Climate change, forest adaptation and technology: perspectives and drawbacks

Andreopoulou Zacharoula 1, Kalfagianni Agni 2
1. Associate Professor, Lab. Of Forest Informatics, Dept. Forestry & Natural Environment,
Aristotle University Of Thessaloniki, 54124 (Greece)
randreop@for.auth.gr
2. M.Sc., B.Sc. Forester and Environmentalist, Thessaloniki, 54655 (Greece)
kalfagianniagni@gmail.com

Abstract
The idea of forest adaptation is new. Up until now the literature is quite few and trying to analyse 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, turned against to this perspective 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.
Europe as a whole is exposed to climate alteration, however there are certain areas that are at greater risk than others. These included: the Mediterranean Basin, mountain areas, densely populated floodplains and the Arctic.
Nowadays, forests have to deal with climate change and at the same time, they meet the growing needs of human population.
It is believed that adaptation and mitigation strategies of climate change can lead to a conflict with biodiversity goals and efforts to restore forest ecotypes and production.
So far, although there is a management plan in Greek forests, it is not taken special consideration in climate change and the vulnerability of forests against the effects of climate change.
Information and Communication Technologies can play a fundamental role in the environmental protection, environmental sustainability, environmental education, rural sustainable development goal and climate change strategies besides, European Union supports the development and promotion of new technologies.

Keywords: Sustainable development, Technological Innovation, Renewable Recourses and Conservation

JEL classifications: Q01, Q23, Q54, Q58

Introduction

Climate change is seen as a consequence of earlier and current human activities on Planet (IPCC, 2007). The average global temperature has risen by about 0,8°C (compared to pre-industrial levels) and export continues to grow. In Europe, the rise of temperature was even faster than the global average (1,3°C compared to pre-industrial levels). The whole of Europe is exposed to climate change, however, certain areas such as the Mediterranean Basin, mountainous areas, densely populated floodplains, coastal areas and the Arctic are considered particularly vulnerable and are more at risk than the other (COM, 2013). In the Mediterranean in particular, the temperature seems to be on the rise and rainfall to decline statistically significant, during the winter and summer season (data for the last half of the 20th century)(Giannakopoulos et al., 2005). Green ICTs have been identified as a strategic tool in the monitoring and mitigation of climate change (Andreopoulou, 2012).

Climate change can provoke increasing of air temperature, changing of precipitation regimes, changes in annual rainfall and snowfall (IPCC, 2013). The global warming of last years has already caused changes in forests (Lucier et al., 2009). Due to this climate change, some trees has been positively been effected as it was mentioned growth in locations were the temperature was altered as also the CO2 levels (Kelly and Goulden, 2008). But this is not what the majority of literature review support.

It should, also, be mentioned the balance between forests and climate change. The global rise of climate change can affect forests in a numerous ways; but also forests impact on climate change is equally important. Forests can influence climate change because of the amount of carbon dioxide that can absorb. This is crucial in case of a fire, because this large amount of carbon dioxide will be released back in the atmosphere, influencing tho global carbon circle (FAO, 2005).

The impact of climate change on forest ecosystems is expected to be direct (for example reduction of productivity and exhaustion of trees due to increased drought) or indirect (for example worsening health of the forest due to pests pathogens). Environmental Informatics can help in environmental protection and sustainability using monitoring, simulation and modelling techniques, database registration, online Decision support systems, etc either in private or government National, trans-national and international level (Andreopoulou, 2009). As an effect, the achievement of management objectives, but also all the services that forests provide are at risk (Working Group of LIFE+ AdaptFor project, 2014).

Forests have the ability to absorb water, store it and release it gradually; limiting floods when it rains and storing water droughts. Trees not only provide habitat for animal and plant species, but also purify the air we breathe by removing dioxide, nitrogen dioxide sulfur dioxide, carbon monoxide and ozone, while store or absorb carbon in their wood (European Union, 2010).

In the previous years forest was known primarily for its financial meaning, especially for the production of wood for different uses. Nowadays we know that the forest serves purposes, functions and has utilities on resulting the production of wood at the second place. The role of the forest to the hydrologic circle (which consists to regulate the river and the quality of the produced water), soil protection from wind and alluvial erosion, wind protection, noise protection, the influence of the climatic factors of the area spreading and the wider region, in the composition of air and atmospheric pollution and aesthetic, recreational, health impact are gaining ground and importance (IPCC, 2007).

Nowadays, forests have to deal with the climate change and by the same time, it is important to cover the increasing demands of human population (Constanza et al., 2014). It can easily be perceived the difficulties that must be addressed by forest ecosystems, as they have to cope with both the needs of humans and their adaptation to climate change (Staudt et al., 2013).

It is believed that climate change adaptation and mitigation strategies can provoke conflict with biodiversity goals and efforts for restoring habitats in producton forests (Felton et al., 2016).

As it was mention during the 90s, climate change affected the distribution of forest types the last 10.000 years (Prentice, 1991). Also, during that time scientist expressed a great fear of rapid changes the following 100 - 200 years as a cause of greenhouse effect (Houghton et al., 1990). It was stated the importance of the topic, mentioning the problems of species composition, production and biomass of forest landscapes that may occur in a rapid climate change and may change the forestial equilibrium (Prentice et al., 1991a). Although of the existence of a great concern of the equilibrium, scientists believed in natural disturbance. Ecosystems that come from forests, provide a wide variety if services not only from the products but also they offer a variety of goods such as wellbeing. Even more, forestial ecosystems contribute to the hydrological cycle, support the soil etc. (MEA, 2005).

According to that theory, in a forestial ecosystem exist patches (sometimes because of natural disasters; such as fires and winds, and sometimes because of harvesting different years) that may help in the development of a new equilibrium under a climate change (Prentice et al., 1991b; Pickett and White, 1985).

So far Greek forest management exist without taking particular account of climate change, the vulnerability of forests in that and the impact that may have in the end (Working Group of LIFE+ AdaptFor project, 2014).

Forest Adaptation

Climate change could damage forest ecosystems in a number of ways including through fire, infestation, disease and wind throw (Sedjo, 1991). Forest could adapt naturally as they have done in the past by altering the ranges of important tree species, but a critical issue is the rate at which tree species would migrate under global warming (Sedjo, 2010). It is customary to classify adaptation measures into: anticipatory, reactive, autonomous and planned. Anticipatory, also referred to as proactive adaptation takes place before impacts of climate change are observed. Early warning systems to prepare for forest fires are a classical example of anticipatory adaptation. Reactive adaptation is that which takes place after the impacts of climate change have been observed (Robledo et al., 2005). For example, salvage logging after a storm (Garforth, 2012) or after a fire (Sedjo, 2010). Behavioural changes taken by private actors as a reaction to actual or expected climate change are known as "autonomous" adaptation. For example, the change of date of planting / seeding and harvesting by the farmer, due to a change in rainfall patterns (FAO, 2010). Planned adaptation is the result of a deliberate policy decision based on an awareness that conditions have changed and that action is required to return to, maintain, or achieve a desired state (Robledo et al., 2005). For example, tree planting and monitoring of forests (Bernier and Schoene, 2009).

Adaptation measures emphasized in the literature are: afforestation, reforestation and agroforestry. According to Sedjo (2010), in 2009 there were 45,083 ha planted forests in China, 32,578 ha in Japan, 17,340 ha in Russia, 16,238 ha in United States, 10,682 in India, 9,871 ha in Indonesia, 4,892 ha in Brazil, 4,425 ha in Ukraine and 2,284 ha in Iran. In southern Africa the afforestation rate is around 11,000 hectares per year. Examples of adaptation measures are summarized within the report of Seppala et al. (2009), Specifically, some indicative adaptation measures include: the afforestation of areas to protect against drought and aridity and provide firewood, fodder, tannin, pulpwood, shelterbelts and soil improvement in Burkina Faso (UNFCCC 2008a) the planting of trees in Tajikistan to protect from erratic rainfall and stabilise eroding soils and slopes (UNFCCC, 2008b) and the Five-year Action Plan for Mangrove Management in the Gulf of Thailand, which preserves mangrove forests and promotes sustainable use of mangrove resources (UNFCCC 2008c).

In Europe, the key adaptation measures are afforestation and reforestation, through enhancing the natural regeneration or by planting seedlings or by seeding, and thinning and harvesting practices (Kolström et al., 2011). The pan-European assessment called 'SilviStrat' (Kellomäki and Leinonen, 2005) explored the impacts of climate change on forest productivity, carbon storage and biodiversity. In general they found that forest productivity and carbon storage increased in northern and central Europe but declined in southern Europe due to drought impacts. They recommended planting new species that are drought-tolerant and frost-tolerant as an adaptation strategy. They also recommended increased intensity of thinning in areas where productivity was likely to increase (Johnston et al., 2010). The more diverse and larger the seedling population is, the more potential there is for populations to adapt to environmental changes. Adaptation measures in tending and thinning support mixed stands of well-adapted tree species, and/or uneven-aged/structured stands. Tending and thinning can also help to manage increasingly mal-adapted stands in a changing environment (Kolström et al., 2011; Lindner et al., 2008).

According to Adger et al. (2005) adaptation of climate change can be implemented by various agents; from individuals, firms and civil society, to public bodies and governments at local, regional and national scales and international agencies. In the case of the forest sector, the majority of adaptation measures are implemented at regional and local levels. The classification of projects in forestry, according to their scale, depends on the geographic coverage of project implementation, i.e. regional, national or local. The scale can refer to specific ecosystems or to political-administrative divisions. Indicatively, the Riparian Forest Restoration Project targets to the reforestation of 1 million ha of riparian rainforest in Brazil, with up to 800 native species. Finally, Chazdon, (2009) stated forest restoration efforts, whether at national, regional, or local scales, will take many decades, long-term financing, political will, labour, and personal commitment.

Climate change and European forests

The impact of climate change on forest ecosystems is expected to be diverse and affect the health and stability of forests. As a result, climate change is expected to negatively affect the functions, charitable effects of forests and the services provided by forests to humans. For example, changes in the hydrological cycle (spatial and temporal changes in rainfall distribution patterns), is expected to reduce the availability of water production from forest and would impair its quality, reducing in this manner the protective role of forests with respect to soil erosion, floods, strong winds, etc. Climate change can have contrasting effects on forests: on the one hand, European forests faced with changes occurring in a gradual way as the modification or movement of forest species and ecosystems which form and changes in forest productivity. On the other hand, forests are likely to be found even more exposed to extreme weather conditions (such as forest fires, drought, pathogen epidemics). The impact from gradual variations and extreme conditions can act either jointly or independently to compensate and neutralize each action of the other. For example, the observed increase in productivity in northern Europe offset by the impact of increased frequency and intensity of phenomena such as storms and insect epidemics. By contrast, in southern Europe, the impact of climate change seems to act collectively, as the gradual decrease in productivity coupled with an increase in extreme events (such as droughts and fires), leading to increased mortality of trees, and even in forest replacement by new types of vegetation (Lindner et al., 2014).

The forest ecosystems of the Mediterranean are expected to suffer to a greater extent of changes in climate parameters compared with forest ecosystems of other regions as the Mediterranean considered the center of climate change (climate change hotspot) (Giorgi, 2006). Moreover, in South Europe the abiotic conditions result in low productivity of forests, throught a combination of limited factors such as low fertility terrain, steep slopes and soil erosion risk. However, in the Mediterranean forests provide a wide variety of socio-environmental services, such as conservation of biodiversity, protection of the floods that make them of greater importance of forest ecosystems of Northern Europe (Linder et al., 2010).

Management and strategies

It is considered as a modern and universal definition of sustainable management (applying exclusively to natural resources)*"The stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfil, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems."* (Helsinki Resolution H1, MCPFE, 1998).

This lead to the six criteria of forest management, voted in Lisbon, in 1998. 1. Maintenance and appropriate enhancement of forest resources and their contribution them in the global carbon cycle 2. Maintaining the health and vitality of the forest ecosystem 3. Maintenance and encouragement of productive functions of forest (Woody and non-woody) 4. Maintenance, conservation and appropriate enhancement of biological diversity in forest ecosystems 5. Maintenance and appropriate enhancement of protective functions in forest management (in particular soil and water) 6. Maintenance of other socioeconomic functions and conditions.

Forestry management is requested to give answers in two key questions: a) How to respond to climate change? b) How to incorporate the mitigation of impacts on service current practices and methods of forest management; Therefore forest ecosystems must both protect themselves and secondly, to protect other ecosystems – including and man - from the effects of climate change, providing additional human and multiple environmental benefits. (Charachristos and Galatsidas, 2015).

A good way to answer these two questions is the calculation, measurement and recording of fixed carbon quantity on the basis of calculation of biomass (standing) and decumbent plant debris (leaves, twigs, fruits) with the aim of incorporating them in carbon storage, and monitoring of weight loss due to decomposition. Also, sample plots should be examined in order to give quality and quantitative data. Moreover it will be useful to establish a monitoring and research network, which will give information for the sample data using new technology systems and real time data (Brown et al., 1995).

What is happening in Greece?

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 temperature will rise to 2oC between 2021 - 2050 and 4oC during the 2071 to 2100 (Zerefos, 2009).

The rise of this parameter can affect 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.

Forests in Greece cover approximately 3.9 million ha, representing approximately 30% of the country area. Although Greece has not a large percentage of forest cover, compared to Nordic countries, indicates a wide variety of forest ecosystems. This diversity is due to the particularly rich flora, the variety of climate types (from Mediterranean to continental climate), the orographic configuration, since Greece is a predominantly mountainous country, with 42 peaks over 2.000 m, the wide variety of geological formations and rocks, the variety of soil types, the historical and cultural development and last but not least due to economic and social structure of the country (FOREST EUROPE, UNECE and FAO, 2011).

The effect of these parameters is giving 5-bioclimatic forest vegetation to Greece: 1. The mediterranean, 2. The subcontinental, 3. The mediterranean mountainous coniferous, 4. The broadleaves of high altitudes and coniferous trees 5. The coniferous trees of high altitude. There can also be the discrimination of the wetland forests, whose appearance is not dependent of climate conditions, but from the diet of the water (riparian forests) (Ntafis, 2010).

Greece is thought to be one of the most vulnerable countries to climate change in Europe (CEC, 2007). Therefore, as to be protected of the consequences of the change in climate, it is necessary to implement the appropriate measures in all management measures in local, regional and national level.

Conclusion

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.

As it was discussed before, climate change could damage forest ecosystems in the following ways: fire, infestation, disease, dissertation and wind (Sedjo, 1991). Although forests can adapt naturally, it is crucial to give local, regional and national guidelines.

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, environmental and economical development.

References

Abel, A.B., and O.J. Blanchard, 1986, "The Present Value of Profits and Cyclical Movements in Investment," Econometrica, 34(2), 249-273.

Andreopoulou Z. S., 2009, "Adoption of information and communication technologies (ICTs) in public forest service in Greece", Journal of Environmental Protection and Ecology, 10(4), 1194-1204.

Andreopoulou Z., 2012, "Green Informatics: ICT for green and Sustainability", AGRÁRINFORMATIKA/JOURNAL OF AGRICULTURAL INFORMATICS, 3(2), 1-8.

Crash," in R.W. Kamphuis, R.C. Kormendi, and J.W.H. Watson (eds.), *Black Monday and the Future of Financial Markets,* Dow Jones Irwin, Homewood, Ill.

Blanchard, O.J., C. Rhee, and L.H. Summers, 1988, "The Sock Market, Profit and Investment," unpublished, Harvard University.

Brown, S., Sathaye, J., Cannell, M., Kauppi, P., 1995, "Management of forests for mitigation of greenhouse gas emissions". In: Climate Change. Robert T. Watson, Marufu C. Zinyowera and Richard H. Moss, (Eds). Climate Change. Ch 24. In: https://www.ipcc-wg2.gov/publications/SAR/SAR_Chapter%2024.pdf

Charachristos, Ch., and Galatsidas, Sp, 2015, "Sustainable management of forest ecosystems and climate change", Department of Forestry and Environment and Natural Resources, Democritus University of Thrace, restiada, 7, 110-120

Cowles Commission for Research in Economics, 1939, *Common Stock Indexes* (2d ed.), Bloomington, Ind.

Romer, C.D., 1987, "Gross National Product, 1909-1928: Existing Estimates, New Estimates, and New Interpretations of World War I and its Aftermath," Working Paper 2187. National Bureau of Economic Research.

Adger W. N., Arnell N.W., Tompkins E. L., 2005, "Successful adaptation to climate change across scales. Global Environmental Change," 15, 77–8

Bernier P. and Schoene D., 2009, "Adapting forests and their management to climate change: an overview." Unasylva 231/232, Vol. 60
Chazdon R. L., 2009, "Beyond Deforestation: Restoring Forests and Ecosystem Services on Degraded Lands"
Climate Change, Impacts and Vulnerability in Europe, 2012,: An Indicator-based Report. Publications Office
COM, 2013, 837 final
FOREST EUROPE, UNECE and FAO., 2011, "State of Europe's Forests 2011." Status and Trends in Sustainable Forest Management in Europe.
FAO, 2010, "Managing forests for climate change"
FAO, 2005, " Global Forest Resources Assessment 2005, Progress towards sustainable forest management,", Chapter 2: Extent of forest resources, 30-36
Felton, A., Gustafsson, L., Roberge, J. M., Ranius, T., Hjältén, J., Rudolphi, J., ... & Felton, A. M., 2016, "How climate change adaptation and mitigation strategies can threaten or enhance the biodiversity of production forests: Insights from Sweden." Biological Conservation, 194, 11-20.
Garforth M., 2012, "Adaptation of forests to climate change: Report of desk-based research on resilience of forests to climate change and transformation measures"
Giannakopoulos, C., Bindi, M., Moriondo, M., LeSager, P. and T. Tin., 2005, "Climate change impacts in the Mediterranean resulting from a 2°C global temperature rise." Rapport préparé pour le WWF. Observatoire national d'Athènes, Grèce.
Giorgi, F., 2006, "Climate change hot-spots." Geophys. Res. Lett., 33(8): L08707, doi: 10.1029/2006GL025734.W.L.
Houghton, J., Jenkins, G., & Ephraums, J., 1990, "Climate Change: The IPCC Scientific." AssessmentCambridge Univ. Press, Cambridge.
IPCC, 2013, "Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change." [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535.
IPCC, 2007, "Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change" [Core Writing Team, Pachauri, R.K. and A. Reisinger (eds.)]. IPCC, Geneva, Switzerland, 104
Johnston M., Williamson T., Munson A., Ogden A., Moroni M., Parsons R. Price D., Stadt J., 2010, "Climate Change and Forest Management in Canada: Impacts, Adaptive Capacity and Adaptation Options"
Kellomäki S. and Leinonen S., 2005, "Final Report of the Project "Silvicultural Response Strategies to Climatic Change in Management of European Forests" funded by the European Union under the Contract EVK2-2000- 00723" (SilviStrat)
Kelly, A. E., & Goulden, M. L., 2008, "Rapid shifts in plant distribution with recent climate change." Proceedings of the National Academy of Sciences, 105(33), 11823-11826
Kolström M., Lindner M., Vilén T., Maroschek M., Seidl R., Lexer M. J., Netherer S., Kremer A., Delzon S., Barbati A., Marchetti M., and Corona P., 2011. Reviewing the Science and Implementation of Climate Change. Adaptation Measures in European Forestry. Forests 2011, 2, 961-982
Lindner, M., J.B. Fitzgerald, N.E. Zimmermann, C. Reyer, S. Delzon, E. van der Maaten, M-J. Schelhaas, P. Lasch, J. Eggers, M. van der Maaten-Theunissen, F. Suckow, A. Psomas, B. Poulter and M.

Hanewinkel, 2014, "Climate Change and European Forests: What do we know, what are the uncertainties, and what are the implications for forest management?." Journal of Environmental Management 146, 69-83
Lindner, M., M. Maroschek, S. Netherer, A. Kremer, A. Barbati, J. Garcia-Gonzalo, R. Seidl, S. Delzon, P. Corona, M. Kolström, M.J. Lexer and M. Marchetti, 2010, "Climate change impacts, adaptive capacity, and vulnerability of European forest ecosystems." For. Ecol. Manag, 259, 698-709.
Lucier A, Ayres M, Karnosky D, Thompson I, Loehle C, Percy K, Sohngen B., 2009, "Forest responses and vulnerabilities to recent climate change." In: Seppälä R, Buck A, Katila P (eds) "Adaptation of forests and people to climate change: a global assessment report", vol World Series Volume 22. IUFRO Helsinki, 29–52
Ntafis, Sp., 2010, "The Greek forests, Goulandris Museum Of Natural History", Thessaloniki, 192
Pickett, S. T., & White, P. S., 1985, "Patch dynamics: a synthesis."
Prentice, I.C., 1991a, "Climate change and long-term vegetation dynamics. Plant succession: Theory and prediction." Chapman & Hall, London, 292-339
Prentice, I. C., & Helmisaari, H., 1991b, "Silvics of north European trees: compilation, comparisons and implications for forest succession modelling." Forest Ecology and Management, 42(1), 79-93
Sedjo A. R., 2010, "Adaptation of Forests to Climate Change: Some Estimates."
Seppala R., Chair P., Buck A., Katila P., 2009, "Adaptation of forests and people to climate change-A Global Assessment Report." IUFRO World Series Volume 22. Helsinki. 224
Staudt, A., Leidner, A. K., Howard, J., Brauman, K. A., Dukes, J. S., Hansen, L. J., ... & Solórzano, L. A., 2013, "The added complications of climate change: understanding and managing biodiversity and ecosystems. Frontiers in Ecology and the Environment." 11(9), 494-501
UNFCCC, 2008a, "Database on Local Coping Strategies: Growing acacia albida in Burkina Faso." Available at: http://maindb.unfccc.int/public/adaptation/adaptation_casestudy.pl?id_project=100
UNFCCC, 2008b, "Database on Local Coping Strategies: Reforestation/Afforestation to prevent soil erosion and land slides in Tajikistan." Available at: http://maindb.unfccc.int/public/adaptation/adaptation_casestudy.
UNFCCC, 2008c, "Database on Local Coping Strategies: Mangrove reforestation in southern Thailand." Available at: http://maindb.unfccc.int/public/adaptation/adaptation_casestudy.pl?id_project=154
Working Group of LIFE+ AdaptFor project, 2014, "Guidelines for the adaptation of Greek forest management to climate change." Directorate General for the Development and Protection of Forests and the Rural Environment - Ministry of Environment, Energy and Climate Change and Greek Biotope/Wetland Centre (EKBY) Greece, Thermi. 92
Zerefos, C., 2009, "Introductory classes to the atmosphere physics", Zerefos, C., Pataki