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Drought management plans and water availability in agriculture: A risk assessment model for a Southern European basin

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ABSTRACT

The Drought Management Plans (DMPs) are regulatory instruments that establish priorities among the different water uses and define more stringent constraints to access to publicly provided water during droughts, especially for non-priority uses such as agriculture. These plans have recently become widespread across EU southern basins. However, in some of these basins the plans were approved without an assessment of the potential impacts that they may have on the economic activities exposed to water restrictions. This paper develops a stochastic methodology to estimate the expected water availability in agriculture that results from the decision rules of the recently approved DMPs. The methodology is applied to the particular case of the Guadalquivir River Basin in southern Spain. Results show that if DMPs are successfully enforced, available water will satisfy in average 62.2% of current demand, and this figure may drop to 50.2% by the end of the century as a result of climate change. This is much below the minimum threshold of 90% that has been guaranteed to irrigators so far.

1. Introduction

Population growth and the improvement of living standards have increased water demand worldwide and, along with decreasing water supply as a result of climate change, the vulnerability to drought events. This situation is to a great extent attributable to agriculture, which is the world's largest water consumer and is often believed to be wasteful (OECD, 2013; Ward and Pulido-Velazquez, 2008). Consequently, policy makers in drought prone areas have called for measures to save water in this sector and thus guarantee the provision of water for priority uses, namely, drinking water and minimum environmental flows. However, the effectiveness of these measures has been burdened so far by the prevailing paradigm, which considers water demand as an exogenous variable outside the field of water policy. As a result, water policy has been mostly based on expensive supply oriented policies, such as the construction of major infrastructures or the modernization of irrigation devices, that paradoxically have ended up increasing water demand, reducing water availability and undermining the robustness and resiliency of the system and its ability to cope with future droughts (Anderies et al., 2004; Ruttan, 2002).

The high financial costs of these policies in a time of crisis and especially the limits of water supply have forced water authorities to alter their policy action. In the EU, some important legal restrictions over agricultural water use have recently been approved to address the problem of recurrent droughts. This is the case of the Drought Management Plans (DMPs). DMPs are inspired in the drought contingency plans implemented in the US since the '80s and thus follow similar rules (NDMC, 2013). Basically, DMPs define the precise thresholds of possible drought situations and set the water constraints that will come into force in each of these cases, with the aim of guaranteeing priority uses. The drought thresholds are obtained from the historical assessment of water supply, while the extent of the water constraints varies from one basin to other and depends largely on the ratio between water demand and water supply, being more restrictive in the more exploited basins and focusing on agricultural uses (the water use with the lowest priority) (EC, 2008). As a result, the declaration of a drought will automatically reduce, in a predictable amount, the quantity of water delivered to the irrigation system from publicly controlled water sources.

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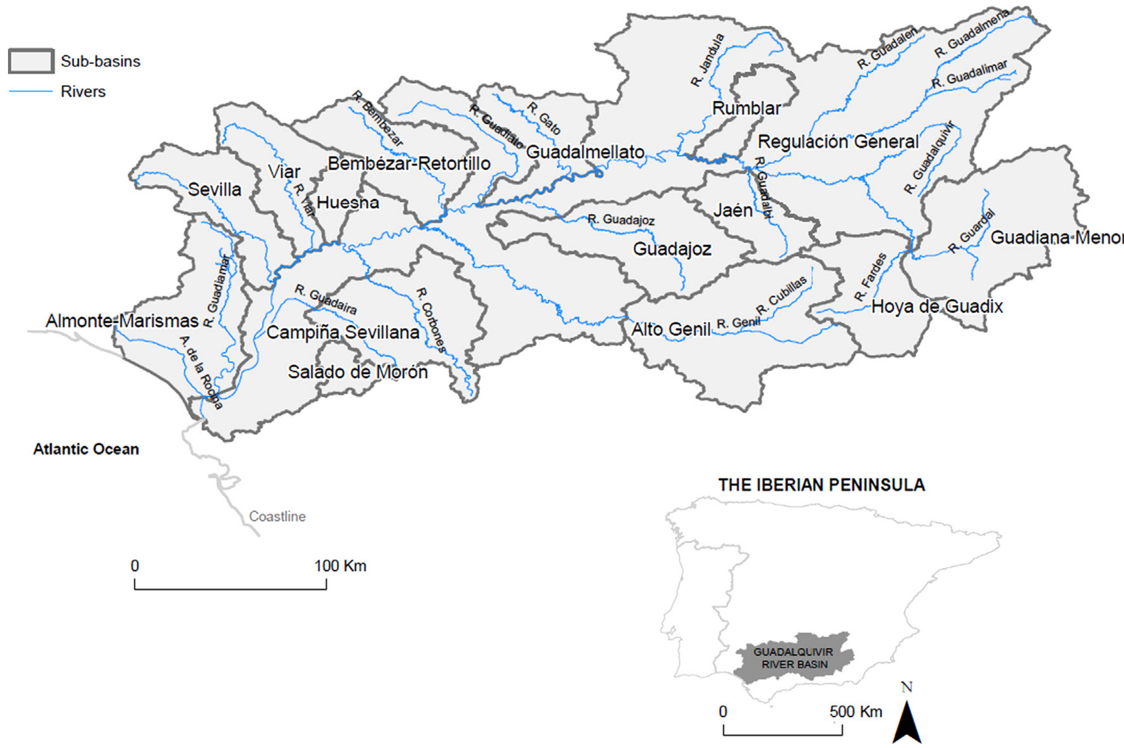

Fig. 1. Location of the Guadalquivir River Basin in the Iberian Peninsula and detail of its sub-basins.

In spite of being relatively new and voluntary, DMPs have rapidly spread across EU southern countries, such as France, Italy, Portugal and Spain[2] (EC, 2008). In particular, Spain has pioneered the adoption of DMPs and every river basin comprising more than two regions (NUTS 2[3]) has already approved its DMP. However, there are no assessments available on the potential impact of DMPs on the economic activities exposed to water restrictions. As a result, the effects of DMPs over water availability in sectors such as agriculture are basically unknown. This paper wants to help bridge this gap. We develop a stochastic methodology to estimate the expected water availability in agriculture resulting from the decision rules of the recently approved DMPs. Then we apply this method to the particular case of the Guadalquivir River Basin (GRB) in Spain, using historical data and official climate change scenarios. Results show that after the implementation of the basin's DMP expected water availability drops to 62.2% of the annual demand, with relevant spatial disparities among sub-basins. According to the previous legislation, River Basin Management Plans (RBMPs) had to guarantee irrigators a water access reliability of 90%. This has happened since the implementation of the first wave of RBMPs in 1998 (Berbel et al., 2012). However, if DMPs are successfully enforced, it will not be possible to guarantee a failure rate below the target of 10% -rather the contrary, this failure rate will be close to 40%.

This paper is structured as follows: in Section 2, we introduce the area where the case study is applied, the Guadalquivir River Basin in southern Spain. Section 3 presents the methodology used to estimate expected water availability in agriculture, and Section 4 presents the results obtained. Section 5 discusses the results and concludes.

2. Background to the case study: the Guadalquivir river basin (Spain)

Because most of the variables involved in the design of the DMPs are site-specific, such as water supply and risk exposure, we illustrate each step of the model with the results for the particular case of the GRB in Southern Spain.

The GRB is a large basin (57,071 km^2) located in the south of Spain (see Fig. 1). 90.2% of its territory is located in the region (NUTS 2) of Andalusia (ES61), with less relevant shares in the regions of Castile-La Mancha (ES42) (7.1%), Extremadura (ES43) (2.5%) and Murcia (ES62) (0.2%)[4]. The GRB has a semi-arid Mediterranean climate, with an average temperature of 16.8 °C, warm summers and mild winters. Rainfall is scarce (548 mm/year in average) and unevenly distributed along time, with peak monthly values between 70 and 80 mm/month from November to February and values below 25 mm/month during the summer (June to September). Due to relatively high temperatures potential evapotranspiration is high, and during the summer months higher than rainfall, resulting in a low runoff with an average value of 128 mm/year (GRBA, 2013).

In spite of water scarcity and recurrent droughts, past economic growth in the GRB has been closely coupled to increases in water demand. As a result, average water demand amounts to 4016 hm^3/year, while renewable resources are estimated to be 3028 hm^3/year,

[2] Unlike other water management instruments such as River Basin Management Plans, DMPs are not prescriptive, although they are already available in several Southern European basins in Spain, Italy, Portugal and France, and also in Finland, Netherlands and UK.

[3] The NUTS classification (for French *Nomenclature des unités territoriales statistiques*, Nomenclature of territorial units for statistics in English) is a hierarchical system for dividing up the economic territory of the EU. For each EU member country, a hierarchy of three NUTS levels is established, which do not necessarily correspond to administrative divisions within the country. A NUTS code begins with a two-letter code referencing the country, followed by up to three numbers indicating the three possible levels of disaggregation. The three NUTS levels are: NUTS 3, usually working at a local level (parish/canton/oblast/city and regency/county/municipality); NUTS 2, which is a set of NUTS 3 and usually works at a level of region/province/state/prefecture (including: autonomous type); and NUTS 1, working at different levels and defined as a set of NUTS 2 (EC, 2003).

[4] ES61: ESpaña (Spain), NUTS 1 number 6, NUTS 2 number 61; ES42: ESpaña (Spain), NUTS 1 number 4, NUTS 2 number 42; ES 43: ESpaña (Spain), NUTS 1 number 4, NUTS 2 number 43; ES62: ESpaña (Spain), NUTS 1 number 6, NUTS 2 number 62.