Technical Report No. 24

SYSTEMATIC CLASSIFICATION OF DROUGHT VULNERABILITY AND RELEVANT STRATEGIES - CASE STUDY SCALE

Eleni Kampragou, Dionysis Assimacopoulos, Joaquín Andreu, Carlo Bifulco, Alessandro de Carli, Susana Dias, Itziar González Tánago, David Haro Monteagudo, Antonio Massarutto, Dario Musolino, Javier Paredes, Francisco Rego, Irmi Seidl, Abel Solera, Julia Urquijo Reguera, Wouter Wolters

30 March 2015

DROUGHT-R&SPI (Fostering European Drought Research and Science-Policy Interfacing) is a Collaborative Project funded by the European Commission under the FP7 Cooperation Work Programme 2011, Theme 6: Environment (including Climate Change, ENV.2011.1.3.2-2: Vulnerability and increased drought risk in Europe (Grant agreement no: 282769). The DROUGHT-R&SPI project started 01/10/2011 and will continue for 3 years.

Title:	Systematic classification of drought vulnerability and relevant strategies - case study scale
Authors:	Eleni Kampragou, Dionysis Assimacopoulos, Joaquín Andreu, Carlo Bifulco, Alessandro de Carli, Susana Dias, Itziar González Tánago, David Haro Monteagudo, Antonio Massarutto, Dario Musolino, Javier Paredes, Francisco Rego, Irmi Seidl, Abel Solera, Julia Urqujo Reguera, Wouter Wolters
Organisations:	National Technical University of Athens (NTUA) Instituto Superior de Agronomia, Portugal (ISA-CEABN) Universita Commerciale 'Luigi Bocconi' Italy (UBCERTeT) Universidad Politecnica de Valencia, Spain (UPVLC) Alterra, The Netherlands (Alterra) Eidgenössische Forschungsanstalt WSL (WSL) University Complutense of Madrid, Spain (UCM)
Submission date:	30 March 2015
Function:	This report is an output from Work Package 2
Deliverable	DROUGHT-R&SPI Deliverable 2.7

Photo: Dionysis Assimacopoulos

Executive Summary

This document synthesises the results from the individual Case Study analyses in the DROUGHT-R&SPI WP2 "Drought vulnerability assessment and risk reduction at different scales: Development of Case Studies" and concludes with recommendations and strategies for drought risk reduction. It is the outcome of analysis in different:

- Spatial scales: National (NL, PT, CH), River Basin (Po, IT; Jucar, ES), and local (Syros island, GR);
- Time frames: Past (1976-2011), Present (2011-2014), and Future (up to 2100, depending on the region and research theme); and
- Themes: Drought characteristics, impacts, vulnerability and responses.

Starting from the analysis of past droughts in terms of hazard, impacts and responses in the six Case Studies (which pertain to different geo-climatic regions and are characterized by different economic structures and levels of awareness), the analysis of future drought characteristics, anticipated future vulnerability and impacts followed, in order to identify and evaluate potential responses for drought risk reduction. The whole process was supported by local stakeholder fora. In total 14 workshops were organised in which past and future drought management were the main topics discussed. In addition, the results were compared with those obtained from Pan-European level analyses.

The main findings can be summarised as follows:

1. Drought frequency and intensity is expected to increase in the future and in addition, water scarcity problems may be also intensified in the future due to climate change, indicating higher exposure to drought. Monitoring of drought conditions is necessary, despite the high uncertainty in climate models and climate predictions.
2. Case Study analyses show that the socio-economic development pattern is the most influencing factor on future drought-related risks, compared to climate change and its effect on drought characteristics.
3. The higher the spatial scale of analysis, the more aggregated the vulnerability factors can be. Detailed vulnerability assessments require data and information that are typically available at lower scales.
4. EU-wide assessments can provide insights for the development of national drought policy (e.g. by indicating vulnerable areas and factors that shape vulnerability) but for detailed plans and actions more detailed assessments at lower scales are required.
5. High priority actions for integrated drought management strategies are: (i) Monitoring & early warning, (ii) development of drought management plans on the basis of risk-based assessments, (iii) development of strategic reserves, and (iv) establishment of institutional frameworks and participation processes for facilitating cross-institutional coordination and increasing awareness.
6. Drought impact mitigation calls for local-specific actions, to account for differences in drought exposure, vulnerability and coping capacity, as well as in institutional structure.
7. The options discussed and analysed in the Case Studies are some of the potential mitigation options and can serve as examples of requirements for successful application (or in some cases examples of successful application; e.g. the Case Study of Jucar River Basin). Past drought management experiences, either successful or not, act also as "learning episodes".

This document has been developed by the NTUA with the cooperation of UPVLC, ISA-CEABN, UB-CERTeT, Alterra, WU, WSL, ETH, and UCM.

Table of Contents

List of Tables

List of Figures

1 Introduction

The guiding question in the DROUGHT-R&SPI project was which actions, part of a drought strategy, would reduce vulnerability to drought in the project's Case Studies. A series of research activities (Figure 1.1) were undertaken to answer that question that involved (past and future) drought characterisation, vulnerability and impact assessment, and identification and assessment of options for future drought risk reduction, all of which were supported by local stakeholder fora.

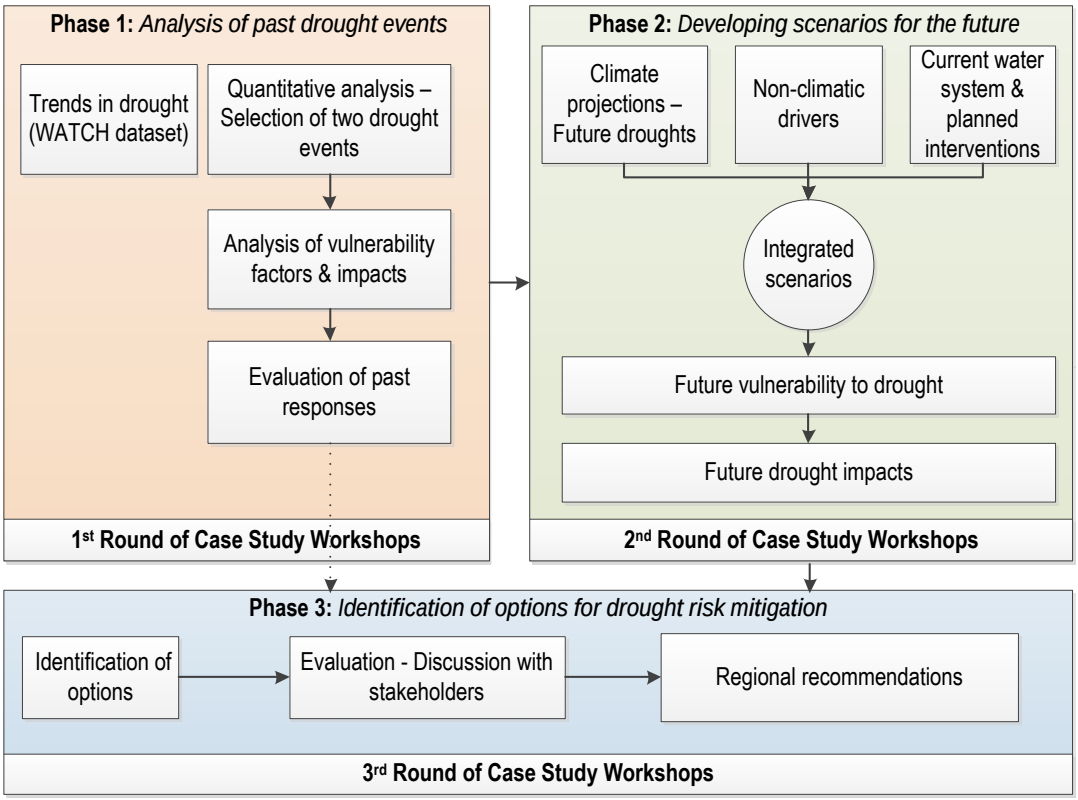


Figure 1.1: *Phases in the DROUGHT-R&SPI Case Study development process.*

Table 1.1 provides an overview of the six DROUGHT-R&SPI Case Studies, summarising some key findings. Despite the differences in the spatial scale of analysis and the tools/methods applied, the common research aim was to identify and analyse the factors that shape vulnerability to drought in order to:

- Propose actions that address the underlying causes of vulnerability in each Case Study separately, and if possible to conclude with best practices for integrated drought risk management;
- Identify similarities and differences among the Case Studies that could support assessments in larger scales (e.g. European); and
- Identify high priority actions per region and sector to support policy making at the national and European level.

Table 1.1: *Typology of the DROUGHT-R&SPI Case Studies.*

	Syros, GR	Jucar RB, ES	Po RB, IT	Netherlands	Portugal	Switzerland
Drought hazard						
Trend in past drought characteristics						
Duration	↑	↑	↑	↑	↓	↑↓[1]
Intensity	↑	↑	↑	↑	↑↓[2]	↑↓[2]
Historical analysis	X	X				
Future drought characteristics (2021-2050; A2/B1 IPCC scenario)[3]						
Duration	+/o	o/+	+/+	+/+	+/+	+/+
Intensity	+/+	+/+	+/+	+/+	+/+	+/+
Drought impacts						
Agriculture	X	X	X	X	X	X
Urban supply	X		X		X	X
Energy production		X	X	X	X	X
Environment		X	X	X		X
Industry		X				
Area burned by wild fires	X	X	X	X	X	X
Vulnerability assessment						
Review-based				X		X
Survey-based	X		X		X	
Model-based		X				
Future vulnerability	↑↓[4]	↑	- (in agriculture) ↑ (in energy Sector)	-↑	-↓	-
Drought management issues						
Current approach	Crisis	Risk	Crisis	Low-risk	Crisis	Crisis
Monitoring (in operation)		X	X	X	X	Under development
Management plans		X	X	X	X	
Ex-post evaluation of responses	X	X	X	X	X	X
Stakeholder involvement[5]	Medium	High	High	Low	High	Medium

Legend key

↑: Increasing trend
↓: Decreasing trend
-: Stable value (no trend)
-↑: Stable to increasing trend
-↓: Stable to decreasing trend
↑↓: Increasing & decreasing trend, depending on the region
+: All 3 GCMs agree on an increase
o: Not all GCMs agree on increase or decrease

[1] Swiss mid lands show an increasing trend; Swiss Alps a decreasing trend

[2] Swiss Alps and coastal area of Portugal show a decreasing trend; rest of the country increasing trend

[3] Synthesis of modelling results from 3GCMS

[4] Increasing or decreasing trend, depending on the socio-economic development pattern

[5] High: Organisation of three Workshops; Medium: Organisation of two Workshops; Low: Organisation of one Workshop

The factors that shape vulnerability to drought are numerous and can be broadly classified as exposure, sensitivity and adaptive capacity factors (Annex A). This classification is necessary, as the physical exposure to drought, as well as the coping capacity, vary significantly from one region to another or even among sectors. Kossida et al. (2012) pinpoint that it is difficult to have a single approach for assessing vulnerability to drought as:

- Drought operates in different scales (spatial and temporal) and severity levels;
- Impacts can be noticed in many economic sectors and are a result of physical and anthropogenic factors; and
- Mitigation depends on the prevailing socio-economic conditions and adaptive capacity of a system.

Therefore regional/ sectoral vulnerability assessments should be a main premise of any drought mitigation and planning strategy (Figure 1.2; Wilhelmi et al., 2002; Swain and Swain, 2011).

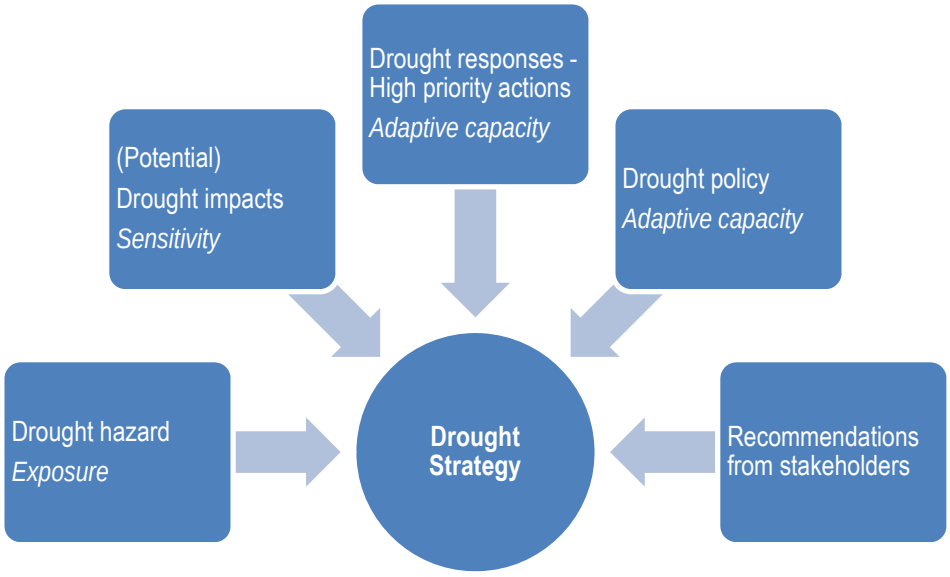


Figure 1.2: *DROUGHT-R&SPI inputs for proposing strategies for drought vulnerability reduction.*

This document discusses vulnerability and strategies for drought risk reduction in the DROUGHT-R&SPI Case Studies. It is structured as follows:

- Chapter 2 presents the classification of drought vulnerability factors in the project Case Studies.
- Chapter 3 focuses on the proposed strategy-related actions for dealing with drought risks in the Case Studies.
- Chapter 4 concludes the document and synthesises the outcomes from the six Case Studies.
- Chapter 5 includes the list of references used in this report.

Five annexes complement the report.

2 Classification of vulnerability to drought in the DROUGHT-R&SPI Case Studies

The factors that define vulnerability to drought (Figure 2.1) differ among systems based on their socio-economic and biophysical features. Vulnerability factors can be classified according to (Fussel, 2007):

- Their type: UN (2004) distinguishes four main types of vulnerability factors, categorised as physical, economic, social and environmental.
- The scale: Factors can be grouped as 'external' and 'internal', in order to distinguish between the external stressors that a system is exposed to and the internal factors that define the type and magnitude of impacts.
- The dimension of vulnerability: Vulnerability is typically defined as a function of exposure, sensitivity and adaptive capacity (e.g. Fontaine and Steinman, 2009).
- The system affected: The assessment may refer to vulnerability of natural, social or sector-related systems.

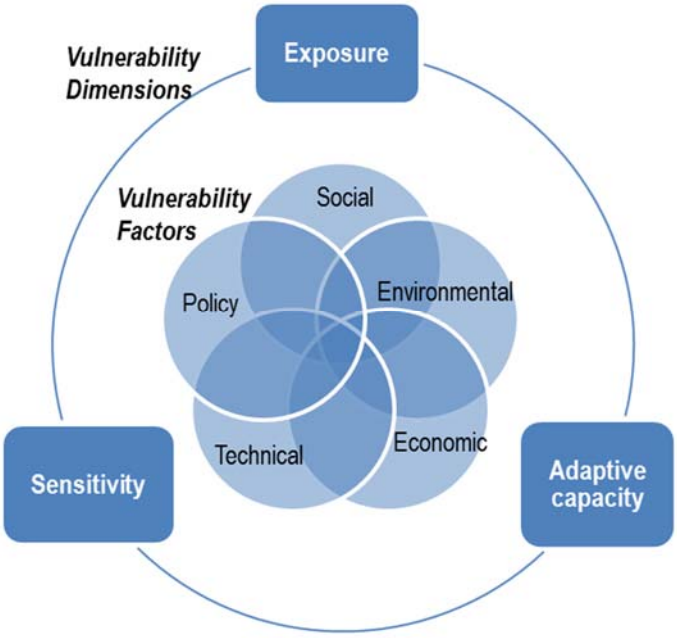


Figure 2.1: *Conceptual framework of drought vulnerability factors.*

The process followed for the identification of vulnerability factors in the DROUGHT-R&SPI Case Studies is given in Annex B. Table 2.1 lists the main factors that have been identified, classified in components and indicating the relevance for the three spatial scales of analysis: local, regional and national. Case Study analyses showed that the socio-economic development pattern is the most influencing factor on future drought-related risks, compared to climate change and its effect on drought characteristics. This is reflected in the vulnerability analysis framework, as there is a wide list of sensitivity and adaptive capacity factors compared to the exposure-related ones.

Table 2.1: *The vulnerability analysis framework in the DROUGHT-R&SPI Case Studies.*

Dimension	Component	Factor	Relevance		
			National	River Basin	Local
Exposure	Drought	Drought intensity		✓	✓
		Drought duration		✓	✓
	Water scarcity	High water exploitation index		✓	✓
Sensitivity	Water resources	Groundwater overexploitation	✓	✓	✓
		Status of glaciers		✓	
		Lack of strategic reserves		✓	✓
		Transboundary dependency	✓	✓	
	Environment	Water dependent ecosystems	✓	✓	✓
		Poor water quality		✓	✓
	Urban sector	Population density		✓	✓
		Demand coverage		✓	✓
	Agriculture	Inefficient irrigation systems		✓	✓
		Crop pattern	✓	✓	✓
		Demand coverage		✓	✓
		% Small-scale farming operations		✓	✓
	Energy production	% Share of hydropower to total energy production	✓		
		Distribution & age of hydropower plants	✓	✓	
Adaptive capacity	Social	Low access to information / drought awareness	✓	✓	✓
		Limited willingness to change		✓	✓
		Water use conflicts	✓	✓	
	Policy-related	Lack of DMPs		✓	✓
		Lack of DM&EW	✓	✓	✓
		Lack of water use rights definition	✓	✓	
		Established water use priorities	✓	✓	
		Actors & institutions	✓	✓	✓
	Technology/ economic	Access to (water saving) technology		✓	✓
		Access to alternative water sources		✓	✓
		Infrastructure	✓	✓	✓

In support of drought strategy development, vulnerability factors are further classified as in Table 2.2. External factors are associated with higher uncertainty as these cannot be directly handled by the system, whereas internal ones could be primarily addressed for reducing vulnerability to drought.

Table 2.2: *Classification of vulnerability factors according to the dimension and scale.*

	Dimension		
	Exposure	**Sensitivity**	**Adaptive capacity**
Internal *(factors that can be controlled by the system)*	• Water scarcity	• Economic system – water use sectors • Water resources	• Social-related factors • Technology/ economic-related factors
External *(factors that cannot be controlled by the system)*	• Drought hazard	• Transboundary dependency	• Policy-related factors

2.1 Vulnerability profiles of the DROUGHT-R&SPI Case Studies

Vulnerability is a dynamic attribute of the system examined that varies in time following the changes in the internal and external elements of the system (Adger and Kelly, 1999; Dalziell and McManus, 2004; Leichenco and O'Brien, 2002; Luers, 2005; Miller et.al, 2010, Karavitis, 2012). Table 2.3 summarises the current and future state of vulnerability to drought in the six Case Studies, whereas Figure 2.2 shows the main vulnerability components.

Table 2.3: *Current and future vulnerability to drought in the DROUGHT-R&SPI Case Studies: key dimensions.*

Case Study	Vulnerability Dimension		
	Exposure	**Sensitivity**	**Adaptive Capacity**
Syros island	O ☹	O 😐	O ☺
Jucar River Basin	O ☹	O ☹	O 😐
Po River Basin	O ☹	O 😐	O ☺
Netherlands	O ☹	O 😐	O ☺
Portugal	O ☹	O ☺	O ☺
Switzerland	O ☹	O 😐	O ☺
Contribution to current vulnerability:	O Low/ not so important O Medium/ important O High/ very important	Future state:	☺ Improvement 😐 No change ☹ Deterioration

Drought frequency and intensity is expected to increase in the future (see Alderlieste and van Lanen, 2013a; Alderlieste and van Lanen, 2013b; van Lanen et al., 2013a; van Lanen et al., 2013b) and in addition water scarcity problems may be intensified in the future due to climate change, indicating higher exposure to drought. Sensitivity to drought is linked to potential drought impacts in the different sectors (see Massarutto et al., 2013; Assimacopoulos et al., 2014) and depends mainly on the socio-economic development pattern. Sensitivity-related factors are more pronounced in the Case Studies located in the wider Mediterranean region. On the contrary, adaptive capacity-related factors are more important in the project's Case Studies where: (i) drought is not a frequent and severe natural hazard, and (ii) the spatial scale of analysis is the national one. The factors that have been identified in more than one Case Study are: Lack of drought management plans, Lack of strategic reserves, Water scarcity, Crop pattern, Water use conflicts and Groundwater overexploitation.

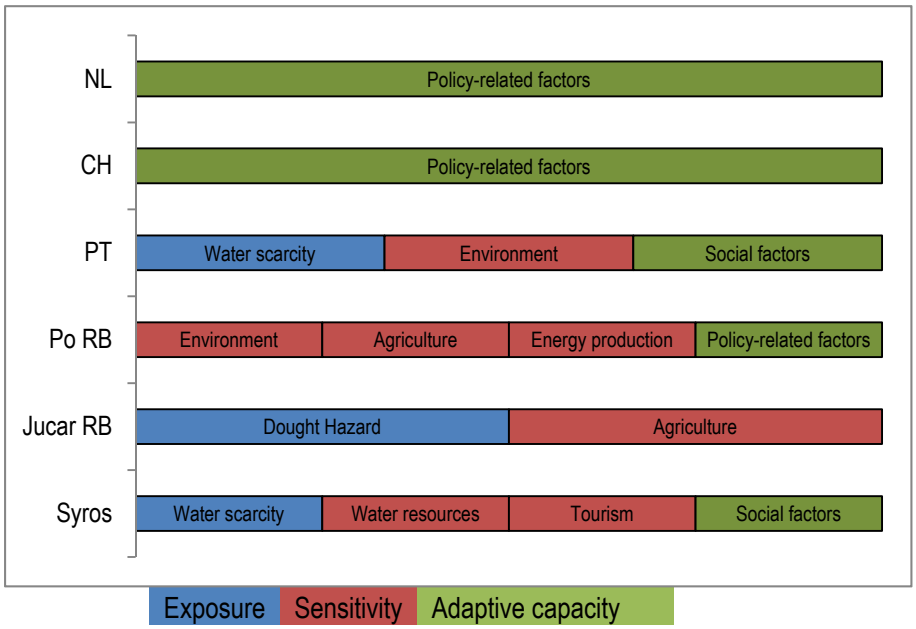


Figure 2.2: *The main vulnerability components in the DROUGHT-R&SPI Case Studies.*

2.2 Vulnerability factors at the Case Study and Pan-EU scales

Vulnerability analysis has been undertaken in the DROUGHT-R&SPI project at two levels (the Case Study and the pan-EU levels), following the same conceptual model, based on IPCC (2007) definition of vulnerability, which describes it as a function of exposure, sensitivity, and adaptive capacity. Nevertheless, it is important to explore to which degree the factors identified in the Case Study areas are of interest from an EU perspective (Figure 2.3) and vice versa.

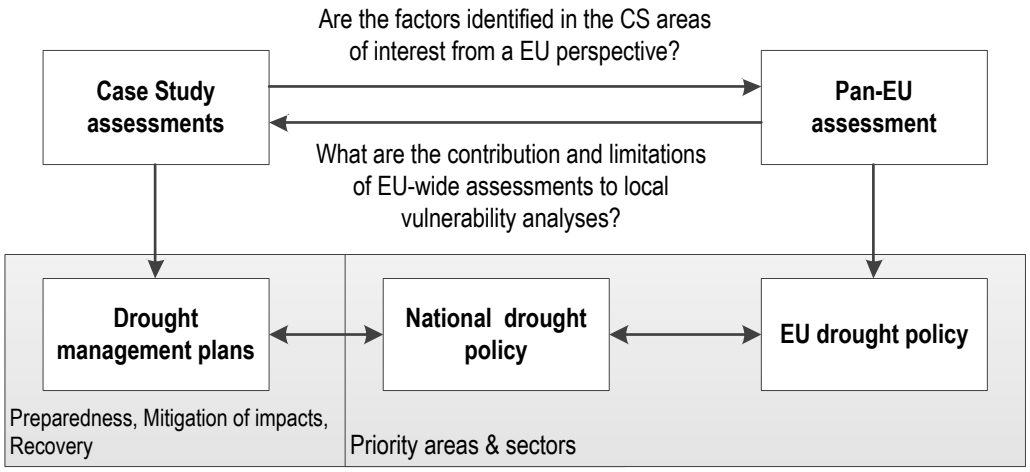


Figure 2.3: *Vulnerability assessment the Case Study and Pan-EU levels.*

To carry out this analysis, the vulnerability factors identified in both studies were compared. As seen in Table 2.4, the majority of vulnerability factors at the Case Study level can be aggregated to variables used in the EU-wide assessment. However, some differences can be observed:

- Water scarcity is a critical vulnerability factor, particularly in regions in the wider Mediterranean basin. This factor has been included in the exposure dimension of vulnerability in the Case Study areas, whereas in the case of Pan-EU analysis this factor is included in the sensitivity dimension as “Water stress” factor. This difference is common within vulnerability assessments due to the fact that the boundaries between dimensions are often blurred (Greiving et al., 2010).
- Case Studies have been able to include aspects within drought vulnerability factors that, due to data constraints, could only be included at theoretical level within the Pan-European assessment (such as "Access to (water saving) technology" and "Access to alternative water sources").
- Financial- and innovation-related factors are included only at Pan-European level, since there were considered less relevant at a Case Study level.
- Overall, detailed vulnerability assessments that provide an in-depth picture of a local context require data and information that might be available or be more easily collected at lower scales. The higher the spatial scale of analysis usually means that the vulnerability factors are more aggregated.
- Broader assessments (EU-wide or national) can provide insights to transnational and national drought policy making by indicating: (i) areas in a region or in a country that may have high vulnerability (e.g. Annex C.1), and the (ii) main factors that shape vulnerability (e.g. Annex C.2). If the aim, however, is to develop contingency plans, then more detailed assessments are needed.

Table 2.4: *Vulnerability factors at the European and Case Study level (adapted from Assimacopoulos et al., 2014, Gonzalez Tanago et al., 2014).*

Vulnerability Dimension	Factors at the Pan-EU scale	Relevant factors at the Case Study scale
Exposure	Drought characteristics	Drought intensity & duration
Sensitivity	Water use	Inefficient irrigation systems; Crop pattern
	Socio-economic relevance (be sector)	% Small-scale farming operations; % Share of hydropower to total energy production
	Population	Population density
	Water stress	Demand coverage; Transboundary dependency
	Water body status (WFD)	Water dependent ecosystems; Poor water quality; Groundwater overexploitation
Adaptive capacity	Law enforcement	Actors & institutions
	Drought management tools	Lack of DMPs; Lack of DM&EW; Lack of water use rights definition; Established water use priorities
	Public participation	Water use conflicts
	Drought awareness	Low access to information / drought awareness
	Education: skilled and trained people	Limited willingness to change
	Innovation capacity (R&D)	
	Water resource development	Access to (water saving) technology; Access to alternative water sources; Infrastructure
	Availability & distribution of economic resources	
	Financial capacity for drought recovery	

2.3 Assessing vulnerability at different scales

Vulnerability assessments are used for bridging the gap between impact assessments and strategy development, by guiding the selection of options that target the underlying causes of vulnerability instead

of impacts (WMO and GWP, 2014). As strategy goals differ at the variant spatial scales (e.g. from impact mitigation to ensuring food supply), vulnerability assessments must be performed at all levels, providing different information at each one (Figure 2.4).

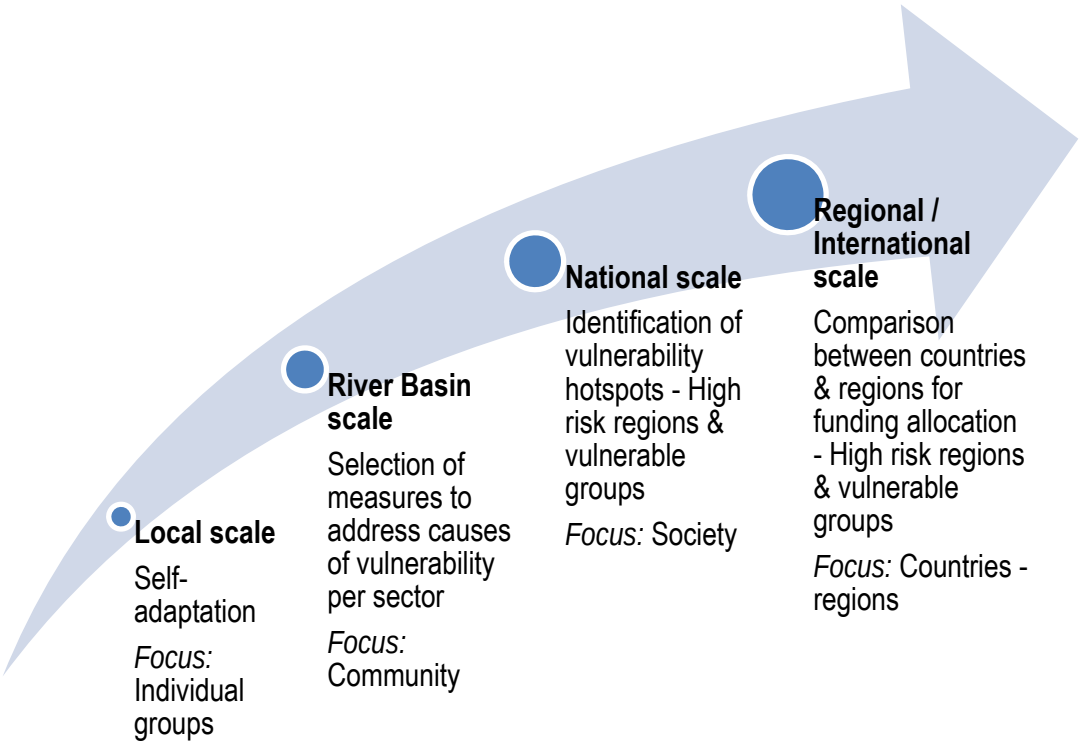


Figure 2.4: *Spatial scale-dependant scope of vulnerability assessment.*

According to Preston (2012) there are no rules to determine the boundaries of a system, and thus the selection of boundaries in a vulnerability assessment should be established according to the objectives of the study and the interests of the policy-makers and stakeholders involved in the process. Different stakeholders might have different understanding of the scale of the system under study; for example a local government will prioritise potential vulnerability within its territory, while water managers will focus more on the vulnerability of the hydrological system (Preston, 2012).

Different scales present pros and cons that should be taken into account before undertaking an assessment (Fekete et al., 2010). Besides, different scales and decision contexts require different kind of information. An indicator designed to describe the vulnerability of e.g. a rural community in the Sahel is probably irrelevant to the European context (Fussel, 2010). Spatial scale (Table 2.5) should be concordant with the aims of the study in order to be functional and useful for the stakeholders addressed on it:

- Subnational scale. Subnational studies with a local orientation allow assessing the vulnerability of a place, identifying specificities that generate vulnerability in each location, getting interesting contextual information, as well as measuring the capacities that the local population owns to prevent potential impacts. These studies usually include more detailed information since they might gather data, both quantitative and qualitative, directly from stakeholders or vulnerable groups, since this scale permits the application of participatory approaches (Fekete et al., 2010). Subnational studies provide deeper insights of vulnerability and thus permit a more pertinent design of measures, addressed to enhance resilience and coping capacity of the vulnerable population and/or territory (Cutter et al., 2009). These studies are necessary for an adequate elaboration of disaster risk management plans. However, these aspects also hamper potential comparison among too specific studies even within the same country or region.

- National scale. Frequently statistics are available at national level, since are produced by national institutions. Also in many countries, decisions regarding policies, strategies and budget allocation are centralized by national authorities, which require studies at national level in order to identify the most vulnerable regions and groups of population within the country. Besides, local actions and decisions are frequently constrained by institutional processes at national level (Adger et al., 2005).
- Transnational scales. These studies allow comparison among nations and territories. Usually they are required by decision makers on international institutions, such as the United Nations and UN Agencies, European Commission, FMI, World Bank. Transnational studies pretend to identify which places require a more in-depth research or where are located the highest vulnerabilities and most vulnerable people, and draw attention to regions where risk management is most needed (Birkmann, 2007). According to Fekete et al. (2010) this scale meets the demand of allocating funds for parts of the world most affected by natural hazard or social vulnerability. Transnational studies usually have to sacrifice high resolution and rich contextual information in order to obtain a bigger picture.

Table 2.5: *Geographical scales within the DROUGHT R&SPI vulnerability assessments (adapted from Preston, 2012).*

Scale	Description	Study area in DROUGHT-R&SPI
Sub-national	Local: Geographic area, process or behaviour associated with an individual local government area, municipality	Syros island
	Regional: Geographic area, process or behaviour associated with a collection of local government areas or catchments, or an individual state or province	Po & Jucar river basins
National	Geographic area, process or behaviour associated with an individual country or national scale process	Portugal, Switzerland and The Netherlands
Transnational	Trans-boundary RBD, Subcontinental – Geographic area, process or behaviour associated with an agglomeration of nations, geographical region or international catchments (e.g. Mediterranean, Sahel, CA and Caribbean, SADC, Middle East, etc.)	Pan-European assessment
	Continental: Geographic area, process or behaviour associated with an individual continent	-
	Global: Geographic area, process or behaviour corresponding with the global extent	-

Each scale is needed for different purposes. The development of effective measures implemented at local or regional scale should be based on subnational studies, whereas policies addressed to mitigate and prevent climate change might require global or transnational orientation that allows international cooperation (Fussel and Klein, 2006).

Comparison within or between scales can be difficult and its feasibility might depend on the similarities between the conceptual and methodological approach used in the studies. In the case of DROUGHT R&SPI project, the results of the diverse vulnerability assessment should be complementary since they have adopted the same approach. Nevertheless, each scale present specificities that enrich the overall results.

3 Strategy-related actions to address vulnerability to drought

A drought strategy describes the "*series of actions designed to achieve the goal of drought vulnerability and risk reduction*" (Wilhite et al., 2014; ISDR, 2003). These actions fall into one of the following constituents (UN/ISDR, 2007; Figure 3.1):

1. Monitoring and early warning: It involves the process of monitoring drought conditions, defining drought stages and declaration processes.
2. Vulnerability and drought risk assessment: It focuses on the data and methodologies for performing vulnerability and risk assessments, in order to define the regions and sectors that are less resilient to drought.
3. Water augmentation / reuse: Supply enhancement during drought is a common practice. Different supply options may be applicable depending on the region and the drought stage.
4. Water conservation: It refers to measures taken to reduce water use during a drought. Long-term measures for water conservation are usually part of a water management plan and thus indirectly contribute to water management.
5. Drought mitigation and preparedness measures: It refers to any other type of measures, in addition to those for water supply and demand management that are implemented to reduce drought-related impacts and risks.
6. Conflict resolution: It includes measures dedicated to conflict resolution during drought episodes.
7. Legislation and governance: The category includes legislative and organisational actions in support of drought management (e.g. jurisdictions, water use priorities, contents of drought management plans, financial instruments).
8. Awareness, education and participation: This category refers to any action designed for increasing awareness on drought-related risks, improving the capacity of actors/agencies to deal with drought and involving all actors in the planning process, as well as in the implementation of a plan.
9. Research: Actions designed for supporting drought-related research and thus policy making.

A drought strategy check list is given in Annex D, which could guide the selection of actions and options for drought risk reduction. The guiding principles for strategy development and policy making are (WMO and UNCCD, 2012): (i) proactive, risk-based management to mitigate impacts, (ii) cooperation and participation in order to increase drought awareness and preparedness, and (iii) incorporation of financial strategies in drought preparedness plans.

Depending on the spatial scale of analysis, the strategy can aim at drought contingency planning (e.g. local and river basin scale) or enhanced water, food, and energy security (e.g. national and European scale). That is why any strategy at the national level should:

- Cover all economic sectors and should be equitable for all regions and population groups (WMO and GWP, 2014);
- Target at institutional arrangements and decision-making mechanisms, and
- Promote the implementation of regional drought monitoring and mitigation measures (Bokal et al., 2014).

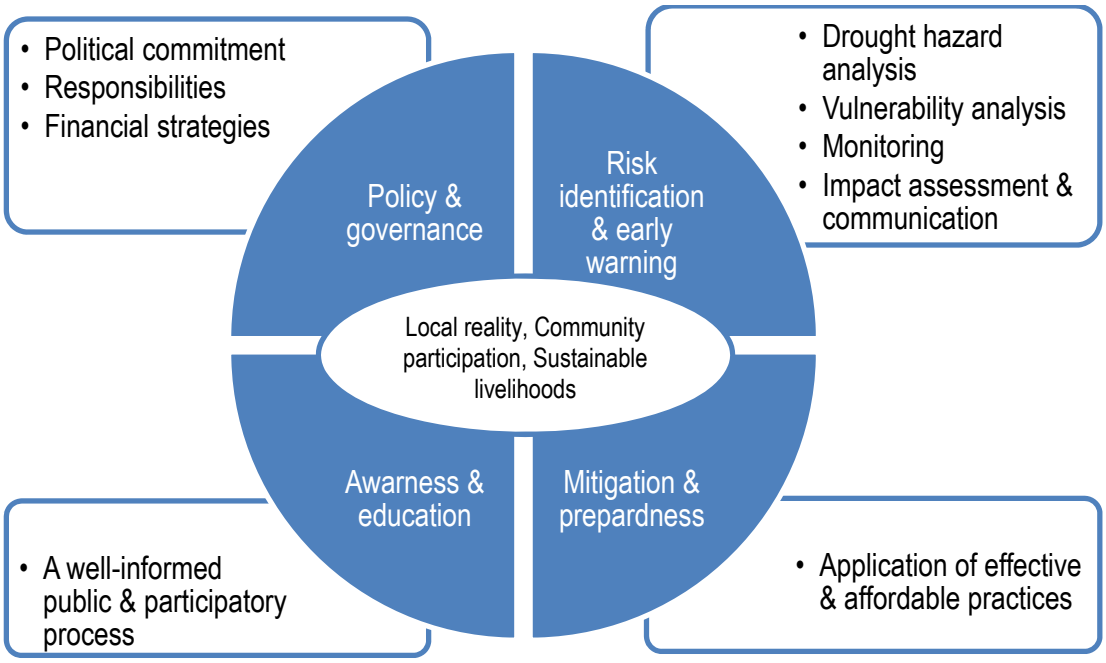


Figure 3.1: *Main elements of a drought risk reduction framework (adapted from UN/ISDR, 2007).*

De Stefano et al. (2012) provide a detailed overview of the measures taken in the past for drought impact mitigation in the project Case Studies (CSs) and concluded that "*in all the CSs the operational measures implemented were more abundant than the strategic/planning ones, and that recovery measures were the least developed ones, which is in agreement with the crisis management approach followed in most of the CSs*". Promoting risk-based management, a series of options for future drought risk reduction has been discussed and evaluated in the Case Studies, most of which are classified as operational/strategic measures (Assimacopoulos et al., 2015).

On the basis of past experiences, the evaluation of options and EU recommendations (Annex E), the following sections describe the high priority actions of a drought strategy in each Case Study and the guiding principles for their implementation, focusing on legislative requirements, technical capacity (tools, data requirements), financial issues, environmental considerations, and any constraints for the strategy development or its improvement.

3.1 Syros Island, Greece

A long-term strategy for dealing with droughts in Syros Island shall be based on measures for supply enhancement (as a means to address also water scarcity), in addition to promoting a risk-based management approach. Therefore, a drought-related strategy is proposed to incorporate the following actions (Table 3.1 to Table 3.5):

1. Improvement of drought-risk awareness of local authorities and people;
2. Assessment of wastewater reuse potential in the island;
3. Development of groundwater reserves;
4. Establishment of an integrated water monitoring network and processes for reporting; and
5. Establishment of formal participatory decision making processes.

Table 3.1: *Guiding principles for improving drought risk awareness in Syros Island, Greece.*

Improve drought-risk awareness of local authorities and people	
Vulnerability component addressed	• Social factors (Adaptive capacity)
Constraints to overcome for its implementation	• Limited knowledge of drought hazard & impacts on the islands • Focus on water scarcity management
Tools & data requirements	• Development of dissemination material (newspaper articles, brochures included in water bills etc.)
Organisational structure (jurisdictions, human resources)	• Incorporation of drought hazard under the jurisdictions of the Directorate for Civil Protection of the Region of South Aegean
Financial issues	• Availability of funds for the development of dissemination material
Other issues	-

Table 3.2: *Guiding principles for assessing the wastewater reuse potential in Syros Island, Greece.*

Assess wastewater reuse potential in the island	
Vulnerability component addressed	• Water resources (Sensitivity) • Technology/ economic (Adaptive capacity)
Constraints to overcome for its implementation	• Social acceptance of wastewater reuse • Upgrading of existing wastewater treatment plant to tertiary treatment
Tools & data requirements	• Estimation of the available wastewater quality & quantity • Analysis of potential uses (types & quantity) • Environmental considerations (effects on groundwater quality) • Health risk analysis
Organisational structure (jurisdictions, human resources)	• Joint action of the Directorate for Agricultural Development of the Region of South Aegean; Water Directorate of the Region of South Aegean; Municipal Enterprise for Water Supply and Sewerage of Hermoupolis
Financial issues	• Limited funds availability for upgrading the WWTP, constructing the network for transferring the treated wastewater, etc.
Other issues	-

Table 3.3: *Guiding principles for developing groundwater reserves in Syros Island, Greece.*

Develop groundwater reserves	
Vulnerability component addressed	• Water resources (Sensitivity)
Constraints to overcome for its implementation	• Limited knowledge on groundwater status • Ownership of groundwater reserves – Water use rights • Water use conflicts (agriculture vs. urban sector)
Tools & data requirements	• Monitoring of groundwater status (quality & quantity) • Assessment of groundwater availability & storage capacity (modelling)
Organisational structure (jurisdictions, human resources)	• Definition of appropriate management and information processes for setting the groundwater use levels • Staff allocated to the monitoring & reporting of groundwater status
Financial issues	• Funds for setting & operating the groundwater monitoring network • Availability of funds (e.g. in the form of subsidies) for compensating farmers for additional cost or losses in case of water use restrictions

Other issues	• Legal & water management frameworks, with regard to groundwater use

Table 3.4: *Guiding principles for establishing a monitoring network in Syros Island, Greece.*

Establish an integrated monitoring network - Reporting	
Vulnerability component addressed	• Policy-related (Adaptive capacity)
Constraints to overcome for its implementation	• Access to historical (climate, water sources) data • Cooperation between authorities for developing a common database • Increase awareness of authorities on drought-related indices
Tools & data requirements	• Database for storing the required data (e.g. precipitation, groundwater levels, water production from desalination plants) • Tools for estimating the indices • Website for disseminating drought monitoring info – Periodic reports
Organisational structure (jurisdictions, human resources)	• Capacity building and knowledge development for using the information provided by the monitoring system • Setting of a Drought Monitoring Committee with the respective allocation of jurisdictions
Financial issues	• Funds for the cost for (i) developing & maintaining the website, (ii) operating the monitoring network
Other issues	• Drought monitoring must be based on composite indices that include information about the water reserves in the island (precipitation, groundwater reserves, desalination capacity) • Definition of triggers by the Drought Monitoring Committee • Establish links with national, pan-European drought monitoring networks

Table 3.5: *Guiding principles for establishing participatory processes in Syros Island, Greece.*

Establish formal participatory decision making processes	
Vulnerability component addressed	• Policy-related (Adaptive capacity)
Constraints to overcome for its implementation	• Lack of / improvement of legislation/guidelines on procedures of participation in decision making processes • Limited experience / reluctance of local authorities in participatory processes due to the "central management model" that was typically followed in water management • Decentralised decision making (delegation of authority and resources to low administrative levels)
Tools & data requirements	-
Organisational structure (jurisdictions, human resources)	• Clear definition of roles among the authorities that are involved in water management
Financial issues	-
Other issues	• Use a bottom-up approach with community participation, both in decision making and implementation • Strengthen scientific & policy networks for technical & management cooperation

3.2 Jucar River Basin, Spain

The strategies for reducing drought vulnerability at the Jucar river basin are developed on the basis of the long- and medium-term planning and management plans developed by the Jucar river basin agency in participative collaboration with the different stakeholder groups in the basin. Along the years, the hydrological planning has been oriented to reducing the vulnerability of the different exploitation systems to drought by maximizing the reliability of water supply to demands and maintaining the water quality in water bodies. The measures adopted or discussed belong to two different categories: structural and non-structural measures. The first category includes mainly public works that affect the physical environment of the basin. The second category involves mainly managerial and operational measures. The recently approved Jucar River Basin Hydrologic Plan for the period 2009-2014 (MAGRAMA, 2014a) and the proposed Plan for the 2015-2021 period (MAGRAMA, 2014b), currently under public information, list all the measures addressed to meet the objectives drafted in the European Water Framework Directive (EC, 2000) and the National Hydrologic Plan (BOE, 2001). Despite the fact that all the measures play an important role, the following are the ones with a more direct relation to drought vulnerability reduction (Table 3.6 to Table 3.13):

1. Development (or revision) of drought management plans;
2. Improvement of water supply infrastructures for the city of Valencia (urban demand) and its metropolitan area;
3. Modernization of irrigation schemes;
4. Improvement of the conjunctive use of surface and groundwater;
5. Increase of unconventional water resources (desalination and reuse);
6. Placement of centers for water rights purchase and exchange;
7. Improvement of reservoirs operation rules;
8. Research and knowledge enhancement to reduce uncertainty; and
9. Improvement of the monitoring networks.

Table 3.6: *Guiding principles for developing (or revising) drought management plans in Jucar River Basin, Spain.*

Development (or revision) of drought management plans	
Vulnerability component addressed	• Water resources (quantity and quality) • Social factors • Policy-related
Constraints to overcome for its implementation	-
Tools & data requirements	• Results from the previous drought and lessons learnt (post-analysis) • Likelihood of future droughts and their severity (monitoring)
Organisational structure (jurisdictions, human resources)	• Clear definition of roles among the authorities and stakeholders that are involved in water management
Financial issues	• Funds for the cost of subcontracting or hiring new personal to carry out the different tasks
Other issues	• Refinement of the existing indicators system and scenario thresholds • Definition of new measures • Components of the Permanent Drought Commission

Table 3.7: *Guiding principles for improving water supply infrastructures in Jucar River Basin, Spain.*

Improvement of water supply infrastructures	
Vulnerability component addressed	• Water resources (quantity and quality) • Social factors
Constraints to overcome for its implementation	• Uncertainty on possible reductions of water quantity under climate change • Risk of effects on quality as open channel exist in most parts of the supply system
Tools & data requirements	• Quantity and quality control of water from Jucar and Turia Rivers • Decision support on when to use water from one source or the other
Organisational structure (jurisdictions, human resources)	• CHJ provides water assignations • The Drinking Water Supply company treats water and distributes it
Financial issues	• Budgetary limits due to on-going financial crisis
Other issues	-

Table 3.8: *Guiding principles for the modernization of irrigation schemes in Jucar River Basin, Spain.*

Modernization of irrigation schemes	
Vulnerability component addressed	• Water resources (quantity)
Constraints to overcome for its implementation	• Old habits of irrigators • Ownership of infrastructures • Vandalism costs associated to more machinery unprotected in the fields
Tools & data requirements	• Plants water consumption/needs • Crops patters
Organisational structure (jurisdictions, human resources)	• CHJ sets the needs for modernization/supervision of work • Government provides funds for irrigation districts • Districts add own funds and carry out the modernization works
Financial issues	• Current economic crisis has reduced the amount of funding provided • Share and recovery of costs
Other issues	-

Table 3.9: *Guiding principles for improving the conjunctive use of surface and groundwater in Jucar River Basin, Spain.*

Improvement of the conjunctive use of surface and groundwater	
Vulnerability component addressed	• Water resources (quantity) • Policy-related
Constraints to overcome for its implementation	• Final ownership of new infrastructures • Vandalism • Water quality of groundwater (irrigation origin pollutants)
Tools & data requirements	• Aquifers definition ((boundaries, usable volume, maximum extraction rates, etc.) • Operation rules for pumping • Inventory of existing and operating pumping facilities
Organisational structure (jurisdictions, human resources)	• In alert and emergency situations, farmers in the lower Jucar Basin give up their surface water assignation for use by urban demands; they use instead groundwater. Urban demands pay for the additional cost of pumping.
Financial issues	• Financial crisis • Share and recovery of costs
Other issues	-

Table 3.10: *Guiding principles for increasing the use of unconventional water resources in Jucar River Basin, Spain.*

Increase of unconventional water resources	
Vulnerability component addressed	• Water resources (quantity) • Policy-related
Constraints to overcome for its implementation	• Acceptance of reused water by end users • Pumping costs of bringing back water to the head of the system
Tools & data requirements	• Quality requirements for the reused water • Amount of recoverable water • Recirculation infrastructures
Organisational structure (jurisdictions, human resources)	• CHJ • Waste water Treatment Company • Farmers
Financial issues	• Share and recovery of costs
Other issues	-

Table 3.11: *Guiding principles for placement of centers for water rights purchase and exchange in Jucar River Basin, Spain.*

Placement of centers for water rights purchase and exchange	
Vulnerability component addressed	• Water resources (quantity and quality) • Social factors • Policy-related
Constraints to overcome for its implementation	• Old established water rights and priorities • Resistance to change of farmers mainly • Difficult to control that once the water has been purchased its original owner does not longer make use of it
Tools & data requirements	• Vigilance of comply with the purchase agreements • Amount of water needed to be purchased • Affection of the different users to the needs/price of purchase
Organisational structure (jurisdictions, human resources)	• CHJ creates and organizes the rights purchase calls
Financial issues	• Rights purchase requires money that is not currently available due to economic crisis
Other issues	-

Table 3.12: *Guiding principles for improving of reservoirs operation rules in Jucar River Basin, Spain.*

Improvement of reservoirs operation rules	
Vulnerability component addressed	• Water resources (quantity and quality) • Social factors • Policy-related
Constraints to overcome for its implementation	• Old established water rights and priorities • Resistance to change of older water rights holders • Compliance of environmental flows • Climate change
Tools & data requirements	• Water resources management models • Negotiation and public participation • Streamflow forecasting
Organisational structure (jurisdictions, human resources)	• CHJ (reservoir withdrawal committees)
Financial issues	-
Other issues	-

Table 3.13: *Guiding principles for research and knowledge enhancement to reduce uncertainty& improve monitoring networks in Jucar River Basin, Spain.*

Research and knowledge enhancement to reduce uncertainty & Improvement of the monitoring networks	
Vulnerability component addressed	• Social factors • Policy-related
Constraints to overcome for its implementation	-
Tools & data requirements	• Data monitoring • Modeling • Remote sensing networks • Measurements on site
Organisational structure (jurisdictions, human resources)	• CHJ • Engineering firms • National weather agency
Financial issues	• Budgetary limits for subcontracting
Other issues	-

3.3 Po River Basin, Italy

Taking the outcomes from the analysis of the data collected, the research analyses realized, and the input and recommendations from the CSDFs into account, a medium and long-term strategy for coping with droughts in the Po river basin could be based on some policy options regarding supply management, demand management, and monitoring / forecasting activities. The measures are especially focused on agriculture, the most relevant and affected by drought sector in the Po basin (Table 3.14 to Table 3.19):

- Improvement of the efficiency and productivity of the irrigation network;
- Development of groundwater storage;
- Strengthening controls on illegal withdrawals and wells;
- Introducing water consumption measurement systems / technologies;
- Modifying water concession system;
- Improving monitoring and forecasting systems.

Table 3.14: *Guiding principles for improving the efficiency and productivity of the irrigation network in Po River Basin, Italy.*

Improvement of the efficiency and productivity of the irrigation network	
Vulnerability component addressed	• Technology / economic (Adaptive capacity)
Constraints to overcome for its implementation	• Limited availability of public and private funds • Limited willingness to invest in technological upgrade of the irrigation network, in particular in some areas (e.g. Lombardy), due to the high water availability
Tools & data requirements	• Identification, mapping and analysis of the irrigation schemes, of their extension, of their technological characteristics, etc. • Technical and economic evaluation of the needs for new investments
Organisational structure (jurisdictions, human resources)	• Joint action of the Po river basin Authority, the regional governments of Lombardy, Piedmont and Emilia-Romagna, the central government (Ministry of Agriculture Food and Forestry Policies), the farmers associations, the drainage and irrigation consortia, the research institutions
Financial issues	• Limited funds availability for improving the efficiency and productivity of the irrigation network, etc.
Other issues	-

Table 3.15: *Guiding principles for developing groundwater storage in Po River Basin, Italy.*

Development of groundwater storage	
Vulnerability component addressed	• Water resources (sensitivity)
Constraints to overcome for its implementation	• Limited knowledge and research on groundwater status • Limited awareness of the potential capacity of groundwater reserves at institutional and political level, mostly due to the lack of willingness to plan in the long and medium term • High fragmentation of competences among institutions regarding water policy
Tools & data requirements	• Monitoring of groundwater status (quality & quantity) • Assessment of groundwater availability & storage capacity (modelling)
Organisational structure (jurisdictions, human resources)	• Identification of the institutions / bodies responsible for managing and carrying out researches and studies, and monitoring & reporting on groundwater status
Financial issues	• Funds for studying and realizing researches on groundwater status
Other issues	-

Table 3.16: *Guiding principles for strengthening controls on illegal withdrawals and wells in Po River Basin, Italy.*

Strengthen of controls on illegal withdrawals and wells	
Vulnerability component addressed	• Social-related factors (adaptive capacity)
Constraints to overcome for its implementation	• Limited knowledge and awareness at institutional and political level of the relevance of this phenomenon • Limited availability of public funds in order to strengthen the role and the action of the competent institutions (ex. AIPO - Interregional Agency for the Po River) • High tendency to illegal withdrawal and to hide the actual consumptions by water users
Tools & data requirements	• Capacity of surveying, monitoring, and mapping legal and illegal withdrawals and wells, and building a database
Organisational structure (jurisdictions, human resources)	• Strengthening of the action and the staff ("polizia idraulica") of AIPO (Interregional Agency for the Po River)
Financial issues	-
Other issues	-

Table 3.17: *Guiding principles for introducing water consumption measurement systems / technologies in Po River Basin, Italy.*

Introduction of water consumption measurement systems / technologies	
Vulnerability component addressed	• Social-related factors (adaptive capacity) • Policy-related factors (adaptive capacity)
Constraints to overcome for its implementation	• Limited availability of public and private funds for buying and installing measuring systems / devices • Scarce attitude by water users to accept and to cooperate in order to introduce and install these technologies
Tools & data requirements	• Measuring technologies • Information, monitoring and reporting system
Organisational structure (jurisdictions, human resources)	• Joint action of the Po river basin Authority, the regional governments of Lombardy, Piedmont and Emilia-Romagna, the central government (Ministry of Agriculture Food and Forestry Policies), the farmers associations, the drainage and irrigation consortia, the research institutions
Financial issues	• Public and private funds for buying and installing measuring systems / devices
Other issues	-

Table 3.18: *Guiding principles for modifying water concession system in Po River Basin, Italy.*

Modification of the water concession system	
Vulnerability component addressed	• Policy-related (adaptive capacity)
Constraints to overcome for its implementation	• Social and "legal" impediments, related to the fact that the permits to withdraw water are largely based on "ancient rights", which set reduced rates for several uses, including agriculture • High fragmentation of competences among institutions as regards water policy
Tools & data requirements	• Capacity of surveying and mapping all rights to withdraw water, in order to eventually plan, design and implement all changes and modifications
Organisational structure (jurisdictions, human resources)	• Joint action of the Po river basin Authority, the regional governments of Lombardy, Piedmont and Emilia-Romagna, the central government (Ministry of Agriculture Food and Forestry Policies), the farmers associations, the drainage and irrigation consortia, the research institutions • Experts in legal affairs
Financial issues	• No financial obstacles
Other issues	-

Table 3.19: *Guiding principles for improving monitoring and forecasting systems in Po River Basin, Italy.*

Improvement of monitoring and forecasting systems	
Vulnerability component addressed	• Policy-related (adaptive capacity)
Constraints to overcome for its implementation	• Access and collection of relevant data • Limited willingness to cooperate and exchange information among competent authorities and bodies
Tools & data requirements	• Formal agreement among authorities and bodies in order to exchange information and data • Creation of a database where to store and classify data (e.g. precipitation, groundwater levels, water production from desalination plants) • Tools for calculating / estimating the indicators / indices • Open access website for disseminating drought monitoring information
Organisational structure (jurisdictions, human resources)	• Body competent for collecting the information provided by the monitoring system • Experts in key fields of knowledge (hydrology, climatology, etc.) and statistical data analysts in order to build and upgrade the database, and to carry out analyses and calculate indicators / indices
Financial issues	• Funds for covering the cost for developing & maintaining the website, and operating the monitoring network
Other issues	-

3.4 Portugal

Drought in Portugal has been managed as a crisis event. Nevertheless a proactive approach based on drought preparedness and long-term risk reduction has received increasing attention, in particular after the 2005 drought and for southern Portugal. Namely, for this region, a drought risk reduction plan was delineated, while water stress mitigation measures, particularly for agriculture were evaluated.

Several national programs attest the need for an action plan to combat drought and list adaptation measures focusing on increasing water reservoir capacity and improvements in water use efficiency (PCM, 2005; MAMAOT, 2013a; MAMAOT, 2013b). The action plan to enhance drought preparedness relies on improvements in the current systems to monitor meteorological and hydrological droughts. Most of the measures to be included in the plan are administrative and institutional (e.g. regulating financial support to agriculture), but in line with the needs discussed among DROUGHT-R&SPI stakeholders within the project.

The quantification of impacts and the measures taken to overcome the last drought events (2003-2005, 2012) were mainly oriented to agricultural and urban supply sectors. As such, the traditional and widespread response to drought events involves the construction of new water reservoirs and the improvement of the current ones, usual highly demanding in both economic and environmental terms.

Implementing conservation measures to increase water supply needs to be addressed in a long-term strategy to deal with droughts in Portugal, particularly in water scarce regions. This strategy needs also to take in consideration specific environmentally oriented measures, promoting best farming practices and clean technologies within water-saving and water-efficiency programmes. Furthermore, the potential for drought mitigation of policies currently fomented by European Commission to protect and preserve "green and blue infrastructures" (EC, 2012; EC, 2013), should be evaluated and explored, at least in a water conservation framework strategy.

Given the above, the following actions (Table 3.20 to Table 3.22), by resuming most of the options discussed by the DROUGHT-R&SPI stakeholders panel, were selected to integrate in the Portuguese long-term strategy for drought mitigation:

1. Improvement of water-saving, including reuse of industrial waste waters, as well as reuse of treated wastewater for irrigation.
2. Improvement of water-efficiency programmes including: (i) water leaks reduction in urban distribution systems, and (ii) more efficient use of water in agriculture (e.g. through new farming practices, crop changes).
3. Implementation of a national investment plan to build Green and Blue Infrastructures taking advantage of investment priorities settled for programmes using European Cohesion Fund and European Regional Development Fund.

Table 3.20: *Guiding principles for improving water-saving programmes in Portugal.*

Improvement of water-saving programmes	
Vulnerability component addressed	• Technology/ economic (adaptive capacity) • Water resources (sensitivity) • Policy-related (adaptive capacity)
Constraints to overcome for its implementation	• Acceptance of wastewater reuse • Linking existing wastewater treatment plant to the distribution network
Tools & data requirements	• Estimation of the available wastewater quality & quantity • Estimation for distribution methods of water to reuse (types & quantity) • Assessment of health risk and effects on groundwater quality reusing treated wastewater in agriculture
Organisational structure (jurisdictions, human resources)	• Ministry of Environment, of Industry and of Agriculture • General Directorate of Agriculture and Rural Development; Portugal Water Institution; Portuguese Federation of Irrigation Farmers
Financial issues	• Transportation costs of treated wastewater
Other issues	-

Table 3.21: *Guiding principles for improving water-efficiency programs in Portugal.*

Improvement of water-efficiency programmes	
Vulnerability component addressed	• Technology/ economic (adaptive capacity) • Policy-related (adaptive capacity) • Water resources (sensitivity) • Water scarcity (exposure)
Constraints to overcome for its implementation	• Costs for devices installation • Cost for extraordinary maintenance of distribution networks • Local knowhow for efficient use of the new technologies an practices
Tools & data requirements	• Estimation of the cost/benefit balance for a more efficient water use in agriculture • Estimation of economic losses for leaks in urban supply networks • Health risk analysis • Guidance support for dissemination of new farming techniques
Organisational structure (jurisdictions, human resources)	• Regulatory Entity for Water and Waste services • Portuguese Federation of Irrigation Farmers
Financial issues	• Funds availability, support programmes
Other issues	

Table 3.22: *Guiding principles for Investment plan for Green and Blue Infrastructures in Portugal.*

Investment plan for Green and Blue Infrastructures	
Vulnerability component addressed	• Policy-related (adaptive capacity) • Water resources (sensitivity) • Water scarcity (exposure)
Constraints to overcome for its implementation	• Civil engineering approaches to hydraulic issues • Lack of environmental sensitivity in public bodies
Tools & data requirements	• Soil bioengineering and Forest engineering
Organisational structure (jurisdictions, human resources)	• General Directorates of Agriculture and Environment involved in European funds management • River Basin Authorities
Financial issues	• Application of funds priorities established within the EU COM 2013-249
Other issues	

3.5 Switzerland

Switzerland's drought policy adopts a sector-specific approach which identifies sectors that are vulnerable, have impact on water availability and supply, and this approach aims at triggering short-term and long-term adaptation and changes. An important constraint to drought policies is that drought risk is not very high yet. Hence, it is difficult to convince stakeholders, politicians, administration, and the public to substantially improve preparedness.

Particularly for agriculture, so far, droughts in most regions are not yet common enough to incite farmers to take prevention measures. Also, even in case of droughts, wide water shortages are improbable in case there is sufficient infrastructure such as reservoirs, tubes, irrigation systems. Yet, investment costs are high, opposition against may come up (e.g. nature conservation, landscape protection), and

unnecessary overuse of water may take place without measures. Also, uncoordinated investments have to be avoided through better political coordination. As an inexpensive measure, adaptation in agricultural practice and economic use of water, for instance via quota, has to be strengthened.

The following options are proposed regarding farming:

- Improve education of farmers;
- Develop and inform about possibilities to adapt agricultural practice;
- Develop and introduce methods for economical use of water (e.g. Quota);
- Coordinate investments in built infrastructure (reservoirs etc.);
- Improve exchange and learn from Swiss regions experienced with drought management.

Table 3.23: *Guiding principles for improving drought preparedness of agriculture in Switzerland.*

Improving drought preparedness of agriculture	
Vulnerability component addressed	• Harvest and other impediments (sensitivity) • Unadapted practices in case of droughts (exposure)
Constraints to overcome for its implementation	• Motivate stakeholder (farmers and agricultural schools) although drought is not pressing • Improve coordination of federal and cantonal offices of agriculture, environment (natural hazards)
Tools & data requirements	• Improve early information and soil moisture measurements • Infrastructure for water exchange and irrigation
Organisational structure (jurisdictions, human resources)	• Set up infrastructure (channels, irrigation) in coordinated manner and develop agricultural practice (federal and cantonal administration)
Financial issues	• Payment and financial support of early information system
Other issues	-

3.6 The Netherlands

The long-term strategy to deal with future droughts in The Netherlands is in development, a.o. through the Delta programme. Although there is no need for major interventions in the main water system until 2050, options for the future are open and need to be considered. The main activities currently undertaken include the establishment of service levels: government and users jointly specify, in the form of region-specific agreements, which responsibilities and obligations the government has and what is the responsibilities and remaining risk of the users (for in as far as relevant, surface and groundwater as well as quality and quantity).

The work on the “service levels” (Table 3.24) is important in dealing with future vulnerability: the current strategy, i.e. trying to answer all water demands, in not tenable. A new strategy is in development: solving bottlenecks and seizing opportunities. The central government, the regions and the users have jointly agreed goals (fresh water for quality of life and the economy): (i) Protecting water use that is societally crucial; (ii) Enhancing the export position of the country; (iii) Striving for a healthy and balanced water system; (iv) Stimulation of water knowledge and water innovation.

Table 3.24: *Guiding principles for establishing 'service levels' in The Netherlands.*

	Establishment of service levels
Vulnerability component addressed	• Water resources (levels users can expect to be delivered) in 'normal' as well as in drought conditions
Constraints to overcome for its implementation	• Need for a paradigm shift: from what the user needs towards what the user can do and is willing to do • Overall, there is not a real sense of urgency for drought as a policy or water management issue
Tools & data requirements	• Water Resources Models (National Hydrologic Instrumentary) and negotiations with users • Plan of approach: o Define boundary conditions (start simple, refine on the way) o Define users (individual, organised, etc.) and governance o Define the level of detail (which information is important for the 'users' e.g. in terms of quality?) o Define the methodology (base info, models, time series, etc.) o Process (how to ensure that what is being done is really acceptable for the regions) o Risk management (will the process lead to the required outcome)
Organisational structure (jurisdictions, human resources)	• Rijkswaterstaat (the part of the Ministry of Infrastructure and Environment responsible for managing the Main Water System of The Netherlands) will, in the next three to five years and together with all 'water users', quantify the service levels for the Main Water System and will then be able to present the agreed water supply in terms of when, where and with which frequency. • Government and users are responsible together: there is a joint commitment to solve bottlenecks and reach the goals: (i) Central government, provinces and Water Boards define their responsibilities and tasks; (ii) Users know what they can count on and this transparency leaves them with choices: deal with the drought through investments, innovation, or acceptance. • International consultations are becoming more important: (i) Cooperation with neighbour countries will be enhanced; (ii) EU Blueprint suggestions may be accepted (including e.g. water accounting, water saving measures, ecological flow, cost of water). • Various regions are working towards stimulating users to achieve self-sufficiency. Pilots are offered and implemented. Besides striving for self-sufficiency, water saving and innovation are also key.
Financial issues	• Budget and planning (i.e. budget, capacity to be made available and phasing) for establishing the service levels needs to be kept over the years (national budget, out of the Delta Programme). • The outcome of establishment of the 'service levels' will give rise to the investments needed by water authorities (both national and regional) as well as the users and user groups! The responsibilities and boundaries of what can be expected as water supply and which are the conditions in which the users are on their own are clear then. • The short-term investment programme (2015-2028) is mainly focused on solving actual bottlenecks and implementation of "no-regret" measures that will make the system more flexible and more robust for extremes • The investments for the Implementation sub-Programme Fresh Water 2015-2028 (in which the main drought-related issues are dealt with) are estimated at € 1.5-2 B, with the government part about € 550 M. The fund for the implementation of all 9 sub-Programmes of the Delta-plan for that period is € 16 B (which equals about € 1 B annually).
Other issues	• Communication: o How to reach target groups?; prevent information overload and taking too much time from co-operators; create a sense of urgency with the stakeholders; o There are two reasons for inviting parties: for content and for governance;

	o The communication plan is interrelated with the interaction plan (i.e. the implementation plan is part of the communication plan).

4 Synthesis of outcomes - Conclusive remarks

The drought-related analyses in the DROUGHT-R&SPI Case Studies verified that droughts are local both in terms of hazard (severity, duration, frequency) and impacts and coping capacity, depending on the level of preparedness and management structures. Therefore, there cannot be a single strategy for drought risk reduction, as countries differ in institutional structure and legal framework and even regions in a country have different socio-economic characteristics and adaptation capacity.

At the policy perspective, there are specific actions that should be promoted and enhanced in every region: (i) monitoring & early warning, (ii) development of drought management plans, (iii) development of strategic reserves, and (iv) establishment of participation processes. As far as concerns monitoring, the aim is different depending on the scale. At the national (or even EU) level, monitoring can be hazard-related to activate drought decrees, while at the regional/local level impact-related in order to activate measures. Drought management plans shall be developed on the basis of detailed vulnerability and risk assessments, at different scales, to conclude with measures to improve preparedness and reduce the need for relief/recovery. Strategic water reserves can increase long-term water security; however their development requires for the establishment of control mechanisms and incentives for reserving water. Finally, it is important to establish clear procedures for stakeholder involvement in drought planning and management. This entails activities such as: clear definition of jurisdictions and roles, establishment of processes for data/information sharing, ensuring transparency in decision making, education and awareness, and enhancing the sense of ownership of agreements and actions.

On the other hand, drought impact mitigation calls for local-specific actions, as also highlighted by Campling et al. (2008): "*Due to the overriding importance of local factors there is a need to find local solutions to local problems*". Local knowledge, needs and coping capacity are critical premises for preparing a drought management strategy. This is reflected in the strategy-related options that have been proposed in the DROUGHT-R&SPI Case Studies for future drought risk reduction (Table 4.1). The common proposed options are: (i) Establishment of (tradable) water right systems, (ii) Monitoring, (iii) Groundwater storage as a strategic reserve, (iv) Improvement of efficiency of irrigation in agriculture, and (v) Wastewater reuse.

Finally, it should be noted that as a region's exposure and vulnerability to drought may change in time, the selection of actions and measures should be a continuous activity, always in line with the wider national policy framework (e.g. on water, land use, agriculture, environmental protection).

Table 4.1: *Strategy-related options proposed in the DROUGHT-R&SPI Case Studies (similar options highlighted in bold).*

Case Study	Policy & governance	Risk identification & early warning	Mitigation & preparedness	Awareness & education
Syros island	• Establishment of formal participatory decision making processes.	• **Establishment of an integrated water monitoring network and processes for reporting.**	• **Assessment of wastewater reuse potential in the island**. • **Development of groundwater reserves.**	• Improvement of drought-risk awareness of local authorities and people.
Jucar River Basin	• Development (or revision) of drought management plans. • **Placement of centers for water rights purchase and exchange.**	• **Improvement of the monitoring networks.**	• Improvement of water supply infrastructures for the city of Valencia (urban demand) and its metropolitan area. • **Modernization of irrigation schemes.** • Improvement of the conjunctive use of surface and groundwater. • Increase of unconventional water resources (desalination and reuse). • Improvement of reservoirs operation rules.	• Research and knowledge enhancement to reduce uncertainty.
Po River Basin	• Strengthening controls on illegal withdrawals and wells. • **Modifying water concession system.**	• Introducing water consumption measurement systems / technologies. • **Improving monitoring and forecasting systems.**	• **Improvement of the efficiency and productivity of the irrigation network.** • **Development of groundwater storage**.	
Portugal	• Implementation of a national investment plan to build Green and Blue Infrastructures taking advantage of investment priorities settled for programmes using European Cohesion Fund & European Regional Development Fund.		• **Improvement of water-saving including reuse of industrial waste waters, as well as reuse of treated wastewater for irrigation.** • Improvement of water-efficiency programmes including (i) water leaks reduction in urban distribution systems; and (ii) more efficient use of water in agriculture.	
Switzerland	• Coordination of investments in built infrastructure (reservoirs etc.).	• Development and financing of a prototype of early information system.	• Development and information about possibilities to adapt agricultural practice.	• Improvement of education of farmers.

Case Study	Policy & governance	Risk identification & early warning	Mitigation & preparedness	Awareness & education
	• Development and introduction of methods for economical use of water (e.g. Quota).			• Improvement of exchange and learning from Swiss regions experienced with drought management.
The Netherlands	• Establishing 'service levels'.			

5 References

Adger, W.N., Kelly, P.M., (1999): Social Vulnerability to Climate Change and the Architecture of Entitlements. Mitigation and Adaptation Strategies for Global Change 4, 253–266.

Adger, W. N., Arnell, N. W., and Tompkins, E. L. (2005): Successful adaptation to climate change across scales. *Global environmental change*, **15**(2), 77-86.

Adger, W.N. (2006): Vulnerability. Global Environmental Change 16 (3), 268–281.

Alderlieste, M.A.A., van Lanen, H. (2013a): Trends in low flow and drought in selected European areas derived from WATCH GCM Forcing Data and simulated multi-model mean run off. DROUGHT-R&SPI Technical Report No 1. Available online at http://www.eu-drought.org/technicalreports

Alderlieste, M.A.A., van Lanen, H. (2013b): Change in future low flow and drought in selected European areas derived from WATCH GCM Forcing Data and simulated multi-model run off. DROUGHT-R&SPI Technical Report No 5. Available online at http://www.eu-drought.org/technicalreports

Assimacopoulos D., Kampragou E., Andreu, J., Bifulco, C., de Carli, A., De Stefano, L., Dias, S., Kartalidis, A., Massarutto, A., Monteagudo, D., Musolino, D., Paredes-Arquiola, J., Rego, F., Seidl, I., Solera, A., Urquijo Reguera, J., Wolters, W., (2015): Drought risk mitigation options – case study scale. DROUGHT-R&SPI Technical Report. Available online at http://www.eu-drought.org/technicalreports

Assimacopoulos, D., Kampragou, E., Andreu, J., Bifulco, C., de Carli, A., De Stefano, L., Dias, S., Gudmundsson, L., Haro-Monteagudo, D., Musolino, D., Paredes-Arquiola, J., Rego, F., Seidl, I., Solera, A., Urquijo, J., van Lanen, H., Wolters, W. (2014): Future drought impact and vulnerability - case study scale. DROUGHT-R&SPI Technical Report No 20. Available online at http://www.eu-drought.org/technicalreports

Birkmann, J. (2007): Risk and vulnerability indicators at different scales: applicability, usefulness and policy implications. *Environmental Hazards*, **7**(1), 20-31.

BOE (2001): Ley 10/2001, de 5 de Julio, del Plan Hidrológico Nacional. 23pp (in Spanish).

Bokal, S., Grobicki, A., Kindler, J., Thalmeinerova, D. (2014): From national to regional plans – the Integrated Drought Management Programme of the Global Water Partnership for Central and Eastern Europe. *Weather and Climate Extremes,* **3**, 37–46.

Campling, P., De Nocker, L., Schiettecatte, W., Iacovides, A.I., Dworak, T., Kampa, E., Álvarez Arenas, M., Cuevas Pozo, C., Le Mat, O., Mattheiß V., Kervarec, F. (2008): Assessment of alternative water supply options. Study undertaken for the European Commission – DG Environment. Available online at: http://ec.europa.eu/environment/water/quantity/pdf/Summary%20Report_extended%20version.pdf.

Cutter, S.L., Emrich, C.T., Webb, J.J., Morath, D. (2009): Social Vulnerability to Climate Variability Hazards: A Review of the Literature. University of South Carolina, Hazards and Vulnerability Research Institute, Department of Geography, Columbia.

Dalziell, E.P., McManus, S.T., (2004): Resilience, vulnerability and adaptive capacity: Implications for systems performance. International Forum for Engineering Decision Making (IFED); Switzerland. December 2004.

De Stefano, L., González Tánago, I., Ballesteros, M., Urquijo, J., Blauhut, V., Stagge, J.H, Stahl, K. (2015): Methodological approach considering different factors influencing vulnerability - pan-European scale, DROUGHT-R&SPI Technical Report. Available online at http://www.eu-drought.org/technicalreports

De Stefano, L., Urquijo Reguera, J., Acácio, V., Andreu, J., Assimacopolus, D., Bifulco, C., De Carli, A., De Paoli, L., Dias, S., Gad, F., Haro Monteagudo, D., Kampragou, E., Keller, C., Lekkas, D., Manoli, E., Massarutto, A., Miguel Ayala, L., Musolino, D., Paredes Arquiola, J., Rego, F., Seidl, I., Senn, L., Solera Solera, A., Stathatou, P., Wolters, W. (2012): Policy and Drought Responses – Case Study

scale. DROUGHT-R&SPI Technical Report No 4. Available online at http://www.eu-drought.org/technicalreports

EC (2013): Green Infrastructure (GI) — Enhancing Europe's Natural Capital. EU Commission Communication. Brussels, COM(2013) 249 final, 6.5.2013.

EC (2012): A Blueprint to Safeguard Europe's Water Resources. EU Commission Communication. Brussels, COM(2012) 673 final, 14.11.2012.

EC (2007): Mediterranean Water Scarcity and Drought Report. Technical report 009-2007 on water scarcity and drought management in the Mediterranean and the Water Framework Directive prepared by the MED WS&D WG. Available online at http://www.emwis.net/topics/WaterScarcity/PDF/MedWSD_FINAL_Edition

EC (2000): Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. Available online at: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32000L0060

Fekete, A., Damm, M., Birkmann, J. (2010): Scales as a challenge for vulnerability assessment. *Natural Hazards*, **55**(3), 729-747.

Fontaine, M.M., Steinemann A.C., (2009): Assessing Vulnerability to Natural Hazards: Impact-Based Method and Application to Drought in Washington State. *Natural Hazard Review*, 11-18.

Füssel, H.M. (2010): Review and Quantitative Analysis of Indices of Climate Change Exposure, Adaptive Capacity, Sensitivity, and Impacts. https://openknowledge.worldbank.org/handle/10986/9193.

Fussel, H.M. (2007): Vulnerability: A generally applicable conceptual framework for climate change research. *Global Environmental Change*, **17**, 155–167.

Füssel, H. M., Klein, R. J. (2006): Climate change vulnerability assessments: an evolution of conceptual thinking. *Climatic Change*, **75**(3), 301-329.

Gallopín G.C. (2006): Linkages between vulnerability, resilience, and adaptive capacity. *Global Environmental Change*, **16**, 293-303.

Gonzalez Tanago, I., Ballesteros, M., Urquijo, J., De Stefano, L. (2014): Pan-European maps of drought vulnerability factors. 3rd Pan-EU Drought Dialogue Forum, 4 November 2014, Brussels, Belgium.

Greiving, S. et al. (2010): Revised Interim Report. ESPON CLIMATE - Climate Change and Territorial Effects on Regions and Local Economies, Applied Research Project 2013/1/4.

ISDR (2003): Drought-Living with risk: An integrated approach to reducing societal vulnerability to drought. ISDR Ad Hoc Discussion Group on Drought, United Nations International Strategy for Disaster Reduction, Geneva, Switzerland, Available online at http://www.unisdr.org/2005/task-force/tf-meetigns/7th%20TF%20mtg/tmp/Drought_information_report.pdf

IPCC (2012): Glossary of terms. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 555-564.

IPCC (2007): Climate Change 2007: Synthesis Report, Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Core Writing Team, Pachauri, R.K. and Reisinger, A. (Eds.), IPCC, Geneva, Switzerland. pp 104.

Karavitis, C. (2012): Drought vulnerability assessment: Introduction and theoretical background. In Drought Management Centre for South-East Europe – DMCSEE Summary of the result of the project, co-financed by the South East Europe Transnational Cooperation Programme (contract no. SEE /A/091/2.2/X), Ed. Gregor Gregorič, Slovenian Environmental Agency. Available at: http://www.met.hu/doc/DMCSEE/DMCSEE_final_publication.pdf

Kasperson, J.X., Kasperson, R.E., Turner II., B.L., Schiller, A., Hsiel, W.- H. (2005): Vulnerability to global environmental change. In: Kasperson, J.X., Kasperson, R.E. (Eds.), Social Contours of Risk, vol. II. Earthscan, London, pp. 245–285

Kossida, M., Kakava, A., Tekidou, A., Iglesias, A., Mimikou, M. (2012): Vulnerability to Water Scarcity and Drought in Europe. Thematic assessment for EEA Water 2012 Report, ETC/ICM Technical Report 3/2012.

Leichenko, R.M., O'Brien, K.L., (2002): The dynamics of rural vulnerability to global change: The case of Southern Africa. *Mitigation and Adaptation Strategies for Global Change*, **7**, 1–18.

Luers, A.L. (2005): The surface of vulnerability: an analytical framework for examining environmental change. *Global Environmental Change*, **15**, 214–223.

Lung, T., Lavalle, C., Hiederer R., Bouwer, L. M. (2011): Report on potential impacts of climatic change on regional development and infrastructure. RESPONSES project Deliverable D6.3. Available online at: http://www.responsesproject.eu/pdf/6.3%20RESPONSES%20project%20report.pdf .

MAGRAMA (2014a): Plan Hidrológico de Cuenca. Demarcación Hidrográfica del Júcar. 481 pp (in Spanish).

MAGRAMA (2014b): Propuesta de Proyecto de Revisión del Plan Hidrológico de Cuenca. Ciclo de Planificación 2015-2021. Demarcación Hidrográfica del Júcar. 707 pp (in Spanish).

MAMAOT (2013a): Seca 2012. Relatório de balanço. Ministério da Agricultura, do Mar, do Ambiente e do Ordenamento do Território. 132 pp (in portguese).

http://www.portugal.gov.pt/media/916024/Relatorio_Balanco_GTSeca2012_v1.pdf

MAMAOT (2013b): Estratégia de adaptação da agricultura e das florestas às alterações climáticas. Portugal Continental. Ministério da Agricultura, do Mar, do Ambiente e do Ordenamento do Território. 88 p (in portuguese)

Massarutto, A., Musolino, D., Pontoni, F., de Carli, A., Senn, L., de Paoli, L., Castro Rego, F., Dias, S., Bifulco, C., Acacio, V., Andreu, J., Assimacopoulos, D., Miguel Ayala, L., Gad, F., Haro Monteagudo, D., Kampragkou, E., Kartalides, A., Paredes, J., Solera, A., Seidl, I., Wouters W. (2013): Analysis of historic events in terms of socio-economic and environmental impacts. DROUGHT-R&SPI Technical Report No 9. Available online at http://www.eu-drought.org/technicalreports

Miller, F., Osbahr, H., Boyd, E., Thomalla, F., Bharwani, S., Ziervogel, G., Walker, B., Birkmann, J., van der Leeuw, S., Rockstrom, J., Hinkel, J., Downing, T., Folke, C., and Nelson, D. (2010): Resilience and vulnerability: Complementary or conflicting Concepts? *Ecology and Society,* **15**(3): art 11 [online], http://www.ecologyandsociety.org/vol15/iss3/art11/

PCM (Presidency of the Council of Ministers) (2005): Programa Nacional para o Uso Eficiente da Água — Bases e Linhas Orientadoras (PNUEA). Resolução do Conselho de Ministros n. 113/2005, 5 June.

Preston, B.L. (2012): Climate Change Vulnerability Assessment: From Conceptual Frameworks to Practical Heuristics. CSIRO Climate Adaptation Flagship Working paper No. 16 http://www.csiro.au/en/Organisation-Structure/Flagships/Climate-Adaptation-Flagship/CAF-working-papers.aspx

Swain, M., Swain, M. (2011): Vulnerability to Agricultural Drought in Western Orissa: A Case Study of Representative Blocks. *Agricultural Economics Research Review*, Vol. **24** January-June 2011 pp 47-56.

United Nations (2004): Living with Risk: A Global Review of Disaster Reduction Initiatives. United Nations International Strategy for Disaster Reduction, Geneva, Switzerland.

UN/ISDR (2009): UNISDR Terminology on disaster risk reduction. UNISDR, Geneva, Switzerland, May 2009.

UN/ISDR (2007): Drought Risk Reduction Framework and Practices: Contributing to the Implementation of the Hyogo Framework for Action. United Nations secretariat of the International Strategy for Disaster Reduction (UN/ISDR), Geneva, Switzerland, 98+vi pp.

van Lanen, H.A.J., Alderlieste, M.A.A, Acacio, V., Andreu, J., Garnier, E., Gudmundsson, L., Haro Monteagudo, D., Lekkas D., Paredes J., Solera A., Assimacopoulos D., Rego, F., Seneviratne, S., Stahl, K., Tallaksen L.M. (2013a): Quantitative analysis of historic droughts in selected European case study areas. DROUGHT-R&SPI Technical Report No 8. Available online at http://www.eu-drought.org/technicalreports

van Lanen, H.A.J., Alderlieste, M.A.A, van der Heijden, A., Assimacopoulos, D., Dias, S., Gudmundsson, L., Haro Monteagudo, D., Andreu, J., Bifulco, C. Gero, F., Paredes J., Solera A. (2013b): Likelihood of future drought hazards: selected European case studies. DROUGHT-R&SPI Technical Report No 11. Available online at http://www.eu-drought.org/technicalreports

Wilhelmi, O.V., Wilhite, D.A. (2002): Assessing vulnerability to agricultural drought: A Nebraska case study. *Natural Hazards*, **25**(1): 37-58.

Wilhite, D., Sivakumar, M.V.K, Pulwarty, R. (2014): Managing drought risk in a changing climate: The role of national drought policy. *Weather and Climate Extremes,* **3**: 4–13.

World Meteorological Organization (WMO) and Global Water Partnership (GWP) (2014): National Drought Management Policy Guidelines: A Template for Action (D.A. Wilhite). Integrated Drought Management Programme (IDMP) Tools and Guidelines Series 1. WMO, Geneva, Switzerland and GWP, Stockholm, Sweden.

World Meteorological Organization (WMO) and United Nations Convention to Combat Desertification (UNCCD) (2012): Policy Document: National Drought Management Policy. Available at: http://www.droughtmanagement.info/literature/WMO_HMNDP_policy_document_2012.pdf

Annex A: DROUGHT-R&SPI drought-related glossary

Term	Definition	Source
Vulnerability	The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effect of a hazard	UN/ISDR (2009)
Exposure	The nature, degree, duration and/or extent to which the system is in contact with, or subject to perturbations	Gallopín (2006), Adger (2006), Kasperson et al. (2005)
Sensitivity	The degree to which a system is affected, either adversely or beneficially, by climate variability or climate change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea level rise).	IPCC (2012)
Adaptive capacity	The combination of the strengths, attributes, and resources available to an individual, community, society, or organization that can be used to prepare for and undertake actions to reduce adverse impacts, moderate harm, or exploit beneficial opportunities.	IPCC (2007)
Drought risk	Function of the drought as a natural hazard and the vulnerability of people and/or environment to drought impacts	EC (2007)
Risk management	The systematic approach and practice of managing uncertainty to minimize potential harm and loss. It comprises risk assessment and analysis, and the implementation of strategies and specific actions to control, reduce and transfer risks.	UN/ISDR (2009)
Drought strategy	Series of actions designed to achieve the goal of drought vulnerability and risk reduction	Wilhite et al. (2014), ISDR (2003)

Annex B: Vulnerability assessment checklist

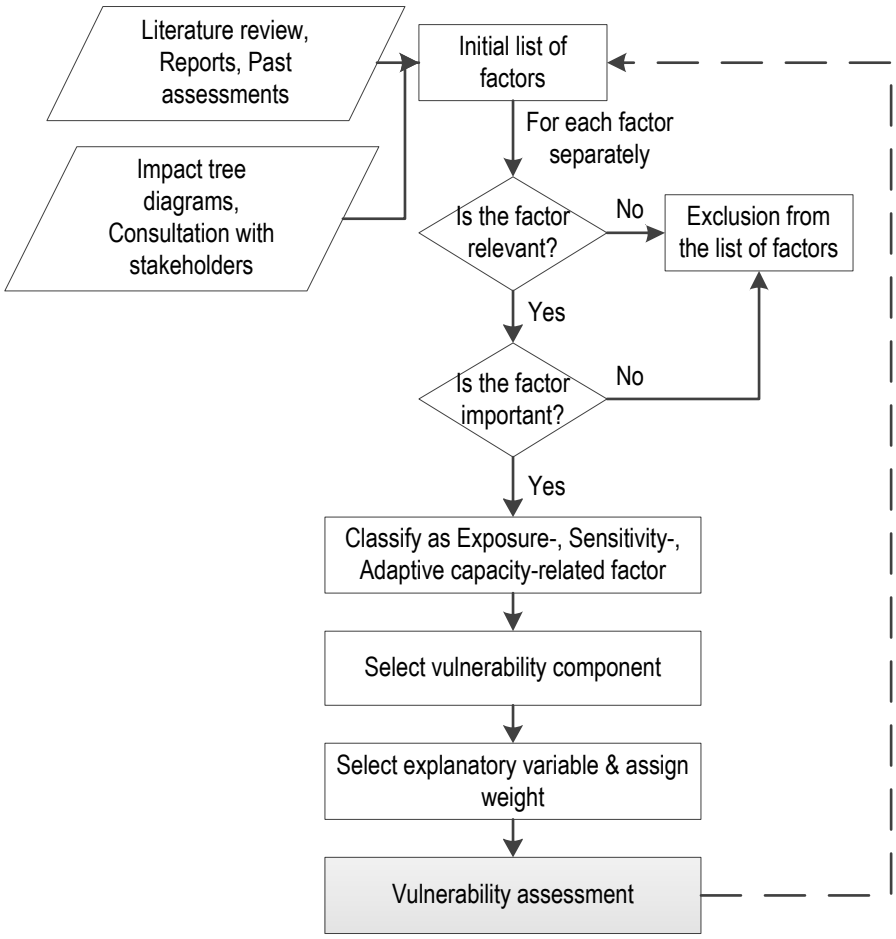


Figure B.1: *The process of selecting vulnerability factors.*

Table B.1: *Vulnerability assessment checklist.*

Vulnerability Dimension	Yes/No
Drought	
Is the region facing regularly droughts?	
Water scarcity	
Is the region facing (seasonal) water scarcity problems?	
Water resources	
Do groundwater supplies in parts of the region lack resiliency during/ after drought events?	
Are coastal aquifers been used for water supply? Has salt intrusion been a problem in the past?	
Is a significant portion of the water supply coming from snowmelt?	
Have been water resources reserved for use in cases of emergency?	
Is there a significant portion of water coming from another region (imports)?	
Environment	
Are there water dependent ecosystems?	
Does the region dependent on water bodies with current or recurrent water quality issues?	
Are increased wildfires a threat in the region?	
Urban sector	
Will there be a lot of people affected by a water supply reduction in case of drought?	
Has the region faced a drought in the past during which it failed to meet water demand?	
Are there significant seasonal variations in water demand (e.g. during summer)?	
Agriculture	
Are there efficient irrigation systems in use?	
Are crops grown in the region drought-sensitive?	
Has the region faced a drought in the past during which it failed to meet water demand?	
Energy production	
Is hydropower a major energy production sector in the region?	
Are existing hydropower production facilities able to cope with reduced water flows?	
Other sectors	
Are there any other sectors affected by drought in the region?	
Social	
Are people aware of drought risks, before or during drought episodes?	
Are people willing to change water use habits / activities in case of drought?	
Are water use conflicts in the region?	
Policy-related	
Are there contingency plans?	
Is there a monitoring & early warning system in operation?	
Are the water use priorities in case of drought been defined?	
If yes, will there be significant impacts on sectors with lower priorities?	
Are the roles and responsibilities of key actors been identified?	
Is the capacity of all involved agencies able to support drought management?	
Technology/ economic	
Is it (economically/ technically) feasibly to invest in water saving/efficient technology?	
Are there alternative water resources available for use in case of drought? Are there accessible?	

Annex C: Drought proneness of EU-27 regions

C.1: Outcomes from the FP7 DROUGHT-R&SPI project (De Stefano et al., 2015)

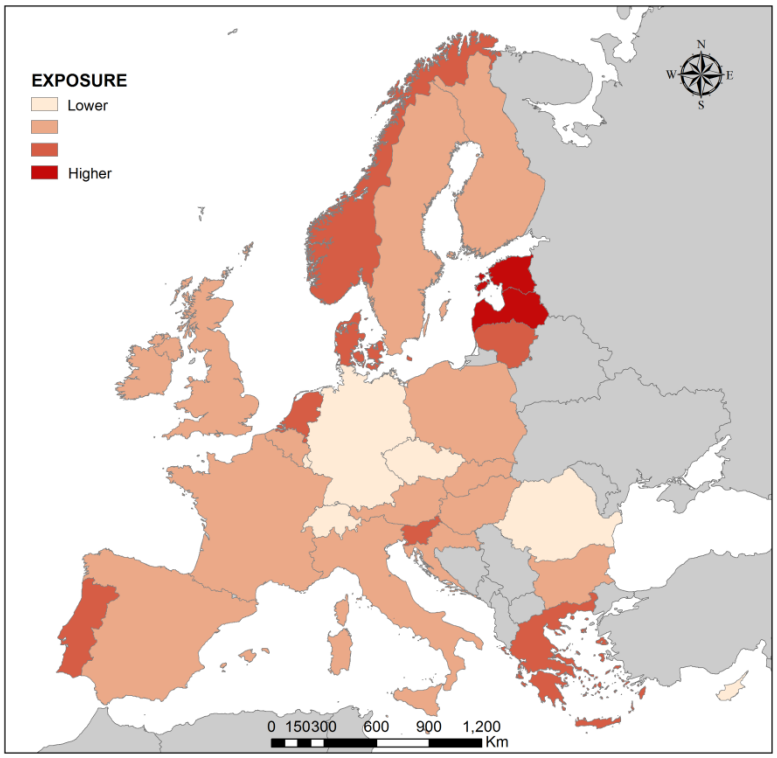


Figure C.1: *Exposure to drought (De Stefano et al., 2015).*

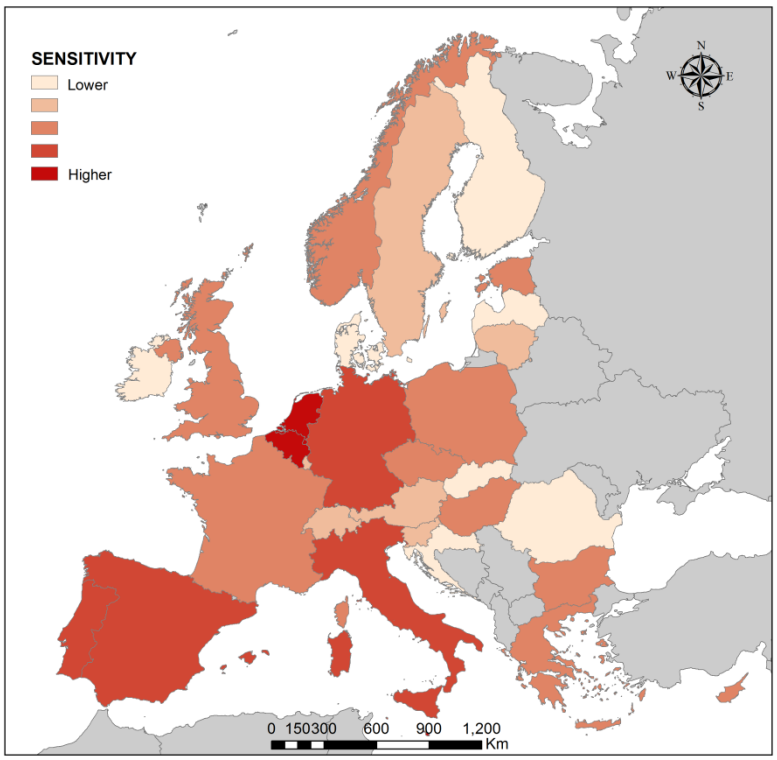


Figure C.2: *Sensitivity to drought (De Stefano et al., 2015).*

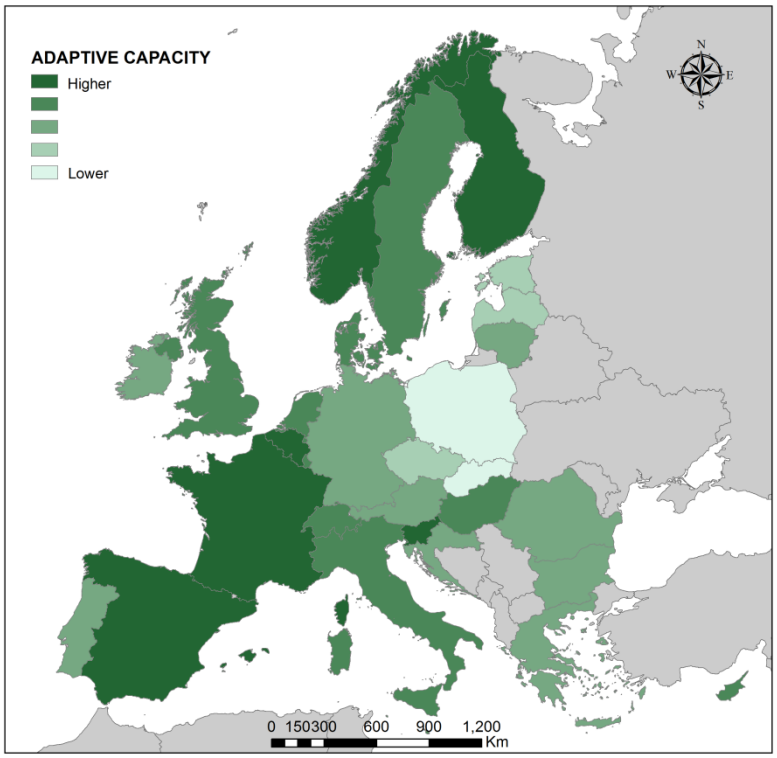


Figure C.3: *Adaptive capacity of EU regions regarding drought (De Stefano et al., 2015).*

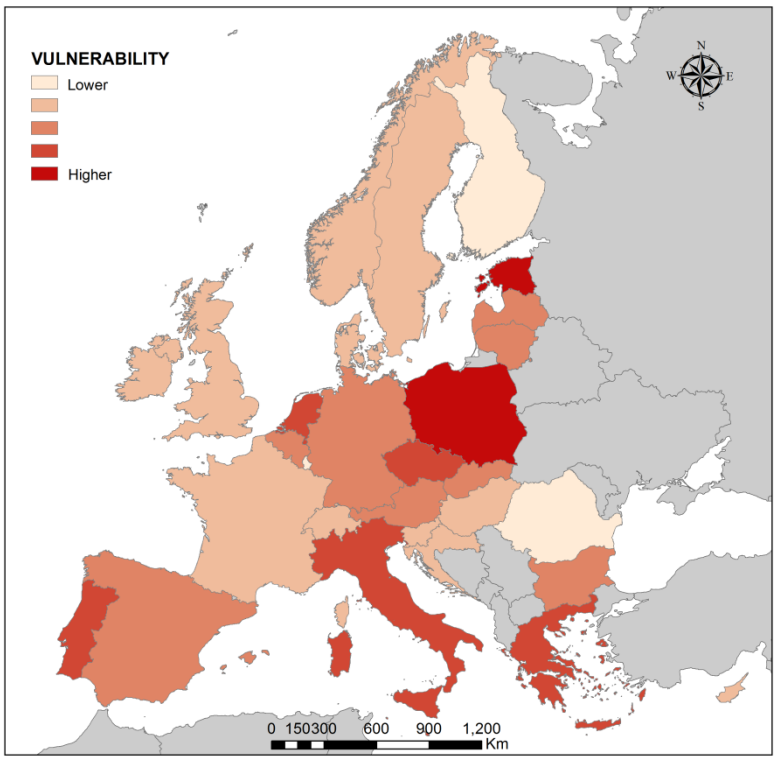
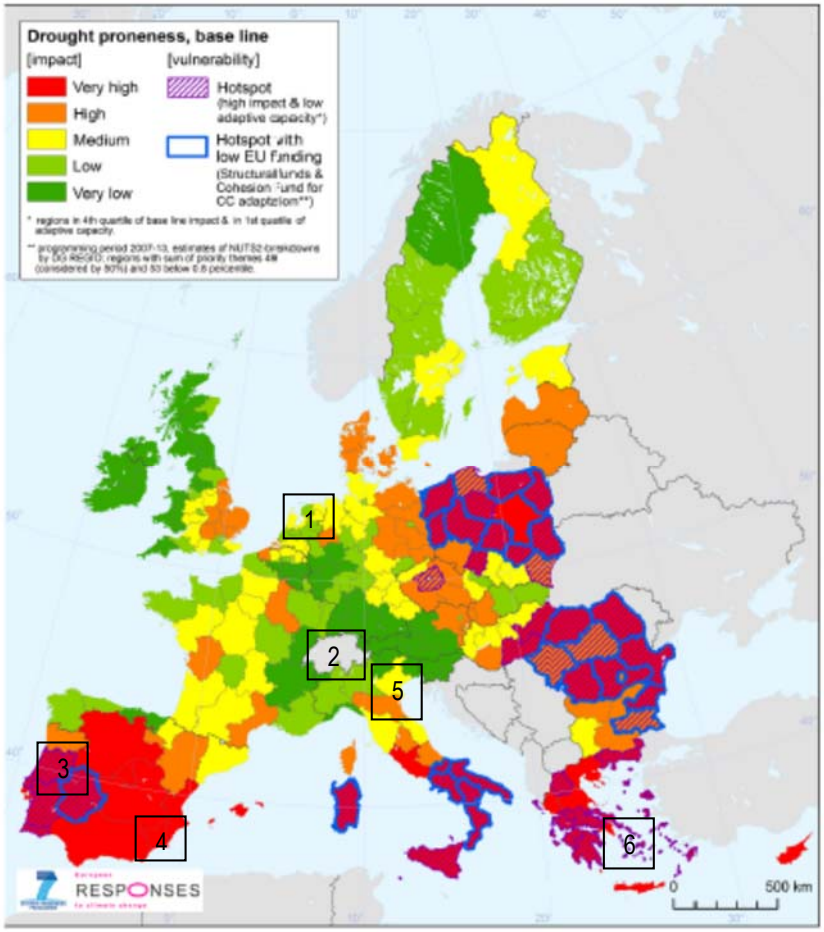


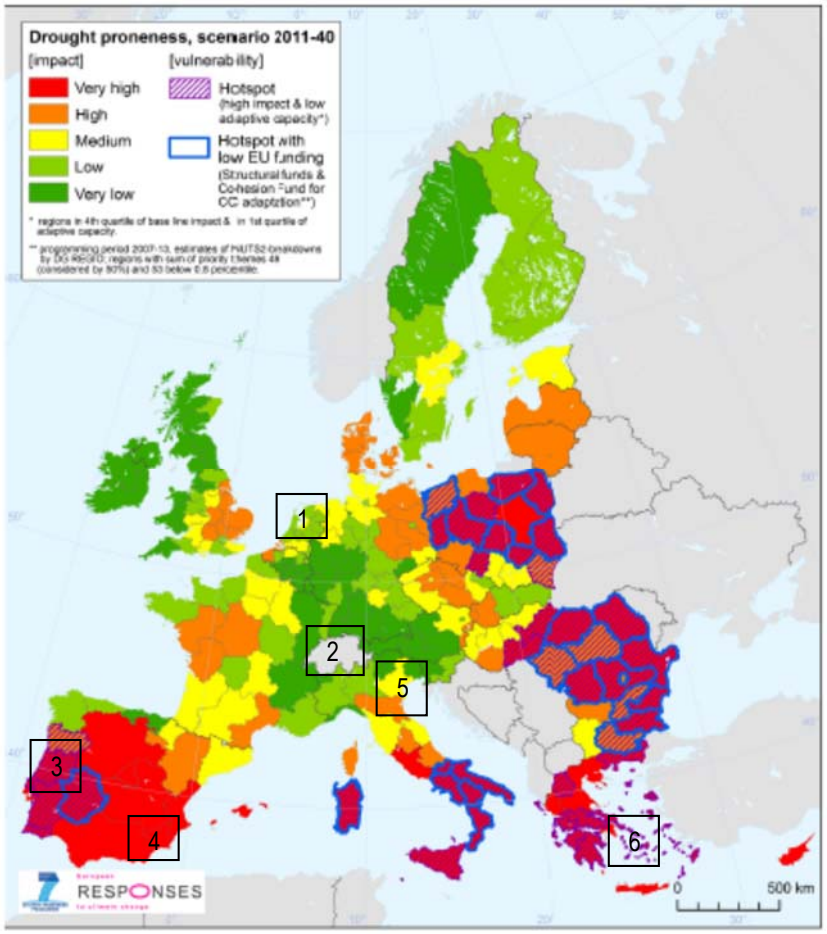
Figure C.4: *Vulnerability of EU regions to drought (De Stefano et al., 2015).*

C.2: Indicative outcomes from the FP7 RESPONSES project (http://www.responsesproject.eu/)



1 The Netherlands
2 Switzerland
3 Portugal
4 Jucar River Basin, Spain
5 Po River Basin, Italy
6 Syros Island, Greece

Figure C.5: *Map of drought proneness together with vulnerability hotspots, at NUTS-2 administrative level for EU-27, baseline period (Lung et al., 2011)*



1 The Netherlands
2 Switzerland
3 Portugal
4 Jucar River Basin, Spain
5 Po River Basin, Italy
6 Syros Island, Greece

Figure C.6: *Map of drought proneness together with vulnerability hotspots, at NUTS-2 administrative level for EU-27, scenario period 2011-2040 (Lung et al., 2011).*

Annex D: Drought strategy checklist

	Yes/No
Are you aware of (future) drought characteristics?	
Have you identified drought-related risks and considered the impacts these may have?	
Have you assessed drought-related risks?	
Have you proposed actions to cope with drought-related risks?	
Monitoring and early warning	
Is the current monitoring network (data availability) able to support drought monitoring & early warning?	
Are there severity drought categories defined?	
Are monitoring results appropriately disseminated?	
Vulnerability and drought risk assessment	
Have vulnerability and risk assessment been undertaken?	
Are the available data able to support vulnerability and risk assessment?	
Are there tools/methodologies for vulnerability and risk assessment?	
Are the most vulnerable sectors and regions been defined?	
Water augmentation / reuse	
Is it necessary to increase water supply?	
Are water recycling/ reusing opportunities been identified?	
Is the current infrastructure sufficient for reuse and recycling?	
Are alternative water sources been Identified?	
Water conservation	
Is water demand by sector estimated?	
Are water demand management measures active, even in case of normal years?	
Are actions for increasing water use efficiency active?	
Conflict resolution	
Are all actors affected by drought identified?	
Are there mechanisms for conflict resolution established?	
Legislation and governance	
Have drought management plans been developed?	
Have these been appropriately documented and communicated?	
Are there financial tools established to support drought management (e.g. disaster assistance programs)?	
Is a water allocations scheme (priorities) defined?	
Are there processes for drought management plan evaluation and updating?	
Awareness, education and participation	
Do people involved in drought management know enough about droughts, the risks it may pose and the management process?	
Are citizens/users aware of drought-related risks and management practices?	
Are there water saving tips disseminated prior to a drought?	
Are all stakeholders engaged in the drought planning and decision-making process?	

Annex E: List of options included in the Blueprint to Safeguard Europe's water resources (COM(2012)673)

2000: Water Framework Directive

Objectives: Good ecological status of water bodies; Access to good quality water in sufficient quantity for all

2007: Communication from the Commission to the European Parliament and the Council - Addressing the challenge of water scarcity and droughts in the European Union (COM/2007/0414 final)

Objective: Increase water efficiency and water savings to address water scarcity & drought

2008-2010: Follow-up Reports

Objective: Assessment of the implementation of the policy options throughout the EU

2012: Water Scarcity and Droughts Policy Review

Objective: Review and further develop the water scarcity and drought policy

2012: Blueprint to safeguard European waters

Objectives: Identification of actions for better implementation of current water legislation; Integration of water policy objectives into other policies; Filling the gaps in particular as regards water quantity and efficiency

Blueprint proposals for action	Relevant option/measure for drought management
Efficiency incentive water pricing	(Emergency) water pricing
Water metering	Water consumption metering & regulation; Transfer of water rights/ Re-allocation among users
Water use reduction in agriculture	Water reuse for irrigation; Improvement of irrigation efficiency; Alternative crop patterns
Reduction of illegal abstraction/impoundments	Development of strategic reserves
Awareness of water consumption	Water saving campaigns
Maximisation of the use of Natural Water Retention Measures (Green Infrastructure)	
Efficient water appliances in buildings	Water saving campaigns
Reduction of leakages	Improvement of existing water systems efficiency
Maximisation of water reuse	Water reuse for irrigation; Water recycling
Improvement of governance	Drought monitoring & Early Warning Systems; Drought Management Plans; Rehabilitation programs; Insurance schemes
Implementation of water accounts	Transfer of water rights/ Re-allocation among users
Implementation of ecological flow	Restrictions to pollutants release
Application of target setting	Determination of minimum water demand requirements; Water use restrictions
Reduction of flood risk	
Reduction of drought risk	Drought monitoring & Early Warning Systems; Drought Management Plans
Better calculation of costs and benefits	
Better knowledge base	Drought monitoring & Early Warning Systems
Support to developing countries	
Tackling pollution	Restrictions to pollutants release