



EFFECT OF HUMAN FACTORS ON OCCURRENCE OF FLOOD AND TORRENT EVENTS IN BATMAN, SOUTHEASTERN TURKEY

BATMAN'DA (GÜNEYDOĞU TÜRKİYE) SEL VE TAŞKINLARIN OLUŞUMUNDA BEŞERİ FAKTÖRLERİN ETKİSİ

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Abstract

The purpose of this study is to emphasize the effect of human factors on the occurrence, frequency and incidence rate of floods experienced in Batman, SE Turkey. Batman is a medium-sized industrial city which has developed rapidly due to its petroleum reserves. It became a province in 1990. Rapid population growth due to labor migration and migrations from rural areas has resulted in unplanned development of the city. Important problems have come about as a result of this rapid and unplanned development, including an increase in the frequency and incidence rate of flood and torrent events. 22 out of 39 districts in the city were variously affected by the flood and torrent events experienced in the autumn of 2006. In this regard, Batman city is a high risk area with respect to hydrography. Improper construction practices, illegal housing and unplanned urbanization are also effective on the escalation of flood and torrent events, sometimes to catastrophic levels, which occur in Batman due to the physical-geographical characteristics of the Basin of Iluh Creek. In order to reveal the effect of these factors, observations were made in the city and household interview surveys were conducted in the districts affected by the flood event. The results of the observations and surveys suggest that human actions are directly effective on the catastrophic escalation of flood and torrent events in Batman city, affecting broad areas and thus causing great loss of life and property.

Keywords: Batman, Turkey, natural disasters, flood and torrent, human factors, hydrographic risk

Öz

Bu çalışmada Batman'da yaşanan taşkınların oluşum, sıklık ve frekansında beşeri faktörlerin etkisi vurgulanmıştır. Batman, petrole bağlı olarak hızlı gelişme göstermiş ve 1990 yılında il statüsü kazanmış orta ölçekli bir sanayi şehridir. İşçi göçü ve kırsal alandan aldığı göçlerle aşırı nüfus artışı şehrin plansız gelişmesini sağlamıştır. Hızlı ve plansız gelişme sonrasında önemli sorunlar ortaya çıkmıştır. Bu sorunların başında sel ve taşkınların sıklık ve frekansındaki artış gelmektedir. 2006 yılı sonbaharında yaşanan sel ve taşkından şehrin 39 mahallesinden 22 mahallesi farklı ölçüde etkilenmiştir. Bu yönü ile Batman şehri hidrografik açıdan yüksek riskli bir alandır. İluh Deresi Havzası'nın Fiziki Coğrafya özelliklerine bağlı oluşan sel ve taşkınların, Batman şehrinde bazı yıllar afet boyutunda etkili olmasında hatalı imar uygulamaları, kaçak yapılaşma ve plansız şehirleşme de etkili olmuştur. Bu faktörlerin etkisini ortaya koymak için şehir merkezinde gözlemler ve taşkından etkilenen mahallelerde hane halkı anketleri yapılmıştır. Gözlem ve anket sonuçlarına göre Batman şehir merkezinde yaşanan sel ve taşkın olaylarının afet boyutunda geniş alanları etkileyerek büyük can ve mal kayıplarına yol açması üzerinde doğrudan belirtilen beşeri faaliyetlerin etkili olduğu görülmüştür.

Anahtar kelimeler: Batman, Türkiye, Doğal afetler, Sel ve taşkın, Beşeri faktörler, Hidrografik riskli alan

1. Introduction

The idea that devastations as a result of natural disasters are due to the social and economic characteristics of the regions where natural hazards occur emerged in the late 1960's (White, 1961, 1964; Kates, 1962; Burton, et al., 1968; Hewitt and Burton, 1971). However, the role of social and economic structures on natural disasters was not known until the 1970's (Alcantara-Ayala, 2002). At present, the importance of this role has been recognized by both geologists and social scientists.

Located between the Kira and Raman mountains in the Southeastern Anatolia Region of Turkey, Batman city was founded on alluvial fans formed by Iluh Creek and its branches and the terraces of Batman Stream (Figure. 1). With the discovery and extraction of petroleum on Mount Raman in the 1940's and establishment of the first refinery, Batman rapidly developed and gained the status of municipal borough in 1955, country town in 1957, and province in 1990. As a medium-sized industrial city, Batman developed as a result of incoming migrations and various important problems, such as flood and torrent events, emerged over time due to the unplanned nature of this development. These problems include.

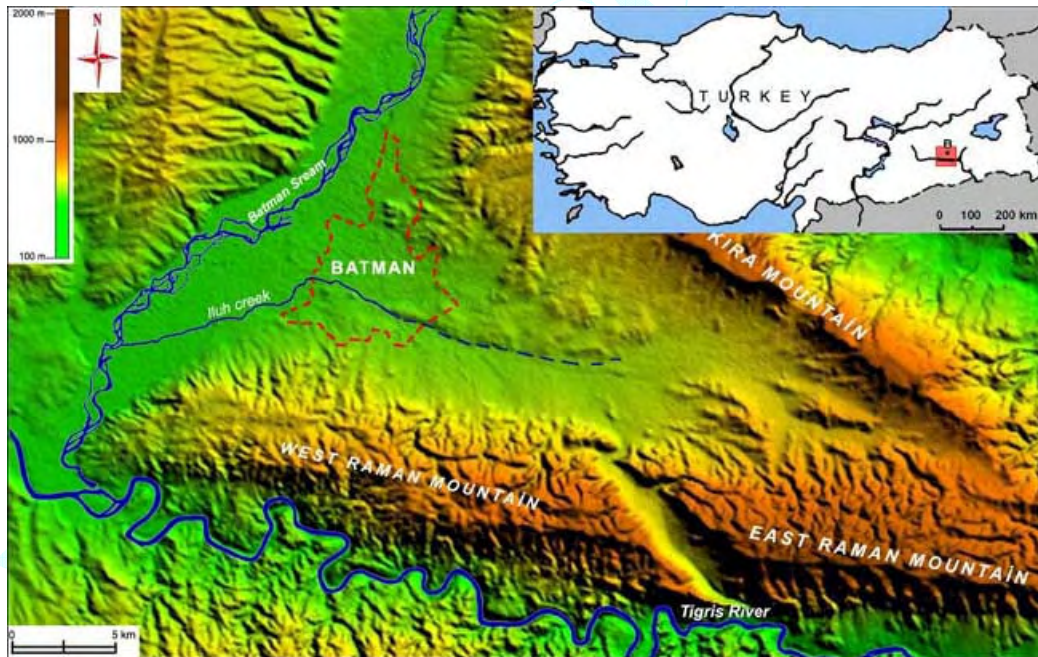


Figure 1. Location map of Batman city

Natural factors which are effective on the occurrence of natural disasters include geomorphologic, lithologic, tectonic, climatic and hydrographic characteristics as well as soil and vegetation properties (Atalay, 1986; Balcı and Öztan, 1987; Strahler and Strahler, 1997; Görcelioğlu, 2003; Turoğlu and Özdemir, 2005). Some of these factors are directly effective

on the occurrence of flood and torrent events while others are indirect. Other than existing favorable natural conditions, human interference is of prime importance on the escalation of floods and torrents to catastrophic level. It is also considered that social and economic systems as opposed to natural properties are also effective on the occurrence of natural disasters (Alexander, 1993).

Major influencing factors in Turkey with respect to flood disaster include improper and illegitimate land use, devastation of forests, and rapid urbanization due to economic developments (Ceylan et al., 2007). In Turkey, rapid population growth has given rise to unhealthy and unplanned urbanization. This increases the intensity of population and industry in areas which are sensitive to flooding. With the construction of new roads and establishment of new businesses in such settlements, the structure of the land changes and forests and pastures are destroyed. This gives rise to disturbance of the geomorphologic and hydrological balance and thus occurrence of floods and torrents that cause loss of life and property (Brath et al., 2006; Şahin and Sipahioğlu, 2007; Zhang, et al., 2007).

Population and settlement features, rapid areal development of settlements, rapid urbanization and land use inconsistent with the characteristics of the natural environment cause loss of life and property in such disasters. The fact that flood events in Batman escalated to catastrophic levels and caused great loss of life and property may also be attributed to the destructive and alternative effect of human beings over the natural environment. Şahinalp (2007), for instance, stated that human factors had a role in the flood event experienced in Şanlıurfa in the autumn of 2006.

The occurrence of floods and torrents in the area where Batman city was founded may be considered as natural. Batman is located in a region where intense downpours fall in the spring due to climatic characteristics of the region. In this regard, flood and torrent events may occur every spring. However, the frequency of flood and torrent events in Batman has increased in recent years. The flooding of Iluh Creek started to damage its neighboring areas after 1970 and caused 10 deaths in 2006. The flood and torrent events occurring before 31 October-1 November 2006, the day of the last flood disaster, had only caused material damage.

It is striking that population and settlement characteristics have rapidly changed in the vicinity of Batman despite no change in physical–geographical conditions. There is a close relation between man-made changes in landscape and increase in the intensity and frequency

of flood and torrent events. The rise in efficiency of flood and torrent events is a direct outcome of rapid urbanization. Studies on hydrologic changes due to urbanization clearly suggest that urban development causes floods to occur more frequently and to affect broader areas (Leopold, 1968). The escalation of the last flood event to catastrophic levels in Batman has demonstrated the importance of human factors, which have proved to be more effective on the occurrence of flood and torrent events compared to factors within the scope of Physical Geography.

Certain physical geographical factors causing flood and torrent events on the Basin of Iluh Creek in Batman were evaluated recent by Tonbul and Sunkar (2008) and Sunkar and Tonbul (2009, 2010). This study aims to research the effect of human factors, such as rapid population growth, improper construction practices and illegal housing, on the occurrence of flood and torrent events in Batman.

2. Methodology and Data

In order to reveal the effect of improper construction practices, illegal housing and other human factors in Batman, studies were carried out on the Basin of Iluh Creek and inside the city to determine the characteristics of overall land use, vegetation and settlement. Observations and explorations were performed in the city on a district-by-district basis and the locations of creeks affecting the overall city were determined. Field studies, topographical analyses, satellite images and geographical information systems (GIS) were utilized in order to fully understand the variations and reconstructions of the streams within urban areas. In such evaluations, reference was also made to previous studies (Hooke and Kain, 1982; Graf, 1975; Graf, 2000).

Data from censuses in Batman city were analyzed and population and settlement characteristics were determined. The following formula was used for the calculation of population growth rate according to censuses:

$$\text{AGRP} = [(\ln P_{n+t} / P_n) / t] * 1000]$$

AGRP = Population growth rate (%o), **P_n** = Population at **n** date (initial period), **P_{n+t}** = Population at **n+t** date (t years later), **ln** = Natural Logarithm, and **t** = time period between two dates (in years).

Historical information and documents were compared with old construction plans and the foundation and development periods of the city were determined. This is shown on the new construction plan using GIS. In order to determine the effect of human activities on the occurrence of flood and torrent events in Batman, surveys were also conducted in districts affected by torrent and flood events. These surveys were applied to more than 100 dwellings in districts most affected by the flood and torrent disaster occurring on the night of October 31-November 1 in the autumn of 2006. The first part of the survey (totaling 30 questions) included questions related to the size and economic structure of the household; the second part included questions about migrations; and the last part included questions regarding flood and torrent events. The survey results were analyzed using SPSS program and then evaluated.

Population data for the Batman city for the period 1935 to 1990 were obtained from the censuses of the Prime Ministry State Institute of Statistics (SIS) and that for the period 1990 to 2008 from the Turkish Statistical Institute (TSI). Data on settlements were received from the Municipality of Batman.

3. Results and Discussion

3.1. Effect of Population Movements on Flood and Torrent Events

Batman, which was once a village in the area now covered by the district of Iluh, rapidly developed due to its petroleum reserves and gained the status of province (Figure 2, 3). Rapid population growth in Batman is primarily based on economic and social factors. The former is related to economic activities developing with the establishment of petroleum-based industrial plants, whereas the latter is concerned with the migration of people living in rural areas to the city due to separatist actions in their districts. As a result of these events, Batman received considerable migration in a short time and developed in an unplanned manner. Due to rapid and unplanned development, a marked increase has occurred in the frequency of floods and torrents in the city. The extent of the area of impervious surfaces has expanded through urban development. According to natural hydrological phenomena, due to increased impervious area precipitation responds quickly reducing the time to peak and producing higher peak-flows in the drainage channels (Nirupama and Simonovic, 2007). When the pre- and post-development situation was compared, it was observed that the enlargement of impervious surfaces caused an increase in the frequency of flood events and maximum flow rate (Booth, 1991).



Figure 2. General view of Batman city, from north towards north-west (1990s) (Directorate of Press, Governorship of Batman)



Figure 3. Batman (Iluh) and Petroleum Refinery in 1960s. At this date, only Iluh and Çarşı districts existed in the area where Batman city was founded (Governorship of Batman, <http://www.batman.gov.tr/fotograflar/Nostalji/index.html>)

Flood risks could increase as a result of potential changing climate worldwide (Frei et al. 2000; Milly et al. 2002; Kundzewicz et al. 2005). However, it is unclear whether or not the increasing flood damage is a consequence of changing climate or human activities such as intensive land use along and on floodplains (Pielke and Downton 2000; Changnon 2003). Flood risk can also accelerate as a result of rapid urbanization (Teng et al. 2006; Nirupama and Simonovic 2007). Urbanization is an important factor with regard to both the increase in global climate change and the number and effect of flood events (Karakuyu (2004).

According to census data, the population in Batman has increased steadily and rapidly (Table 1; Figure 4, 5). This population growth in the city is due to the social and economic developments described above. It is clearly observed in the censuses that Batman city has received considerable migration and thus developed (Table 1).

Table 1. Population, growth, and growth rate by census year in Batman

| Census Year | Population | Growth by Number | Census Period | Population Growth Rate (%) |
|-------------|------------|------------------|---------------|----------------------------|
| 1935 | 319 | - | 1935-1940 | 49.70 |
| 1940 | 409 | 90 | 1940-1945 | 15.97 |
| 1945 | 443 | 34 | 1945-1950 | 145.07 |
| 1950 | 915 | 472 | 1950-1955 | 327.83 |
| 1955 | 4.713 | 3.798 | 1955-1960 | 193.49 |
| 1960 | 12.401 | 7.688 | 1960-1965 | 140.13 |
| 1965 | 24.990 | 12.589 | 1965-1970 | 117.59 |
| 1970 | 44.991 | 20.001 | 1970-1975 | 71.68 |
| 1975 | 64.384 | 19.393 | 1975-1980 | 58.29 |
| 1980 | 86.172 | 21.788 | 1980-1985 | 48.89 |
| 1985 | 110.036 | 23.864 | 1985-1990 | 85.55 |
| 1990* | 168.779 | 58.743 | 1990-2000 | 48.01 |
| 2000* | 272.787 | 104.008 | 2000-2007 | 10.22 |
| 2007* | 293.024 | 20.237 | 2007-2008 | 17.98 |
| 2008* | 298.342 | 5.318 | 2008- | |

Source: General Censuses (1935-2008) from Turkish State Institute of Statistics (SIS), *TSI Data

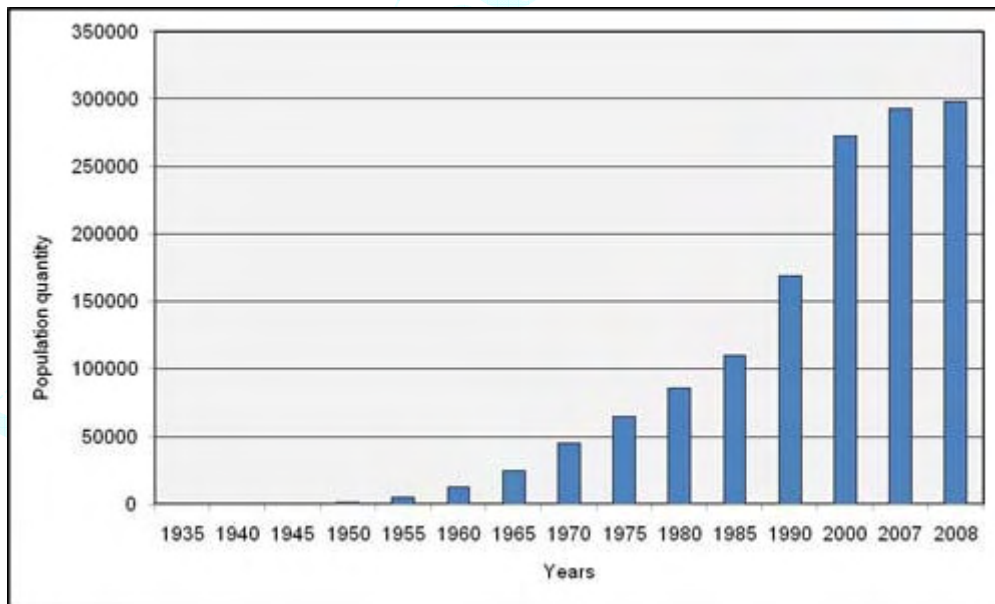


Figure 4. Population growth in Batman according to census data

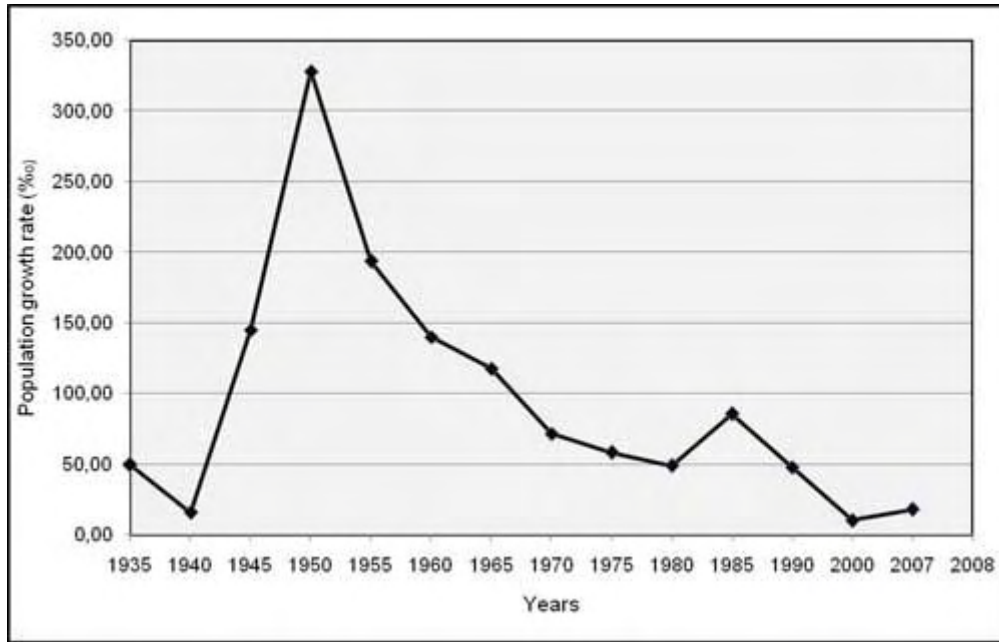


Figure 5. Population growth rate in Batman according to census data

The rapid population growth in Batman city after 1970 is due to the social and economic factors described above. The following observations may be made:

1. Population growth in Batman in the period 1945 to 1950 may be attributed to petroleum exploration, establishment of the first refinery, and construction of the railway. The rapid population growth after this period is based on industrial investments due to the extraction of petroleum. The establishment of the modern refinery in 1966 caused the population to double in the period 1965 to 1970 (Table 1; Figure 4). Batman was the newest mining town in Turkey in the late 1960's. During this period, 39% of the active population was engaged in the extraction of petroleum and 10% served in the industrial sector (Tümertekin, 1973).
2. The rapid population growth in Batman up to 1970 was based on incoming labor migrations due to the extraction of petroleum and establishment of two refineries. The effect of petroleum is seen even after this period. According to the census results for 1980, Batman is characterized as a city of public utilities and geographical urban settlement (Meşeli, 1993).
3. The high rate of population growth in Batman up to 2007 may also be attributed to an increase in petroleum-based investments and migrations from rural to urban areas (Figure 5). 48.6% of migrations to the city center of Batman were by those seeking

employment and 26.2% were for safety purposes (Table 2). A large proportion of migrations for employment were petroleum-related.

Table 2. Reasons for migration of population living in districts most affected by flooding in Batman in autumn 2006 (Household survey, 2008)

| What is the reason for your migration to Batman? | Frequency | Percentage (%) |
|--|-----------|----------------|
| 1 Employment | 52 | 48.6 |
| 2 Education | 5 | 4.7 |
| 3 Health | 13 | 12.1 |
| 4 Safety | 28 | 26.2 |
| 5 All | 9 | 8.4 |
| Total | 107 | 100 |

Rapid population growth in Batman from 1945 to 2007 brought about unplanned development and urbanization. The irregular distribution of urban population in districts indicates rapid and unplanned urbanization (Figure 6). The density of population caused the characteristics of the natural environment to change rapidly. Especially from 1990 onwards, the stream beds were occupied by settlements after migrations from rural to urban areas for safety reasons. During this period, the poor economic conditions of the population arriving through migration promoted illegal housing. The results of surveys conducted in the districts most affected by the flood event reveal that 63.7% of dwellings were not registered in the land register (i.e. they can be categorized as illegal housing) due to the poor economic situation of the inhabitants (Table 3). Consequently, the rapid population growth in Batman due to petroleum caused the flood and torrent events to escalate to catastrophic levels.

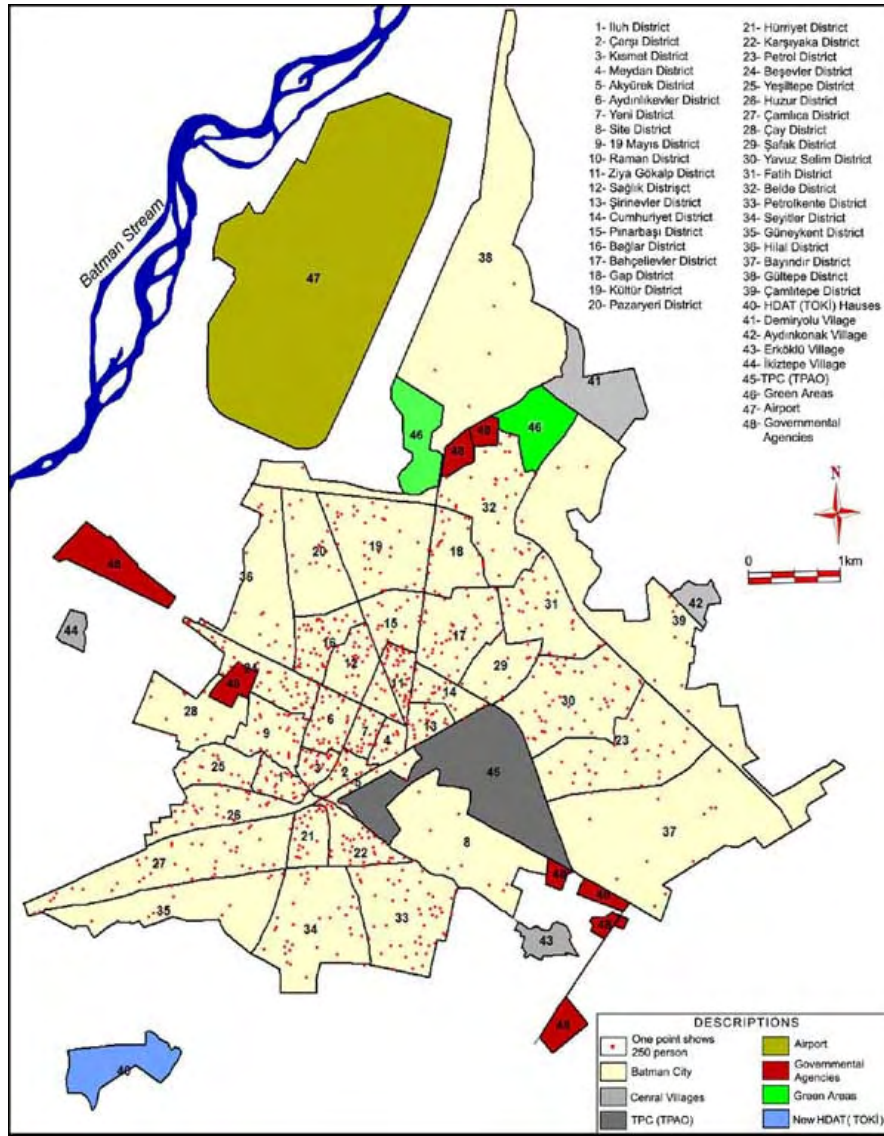


Figure 6. Distribution of population by district in Batman city (one point indicates 250 individuals). It can be seen that the population is centered around the central districts. The density of population is also high in the districts of Petrolkent, Karşıyaka, Hürriyet, İlüh, Çarşı, 19 Mayıs, Çay and Yeşiltepe, which are under high risk of flood.

Table 3. Status of property in districts most affected by flood in Batman in autumn 2006 (Household survey, 2008)

| Is your dwelling registered on the land register? | Frequency | Percentage (%) |
|---|-----------|----------------|
| Yes | 39 | 36.3 |
| No | 72 | 63.7 |
| Total | 113 | 100 |

3.2. Effect of Selection of Inappropriate Settlement Area on Flood and Torrent Events

The development, size and functional characteristics of city centers are largely due to natural conditions. One or a number of characteristics, such as elevation, climate, geographical formations, exposure, soil and hydrography, are of primary importance with regard to the selection of settlement areas (Özdemir and Karadoğan, 1996). In addition, both physical and human factors are effective on the population and settlement characteristics (Tolun-Denker, 1977). Petroleum extraction and industrial investments have played a role on the foundation and development of Batman city. The city has developed around the refinery area, which is not suitable for settlement (Figure 2).

When the pre- and post-1970 expansion areas of Batman city were compared, important results were obtained (Figure 7), which, in particular, include aerial growth. With aerial growth and development and interventions in the stream bed of Iluh Creek, the volume of the bed was reduced. The stream beds of side creeks linked to Iluh Creek in the city were destroyed. This resulted in the overflow of Iluh Creek and caused other creeks to flood as a result of intense precipitations.

As a result of the continuing wave of migration, the stream beds were allocated for construction of housing as per Article 18 of municipal housing plans. Therefore, a large part of the population settled in stream beds under high risk of flooding. This process was completed within approximately 30 years and some of structures were licensed. As residents living in the area exposed to the 2006 flood event are familiar with the existing situation, they do not think that the area of their dwellings is safe. According to household interview surveys conducted in the area exposed to the flood event, 65.5% of households was of the opinion that the area in which their dwellings are situated is unsafe (Table 4).

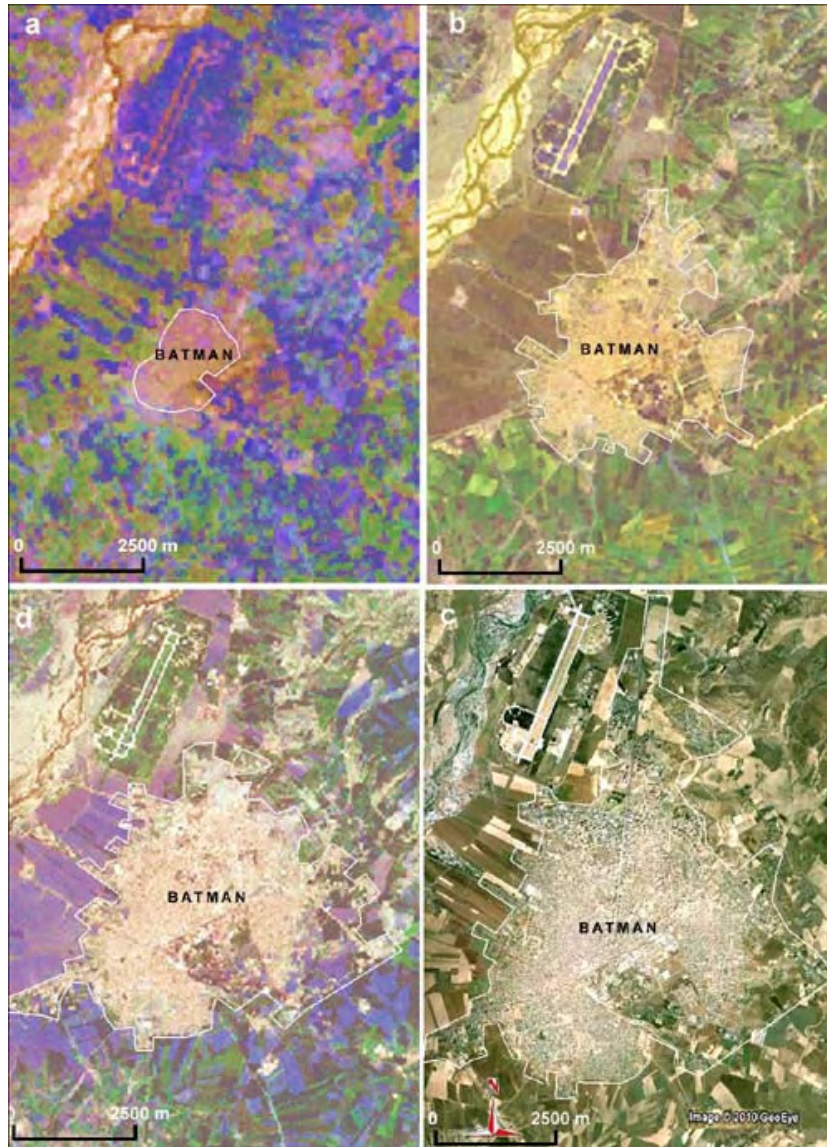


Figure 7: Historical development of Batman city according to satellite images. a, b, c) Landsat images (1,2,3 bands), d) Google Earth image, a) 1975, b) 1990, c) 2002, d) 2009 images

Table 4. Views on dwelling location of residents in districts most affected by flood in Batman in autumn 2006 (Household survey, 2008)

| What is the safety status of your dwelling(s) against natural disasters? | Frequency | Percentage (%) |
|--|-----------|----------------|
| 1 Safe | 15 | 13.3 |
| 2 Unsafe | 74 | 65.5 |
| 3 I have no idea | 24 | 21.2 |
| Total | 113 | 100 |

Flood and torrent events occurring in Batman before 2006 did not cause great loss of life and property. These historical events are the precursor of greater disasters. In addition,

38.9% of the population affected by the flood and torrent event in 2006 anticipated that they would be exposed to such a disaster one day (Table 5).

Table 5. Anticipations on flood and torrent events by residents living in districts most affected by flood in Batman in autumn 2006 (Household survey, 2008)

| Did you anticipate that the flood and torrent event in 2006 would affect you? | Frequency | Percentage (%) |
|---|-----------|----------------|
| 1 Yes | 44 | 38.9 |
| 2 No | 53 | 46.9 |
| 3 I have no idea | 16 | 14.2 |
| Total | 115 | 100 |

Iluh Creek flooded at various times during the development process of Batman city. However, these flood events were ignored as they only affected a number of dwellings located around the stream bed of Iluh Creek. Iluh Creek and its side branches used their former stream beds and thus reached maximum level in the last flood event in 2006. 51.3% of families affected by the flood and torrent event in 2006 did not think of abandoning their dwellings (Table 6).

Table 6. Views on dwelling abandonment by residents in districts most affected by flood in Batman in autumn 2006 (Household survey, 2008)

| Would you think of abandoning unsafe dwellings? | Frequency | Percentage (%) |
|---|-----------|----------------|
| 1 Yes | 55 | 48.7 |
| 2 No | 58 | 51.3 |
| Total | 115 | 100 |

Rapid population growth within the last three decades has also caused settlement characteristics to change. Within this period, the area of the city has expanded in parallel with the increase in the number of dwellings. Batman city is divided into two parts with regard to settlement characteristics. The area on the north side of Iluh Creek has new and modern settlement patterns whereas the area to the south has historical settlement characteristics. Both sides of Diyarbakır Avenue and the areas newly zoned for settlement in the most northern part of the city are districts covered by modern buildings constructed in recent years (Figure 8).



Figure 8: Dwelling types in different districts of the city center of Batman. a) Multi-storey buildings constructed in the north of the city in recent years and single-storey dwellings in the south. b) Dwellings constructed illegally and severely damaged in the flood disaster of 2006. c) Modern buildings constructed in the northern part of the city in recent years.

The area bordering Iluh Creek generally comprises single-storey earth dwellings as it is an old settlement center. Due to the poor economic status of the population living in the areas neighboring Iluh Creek, single-storey and brick dwellings are common in these areas.

Furthermore, materials not resistant to natural disasters were used for the construction of dwellings around Iluh Creek. These dwellings are not resistant to flood and torrent events. All the dwellings heavily damaged or destroyed in the autumn of 2006 were those made of adobe brick and briquette (Figure 9).



Figure 9. Dwellings made of adobe brick and briquette on the stream bed of Iluh Creek that were affected by the flood in Batman in 2006.

The fact that more than 50% of dwellings in the flood area are made of adobe brick and briquette (Table 7) indicates that great damage will occur after a possible flood/torrent event. Furthermore, as the settlement plan of the city center is an old one, the city is comprised of small and narrow streets. This played a role in the escalation of the flood.

Table 7. Dwelling types in districts most affected by flood in Batman in autumn 2006 (Household survey, 2008)

| What is your dwelling type? | Frequency | Percentage |
|-----------------------------|-----------|------------|
| 1 Adobe brick | 12 | 10.4 |
| 2 Briquette | 51 | 44.3 |
| 3 Brick | 52 | 45.2 |
| Total | 115 | 100 |

Poor people coming from rural areas have preferred to live in parts of the city which have similar environmental characteristics to rural areas. A large proportion of the residents in these areas, generally comprising two-storey dwellings, are engaged in agriculture and animal breeding. It is striking that even though the Batman city exhibits urban characteristics, the number of barns in the neighborhood districts is high. This has arisen from the settlement of rural people whose livelihood is animal breeding moving to the urban areas. The destruction of more than 6000 ovine and bovine animals in the 2006 flood event is evidence of this situation.

3.3. Effect of Stream Beds permitted for Settlement on Flood and Torrent Events

The district of Iluh, which was the original center and growth core of Batman city, was founded on higher terraces of Batman Stream as that locality does not pose a flood risk. However, the continuous growth of Iluh village caused areas unsuitable for settlement, especially the stream beds of Iluh Creek, to be permitted for settlement (Figure 10).



Figure 10. Settlements constructed on the flood bed of Iluh Creek affected by the flood event in 2006. a) Dwellings constructed adjacent to the canal in the district of Karşıyaka. b) Dwellings restored and re-occupied after the flood event.

As the level of education of the population is rather low and the water level in the creeks is seasonal in the area where the city was founded, the stream beds dried up in arid periods and ceased to exist. The stream beds were included in city plans as agricultural lands and then cultivated, which constitutes the second reason for the destruction of these beds. As the stream beds were not apparent and classified as agricultural lands, people settled in these areas (Figure 11). Due to the topographical structure, the buildings of official institutions such as schools and civic buildings were constructed in these areas.

In cadastral documents, the stream bed was described as narrow and the flood bed was recorded in the land register as agricultural land. Therefore, the population coming from rural areas settled along the flood bed of Iluh Creek. Such was the extent of this habitation that settlements constructed in the village of Erköklü caused the stream bed of Iluh Creek to shift and move out of its natural bed. This was detected after GPS measurements (Figure 12).



Figure 11. Dwellings constructed on a stream bed in the district of Karşıyaka and flood prevention works carried out in Street 311 after 2006.

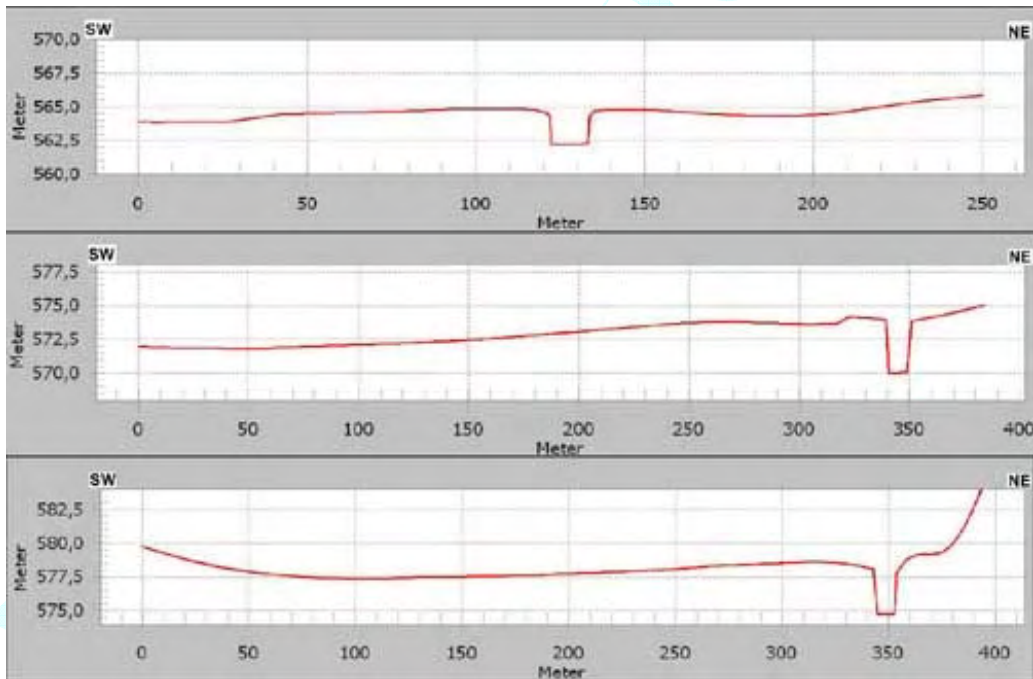


Figure 12. Profiles from east to west (northeast to southwest) according to GPS measurements of the Iluh Creek bed at entrance to the city. As seen, the canal of Iluh creek has shifted out of its natural bed.

The stream beds (including Iluh Creek) located in Batman have been occupied by industrial plants and dwellings (Figure 13). This is due to squatting and illegal housing in

recent years. There are two forms of illegal housing in these districts. The first includes dwellings constructed directly on the stream beds and the second includes unauthorized buildings on private registered lands. Both situations have brought about unplanned urbanization. According to the results of surveys conducted in the districts named Çay, 19 Mayıs, Kısmet, Çarşı, Hürriyet, Karşıyaka and Petrolkent, the rate of illegal housing in this area is high. The dwellings of 63.7% households that participated in the survey are not recorded in the official land register (Table 3).



Figure 13. Savaro (Dodik) Creek affecting the southern part of Batman city. It is seen that the stream bed is wide at the entrance of the city but appears narrow in the district of Hürriyet. a) Wide bed of Savaro Creek at the entrance of the city. b) Status of Savaro Creek in the district of Hürriyet.

Rapid and unplanned development of the city caused sections of side branches linked to Iluh Creek, which are within the city, to disappear. Therefore, the connection of side branches to Iluh Creek was cut and the stream beds were occupied by streets, avenues and dwellings (Figure 10, 11, 13). This causes flood events to reach catastrophic levels even in medium downpours. The areas connecting Şakuli Creek to Iluh Creek were zoned for construction as per the revised city construction plan of 2006 and this indicates that no lesson was learnt from the flood event in 2006 (Figure 6).

With the construction of Turkish Petroleum Corporation (TPC) facilities, the connection of Çay Creek with Iluh Creek was cut. Consequently, the waters of Çay Creek accumulated in front of the concrete walls surrounding these facilities, followed the main road, and threatened the city center in when flooding occurred. The concrete walls were demolished by the authorities and a path opened for water to flow through in the flood event of autumn 2006 in order to save other districts in the city center. After the situation had been

considered to have returned to normal after the flood event, the walls which were torn down were rebuilt (Figure 14). Therefore, the probability of further floods was again ignored.



Figure 14. Retaining wall of Turkish Petroleum Corporation facilities demolished in the flood event on October 31-November 1 2006 and later rebuilt.

3.4. Canal of Iluh Creek and Engineering Failures

As a result of floods, whose frequency and severity has increased after 1970, the improvement of Iluh Creek was continually discussed but a new canal was completed only as late as 2005. This indicates that the possibility of flood events was underestimated and given insufficient importance. The width of the canal constructed during improvement works on Iluh Creek, completed in 2005, is not adequate. The construction of the canal, necessarily of a small size, may be due to the dwellings and private properties occupying the stream beds. As this problem was not overcome through expropriation of land, the new canal was formed of sinuous structures in many areas (Figure 15). Sinuous curves cause the water in the stream bed to overflow the canal. The new canal, which was constructed according to a maximum flow rate of $151 \text{ m}^3/\text{s}$ (BLBIP), is not so large considering the basin area. Despite the inadequateness of the canal constructed within the scope of improvement works, it prevented further loss of life and property in the flood event experienced in 2006. The construction of an earth-lined canal at the exit of the city prevented further damage to rural settlements and agricultural areas located outside the city.



Figure 15. Sinuous structures on the canal of Iluh Creek between the districts of 19 Mayıs and Yeşiltepe.

Sinuous curves arising out of necessity in the construction of Iluh Creek canal decrease the water-carrying capacity of the canal. These structures, which form angles of approximately 90 degrees in some areas, further increase the risk of flooding since they serve as embankments in a flood period. The water flowing through the canal slows down after running against these structures and thus easily overflows the canal. In addition, debris the materials carried by water are accumulates in the area of the slowdown and thus the volume of the canal is reduced and the severity of the flood increases. In the flood event of 2006, the canal of Iluh Creek filled up and flood water spread over the surrounding area in a short time (Figure 16). The risk of flooding on stream beds crossing the canal is relatively more than normal stream beds (Leopold, 1968). The higher level of canals in the western part of the city, as compared to the east, is also an important factor with regard to the spread of flood water over the nearby area.

People living in areas bordering the canal use it as a refuse site (Figure 17). As waste materials in the districts around the canal are not regularly collected, people of necessity resort to this method. In the course of carrying out our field survey, residents stated that there were no garbage containers in some streets in their districts and their waste materials were not collected. Waste materials dumped into the canal throughout the summer adhere to the ground and thus decrease the water-carrying capacity of the canal. Consequently, even though the volume of water flowing through the canal corresponds to the capacity of the canal, it overflows and affects neighboring buildings. This negative consequence has continued even after the 2006 flood event. Residents living alongside the canal continue to dump their waste materials into the canal and the Turkish Petroleum Corporation (TPC) discharges their waste waters into the canal. This results in high pollution in the summer.



Figure 16. Canal of Iluh Creek flowing through city center of Batman that filled up with flood debris in the flood event on October 31-November 1, 2006.



Figure 17. The volume of the Iluh Creek canal is reduced and negative environmental conditions prevail in the summer as the creek flowing through the city center is filled up with domestic waste. a) Even though garbage containers are available in the district of Iluh, domestic wastes are dumped into the canal. b) In the district of 19 Mayıs, waste materials are dumped into the canal in areas where no garbage containers exist.

Sewage discharged into the canal in the summer is used for irrigation of agricultural land in the lower parts, leading to negative consequences. The soil irrigated with this water, posing a considerably high risk of pollution, is disturbed and results in unhealthy products being grown.

4. Conclusions

Even though physical-geographical characteristics are effective on the occurrence of floods and torrents, human factors are of importance with regard to the escalation of these events to catastrophic levels. The role of economic and social structure on the occurrence of natural disasters was not known until the 1970's. After this period, it has been recognized that social and economic conditions are as effective as natural characteristics on the occurrence of disasters in urban areas. These factors have been divided into four main groups, including social, economic, political, and cultural factors (Alcantara-Ayala, 2002).

The streams in an arid region, especially dynamic ones, may cause fallacies with regard to urbanization. These streams may be effective in a different manner compared to those in temperate zones (Chin, 2006). On the other hand, the case is rather different in semi-arid regions, including Batman city. The variable characteristics of the amount and regime of precipitation in arid regions give rise to the formation of temporary streams. This causes great fallacies with regard to urbanization. However, the climatic characteristics of semi-arid regions give rise to the formation of seasonal streams. The beds of seasonal streams are apparent to some degree. Therefore, the streams in semi-arid regions do not cause fallacies as in arid regions. The occurrence risk of floods and torrents in cities located in semi-arid regions is due to planning failures. The destruction of stream beds in cities located in the Southeastern Anatolia Region of Turkey is based on improper construction practices, semi-arid conditions, and geomorphologic characteristics.

Improper construction practices, illegal housing, and human factors were effective on the catastrophic escalation of flood and torrent events in settlement areas after the intense precipitation in the Southeastern Anatolia Region of Turkey in the autumn of 2006. In recent years, migrations from rural to urban areas have caused rapid and unplanned development of cities. Stream beds have become occupied by dwellings. This negative circumstance with respect to the characteristics of the natural environment gives rise to the occurrence of flood and torrent events.

Human factors are directly effective on the occurrence of urban floods. Physical-geographical characteristics of the Iluh Creek are effective on the occurrence of flood and torrent events in Batman while human factors have a role in the escalation of these events to catastrophic levels. Rapidly developing due to petroleum reserves, Batman city has grown in an unplanned manner as a result of improper construction practices. Migration from rural to

urban areas in the region in the 1990s for safety and security caused unplanned development of the city. 48.6% of all migrations to Batman were for reasons of employment, 26.2% for safety, and the remaining proportion for education, health and other reasons.

The population migrating from rural areas settled in areas neighboring the city center, which exhibit rural characteristics. These areas were not inspected as they were outside the boundaries of the municipality. The poor economic conditions of the population settling in these areas of the city caused stream beds to be occupied and perishable dwellings to be built. The fact that 63.7% of dwellings in the districts most affected by the flood event of 2006 were not recorded on the land register shows that the stream beds were occupied. 10.4% of dwellings in these areas were made of adobe brick and 44.3% were made of briquette. This constitutes another problem with regard to flood and torrent events.

Furthermore, the stream bed of Iluh Creek shifted and moved out of its natural bed. Industrial enterprises established as Batman city developed gave rise to the location of industrial plants on stream beds.

Therefore, it can be said that human factors are directly effective on the catastrophic escalation of flood and torrent events occurring in Batman due to the physical-geographical characteristics of Iluh Creek.

In conclusion, Batman city is a high risk settlement area with regard to hydrography. Therefore, it is essential for hydrographic risk reports to be carried out in addition to the ground studies and reports employed in regular construction practices.

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