

POSSIBLE EFFECT OF THE GLOBAL CLIMATE CHANGE ON WATER RESOURCES AND FLOODS IN TURKEY

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ABSTRACT

Nowdays the topic of the climate change and its negative effects on human life are being studied all over the world. There are many publications and various evaluations in this respect. On the other hand, scientific research studies on this issue are still going on. The most important aspect of these studies is the negative effects of the climate change on water resources.

In this study, briefly evaluating the country's water resources and taking into account of climate change projections for the whole region, the authors have studied the effect of the climate change on water resources and floods .

Key Words: Climate change, water resources, floods.

KÜRESEL İKLİM DEĞİŞİKLİĞİNİN SU KAYNAKLARIMIZ VE TAŞKINLAR ÜZERİNE OLASI ETKİLERİ

ÖZET

Günümüzde küresel iklim değişikliği ve bunun insan yaşamı üzerindeki olumsuz etkileri konusu oldukça yoğun olarak tartışılmaktadır. Bu konulara ilişkin çok sayıda ve oldukça çeşitli değerlendirmeler ve bilimsel çalışmalar yapılmaktadır. Bu konulardan en önemlilerinden biri de iklim değişikliğinin su kaynakları üzerine olan olumsuz etkilerinin ortaya konması için yapılan çalışmalardır.

Bu çalışmada öncelikle ülkemiz su kaynakları potansiyelinin değerlendirilmesi yapılmış, daha sonra yapılan iklim değişikliği senaryoları dikkate alınarak iklim değişikliğinin su kaynakları ve taşkınlar üzerine olası etkileri konusunda genel bir değerlendirme yapılmaya çalışılmıştır.

Anahtar Sözcükler: İklim değişikliği, su kaynakları, taşkınlar.

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WATER POTENTIAL OF TURKEY

Of 501 billion m³ of annual precipitation, 274 billion m³ is assumed to evaporate from surface and transpire through plants. 69 billion m³ of precipitation directly recharges the aquifers, whereas 158 billion m³ forms the precipitation runoff. There is a continuous interaction between surface runoff and groundwater, but it is estimated that a net 28 billion m³ of groundwater feeds the rivers. So, average annual surface water potential is 186 billion m³, with the surface runoff of 7 billion m³ coming from neighboring countries, total surface runoff within the country reaches 193 billion m³. However, not all of the renewable water resources can be utilized because of economic and technical reasons. Exploitable portions of surface runoff, inflow from bordering countries, and groundwater are 95, 3, and 12 billion m³, respectively. Thus, the total of exploitable water resources amount to 110 billion m³ (Table 1).

SURFACE WATER	RAINFALL (mm)	WATER AMOUNT (billion m ³ /year)	GROSS WATER POTENTIAL (billion m ³ /year)	EXPLOITABLE (billion m ³ /year)
TURKEY	643	501	186	95
FROM BORDERING COUNTRIES			7	3
GROUNDWATER			41	12
TOTAL			234	110

Table 1 : Gross total amount and consumable water in Turkey.

SECTORAL WATER DEMAND

It is estimated that together with mainly DSI and other governmental institutions and private sector will be able to offer 110 billion fresh water to the consumption of various sector by developing additional project by the year 2030. For realizing this aim, Financial resources should be increased year by year.

Gross irrigable area of Turkey is 8,5 million hectares. The aim is to start to irrigate the whole of this area until 2030. Water requirement for this area will be 71,5 billion m³. From 2000 to 2030, In total consumption, the percentage of the irrigation will drop from 75 to 65 %.

According to the estimations of population growth rate, although the growth rate of population is decreasing year by year, Turkey's population will reach to 110 billion in 2030. per capita available water was 250 litre/day in 2000. With the assumption of Turkey will develop, this amount will increase and become 500 litre/day in 2030. So Turkey will have reached to the present value of the European Union. Furthermore, it is estimated that tourism sector will need 5 billion m³ of water in 2030. So, the total water requirement for domestic consumption will be 25,3 billion m³.

Industry sector used 4,2 billion m³ of water in 2000. But with the increasing rate of % 4 for every year, water demand of industry sector will become 13,2 billion m³ (Table 2).

YEAR	TOTAL WATER CONSUMPTION		SECTORES					
			IRRIGATION		DOMESTIC USAGE		INDUSRY	
	km ³	%	km ³	%	km ³	%	km ³	%
1990	30,6	28	22,0	72	5,1	17	3,4	11
2000	39,3	36	29,3	75	5,8	15	4,2	10
2030	110,0	100	71,5	65	25,3	23	13,2	12

Table 2 : Sectoral water consumption in Turkey (DSİ, 2003).

CLIMATE CHANGE

In addition to natural variability, some of human activity (industry, transportation, energy production and consumption etc.) has started to affect the earth climate. These activities has produced large amount of greenhouse gases. Accumulation of these gases, deforestation and increasing of land use has caused to tend to increase the mean temperature of the earth.

According to the IPPC report of 2001, The global average surface temperature has increased by approximately $0,6 \pm 0,2$ °C since the late 19 th century (IPPC TAR Chapter 2). It is also satated that greenhouse gases has been the main reason of global warming during the last 50 year. It is very likely that 1990s warmest decade and 1998 the warmest year in the instrumental record in the period of 1860-1996. According to the updated records, 2001 was the second warmest year and it has a positive anomaly of $0,42$ °C.

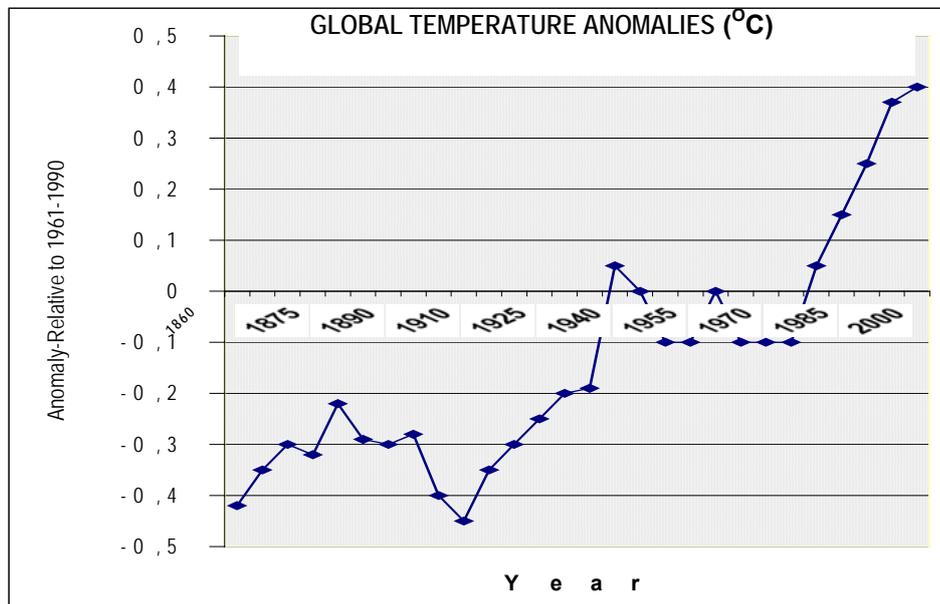


Figure 1: Annual anomalies of global average land surface air temperature (IPCC).

Figure 1 shows the anomalies of the mean temperature of the world. These anomalies are of the deviations from the average of 1961-1990. Values are the simple averages of the anomalies for the two hemisphere. It is very likely that precipitation has increased by 0,5 to 1 % per decade over most mid and high latitude of the northern hemisphere. It is also likely that rainfall has decreased over much of the northern

hemisphere subtropical (10⁰ N to 30⁰ N) land areas by about % 0,3 per decade during the 20 th century. It is likely that there has been 2 to 4 % increase in heavy precipitation events in the same areas.

CLIMATE CHANGE SCENARIOS

The global surface temperature is projected to increase by 1,4 to 5,8 °C over the period 1990 to 2100. Global average water vapour concentration and precipitation are projected to increase during the 21 st century. By the second half of 21 st century it is likely that precipitation will have increased over northern to high latitudes in winter. The return period for extreme precipitation events decreases almost everywhere. At low latitudes there are both regional increases and decreases over land areas. It is also likely that more intense precipitation events will have increased over many northern hemisphere mid to high latitude land areas. Snow cover and sea-ice extent are projected to decrease. Global mean sea level is projected to rise by 9 to 88 cm over the period 1990 to 2100.

According to the same projections, in Mediterranean region which comprises Turkey, average temperature is projected to increase by 2 °C in winter and 2-3 °C in summer. Precipitation will have decreased by 15 to 25 % in summer. But it will have increased by 5 to 15 % in winter. Soil moisture will have decreased by 5 to 15 % and sea level will have raised by 35-65 cm (IPCC).

EFFECT OF THE CLIMATE CHANGE ON WATER RESOURCES IN TURKEY

Streamflow is the main factor of the water resource. Changing in flows based on the precipitation mostly. But some other parameters, such as land use, deforestation and vegetation may be more effective than climate change (IPCC). These parameters may also change the characteristics of a basin and flow conditions. There are a few study implemented on this subject. Flow measurement values taken from gauging stations of the various streams had been used in these studies. It was stated that especially average and low flows had decreased slightly in western, interior and south part of Turkey. Statistically significant change had not been seen in the other part of Turkey (Cıgızoğlu at all, 2004). In another study, it was stated that except for the 13 th, 22 th (in the Black Sea region) and 23 th basins (in the North east of Turkey) there is a slightly decrease in flows in the other regions of Turkey. This decrease shows difference from one region to another. But the trends of decrease are especially notable in Marmara and Aegean regions (Angı at all, 2004).

In Mediterranean region, the rate of snow melting/evaporation is higher than the surrounding regions. As a result of this situation, especially in eastern region of Turkey, water levels of the streams and dam reservoirs don't rise even though it snows as much as old times (Kadioğlu, 2001). Additionally, Japan Meteorology Agency states that the intensity of drought has been increasing in the period of September-December in the Mediterranean region. Related to this knowledge, Figure 2 given by Arnell, shows the effects of climate change on water resources of some countries.

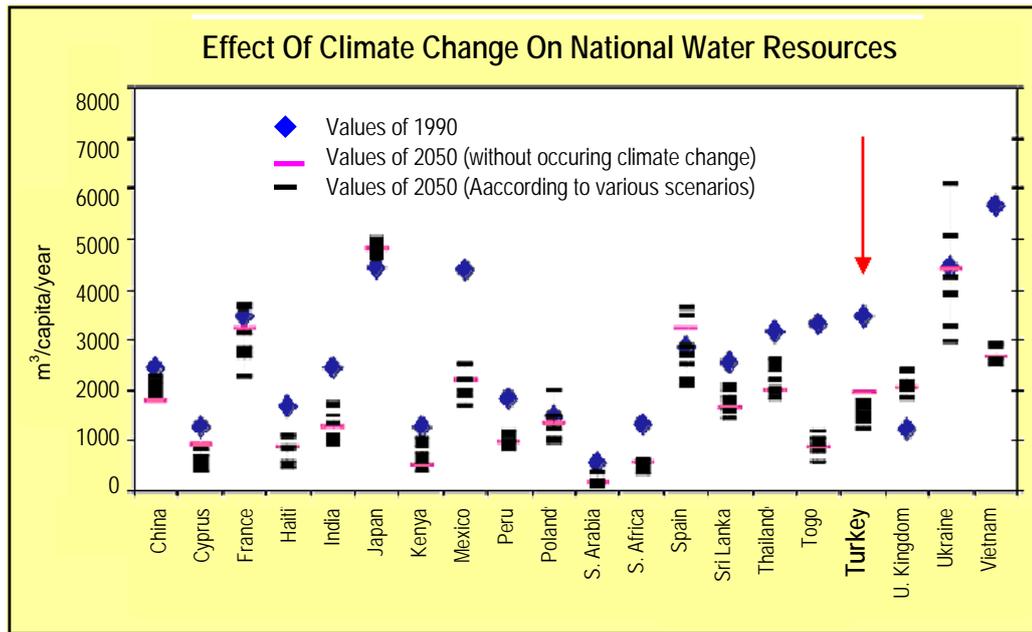


Figure 2 : Change of water resources of some countries (Arnell, 2000).

Figure 2 shows that the changes of water amount in various countries in (a) 1990, (b) 2050-without occurring climate change, (c) 2050-according to the various climate change scenarios. As seen from figure 2, like many other country, water amount in Turkey will have been decreased very seriously by 2050. Per capita availability of potential water resources is 3070 m³/year in 1990, which is high for the Middle East. However, water resources are not evenly distributed in Turkey. Even if we assume that climate conditions are stable, due to the growth of the population of Turkey, per capita of water potential will be 1240 m³/year. When climate change is taken into account, by the year 2050, per capita of water potential will be 700-1910 m³/year in Turkey (Kadıoğlu, 2001).

According to the Climate change scenarios, the impacts of the climate change can be generalised as following;

- Precipitation will increase slightly in winter, conversely it will decrease in summer.
- Seasonal distribution and intensities of precipitation will change.
- Snow cover have been decreasing since 1987. This state will continue.
- In project studies, snow-line should be updated.
- Not only will the water amount in streams decrease, but their peak times will change .
- Frequency and intensity of drought and flood induced loses will increase
- Because of the water stress to which water deficit is caused will increase nation wide.
- Uncertainties will occur in water supply studies. That is why cost of projects will increase.
- Importance of small dams will increase.
- More realistic prices should be fix.

EFFECTS OF THE CLIMATE CHANGE ON FLOODS IN TURKEY

It is well known a fact that climate change is among the trigger agents of unusual floods. It causes changes in timing, regional patterns and intensity of precipitation events, and in particular, in the number of days with heavy and intense precipitation occurrences. Floods are now being experienced in areas where there were no floods in the past. This may be linked to the regional effects of the global climate change.

The potential for increased flooding following climate change would be exacerbated by erosion associated with deforestation and overgrazing both of which are now very widespread in many parts of Turkey. Such environmental degradations also increase surface runoff and the severity of flooding and contribute to landslides.

Although the possible relationship between floods and climate change, exacerbated by erosion associated with deforestation and overgrazing, has often been mooted, it is unclear to what extent the two can be linked. Ultimately, the climate change component has an incremental effect, likely to make extreme floods more frequently in some areas in Turkey. Nevertheless, not all floods can be attributed to climate change.

As seasonal fluctuations in flows are more sensitive to air temperature than other parameters in Mediterranean region, flows are mainly affected by warming (Kadıoğlu, 2001). But in general, changes in annual streamflow relate well to changes in total precipitation (IPCC). In this region very heavy rainfall may occur and cause destructive flood events. The flood coefficient that is described as the rate of peak flow to mean annual flow is higher than other regions (Figure 3).

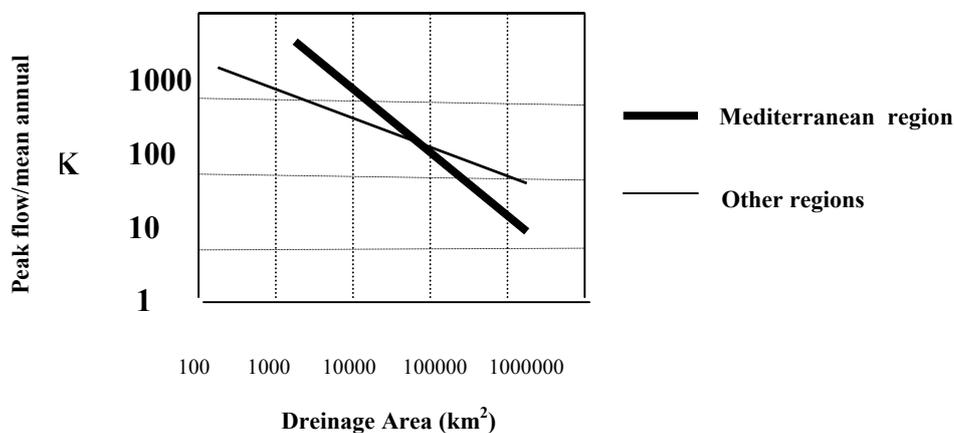


Figure 3 : The flood coefficient, in Mediterranean and other regions (Palutikof, 2000).

Flash floods occur rather often in Mediterranean region. Turkey often undergoes effects of natural disasters. It can be seen that the number of floods and flash floods has been getting more and more (Figure 3). Similarly, flood events have increased in Europe in the period of 1975-2001 too. In Turkey, flooding is the second important natural hazard after the earthquakes, with 22 floods and 19 deaths per year on average (Figure 4).

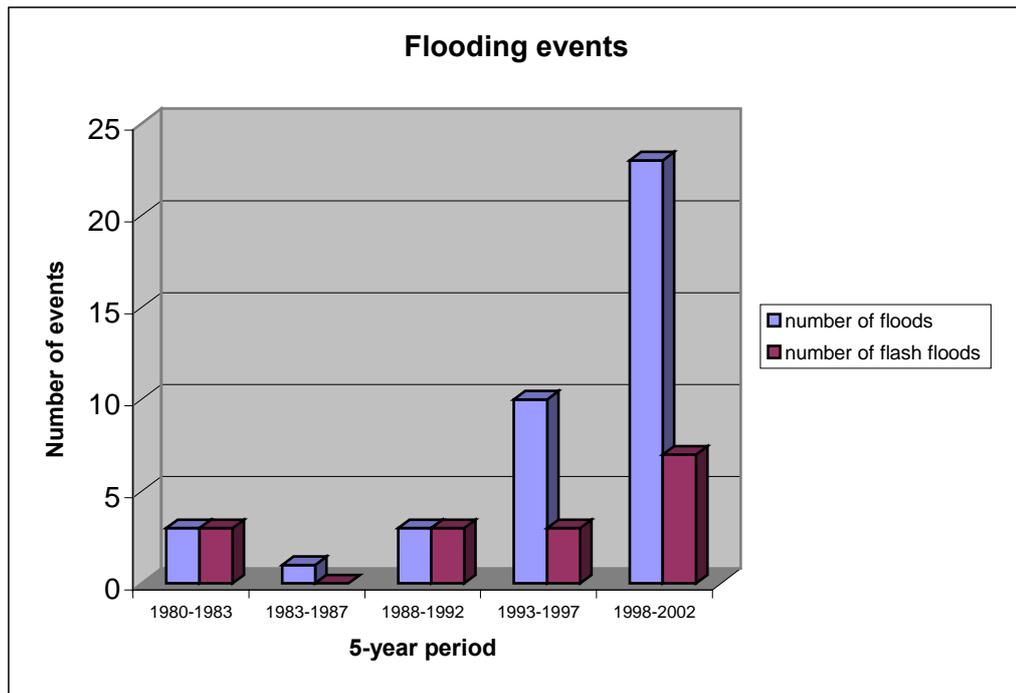


Figure 4 : The number of floods in last decade (Özgüler, 2003).

Some information of the floods of last two decades, from 1980 to 2002, in Turkey are shown in Figure 5. In some individual years, for example 1995, the monetary values of the total annual losses caused by floods reached up to 0,5 % of the total real Gross Domestic Product (GDP) of the country. In addition, floods cause the highest monetary losses among natural disasters. Figure 5 shows that flood-induced monetary losses rising up to a few billion-dollar range.

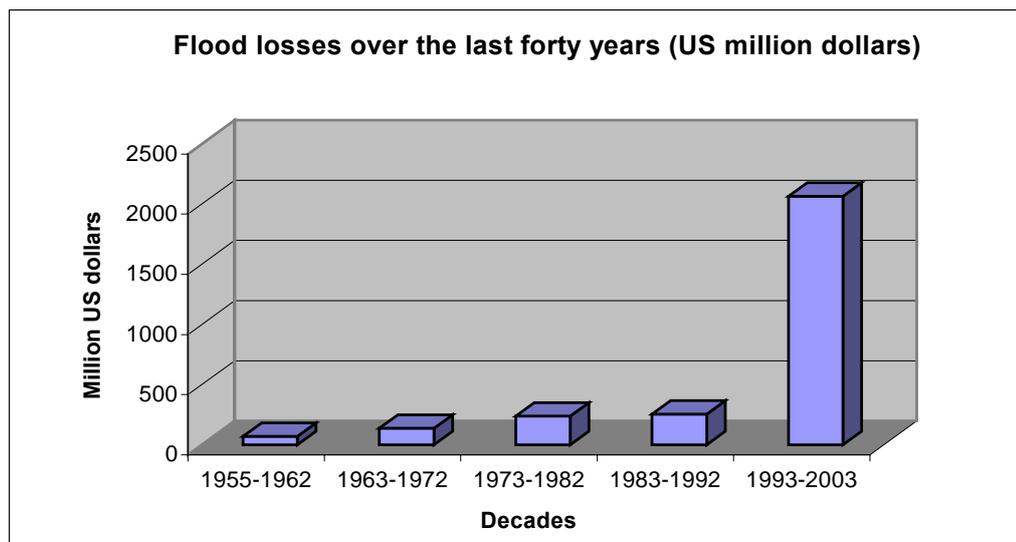


Figure 5 : Flood-induced monetary losses in Turkey (Özgüler, 2003).

CONCLUSION

Some regions of Turkey will likely feel more the effects of the drought in future. In basin planning, water resources and agricultural areas should be considered as a whole. To do this, groundwater resources should be managed better.

Under the effect of the changing climate, water balance analyses, climate change projections and drought monitoring studies should be done and various management plans should be prepared.

To estimate the situation of the water resources in future, changes in land use and vegetation should be monitored and evaluated. For his purpose investigation studies should be increased.

Impacts of the climate change should be taken into account in reservoir operation studies.

Agricultural areas of Turkey should be determined considering the conditions of climate, soil, and water.

Dams and hydroelectric power plants may be preferred as a source .

People should be educated on the topics of water saving and using the water more carefully.

To determine the regional effects of climate change in Mediterranean region, related countries should work together, such as Med-Hycos and Friend-Ahmy projects.

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