 | - | - | - | 0 | 0 | 0.004 | - | - | - |
| 3 | 11/1995 | Izmir, Antalya, Isparta | 63 | 306,617 | 50 | 62 | - | - | 61 | 0 | 0 | 61 ^{1,2,3} | - | 50 ^{1,2,3} |
| | | | | | | | | | | | | 67 ⁴ | - | 30 ⁴ |
| | | | | | | | | | | | | 63 ⁵ | 300,000 ⁵ | 1,000 ⁵ |
| | | | | | | | | | | | | 61 ⁶ | - | - |
| | | | | | | | | | | | | 63 ⁷ | - | - |
| | | | | | | | | | | | | 61 ⁸ | - | - |
| | | | | | | | | | | | | 61 ⁹ | - | - |
| | | | | | | | | | | | | 63 ¹⁰ | - | - |
| | | | | | | | | | | | | 61 ¹¹ | - | 1 ¹¹ |
| 4 | 08/1998 | Trabzon, Rize | 60 | 1,000 | 0 | 50 | - | - | 91 | 0 | 21.57 | 50 ¹² | - | 44 ¹² |
| | | | | | | | | | | | | 10 ¹³ | - | - |
| | | | | | | | | | | | | 43 ^{14,15} | - | - |
| | | | | | | | | | | | | 47 ¹⁶ | - | - |
| | | | | | | | | | | | | 50 ¹⁷ | - | - |
| | | | | | | | | | | | | 50 ¹⁸ | - | 54 ¹⁸ |
| | | | | | | | | | | | | 60 ^{19,20} | 1000 ^{19,20} | - |
| 5 | 06/1990 | Giresun, Gumushane, Trabzon | 51 | 4,500 | 150 | 48 | - | 150 | 51 | 0 | 0 | 57 ²¹ | - | 348 ²¹ |
| | | | | | | | | | | | | 57 ²² | - | - |
| | | | | | | | | | | | | 57 ^{23,24} | - | 421 ^{23,24} |
| 6 | 10-11/2006 | Sanliurfa, Diyarbakir, Sirkak, Batman | 47 | 6,015 | 317 | 46 | - | 314 | 41 | 0 | 4,895,105 | 39 ²⁵ | - | 300 ²⁵ |
| | | | | | | | | | | | | 10 ²⁶ | - | 21 ²⁶ |
| | | | | | | | | | | | | 46 ²⁷ | - | 21 ²⁷ |
| | | | | | | | | | | | | 44 ²⁸ | - | - |
| 7 | 05/1991 | Diyarbakir, Malatya, Adiyaman, Elazig, Bingol, Mus | 42 | 500 | 25 | 42 | - | 25 | 38 | 157 | 0 | - | - | - |
| 8 | 09/2009 | Istanbul, Tekirdag | 40 | 35,020 | 550 | 31 | - | - | 31 | 0 | 0 | 32 ²⁹ | 35.000 ²⁹ | 80 ²⁹ |
| | | | | | | | | | | | | 31 ³⁰ | - | 70 ³⁰ |
| | | | | | | | | | | | | 31 ³¹ | - | - |
| | | | | | | | | | | | | 32 ³² | - | - |
| 9 | 07/2002 | Rize (Black sea region), Corum and Yozgat (central), Kars and Mus (Eastern) | 34 | 3,000 | 0 | 34 | - | - | 33 | 0 | 18.60 | 27 ³³ | - | 11 ³³ |
| | | | | | | | | | | | | 40 ³⁴ | - | 20 ³⁴ |
| | | | | | | | | | | | | 27 ³⁵ | - | 8 ³⁵ |
| | | | | | | | | | | | | 32 ³⁶ | - | - |
| | | | | | | | | | | | | 27 ³⁷ | - | 14 ³⁷ |
| | | | | | | | | | | | | 27 ³⁸ | - | 9 ³⁸ |
| 10* | 11/1974 | Sirkak | 33 | 0 | 0 | - | - | - | - | - | - | - | - | - |
| 11 | 06/1998 | Diyarbakir (Sanliurfa, Agri, Erzincan, Ardahan, Erzurum) | 22 | 0 | 0 | 9 | - | - | 18 | 0 | 0.16 | 8 ³⁹ | - | - |
| 12* | 02/1990 | Kahramanmaraş Bingol Gaziantep | 18 | 0 | 0 | 18 | - | - | - | - | - | - | - | - |
| 13 | 03/2004 | Erzurum, Batman, Bitlis, Mus, Konya, Silifke | 15 | 50,000 | 0 | 8 | - | - | 4 | 132,983 | 0 | - | 4868 ⁴⁰ | - |
| | | | | | | | | | | | | - | - | 6 ⁴¹ |
| 14* | 06/1988 | Ankara | 13 | 1,500 | 0 | 16 | - | - | - | - | - | - | - | - |
| 15 | 05/2007 | Agri, Van, Bitlis, Gaziantep | 13 | 750 | 0 | 13 | - | 0 | 3 | 0 | 0 | 8 ⁴² | - | - |
| 16 | 07/2012 | Samsun | 13 | 0 | 0 | - | - | - | 9 | 0 | 0 | 12 ⁴³ | - | - |
| 17 | 07/2006 | Bitis, Mus, Kirklareli, Trabzon, Rize, Samsun, Giresun (Black sea region) | 12 | 0 | 0 | 9 | - | 0 | 3 | 1,520 | 7,034,965 | - | - | - |
| 18* | 12/1981 | Western (Samsun) | 10 | 0 | 0 | - | - | - | - | - | - | - | - | - |

MOST SEVERE FLOOD EVENTS IN TURKEY

| Flood Events | | | EMDAT | | | Dartmouth | | | TABB | | | Literature | | |
|--------------|---------|-------------------------------------|------------|-----------|---------------------------|------------|----------|---------------------------|------------|----------|--------------|------------------------|-------------------------|---------------------------|
| Ref. Nr. | Date | Location | Fatalities | Affected | Total Damage (in Mio. \$) | Fatalities | Affected | Total Damage (in Mio. \$) | Fatalities | Affected | Total Damage | Fatalities | Affected | Total Damage (in Mio. \$) |
| 19 | 05/1998 | Zonguldak, Karabuk, Bartın, Sakarya | 10 | 1,240,047 | 1,000,000 | 19 | - | 2,000 | 5 | 4,547 | 61.3 | 20 ⁴⁴ | - | >150 ⁴⁴ |
| | | | | | | | | | | | | 27 ⁴⁵ | - | 2.000 ⁴⁵ |
| | | | | | | | | | | | | 10 ⁴⁶ | 1.200.000 ⁴⁶ | 1.000 ⁴⁶ |
| | | | | | | | | | | | | 17 ⁴⁷ | - | 1 ⁴⁷ |
| | | | | | | | | | | | | - | - | 235 ⁴⁸ |
| | | | | | | | | | | | | - | 2.200.000 ⁴⁹ | - |
| 20 | 06/2002 | Giresun | - | - | - | - | - | - | 0 | 0 | 13,955,876 | - | - | 16 ^{50,51} |
| | | | | | | | | | | | | - | - | 4 ⁵² |
| 21 | 07/1995 | Isparta (Senirkent) | - | - | - | - | - | - | 74 | 0 | 0 | 74 ^{33,54,55} | - | - |
| | | | | | | | | | | | | 10 ⁵⁶ | 10.000 ⁵⁶ | 65 ⁵⁶ |
| | | | | | | | | | | | | 70 ⁵⁷ | - | 30 ⁵⁷ |
| 22 | 12/1997 | Antalya | - | - | - | - | - | - | 0 | 0 | 231.25 | - | - | - |
| 23 | 07/2009 | Giresun | - | - | - | -** | -** | -** | 0 | 0 | 0 | 1 ⁵⁸ | - | 98 ⁵⁸ |
| | | | | | | | | | | | | 1 ⁵⁹ | - | 10 ⁵⁹ |
| 24 | 05/2000 | Samsun, Tokat, Amasya | 2 | 1,000 | 40,000 | 2 | - | 40 | 2 | 0 | 11.23 | 2 ⁶⁰ | - | - |
| 25 | 12/2003 | Antalya | 8 | 0 | 0 | 6 | - | - | 5 | 0 | 21.4 | 5 ⁶¹ | - | 22 ⁶¹ |

*Only in EMDAT and/or Dartmouth database

** This event is also in Dartmouth database but no information about fatalities, affected people or economic loss.

¹Kömüşcü & Çelik (2013)

²Ceylan et al.(2007)

³Avsar (2014)

⁴Gürer (1998)

⁵Ergünay (2007)

⁶Kocman et al. (1996)

⁷Sezer (1997)

⁸Mutluer & Isik (2000)

⁹Zeybek (1998)

¹⁰Altundal (2010)

¹¹Kadioglu (2012)

¹²Yüksek et al. (2013)

¹³Ceylan et al. (2007)

¹⁴Gürgen (2004)

¹⁵Yurt (2012)

¹⁶Sahin (2002)

¹⁷webarsiv.hurriyet.com.tr/2005/09/03/696161.asp

¹⁸T.C. Çevre ve Orman Bakanlığı (2008)

¹⁹Anonymous (2011)

²⁰Altundal (2010)

²¹Yüksek et al. (2013)

²²Gürgen (2004)

²³T.C. Çevre ve Orman Bakanlığı (2008)

²⁴Avci & Sunkar (2015)

²⁵Gürer & Uçar (2009)

²⁶Tonbul & Sunkar (2011)***

²⁷Şahinalp (2007)

²⁸Türkoğlu (2009)

²⁹Kömüşcü & Çelik (2013)

³⁰tr.wikipedia.org/wiki/2009_Marmara_sel_dizisi

³¹Turoglu (2011)

³²Kömüşcü et al. (2009)

³³Yüksek et al. (2013)

³⁴Ceylan et al. (2007)

³⁵Gürer & Uçar (2009)

³⁶webarsiv.hurriyet.com.tr/2005/09/03/696161.asp

³⁷T.C. Çevre ve Orman Bakanlığı (2008)

³⁸Reis et al. (2007)****

³⁹Ceylan et al. (2007)

⁴⁰Anonymous (2004)

⁴¹Buldur et al. (2007)

⁴²Anonymous (2007)

⁴³Bahadır (2014)

⁴⁴Kömüşcü & Çelik (2013)

⁴⁵Ceylan et al. (2007)

⁴⁶Ergünay (2007)

⁴⁷Zeybek (1998)

⁴⁸Altundal (2010)

⁴⁹Kadioglu (2012)

⁵⁰Avci & Sunkar (2015)

⁵¹Anonymous (2011)

⁵²Aksoy & Coskun (2010)

⁵³Özden (2004)

⁵⁴Zeybek (1998)

⁵⁵Ertek (1995)

⁵⁶Altundal (2010)

⁵⁷Ceylan et al. (2007)

⁵⁸Avci & Sunkar (2015)

⁵⁹Onsoy (2011)

⁶⁰Ceylan et al. (2007), [13]

⁶¹Anonymous (2003)

*** This information is only for Batman province

****This information is only for Rize province