CLIMATE CHANGE AND FOREST ADAPTATION

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Prologue

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Abstract

Natural ecosystems and biodiversity are characterizes by the majority of the benefits that they offer to human beings. This support is extremely threatened by the changes in the climate, the biodiversity loss that may occur because of the transformation of the temperature to plus 3oC. In recent years we have witnessed a progressive climate change and the important global impact but the financial crisis tends to distract from the long-term benefit of investment in climate change adaptation. The changes will be huge, according to the IPCC (2007) there will be a 3oC warming which is expected to tranform about one fifth of the world' s ecosystems. All these factors explain the urgent need of adopting actions. Greece in an effort to follow the policies of the European Union has recommendatory Commission Study Impact of Climate Change (EMEKA) that aims to present in detail the projected climatic and environmental changes, to assess the cost of these changes for the Greek economy and to assess the cost of adaptation to climate change. Thus estimated to be offered the opportunity to contribute to the knowledge in designing a uniform policy for adapting the Greek economy. The results of the study conducted in collaboration of experts from different reasons sectors demonstrate not only the need for action to address climate change and the need for further in-depth research, which will help and provide appropriate direction to the next generations. Prompted by the above study created, this dissertation aims to contribute to the action preceded by scientists.

Introduction

Greece is a country with a wealth of natural resources, yet a large number of risks that threaten the natural and human environment. With a total length of 16,300 km (as approximately one third of the circumference of the planet) Greece show great vulnerability to climate change as well as approximately 1,000 miles are areas of high vulnerability to climate change (Zerefos *et al*., 2010). The environment of Greece, apart from a very particular point of very extensive coastline, also features high biodiversity and different climatic conditions, due to the interaction between weather systems and other complex topography and percentage distribution of land and sea from west to the east and from north to the south.

Our planet has a history of 4.5 billion years, the parameters that characterize the climate of the earth is undergoing major changes. From the late 19th century it is noticed a warming in the atmosphere, which continues with variations until today. The average heating rate of atmospheric warming in the 20th century was 0,7oC per 100 years (IPCC, 2007). An important part of this heating, as is known , has been attributed to a change in the composition of the atmosphere due to human activity and has come to be called "anthropogenic component of climate change" or simply "anthropogenic global warming". The Jones and Moberg (2003) calculated the increase in the average temperature of the atmosphere of the continental parts of the world during the 20th century to 0,78oC per 100 years. It should be noted here that the increase was not constant throughout the course of the 20th century, but appeared mainly in the periods 1920 to 1945 and from 1975 until today, while from 1945 until 1975 many works have tried to interpret the observed then cooling due to obscuration of the sun by anthropogenic aerosols. However, the recent upward trend in temperature is statistically significant at the 95% confidence level in almost all populated areas of the planet, and the World Meteorological Organization, the decade 1995-2005 was the warmest of the last 500 years (WMO, 2006).

According to the forecasts made by the Intergovernmental Panel on Climate Change (IPCC, 2007) show that the upward trend of the temperature of the atmosphere will continue in most areas of the planet in the 21st century. More specifically, based on the average of a set of climate simulations, the average temperature of the atmosphere is expected to increase, depending on the evolution of concentrations of greenhouse gases by 1,8-4oC during the current century. Global warming is thought to be important in high latitudes and stronger on the mainland compared to the oceans (IPCC, 2007). Global warming will lead to reduction of marine and terrestrial areas covered by ice, and the increase in mean sea level. Indeed, the observed and expected warming of the atmosphere is accompanied in many areas and a trend of increasing frequency of extreme weather events, as evidenced by the forthcoming report of the Intergovernmental Panel on Climate Change (IPCC) which is dedicated to extreme weather events (IPCC, 2013). Estimation of the amount of precipitation is more complex due to local factors and the geological terrain, which affects the amount of rain. In the 20th century the amount of rain in inland areas showed an average growth trends in a large segment of medium and high latitudes, whereas in tropical regions kept downward trends. A similar picture is expected to show the amount of rain in the 21st century, according to the results of climate simulations. Generally expected increase in precipitation in the mid and upper latitudes and in the Equatorial Convergence Zone, and reduction of the tropics (IPCC, 2007).

Southern Europe and the Mediterranean region have been identified as vulnerable areas in regard to the effects of anthropogenic component of climate change (IPCC, 2007). The areas which are located at the boundaries of the zone where exist semi-desert conditions, this means that a possible northward shift of the baroclinic instability zone, due to climate change, can lead to serious changes, especially in the balance of water in the Mediterranean. More specifically, a series of climate simulations conducted under different emissions scenarios for the Mediterranean region, predicts that by the end of the 21th century the temperature rose significantly while the amount of precipitation are expected in the region will be reduced (Pal *et al.*, 2004).

Studies focused on the extreme changes of temperature and precipitation, showed that in the future, in the Mediterranean region, there will be a dramatically increase concerning the intensity of hot intrusions (Diffenbough *et al.,* 2007) and during periods of drought (Goubanova and Li, 2007), resulting in significantly increasing the risk of forest fires. These changes are expected to have significant impacts on the ecosystems of the Mediterranean region but also in a number of fields and effects of human activity (such as health, agriculture, tourism, energy demand, natural disasters, reduction of biodiversity, etc.).

In Greece there are formed four climate types (Mariolopoulos, 1938)

a) The type of the Mediterranean Sea, with pleasant features a temperate climate, the west coast of Greece and the Ionian Islands

b) The land in the Mediterranean, including the SE Greece, part of Central Greece, parts of East Peloponnese, the islands and the coast of Central Aegean and Crete, with drier summers and colder winters than the corresponding latitudes in the Ionian

c) The Continental type, the greater part of Thrace, Macedonia and continents course and part of Thessaly, who displays characteristics of a continental climate of the northernmost Balkan regions, and

d) The Mountain Press, which includes the mountain ranges that cross the Greece. In the mountain these tumors are woodlands with forest climate, and small areas of high altitude alpine climate during the winter.

The islands of the North Aegean present transitional continental climate type to land and the Dodecanese temperate marine type.

The human activity can provoke changes at the atmospheric conditions in three ways: a) by differentiating the characteristics of the land surface and land use change (urbanization, deforestation, drainage water surfaces etc.) b) with the release of energy in the atmosphere (industries, heating, lighting, etc.) and c) with the enrichment of air with different gases (pollutants) and particles. The human impact on the atmosphere is most visible in large cities. This phenomenon is called "urbanization" and has resulted in a significant modification of the climatic parameters of urban environment.

The majority of the countries lack off the estimation of the costs they need to incur in order to adapt to climate change. The problem is becoming more complicated when it has to do with the adaptation of an ecosystem. The current estimations are quite a few and they are mostly based on the financial flow that is needed to conserve. Up until now there is not a standard methodology that is followed driving to the augmentation of the problem.

Climate change and forests

According to a research performed on the maximum summer and minimum winter temperature, all regions of Greece is expected to have about 1,5oC the 2021-2050 and the 2071-2100 3,5oC higher minimum winter temperatures. These results are in agreement with findings in a large scale, according to which in recent decades have witnessed a significant trend of increasing minimum temperatures. This warming will be greater in the more mountainous areas, particularly in the mountain ranges of the Pindos and Northern Greece. There, the figure will rise to 2oC between 2021 - 2050 and 4oC during the 2071 to 2100 (Zerefos, 2009).

The rise of this parameter can affect the forests, which are common in colder conditions. If conditions become prohibitive for certain categories of forests (eg spruce forests), they may begin to prefer to grow at higher altitudes.

Forest fires, like any other natural process in an ecosystem are influenced very easily by the changes in the climate, as the fire behavior dovetails with the moisture of fuel, which in turn is determined by rainfall, relative humidity and the air temperature and wind speed. Thus, the projected rise in average temperatures due to climate change will increase the dryness of fuel, reducing the relative humidity, and this phenomenon will be more pronounced in areas where reduced rainfall. At the same time, the increasing frequency of extreme weather conditions are expected to have a significant impact on the vulnerability of forest fires. The increased risk of fire will be increased by 20 days from 2021 to 2050 and by 40 days from 2071 to 2100 across eastern Greece from Thrace to the Peloponnese. Smaller increases are expected in western Greece, mainly due to the humid climate of the region (Mouillot *et al.,* 2002).

The existence of coastal forests and wetlands ensures minimized flooding, erosion and other natural disasters, offering valuable regulatory and supported ecosystem services.

The impact of climate change on ecosystems is essential as they play a vital role in the economy and the quality of human life. In Greece forest ecosystems cover 65% of the total land area (more specifically 25% is forested, while the remaining 40% is covered by grassland). Forest ecosystems are highly degraded in the country mainly because of improper and excessive use of which implies reduced production. With the proper use of the forest ecosystem can provide a variety goods such as wood biomass, the forage material, various nuts, mushrooms, honey, herbs even contribute to air quality and commitment - storage of CO_2. Of course we must not forget and intangible services that they provide, such as the protection of soil resources, biodiversity, and the fact that they provide habitat and food in abundance living beings etc. They also have great cultural and aesthetic value. Finally, provide opportunities for varied recreational activities (hiking, camping, hunting, cycling etc.), which are essential for the welfare of man. The abundance of goods and quality of services depends primarily on the stability of ecosystems, which is a function of biodiversity and physiological functions (Papanastasis, 1982).

The health and the dynamic growth of forest species is directly dependent on environmental factors such as temperature, solar radiation, water that is available to them and the soil nutrients, and also depend on pure ecological factors such as competition, animal - community effects of microorganisms and fires (Johnsen *et al.,* 2001). In the 20th century found a small increase in temperature and decrease the amount of precipitation. This trend is expected to continue in the 21st century (Zerefos, 2009).

However, the overall decrease in precipitation in the year 2100 will not be uniform throughout the Greek territory, as well it should decrease on the mainland (where there are the productive forests of Greece) and an increase in the Aegean islands (except Crete). Forest ecosystems will be harmed primarily by reduced precipitation and high temperatures that prevail during the dry and hot period and increased risk of wildfire (Giannakopoulos *et al*., 2009). The question is to what extent forest species are able to adapt to rapidly fluctuating environment. If they are not going to adapt in a short time, the forest ecosystems will be exposure at an increase risk of destabilization and, in extreme cases , they will collapse. These impacts could be mitigated considerably if taken early appropriate management strategies, such as crop specific care (FAO, 2003). So, it is necessary for forest policy and management strategy to adapt quickly, to mitigate and cope more effectively with the negative impact of the upcoming climate change.

According to the current applied management strategy without adopting additional measures, it is estimated that, due to climate change by the year 2100, there will be a spatial redistribution of the country's forests and forest canopy cover overall will decline. Trees and forest who prefer warm conditions (de Dios *et al*., 2007) will be extended by 2% to 4% and forests of spruce, fir, beech and black pine will shrink by 4% to 8%. Also, some coastal forest ecosystems risk being converted to pasture or desert fields (Le Houérou, 1996). From the spatial redistribution and reduction of area of productive forest average of 160 to 320 thousand ha reduction of production of wood biomass at 0.5 kgm/ Ha / Year and a total of 80 to 160 thousand kgm / for the respective scenarios.

With the expected increase of the CO2 emissions and the increase of the temperature we will notice an extend to the growing season of the crop at 10 to 15 days (Chmielewski and Rötzer, 2001), which will have a positive contribution to the production of forests and meadows, while during the winter period there is adequate soil moisture. Increased productivity is however very likely be mitigated by the reduction of precipitation and the frequency and intensity of extreme weather events such as heat waves, floods, etc. It is estimated that the rate of carbon sequestration by forests will be reduced by approximately 25% and 30% by the year 2050 and by 7 % and 15% above the previous to 2100. Overall in Greece is expected to be a decline in timber production averaged about 27% to 35% by 2100. That is, the expected decrease in production of wood biomass with the average for the last 21 years (1960 thousand cubic meters, Ministry of Environment 2010). At the same time there will be a reduction of Rangeland production due to reduced precipitation (Papanastasis, 1982) by 10%, but may be up to 25%. Reducing Rangeland production is estimated at 120 kgm / Ha up to 300 kgm / ha in 2100. Given that in Greece there are currently about 5.2 million ha of grassland, the forage material for the whole country will be reduced by 312 thousand tonnes to 780 thousand tonnes in 2100.

With the rise in temperature there will be an increase at the number of fires during the summer period and the total burned area and, also, we will notice a reduction of the time between two successive fires (Mouillot et al., 2002). The forests of the southern mainland and Crete will be harmed more (Giannakopoulos et al., 2009).

During the decade 2000-2010 in Greece occurred over 100 thousand fires, destroying an average of 62 thousand ha of agroforestry land annually (Gkourmpatsis, 2010) . It is estimated that the burned area and proportionally the total cost of fire suppression, damage and reconstruction costs will rise from around10% to 20% per annum plus the current (Torn et al., 1999, Giannakopoulos *et al*., 2009). The total cost of fire suppression and fire damage, as assessed, currently stands at more than € 400 million annually. With the expected climate change will increase by € 40 millions to € 80 millions.

With the structural changes of forests, such as the reduction of canopy cover, and the expected increase in extreme weather events is expected to increase surface runoff and soil erosion by 16% to 30%. Result will be the loss of deep filtration and enrichment of groundwater aquifers. This, coupled with the expected increase in evaporation - transpiration, will have the effect of reducing the amount of usable by - disposable water (Arora and Boer, 2001) by 25% to 40%, from 5 billion to 8 billion cubic meters / year. Also it is expected to reduce the value of intangible assets and other environmental services by 5% -10% (de Dios *et al*., 2007, Founda and Giannakopoulos, 2007).

The rise in sea level is expected to continue at a faster pace than today and will jump from 0.25cm to 1 m by the year 2100, this will lead to diversify land uses in areas around the sea (Nicholls, 2004).

Coastal wetlands are expected to be hit hardest are those of Ebros (Delta of Nestos), Axios River, Loudias River, Aliakmona River and Achelous River, the lagoon of Messolonghi and the lagoon of Kyllinis and the Gulf Ambracian and Pagassitikos. In insular Greece the major problems are expected to occur in Lemnos, Samos, Rhodes, Crete and Corfu (Nicholls and Klein, 2005).

Due to these changes, there will be a lot of negative impacts on tourism and refreshment, especially in July and August, as the average air temperature and the frequency of that and the intensity and duration of heat waves will increase. But the extension of the tourist season, mainly during the months of May and September, is expected to offset these negative effects, resulting in the total tourist traffic are not altered significantly by the end of the 21th century (Rutty, 2009). With the degradation of forest ecosystems is expected to have and to the quality of life especially in urban centers, where we observed increased incidence associated with environmental degradation, such as allergies and heart attacks. This situation will even lead to an increase in health care costs and in treating diseases.

Climate change - Adaptation

As we discussed before, climate change could damage forest ecosystems in the following ways: fire, infestation, disease, dissertation and wind (Sedjo, 1991). The idea of adaptation is new. Up until now the literature is quite few and trying to analyze the economic costs of a climate change by estimating the different type of infrastructure that might be needed against a future sea level rise. A new approach given by Tol *et al*. (1988); turned against to this prespective and present this method as a quite easy and away of the reality. According to them, the majority of the studies failed to compare the benefits of adaptation in terms of damages avoided against the costs of the measure needed to achieve the reduced damages (Tol *et al.,* 1988).

The adaptation costs are relevant compared to the benefits from mitigation and adaptation policies. Trying to estimate a benefit – cost approach in order to find the solutions of adaptation we should consider the time and the resources that might be needed in order to conclude in a solution. Up until now in order to conclude we use a global set of estimations that adopt different approaches. In many studies, it is used the study of UNFCCC (Berry, 2009) and the James *et al*. (2001).

Following them, the estimation of the costs under the goals of IUCN in order to protect the natural ecosystems and to enhance the global protected areas is crucial. To accomplish this should initially become increase expenditure than 12 to 22 billion dollars a year (James *et al*., 2001). Having in mind that these costs cover part of biodiversity, rather than all this, the full cost of adaptation of ecosystems to be converted, providing an estimate of $ 64.5 billion and $ 83.5 per year (Berry, 2009). Looking at the UNFCCC study we find that using two adjustment scenarios , the first is the "business as usual " and the second "scenario with mitigation". Both these proposed scenarios have no clear level of adaptation to climate change to be achieved. But they are based on the assumption of the creation of an adequate network that will provide at least the first step in achieving the necessary adaptation to climate change for natural ecosystems. Both of these scenarios we could assume that they are designed to adjust to maintain rather than adaptation.

According to James *et al*. (should waste around 12 to 22,000,000,000 U.S. dollars) based on an increase of 10% in the areas to be protected. In another study of Blamford *et al*. (2002), and following a similar approach to calculate the cost of extending protected areas covering 15% of the total area of each terrestrial region. It will be an estimate of $23 billion annually on marine protected areas and 20 to 28 billion U.S. dollars annually for terrestrial protected areas. While Lewandroski *et al*. (1999) had already estimated that the cost to regional economies generating set aside for the protection of ecosystems, although it is not necessarily under the threat of climate change. These costs are measured by the value of goods and services protect against loss of land acquisition. The total annual cost ($ 1.990) retire 5, 10 and 15 % of the earth' s surface to protect these resources were $ 45.5 , $ 93.3 and $ 143.8 billion, respectively.

According to this approach and trying to have a wide range of protected areas it is possible to underestimate the situation. To begin with, we should consider of the areas that are not included in the testing area but could also be affected from a climate change. Another important thing is that the methodology is too top down and a more bottom - up or local approach is warranted (Callaway, 2004).

Passing through the literature we found out studies that focus on the cost of adaptation at regional or country level. Some of them are: migration corridors in Kenya (Ferrano and Kiss, 2002), coastal reforestation in Croatia (Pagiola et al., 2004), conservation of tropical forests in Costa Rica (Ferrano and Kiss, 2000) or estimating the costs for restoration and recreation of natural habitats under climate change, at annual costs that amount to £2.5 million (US$4 million) under a 2050s high-emissions scenario in the United Kingdom (Metroeconomica, 2006).

As we have noticed before, there are two ways to cost the adaptation in natural ecosystems. The first one is to focus at single and isolated areas and the second one to examine the situation looking for a more global based level of adopting without justify the targets correctly. A different way was examined by Busch *et al*. (2009) where trying to estimate the adaptation costs and option in Madagascar, the authors, calculated the cost of ensuring minimum acceptable viable areas of stable forest habitat for 72 endemic species of plants under different levels of climate change. For this study the analysis was based regarding the area that specie needs to survive in a natural ecosystem and a target based set on the climate change impacts that were expected. In order to achieve those Busch *et al*. followed three adaptation strategies guided by an expert workshop:

1. Avoiding forest degradation through wood product substitution
2. Avoiding deforestation through agricultural stabilization
3. Restoring natural forest to achieve a minimum cover

Following that, for each species Busch *et al*. identified the expected impact of climate change in terms of the area of habitat, by setting as a minimum area 10.000Ha of stable forest as established by the IUCN. Although this paper is an important step forward in assessing ecosystem adaptation costs, it stills fails to provide the total adaptation costs or to identify vulnerable areas, since multi species conservation strategies should need less land allocated to conservation, as compared to a species by species estimation.

In the majority of the studies that have to deal with the measurement of the cost of adaptation in an ecosystem (forest) there are two different ways of estimation. According to the first method it is examined the cost of adapting to a future without the effects of climate change and in accordance with the second method it is considered a future with climate change impacts. Adaptation could be elected from various levels, from covering all impacts to covering as much as cost - effective measures allow or even not adapting (WB, 2009). Because of the lack of evidence on the success of an adaptation plan and in order to make the approach easier and simpler, the most appropriate level of adaptation is being count as being the one that equals the current situation with a future scenario in which there is no change. After that the amount of adaptation can be identified from the magnitude of the expected impact. The basic idea is to set targets to reheal “without climate change” conditions in the future, based on projected impacts (Peterson *et al*., 2008). As an example of this we might think the risk may bring about a climate change on forests. This could lead to a reduction in the size of forest ecosystems. In this example, the objective should be asking is the adaptation of this forest to climate change in order to maintain its original boundaries. In this example, the concept of "conservation triage" as a means for setting priority targets to tackle climate change is emerging conservation policy regarding climate change. During the evaluation of the cost adaptation, setting targets based on climate impact and evaluation of their cost is so effective for the conservation and economic analysis (Hagerman *et al*., 2009).

Measuring the effectiveness of adaptation in an ecosystem. If we try to study the efficiency (which in this dessertation is considered as a measure of success of the adaptation of an ecosystem to avoid adverse impacts from climate change) we will realize that if it is not possible to quantify the impact, the effectiveness will be the measure showing the size of the adjustment of the ecosystem should be applied. The key question to be answered is the number of units of adjustment that must be defined to avoid environmental impacts or, if this is not possible, to minimize. So far, few studies report the UNFCCC examine the cost effectiveness of a natural ecosystem, it is because there is lack of efficiency measures on adaptation actions (Barry, 2009). Estimating adaptation costs for enhancing ecosystem services could be crucial as ecosystem-based adaptation is gaining attention (Zaunberger e*t al.,* 2008). Ecosystem-based adaptation can be defined as the use of sustainable management of ecosystems to support social adjustment (CBD 2009). The main objectives of this adaptation strategy are to maintain the biodiversity of ecosystems, to enable them to resist climate change and to provide services and the conservation of natural ecosystems that can provide cost-effective protection against climate change. An example would be a wetland restoration, which can benefit biodiversity and provide protection against floods or rising sea levels. Innovation approaches ecosystem implies a lack of information and data on the benefits, costs and effectiveness of these approaches. This makes it difficult to carry out cost-benefit analysis and other considerations that are often required for funding and policy decisions. In economic terms, when measuring the cost of adapting ecosystem, one has to face the difference between cost adjustment in natural ecosystems, as clearly linked to the existence of current and future ecosystems and biodiversity components, or if the services ecosystem include the benefits of adaptation (Berry, 2009). The Millennium Ecosystem Assessment defines a framework for the valuation of such services could be adapted in the arena of climate change. However, if the consideration of ecosystem services in adaptation issue of double counting could easily arise and will be a major problem. To conclude with, Heller and Zavaleta on a published work in 2009 on the existing literature over the management and biodiversity adaptation to address climate change. They recorded 113 published works, in all 524 , which are ranked according to frequency. According to the conclusions of their work 33% of the work exists addressing biodiversity conservation in conjunction with the services provided by ecosystems. Among the first three measures are ranked:

1. The increasing connections of habitats
2. The integration of climate change into planning exercises and mitigation of other threats to ecosystems (Heller and Zavaleta, 2009).

If there are targeting species conservation, adaptation should operate at the landscape level that allows the migration of species and natural ecosystems for these components of articles should serve as a criterion for identifying vulnerable areas where focus adaptive design. It would be desirable that future approaches to costing adaptation examine adaptation options, except of those within the protected area system.

On the other hand, Callaway (2004) is proposing an alternative method named "no regrets actions". These actions are taken in order to avoid climate change damages, but which nevertheless softens the impacts of climate change as they occur. In developing countries these actions are potentially related to development goals that can be still effective to reduce vulnerability to climate change. In some cases where they estimation of the climate change impact is a long term process the impacts are presented as being expected while there are cases where the climate change impact for the year 2030 or 2050 is unknown and uncountable (DEFRA, 2005).

If in a study there is a try to include the impact of the climate change against the biodiversity the issue is becoming more complicated. In order to have the balance in the ecosystem and the human wellbeing the maintenance of biodiversity is consider crucial. Based on biodiversity indicators, those ecosystems with higher indices should be favored as adaptation goals. The most species can be protected more cheaply under climate change by focusing resources on avoiding forest degradation and deforestation now, through the creation of substitute sources of wood products and agricultural commodities. To set targets and goals for the maintenance of biodiversity include many challenges as interactions occur between species and habitat composition. To avoid this problem, we may consider focusing on habitats or ecosystems in order to identify the adaptation targets, and include biodiversity in the analysis as criteria for vulnerability to climate change of these habitats.

According to the literature we can classify the forest adaptation in the following steps:

1. Anticipatory
2. Reactive
3. Autonomous
4. Planned

By telling anticipatory we mean to take measures in a specific forest before the first changes of the climate change will be noticed. Taking measures for the forest fires can be included in this category. The second step, which is reactive is referring to adapt after the first changes of the climate change in a forest ecosystem. Here we can include measures that have been taken after floods or strong storms. To the third step we have the autonomous adaptations that are measures taken by individuals as a reaction to an expected change. In the third step can be included the differences in tome of seeding or harvesting by a farmer because of expected weather changes. The fourth and final step is the planned adaptation which has to do with a policy or decisions that have been decided because of the knowledge that something has changed and we are concerning for its maintenance. (Garforth, 2012, Sedjo, 2010, Robledo *et al.,* 2005).

As adaptation measures for forests in the literature we can see:

1. Afforestation
2. Reforestation
3. Agroforestry

examples around the world. In Europe it s most common to have adaptation measures about afforestation and reforestation. According to the «SilviStrat», a pan - european organization because of the results that are found for the impact that the climate change has on forest productivity and the carbon storage (Kellomäki and Leinonen 2005) they recommend the plantation of new species that can tolerate to dry and frozen – nip conditions as a new adaptation strategy for the forests of European zone. Also they support the great diversity between the species as they say that may provoke them to adapt earlier to the new climate changes. Last but not least, they propose to have an augmentation an intense productivity to those areas that are likely to increase the biomass (Johnston *et al*., 2010).

Climate change - Mitigation

When we refer to climate change mitigation a we are talking about actions that are taken in order to prevent, reduce or offset the emissions of greenhouse gasses (GHG) such as carbon dioxide and methane which are thought to be contributed to the global climate change. Actions like that may refer to the reduction of greenhouse gasses emissions from power plants, industrial facilities and combustion – powered vehicles. According to the website of UNEP (accessed at 11/2013) mitigation may mean the use of new technologies and renewable energies and sources, making equipment (from the past or design new) more energy efficient, changing old – fashioned managing practices or even sometimes changing the every day consumer behavior.

«Mitigation is quite complicated and can became as complicated as redesign a city or as simple as cooking» (UNEP, 11/2013). Protecting natural carbon sinks like forests and oceans, or creating new sinks through silviculture or green agriculture are also elements of mitigation.

Mitigation may also be achieved by increasing the capacity of carbon sinks, e.g., through reforestation. The most characteristic way of mitigation is to include and store carbon in forests, trees and vegetation in general (Garforth, 2012). Forests it is estimated to include1.2 trillion tonnes of carbon which is a huge quantity (Patosaari, 2007). According to another reference, forests and wetland are able to maintain for a long time carbon (MEA, 2005). It is also observed that there are differences in the way that forests can store the carbon. For example, well – managed forests are consider to be able to store greater amount of carbon from those who are old – growth (Patosaari, 2007).

Discussion

Mediterranean has been recognized internationally as a region vulnerable to the impacts of anthropogenic climate change.

As shown by the results of a series of climate simulation, by the end of 21th century the temperature in Greece will make significant rise, while the amount of precipitation is expected to continue declining. In the coming decades is expected to grow significantly and the incidence of extreme temperature values and rainfall extremes.

Forest ecosystems (forests 25%, 40% lands) occupy about 65% of the land area of Greece. With the current management strategy and without additional measures and due to climate change by the year 2100, there will be an augmentation in forests who prefer warmer climate who will expand by 2% to 4%, while the forests of spruce, fir, beech and black pine will shrink by 4% to 8%. Some of the coastal forest ecosystems are at risk of desertification. With the rise in temperature is expected to increase the number of forest fires.

Climate change will have significant negative impacts in several areas in Greece. These effects lead to a decrease in productivity, capital loss and additional costs to repair the damage. Negative effects will also occur in the areas of biodiversity, ecosystems and health.

Countries lack sound estimates of the costs they need to incur to adapt to climate change. The problem is particularly serious for ecosystems adaptation, where current estimates are scarce and mainly based on the global financial flows needed for conservation. Methodological challenges remain unsolved and new approaches that operate not only on the protected area networks and at a level where policy action can take place are needed.

We believe that it is necessary to create a strategic planning as adaptation measures and emission reduction measures in the context of the global mitigation effort is needed to tackle climate change and reduce its negative effects on welfare, the environment and economic development.

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