Impacts of Climate Change on the Mediterranean Area: Its Relevance to the Water Issue

Marta Moren Abat
Civil Engineer

In the light of observational evidence of mean air and ocean temperature rises and the disappearance of glaciers and perennial snows, as well as average sea-level rises, planetary warming is indisputable. The earth's mean temperature has risen by 0.76°C since 1850, according to available data. Climate change is an unquestionable fact, tightly linked to development, representing an unprecedented challenge because of the difficulty it presents in finding an answer, owing to the global nature of the problem and the territorial disconnect between greenhouse gas emissions and impacts. These have a global effect on essential natural resources affecting our development model and creating the need to mitigate its effects and put in place the appropriate measures to adapt.

The United Nations Framework Convention on Climate Change, which came into effect in 1994, constitutes the multilateral political initiative that establishes the foundations for confronting climate change.

Introduction

European sensitivity to climate change varies between North and South: specifically there are various studies which indicate that southern Europe, and particularly the Mediterranean area, will be severely affected. The dry hot climate of south-eastern Europe is expected to become even dryer and hotter, threatening river courses, the resources needed for hydroelectric energy production, agricultural production and forestry plantations. Forecasts predict a considerable reduction in summer rain precipitation, leading to even worse droughts that in the current situation.

The main pressures that the environment is expected to be subjected to will chiefly affect biodiversity, territorial planning and landscape, soil and degradation in the territory, woodland degradation, natural disasters, water management and leisure spaces. These effects will bring with them significant consequences, particularly in zones having the territorial distribution, population density and economic development that are characteristic of the Mediterranean area, where the majority of European ecosystems are planned or semi-planned and are frequently fragmented, as well as affected by pollution or other human intervention.

Forecast Effects[1]

In general terms a reduction in average annual rainfall is foreseen for all the scenarios used. This rainfall diminution varies significantly from one season to another and from one zone to another, in response to changes in circulation at a greater scale and the water vapour concentrations. Specifically in the Mediterranean, summer precipitation is expected to reduce substantially (in some zones by up to 70% according to the SRES A2 scenario[2]).

Various authors (Giorgi et al., 2004) have identified a summertime anticyclonic circulation towards the north-western Atlantic, causing a high pressure ridge in Western Europe and a low pressure trough in Eastern Europe. That structure, which acts as a barrier, diverts storms toward the North causing a gene-

[1] As a result of statistical modelling and analysis

[2] The A2 emissions scenario model is characterised by placing special emphasis on regional and local culture, contemplating a return to "family" values in the majority of regions. Detailed information can be found at: www.geo.vu.nl/~ivmadapt/fb_scenario.htm

ralised and substantial rainfall reduction in the Mediterranean basin.

Forecasts indicate that climate change will have a whole series of impacts on water resources. Annual flows will probably diminish by between 0 and 23% in 2020 on average in the Mediterranean zone, and by a mean 6 to 36% by 2070, using the premises of scenario A2 and B2[3] and climate scenarios from two different climate models (Alcamo et al., 2007). The same trend applies to the replenishment of underground water tables that are expected to decline across the whole of Eastern Europe.

A rise in average seasonal water flows is also foreseen, with important runs often presenting themselves with great intensity over a short duration in the rainy season (generally spring and autumn in Mediterranean areas) and also phenomena of very low flows during the dry season, with an extension in time (and therefore in area) of dry periods. The risk of flooding is also forecast, particularly sudden surges and concurrent droughts.

Climate change furthermore brings with it an increase in the intensity and frequency of extreme phenomena accompanied by a drop in mean precipitation, resulting in significant consequences for the availability of water resources and land management.

River flows during the summer season could reduce by up to 50% in central and some zones of southern Europe, and by up to 80% in some of the rivers of the Mediterranean area.

The Mediterranean zone has a high probability of suffering a significant increase in drought risk, and it is precisely in this zone that a population density exists, as also a considerable demand for irrigation. This will imply a need to develop sustainable management of land planning. Consequently, it is foreseen, with a high degree of probability that the Mediterranean area will be affected by major water shortage (percentage of extraction to availability greater than 40%) due both to climate change and to increased water extraction. That brings along with it important socio-economic consequences resulting from raised competition for water resources.

The following table (Table 23) summarises drought and flood frequencies foreseen for the Mediterranean zone over various time horizons according to a variety of scenarios based on ECHAM4[4] and HadCM3[5] models:

TABLE 23 **Drought and Flood Frequency Forecasts**

Time Horizon	Water Resource Availability and Drought	Flooding
2020	Annual decrease in flows of up to 23%. Particular drop in summer season.	Sudden surge phenomena
2050	Annual decrease in flows of up to 20/30%	Sudden surge phenomena
2070	Annual decrease in flows of up to 36%. Particular drop in summer season that could reach up to 80% decrease relative to current mean values.	Sudden surge phenomena. Surges at present have recurrence periods of 100 years; it is foreseen that they will recur more frequently in the Mediterranean zone (Spain and Portugal) and less frequently in other zones.

Source: Alcamo et al. (2007), Arnell (2004), Lehner et al. (2006) and Santos et al. (2002).

The combination of high temperatures and a reduction in mean precipitation during summer periods brings with it an increase in heatwave and drought phenomena, with their considerable social, economic and environmental consequences. In addition, the forecasts also indicate an increased risk year-by-year.

In short, climate change impacts on temperature, precipitation and water flow will have an important effect on water resources.

Observed Effects

In the Mediterranean zone over the 1950-2000 period the trend in annual precipitation has been one of progressive reduction, most particularly in the east of the Mediterranean area. In certain zones an increase in mean precipitation has been observed, but the irregular distribution of this precipitation entails that many zones are becoming all the more arid.

As a result of these and other changes in temperature and hydrological determinants, impacts are also detected in other sectors such as, for instance, alterations to ecosystems, biodiversity, forest cover, fish life, with the consequences this brings to the sectors of production and dependent development.

[3] Greenhouse emissions effect scenarios (See 4th IPCC report).

[4] General atmospheric circulation model, based on the European Centre for Medium Range Weather Forecast – ECMWF model. Detailed information can be found at: www.ipcc-data.org/is92/echam4_info.html.

[5] HadCM3 is a general circulation model that takes into account coupled ocean-atmosphere factors and has a stable control climatology. Detailed information can be found at: http://cera-www.dkrz.de/IPCC_DDC/IS92a/HadleyCM3/Readme.hadcm3

Adaptation and Vulnerability

Climate change impacts on natural features will have a knock-on effect on water use through systems that exploit water resources which perform the functions of regulating, transporting and distribution. Operational systems – hydraulic infrastructure and management regulations – allow for different planning and management options that can act as a barrier to lessen or amplify impacts.

A vital issue consequential upon the need for climate change adaptation is the manner in which water policies are directed under a horizon where guaranteed resources are more restricted

Water resources are a conditioning factor in planning, managing and developing many other sectors and systems – and in particular with a special effect in the Mediterranean area – notable among which are conservation of biodiversity (especially aquatic ecosystems), industrial production, agriculture and tourism. Additionally, among issues of a social nature, it is worth highlighting competitiveness, employment, the need for infrastructures, sustainability and health.
As regards adaptation strategies in the sector, there is a requirement to establish specific policies for water resource management to guide the evolution of the sector in response to climate change forecasts. There is a great potential to direct a rational long term adaptation to climate change which would minimise the projected impacts, but this must be done within a general territorial planning framework. This framework should permit the setting of priorities in sector policies so as to identify and prioritise water demand and achieve an integrated management of water resource systems.

Effects on Adaptation Policies

A vital issue consequential upon the need for climate change adaptation is the manner in which water policies are directed under a horizon where guaranteed resources are more restricted: protection of economic systems, protection of biodiversity, rural development, etc. While clearly the end result will be a combination of all of them, each determines different methods of allocation and subsequently of management.
It is evident in the case of the Mediterranean area, owing to its particular vulnerability, the state of its natural resources and required sustainable development, that the evolution from the current situation should tend towards an adaptational solution, i.e. maintaining the allocation structure (subject to reviewing needs and uses) whilst improving its efficiency, ensuring that it is more flexible and simultaneously more resilient.
A range of measures exist to that end, among which it is worth mentioning as examples:

- Pro-active initiatives in territorial policy promoting those activities that are least "water-dependent" (in terms of both space and time). Factors of importance in the construction sector are practices applied to equipping homes and avoiding soil sealing (open housing).
- Demand management policies that go beyond mere water saving and could include conversion of user sectors in the medium and long term. In addition there can be redefinition of management guidelines.
- Use of new technologies subject to analysing the twin factors of water and energy in their production.
- Bearing in mind that one of the consequences of climate change in the Mediterranean basin is determined by the rise in the torrential degree of rainfall, every attempt needs to be made to maintain availability at a constant level, taking into account the need to consider aquifer replenishment, territorial and infrastructure management planning, and assessing the probability of these types of events occurring.
- Reclaiming spaces neighbouring water courses and affected zones, where possible.
- Improving vegetation cover to prevent erosion processes and encourage condensation.

One of the best instruments in the fight against climate change and the search for solutions to its impacts is rationality, awareness and knowledge of the issues relating to climate change in all its aspects both as to how it is caused and to the short, medium and long term consequences.
For that purpose there is a need to apply measures with the knowledge of scientific results in the public

domain. A number of projects financed by the European Commission are working on the effect of climate change – global alterations in water resources. Examples worth highlighting are:

- WATCH Project (Water and Global Change) www.eu-watch.org/templates/dispatcher.asp?page_id=25222705
- CIRCE Project (Climate Change and Impact Research: The Mediterraneann Environment) www.circeproject.eu/index.php?option=com_content&task=view&id=69&Itemid=1
- ENSEMBLES Project (Ensemble Based Predictions of Climate Changes and Their Impacts) http://ensembles-eu.metoffice.com/

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