DETERMINATION OF NATURAL DISASTER BY INTEGRATION OF REMOTE SENSING AND GIS: THE YENİÇİFTLİK STREAM BASIN MODEL IN ISTANBUL, TURKEY

İrfan Akar[a]*, Cihan Uysal[b], Derya Maktav[b]

Aatatürk University, Institute Of Social Sciences, Erzurum, Turkey, Irfanakar@Gmail.com
[b] ITU, Civil Engineering Faculty, 80626 Maslak Istanbul, Turkey, (uysalc,maktavd)@itu.edu.tr

KEY WORDS: Remote Sensing, GIS, Disaster, Yeniçiftlik Stream, DTM, IKONOS, LANDSAT.

ABSTRACT:

Various methods have been developed to minimise the consequences of natural disasters. GIS and Remote Sensing methods are very attractive, fast and reliable tools for various natural disaster applications and management. In this study, we investigated natural disasters such as flash-floods, floods, erosion and landslide risks, which have occurred, and are likely to do so again, in a study area in Istanbul, to determine the potential use of these methods with respect to these disasters. Disasters which caused loss of life and property in the Yeniçiftlik stream basin, located within the boundaries of Beykoz, a suburb of Istanbul, attracted our attention owing to their particular negative impact on human life and activities. This was selected as the study area. Many geographical parameters, such as vegetation, topographical and geological features, precipitation and land use features played a significant role in the occurrence of other kinds of disasters triggered by flash-floods and flood-related incidents. The data used were topographical, soil, vegetation and geological maps with a scale of 1:25000 (LANDSAT TM (01.08.1987), LANDSAT ETM (28.08.2000), IKONOS (02.03.2008)), and aerial photographs taken in 2006. Geological, soil and vegetation data were converted into raster format by Arcinfo 9.1 software for use in analysis. Land use and vegetation features were determined by the application of a supervised classification technique to IKONOS data. Drainage network morphometric changes were derived from DTM and topographic maps. Land use changes were determined from LANDSAT-TM (1987) and LANDSAT-ETM (2000). Risk maps for landslides, flash-floods, floods and erosion were created in which different weights were assigned to vegetation, geological features, land use, and other geomorphological features, such as slope, aspect, etc.

1. INTRODUCTION

Floods and flash-floods, as well as disasters of hydrographic origin triggered by them, are some of the most destructive disasters in terms of loss of life and property (CEOS, 2003). In developing and underdeveloped countries particularly, the effects can be devastating (Smith, 2003). Among the natural disasters that occur in Turkey, floods and flash-floods are second only to earthquakes in terms of the destruction they cause (BDAKBM, 1997). GIS and Remote Sensing (RS) are the most commonly-used technologies in applied studies today. GIS and RS have significant advantages in reaching numeric, accurate and reliable information in relation to disasters of hydrographic origin., Advances in satellite technologies in particular enable researchers to study the progress of natural disasters immediately prior to, during and after their occurrence. Data obtained with RS can be assessed and analysed by GIS media. The purpose of this study is to research and evaluate the causes and consequences of recent natural disasters in the Yeniçiftlik stream basin and suggest possible solutions (Figure 1) and precautionary measures.

2. METHOD AND DATA

Creation of base maps is a significant stage in the risk zoning of the study area (Van Westen, 1993). Topographical maps with a scale of 1:25000, aerial photos, IKONOS pan-sharpened (02.03.2008) satellite imagines, numeric geology and soil maps with a scale of 1:25000 are the data used for the risk analysis. A triangulated irregular network (TIN) is generated from the topographical base created and the 3D Analyst module of ArcGIS 9.1 software from the numeric map. A Digital Terrain Model (DTM) model with a raster data structure is created from the 3D Analyst module from the TIN model. Training and aspect maps are generated by Surface, which is included in the 3D module. The vegetation, land utilisation characteristics and geological data are converted into the raster data structure for purposes of analysis. Parameters pertinent to disaster types of hydrographic origin in the study area are assessed and weight value assigned to each of them (Table 1). Weight values range between one and ten. Those closer to one carry the least risk, and those closer to ten carry the highest risk. The reclassify module of the Spatial Analyst module is used for applications at this stage. Owing to the fact that the impacts of parameters on relevant by means of this module. The overlay process is realised from this value assignment.

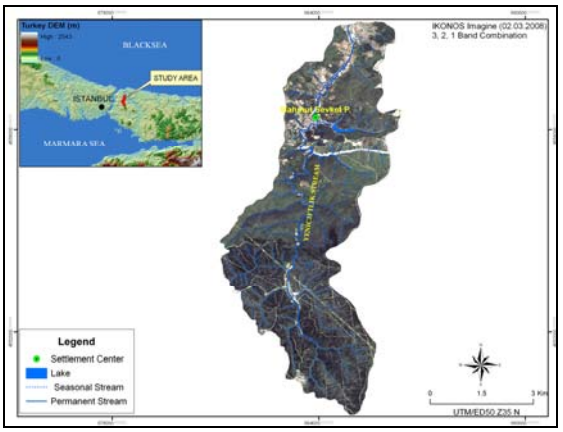

Figure 1. Map and IKONOS pan-sharpened data (2008) of the study area.

3. DETERMINATION OF CERTAIN NATURAL DISASTER RISKS IN THE YENIÇIFTLIK STREAM BASIN

Owing to its physical and human geography, the Yeniçiftlik stream basin faces certain disaster risks. The most important of these are of hydrographic origin. This disaster class includes floods, flowing, flash-floods, erosion triggered by them, and any type of mass movements (Zezere, 2002). In determination of the risky areas, the parameters are studied singly and different weight values assigned to each one (Table 1). Basic elements of the risk zoning comprise the geographical characteristics of the basin and the features of disaster types. Geographical features have been taken into consideration in determination of the areas under risk.

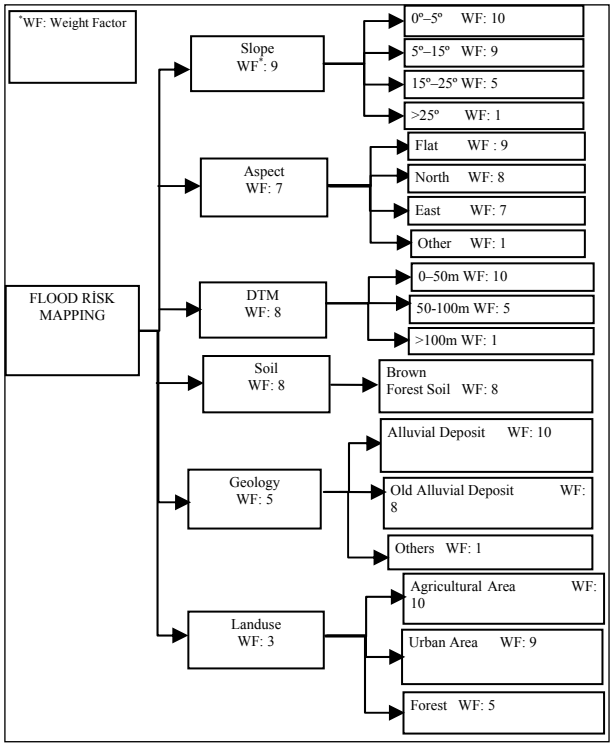

Table 1. Weight factor values applied to risk zoning.

3.1. Yeniçiftlik Stream Basin Flood Risk Zoning

Flood is a disaster of hydrographic origin (Hyndman and Donald, 2006). In the risk zoning conducted in relation to the study area, the factors in the occurrence of flood disaster and its magnitude, as well as the level of affectivity, have been taken into consideration. Parameters are assessed in GIS media and a flood risk map has been created. Five different zoning degrees are selected for flood disaster risk. When the flood risk

results are assessed, it can be seen that it is effective in fields where the slope values are particularly high and the vegetation becomes sparse. It is observed that this risk is extremely high at the south-east part of the Yeniçiftlik stream valley. The increased risk inside the valley compared with other parts is related to the high level of slope values. It is apparent that the flood risk is quite high at the closest parts to the settlement areas; a flood disaster in these areas could therefore lead to damage which could be classed as significant. In addition to these areas, severe damage may occur in cases where there is excessive water, where slope conditions increase and the river exceeds the carriage capacity of its bed. When considered in general terms, the study area has a potential which could be considered as significant in terms of flood disaster. It is essential to analyse this feature carefully and take prompt and appropriate precautions.

3.2. Yeniçiftlik Stream Basin Flash-Flood Risk Zoning

Flash-floods are among the types of disasters which have important negative impacts across the world and in Turkey particularly (Ozdemir, 2006). Although the primary factors determining the risk of flash-flooding, or inundation, are the geomorphological characteristics of the basin, the excessive precipitation, land use and modifications made to the river-bed, and destruction of the vegetation also have significant impacts. The human activities in the basin have also played a role in directing the disaster and increasing its magnitude. A flash-flood risk map has been prepared in line with the methods applied in GIS media (Figure 2). Flash-floods that occur in the Yeniçiftlik stream basin are mainly concentrated along the valley of the Yeniçiftlik stream. The fields where the Mahmut Şevket Paşa settlement and agricultural holdings are located have a very high degree of risk (Figure 7). The lower section of the Yeniçiftlik stream has the most suitable conditions for the emergence and development of flash-flooding. In this regard, in the flood that hit the area on 10 October 2006 around seventy houses and workplaces became unusable. Devastating damage was incurred at the construction site where the Melen stream project of the Istanbul Water and Sewage Administration was ongoing, where 300 people were employed. Six animals were drowned in stalls, one being a goat. Around eight thousand birds perished at a poultry farm. The material loss amounted to 3 million USD.

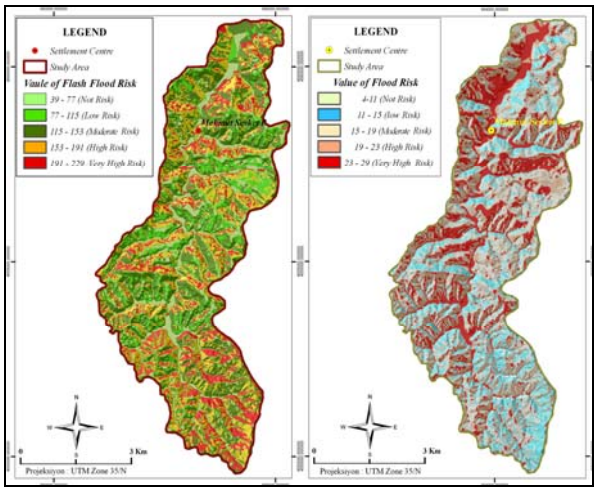

Figure 2. Flood and Flash-flood risk map of the study area.

3.3. Yeniçiftlik Stream Basin Erosion Risk Zoning

Erosion, caused by disasters of hydrographic origin in the Yeniciflik stream basin, can be easily distinguished throughout the basin in all its different forms and erosion magnitude characteristics. Rill and gully erosions on hillsides caused by floods and flowing, erosion that occurs with lateral corrosions on the bed of the Yeniçiftlik stream, and erosion which is caused by flowing waters as these cover and sweep the hillside

can all be counted among the characteristics of erosion that occurs in the basin. In general terms, the geographical characteristics are assessed in GIS media, five erosion risk zonings conducted and risk map prepared (Figure 5). When the map is examined, it can be seen that the erosion activities have peaked in the area where the Mahmut Şevket Paşa settlement is located and on the south sections of the area. This is because the vegetative destruction in the basin is high (Figure 3). The erosion development, which is triggered by flood and inundation, and which is considered as a type of disaster that is directly impacted by the type, magnitude and period of precipitation as well as the destruction of vegetation, appears as the loss of natural resources in the Yeniçiftlik stream basin which are impossible to recover. Destruction of the vegetation increases the corrosive impact of the ground waters on the soil. This could be seen particularly in areas where the slope is high and where soil characteristics are suitable for erosive activities. It was determined by means of satellite images that there had been significant vegetative destruction in the study area over many years (Figure 4). This forest destruction, which is committed in an uncontrolled and unconscious manner, leads to increase of erosive activities, and makes soil gains difficult. The drainage network characteristics of the study area have a significant impact on the erosive activities. There is an increase in the number of gullies in the basin proportional to the difference between the values which emerge in first and second concordances in furcating rates inside the basin and the values which emerge between the highest concordance and the previous concordance (Verstappen, 1983). The relation between the degree of splitting rates of the Yeniçiftlik stream basin shows that there is a high possibility that gully erosion could occur in this basin (Table 2).

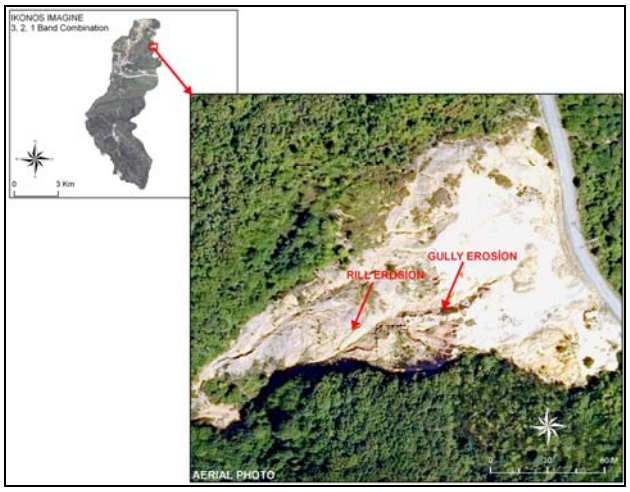

Figure 3. Determination of the erosion in the study area via aerial photos.

Index 1	Index 2	Index 3	index 4
4.2	4.6	6	4.7

Table 2: Degree of splitting rate of study area

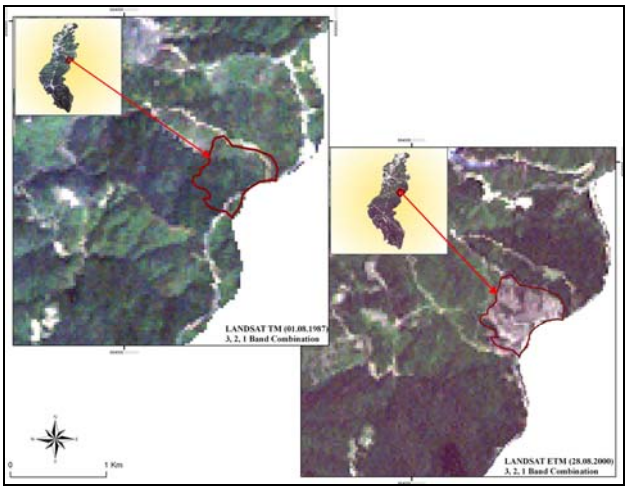

Figure 4. Sample vegetative destruction in the study area (Landsat TM and Landsat ETM).

3.4. Yeniçiftlik Stream Basin Mass Movements Risk Zoning

Among the important disaster types triggered by natural disasters of hydrographic origin are mass movements (Baker, 1988). Mass movements that occur in the study area include slides, breaks, landslides, landslips, etc. The suitable slope conditions, soil characteristics and the stress occurring on the surface have significant impact in the emergence of mass movements in the study area. When we look at the areas which constitute risk, we see that the south-east part of the Mahmut Şevket Paşa settlement and the lower sections of the Yeniçiftlik stream valley, where the agricultural areas are located, are at very high risk (Figure 5). The south-east part generally is at very high risk: in particular, soil which becomes saturated with water constitutes a high risk when coupled with the right slope conditions.

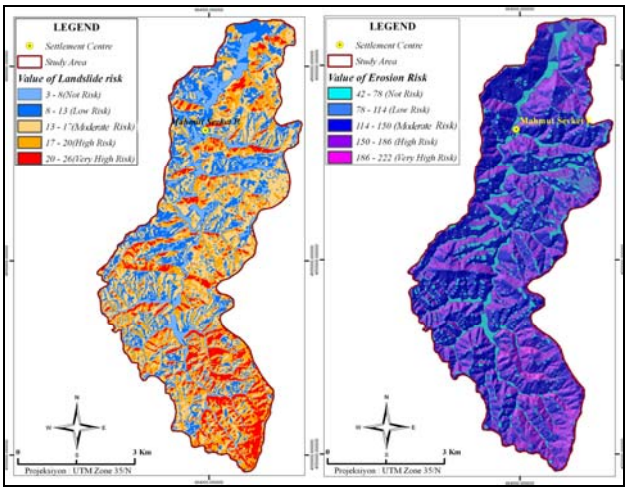

Figure 5. Mass movements in study area and erosion risk map.

4. LAND USE CHARACTERISTICS AND HYDROGRAPHIC RISK

Determination of up-to-date land use characteristics in the Yeniçiftlik stream basin and data gathering were accomplished

with the help of RS and GIS system technologies. A high-resolution IKONOS pan-sharpened (02.03.08) satellite image was used in determination of current land utilisation characteristics, together with a supervised classification method by means of Erdas 8.5 Image software (Figure 6). Nine classes were general accuracy rate was determined as 92.31 % (Table 3). When Figure 6 is examined, it can be seen that the economic activities and settlement areas are concentrated on the sides of river valleys. The fact that the agricultural areas are located at parts where the slopes decrease and where there is risk of flash-flood constitutes a significant risk (Figure 7).

Buildings constructed in areas where the slope values are high, and lithologic characteristics and soil features are adequate, create pressure on the surface (Hyndman, 2006). Movement motions can be encountered in such conditions. Modification performed on the characteristics of river networks and valleys may also lead to significant and damaging floods and flash-floods (Baker and Kochel, 1988). This can be seen in many parts of the study area. Public agencies and organisations in particular should pay attention in this regard. It is, however, apparent that the study area is not of much concern. The fact that Mahmut Şevket Paşa Primary School was constructed in the valley by diverting the course of the river is the best example of this (Figure 8). The flood and flash-flood which occurred on 10 October 2006 caused great damage to the primary school. The fortunate fact that this disaster occurred around 03.00 prevented a possible catastrophe. The boarding accommodation was also damaged by this natural disaster. There have been no significant changes over the years in the characteristics of land use in the Yeniçiftlik stream basin, and there are some clearly undesirable practices which do not take into account the natural environmental conditions and are not properly regulated.

Sınıf	**Correct Accuracy Number Producers (%)**	**Users Accuracy (%)**
Settlements	100	100
Forest 1	77.78	100
Forest 2	100	90
Agricultural Field 1	100	85.71
Agricultural Field 2	100	85
Waste	81,82	90
Artificial Lake	100	100
Glasshouse	100	100
Roads	90	90
Overall Classification Accuracy = 92.31%		

Table 3. Accuracy Analysis Pertinent to Classification Results.

Agricultural, industrial and settlement areas in the Yeniçiftlik stream basin are constructed on flash-flood beds where the river-bed widens and the slope of the valley decreases (Figure 7). This abuse of the land use leads to flash-floods which have at times caused significant economic losses. Changing the river-beds without due care creates a negative impact on the natural flow characteristics of rivers. Release of the filling materials to valleys is among the significant elements of flash-flooding.

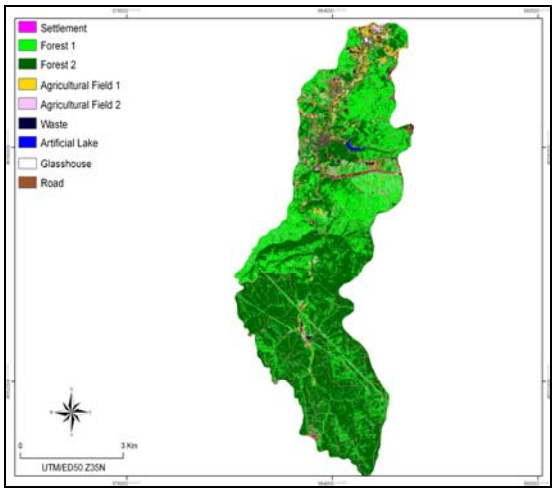

Figure 6. Classified IKONOS pan-sharpened images (02.03.2008).

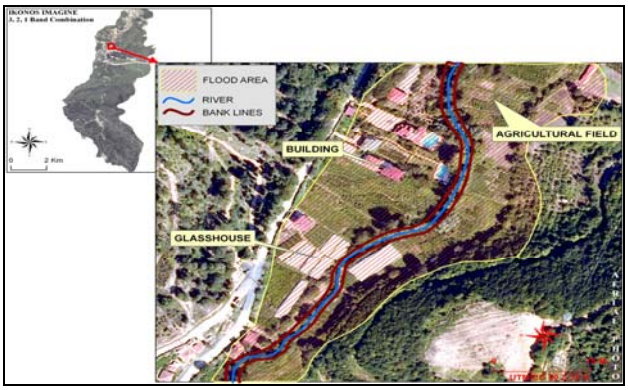

Figure 7. Determination of the flood area received from aerial photo (2006).

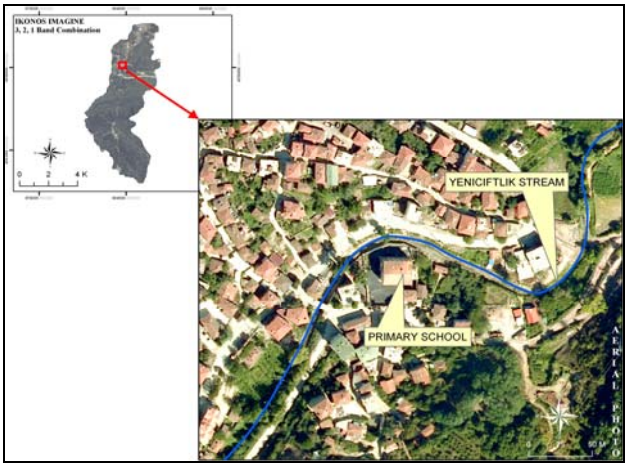

Figure 8.The Primary School building construated near the stream bed.

5. CONCLUSION

It is essential to examine the floods and flash-floods, which impact on the Mahmut Şevket Paşa settlement within the scope of more local and long-term studies. Floods and flash-floods,

together with flowing under suitable geographical conditions, which affect the Mahmut Şevket Paşa settlement occur under unique circumstances, and their various characteristics have a triggering effect on mass movements and erosion. The occurrence of floods and flash-floods in the Yeniçiftlik stream basin and other disaster types triggered by them is linked with the surplus water when the carriage capacity of the Yeniçiftlik stream is exceeded. Geomorphological characteristics of the basin (slope, aspect, drainage, etc.) are a suitable environment for natural disasters of hydrographic origin. No result was obtained in terms of drainage characteristics that could impact on flood and flash-flood disasters. The infiltration capacity, which is among the important factors in terms of transformation of precipitation to ground streams, is extremely low owing to the soil characteristics of the basin. For this reason, the water loss is minimal, and it has a limited impact in terms of decreased precipitation, which falls on the basin and is transformed to surface stream. Another factor affecting the surface stream is vegetation: the fact that the vegetation of the basin is destroyed in certain parts, in particular, for the purposes of creating agricultural fields and settlement areas, increases the surface stream, thus accelerating erosive activities. Erroneous land use has significant negative impact on the occurrence of disasters related to flood and flash-floods in the basin. Establishment of settlement areas inside the valleys and creation of agricultural fields on the basin bed appear to be the most misguided practices. Filling of the river bed with fill materials and narrowing the bed decrease its water carriage capacity.

6. RECOMMENDATIONS

A group of scientists should be appointed with expertise in basin management, climatology, soil and geomorphology, and this group should engage in long-term research on this basin. Any type of structuring and any practices that could impact on the flow of water in the natural drainage system should be avoided. The geographical characteristics of the research area should be taken into consideration, and natural plan and disaster risk analysis should be conducted for settlements of any size. Natural Disaster agencies should collaborate with the university to form research units, and should research the problems in the basin through multidimensional projects. Land classification, breakdown and assessment should be re-conducted. In technical interventions to be made in forests and agricultural areas, the impact of changes to the ecological conditions of the environment should be researched. The local community should be informed about flooding. Administrators should be trained well on flood and flash-floods. Environmental laws should be enforced more efficiently. Penalties imposed for forest destruction should be heavier. It would be beneficial to establish an organisation to coordinate the work of all agencies in the region dealing with floods, flash-floods, earthquakes and other natural disasters. Damages and animal losses which occur in agricultural lands as a result of floods experienced should be determined realistically, and these losses should be made good. Geological and geo-technical reports should be urgently prepared on areas to be opened up for development, and structuring performed accordingly. Such areas should only be developed after the infrastructure services are completed. Such infrastructure services as road, sewage systems, drinking water, bridges, vents, rainwater systems, etc. should be implemented through accurately drafted projects. In order to ensure that the central and local administrations work in collaboration before any further disaster hits, disaster coordination centres encompassing urban components should be established. Relevant regulations should be put into force in order to mobilise immediate action, and the risk regions that could be affected by disasters should be determined by the coordination centres. Loss and damage costs should be fairly determined by people who are expert in their fields Flash-flood areas which are also settlement places should be evacuated, and people who experience property losses should be compensated.

REFERENCES

Baker, V.R., Kochel, R.C., Paton, P.C., 1988. Flood Geomorphology, John Wiley & Sons, USA.

Committee on Earth Observation Satellites (CEOS), 2003. The Use of Earth Observing Satellites for Hazard Support: Assessments and Scenarios. Final Report of the CEOS Disaster Management Support Group (DMSG). http://www.ceos.org/pages/DMSG/2001Ceos/Reports/flood.html (accessed 14 April 2008).

Başbakanlık Doğal Afetler Koordinasyon Başmüşavirliği (BDAKBM) 1997. Doğal Afetler Raporu from http://www.bayindirlik.gov.tr/turkce/dosya/Basbak_DAfetRap4.pdf (accessed 25.06.2007).

Hyndman, D., ***Hyndman,*** *D., 2006.* **Natural hazards and disasters,** *Thomson Higher Education, Australia, pp. 297-325, pp. 197-227.*

Özdemir, H., (2006) Comparision Of Drainage Morphometries Drived From Topographic Sheets And DEM In The View Of Flood Studies, 1.Remote Sensing-GIS Workshop And Panel, 2006 (UZAL-GIS-2006), ISBN : 975-561-290-4, (CD), ITU Civil Engineering Faculty Remote Sensing Division, İstanbul, Turkey.

Smith, G., 2003, Flash Flood Potentıal: Determınıng The Hydrologıc Response Of Ffmp Basıns To Heavy Raın By Analyzıng Theır Physıographıc Characterıstıcs www.cbrfc.noaa.gov/papers/ffp_wpap.pdf (accessed 25 June 2007).

Van *Westen, C.J., 1993, Applicaiton of Geographic Information Systems to Lanslide Hazard Zonation, ITC Publication Number 15, The Netherlands.*

Verstappen, H.Th., 1983. Applied Geomorphology, ITC, Enschede, The Netherlands, pp. 66-69.

Zezere, J.L., 2002, "Landslide Susceptiblity Assessment Considering Landslide Typology, A Case Study in The Area North of Lisbon (Protugal)", Naturla Hazards and Earth System Science, European Geophysical Society, 2, pp. 73-82.