Revision of the Scarcity State Indicator in the Spanish Drought Management Plans

Palop-Donat C.[1,*], Paredes-Arquiola J.[1], Andreu J.[1]

[1]Research Institute of Water and Environmental Engineering (IIAMA), Universitat Politècnica de València (UPV), Valencia, Spain; IIAMA, UPV, Camino de Vera S/N 46022 Valencia, Spain

*corresponding author: Carla Palop-Donat; e-mail: carpado@cam.upv.es

Abstract

Droughts are one of the gravest natural threats currently existing in the world and their occurrence and intensity might be exacerbated due to Climate Change. Scarcity is defined as the period when demand does not accomplish the normal reliability levels due to poor water management. Water and drought management plans (DMP) prevent scarcity periods by anticipating to drought and adapting to limited water resources. DMP in Spain were updated in December 2018. Two types of indicators were included: The Prolonged Drought Indicator and the Scarcity State Indicator (SSI). This study presents a comparison of the SSI among seven river basins in Spain, with the aim of making a starting point for its optimization and computation. The scarcity indicator is based on the relationship between the availability of resources and demands, identifying situations of short-term deficit in each of the areas defined. Its computation consists of a seven-step iterative process. Results detect two different approaches when determining the threshold values for the SSI. One method bases the threshold estimation on the risk of supply of the demands while the other obtains the threshold values from direct statistics of historical variables.

Keywords: Water scarcity, Scarcity state indicator, Drought management plan, Spanish water policy

1. Introduction

The increase in the frequency of droughts together with the increase in population makes it necessary to develop tools to better prevent and manage scarcity events (CEDEX, 2017). Indicators, in water management, are a widely used tool to support decision-making (Pedro-Monzonís, 2016). At the European level, drought events cause economic and environmental impacts of up to billions of euros (CHJ, 2018; EC, 2012). Forecasts state an increase in the frequency of drought as the 21st-century progress in Europe (CEDEX, 2017; CHJ, 2018; EC, 2012). Drought is an unpredictable natural phenomenon that occurs mainly due to a lack of precipitation that results in a significant decrease in water resources on a temporary basis (CHJ, 2018). When the lack of water affects the demands of a water resource system, a deficit appears. The concept of scarcity is associated with a situation of deficit with respect to the possibility of meeting the demands of a system (Pedro-Monzonís, Solera, Ferrer, Andreu, & Estrela, 2016). This scarcity is characteristic of water supply systems subject to a strong exploitation that, therefore, are especially vulnerable to drought, as it is the case of the semi-arid regions of the Iberian Peninsula. Drought management policies started in the European Union (EU) with the Water Framework Directive (EU, 2000). Since then, different policy-related documents have been published in the EU relevant to drought management (EC, 2012). The first Drought Management Plans (DMP) for each Spanish River Basin (RB) were approved in 2007. Its revision was conducted in December 2018.

2. The Scarcity State Indicator

There are 7 main RB districts in Spain. In the Atlantic side: Duero, Tajo, Guadiana, Guadalquivir, and in the Mediterranean side: the Ebro, Júcar and Segura. All of them have published a DMP with common characteristics and indicators that are comparable among them. In DMPs revision two types of indicators are included: the prolonged drought indicator and the scarcity state indicator (SSI). Regarding the SSI, it is a non-dimensional indicator that varies from 0 to 1, it integrates different variables (precipitation, groundwater and reservoir volumes and river flows discharge).

2.1. The computation of the Scarcity State Index

The generic method of calculating the SSI in the different RB consists of 6 steps. Previously each RB Authority divides the basin district in territorial units (TU). A TU is an area where demands are supplied by water resources produced in that unit. The methodology used for assessment and selection of the SSI is generally common among the most important RB. **Figure 1** shows the methodological scheme for the establishment of the SSI por each TU. It is important to comment that the obtention of the SSI is an iterative process. The calculation steps are discussed. (1) In first place, the most representative hydrometeorological variables associated with the control elements of the water resource evolution are chosen. In general, reservoir volumes are the most used variables since it is the most intuitive and practical, it also has historical management experience and responds to the diagnosis of scarcity. (2) Secondly, each variable's data is gathered in different temporal series of the historical data. (3) Regarding the modelling and establishment of threshold values, the use of a water allocation model in order to provide objective demand supply thresholds and the settlement of limits for each scarcity scenario is conducted. Aquatool-SIMGES model (Andreu, Capilla, & Sanchís, 1996) is used by most of the RB. (4) Afterward, the SSI is calculated by different methods depending on the RB. The indicator value will be rescaled between 0 and 1 to provide a common value for all of the RB. (5) The weighting and combination of IEE values into a unique SSI per TU. (6) Then, the obtaining of a single value of the SSI per TU. (7) Finally, the validation of the SSI to achieve representative results in each TU with objective values obtained from water allocation models or from the historical period of droughts. After obtaining the SSI the values are categorized in four state scenarios: Normality, pre-alert, alert and emergency. Depending on the RB some premises are stablished to move from one scenario to another each month.

3. Results and Discussion

At the RB level each RB authority has calculated the SSI following the basic guidelines but adapting to the characteristics of each basin. Among the 7 methodological steps followed, certain differences have been found. Difference between the Duero, Tajo, Guadiana, Guadalquivir, Ebro, Júcar and Segura RB. The most remarkable difference found was in step 3 and 4 of the methodology. Two different approaches are detected when determining the threshold values of the variables. On the one hand, in the Tajo RB the threshold values of each scarcity level are defined as the necessary storage volume to satisfy the water demand, during a time horizon and considering predetermined water incomes volume associated with a risk value. Finally, in order to calibrate these thresholds, the SSI is compared with the simulation in Aquatool-SIMGES model. On the other hand, the rest of the RB use the water allocation model Aquatool-SIMGES before, to stablish the threshold values for each selected variable. Then, the SSI is computed, and results are compared with scarcity periods in the historical series and with the deficits of the model. Furthermore, regarding the threshold establishment, whereas some RB have the same threshold for all the year, others (Tajo, Duero, Guadalquivir, Ebro) show different values for each month. Despite their differences, the SSI values are standardized (from 0 to 1) to define the same drought scenarios among all RB: normality (>0.5), pre-alert (0.3-0.5), alert (0.3-0.15) and emergency (<0.15).

4. Conclusions

Scarcity could be prevented or at least diminished if a good planning and management is conducted. Drought management plans is Spain stablish a useful tool for the assessment the water scarcity in a RB.

Acknowledgments

The authors thank the Spanish Research Agency (MINECO) for the financial support to ERAS project (CTM2016-77804-P, including EU-FEDER funds).

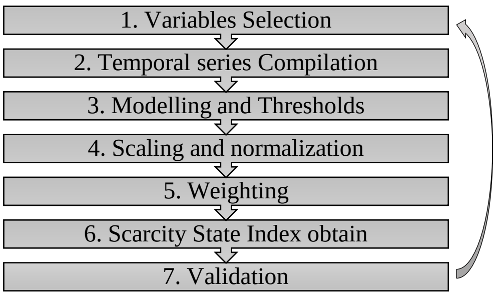

Figure 1. Methodology for the Scarcity State Index computation

References

Andreu, J., Capilla, J., & Sanchís, E. (1996). AQUATOOL, a generalized decision-support system for water-resources planning and operational management. *Journal of Hydrology*, **177**(3–4), 269–291.

CEDEX. (2017). *Evaluación del impacto del Cambio Climático en los recursos hídricos y sequías en España*. Centro de Estudios Hidrográficos. Madrid.

CHJ. (2018). *Plan Especial de Sequía Demarcación Hidrográfica del Júcar*.

EC, (2012). *Communication from the commission to the European parliament, a Blueprint to Safeguard Europe's Water Resources*.

EU, (2000). *Directive 2000/60/EC of the European parliament and of the council*.

Pedro-Monzonís, M. (2016). Assessment of water exploitation indexes based on water accounting, 210.

Pedro-Monzonís, M., Solera, A., Ferrer, J., Andreu, J., & Estrela, T. (2016). Water accounting for stressed river basins based on water resources management models. *Science of the Total Environment*, **565**, 181–190.