Climate Change Assessments for Lakes Region of Turkey

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Abstract. Climate change is one of the most important challenges for forestry. Forests are known to be most efficient natural tools to ensure availability and quality of water in many regions. Besides, planning of forest resources towards water quality and quantity is essential in countries that are expected to face with more frequent drought periods in the next decades due to climate change. Watershed management concept has been supposed as the primary tool to plan natural resources in a more efficient and sustainable way by both academicians and practitioners to mitigate and adapt climate change. Forest cover among other land use types provides the best regulating mechanism to mitigate erosion, sedimentation, desertification, and pollution. In addition, climate change can potentially affect forest stand dynamics by influencing the availability of water resources. Therefore, the amount of forest cover in a watershed is an indicator of climate change mitigation and adaptation. Climate change is a concern and risk for the sustainability of water resources in Lakes Region of Turkey. The objective of this study is to make a comprehensive assessment in lake watersheds of the Lakes region considering the forest cover. For this purpose, the study gives a general view of trends in climatic parameters using Mann Kendall trend test. The results showed that Mann Kendall trend test for temperature and precipitation data is not enough to evaluate the magnitude of potential changes of climate in terms of forest cover. Understanding impacts of changes in temperature and precipitation on forest cover, runoff data should be evaluated with temperature and precipitation for watersheds of forest areas in Lakes Region.

Key words: Climate change, Mann Kendall test, Watershed management, Watersheds forest cover.

Introduction

Ecological systems are intrinsically dynamic and are constantly influenced by climatic variability. The water resources sector in many regions and countries, therefore, is vulnerable to changes in climate (WATSON *et al.*, 1998). The outcomes of different climate change scenarios have showed regional variability of climate change. Forests are particularly sensitive to climate change, because the long life-span of trees does not allow for rapid adaptation to environmental changes. The changes in average temperatures that forests will have to face over the next 100 years range, according to latest projections, is between 4 - 5°C increase in some parts of the Mediterranean region (LINDNER *et al.*, 2008). Climate is expected to become more variable with greater risk of extreme weather events, such as prolonged drought, storms and floods. Forests will have to adapt to changes in mean climate variables but also to increased variability (UNFCCC, 2011). Temperature is predicted to increase and this will have a positive impact on forest growth and wood production in northern and western parts (i.e. less water limited) and a negative impact on southern and eastern parts of the Mediterranean region (i.e. water limited). Adaptive capacity is also robustly limited in the Mediterranean region where large forest areas are only extensively managed or unmanaged. The extreme forest

fire risk is the major threat in the Mediterranean region (LINDNER *et al.*, 2008). Forest ecosystems play an important role in the global biogeochemical cycles (MAGNANI *et al.*, 2007). Forests can contribute to the mitigation of climate change, but under the existing global climate policy frame this alone will not be enough to halt climate change. Mediterranean forest growth is constrained by drought and high temperatures during summer. Effects of climate change on these forests depend on how changes in water availability and temperature will take place. Temperature and rainfall may constrain growth during certain periods but if rainfall increases in the future, a positive effect on growth is likely to happen (SÁNCHEZ *et al.*, 2002).

Forest ecosystems are being rapidly and directly transformed by the land uses of the expanding human populations and economies. Currently less evident are the impacts of ongoing climate change on the world's forests. The common implicated causal factor in these examples is elevated temperatures and/or water stress, raising the possibility that the world's forests are increasingly responding to ongoing warming and drying (ALLEN *et al.*, 2010). The main characteristic of plants is to response to water scarcity. Water use efficiency, on the other hand, can have profound effects on forests in possible decreases in precipitation attending changes in climate.

This study uses Mann Kendall trend test to asses to climate change for Lakes Region of Turkey in the Mediterranean Region. Major objectives of the study is (i) to assess spatial distribution of forests in Lakes Region, and (ii) the potential changes in climate depending on temperature and precipitation in the watershed ecosystems of Lakes Region.

Background

Basins in Turkey and Forest Cover. Turkey is divided into 26 river basins. Around 50 % of the forested areas in all basins are coniferous forests (HIZAL *et al.*, 2008). The Mediterranean river basin is one of them and includes Lakes Region in Turkey.

Lakes Region of Turkey. In Lakes Region, many natural lakes provide drinking and irrigation water to the settlements in the region. Besides, some of the lakes are declared as Ramsar site providing habitat to wildlife. The water use from the lakes has been increasing in the recent years due to increasing population and urbanization. Climate change is another concern and risk for the sustainability of water resources of the region.

Lakes Region, covering Antalya, Isparta, and Burdur provinces is located in the western Mediterranean Region of Turkey and has an area of 36.672 km². The significant lakes in the region are Egirdir, Burdur, Golcuk, and Kovada. Lake Egirdir is the fourth largest lake of the country and also is the second according to irrigation potential after Lake Beysehir. Lake Kovada is located below Lake Egirdir and also has a linkage with it. A portion of Lake Egirdir waters drains into Lake Kovada, which also provides water for hydroelectric power unit. Lake Golcuk is a crater one at 1300 m altitude. Among these Lake Burdur is a protected, and Egirdir Lake is an important wetland due to biodiversity they acquired according to Ramsar Convention. Besides, Lake Kovada and its watershed have a National Park, Lake Golcuk and its watershed has a Nature Park status given by Ministry of Environment and Forestry.

The significant wetlands located in this region make it a region of priority for watershed planning purposes. The area of the region makes 4.5 % of total country area. The area is estimated to face with drier conditions during the next century according to climate model outputs. Therefore, forest cover in the watersheds of these lakes and evaluating their conditions and impacts from water production point of view is essential. Egirdir watershed is a semi-closed watershed while Burdur and Golcuk are closed ones, which means not drained outside the watershed with any fluvial system. Lake Kovada watershed is an open and drains into Mediterranean Sea.

Lake Egirdir Watershed. Lake Egirdir is a tectonic formation on a karstic parent material. The water flowing out of the lake

flows into Lake Kovada and then to the Mediterranean Sea. The drainage area of the lake is 282.368 ha (BASAYIGIT, 2002). It is the largest lake of the region. The mean elevation of the lake is 918.8 m. The lake is listed in Ramsar Convention as "International significant wetland" (ERDEM, 2004). It provides water for Kovada I and II hydroelectric power plants (KARAGUZEL, 1995). The outflow of the lake is also used for irrigation, and drinking water supply for Isparta city. The annual water inflow and outflow rates of the lake are 817.85 hm³, and 848.37 hm³, respectively (ESENDAL, 2007). There are 22 towns inside the watershed and the tree species are Black pine, cedar, and junipers. There is also deciduous coppice inside the watershed. Agriculture and livestock are the major means of living in the watershed. Afforestable land area in the watershed is 68.000 ha. The total forested area (100.024 ha) is composed of productive high forests (32.5%), degraded forests (36.5%), productive coppices (0.5%), degraded coppices (12.5), and shrublands (17.5%). Over 80% of the forests are composed of coniferous species (KARATEPE, 2004) due to be the mountain area.

Lake Kovada Watershed. Lake Kovada is a natural extension of Lake Egirdir. It is also a tectonic formation. It has been assigned as a National Park in 1970 because of biodiversity its environment posses. The area of the lake is 6763.5 ha on an elevation of 900 m. The streams that drain into the lake are intermittent (TABUR, 2002). The wide variety of tree and shrub species include red pines, black pines, junipers, cedars, oaks, blackberry, laurel, and cistus.

Lake Golcuk Watershed. Lake Golcuk had been formed by filling of a crater with water at an elevation of 1300 m. The Lake has been providing water to Isparta city for a long time. The lake surface has an area of 94 ha (DAVRAZ & KARAGUZEL, 2001). It has been assigned as Nature Park in 1991. Therefore, it is used as a recreation area. The tree species of the area are Black pine, Red pine, Black locust, Oak and Cedar. The larger part of the plantations inside the watershed was done by State Hydraulic Works and General Directorate of Forestry in 1956. Vegetation cover was poor before that. Any treatment inside the watershed has a potential to affect water quantity and quality (EROL, 2005) because of coniferous species near the lake and a grove of apple trees.

Lake Golcuk is in a distance of 12 km to Isparta and 25 km to Burdur cities. The lake watershed is inside the Natural Park of 5842 ha. The mean annual precipitation is 702.5 mm.

Lake Burdur Watershed. This lake one of the largest lakes of Turkey is also a tectonic formation. Due to degradation of ecosystems in its watershed, water pollution is a major problem. 38.125 ha of the lake watershed was assigned as Wildlife Protection area in 1993 and 50 % of the lake area has been one of Ramsar areas of Turkey since 1994. The elevation of the lake is 845 m. The lake watershed is a closed one drained by small streams. Only 6.1 % of the lake watershed is covered with productive forest. There are wide degraded Maquis formations (KIRIZOGLU *et al*., 1995). The forested areas of the watershed (688.700 ha) is 320.338 ha.

The study area is in the Mediterranean region of Turkey. In Figure, 1 Lake Egirdir, Kovada, Burdur and Golcuk are shown by numbers 1, 2, 3 and 4 respectively.
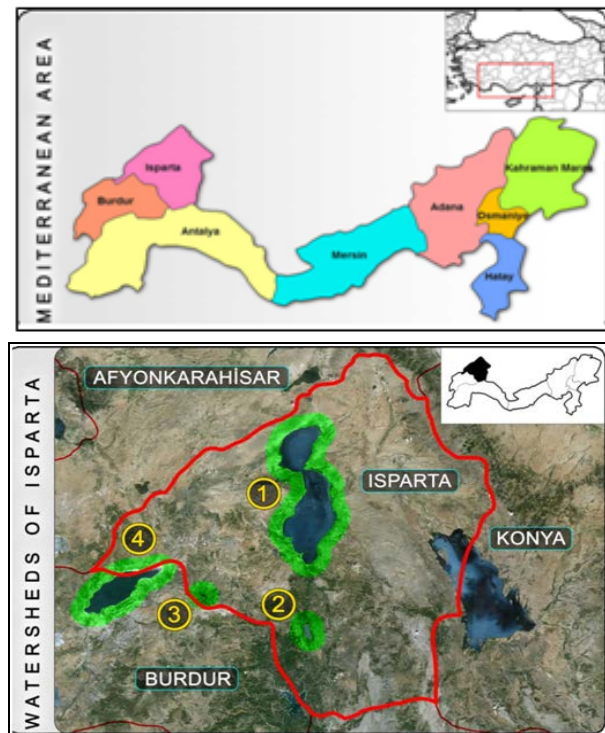

Fig.1. Location of the study area

Material and Methods

The data used in this study include annual maximum precipitation (mm), monthly mean temperature (°C), and monthly total precipitation (mm). All data used in the study belong to Turkish State Meteorological Service. The data have been completed for the period of 1975-2009 from 7 stations in only one part of Lake Region, which include Lake Egirdir, Lake Kovada, a part of Burdur and Lakes Beyşehir. To identify statistically significant trends, the original data series were tested with Regional Mann Kendall statistic, assuming 95% significance level (DENNIS *et al.*, 2006a). The study performes time series analyses on long term monthly precipitation, temperature, and maximum rainfall data to assess the risks that may emerge due to climate change. The forest cover in the watersheds of Lake Golcuk, Burdur, Kovada, and Egirdir has been determined based on the data provided by General Directorate of Forestry.

The Mann-Kendall trend test. The Mann-Kendall trend test (MANN, 1945; KENDALL, 1975) is based on the correlation between the ranks of a time series and their time order. In the test trend, the test statistic is given for a time series.

A Mann-Kendall test is computed for individual locations and results are combined into one overall test for consistent regional trend (HELSEL & FRANS, 2006). The Regional Kendall test performs the Mann-Kendall (MK) trend test for individual locations in area (DENNIS *et al.*, 2006b). In the test, trends at numerous locations within a region are tested to determine whether the direction of trend is consistent across the entire region.

Regional Kendall test. The Regional Kendall test extends to spatial locations rather than seasons and looks for consistency in the direction of trend at each location, and tests whether there is evidence for a general trend in a consistent direction throughout the region. Patterns at an individual location occurring in the same direction as the regional trend provide some evidence toward a significant regional trend, even if there is insufficient evidence of trend for that one location (HELSEL & FRANS, 2006). In the study the Lakes region data were used as the basis for the Regional Kendall test for trend. In the test trend analysis has been extensively used to assess the potential impacts of climate change using temperature and precipitation data in the region to assess the spatial distribution of forests in the Lakes region including lake watersheds.

QIAN & LIN (2004) and KARL *et al.* (1993) have reported in their studies that a statistically significant decreasing trend in the precipitations and temperatures is to be expected as an indicator of a global warming signal. Meteorological data which such as temperature and precipitation are indicators of climate change (DENNIS, *et al.*, 2006). In this study, meteorological data which such as temperature and precipitation are used as some parameters of the climate change.

Table 1. Mann-Kendall trend results for annual max. precipitation (mm)

Well ID	Number of Data Points	Minimum value	Maximum value	Mann Kendall Statistic (S)	Normalized Test Statistic (Z)	Probability	**Trend (At 95% level of significance)**
Burdur		0.0	91.0				
Isparta		0.0	100.7				
Senirkent		0.0	94.5				
Yalvaç	35	0.0	71.6	315.0	1.686	0.0918	No Trend
Uluborlu		0.1	76.0				
Egirdir		0.0	141.0				
Beyşehir		0.1	90.5				

Table 2. Mann-Kendall trend results for monthly mean temperature (°C)

Well ID	Number of Data Points	Minimum value	Maximum value	Mann Kendall Statistic (S)	Normalized Test Statistic (Z)	Probability	**Trend (At 95% level of significance)**
Burdur		-1.3	27.4				
Isparta		-2.8	26.0				
Senirkent		-5.0	27.1				
Yalvaç	35	-5.7	25.8	1149	6.173	0.0000	No Trend
Uluborlu		-4.0	25.7				
Egirdir		-3.1	25.7				
Beyşehir		-7.1	24.9				

Table 3. Mann-Kendall trend results for monthly total precipitation (mm)

Well ID	Number of Data Points	Minimum value	Maximum value	Mann Kendall Statistic (S)	Normalized Test Statistic (Z)	Probability	**Trend (At 95% level of significance)**
Burdur Isparta Senirkent Yalvaç Uluborlu Egirdir Beyşehir	35	0.0	195.1	66.0	0.349	0.7272	No Trend

Results and Discussion

This study highlighted 1975–2009 trends by using the Regional Mann Kendall test, which performs the Mann-Kendall (MK) trend test, for climate change assessment for Lakes Region. The results of the study show that the region has not a likely threaten to the climate change. Concluding this study shows that assessments for changes in the climate should be taken account of runoff with the precipitation and temperature.

Results of the Regional Mann Kendall test for annual and monthly time series of precipitation and monthly temperature indicate that 7 stations data, which have 245 component of well ID, exhibited no trend during the past 35 years statistically. The study results show that (Table 1, 2, 3) the precipitations and temperatures exhibites to have no trend for the 35 years. The main point is that the environmental conditions in Lakes Region have a significant role for the conservation of water resources. It is thought that the presence of water resources, especially in watersheds of Lake Egirdir and Burdur have a tendency to be affected to changes in the climate, even though the trend of precipitation and temperature detected in this study. In the Lakes Region, in addition, some forest sites including watersheds of Lake Egirdir and Lake Burdur have degraded. In watersheds of Lake Egirdir and Burdur there are degraded forested area, 59% and 93% of total forested watershed areas, respectively.

It is clear that there is need further research to verify the results of this study. Some studies focused on climate change show that precipitation and runoff should be determined together because precipitation is the main driver of runoff (BLAKE *et al.*, 2000; GREGORY *et al.*, 1997; CHIEW *et al.*, 2009). In this case, more reliable results can be likely to occur to assess effects of climate change on soil and water resources for the region.

There is need more monitoring data and further research on watersheds in Lake

Regions to assess soil and water conservation functions of these forested areas using Mann Kendall trend test. It is known that the watershed areas are very mountainous and their soils are prone to erosion. This reason alone is enough to say that the region would be likely sensitive to climate change so it is important to understand effects of climate change on runoff from precipitation and by drainage from water stored in soils.

Conclusions

The forested area inside the watersheds of lakes in Lakes region of Turkey has been evaluated with this study. All watersheds mentioned in the study have a special conservation status. The forested areas are generally composed of coniferous stands and also degraded deciduous. The magnitude of climate change cannot be detected with the Mann Kendall trend test results. The existing forest cover should be conserved to keep the lakes from sedimentation even if not any change of climate in the present conditions.

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