INTERNATIONAL CAUCASIAN FORESTRY SYMPOSIUM
24-26 OCTOBER 2013
ARTVIN TURKEY

Climate Change and Forestry in Turkey: Impacts and Adaptation Measures

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Abstract:

Turkey has various climate types in different regions. A Mediterranean climate prevails in Turkey's Mediterranean and Western Anatolian regions, a temperate climate with high precipitation in every season along the Black Sea coast, a continental climate in the inland regions and a semi-arid climate in Central and South-eastern Anatolia. Most precipitation occurs in the winter months. Total annual rainfall is least in the low-lying areas of eastern Anatolia (220mm), and highest along the eastern Black Sea coast (2420mm). The average annual rainfall for the entire country is 643 mm, generating a water potential of 501 billions m^3/year. Turkey has about 21.3 million hectares of forest area that covers around 27.2% of the country's land area. Half of the total forest area is high forests and the remaining is coppices. Forests are generally located on mountainous areas and they are usually natural and semi-natural with high biodiversity values. It is expected that climate change will seriously affect Turkeys' forests. Dalfes at al. (2007) analyzed the climate data from 113 stations of the State Meteorological Service in Turkey for the period between the years 1951-2004 and they observed that winter precipitation in western Turkey has decreased significantly whereas autumn precipitation has increased at stations in the northern parts of central Anatolia. The reason behind these changes is not well understood, and the need for more comprehensive study is underlined. The authors report widespread increase in summer temperatures mostly in the western and southwestern parts of Turkey while winter temperatures show a general tendency to decrease. The more significant changes are concentrated in coastal stations. Stream flow data based on measurements from 1969 to 1998 indicate a decreasing trend in western and southwestern regions and some increase in the north.

Key Terms: climate change adaptation, forestry sector, Turkey, precipitation, temperature

Introduction:

Turkey has about 21.3 million hectares of forest area that covers around 27.2% of the country's land area. Half of the total forest area is high forests and the remaining is coppices. Forests are generally located on mountainous areas and they are usually natural and semi-natural with high biodiversity values. The country has around 10.000 plant species of which around 3000 are endemic. Most of these plants are located in the forest areas.

Deciduous forests are prevalent and relatively uninterrupted at moderate elevations along northern Turkey. Coniferous forests, depending on the species and locations, are found at varying altitudes from sea level to the timber line (2200m). Forest formations of the country include species belonging to different floristic regions, namely Irano-Turanion, Mediterranean and Euro-Siberian. Approximately 800 woody taxa occur in the country's forests. The predominant species are *Pinus brutia, Pinus nigra, Pinus sylvestris, Abies spp. (A. cilicica, A. nordmannia, A. equi-trojani are unique), Picea orientalis, Cedrus libani, Juniperus spp., Pinus pinea, Cupressus sempervirens, Pinus halepensis, Fagus orientalis, Quercus spp., Alnus spp., Castanea sativa, Carpinus betulus.*

Main threats that Turkey's forests facing are: forest fires, drought, illegal cutting, erosion, climate change (CC), air pollution, insect damages and fungal diseases. Some of these threats are directly related to CC (e.g. drought, forest fires) while the others indirectly related to CC (increased bark beetle attacks in spruce forests).

Climate change information for Turkey:

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Annual average precipitation of Turkey for the 1971-2000 climatic periods is about 640mm and has 29mm/100 years decreasing trend (Sensoy et al, 2008). Turkey mean temperature for the 1971-2000 climatic periods is about 13°C and has 0.64°C/100 years increasing trend (Sensoy et al, 2008)

Dalfes et al.(2007) made future climate simulations for Turkey using RegCM3 climate model based on SRES A2 emission scenario for the period between the years 2071-2100. These simulations revealed that estimated winter time temperature increase is higher in the eastern half of the country while in summer time this pattern is reversed and the western half of the country, especially the Aegean Region experiences temperature increases up to 4-6 °C (Dalfes et al. 2007) (Fig.1).

For the precipitation the model predicted decreases along the Aegean and Mediterranean coasts and increases along the Black Sea coast of Turkey. Central Anatolia shows little or no change in precipitation. The most severe (absolute) reductions will be observed on the southwestern coast; in contrast, Caucasian coastal region is expected to receive substantially more precipitation. These observations are valid both for the annual and the winter totals (Dalfes et al. 2007) (Fig. 2).

Much of the Turkish coast appears to experience sea-level changes within the generally accepted range of sea-level rise (1-2 mm/yr) (Dalfes et al., 2007). For the Mediterranean, and Black Sea regions, sea-level rise is around 12cm in the last century. Although coastal cities cover less than 5% of the total surface area of Turkey, over 30 million people live in coastal areas. More than 60% of the GDP in Turkey is produced in the coastal strip from Tekirdağ to Kocaeli, along the northern shoreline of the Marmara Sea (DPT, 2001; after Dalfes et al. 2007). According to Karaca (2001, after Dalfes et al. 2007) when the Common Methodology of the IPCC CZMS (1992 after Dalfes et al.2007) is applied to both Turkey and Istanbul province assuming 1-m ASLR scenario, Turkey lies in the class of low risk countries, but Istanbul has high risk values. The preliminary assessment of vulnerability analysis yields about 6% of its GDP for capital loss, and about 10% of its GDP for protection and adaptation costs of the country.

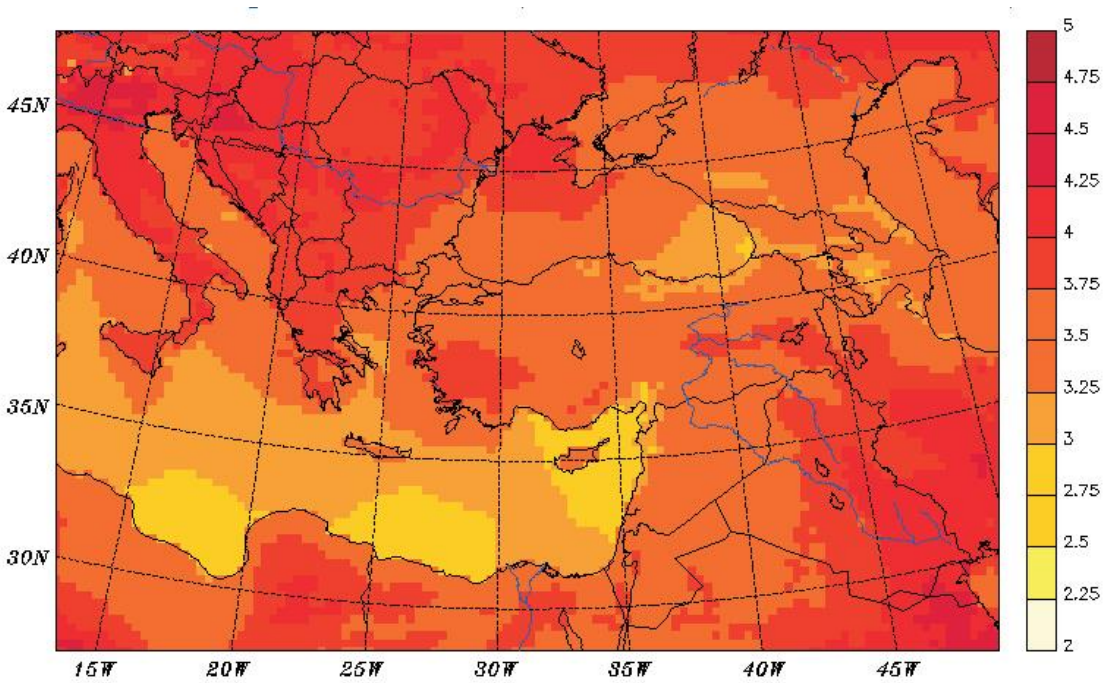

Figure 1. Predicted annual temperature differences (2071:2100 - 1961:1990 °C) (Dalfes et al. 2007)

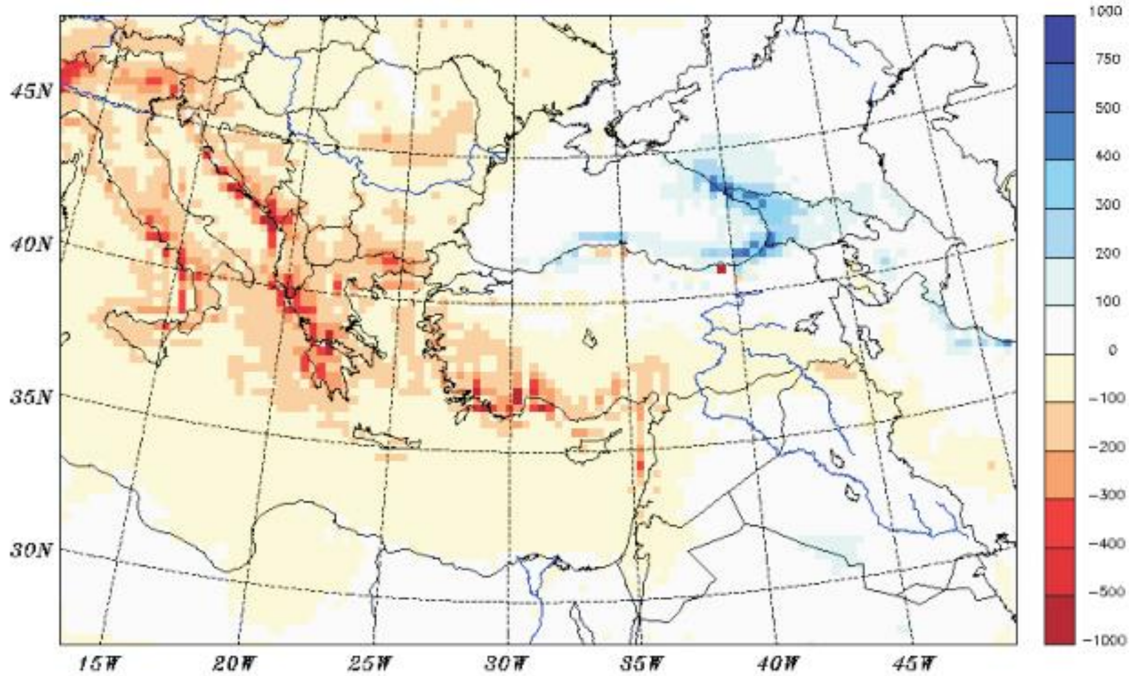

Figure 2. Predicted annual precipitation differences (2071:2100 - 1961:1990 mm) (Dalfes et al. 2007)

Climate change impacts and adaptation measures in forest sector:

Forests provide lots of services to other sectors that are called ecosystem services. These services are inter-alia: erosion control, oxygen production, carbon sequestration, protection of biodiversity, stabilization of water flow, soil protection, food for livestock, and additional income for villagers through ecotourism, non-wood forest products and honey forest establishments etc. Continuity of these services depends on health of forest ecosystems against biotic and abiotic stresses.

Climate change is one of the main stress factors for the forest ecosystems in Turkey.

Climate change negatively affects forest goods and services and reduce the magnitude of benefits they provide to the other sectors. It will significantly reduce timber production, carbon sequestration, water quality, soil stabilization, erosion control, recreation, ecotourism, non-wood forest products and biodiversity functions of forests. Effects like more insect outbreaks and pest damage, decrease in biomass growth, upward movements in plant belts, and increase in forest fires are expected (Table 1). According to a modeling study done by DKM (Zeydanlı and Ulgen; URL 1) (2009), significant changes in distribution of Taurus cedar (*Cedrus libani*), brutian pine (*Pinus brutia*), black pine (*Pinus nigra*), and Taurus fir (*Abies cilicica*) are expected in Seyhan Watershed.

The results of the study showed that 93.1% of the forest area of Taurus cedar, 56.2% of the forest area of brutian pine, 68.5% of the forest area of black pine and 85.7% of the forest area of Taurus fir will not be suitable for the growth of related species in year 2050. But it should be kept in mind that the study used only distribution data of the each species in Seyhan Watershed to model and predict the future distributions of them. For example distribution of brutian pine starts from Egypt and extends to North up to Blacksea coast. Therefore, the results of the study need to be interpreted carefully.

To overcome negative effects of climate change, adaptation measures that listed in Table 1 need to be carefully implemented in the forest sector.

Table 1. Climate change (CC) impacts, adaptation measures and required changes in policy and plans of forest sector in Turkey.

Factor	**Impact**	**Adaptation Measure**	**Required change in GDF Strategic Plan**	**Required Change in Forest Policies**
Longer growing season	Earlier bud burst; later bud set, more mammas growth.	Select planting stock with an origin up to 3º latitude south of site, and up to 6º south as a small component of mixed provenance stock in species of low frost sensitivity	Take into account CC adaptation measures in strategic goal I and II	Revise Afforestation Regulation considering CC adaptation measure
Warmer growing season increased CO_2 concentration	Increased growth rates, improved yield.	Choose conifer and broadleaf species that will produce better quality timber grown in a warmer climate, but beware of frost sensitive species on frost prone sites.	Take into account CC adaptation measures in strategic goal I and II	Revise Afforestation Regulation considering CC adaptation measure, revise Forest Management Regulation
Fewer frost days – milder winters	Reduced hardening, later dormancy, increased risk of autumn frost damage to sensitive species with extended growing season.	Change to less frost sensitive species/provenances; change to species requiring less cold to harden, and increase genetic diversity.	Take into account CC adaptation measures in strategic goal I and II	Revise Forest Management Regulation
Reduced summer rainfall	More frequent and drier summers, reduced growth, increased drought stress, secondary pest/disease outbreaks resulting from drought stress, increased fire frequency.	Change/mix species to drought tolerant types on sensitive sites. More thinning to reduce moisture demand in open stands. Increase public awareness and vigilance. Contingency plan and regular training for fighting fire.	Take into account CC adaptation measures in strategic goal I and II	Increase fire monitoring and fire fighters, revise forest management regulation
Longer growing season	More generations of insect pests per year (increased	Increase tree species diversity; enhanced monitoring and intervention	Take into account CC adaptation measures in	Increase monitoring, pest control and research related pest

	voltinism).	where possible or appropriate.	strategic goal I	control
Milder winters, warmer growing season, increased CO2 concentration	Increased productivity; increase in woodland mammal populations, insect pests and tree diseases and colonisation by alien invasive species.	Enhanced pest and disease monitoring and intervention where appropriate. Increase tree species diversity	Take into account CC adaptation measures in strategic goal I	Revise forest management regulation to permit species change
Increased windiness	Increased wind damage and resultant bark beetle outbreaks	Reduce risk through shorter rotations, species diversification and early thinning, and self-thinning mixtures.	Take into account CC adaptation measures in strategic goal I and II	Revise forest management regulation to emphasize doing thinning regularly
Upward movement in plant belts	Dominant tree species change in certain areas, new forest areas in alpine areas, some forest areas might turn into grassland-shrub areas in lower elevations	Select planting stock with an origin up to 300 m lower elevation of site Determine potential areas that might turn into from grassland to forest in alpine areas or from forest to grassland-shrub areas in low elevations. Establishment of new seed stands especially in low elevations	Take into account CC adaptation measures in strategic goal I and II	revise Forest Management Regulation
Sea level rise	Salinization in soil and water, death of low elevation and sea coast forests	Develop salt tolerant ecotypes of coastal tree species, establish shelterbelts to reduce salt and sand movement	Take into account CC adaptation measures in strategic goal I and II	
Depletion in ground water level	Species change in flat land forests, increased drought stress, disease and insect damage	Enhanced pest and disease monitoring and intervention where appropriate. Increase tree species diversity, water saving techniques, use low water consuming tree species %30 in mixture	Take into account CC adaptation measures in strategic goal I and II	Revise Ground Water Regulation accordingly (get advise from water department, SWW(DSİ))
Increased floods and landslides	Destruction in some riparian, alluvial and slope forests	Leave more forest area as protection forest and decrease the percentage of conifers in mixtures in areas having high risk of flooding, increase deep rooting tree species in mixture where land sliding is possible, protect existing riparian forests and establish new riparian buffers where riparian forest has been destroyed	Take into account CC adaptation measures in strategic goal I and II	Revise “Article 52-k” of Forest Management Regulation
Increased avalanche risk	Destruction in some slope forests, increase in bark beetle attacks	Enhance monitoring, protect forests in areas having high avalanche risk	Take into account CC adaptation measures in strategic goal I	Add “avalanche” into “Article 52-k” of Forest Management Regulation

What need to be done to overcome challenges that climate change brings into forest sector?

To overcome challenges that climate change brings into forest sector, activities, structured in four components and listed below, need to be realized in an integrated watershed management approach by the related sectors with the coordination with each other.

a. Research and awareness raising on climate change

1-Research on Climate Change (CC) effects (esp. on water and agriculture)

- *Establishing stronger relationships between researchers and management to help identify resilience threshold for key species and ecosystems processes*

  Even though CC changes in the Country is anticipated through CC models, response and resilience of each species is not known. Collaboration need to be done with research stations and universities to do these studies.

2-Awareness raising on CC effects (esp. DSI and agriculture)

- *Increasing "Climate-smart" capacity by trainings*

  Training of technical staff all sectors, farmers and NGO's are crucial in combating CC and success of implementation of adaptation measures. The percentages of population that have taken CC training courses are 14.8% for cities and 2.9% for rural areas in the watershed (URL 1). This data show a strong need for training in the watershed regarding CC.

b. Promoting the use of forest goods and services as ecosystem based approach

1-Enhance erosion control measures

- *Increasing afforestation and erosion control studies in watershed*

  Use low elevation seed sources in these plantings and allow larger distances among seedlings. These activities will reduce erosion and flooding and will increase carbon sequestration, soil quality, stream flow, ecotourism, aesthetic view, wildlife and NWFP.

2-Protection of riparian forests

- *Restoring, protecting and establishing riparian forests*

  Riparian forests are crucial for ecosystems. They provide a transition between aquatic and terrestrial ecosystems. They reduce flood damage and erosion, and increase biodiversity, carbon sequestration, wildlife, wood production and aesthetic view. A guideline related how to manage riparian forests need to be prepared by GDF and forest management plans need to be revised according to these guideline in the watershed.

3- Income diversification of forest villagers

- *Providing additional income to villagers through utilization of NWFP*

  The NWFP's like laurel, thyme, sage, rosemarine, peanut, resin, blue berry, mushroom etc. are important income source for villagers. The inventory study of NWFP in each forest district need to be done in each region.

- *Supporting establishment of additional "Honey Forest" to increase honey production as an alternative income source for villagers*

  Forest districts have already started establishing "honey forests" or leaving an existing forest as "honey forest" changing its management plan. But establishment of these honey forests should be increased and coordinated through a plan.

- *Promoting ecotourism in the watersheds*

  Most of the watersheds are very rich in terms of biodiversity and natural views. Forested high plateaus in mountains offer good opportunity for ecotourism. National parks, refuge areas, lagoons, and biosphere reserve areas have high potential for flora and fauna tourism and ecotourism.

- Forage production

  Forage production is a provisioning service in the forests and grasslands ecosystems that supports both native herbivores and domestic livestock in the watersheds.

c. Improving forest resilience

1- Improved forest maintenance

- *Reviewing current tending plans of the forest districts to look for opportunities to apply more tending and thinning works to reduce fuel load and demand for soil moisture*

  Thinning and tending activities will decrease fuel load in forest stands preventing chances of surface fires turning into crown fire. These activities also decrease interception by canopy letting more water to infiltrate into soil. With the increase of temperatures and decrease of precipitation water demand of trees will increase and availability of water will decrease. To reduce competition among trees more spaces should be given to each species to cope with climate change.

2-Promotion of forest diversity

- *Promoting heterogeneous, multiple-age forest stands to increase biodiversity*

  Multiple-age forest stands allow lighter to penetrate into ground, letting shrubs and grasses to grow.

- *Increase genetic diversity in planting materials*

  It may make sense to ensure that when new trees are planted, reproductive materials include ample genetic diversity. This will provide insurance against future changes of climate. This can be done by giving trainings to nursery technicians and legislation change.

3- Introduction of climate change resilient tree species

- *Giving priority to species that are more resistant to drought in regeneration and afforestation activities*

  Both in regeneration and afforestation activities priority should be given to those tree species that are more resistant to drought.

4- Improve the fire management system

- *Taking an initiative to train and convince technical staff to apply prescribed ground fires to reduce fire fuel load*

  Ground surface prescribed fires reduce fuels and increase resistance to fire. It also allows more water to penetrate into soil. Currently forest technicians are not using this technique in the region.

5-Preventing insect outbreaks and pest damage

- *Preventing insect outbreaks*

  Try to forecast insect outbreaks using enhanced monitoring system with pheromone traps. Thinning and prescribed thinning will also reduce insect outbreaks. Removing fallen and dead tree stumps will also help prevention of insect outbreaks.

- *Building additional roads to increase road network and density to better fight with forest fires (15m/ha)*

  To effectively fight with fire, forest stands need to have an appropriate road network and density to allow fire hose to reach every single fire. These roads should build in a way that should not damage the stands.

- *Placing additional firebreaks and other area treatments*

  These establishments will reduce the continuity of forest floor debris near important residential areas, municipal watersheds and habitats that are designated as critical for the survival and recovery of threatened or endangered species.

6-Establish ecosystem monitoring systems and early warning systems

- *Take additional sites besides ICP sites for ecosystem monitoring and early warning system*

  There are ICP sites that have been taken by General Directorate of Forestry staff to monitor forests health in Turkey. But the numbers of these sites are not enough to have a good knowledge about forest health for a local area.

Figure 3. Landscape-scale thinning and fuel reduction treatments represent a short-term adaptation for improved resistance to fire: a 70 000 ha wildfire in the Okanogan-Wenatchee National Forest in Washington State (USA) in 2006 caused 100 percent mortality in a high-density mixed conifer stand (left), whereas a stand that had been thinned and had surface fuels removed by prescribed fire sustained low scorch and minimal overstorey mortality (right)(URL. 2).

d. Capacity development and policy

1- Intersectoral cooperation

- *Enhancement of intersectoral cooperation by regulations and managing authorities*

  One of the most important challenges in management is intersectoral cooperation in the watershed. This weakness can be eliminated by new regulations and training of managers.

2- Integrated watershed management

- *Preparing integrated watershed management plan for the main basins of Turkey*

  It is necessary to prepare an integrated watershed management plan for the main watersheds of Turkey to effectively combat with climate change.

3 -Effective water management

- *Applying drip irrigation system*

Drip irrigation significantly reduces the amount of water used for per area. It should be further promoted in the watersheds.

4- Revision of forest management plans according to CC projections

- *Review existing forest management plans*

  The purpose of this activity is to identify weaknesses in measures for coping with extreme climate-related events (e.g. drought, fire, floods) as well as for managing water use, recreation and extraction of timber, forage and other natural resources before, during and after these disturbances. This review will also shed light on the potential impacts of more intense climate-related events in the future. Insights gained from such a review will help managers develop plans to alter the successional trajectory of ecosystems after catastrophic fire or wind events and to aim for a condition more likely to thrive under future climate.

- *Updating forest management plans of each district to ensure landscape corridors and ecosystem patches to permit species migration and dispersal as a long term adaptation strategy*

  Current forest management plans of forest districts in the forest areas need to be updated to allow forest managers to leave some areas as a corridor or ecosystem patches.

- *Incorporating climate change into existing forest management plans of watersheds.*

  These plans need to be updated according to current and expected CC impacts in the watersheds. Tending and thinning activities should be increased in the plans. The areas left for production of non-wood forest products such as resin and laurel should also be increased in the plans.

Conclusions and Suggestions:

Climate change poses significant risks to forest sector in Turkey. To reduce its impact, adaptation measures should be determined and implemented as early as possible. Some of these measures can be summarized as follow:

- There is a great need for capacity building and awareness raising on CC,
- More research is needed on impact of CC on different species and ecosystems and tree resilience,
- More vulnerability analysis are needed,
- Pilot sites and pilot projects related to CC are needed,
- More awareness raising works needed on goods and services provided by forests,
- Seeds from more southern origins and lower elevations of trees need to be used in plantations more,
- More seed stands need to be established in lower elevations,
- Priority should be given to natural regeneration and establishment of mixed stands in regeneration studies,
- Regular thinning treatments should be implemented,
- A good road density or road network should be kept in forest areas,
- Forest biodiversity need to be increased,
- Forest monitoring and conservation studies need to be increased.

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