Building the Mediterranean future together

WATER

Resources and natural environment

ANTICIPATING WATER STRESS IN THE MEDITERRANEAN

a decision support approach for better water resources management

Over the past thirty years, climatic variations as well as water-use changes induced a net decrease in streamflows over the Mediterranean basin. The question arises on climate and human activities evolution trends and on their impacts on water resources. An integrated water resources modeling framework was developed to describe current pressures at the catchment scale, to evaluate changes in water allocation and to apprehend the capacity of adaptation strategies to reduce water tensions. Applied over the Ebro catchment (Spain), the approach enabled identifying areas most vulnerable to climatic and/or anthropogenic pressures.

PLAN BLEU NOTES

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Need for a more resilient management of water resources and their use

Increasing pressures on water resources due to climatic and anthropogenic changes as well as increasing competition among users are recognized as world water stakes. Global scale studies have identified the Mediterranean basin as one of the most vulnerable regions to "water crisis" due to limited water resources, significant climate change, and increasing anthropogenic pressures. Water withdrawals in Mediterranean catchments in Spain, and on the southern and eastern rims are close to the current mean annual volume of renewable water resources. In the 2050 horizon, these regions could experience water shortages (Milano *et al.*, 2013a).

Questions relating to water resources management are pressing in these particularly vulnerable regions.

Assessing the capacity of water resources to meet current and future water demands

Developing practical tools at the catchment scale

Methods assessing whether future water needs will still be satisfied are necessary to advise decision makers on which adaptation strategies are best suited to fulfill water demands and to prevent water tensions. This calls for modeling approaches that evaluate and compare water resources and water use evolution, and define the current and future capacity of water resources to meet water demands. These approaches support the

Mediterranean-wide promotion of better-integrated water resources management at the catchment scale, i.e. protection or reinforcement of hydrosystems' production to fulfill water needs of both society and ecosystems, fair distribution of water resources among users, and dynamic management of water demands (Plan Bleu, 2005). Such management goals require a good knowledge of hydrosystems, water uses, of how flows are regulated by storage dams, and of local adaptation strategies.

Uneasy representation of relationships between water supplies and demand sites

Integrated water resources management models describe the current situation of a catchment, evaluate water resources availability and future water demands based on climatic and socio-economic scenarios and then allocate water according to predetermined guidelines. Commonly used models, such as WEAP, REALM, Aquatool, hampers the takeover of hydrological and calibration processes suitable to the modeling objectives. Priorities among users cannot always be settled. River flows tend to be influenced by simplified storage-dam modules, which releases are often disconnected from water demands. Therefore, the representation of hydrosystems and of the relationships between water supplies and demand sites are still uneasy. It compromises the operational effectiveness of existing integrated models. Finally, no indicators and no graphical support of the spatial and temporal variability of the latter have yet been defined to simplify the decision making process.

A new decision support system for water managers

A new decision support system accounting for prospective climatic and water-use scenarios as well as river flow regulations by hydraulic structures was set up in partnership with HydroSciences Montpellier laboratory (*Figure 1*). It aims to evaluate at the catchment scale whether water use trends defined by water managers are compatible with projected hydro-climatic changes. This approach takes into account:

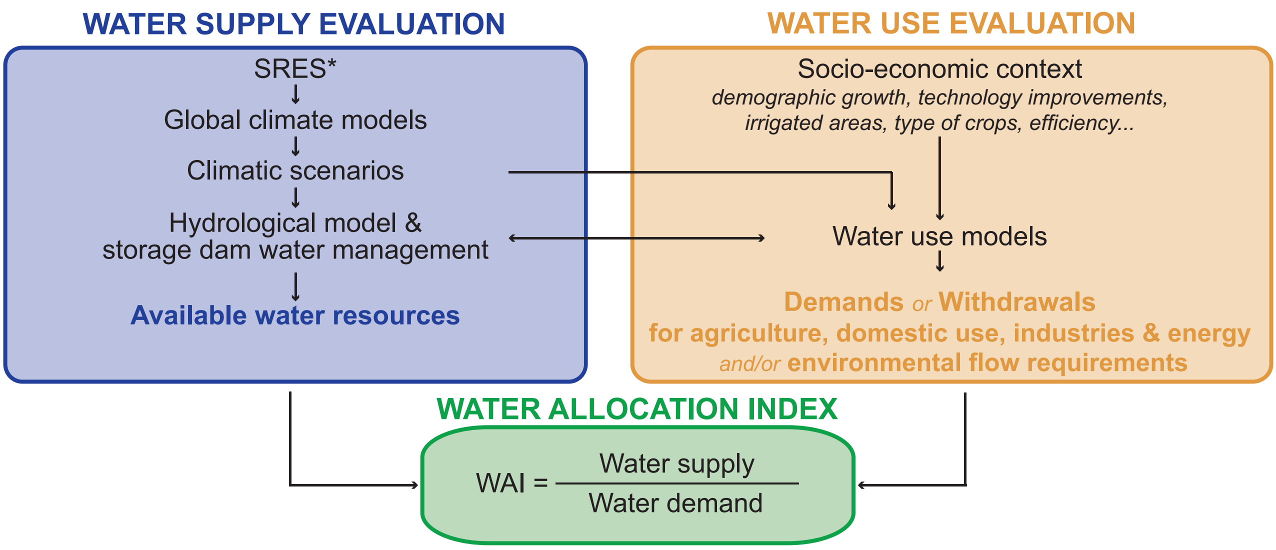
- the different hydro-climatic conditions of the hydrosystem;
- the main storage-dams regulating flows;
- the spatial and temporal variability of domestic and agricultural water demands;
- return flows and environmental flow requirements;
- priorities among water users;
- and different water supply sources (surface water, storage-dam) among which priorities are set.

The storage-dam model was designed to regulate flows according to downstream water demands and seasonal water storage objectives. A water allocation index (WAI) was set up, based on the ratio of water supply to water demand (*Figure 1*). It gives the share of the demand that could be satisfied by water resources. Allocation rates were defined according to the consideration of local water managers. An intuitive typology in the representation of the results was also set to enable a rapid overview of the most vulnerable sectors and areas of the basin.

The Ebro catchment: a representative catchment of the Mediterranean water issues

This integrated modeling approach was applied over the third largest Mediterranean catchment: the Ebro basin. It extends over 85 000 km² in northeastern Spain. It is one of the most vulnerable catchment of the northern Mediterranean rim to climatic and anthropogenic changes. Since the late 1970s, a 20–40% decrease in mean annual discharge has been observed, attributed to a 12% decrease in precipitation, a 0.7°C rise in mean annual temperature, and a water consumption increase. This catchment is indeed a key region for Spain's agricultural sector with 60% of the fruit and vegetable production of the country. Its population has increased by 20% over the last 30 years (CHE, 2011). Over 230 storage dams, built for hydropower production and irrigation water supply, regulate river discharge in the basin. By the year 2027, the *Confederación Hidrográfica del Ebro* (CHE) projects a 30% expansion of irrigated areas and an increase of 0.5 million of its population.

Figure 1: Methodological approach



*SRES: greenhouse gas emission scenario

Source: According to Milano 2012

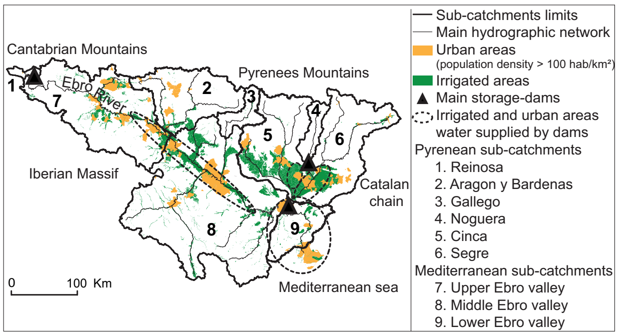
Towards a warmer and drier climate, and declining water resources

By the 2050 horizon, temperatures are expected to rise by 1.5°C throughout the year and by 3°C during the summer season over the Ebro catchment, based on the most pessimistic greenhouse gas emission scenario set up by the Intergovernmental Panel on Climate Change (SRES A2) and on four global climate models. Precipitation should decrease, on average, by 10–25% during spring and summer (Milano et al., 2013b). As a result, freshwater resources could drop by 15–20% during spring and by 25–35% during summer in the Pyrenean sub-catchments of the Ebro basin. In the Ebro valley, a 15–30% decrease of water resources is projected throughout the year. The most significant decrease should be during the summer season but variation rates among models vary (-10 to -65% ; Milano *et al.*, 2013b).

Water demands on an upward curve

Total water demands over the Ebro catchment were close to 9240 Hm³/year in 2007 (CHE, 2011). Agricultural water demands represented 92% of this volume, followed by domestic water demands (3.8%), the industrial sector (2.7%) and water transfers (1.5%). Highest total water demands were located in the middle and lower Ebro valley (1660–2750 Hm³/year; *Figure 2*) and in the Pyrenean sub-catchments Cinca, Segre and Aragón y Bardenas (900–1400 Hm³/year). The largest and most productive irrigated areas are located in these catchments (*Figure 2*). By the 2050 horizon, areas with the largest water demands should remain the same due to a 30–40% expansion of their irrigated areas and a 25–30% increase of their population.

Figure 2: The Ebro catchment and its main anthropogenic pressures

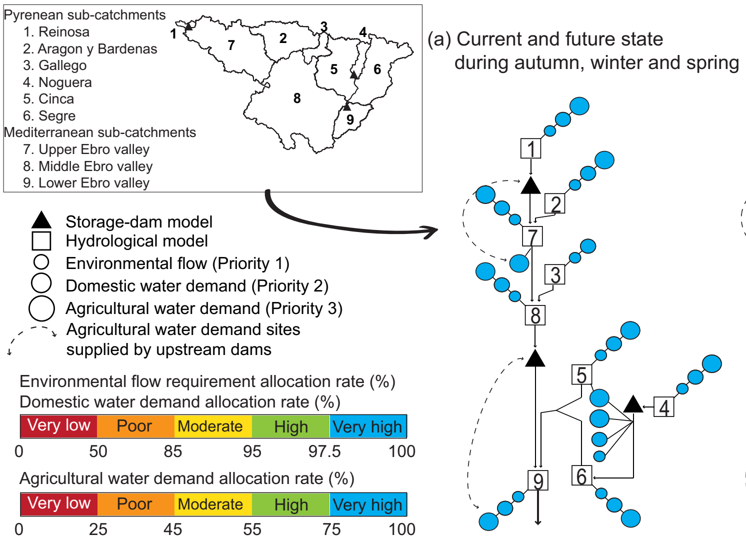


Source: Milano *et al.*, 2013b

Rising water tensions during summer due to a lack of adaptation strategies

According to the developed modeling approach, water resources and current dams' management are able to fully meet current water demands, except agricultural water demands (AWDs) in the Cinca sub-catchment during summer (*Figure 3a-b*). In the 2050 horizon, environmental flow requirement and domestic water demands should still be fully satisfied all year round. Only AWDs should face some water shortage during summer. Considering the changes in water demands as estimated by the CHE and the four climatic scenarios, on average, AWDs of the Cinca sub-catchment should be poorly to very poorly met in the Cinca, Segre and Aragón y Bardenas sub-catchments. In the Ebro valley, they should be partly met (moderate WAI). In any other irrigated areas of the Ebro catchment, water resources should meet AWDs at a high to very high level (*Figure 3c*).

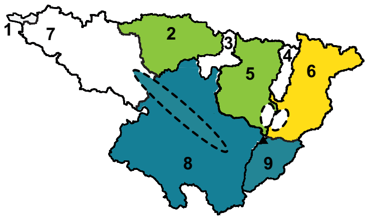
Figure 3: Water allocation rate over the Ebro catchment during autumn, winter and spring (a) and during summer over the 1971–1990 period (b) and by the 2050 horizon on average (c)



Source: Milano, 2012

This integrated approach enabled representing the current stakes of the basin and identifying the most vulnerable regions to climatic and/or anthropogenic pressures (*Figure* 4) as well as sectors and seasons during which water shortage might occur.

Figure 4: Vulnerability of the Ebro catchment to climatic and anthropogenic changes



Source: According to Milano 2012

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Recommendations

- The development of integrated water management models is necessary to assess the capacity of locally planned adaptation strategies to reduce pressures on water resources, and thus contribute to their implementation;
- Integrated modeling approach must be coupled to an intuitive graphical support. It enables comparison of local water systems, objective advice on water management priorities, and easy transfer of results to decision-makers;
- Collaborations between local water managers and scientists are required in order that the approach fits to water management facilities and that the appropriate water-use scenarios are considered;
- However, one must be aware of methodological and technical choices made. Uncertainties rise at every step in prospective studies related to the complexity in forecasting climate and socio-economic changes;
- The set up method aims to be as reliable and generic as possible over the Mediterranean basin. It is encouraged to apply this approach over catchments on the eastern and southern rims. It will assist decision making in water resources planning to prevent water shortage by the 2050 horizon.

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