

LESSONS LEARNT FROM THE ANALYSIS OF PAST DROUGHT MANAGEMENT PRACTICES IN SELECTED EUROPEAN REGIONS: EXPERIENCE TO GUIDE FUTURE POLICIES

De STEFANO¹ L., URQUIJO¹ J., KAMPRAKOU² E., and ASSIMACOPOULOS² D.

¹ Departamento de Geodinámica, Facultad de CC Geológicas, Universidad Complutense de Madrid, 2 c/ José Antonio Nováis, 28040 Madrid, Spain, ² School of Chemical Engineering, National Technical University of Athens, Zografou Campus, 9 Heroon Polytechniou str., Athens GR-15780
e-mail: ekamp@chemeng.ntua.gr

EXTENDED ABSTRACT

Drought, as a natural hazard, receives increasing attention by policy makers and scientists due to the wide range of impacts and the associated cost of mitigation and recovery. Drought preparedness is emerging as a critical component of water management, placing emphasis not only in the analysis of drought characteristics but also in the anticipated impacts, in order to define the measures for reducing vulnerability to drought. Drought mitigation measures include a wide list of options, targeting impact mitigation, supply enhancement or demand reduction. The identification of the appropriate mix of options is region- and impact-specific and should address the underlying causes of vulnerability to drought.

In order to support the development of drought policies, an ex-post evaluation of past practices to cope with drought could support the refinement of options for future drought risk reduction. This requires a detailed inventory of the responses implemented in the past, the processes followed and their contribution to drought mitigation. It is a participatory process that involves the review of vulnerability factors in each sector and the assessment of responses using criteria such as cost effectiveness, adequacy of activation time, environmental considerations, etc. A tool to support this kind of analyses is the DPSIR framework, as it can be used to link vulnerability factors to impacts, and finally responses. In this regard, it supports the assessment of the capacity to cope with drought, given the socio-economic and environmental conditions in place.

This process has been followed in the FP7 DROUGHT-R&SPI project that aims at enhancing knowledge over drought hazard, impacts and vulnerabilities, in order to support the development of drought management plans. Particularly the current drought management framework has been reviewed in the six Case Studies that cover a wide range of environmental and socio-economic conditions and thus a wide variety of contexts affecting drought vulnerability and responses: Syros Island, Greece; Po River Basin, Italy; Jucar River Basin, Spain; Portugal; Switzerland; and The Netherlands. The analysis resulted in a better understanding of the drought management context and in the documentation of best practices in each Case Study in terms of actors involved, resources required, processes and outcomes. Even though drought events are primarily “local” both in terms of hazard and impacts, there is a significant potential for cross-learning and exchange of experiences that could improve drought mitigation efforts at the local level and drought policy development at the national or European level.

Keywords: Drought management, Responses, Europe, DROUGHT-R&SPI

1. INTRODUCTION

Drought management is receiving increasing attention by policy makers at the European level, as the reduction of drought risk is one of the objectives set by the Blueprint to Safeguard Europe's Water resources (EC, 2012). Drought preparedness is thus emerging as a critical component of water management, placing emphasis not only in the analysis of drought characteristics (severity and duration) but also in its impacts, their causes and the options for reducing impacts and vulnerability to drought (Fontaine and Steinemann, 2009).

Drought mitigation and preparedness measures include a wide list of options, targeting impact mitigation, supply enhancement or demand reduction and can be applied from the local to the national level. Given the wide range of options, the ex-post evaluation of past practices to cope with drought is being promoted as a key element of drought planning, in order to define the most effective actions and identify strengths and weaknesses of the current management scheme (Wilhite, 1996). It is indicative that at the European level the need for evaluating the efficiency of various quantitative measures (e.g. water saving, reuse, desalinization) is acknowledged as a means for improving drought preparedness (Rossi, 2009).

The ex-post evaluation requires a detailed inventory of the measures implemented in the past, the processes followed and their contribution to drought mitigation, in close cooperation with the stakeholders that were involved in the management of drought (either as implementers of the measures or as actors affected by the measures). A specific element of the process is the definition of the link between drought impacts and responses that is typically performed through vulnerability assessments (Knutson et al., 1998). The aim is to identify measures that target the underlying causes of vulnerability to drought, rather than merely its impacts, so as to improve future resilience to drought.

The FP7 DROUGHT-R&SPI (Fostering European Drought Research and Science-Policy Interfacing) project aims at enhancing the understanding of drought hazard, impacts and vulnerabilities, in order to support improved preparedness to drought. Specific activities involve the analysis of current vulnerability to drought and the ex-post evaluation of past responses in the six project Case Studies (Syros Island, Greece (SY); Po River Basin, Italy (PO); Jucar River Basin, Spain (JU); Portugal (PT); Switzerland (CH); and The Netherlands (NL). This paper summarises the main outcomes from the analysis of past management practices and concludes with a series of recommendations for improving future drought management efforts. Section 2 describes the methodology followed for the systemic evaluation of measures, whereas Section 3 summarises the main results.

2. METHODOLOGY

A two-step process has been followed in the DROUGHT-R&SPI project for analysing and assessing past management practices to cope with drought. The overall process was based on the Driver-Pressure-State-Impact-Response (DPSIR) framework, as it can be used to link vulnerability factors to impacts, and finally responses.

The first step involves the analysis of vulnerability to drought, focusing on the social, economic, technical, environmental and social factors that resulted in the recorded impacts. The aim is to understand why drought impacts have occurred in the past and to identify the cause-effect links between vulnerability factors and the associated drought impacts, and thus responses to cope with vulnerability (Khajuria and Ravindranath, 2012). Vulnerability was analyzed using impact tree diagrams, in order to present in a

comprehensible form the main underlying causes of drought impacts and to assess as a next step whether the implemented measures addressed these basal causes.

The second step refers to the ex-post evaluation of responses, which in turn lead to the identification of policy gaps and the formulation of recommendations to deal with vulnerability and therefore improve future preparedness to drought. Response to drought can take several forms, working at different levels and dealing with a variety of impacts that affects different economic sectors or populations (MEDROPLAN, 2007). Indeed, droughts occur in virtually all climatic zones (Med EUWI, 2008; Mishra and Singh, 2010) but have context-specific characteristics and impacts that require context-specific solutions (Kallis 2008).

Given the complexity and multidimensionality of the analysis, drought measures were analysed taking into account the political and institutional contexts where policy responses took place. This approach aims at focusing on the factors and conditions that facilitate or hamper drought measures adoption and implementation instead of focusing only on the impact of the implemented measures. The multidimensionality of the evaluation object also made it necessary to analyze past response to drought from different perspectives and using different, complementary data and methods, including both 'hard data' and opinions or perceptions of key actors involved in the management of the considered drought episodes.

The ex-post assessment included the following sub-steps: (1) Literature review in different disciplines (e.g. drought management, water resources, climate change, risk reduction) to identify the key dimensions to frame the ex-post analysis of drought responses; (2) Selection and characterization of those dimensions following an iterative process which identified 25 variables grouped into 7 dimensions (Table 1); (3) Elaboration of the tools for data collection and their preliminary testing in the Júcar river basin; (4) Data collection at a Case Study level through literature review, interviews, questionnaires and stakeholders discussion at a workshop; and (5) Data analysis using qualitative and semi-quantitative techniques and triangulation methods.

Table 1. Dimensions and variables analyzed

Drought conceptualization	Regulatory frame
<ul style="list-style-type: none"> • Existence of an official drought definition • Existence of an 'operational' definition of drought • Responsible institution • Practical influences • Drought perception by stakeholders 	<ul style="list-style-type: none"> • Drought policy • Specific drought strategies and planning (e.g. DMP) • Drought Emergency law provision • Regular law provision specific to drought • Other regulatory initiatives
Drought management approach	Participation
<ul style="list-style-type: none"> • Approach 	<ul style="list-style-type: none"> • Degree of participation • Participation process • Main types of participation • Inclusiveness and balance of stakeholders' participation • Strengths and weaknesses • Conflicts on & Conflicts between
Resources	
<ul style="list-style-type: none"> • Level of available resources • Economic resources • Human resources 	
Measure's adequacy	Impacts
<ul style="list-style-type: none"> • Adequacy of measures typology • Best/worst measures perception 	<ul style="list-style-type: none"> • Most affected sectors • Main achievements in impact reduction • Impacts that could have been better addressed

Key stakeholders were involved in the data gathering so that their knowledge, opinions and perceptions on the assessment dimensions could inform the analysis. A stakeholder

analysis was used to identify the key agents and actors in each case study, map their interests and plan their involvement in the analysis based on their role in drought management. The involved stakeholders were categorized as (i) policy makers, (ii) decision-makers/ managers, (iii) users and (iv) other actors.

The dataset for the analysis includes 40 semi-structured interviews to key experts, managers or sectors affected by drought, 65 replies to a questionnaire and 5 one-day Case Study Fora (81 participants in 5 Case Study fora) to discuss past drought management with the support of a SWOT analysis.

3. RESULTS

Current vulnerability to drought (Table 2) and the associated impacts have been analyzed in the six DROUGHT-R&SPI Case Studies. Drought impacts mainly concern agriculture (i.e. loss of produce), energy production, navigation, environment and in some cases domestic supply. In total eight impact tree diagrams have been developed (4 for agriculture, 1 for the domestic sector, 1 for environmental impacts, 1 for energy production and 1 for conflicts on water use) and the information available was organized using the DPSIR framework, so as to present in a common layout vulnerability to drought and the responses implemented (e.g. Figure 1 for the Syros Island, Greece).

Table 2. Vulnerability to drought: A summary of findings from the six Case Studies

Category	Vulnerability factors
Social	<ul style="list-style-type: none"> • Limited awareness of drought-related risks
Economic-Technical	<ul style="list-style-type: none"> • Water scarcity • Crop pattern – Irrigation practices • Limited implementation of efficient water use practices
Environmental	<ul style="list-style-type: none"> • High (ground)water exploitation index • Degradation of water quality • Dependency on transboundary waters • Climate change
Institutional	<ul style="list-style-type: none"> • Lack of drought management plans • Limited cooperation among authorities – Lack of conflict resolution mechanisms • Limited integration among policies

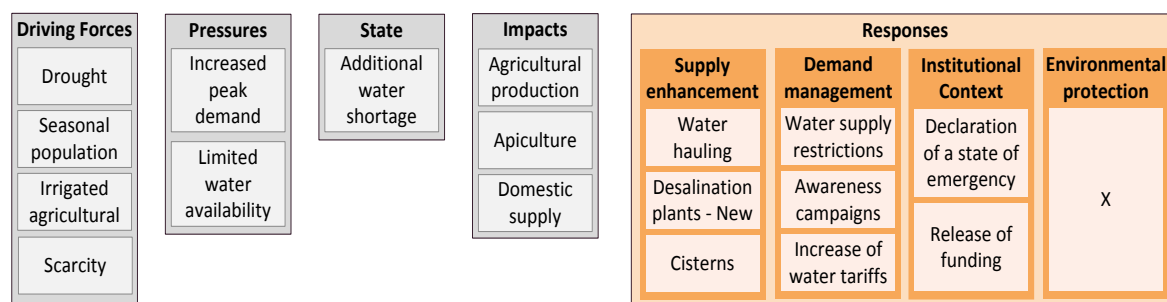


Figure 1. Vulnerability and responses to drought in Syros Island, Greece

The analysis of the seven dimensions (Table 1) in selected past drought events produced findings by case study and allowed for the identification of common trends, which can be found in De Stefano et al. (2012). In the next pages the main overall findings for three dimensions (approach to drought management, measures adequacy and impact of drought measures) are presented as an example of the analysis outcomes.

3.1. Drought management approach

Drought episodes in Europe often are tackled mainly through a crisis-management approach, by issuing a national or regional drought emergency program to alleviate drought impacts (EC, 2007). However, in light of an expected exacerbation of drought impacts and an increase in episodes occurrence and severity, it should be a priority to move from crisis management approach to risk management approach (EC, 2007). Table 3 shows that the current approach to drought management differs across the case studies, suggesting that they are at different stages of development of their drought management policy toward a risk management approach to drought.

Table 3. Drought management approach at Case Study level

	SY	JU	PO	PT	CH	NL
Approach	Crisis	Risk Management	Crisis	Crisis	Under development	Low-risk management

Source: Own elaboration based on data provided by the Case Studies.

3.2. Measure's adequacy

Drought responses were defined all drought management actions and initiatives that were planned and/or implemented, mainly by the public authorities, in order to reduce drought vulnerability risk through preparedness, mitigation or impact reduction in selected past drought events. Several studies, reports and articles on drought define their own classification of drought measures depending on their goals or characteristics of the study (MEDROPLAN, 2007), but there is no universally accepted categorization of responses to drought that could be used for our study. An ad hoc classification of drought measures was developed for analytical purposes based on the measures characterization of Spain's drought management plans (Box 1, Source: Own elaboration based on MEDROPLAN, 2007; MMA and CHJ, 2007; EC, 2007).

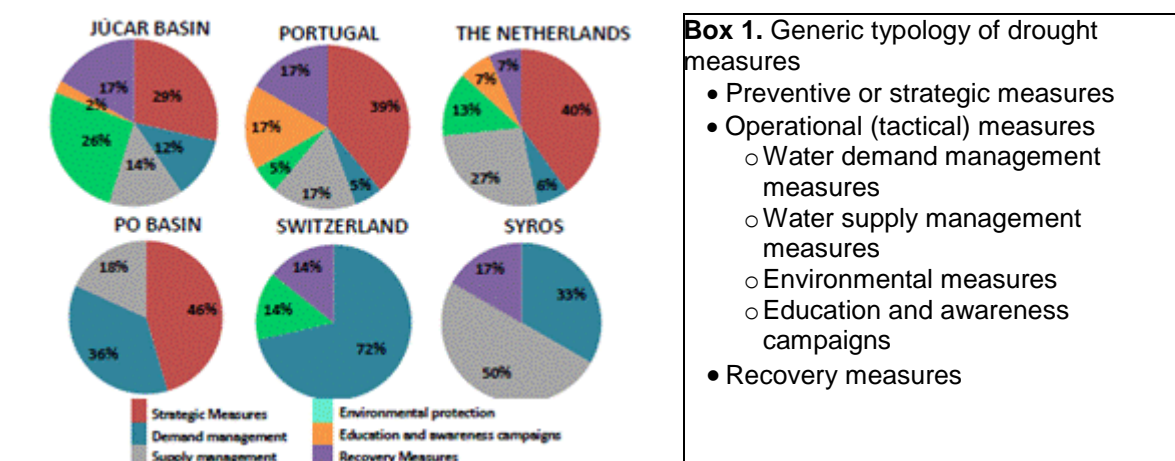


Figure 2. Type of measures implemented in the Case Studies

The application of such classification to the Case Studies led to the identification and categorization of response to drought during a specific drought event in the past. Although the number of measures in each category is not an absolute indicator of the weight given to each type of measures it does provide hints on the current focus of the response to drought and on possible gaps in the management of dry spells.

The stakeholders' perception about the implemented response to drought was captured through targeted questionnaires and interviews. The strategic and the operational measures related to demand and supply, were evaluated according to their: (i) Design; (ii) Implementation; (iii) Cost-effectiveness; (iv) Adequacy of activation time; and (v)

Contribution to impact reduction. The relevance of environmental protection in the response to drought was assessed in terms of the level of priority given to: (1) ensuring good chemical status of water bodies; (2) nature conservation and (3) protection; environmental restoration actions after drought. Finally, recovery measures were assessed according to: (i) Measures content, (ii) Total budget available, (iii) Distribution of the budget among the affected peoples/areas, (iv) Implementation of measures, (v) Time of adoption of measures, (vi) Measures duration and (vii) Contribution to minimization of negative impacts of drought.

Table 4. Assessment of drought measures implemented in past drought events in the CSs according to the perception of the consulted stakeholders. Scores over 4.

	SY	JU	PO	PT	CH	NL
Preventive or strategic measures	N/A	--	2.5	2.8	N/A	3.0
Operational measures - Demand	2.3	3.0	2.4	2.0	3.0	2.5
Operational measures - Supply	1.9	3.0	2.2	2.1	N/A	3.0
Awareness campaigns	2.0	1.7	2.5	2.4	2.5	3.0
Environmental issues	1.8	3.3	2.0	1.9	2.6	3.1
Recovery	1.4	--	N/A	1.9	3.1	3.8

Nº of questionnaires analyzed for each case study: SY: 6; JU: 9; PO: 19; PT: 10; CH: 14; NL: 4.

Note: values represent the average by typology of the scores given to each of the considered measures. N/A: not applicable. no measures of this typology were identified; (--): not analysed

3.3. The impact of drought response

The impact of drought response could not be measured directly due to two main reasons: the complexity and uncertainty of the linkage between measures and their impacts; and the time lag between the considered drought episodes and the development of the analysis. Thus, the impact of drought responses at a Case Study level was assessed through the perception of stakeholders on how each measure contributed to drought mitigation (Table 5).

Table 5. Stakeholder perception of measure's contribution to drought mitigation

Case Study	Most affected sectors	Main achievements in impact reduction
Syros Island	<ul style="list-style-type: none"> • Agriculture • Public water supply 	<ul style="list-style-type: none"> • Urban water supply needs were met. • Increased awareness on water availability issues. • Increase in the number of cisterns for rainwater harvesting.
Júcar River Basin	<ul style="list-style-type: none"> • Urban water supply • Agriculture • Environment 	<ul style="list-style-type: none"> • The efficiency of the measures adopted was high and the consequences of the drought episode, given its severity, were reasonable
Po River Basin	<ul style="list-style-type: none"> • Agriculture • Energy sector 	<ul style="list-style-type: none"> • Energy production was prioritized to avoid interruption of the energy supply, by maintaining the minimum in-stream flows for thermoelectric plants
Portugal	<ul style="list-style-type: none"> • Urban water supply • Agriculture and livestock • Hydropower • Pulp industry • Environment (fish population) 	<ul style="list-style-type: none"> • Most of the drought impacts were addressed to some extent

4. CONCLUSIONS

The ex-post analysis and assessment of past practices/responses to cope with drought in the DROUGHT-R&SPI Case Studies allowed for the identification of gaps and for formulation of policy recommendations to:

- Enhance preventive measures and structured planning of response to drought (e.g. Drought Management Plan) and develop monitoring systems & forecasting;
- Widen the array of stakeholders involvement and formalize participation mechanisms, which should be active even during normal conditions;
- Create mechanisms to solve possible disputes among the involved authorities;
- Target awareness campaigns to sectors whose behavior can really make a difference in terms of water saving;
- Enhance the enforcement of the regulation regarding water use restrictions and environmental and protection;
- Ensure a more even & transparent distribution of funds among the affected sectors;
- Foster staff continuity in the agencies responsible for drought management framework in these areas; and
- Undertake systematic ex-post evaluation processes as a means to foster adaptive learning.

Moreover, the analysis and assessment of past practices to cope with drought in the DROUGHT-R&SPI Case Studies indicated that, despite the differences in the socio-economic, environmental and management framework in these areas, the key elements identified for an effective drought management are the same: (i) monitoring and early warning, (ii) risk-based management, (iii) establishment of evaluation processes, and (iv) mitigation of drought risk through long-term options.

Drought monitoring and early warning, using case-specific drought indicators that can link drought severity to impacts, was highly acknowledged by the stakeholders as an important prerequisite for improving preparedness to drought. The availability of timely and reliable information regarding drought characteristics and the anticipated impacts supports decision making and the selection of responses. Monitoring and early warning is a critical component of risk-based drought management, which places emphasis to preparedness rather than simply the mitigation of impacts. In all Case Studies, stakeholders supported the need for moving from crisis to risk-based management as a means for reducing future impacts and improving coping capacities.

Measures to cope with drought risk should primarily address the factors that shape vulnerability to drought and have to be part of a wider water management strategy. Emphasis should be placed in developing “win-win” strategies that include measures for improving long-term preparedness (e.g. demand management, introduction of alternative water supply sources) and address both water scarcity- and drought-related problems. In addition, the post-drought evaluation of measures should be integrated in drought management, so as to ensure the continuous improvement and adjustment of management practices to the conditions in place.

Even though drought events are primarily “local” both in terms of hazard and impacts, there is a significant potential for cross-learning that could improve drought mitigation efforts at the local level and drought policy development at the national or European level. In particular, the experiences and lessons learnt from past management efforts in drought-prone areas (e.g. in the Mediterranean) should be shared to guide future drought management.

5. ACKNOWLEDGEMENTS

The authors of this paper would like to thank the stakeholders from the DROUGHT-R&SPI Case Studies for their cooperation and valuable input for assessing existing drought management practices. The authors also thank the DROUGHT-R&SPI partners that contacted and interviewed the stakeholders.

REFERENCES

1. De Stefano L., Urquijo Reguera J., Acácio V., Andreu j., Assimacopoulos D., Bifulco C.,..., Wolters W. (2012). Policy and drought responses – Case Study scale, *DROUGHT-R&SPI Deliverable 2.3*. <http://www.eu-drought.org/technicalreports>
2. European Commission (2007). Drought Management Plan Report: Including Agricultural. Drought Indicators and Climate Change Aspects. *Technical Report 2008 – 023*. Water Scarcity and Drought Expert Network. DG Environment.
3. European Commission (2012). A Blueprint to Safeguard Europe's Water Resources. In *COM(2012) 673 final*. Brussels. Belgium.
4. Fontaine M.M. and Steinemann A.C. (2009). Assessing Vulnerability to Natural Hazards: Impact-Based Method and Application to Drought in Washington State. *Natural Hazards Review*. 11- 18.
5. Kallis. G. (2008). Droughts. *Annual Review of Environment and Resources*. **33** (1). 85-118. doi:10.1146/annurev.enviro.33.081307.123117
6. Khajuria A. and Ravindranath N.H. (2012). Climate Change Vulnerability Assessment: Approaches DPSIR Framework and Vulnerability Index. *J Earth Sci Climat Change*. **3**. 109. doi:10.4172/2157-7617.1000109
7. Knutson C., Hayes M. and Phillips T. (1998). How to reduce drought risk. Preparedness and Mitigation Working Group. Western Drought Coordination Council.
8. MED EUWI –Mediterranean Water Scarcity and Drought Working Group (2008) Mediterranean Water Scarcity and Drought Final Report | Euro-Mediterranean Information System on know-how in the Water sector. Joint Mediterranean EUWI/WFD Process.
9. MEDROPLAN (2007). Drought Management Guidelines and Examples of Application (2 volumes in 6 languages). Iglesias. A. Cancelliere. S. Gabiña. D. López-Francos. A. Moneo. A. and Rossi. G. (eds). European Commission. MEDA-Water programme. Zaragoza.
10. Ministerio de Medio Ambiente & Confederación Hidrográfica del Júcar (2007). Plan Especial de Alerta y Eventual Sequía de la Cuenca Hidrográfica del Júcar. Dirección General del Agua – Confederación Hidrográfica del Júcar.
11. Mishra AK & Singh VP (2010). A review of drought concepts. *Journal of Hydrology*. **391** (1–2). 202–216
12. Rossi G. (2009). European Union policy for improving drought preparedness and mitigation. *Water International*. **34** (4). 441–450.
13. Wilhite A.D. (1996). A Methodology for Drought Preparedness. *Natural Hazards*. **13**. 229-252.