7TH FRAMEWORK PROGRAMME

THEME 6

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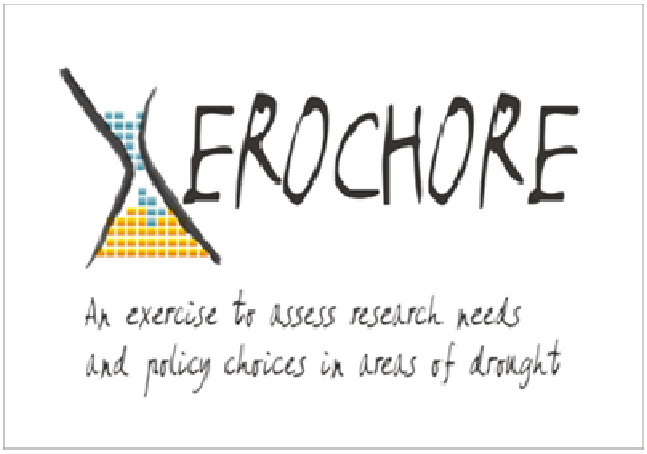

Background Document II (D. 5.1.)

Synthesis report on Management and Policy Options for Conference on Drought

Work Package 5

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About this document

Deliverable 5.1 “Synthesis report on Management and Policy Options for Conference on Drought” is the third part of Background Document II on Existing policies and drought management measures, together with Deliverables 4.1 “State of art report: Drought existing EU policies and research needs to develop a EU drought policy” (Part I) and 4.2 “Synthesis report: Potential impact of new forthcoming EU policies on droughts” (Part II).

Deliverable 5.1 provides an overview of existing drought policies, drought management efforts and drought-related research projects, and will form the basis for discussion during the Xerochore Conference on ‘Drought Policies and Management’, to be held in the Marriott Hotel Brussels, Belgium, on February 23-24 2010. It was jointly developed by the following Xerochore project partners: NTUA (Greece), FEEM (Italy), CEMAGREF (France), WMC (Germany) and MATTM (Italy).

The document is structured in three (3) parts.

Part A focuses on the main premises for drought planning and management. Chapter 1 emphasizes on the actions enabling the shift from crisis to risk management, addressing drought preparedness, mitigation, response and recovery. Chapter 2 further analyses issues pertaining to the EU Water Policy framework, highlighting current policies for drought management at national level in EC Member States and other countries. Particularly with regard to Drought Management Planning at regional level, Chapter 3 highlights steps and processes for the development of Drought Management Plans at regional (river basin) level, and presents relevant case applications to further emphasise on the necessity to engage into integrated planning approaches. Finally, Chapter 4 presents results from (i) an assessment survey on water scarcity and drought management, undertaken within the framework of the EU Water Initiative, and (ii) a questionnaire survey on drought management efforts among the Xerochore Project Participants and Network Partners.

Part B presents drought-related research efforts for identifying research areas that require further analysis and elaboration, in order to improve existing instruments and practices for coping with drought.

Finally, **Part C** presents the guiding principles for developing policies and drought management plans, taking into account current EU efforts for addressing drought (i.e. Water Scarcity & Drought Communication Documents, implications of the Water Framework Directive, the Draft Guidance Document on “River basin management and Changing Climate”). This part concludes with the Xerochore policy outcomes and considerations that should be further elaborated to enable integrated planning for drought, keeping in mind the key issues and challenges identified throughout the Deliverable.

The final version of the Deliverable 5.1 will be prepared taking into consideration comments and contributions from the consortium partners and from the scientific and research society, as this will be represented in the Xerochore Conference

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Summary for policy makers and water managers

Drought events call for management actions, as less water becomes available to meet the needs of the same or even higher water demands. Reacting to drought has proven far more expensive and less efficient than planning beforehand to minimize drought risk. Therefore, three elements emerge as the fundamental aspects of an integrated drought management framework: 1) **Preparedness**, through monitoring and development of Drought Management Plans, 2) **Drought Mitigation** responses, as actions to be undertaken both prior and during a drought event, and 3) **Drought Recovery**, describing a series of actions for restoring drought damages to economic activities and the environment.

In the above context, drought management policies should favour a proactive approach, aimed at reducing vulnerability to extreme events, and clearly define actions and responsibilities for responding to drought episodes according to their severity and potential impact. The main principles that should guide the formulation of drought management policies are summarized in the following paragraphs.

Favor risk than crisis drought management

Drought is a recurring natural phenomenon that can evolve to disaster, depending on the vulnerability and the capacity of a society to manage its impacts. Thus, the appropriate management approach lies in placing emphasis on risk management, rather than relief and compensation during or after the event.

The basic elements of a drought risk management approach are Preparedness, Mitigation and Response & Recovery. They respectively include:

- The establishment of a drought forecasting and early warning system, including the definition of indicators and triggers to describe the onset, ending, and severity of a drought event, and the development of Drought Management Plans.
- The selection of a combination of short-term and long-term mitigation measures to be taken prior, during or after a drought event, in order to minimize the impacts on the society, the economy and the environment. These measures should be differentiated according to severity of the event and clearly defined both technically and in terms of actual responsibilities for implementation.
- The activation of emergency response and recovery actions in case of severe events, depending also on a thorough assessment of the resilience of societies and water systems.

Identify and analyze the interrelationship among drought-related policies

Drought management is not related to water management alone, but also affects and is affected by land use policies, climate change, agricultural production and food provision, energy production, fire prevention and protection of natural resources. Drought policies should form part of an integrated management effort, addressing both the diverse drivers that can result to increased vulnerability, and the impacts on different use sectors, the economy and the environment. Cooperation among agencies is of critical importance for achieving a sufficient level of integration. A key issue that should be explicitly considered is increased awareness of the interrelationships between drought and other policies.

Promote the development of Drought Management Plans, as part of the River Basin Management Planning process

The increasing frequency and severity of drought episodes and of their impacts on water systems necessitate that drought risk is addressed while developing the River Basin Management Plans required by Art. 13 of the Water Framework Directive.

Drought risk management can also provide an opportunity for enhancing water saving, recycling and reuse. Specific aspects of drought management touch upon water quality, particularly in low flow conditions, water priorities and allocation schemes, water pricing as an instrument for demand management, conjunctive use of groundwater and surface water resources, transboundary water systems, new water uses, water transfers, participatory planning and water system assessment (availability of water resources and projected demand, climate change impacts).

Finance drought-related research activities

Drought-related research should be oriented at providing the necessary information for improving the understanding of drought phenomena (frequency and severity), for establishing monitoring and early warning systems, for evaluating drought management processes and mitigation options, and for understanding the factors that can assist in building more resilient water systems. The sharing of experience, through knowledge networks, is essential so that researchers and water managers gain a better understanding of past successes and failures. In this regard, multi-stakeholder platforms can be established to define research priorities, and assist in the strengthening of cooperation and information sharing between institutes and public authorities. Coordinated, EU-wide, monitoring can also be help to timely address drought impacts, particularly in the case of transboundary river basins.

Executive Summary

Part 3 of *Background Document II* focuses on drought policies and management efforts, integrating regional "experiences" and information on "case studies". The objective is to present existing information on drought management and to identify current policy and research gaps.

In particular, the following issues are addressed:

1. The importance of Integrated Water Resources Management (IWRM) in Drought Management;
2. The main elements of Drought Management;
3. Experiences in Drought Management; and
4. Drought-related research.

Responding to Drought following a New Paradigm

Drought has significant impact on the temporal and spatial availability of water resources, thus affecting the wellbeing of society and the environment. Therefore, drought policies need to be mainstreamed with existing water management and climate change adaptation policies, rather than being developed aside from these.

Drought-related aspects should be integrated into water management policies on two levels:

- Through the development of drought management plans, specifying a concerted course of action, to be implemented once a drought event occurs;
- Through the development of a permanent strategy for enhancing resilience to drought events, thus helping to achieve water security.

The new proposed paradigm for drought management focuses on **risk management** rather than the previously adopted crisis management approach, which has been thought to contribute to increased societal vulnerability to droughts. The concept of risk management is based on long-term **drought preparedness** (to include the concepts of characterization, risk and impact assessment, prediction and early warning, and development of Drought Management Plans) in order to reduce vulnerability and increase resilience to drought in the society. **Mitigation** actions are planned either in advance or during a drought episode, in order to minimize the impacts on people, the economy and the environment. Emergency **response** and **recovery** activities are also planned in advance of a drought event; however, they comprise measures to be implemented in case of extreme situations, when typical mitigation options cannot alleviate impacts, and after the end of a drought event so as to enable reinstatement to the pre-drought conditions.

Drought Management and Planning

The challenges of water scarcity, drought and climate change are receiving increasing attention by researchers and policy makers. At the EU level, several initiatives have been undertaken for establishing a common policy framework for drought management (e.g. Communication Documents relating to water scarcity and droughts COM (2007) 414 and COM (2008) 875, Drought Management Plan Technical Report, 2007 and the European Drought Observatory), in order to foster national initiatives and efforts in this field.

In accordance to national drought management plans, regional plans define specific actions to be undertaken to enhance preparedness and increase resilience to drought. As the most common spatial scale for the development of drought management plans is the River Basin, or, in some cases the sub-basin, the drought management plans can be considered as supplementary to River Basin Management Plans, developed and implemented by the corresponding competent authorities.

Drought management plans should, therefore, clearly define the measures and actions to be taken by different administrative levels in the case of a drought event, according to its severity and for each water use sector affected. Furthermore, the Drought Management Plan should foresee procedures for the post-evaluation of the followed processes, in order to allow its revision and updating to address possible deficiencies.

A process for the development of Drought Management Plans (DMPs) is proposed, to include: a) preparatory actions, such as the development of the organizational structure to support the drought definition and risk assessment activities, and the integration of science and policy aspects, b) publication of the draft DMP and stakeholder consultation processes, c) DMP implementation, and d) development of public awareness programmes and post-drought evaluation processes.

Assessing Water Scarcity Impacts - Surveys on drought management

A recent EU Water Initiative survey on drought and relevant policy instruments among the EU Member States highlighted the need for engaging into holistic drought management. Rather than focusing only on drought mitigation and recovery, equal (or more) emphasis needs to be placed on drought preparedness and enhanced water security.

On the basis of this EU-wide survey, a similar initiative was also developed through Xerochore, in order to identify currently applied drought policy elements at national level. The corresponding questionnaire, completed by the participants of the 1st Xerochore Workshop (15-17 June 2009, Noordwijkerhout, the Netherlands), also included a preliminary evaluation of the applied mitigation options. Results demonstrate the need for integrated approaches, adapted to local and regional needs and specificities.

Drought-related research and identified gaps

Drought-related research addresses drought forecasting, drought management, drought preparedness and drought impact assessment. Several research projects, focusing on one or more of the above aspects are analysed in this document. On the basis of the themes covered, research outputs and recommendations, the following research gaps can be identified:

Drought Forecasting

Drought forecasting tools are still inadequate, since the selection of Indicators and Triggers should be based on regional climatic conditions, the spatial scale of the analysis, the vulnerability of water use sectors and the uncertainties associated with the description of drought events.

Drought Management

Drought events primarily affect water availability. However, they also have secondary impacts in terms of land degradation, ecosystem impacts, food provision and security,

energy production, economic growth and social stability, thus affecting different policy sectors. Secondary impacts and potential interrelations need to be carefully assessed at regional and local level in order to enhance the efficiency of selected drought mitigation options.

Particular attention should be paid at estimating minimum flow requirements during drought episodes, the comparative evaluation of mitigation options and the enhancement of public involvement in drought management.

Drought Preparedness

Enhanced preparedness for drought can be achieved also by improving tools for risk and vulnerability assessments and decision support. Furthermore, research should be made in order to assess the effect and secondary impact of innovative concepts (e.g. tradable water quotas, weather insurance, water emergency pricing) as elements of drought preparedness and management.

Developing policies for adaptation to drought

Despite the policy efforts and the EU initiatives on water and drought management, research to date has raised several issues in relation to planning for drought, which should be further considered and elaborated. Those issues are related to the impacts of drought on the Natural Systems, the Environment and the Society (socio-economic impacts), as well as to existing gaps and deficiencies at national and regional scale. Finally, there is also pressing need for increasing integration among the existing policy tools and frameworks at national and EU level, and with the new policies, so as to enable meeting the short, mid and long-term opportunities and goals.

Contents

PART A: DROUGHT PLANNING AND MANAGEMENT: EXPERIENCES AND PERSPECTIVES

1 Responding to Drought: The Challenge

"Drought is a normal, recurrent feature of climate, although often erroneously considered an unexpected and extraordinary event, which occurs in virtually all climatic zones, and its characteristics vary significantly between regions". It is the result of a combination of natural factors and anthropogenic influences, and can be considered as a temporary aberration within the natural variability or even an insidious hazard of nature (EUWI-Med, 2007).

Drought incidences affect the wellbeing of society and the environment; impacts on society result from the interplay between the natural climatic variability and water demand. Under the pressure of climate change, which intensifies water availability problems, drought management is becoming increasingly important, especially in drought-prone regions such as the Mediterranean basin. Therefore, drought policies should be mainstreamed with existing water management and climate change policies, rather than being developed aside from these (UNEP-WMO, 2008).

Planning for drought should not be an independent management task, but an inextricable part of Integrated Water Resources Management (IWRM), which, according to the Global Water Partnership can be defined as follows (Jønch-Clausen, 2004): *"IWRM is a process which promotes the co-ordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems"*. IWRM introduces a holistic approach in the use and management of water resources and can thus be used to meet the challenges of drought planning in matters of:

- Promoting risk-based approaches,
- Eliminating conflicts over water use,
- Developing drought resilient societies, and
- Ensuring the financial and human resources necessary for the implementation of drought management plans.

Experience from the implementation of drought management schemes in several EU countries and worldwide demonstrates the need for adopting holistic drought management approaches, adapted to local and regional needs and specificities. An EU Water Initiative assessment survey on the impacts of drought and relevant mitigation instruments applied in the EU countries reached similar results. The survey underlined the need for engaging into integrated approaches that place focus not only to mitigation but primarily to preparedness.

1.1 IWRM and Drought Planning

The concept of IWRM was introduced in the United Nations Conference on Water in the Mar del Plata (1977). The guiding principles were defined in the International Conference on Water and Environment, held in Dublin in 1992 (Box 1). Since then, a tremendous effort was undertaken worldwide to ensure the adoption of IWRM at national level, one of which being the adoption of the Directive 2000/60/EC - the Water Framework Directive in the European Union.

Box 1: The Dublin Principles

1. Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment
2. Water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels
3. Women play a central part in the provision, management and safeguarding of water
4. Water has an economic value in all its competing uses and should be recognized as an economic good.

Source: International Conference on Water and Environment, 1992

IWRM is a dynamic process and, furthermore, a learning process, aiming at the continuous improvement of the efficiency of water management efforts. It is a holistic paradigm of how to use and manage water, in order to secure water availability even in cases of extreme events, and to ensure the sustainability of water resources, of ecosystems, as well as social welfare. The horizontal and the vertical components of IWRM are presented in Table 1.

Table 1. Levels of integration in water resources management

Horizontal integration	Vertical integration
▪ Water allocation among all water related sectors ▪ Integration between land and water ▪ Water management at the national and regional level	▪ Integration of social, environmental, technical and economic constraints ▪ Use of legislative, financial and technical instruments ▪ Supply and demand management

However, a major challenge in water resources management is the improvement of the planning and decision making process in order to account for water-related disasters, including floods, drought, desertification, landslides, and nowadays climate change impacts. It is indicative that the principles adopted by the World Conference on Natural Disaster Reduction in 1994 (Box 2) reflect the need for a common approach that should be based on risk-based management, preparedness and contingency planning, participatory processes and capacity building.

Box 2: The Yokohama Principles

1. Risk assessment is a required step for the adoption of adequate and successful disaster reduction policies and measures.
2. Disaster prevention and preparedness are of primary importance in reducing the need for disaster relief.
3. Disaster prevention and preparedness should be considered integral aspects of development policy and planning at national, regional, bilateral, multilateral and international levels.
4. The development and strengthening of capacities to prevent, reduce and mitigate disasters is a top priority area to be addressed during the decade so as to provide a strong basis for follow-up activities to the decade.
5. Early warnings of impending disasters and their effective dissemination using telecommunications, including broadcast services, are key factors to successful disaster prevention and preparedness.

Box 2: The Yokohama Principles (cont'd)

6. Preventive measures are most effective when they involve participation at all levels, from the local community through the national government to the regional and international level.
7. Vulnerability can be reduced by the application of proper design and patterns of development focused on target groups, by appropriate education and training of the whole community.
8. The international community accepts the need to share the necessary technology to prevent, reduce and mitigate disaster; this should be made freely available and in a timely manner as an integral part of technical cooperation.
9. Environmental protection as a component of sustainable development consistent with poverty alleviation is imperative in the prevention and mitigation of natural disasters.
10. Each country bears the primary responsibility for protecting its people, infrastructure, and other national assets from the impact of natural disasters. The international community should demonstrate strong political determination required to mobilize adequate and make efficient use of existing resources, including financial, scientific and technological means, in the field of natural disaster reduction, bearing in mind the needs of the developing countries, particularly the least developed countries.

Source: WCNDR, 1994

Figure 1 presents an integration scheme that could serve as a planning platform for minimizing the impacts of extreme events. The platform indicates the importance of ***monitoring*** and ***early warning*** as means of **preventive action**, and identifies the ***risk-based assessment of the efficiency of measures*** as the method for the selection and implementation of the most appropriate **reactive measures** for addressing extreme events.

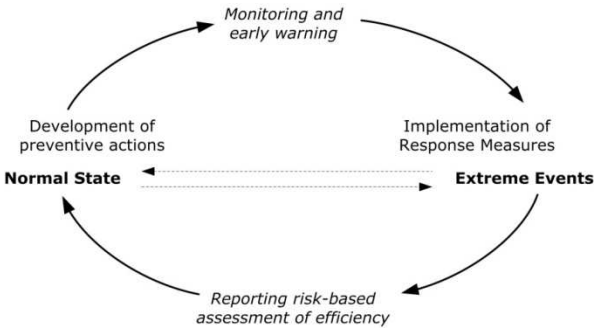


Figure 1: Integrating risk-based approaches in water management

Of great importance are the impacts of drought, since drought affects all dimensions of IWRM (Savenije and van der Zaag, 2008):

- The natural dimension, representing the availability of water recourses in terms of quantity and quality;
- The human dimension, accounting for water use(r)s and all economic interests;
- The spatial dimension, referring to the spatial distribution of water resources and uses as well as to the (appropriate) management scale; and
- The temporal dimension, corresponding to the temporal availability of water and the variability of demand.

Planning for drought should not be an independent management task, but an inextricable part of IWRM, addressing drought events as:

- A natural phenomenon, bound to occur, thus requiring the a priori development of drought management plans to be implemented when required;
- A reality that demands the development of a strategy for achieving water security, where water management is targeting the limited water availability and the preservation of water resources.

In this regard, Table 2 presents the links between IWRM processes and drought planning, illustrating the ways through which drought planning and management can be incorporated in the formulation of water policies.

Table 2: Links between IWRM and drought planning (adapted by Jønch-Clausen, 2004)

IWRM element	Main activities	Links with drought planning
Analyse current state	▪ Problem analysis ▪ International provisions ▪ Objectives ▪ Criteria of evaluation	▪ Analysis of future water problems ▪ Drought forecasting- risk management ▪ Drought triggers
Build commitment to reform	▪ Political commitment- policy objectives ▪ Participation processes ▪ Awareness creation	▪ Common definition and understanding of drought among organizations
Analyse gaps	▪ Management potential and constraints ▪ Delineation of analysis conditions	▪ Delineation of drought affected regions ▪ Social, economic, environmental impacts
Prepare strategy and action plan	▪ Enabling environment ▪ Institutional roles ▪ Management instruments ▪ Impact analysis of alternative strategies	▪ Drought preparedness and mitigation strategies
Build commitment to actions	▪ Political adoption ▪ Funding mechanisms ▪ Stakeholder acceptance	▪ Information flow on the status of water resources/ magnitude of drought events
Implement actions	▪ Capacity building ▪ Framework for water infrastructure development	▪ Information / technical assistance for implementing a drought plan
Monitor and evaluate progress	▪ Indicators of progress	▪ Evaluation of the plan ▪ Ongoing (adaptation to changes, simulation of drought events) ▪ Post drought analysis of the event & the process followed

1.2 Towards a New Paradigm for Drought Management

The new paradigm for drought management focuses on risk management rather than the previously followed crisis management approach, which contributed to increased societal vulnerability to droughts. The risk is a combination of natural factors (hazard) and social factors (vulnerability), which should be addressed within drought management. This concept is based on long-term drought preparedness in order to reduce vulnerability and increase resilience to drought in the society (Figure 2).

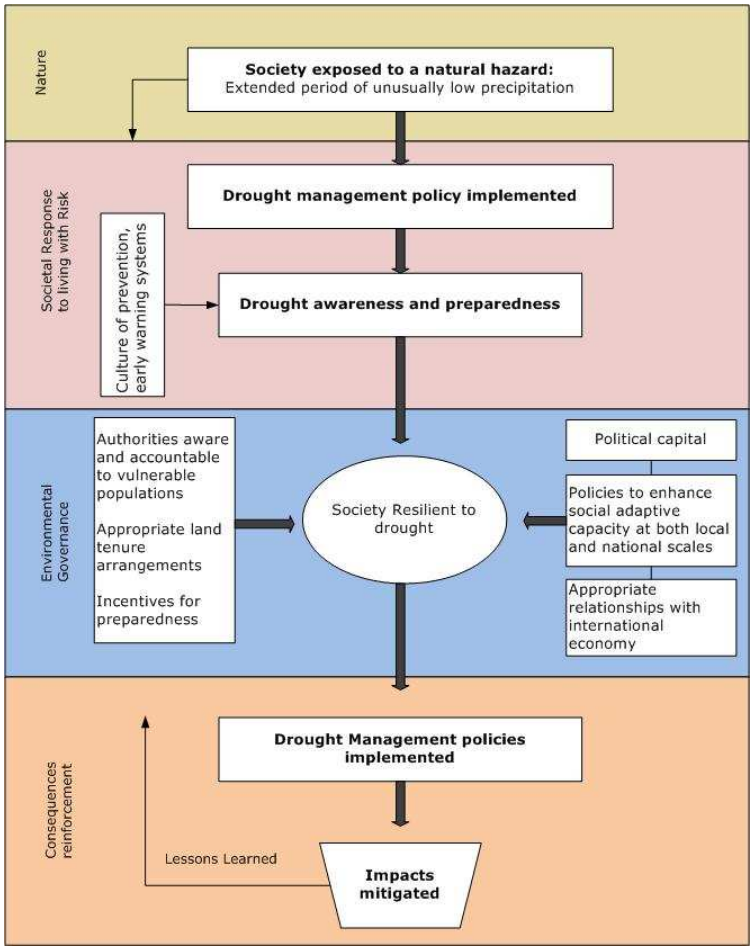


Figure 2: Towards the development of a Drought Resilient Society (ISDR, 2003)

The high cost of recovery actions and the increasing concern over the frequency and severity of future drought events boosted national and international efforts for the promotion of risk management and preparedness. Furthermore, the current, rather poor, integration of risk management approaches in planning is indicative of the limited understanding by water managers of the parts and functions of the water system that affect vulnerability to drought (EurAqua, 2004). Therefore, similarly to the "water saving culture", a "drought mitigation culture" is proposed, based on the following principles (UN, 2007):

- Dissemination of long-term benefits and effectiveness of preparedness and mitigation;
- Incorporation of long-term drought mitigation and preparedness activities into drought response and recovery processes;

- Enhancement of stakeholder participation and ownership;
- Assessment of the capacity of local communities to implement a drought strategy;
- Clear distinction of responsibilities among authorities for action implementation;
- Increase of investments in natural hazard preparedness and mitigation.

The elements of risk-based management are illustrated in Figure 3.

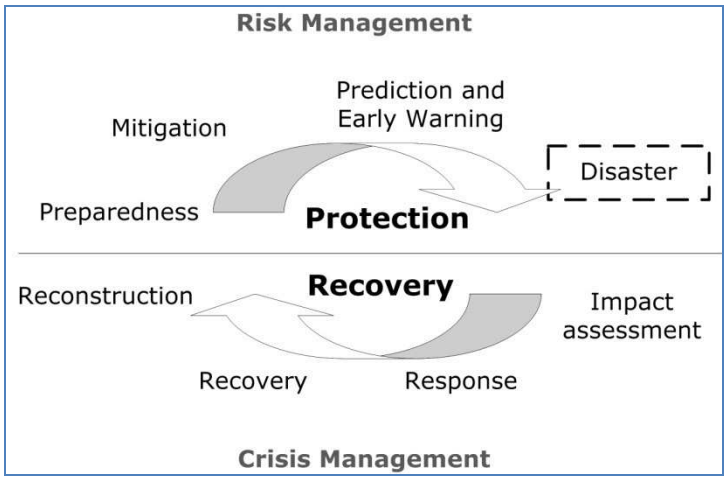


Figure 3: Risk and crisis management cycle (Wilhite, 1999)

Engaging into a risk management approach is currently considered as the means to respond to the aforementioned challenges. The activities related to risk management can, generally, be categorized under (Alexander, 2002):

- **Protection**, i.e. actions undertaken before drought events. It refers to activities of **preparedness** and **risk mitigation**, covering, among others, the issues of drought characterization, risk mapping and early warning. Drought preparedness refers to pre-drought activities designed to improve institutional and operational capabilities for responding to a drought event. Drought mitigation corresponds to actions taken or planned in advance of a drought event, so as to minimize the impacts on people, the economy and the environment.
- **Recovery**, i.e. actions undertaken after the drought event. In this phase emergency response and recovery activities are initiated. An important task is the post-drought evaluation of the process followed and of the actions undertaken (lessons learned), in order to continuously update and improve drought management efforts.

A risk management approach primarily concerns the issues of hazard prediction and vulnerability, placing the focus on pre-disaster activities, and addressed all levels of governance. In this regard, the following paragraphs describe in more detail the main elements of the approach described in Figure 3, focusing primarily on Drought Preparedness, Drought Mitigation and Drought Response & Recovery.

1.2.1 Drought Preparedness

Drought preparedness refers to pre-drought activities designed to improve institutional and operational capabilities for responding to a drought event. It corresponds to the planning of activities in advance of a drought event (Bazza, 2002).

The main components of Drought Preparedness include Drought Characterization, Risk and Impact Assessment, Prediction and Early Warning and the Development of Drought Management Plans.

Drought characterization

Drought characterization refers to the collection and assessment of regional information in order to:

- Select and develop drought indicators for the monitoring of drought conditions (amount and frequency of precipitation, frequency and time span of drought event, etc.);
- Define triggers describing the beginning and the end of a drought incident, as well as indicator thresholds so as to activate mitigation measures (Steinemann and Cavalcanti, 2006).

The information collected is mainly aimed at defining the type of drought. Overall, and according to Hennessy et al. (2008), the following types of drought can be distinguished:

- Meteorological drought, which corresponds to an extended period of time (months to years) when atmospheric conditions result in low rainfall. This can be exacerbated by high temperatures and high evaporation, low humidity and desiccating winds.
- Agricultural drought, referring to short-term dryness in the surface soil layers (root-zone) at a critical time in the growing season. The start and end may lag the one of a meteorological drought, depending on the preceding soil moisture status.
- Hydrological drought, corresponding to prolonged moisture deficits that affect surface or subsurface water supply, thereby reducing streamflow, groundwater, reservoir and lake levels. Hydrological drought may persist long after a meteorological drought has ended.
- Socio-economic drought, which refers to the effect of elements of the above droughts on supply and demand of economic goods, human well-being and quality-of-life.

Risk and Impact Assessment

Risk and Impact Assessment refers to the rating of impacts and water user groups in order to assess the vulnerability to drought. Drought-prone regions should conduct risk assessments in order to determine the degree and extent of exposed risk as well as the actors mainly affected. The risk assessment is, therefore, an important part in drought preparedness.

Prediction and Early Warning[1]

Prediction and Early Warning as essential components of drought preparedness plans and policies aim to improve the efficiency of drought planning by providing reliable information to support drought risk assessment and the selection and implementation of mitigation actions. Early warning systems combine meteorological (e.g. temperature, precipitation) and water system related (e.g. water availability, water demand and supply) information in order to assess the probability of occurrence, as well as the severity of a drought event. This

[1] *Drought monitoring and early warning have also been addressed by Wipfler et al., 2009, in the Xerochore Guidance Document on "Natural Systems & Drought".*

stresses the need for coordinated action in terms of collecting and analyzing the data. In many cases a Monitoring Committee is responsible for setting the requirements for monitoring and setting the thresholds that describe different drought severity levels.

The need for efficient early warning systems was highlighted during an Expert Group meeting for drought preparedness and drought management, held in 2000, in Lisbon, Portugal. The meeting concluded with a set of recommendations for enhancing efforts on early warning (WMO, 2000):

- Priority should be given to improving and making better use of existing monitoring/data networks and establishing new, if required;
- Emphasis should be given to the selection of suitable indicators and triggers for describing drought events, as well as to the assessment of potential social, environmental and economic impacts.

The shortcomings identified in preparation for Early Warning include:

- Data networks - density and data quality of meteorological and hydrological networks and data networks on all major climate and water supply parameters;
- Data sharing - between government agencies; the high cost of data consist often restricts their use during designing for drought preparedness, mitigation, and response;
- Early warning system products - data and information products to be more user friendly;
- Drought forecasts - reliable seasonal forecasts and information addressed to farmers and other actors;
- Drought monitoring tools - indices for detecting the early onset and end of drought (the Standardized Precipitation Index (SPI) was cited as an important new monitoring tool to detect the early emergence of drought);
- Integrated drought/climate monitoring – drought monitoring systems should be integrated and based on multiple indicators to fully understand drought magnitude, spatial extent, and impacts;
- Impact assessment methodology;
- Delivery systems - data and information on emerging drought conditions, seasonal forecasts, and other products;
- Global early warning-there is need for the development of drought assessment outputs available to help international organizations, non-governmental organizations etc. to identify emerging drought areas (ISDR, 2003).

Development of a Drought Management Plan

The preparedness phase ultimately targets to enable the development of Drought Management Plans and related implementation strategies.

A Drought Management Plan could be considered a supplement to the River Basin Management Plans, foreseen by Art. 13 of the Water Framework Directive. Wilhite et al. (2006) note that Drought Preparedness Plans should refer to the management of multiple water supplies and effluents, using improved climate information. Their content is defined through an a priori drought characterization and impact assessment, normally undertaken at

the River Basin level, and in line with the guiding principles of other related policies (water policy, land use, energy management etc.).

In addition, important elements of a Drought Management Plan include:

- The specification of actions, based on an increased knowledge over the water system status and the severity/stage of the drought event;
- The description of a plan for implementing the mitigation actions that should address both technical and organizational aspects; and
- A plan for public sensitization and information activities.

It is clear that the development of Drought Management Plans (DMPs) can be undertaken at national and at regional/river basin level. National plans normally define frameworks, institutional competences and general procedures to be followed, whereas river basin management authorities refine and adapt these to the specificities of the area(s) under their responsibility (Table 3).

Table 3: Indicative contents of National and Regional Drought Management Plans

National Drought Management Plan	Regional Drought Management Plan
▪ Establishment of committees and task groups → Definition of responsibilities ▪ Establishment of monitoring networks and drought declaration processes → Drought severity ▪ Drought impact assessment & vulnerability per sector and district → Priorities in the allocation of resources ▪ Formalisation of reporting mechanisms	▪ Regional drought triggers & indicators ▪ Regional drought characterization & vulnerability assessment ▪ Mitigation options per sector and drought severity level ▪ Allocation of tasks among regional agencies ▪ Processes for plan review

The EU Water Scarcity and Droughts Expert Network issued in 2007 a guidance document on the development of Drought Management Plans, in order to assist Member States towards drought preparedness and mitigation (EC, 2007c). According to this Guidance Document, DMPs should address the following topics:

- General basin characterisation under drought conditions;
- The River Basin's experience on previous (historical) drought events;
- Characterization of droughts within the basin;
- Implementation of a drought warning system;
- Programme of measures for preventing and mitigating droughts linked to indicators systems;
- Organizational structure of the DMP (identification of competent entity, committee or working group to identify drought impacts and propose management measures);
- Update and follow-up of the DMP;
- Public supply specific plans;
- A section dedicated to 'prolonged drought management'.

Individual steps and processes for the development of Drought Management Plans are presented in detail in Section 3.2.

1.2.2 Drought Mitigation

Drought mitigation refers to the actions undertaken prior or during drought periods in order to minimize impacts on people, economy and the environment. Mitigation actions address all water use sectors and governance levels, and should be preferably implemented at the River Basin scale. There are several classification schemes, which, according to Rossi et al. (2007), can be summarized in the following:

- Classification according to the objective of measures, which can aim at water supply enhancement, demand regulation or impact minimization.
- Classification according to the implementation timeframe: Actions can be distinguished as proactive and reactive, since they are implemented in advance and when a drought occurs respectively.
- Classification according to the implementation duration: As mentioned above, mitigation measures can be either long or short-term.

The selected measures can be further grouped into drought severity levels. Three levels are widely used: pre-alert, alert and emergency. The transition from one level to the next corresponds to the implementation of more costly measures and at higher administrative levels (e.g. from regional to national). Table 4 (p. 25) indicates the differences in drought planning for the different drought alarm stages, whereas Box 3 presents two alternative classification schemes for drought mitigation measures addressing their scope, drought severity and timeframe of implementation.

Box 3: Classification of drought mitigation measures

Classification according to the United States of America Corps of Engineering, 1994

Strategic measures: long term physical and institutional responses→ preparedness.

Tactical measures: measures developed in advance to respond to expected short-term water deficits.

Emergency measures: measures implemented as an ad hoc response to conditions that are too specific or rare to warrant the development of standing plans.

Classification according to the report on Drought Management Plans (EC, 2007c)

Preventive or strategic measures: measures for reinforcing the structural system to increase its response capacity towards droughts.

Operational or tactical measures: control and information measures, water conservation or restriction measures.

Organizational measures: measures related to the establishment of agencies and an appropriate organizational structure for the development and implementation of drought plans.

Follow-up measures: actions undertaken for assessing the application of the drought management plans and their effects.

Restoration or exit-drought measures

Table 4: Distinction among different drought alarm levels (Source: Iglesias et al., 2007)

	Preparedness	Pre-alert	Alert	Emergency
Monitoring indicators	Indicators show a normal situation	Indicators show initial stage of danger; no observed impacts (meteorological drought)	Drought is occurring and impacts will be eminent if measures are not taken (meteorological & hydrological drought)	Drought is persistent and impacts have occurred; water supply is not guaranteed (socioeconomic drought)
Objective of the plan in this stage	Ensure that a preparedness and early warning plan is in place	Ensure acceptance of alarm or emergency measures by raising awareness of drought risk	Overcome the drought situation and ensure water supply. Emergency measures can be put in place	Minimize damage, the priority is drinking water
Measures	Development of DMP - Strategy for revision and review	Low cost, indirect, voluntary	Low cost, direct, coercive, direct impact on consumption costs	High cost, direct, restrictive, approved as general interest actions
	Implementation of a monitoring and early warning system	Non structural directed to influence water demand and avoid worse situations	Non structural directed to specific water use groups	Structural, new infrastructure intra-basin, inter-basin and transboundary transfers
	Integration with development and land use policies	Focus on communication and awareness	Water restrictions for uses that do not affect drinking water	Non structural, such as permission for new groundwater abstraction points
		Intensification of monitoring and evaluation of worse case scenarios	Changes in management	Water restrictions for all users, including urban demand
			Revision of tariffs, Water banks	

Knutson et al. (1998) propose a three-step process for selecting the most appropriate mitigation measures:

1. Analysis of the underlying causes of vulnerability to drought;
2. Identification of the necessary actions for reducing drought risk; and
3. Selection of actions using the following criteria: feasibility, effectiveness, cost, and equity.

A tentative list of actions and management options to reduce drought risk, according to Knutson et al. (1998) is provided in Annex I.

1.2.3 Drought Response & Recovery

Drought response measures are implemented in case of emergency situations, when typical mitigation options cannot alleviate impacts. According to the UN/ISDR Terminology of Disaster Risk Reduction (2009) response measures include "*The provision of emergency services and public assistance during or immediately after a disaster in order to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of the people affected*". Table 5 presents examples for mitigation and response actions.

Table 5: Response measures vs. mitigation actions

Response actions	Mitigation actions
Alert appropriate agencies of emerging rainfall deficits	Expand current network for rainfall monitoring
Alert appropriate agencies of declining ground- and surface-water storage	Enhance current monitoring of ground- and surface-water levels
Implement voluntary and/or mandatory water use restrictions	Establish conservation programs to reduce water consumption
Seek authorization to convert and utilize monitor wells to provide emergency sources of water	Seek authorization and funding for development of new water supply sources
Utilize models and monitoring data to assess drought recovery or escalation of drought conditions	Identify areas at risk to drought and plan for regional response actions and strategies
Provide for regular and timely media advisories	Develop and implement drought-related public awareness programs
Initiate requests for federal drought assistance	Develop incentive programs for drought resistant practices

Source: Wilson Okamoto Corporation, 2005

Response measures have an immediate effect on people's life (e.g. compulsory water restrictions, compensation measures, distribution of food); however these measures should be carefully designed in order to avoid dependencies or an increase of vulnerability (UN, 2007). For example, Wilhite and Pulwarty (2005) stress the fact that relief measures act as disincentive for improved water management, since through these measures poor management is rewarded and those better prepared are not eligible of assistance.

Drought recovery refers to the activities undertaken after the end of a drought event is reported (i.e. actions to return to normal state). The aim is to return as soon as possible to

the pre-drought conditions of production, quality of life and cash flow (Mackay, 2005). The UN/ISDR Terminology of Disaster Risk Reduction (2009) defines recovery as "*the restoration, and improvement where appropriate, of facilities, livelihoods and living conditions of disaster-affected communities, including efforts to reduce disaster risk factors*".

Recovery programs should be developed in advance of a drought event, so that responsibilities among agencies are clearly defined. Community support should be ensured, through participatory processes, in order to engage the public in the implementation of recovery measures and preventive actions. Recovery periods provide a good opportunity for identifying the root causes of drought-related disasters and reassessing priorities for reducing vulnerability to drought (UNDP, 2004).

Another important activity during this phase is the review and update of the drought planning process and plans in particular. The evaluation process can indicate the successes and failures of the existing drought management framework and, thus, help to develop proposals for improving its efficiency (Shepherd, 1998).

1.3 In summary: Key issues and challenges

The Commission of Sustainable Development of the UN issued a report in 2008 on drought management (UN CSD, 2008). The report concludes by outlining the following priority areas:

- The promotion of a risk-based approach in drought management;
- The improvement of collaboration among neighbouring countries and the elaboration of water allocation agreements, in order to avoid conflict over the use of (more) limited water resources in case of drought;
- The development of drought resilient societies;
- The provision of adequate financial support and the development of the technical capacity required to implement drought management plans; and
- The development of drought monitoring and early warning systems, as well as of mechanisms for the collection and analysis of drought-related data.

In addition to these recommendations for future policies, the effectiveness of drought management efforts is also affected by the capacity of policy makers and water planners to address:

- **Drought characterization**, as the onset, the severity and the end of a drought event and its spatial extent are difficult to determine. Drought declaration processes have already been developed in several countries, but they usually refer to the processes that follow the initiation of a drought episode (i.e. after the first impacts have already been recorded).
- **Increased conflicts among water users**, as drought episodes exacerbate water scarcity and quality issues. The management of shared resources requires strong collaboration among the many authorities and stakeholders involved. Furthermore, it is often the case that the complexity of the system hinders the development and implementation of integrated drought management plans.
- The **forecasting of drought events**, in terms of severity, spatial extent and duration. Although early warning systems have already been developed in several parts of the world, forecasting remains an open field for research. This knowledge gap is primarily

associated with the fact that risk is shaped by a region's vulnerability to drought (Wilhite, 2000). Thus, it becomes critical to regionally define and analyse the different factors that affect vulnerability, to better focus preparedness and mitigation options.

Additional key challenges for drought management include:

- Guiding principles developed both at the EU level and internationally, point out that drought management plans should follow a holistic approach, integrating the relevant economic, social and environmental aspects and clearly addressing interrelationships with other, drought-related, policies. Drought risk mitigation should form an integral part of water management policies, also considering the impacts of climate change.
- Risk management approaches can help to minimize drought impacts; however they cannot completely eliminate the need for response measures. In this regard, and although risk management is the main element of efficient policy design, a comprehensive drought management plan should also incorporate procedures and actions for crisis management.
- Virtual Drought Exercises (VDEs) can be used for testing a drought preparedness strategy and for identifying potential conflicts during a future drought episode (Werick and Whipple 1994). Thus, they can be useful in identifying potential deficiencies of drought management plans and for training the personnel involved in the corresponding tasks.
- During a response and recovery phase there is still increased political commitment and public engagement for drought mitigation. This provides a good opportunity for developing long-term risk mitigation and preparedness activities and embedding these in drought-related policies (UN, 2007).
- Post-drought evaluation aims at assessing the effectiveness of the procedures followed and actions implemented during a drought event. In this regard, mechanisms should be developed to allow the objective review of drought management plans to identify areas where performance should be improved.
- Success stories in drought management could be used as illustrative examples for future policy design and implementation. In this regard, the reporting and publication of post-event analyses concerning drought management practices should be encouraged, also through the development of a platform for information exchange and dissemination of good practice examples.

2 Drought Planning and Management at National Level

2.1 Introduction: Policy frameworks for Drought Management

Drought planning and management touches upon many water-related policies. Its main requirements include:

- The incorporation of drought risk in water management, as well as other sectoral policies, particularly for those sectors that are most vulnerable to drought events (e.g. agriculture, energy production, etc.);
- The definition of monitoring procedures to early identify drought events and assess their severity;
- The development of drought preparedness and management plans, to cope with drought events and minimize their impacts.

The above can be undertaken either as separate tasks or embedded into other relevant policies. However, experience demonstrates that drought planning and management should be addressed in a holistic way that coherently addresses interrelationships between reduced water availability and relevant impacts. In turn, this allows the consistent definition of risk mitigation options, as well as response actions during a drought event.

Drought policies should define the use of national resources (natural, human and financial) in order to support regional efforts to address drought, and to encourage research for improving preparedness and mitigation. National drought policies are formulated on the basis of international recommendations and provisions, taking into consideration the national economic structure, available institutional and financial mechanisms, social status and environmental conditions. In the majority of cases, a drought policy is not independent; its elements are incorporated form part of the water policy, civil protection acts and legislation related to natural disasters.

In the **EU**, the Water Framework Directive (WFD) can be considered a first step for incorporating drought risk management in water resource planning. The WFD does not explicitly address drought-related issues; however both its environmental objectives and several specific provisions are linked to drought management. Examples include art. 1.e, which refers to the contribution of the Directive in the mitigation of drought impacts, art. 1.b, on the promotion of sustainable water use, and art. 4.1(b)ii), which refers to environmental objectives for groundwater management.

Recognizing the expected exacerbation of water scarcity and drought among EU Member States, the European Commission pursued in 2006 and early 2007 an in-depth assessment of water scarcity and droughts in the European Union. Following this assessment, the Commission presented an initial set of policy options to enhance water efficiency and water savings in a 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), which was officially released in July 2007. A follow-up report to the 2007 Communication was released in 2008 (EC, 2008). The report noted that little progress has been made at the national level and still a lot needs to be done in order to improve water management and be prepared for drought, especially in water-scarce areas. In this

regard, the report proposed a work programme, and identified priority areas related to water scarcity and drought management.

The EC initiative was further pursued through the development of the Technical Report-2008-023 "Drought Management Plan Report - Including Agricultural, Drought Indicators and Climate Change Aspects" (EC, 2007c), prepared by the Water Scarcity and Droughts Expert Network. The report, communicates general, non-binding guidelines for the development of DMPs, in order to assist Member States in integrating drought risk and management in water resource planning, taking into account the policy framework established by the WFD.

In addition, the development of a Guidance Document on River basin management and Changing Climate was initiated in 2007, within the context of the WFD Common Implementation Strategy. The Guidance Document is aimed at providing guidance on how Member States should incorporate consideration of climate variability and change into the implementation of EU water policy. Its final version will be released by the end of 2009 (Ecologic, 2009).

Box 4: Main elements of the Drought Management Plan Technical Report

The EC Drought Management Plan report was developed in response to the priority areas identified by the EC Communication COM/2007/0414. It outlines guiding principles and recommendations on the drafting of Drought Management Plans and the development of an EU-wide strategy to address drought. It further notes the need to establish European Drought Observatory to facilitate the enhancement of knowledge and to improve preparedness for addressing drought events.

The Technical Report presents a wide range of possible options to address water scarcity and drought-related issues, describing several good practice examples, already applied in different countries. In line with the priority actions specified by the EC Communication COM/2007/0414, the guidance document underlines that all possibilities to improve water efficiency must be explored. Furthermore, the development of water policies should be based on a clear water hierarchy, from water saving to water pricing policy and alternative solutions) and taking due account of the cost-benefit dimension of alternatives.

The Report is considered as a fundamental and well-developed first set of options for future action, within the framework of EU water management principles, policies and objectives. It recognises, in particular, the need to address drought planning and management within the framework of the River Basin Management Plans of the WFD. Demand side options and soft instruments are also prioritized over supply enhancement interventions.

Source: EC, 2007c, 2007d and Ecologic, 2009

Another policy framework, particularly relevant to semi-arid countries, is set through the **National Action Programmes for Combating Desertification**, under the relevant United Nations Convention (UNCCD). Among expected results, the corresponding Regional Action Plan lists the identification of *"areas that need the development of pro-active drought contingency planning which includes water management, legislations, participation and training, Environmental Impact Assessment, emergency programs"* (UNCCD, 2001, p.5). EC Member States that have submitted their corresponding National Action Programme, also addressing aspects of drought planning, include Greece (2001), Romania (2000), Italy (2000), Portugal (1999), and Spain (2008).

Box 5: Examples of national policies related to drought

The drought management policy of Greece

In Greece, and although no specific drought management plans have been developed, the responsibility for drought preparedness and mitigation has been allocated to water competent authorities at regional and national level. The 2001 Greek National Plan for Combating Desertification (GNCCD) further defines a series of drought-related measures, addressing institutional aspects and specific water use sectors. Priority areas of intervention, as defined by the GNCCD comprise:

- The development of water management plans at all levels (national and river basin level);
- The enhancement of the capacity and functions of Regional Water Directorates;
- The issue of specific regulations for the protection of water resources at the river basin scale;
- Law enforcement, strict monitoring and application of the corresponding penalties in case of violation.

In addition to the above, a review of the Greek institutional framework, undertaken by Tsakiris et al. in 2005, denotes that effective drought planning and management in the country is hindered by lack of:

- A network for monitoring drought occurrence;
- Water abstraction permit systems, especially for groundwater, and detailed records of water use in agriculture;
- Coordination and cooperation among organizations and stakeholders having experience in drought management for addressing drought-related issues;
- Definition and development of drought indicators and triggers that could guide the implementation of appropriate mitigation measures; and
- A comprehensive compensation policy to address damages incurred to the most affected economic sector, agriculture.

The drought management policy and legislation of Spain

The Spanish Water Act requires from River Basin Authorities to plan for drought episodes and from municipalities to develop contingency plans for drinking water supply. Despite the fact that drought planning and management is decentralised at the River Basin level, the State maintains control over individual River Basin plans and the operation of a Global Hydrological Indicators' system, to be used, among others, for monitoring drought episodes (EC, 2007c).

Furthermore, through art. 71 of the Water Act, the Government can authorize River Basin Authorities to establish Water Interchange Centres (Water Banks) to enable the trading of water use rights through voluntary agreements. Specific legislation related to drought can be found in the National Water Plan Act (Act 10/2001, article 27 "Droughts management"), which states that *"the Ministry of the Environment must establish a global Hydrological Indicators' System, and River Basin Authorities (Confederaciones Hidrográficas) must prepare Drought Plans to be submitted to the respective River Basin Councils and to the Ministry of Environment for approval".* To facilitate the development of drought management plans, the Ministry of the Environment of Spain developed a Guidance document, addressed to River Basin Authorities, and further developed a national plan, to harmonize and coordinate individual River Basin plans and address issues relating to shared groundwaters, regulation of interbasin transfers and operation of the corresponding public works.

2.2 National policies for drought management

Provisions for drought planning and management encompass both the a priori definition of instruments for dealing with crisis situations, as well as the integration of drought risk and related aspects in water management policies and plans.

In cases where drought management forms part of an integrated water management policy, relevant provisions and regulations are set at the national level, in order to define (more or less precisely) the processes for drought management and planning to be undertaken by water competent authorities. In several cases, the legal framework also identifies the issues that should specifically be addressed by (River Basin) Drought Management Plans, which generally include:

- The definition of indicators and triggers;
- The identification of specific actions, based on an in-depth knowledge and analysis of the water system addressed;
- The detailed description of a mitigation action plan, covering not only technical, but also organizational aspects;
- Public information and sensitization activities.

In **Spain**, drought planning and management is integrated in National Water Policy; planning is undertaken at the River Basin level, whereas the State exercises control and is responsible for the overall coordination among the different River Basin Drought Management Plans. Furthermore, the Ministry of the Environment is responsible for defining appropriate indicators, and for country-wide monitoring. The overall process for the development of drought management plans is defined by the Water Act; legislation further specifies the contents of DMPs to be developed by water management authorities. Foreseen mitigation measures include tradable water use rights and infrastructure-based options, such as interbasin transfers to meet water deficits in areas facing acute water scarcity.

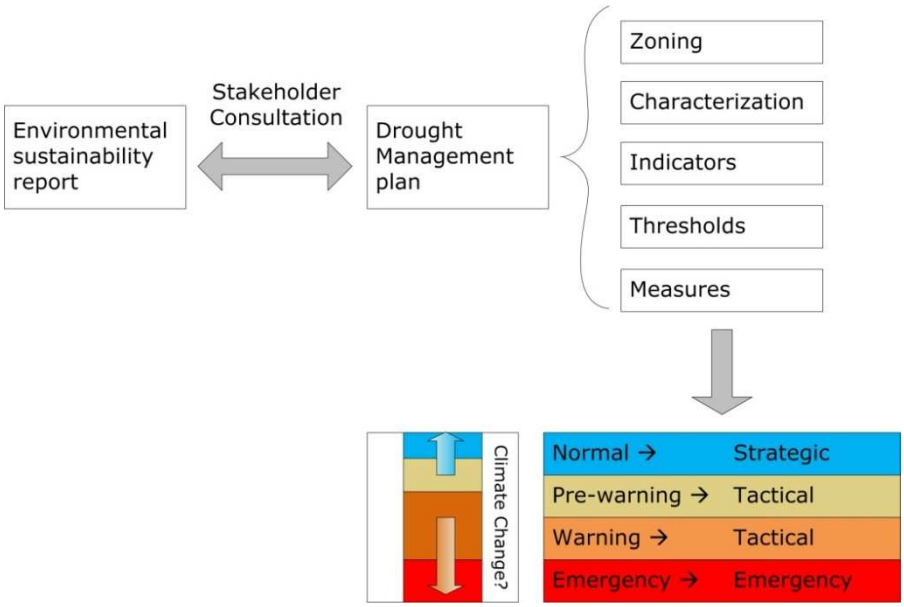


Figure 4: Overview of Drought Management Plans (Ministry of the Environment, Spain)

In more detail, the Water Act specifies that the DMPs developed by River Basin Authorities should (EC, 2007c, p.63):

- Define Basin specific indicators for monitoring and forecasting of drought episodes, to allow for early reaction. Examples include inflows, outflows and storage in reservoirs, measured river flows, precipitation and piezometric levels;
- Provide information on the water system and the options for regulating water use under scarcity conditions;
- Provide information on the demand of different water use(r)s and assess their vulnerability under drought;
- Present structural and non-structural alternatives for mitigating drought impacts, adapted to different drought severity levels;
- Estimate the cost of alternative measures and assess the corresponding benefits;
- Adapt the organizational structure to local specificities and pursue coordination among the different authorities involved (Ministry, Regional Governments, municipalities); and
- Disseminate and discuss plans, results and follow-up with all interested parties, ensuring full public participation in order to avoid social conflicts.

In **England and Wales**, the *Department for Environment, Food and Rural Affairs (DEFRA)* in and the *Welsh Assembly Government* respectively in Wales have policy responsibility for the legislation that governs water resources, and for drought management. During drought, both bodies work closely with the *Environment Agency* and *private water operators* to ensure that public water supply is maintained and that environmental impacts are minimized as far as possible. The Government's formal role in water stress situations is to deal with drought order applications to Ministers. The *Environment Agency* is the statutory body responsible for water management and for controlling both surface and groundwater withdrawals through a licensing system. During drought, the Agency can issue short-duration drought permits, which allow higher water abstraction for public water supply than normally allowed. On the other hand, during a drought event, private water operators have the power to impose temporary sprinkler and hosepipe bans without the approval of the Government or the Environment Agency. Drought management plans are produced both by the Environment Agency and by private water operators (water companies).

The *Environment Agency* develops drought management plans at different levels of hierarchy, ranging from plans for the high-level coordination of drought management activities over England and Wales down to local plans that define the specific operational activities to be undertaken by the Agency. Overall, DMPs are developed with the objectives to: (a) reconcile the competing interests of the environment, the need for public water supply and other abstractions under drought and (b) ensure consistency in the way the Environment Agency coordinates drought management activities in England and Wales. They outline (a) how the Agency will manage water resources during a drought, also defining its role and responsibilities; (b) a framework for liaison with water companies, awareness campaigns and determination of drought permits, and (c) additional environmental monitoring to be carried out during a drought episode. They further explain drought vulnerability in England and Wales, so that the Environment Agency can advise senior management and Government on prospects and possible actions.

Water companies in England and Wales have produced DMPs on a voluntary basis since 1999. The Water Act of 2003 made it a statutory requirement for water companies to prepare, maintain and publish DMPs, which are produced in accordance with guidelines from the Environment Agency and submitted to Ministers for approval. Before their finalization, drafted plans must be published and consulted upon. At this level, DMPs define how the company will continue to supply adequate water quantities during drought periods, with as little recourse as possible to drought orders or drought permits that may adversely impact the environment. Depending upon the severity of the drought, this can include campaigns to encourage reduced consumption, hosepipe bans, enhanced leakage control and pressure reduction. Increasing severity may lead to the use of drought orders or permits to increase abstraction or change discharge regimes, to prevent other abstractions that could impact on public supply or to restrict non-essential use.

Box 6: Guidelines for the development of DMPs in Queensland, Australia

The Department of Natural Resources and Water of the State of Queensland, Australia has prepared guidelines to be used by water service providers while developing DMPs. The Guidelines do not describe the procedure to be followed for selecting drought mitigation actions, but instead set the requirements to be considered while preparing a DMP, in accordance with the provisions of the Water Act 2000.

The DMPs introduce actions and procedures that will minimise the impacts caused by drought, by defining the water use activities and groups at risk, and mitigation actions that address the associated impacts under drought. According to the guidelines, the DMPs should at least provide:

- An overview of the water system, including a description of the water uses serviced by the provider and of the infrastructure, and an assessment of current and future demands.
- Assessment of available water resources, including also potential future and emergency sources of water supply.
- An operational strategy for the management of the system, covering all water users. The strategy should include a consultation process with water users, triggers for describing the onset and outset of a drought, actions that can be implemented so as to minimise economic and social impacts, and the organizational structure for its implementation.

Source: DNRW, 2007

A critical aspect in achieving successful drought management is the **revision** of the corresponding plans. Revisions normally start from the evaluation of experiences from their application during a drought event, by assessing their effectiveness and the impacts of actions taken. The drought preparedness plan of the State of **Arizona, USA** is reviewed on a yearly basis, to account for technological advances, and to assess the effectiveness of already applied mitigation options (Arizona Governor's Drought Task Force, 2004). The plan comprises:

- A *Background and Impact Assessment* document that defines drought in the State and reviews the vulnerability of the various water use sectors; and
- An *Operational Drought Plan*, which defines the actions that should be undertaken in the case of a drought event by the Government, the communities and individuals.

Furthermore, the plan describes the process for communication and coordination among the responsible authorities and water users, including State Agencies, Federal Agencies, local governments, water users, resource managers, and the scientific community.

Overall, the plan defines 5 drought stages, Normal, Abnormally dry, Moderate, Severe and Extreme conditions. Specific actions correspond to each stage, aimed respectively at: (i) reducing vulnerability, (ii) raising consciousness, (iii) promoting voluntary reductions, (iv) restricting uses and (v) eliminating non-essential water uses. The implementation of the plan is undertaken by three Committees:

- The Monitoring Technical Committee, in charge of providing early detection and warning of impending drought conditions;
- Local Area Impact Assessment Groups, mainly responsible for public awareness activities and the provision of impact assessment information to local and state leaders. Furthermore, the Groups initiate the implementation of local mitigation or response options; and
- An Inter-agency Coordinating Group, that consists of governmental and nongovernmental organizations. The Group is responsible for the policy guidance regarding the implementation of the plan, for the realization of emergency response options, as well as for the plan review.

The responsibility for overall management and coordination is vested in the Arizona Department of Water Resources.

Box 7: The new water policy of Tanzania

In Tanzania, a new National Water Policy entered into force in 2002. In light of demographic, as well as climate change projections of increasing water stress, a new approach to water resources management has been taken on in order to manage water scarcity, based on the following principles: (i) *comprehensiveness* to capture multi-sectoral and multi-objective planning as well as indirect and cumulative aspects, (ii) *subsidiarity*, to shift planning, decision and management processes closer to the beneficiaries, and (iii) *economic effectiveness*, to ensure that public as well as private investments reflect water scarcity, equity and incentives for rational use of water.

With regard to the application of the subsidiarity principle, River or Lake Basin Management Authorities are invested with comprehensive planning competences, and receive financial support by the economic provisions of the policy. As the Basin Water Office relies on payments from water rights users, the emphasis is placed on cost recovery, for the financing of public works and management efforts.

Sources: Arvidson and Nordström, 2006; Sarmett and Kamugisha, 2002

2.3 Drought management through the UNCCD

In some countries drought planning forms part of more comprehensive action plans for the prevention of desertification. These national action plans, which are developed under the UN Convention to Combat Desertification (UNCCD), require vulnerability assessment to identify threatened areas, as well as preventive actions addressing agriculture, forestry and water management.

For example, this is the case of **Greece**, where water resources planning, institutional assets for drought planning and public awareness campaigns, are part of a broader strategy for combating permanent deterioration of environmental conditions due to desertification (GNCCD, 2001, p.21). The activities planned under the Greek National Action Plan comprise activities in the field of agricultural practice and forestry, but also improvement of water

management. Options include improvements in the efficiency of water use in irrigation and the urban environment, incentives to foster private investment in rainwater harvesting, public investments in water storage and reuse capacities as well as public awareness policies and change of land use policies. The 2nd Report of the National Action Plan also includes a series of measures related to drought management (GNCCD, 2002, p.19). It further describes a specific programme for addressing extreme drought events and water shortage, and for promoting the implementation of the WFD.

The integration of drought planning in the broader initiative of combating desertification in Greece, can help in placing focus on comprehensive and long-term actions aimed at reducing risk and enhance resilience to drought, rather than mitigate drought impacts. The Greek plan emphasizes on the need to change land use patterns and invest in traditional agricultural techniques. On the other hand, the Action Plan of **Cyprus** focuses on the need to maximize the use of non-conventional water resources as part of the country's national strategy (Cyprus Ministry of Agriculture Natural Resources and Environment, 2007, p.11).

Also in **Spain**, the National Action Plan creates an opportunity to develop management tools based on IWRM concepts to integrate policies for environmental protection, spatial development, and management and protection of coastal areas and water bodies (Ministerio de Medio Ambiente, 2008). One of the foreseen activities concerns the establishment of the National Drought Observatory (ONS) at the request of both the Ministry of the Environment and the Ministry of Agriculture, Fisheries and Food, in order to involve every Spanish water administration in the setting up of a Centre for knowledge, early warning, mitigation and monitoring of drought effects (Ministerio de Medio Ambiente 2006, p.5).

2.4 Aspects of Drought Management

2.4.1 Drought declaration processes

In most cases, the framework that establishes common monitoring procedures and indicators to describe drought episodes forms part of National Drought Management Plans or Strategies. It is then adapted to the specificities of particular regions and river basins, according to their physical characteristics, taking into account the vulnerability of water use sectors and dependent ecosystems.

For example, the French Water Act of 1992 broadly defines three drought alarm levels, each corresponding to a different type of action that entails different restrictions in water withdrawals for specific water use sectors (Box 8, p. 37). The thresholds describing alarm levels are defined by the authority responsible for crisis management. As pointed out by Barbier et al. (2007), this, in turn, leads to a differentiation of monitoring and threshold estimation methods among the different River Basins.

In **Portugal**, under normal climate conditions and before a drought period is detected and declared, the Meteorological Institute and the Water Institute of the country are responsible for monitoring the main variables, i.e. precipitation, river water flows, reservoir water levels, groundwater levels and river water quality (EC, 2007c). Conditions of meteorological drought are identified through the application of the Standardized Precipitation Index (SPI), the Palmer Drought Severity Index (PDSI) and the Regional Drought Distribution Model, using

monthly data. When precipitation levels are very low and meteorological drought indicators show the beginning of drought episode, the Meteorological Institute informs the Commission for Reservoir Management, a national permanent commission, including the main users and water state organizations. The Commission analyses the situation, focusing on water storage levels in several reservoirs (particularly those that are multi-purpose) and the imbalance between water availability and projected water demand. If the analysis reveals that a drought is occurring, the Commission proposes to the Government to declare a state of drought, and to implement a Drought Monitoring and Impact Mitigation Programme.

Box 8: The provisions for drought declaration in France

The French Water Act (3 January 1992) establishes a framework for a national early warning system in which three different thresholds are defined, together with the range of mitigation measures that need to be implemented once these thresholds are reached. A permanent monitoring scheme regarding surface water has been established defining indicators for stream flows which are regularly monitored:

- The *"target flow of dry season"*: It is the average monthly flow that can sustain both economic activities and ecosystems and is calculated downstream a monitoring point.
- The *"flow of alert"*, which refers to a daily flow level, below which an economic activity or an ecological function of the river (the most vulnerable ones) are in danger. To reinitiate this function or activity, some abstractions of water or discharges of wastewater will need to be curtailed (e.g. garden irrigation, agriculture, car washing) for a certain period. As soon as this level of alert is reached, Basin Authorities start implementing a crisis plan. If the situation worsens, additional restriction measures will be taken (e.g. for water use in industry).
- The "*crisis flow*", which corresponds to the daily flow below which drinking water supply is threatened. In this case, water for human life cannot be guaranteed, whereas river flows are below the minimum environmental flow. Significant restrictions are to be implemented, addressing also drinking water supply, and bottled mineral water could be distributed to the population.

Thresholds related to groundwater levels, again defining three levels of alert, are calculated for each important aquifer. They are based on piezometric measurements, using a time series of more than 40 years. Critical thresholds are established using 9 piezometers on average: Alert Level 1 initiates public awareness activities, Alert Level 2 sets restrictions in water abstractions, mainly for agriculture, and Alert Level 3 corresponds to a crisis situation. In the latter case, abstraction for irrigation purposes is prohibited and drinking water supply can be affected.

Drought management in **Cyprus** is performed by estimating the overall water budget, throughout the island and per Hydraulic Scheme, in regular intervals. The estimate is performed every two months, taking into account the actual and projected water inflows and demand under different scenarios of precipitation (Tsiourtis et al., 2007). The results are then evaluated in terms of economic and environmental impact and further communicated to the Council of Ministers. Subsequently, the Council of Ministers, in cooperation with the Water Development Department, sets the goals and defines the actions for drought mitigation. The followed process is illustrated in Figure 5.

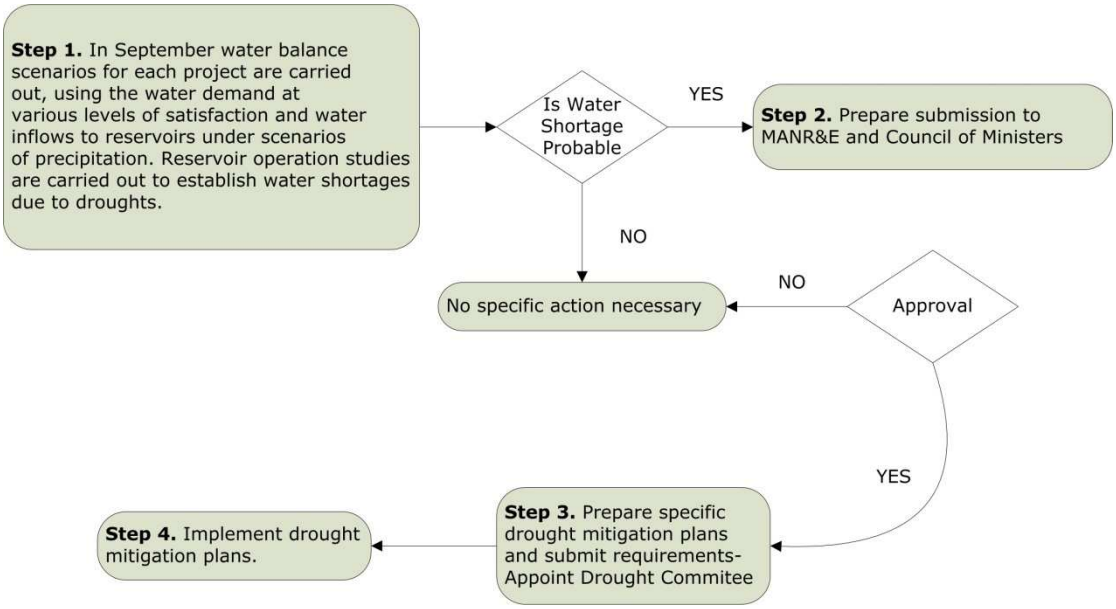


Figure 5: Drought mitigation proactive plan steps undertaken by the Water Development Department in Cyprus (Tsiourtis et al., 2007)

Information on the drought management framework of **India** can be found in Samra (2004), who indicates that the main goals are to account for economic losses in agriculture and to secure food provision. Drought monitoring in the country is both a responsibility of the State and of the Federal government, which collaborate through information exchange. At the Federal level, the Meteorology Department is in charge of monitoring and forecasting, and prepares aridity maps and rainfall reports on a weekly basis. The Crop Weather Watch Group of the Ministry of Agriculture evaluates the relevant information, and convenes accordingly, i.e. once a week during the rainy season and more frequently during drought episodes. A similar Group operates at the State level, and jointly decides with the Federal Group on the implementation of drought response actions. However, drought declaration is the primary responsibility of the States, while the Federal Government's main role is to facilitate the process. The States also operate weather monitoring systems and set procedures for distinguishing different types of drought (e.g. hydrological from agricultural drought) and their severity. Following the drought declaration from States, the Central Relief Commissioner assigns a central team to verify the States' claims on drought-induced losses.

2.4.2 Drought risk mitigation

Past approaches to reduce drought risk included the development of strategies for enhancing water availability, considering that an increase in water supply (e.g. through storage) can help achieve a minimum water supply during a drought episode. Options employed also included the development of interbasin transfer schemes, from other, less drought vulnerable areas, as well as the use of non-conventional water sources, whose availability does not depend from weather conditions (e.g. desalination).

On the other hand, the engagement into large-scale infrastructure, demanding heavy public investments, is receiving important criticism, as often small-scale works or investment in demand management proves far more efficient, both under normal and under drought conditions. However, priority interventions recommended in action plans are often superseded. For example, initially, priorities set in the Irrigation Programme of Italy (Piano

irriguo) noted, among others, the need for the urgent rehabilitation of irrigation distribution networks and canals. Public investment was however oriented towards "mature" projects, whose detailed assessment and design had already been completed (Rossi et al., 2005).

Box 9: The assessment of drought impacts in the Netherlands

In the Netherlands, no specific framework has been created for drought management. However, a survey was recently carried out at national level, in order to analyse water policy options for drought management.

The survey was jointly carried out by Government agencies at central and regional level and water management authorities. It included assessments of the economic and social impacts of past drought events, and of possible scenarios, based on outputs from climate change models. Considered policy options concerned primarily water logging and water quality.

The assessment concluded that large-scale infrastructure in primary systems, as well as the construction of large storage reservoirs was both impractical and economically inefficient. Drought issues should primarily be addressed through customized solutions in local systems, taking into account water surpluses and water quality issues. In this regard, it was considered that water shortage should be a priority issue in future water policies.

Source: Netherlands Drought Study web site, 2005

Box 10: Drought mitigation in Brazil

Drought is a common phenomenon in the semi-arid region of Northeast of Brazil.

The discussion on the need to establish a framework for implementing conventional and non-conventional solutions in order to address drought-induced water shortages emerged in the 19th century, after the severe drought episode of 1877-1879. Adopted solutions concerned the construction of dams, water transfer from São Francisco River and the development of a different economic profile, so as to reduce vulnerability and enhance water security. However, despite the emphasis placed on hydraulic infrastructure development, water scarcity and drought risk remained significant.

Nowadays, in Northeast Brazil, the National Water Agency focuses its attention on ways to address prolonged droughts and river pollution. Decisions taken are based on the premise that permanent or repeating drought phenomena cannot be addressed through the enhancement of water supply alone; efforts should prioritize demand management, including prevention, and water saving. In cases of severe shortage, use quotas should be established, in combination with compensation payments to affected users.

With regard to the North-East Region of Brazil, has focus attention on i) the prolonged droughts and ii) river pollution. Particularly, the decisions of the NWA are currently based on the assumption that dealing with permanent or cyclic drought situations could not only be addressed through increase of the water supply but should rather be addressed mainly through demand management, which includes prevention and saving water measures such as the establishment of use quotas and compensation payments to affected users (National Water Agency, 2009).

Sources: Campos and de Carvalho Studart, 2008; Brazil National Water Agency, 2009

Along the same lines, the discussion on important inter-basin water transfers in **Spain** seems to be heavily influenced by a preference given to important infrastructure works instead of small-scale interventions. Garrido and Llamas (2009) note changes of consensus in water policies and a decreasing importance of engineers in the water management sector as an important driver in changing focuses in water policies. In fact, the project has been repealed

in favour of desalination and wastewater reclamation projects. With regards to these alternative sources of water, the Spanish Water Act has defined specific water rights. Institutional arrangements for the trading of water use rights have been an important milestone of the Spanish water reform at the beginning of the 1990s, which contributed, where applied, to an increase in efficiency of water use in agriculture: trading of water use rights proved far more profitable than crop cultivation, thus reducing forms of inefficient use of water in agriculture. The trading of water use rights can be implemented, either among private holders of water rights, or using water banks, organized by Basin Authorities.

2.4.3 Drought response and recovery

Drought response refers to the implementation of emergency measures during or immediately after a drought event. The implementation of response measures is aimed at ensuring public safety and at reducing socio-economic, environmental and health impacts.

The 1987-90 droughts in **Sicily, Italy** have resulted in widespread impacts on the water supply systems of several municipalities and agricultural areas, and in particular in the communities of the southern and western parts of the island, most of which suffered perennial shortages in drinking supply, and experienced very severe mandatory restrictions in water use. The water use restrictions, already in place in many small communities of Sicily, have been further intensified after the drought period of 1989-1990 to even include water delivery for a few hours every 2, 3 or, in some cases, 7 days. Additional emergency measures included:

- Water transfers from other municipal supply systems through new connections among the existing aqueducts;
- Wider use of water resources usually devoted to agricultural purposes (groundwater and surface reservoirs).
- Exploitation of sources previously neglected due to their low quality or high costs.
- Use of desalinated water and transportation of water by trucks.

A main component of the emergency response plan was the effort to simplify the administrative procedure so as to accelerate the completion of multi-purpose water systems already initiated before the drought event. Only about 24% of the investments concerned projects specifically designed as drought emergency measures and directly supported by funds supplied from the government. The main interventions were devoted either to rehabilitate or to complete conveyance aqueducts (49%) and to construct desalination plants (20%). The use of water from private wells has significantly contributed to eliminating the damages caused by drought, while a number of farm reservoirs have been built in that period, as well as in the successive decades, to add storing capacity to the system managed directly by the farmers (Rossi et al., 2005).

Drought **recovery** can entail the implementation of compensation schemes addressed to those that are mostly affected. Compensation, also through public insurance schemes, is common to most countries that have experienced severe drought episodes. These are mostly addressed to the agricultural sector, as crop irrigation is usually the first water use curtailed in response to a drought event. Compensation can be offered on the basis of a private insurance scheme with public subventions, and through direct schemes. In **Italy**, compensation to farmers is subject to the declaration of state of emergency, which is made

by the Government, based on the observation of the state of river basins and using information collected by the Authority for Civil Protection. These declarations further give way to the nomination of a Commissioner with special competences in terms of water use regulation, overriding the competences of other administrative bodies, including river basin management authorities (D.P.C.M. 4 marzo 1996).Mechanisms of compensations to farmers create a particular public interest. Compensation schemes, similar to those adopted in Italy, have been intensively discussed in Australia, when the reform of the National Drought Policy towards risk-oriented approaches was initiated. In this case, compensation for drought-induced economic damage was perceived as an instrument that would impede adaptation to changes in water availability and higher frequency of drought episodes (Botteril, 2005). The most recent discussion in Australia considers "weather derivatives"[2] as financial instruments that can be used to reduce risk associated with adverse or unexpected weather conditions, thus helping farmers to respond to potential loss of income (Botteril, 2005; Hertzler, 2005).

Box 11: Drought mitigation in Cyprus

Cyprus is one of the most drought-prone countries of the European Community. However, until recently, the country did not have a coherent water scarcity and drought management scheme. Nevertheless, mechanisms for drought management are being developed since Cyprus joined the UNCCD Programme, and the development of an appropriate National Action Plan is currently underway.

Independently from this coordinated action which is now being set up, isolated measures have already been implemented in the past, in order to mitigate drought impacts. Examples include the enhancement of storage capacity to increase water supply during drought, and the "Agricultural Insurance Law" to mitigate the economic impacts of natural disasters in agriculture.

The Agricultural Insurance Law was established in 1978; it requires compulsory insurance of orchards against losses due to meteorological events such as hail, windstorm, etc., whereas compensation for drought-induced damage is foreseen only for cereals and dry-land forage crops. The premium paid by the farmers equals 3% of the total crop value and is the same for all crops covered by the scheme, which is public. The Government subsidizes this premium by an amount equal to the amount of premiums paid by the farmers. The long-term goal of the relevant policy is the gradual improvement and expansion of the legislation and the formulation of an integrated insurance scheme, to cover the main crops against all major calamities.

Sources: Tsiourtis, 2005, Cyprus Ministry of Agriculture, Natural Resources and the Environment, 2007

2.5 In summary: Key issues and challenges

- The effectiveness of drought management policies is highly dependent of the capacity of the authorities involved to implement their key components. This stresses the need for clearly defining responsibilities at all levels and for enhancing their capacity to understand and monitor drought events. Drought declaration processes should be based on a selection of indicators and triggers that are easily understood by authorities and stakeholders involved.

[2] *Weather derivatives cover low-risk, high probability events. On the other hand, weather insurance typically covers high risk, low probability events (Chicago Mercantile Exchange, 2006).*

- Being proactive involves the improvement of efficiency in water management and use, even in normal conditions, rather than trying to enhance water supply through costly solutions during drought. Emergency water supply should be applied only in cases of extremely acute events, when typical options (demand management, water use restrictions, and public information activities) prove insufficient. Furthermore, selected options should be developed taking into account the vulnerability of water use sectors, regions, and population groups.
- The selection and definition of mitigation measures should be consistent with the environmental objectives, as described in the Water Framework Directive. Therefore, prior to the definition of options, an assessment of the anticipated impacts on the environment (and the economy) is required.
- Societies in drought-vulnerable areas should be made aware of drought risks. Risk communication is critical to ensure that selected risk mitigation options are acceptable by the public. Furthermore, local knowledge is useful for defining region-specific or water-use specific mitigation options. In this regard, the development of mechanisms stakeholder engagement and public participation is also a priority for drought planning.
- Compensation schemes, as means to mitigate drought impacts, should be carefully designed, in order to ensure equity among the drought-affected groups/recipients. Furthermore, recovery should primarily aim at improving society's capacity to cope with drought, rather than solely rely on relief measures.
- National experiences on the use of new technologies, the implementation of innovative instruments, and the development of drought policies, should be shared in order to learn from past successes and failures. Efforts should be made to establish international fora for information exchange on the options applied and their effectiveness. Wilhite (2002) proposes the development of drought-preparedness networks, as a tool for exchanging information that can facilitate adaptation under evolving conditions.

3 Drought Management and Planning at Regional (River Basin) Level

3.1 Introduction

The common spatial scale for the development of drought management plans is the River Basin, or, in some cases the sub-basin. In this regard, drought management plans can be considered as supplementary to River Basin Management Plans, developed and implemented by the corresponding water management authorities. Similarly to river basin management, drought management in transboundary river basins would require the development of a joint plan among the neighbouring countries (EC, 2007c, p. 19). In this context, this chapter describes the general premises for the development of drought management plans, outlining also specific case examples from the EU and other countries.

In accordance to national drought management plans, regional plans define specific actions to be undertaken to enhance drought preparedness. Examples include the planning of the necessary works to increase storage capacity and the a priori definition of response measures. Regions that face severe droughts often engage into actions, as reaction to an emergency situation, by restricting water use, applying priority schemes for water withdrawals, and increasing water tariffs.

Box 12: The development of a drought risk management approach in Sub-Saharan Africa

Drought is a major threat to sustainable livelihoods in many parts of Sub-Saharan Africa, and in particular in dryland areas of arid and semi-arid regions. The impacts of drought events in the region are economic, social, and environmental and often result in land degradation, human migrations or relocations, famine, diseases, and loss of human life. The lack of contingency planning for drought events in the Sub-Saharan countries is the result of the limited financial resources, inadequate understanding of drought impacts, and poor co-ordination among government agencies. Among the countries of the region, only Botswana and South Africa have made serious efforts to develop drought preparedness and response plans.

Until now, the main focus regarding drought planning in Sub-Saharan countries has been placed on crisis management rather than on risk management, which would include preparedness, mitigation and prediction for reducing impacts and for lessening the need for government interventions in the future. As a result of this policy, the number of disaster incidences has not been reduced and, consequently, there is also little, if any, reduction in risk.

As a response to the existing needs, the planning process developed by Wilhite (1991) for the development of drought preparedness plans was presented in several sub-Saharan countries, in through a series of workshops. The suggested process was intended to be generic and adaptable to all drought-prone regions, and also to address the needs and issues of any level of governance. Several task groups and institutions are involved in the process. Workshops demonstrated that, with the appropriate modifications to address local administrative and governmental issues, this process could be helpful in dealing with issues associated with local drought preparedness.

Sources: Wilhite, 1991 and 2000

Preventive measures encompass a much wider range of options, which primarily affect the water budget, by increasing supply and rationalizing demand either through physical

interventions (dams, networks, desalination) or by applying economic instruments (e.g. water pricing or trading of water use rights). Preventive measures are defined by considering drought as a risk that cannot be completely avoided, but can, however, be reduced. Preparedness further requires the definition of indicators and their thresholds that describing alert situations, and the development of monitoring and early warning systems, considering the specific characteristics of the river basin or aquifer. However, the definition of indicator thresholds and management strategies can be a source of disagreement among stakeholders.

In this regard, and in addition to action plans, DMPs can also encompass the assessment of vulnerability and needs of strategic water use sectors, as well as recommendations for reducing drought risks. Environmental conservation is also an issue of concern within drought management plans; although quality regulations allow for temporary deviations from standards, droughts represent a severe stress to natural environments and amplify environmental impacts of water use. In this regard, and as presented below, drought management plans in Victoria, Australia, also consider environmental flow regimes, in an effort to minimize the stress imposed on natural systems.

3.2 Developing a Drought Management Plan

Wilhite (1991) proposed a 10-step process for drought planning that was subsequently updated to account for risk assessment and mitigation. A similar approach has also been developed by the USACE (1994). Both methodologies emphasize on the need for a common approach between organizations and stakeholders in the following:

- *Defining the drought*: Various organizations may use different terminology for drought, which makes it difficult to derive meaningful drought indicators and triggers.
- *Setting the objectives of the plan:* A common issue is the conflicting goals set by authorities and stakeholders involved. The fragmentation of data among different management authorities and overlapping jurisdiction also hinder the process of reaching consensus over the desired goals and course of action.
- *Evaluating the effectiveness of individual measures and plans*: Cost-effectiveness of alternative options should be carefully assessed beforehand, and post-evaluated after a drought incidence, in order to refine and update the corresponding plan.

Suggested steps in the development of drought management plans, according to Wilhite (2005) are further elaborated below.

Step 1: Appointment of a Drought Managing Body

The Drought Managing Body is aimed at supervising and coordinating the development of the plan and the related activities, mitigation options and response programs, as well as making policy recommendations on how to improve Drought Management Planning. The Drought Managing Body is encouraged to oversee the development of the plan with respect to the changing conditions due to climate change and the impacts of anthropogenic factors. The Structure of this Body should reflect the multidisciplinary nature of drought and its impacts, and, therefore, it should include representatives of the state, research community, and the private sector.

Step 2: Definition of the Purpose and Objectives of the Drought Plan

The overall purpose of a plan is to reduce the impacts of drought by identifying the principal activities, groups, or regions most at risk and developing mitigation actions and programs that alter these vulnerabilities. Therefore, the objectives of the Drought Plan should be defined in the early stages, taking into account issues such as:

- Purpose and role of State government in drought mitigation and response efforts;
- Scope of the plan;
- Identification of the most drought-prone areas;
- Historical impacts of drought in the respective regions;
- Historical response to drought in the respective regions;
- Most vulnerable economic and social sectors;
- Role of the plan in resolving conflict between water users and other vulnerable groups during periods of water shortage;
- Current trends (e.g., land and water use, population growth) that may increase/decrease vulnerability and conflicts in the future;
- Resources (human and economic) that the state is willing to commit to the planning process;
- Legal and social implications of the plan;
- Principal environmental concerns caused by drought.

The plan is, overall, directed at providing the Drought Managing Body with an effective and systematic means of assessing drought conditions, developing mitigation actions and programs to reduce risk in advance of drought, and developing response options that minimize economic stress, environmental losses, and social hardships during drought.

At this stage the objectives of the Drought Management Plan should be clearly defined so as to allow:

- Collecting and analysing drought-related information in a timely and systematic manner;
- Establishing criteria for declaring drought emergencies and triggering various mitigation and response activities;
- Providing an organizational structure and delivery system that assures information flow between and within levels of government;
- Defining the duties and responsibilities of all agencies with respect to drought;
- Maintaining a current inventory of programs and plans already in place for assessing and responding to drought emergencies;
- Identifying drought-prone areas and vulnerable economic sectors, individuals, or environments;
- Identifying mitigation actions aiming to address vulnerabilities and reduce drought impacts;
- Identifying and providing mechanisms to ensure timely and accurate assessment of drought's impacts on agriculture, industry, municipalities, wildlife, tourism and recreation, health, and other areas;

- Providing information to the public on current conditions and response actions (e.g., press, media and the World Wide Web);
- Establishing a strategy to overcome obstacles related to the equitable allocation of water during shortages and establishing requirements or providing incentives to encourage water conservation;
- Establishing a set of procedures for the continuous revision and impact evaluation of the Drought Management Plan.

Step 3: Stakeholder Participation and Conflict Resolution Processes

Social, economic, and environmental values often compete in water use, especially when the problem of scarce water resources intensifies. The groups to be involved in the Drought Planning process should be engaged in the early stages of planning so as to express their concerns and ideas on mitigation options and collaborative solutions.

Although the level of stakeholder involvement may vary notably among regions, the power of public interest groups in policy making is considerable, as they are those who are mainly affected by the impacts of drought and are the arbiters of success and failure of the Drought Management Plans.

Step 4: Development of Resource Inventory and Identification of Groups at Risk

An inventory of natural, biological and human resources should be developed so as to enable defining their vulnerability in periods of water shortage; the constraints faced in the planning process and in the implementation of the plan should also be taken into account. The term natural resources primarily refers to information related to the location of water sources, the biological resources correspond to the quantity and quality of grasslands/rangelands, forests, wildlife etc., and human resources include the labour needed to develop water resources, lay pipeline, haul water and livestock feed, process citizen complaints, provide technical assistance, and direct citizens to available services.

In drought planning, the transition from crisis to risk management is difficult, as the risk associated to drought is not always understood and addressed. In this respect, it is important to identify the high risks before drought occurs, by identifying the location at risk and its vulnerability to drought (Blaikie et al., 1994).

Step 5: Development of Organizational Structure and Preparation of the Drought Plan

This step describes the process of establishing relevant groups aimed to develop and write the drought plan, as well as develop the necessary organizational structure to carry out its responsibilities. The drought plan should have three primary components: monitoring, risk assessment, and mitigation and response. The group should undertake their own tasks and goals in preparation of the plan while ensuring communication and information flow among them and with the actors involved. Developing the mitigation and response options should be done in close collaboration with the risk assessment group so as to enable coming up with short term responses implementable during drought and long-term mitigation projects. In addition, a drought monitoring system should be developed to enable for monitoring climate and water supplies and identifying potential shortfalls.

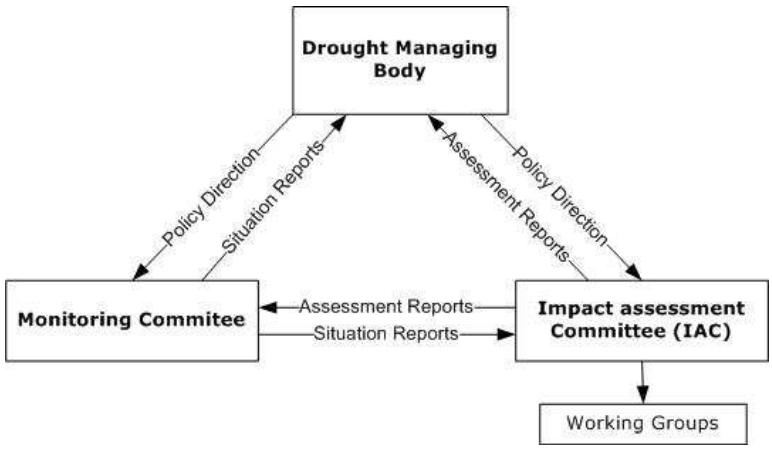


Figure 6: Organisational structure for developing and implementing DMPs (Wilhite et al, 2005)

Step 6: Integrating Science and Policy and Addressing Institutional Gaps

An essential aspect of the planning process is achieving integration of the science and policy aspects. The understanding of policy makers regarding scientific issues and technical constraints, as well as the understanding of scientists on the existing policy constraints are limited. Efforts should, therefore, be made so as to enhance communication and understanding between the science and policy communities, if the planning process is to be successful. The integration of science and policy during the planning process will enable setting research priorities and taking into consideration various alternatives on how to better succeed in bridging gaps among these groups so as to maintain a strong working relationship.

Step 7: Publication of the Draft Plan and Public consultation

The public should be constantly informed on the developments regarding the different stages of preparing a drought management plan so as to be able to express concerns and form recommendations. Public suggestions should be sought on how the drought plan is expected to minimise impacts of drought, economic effects, social and environmental consequences, as well as to reduce the cost for the implementation of each option and enable changes in behaviour regarding water use. During drought the Drought Managing Body should closely work with public information professionals to keep the public well informed of the current status of water supplies, and of the recommended responses.

Step 8: Plan Implementation

The Drought Managing Body has the task to oversee the implementation of both the short-term operational aspects of the plan and the long-term mitigation measures. Periodic testing, evaluation, and updating of the drought plan will help keep the plan responsive to the current needs. Evaluation keeps track of societal changes in matters of new technology, research, legislation, as well as on drought risk due to climate change and anthropogenic parameters.

Step 9: Development of Awareness and Education Programmes

Education programmes would have to be designed aiming not only to raise public awareness of the development and implementation of Drought Management Plans but also to ensure that people are aware of way to respond when drought occurs. The information provided should be tailored to the needs of stakeholder groups and would ideally be presented through press and various events.

Step 10: Post-Drought Evaluation

The post-drought evaluation or audit documents and the assessment of the Drought Plan response actions, implementation and results, provides for a mechanism to support learning from past successes and mistakes and to form recommendations for improving the system.

Post-drought evaluations should include: an analysis of the climatic and environmental aspects of drought; its economic and social consequences; the extent to which pre-drought planning was useful in mitigating impacts, in facilitating relief or assistance to stricken areas, and in post-recovery; and any other weaknesses or problems caused or not covered by the plan. Attention must also be paid to situations where there was social resilience in adapting to drought-coping mechanisms. Non-governmental organisations can play a key role in obtaining unbiased results of the appraisal of Drought Plans (Wilhite et al, 2005).

3.3 Case examples of drought management at regional level

The most common drought preventive options applied in **Greece** concern the construction of small scale dams and the improvement of water supply networks, with the emphasis placed on the modernization of irrigation networks and the minimization of losses. On the other hand, reactive measures include water conservation, water transfers, supply augmentation with groundwater resources, use of brackish water and reallocation of water resources, according to the priorities defined in the corresponding legislation (MEDROPLAN, 2007).

Indicative is the case of the drought faced by the city of Athens in 1990 and 1993. The corresponding drought episodes significantly affected the drinking water supply of the Athens metropolitan area. To address the situation, a series of measures were launched, both short-term and long-term. These resulted in a 25% reduction of water demand; furthermore, an additional storage reservoir in River Evinos of Western Greece, to complement the already significant hydraulic schemes supplying Athens, and to enhance water security against future episodes (Karavitis, 1998). In more detail, applied options included:

- Short-term options:
  - Penalties for excessive water use;
  - Water conservation measures combined with public information campaigns;
  - Increase of water tariffs;
  - Emergency water hauling;
  - Supply augmentation measures, through the use of groundwater reserves.
- Long-term options:
  - Construction of a new dam in Evinos river;

- Launch of a leakage reduction and loss minimization programme.

Drought planning in the **Garonne Basin, France** was defined with the objectives to conciliate conflicts in water use and ensure environmental protection. A Drought Management Plan was developed in 2003, in consultation with the Adour-Garonne Water Agency, the French Energy Company, EDF[3], as well as other key players involved in regional water management. This plan is detailed in the"PGE - Plan de gestion des Etiages, Vallée de la Garonne et bassin de l'Ariège" ("DMP - Drought Management Plan, Valley of the Garonne and the Ariège catchment", Collectif, 2004), and has the following objectives:

- Conciliate water uses, while respecting ecological needs and constraints;
- Recover natural low flow and reduce the risk of water shortage;
- Ensure consistent water management at the River Basin level, and
- Ensure equitable allocation among the different water uses.

The drought monitoring network involved the selection of five (5) discharge monitoring points along the Garonne River. An additional point was selected in the Ariège River, downstream six (6) main large reservoirs with capacity higher than 3 Mm^3. For each monitoring point, four (4) specific discharge thresholds were defined to characterise the severity of low flows, which would signal the need for mitigation and emergency actions:

- The DOE (Débit Objectif d'Etiage) is the "target discharge", representing the minimum flow necessary for the protection of the ecosystem, as well as the threshold under which low flows impact economic activities. Its value is close to the annual minimum 10-day flow with a 5-year return period;
- The DCR (Débit de CRise) is "the crisis discharge", under which water abstraction for irrigation purposes is not allowed. Additional restrictive measures can be adopted to limit industrial outflows and water abstraction, while preserving drinking water and sustaining water levels by supplementary releases from the reservoirs;
- Two additional critical low flow warning levels, derived from the DCR and the DOE thresholds are:
  - The QA, equal to 80% of the DOE, which corresponds to a "medium level" (alert threshold), and
  - The QAR, equal to DCR + (DOE-DCR)/3, corresponding to a "high level" (strengthened alert level).

Observed mean 5-day discharges (Q5) are compared to the above warning levels. If the last observed Q5 is below QA and DCR levels, specific restrictions predefined for these levels are applied. Such restrictions are lifted when Q5 exceeds both levels and when a positive trend in discharge evolution has been observed during the previous two days.

Each year, performance indicators are recomputed to check if the Garonne-DMP was well implemented and efficient in preventing water shortage in the River Basin. These indicators include the number of days below the four critical thresholds and the annual minimum 10-day streamflow at each flow monitoring station, computed with and without intervention. For example, in 2003 the Garonne-DMP demonstrated its ability to face severe droughts:

[3] *The EDF is one of the major stakeholders in the catchment, responsible for the management of several reservoirs in the Pyrenees.*

15 Mm^3 were released from the upper reservoirs to sustain water levels downstream, reducing the number of days with daily discharges below the DCR critical level from 30 (number of days that would have been observed without the release) to 20 days (SMEAG, Info Garonne n°6, October 2003).

Box 13: Water management under drought conditions in the Pangani Basin, Tanzania

In the Pangani Basin, Tanzania, conflicts over water use are frequent and can be expected to exacerbate under increasing drought conditions. The new management approach for the River Basin, developed by Government, has been prepared with the help of a number of local and international environmental organisations, including IUCN, and introduces a new approach in the management of the Pangani water resources.

The activity includes the detailed assessment of natural resources and their links to the social and economic value of the River's resources. Scenarios on possible water management options are developed with the participation of water authorities and stakeholders. Each scenario describes the potential consequences of a development pathway, in terms of changes in the state of the river, the economics of the natural resources, hydroelectricity production, irrigated agriculture, and social impacts. Projections of how flows would be affected by global climate change, including drought, are incorporated among scenario variables.

The second, ongoing, step of the project should see the creation of local fora to aid in conflict resolution and coordinate water management at the sub-basin level. These fora can further become a channel for local users to make recommendations on water allocation to the Pangani Basin Authority. Furthermore, the implementation of the 2002 policy was fostered through the formation of Water Boards at different levels. In more detail, the Pangani Basin Water Office reports to the Pangani Basin Water Board, which includes representatives from governmental departments, representatives of the private sector and NGOs, with nominal representation by community interests. The Board's task is to advise the Basin Water Officer on different matters, including the measures to be taken in case of drought.

The Pangani Basin Water Office (PBWO) is theoretically administratively and financially autonomous. Similarly to the entire country, fees are to be collected from licensed users. Studies are planned to define fees in a way that takes into account the economic value of water, as this will differ among basins. However, still, many water users believe that water is a 'gift from God', and refuse to pay for their use rights, even though the corresponding rates are very low. In this regard, the PBWO faces serious financial difficulties, also because the pertinent legislation does not include provisions for this case. As a result, almost 60% of the annual fees for water use rights fail to be settled.

Sources: Sarmett & Kamugisha, 2002; IUCN Eastern Africa Programme, 2003

Along the same lines, the **River Po Basin Authority, Italy,** has succeeded in developing a management model to address water crises affecting the Po River Basin, moving from a fragmentary and reactive to integrative and preventive management approach (Autorità di bacino del fiume Po, 2004). From 2003, an evolving drought episode, whose first impacts affected summer energy production due to lack of water for cooling purposes, motivated the initiation of processes for drought management. A local forum held at the time led to the establishment of a Direction Group, involving all institutions dealing with water management in the area, under the coordination of the Po River Authority. The outcome of this process, which was based on the collaboration of all institutions and actors, was an Agreement Protocol for Water Management in the Po River Basin (Gestione Unitaria del

Bilancio Idrico del Bacino Idrografico del Fiume Po). The Protocol defined rules and actions for every actor, with the objectives to ensure minimum flow, from the lakes of the Basin, for irrigation and in the Po River itself, and adequate flow to guarantee the maximum electricity production from thermal power plants. Moreover, the Protocol described actions for the efficient use of the alpine water resources, which, in fact, are the only manageable resources of the area. Measures included the increase of releases from the alpine hydroelectric reservoirs, the direct transfer of the additional releases towards the lakes, and the reduction of withdrawals. These measures proved successful in stopping the decline of the Po River levels, allowing the normal operation of the thermal power plants and the continuation of withdrawals at pre-drought levels. Subsequently, the system was further developed to address not only exceptional water scarcity but also water management under normal conditions. Efforts were made to centrally coordinate the monitoring of water availability and the regulation of lakes, also by developing technical and information support (short and medium term forecasts, including drought indicators and event evolution scenarios, and numerical simulation models). Although some problems still exist, the Protocol was successfully applied in 2005 and in 2007, thus confirming the positive results obtained in the previous period, also in terms of communication among actors and territorial agencies (Ministero dell'Ambiente, 2007). Problems primarily concern the insufficient decisional powers of the Direction Group. This is partly due to conflicts with the national legislative framework: when a state of drought emergency is declared, the (basin based) Direction Group should entrust the National Department of Civil Protection with the planning and the application of required action.

Another important issue concerns the preservation of environmental flow during a drought episode. In the **State of Victoria, Australia**, environmental flows are recognized as a legitimate and essential part of the State's water allocation framework. The decision making process has established a range of priorities for natural resources and biodiversity, which has to be reconciled with the vital interests of farmers depending on irrigation. The State of Victoria is currently considered a leading State in Australia, particularly with regard to the formulation of policies and the implementation of actions to maintain river ecological flows. In very dry periods, an environmental watering programme is initiated, focusing on the survival of key species, so that when conditions improve, plants, animals and habitats are still able to recolonise and recover. This programme manages key sites, which are identified on the basis of the following criteria, ranked in order of importance:

- Avoidance of critical loss of threatened species and communities,
- Avoidance of irreversible loss or catastrophic events and
- Protection of habitats.

In all cases, environmental flows originate from two main water sources that do not impact on water allocation for irrigation and potable supply, and are reduced along with the allocation to other water use sectors.

3.4 Planning for drought in transboundary river basins

The preparation of drought management plans and the implementation of mitigation options is more complex in the case of transboundary waters. In the case of the Meuse River Basin, a decision support system facilitated the joint development of a drought management

strategy between Belgium and the Netherlands. In the case of the Rhine, the threat of low flow regimes, which in turn create problems to navigation, motivated the establishment of an International Commission, bringing together stakeholders from all the countries concerned.

In **Belgium and the Netherlands**, periods of low discharge in the Meuse River can induce serious crises in Dutch and Flemish regions. Until recently, the understanding of these events and the awareness of their impact was rather poor. Water management in Flemish regions focused primarily on flood prevention, until a minor water shortage occurred in the summer of 2003. The episode demonstrated the need to enhance knowledge on the potential impacts of low discharge. In this regard, an inventory of water fluxes and water users in the Flemish, Meuse-dependent canal system was made, based on literature, field research and measurements, and topography. On the basis of this assessment, water users were selected to be interviewed on their dependency on Meuse waters, their water use patterns and their perceptions towards certain measures. A workshop was also organized to get feedback on the information received and to inform water users about the outcomes of the assessment. Next, a water balance model was developed for the system, using the MIKE Basin software, integrating all gathered data and information. The model was used to simulate the water system and the dependent water supply and use chain. Water use was estimated using daily water-chain values of 2002, while input on the water system (Meuse discharge and local meteorology) reflected a historical water shortage period. The model evaluates whether the Flemish region fulfils the stipulations of the Flemish-Dutch Meuse treaty at a given Meuse discharge. If the Flemish water demand is very high, a low-flow strategy is applied to reduce the Flemish water use. Different alternative low-flow strategies have been evaluated based on indicators reflecting economic impact and the number of days of certain non-quantifiable impact. The developed model enhanced knowledge on the dependency of the Flemish region on water from the Meuse and identified possible measures to lower this dependency during water shortage periods (EC, 2007c, p.72).

For the **Rhine**, an International Commission for the Hydrology of the Rhine Basin (CHR) was established in order to improve the efficiency of water management in the river basin. The CHR works within the scope of the International Hydrological Program of UNESCO and the Hydrology and Water Resources Programme of WMO, with the participation of Switzerland, Austria, Germany, France, Luxembourg and the Netherlands. It brings together hydrological and water resources research institutes of the Rhine countries and supports transnational hydrological projects addressing different research themes. The CHR's mission and tasks concern the expansion of knowledge on the hydrology in the Rhine basin, in order to provide support for the resolution of cross-border water management issues. The CHR has often dealt with low flows in the Rhine basin; the issue further emerged during a workshop on “Low flows and droughts” in September 2007 (CHR-IHP/HWRP Wasser- und Schifffahrtsdirektion Süd in Würzburg, 2007). The workshop was jointly organised by UNESCO, CHR and the German IHP/HWRP National Committee and addressed three main topics: observed low flow and dry periods, potential implications of climate change, and management and adaptation strategies. Emphasis was placed on seasonal predictions and real-time forecasts (including water temperature), prediction at non-monitored sites, risk and crisis management, and the role of stakeholders and the public in decision-making processes.

The following aspects were highlighted:

- Drought research and operational applications have been lagging behind when compared to the analysis of flood-related aspects. There is urgent need to address emerging issues in drought research and management and to interact with the scientific and management communities, as well as policy-makers and the public at large, to raise awareness about potential drought hazards.
- Still no adequate and adapted drought forecasting tools exist.
- It is anticipated that climate change will result in more frequent and more severe drought episodes. An increase of the variability of meteorological events is to be expected at regional level, thus leading to greater uncertainty in scientific forecasts.
- The selection of appropriate measures to address drought and mitigate its potentially significant social, economic and environmental impacts remains central.
- Regional differences in vulnerability to drought episodes are of great importance, both in terms of research and in terms of planning.

3.5 In summary: Key issues and challenges

- Drought, as a natural phenomenon, represents a deviation from normal climate conditions. In this regard, all countries can eventually experience a drought event and should thus be prepared for drought.
- The selection of the set of indicators describing a drought episode and its severity (i.e. of the critical drought thresholds, describing alert and crisis situations) is critical. There is a general agreement that these thresholds and their use in local plans need to be revised. Different methods exist and have already been applied; there is however support for developing harmonized methods and for the definition of clearer methodologies to be used as reference nationwide or, at least, region-wide. Emphasis should be placed on the improvement of the monitoring of water flows and availability at the River Basin level, to account for existing and changing hydrological conditions, uses, capacities of reservoirs and other factors affecting water availability.
- The lack of an objective definition of critical streamflow thresholds can create confusion among users, as these are used for design, diagnostic and policy purposes. In practice, there are cases when the defined thresholds are not fully taken into consideration, as these are not accepted by some actors. Furthermore, thresholds are usually defined without considering the associated uncertainties. The issue becomes more important when thresholds are evaluated at (few) selected flow monitoring stations and then extrapolated to the entire catchment. Upstream-downstream interactions and their spatial variability in real-time conditions are difficult to assess and can generate conflicts between users and water managers. This occurs, for example, when, during drought periods, flow measurements indicate that critical thresholds have been reached. Then, according to the provisions of a DMP, restrictions are to be imposed to the entire area, (i.e. the whole catchment or the administrative department). It is often the case that water users of other (unmonitored) sites in the vicinity are not aware of the critical situation; as such, they cannot understand why restrictions in water use are to be applied also in their areas, a fact that can create conflicts between users.

- As with RBMPs, the process of developing Drought Management Plans should engage all actors and stakeholders involved in water management in the area concerned. Information sharing and public sensitization are also important for the implementation of drought mitigation options, thus improving the effectiveness of DMPs.
- Although the WFD provisions allow temporary deviations from environmental objectives in the case of exceptional or unforeseen prolonged droughts, these are to be reported in the River Basin Management Plans required by art. 13. Furthermore, Member States should define the relevant restoration measures. In this regard, it is important to assess potential impacts on water-dependent ecosystems, and ensure, as far as possible, that the corresponding environmental damage can be mitigated after the end of the drought.
- In the case of transboundary River Basins, international cooperation is required for impact minimization and effective action. Necessary elements of cooperation among neighbouring countries include information sharing, joint research programmes, as well as elaboration of agreements for the allocation of water resources during drought episodes and development coordinated action plans.

4 Assessing Water Scarcity Impacts and Policy Instruments in the EU –Two Surveys

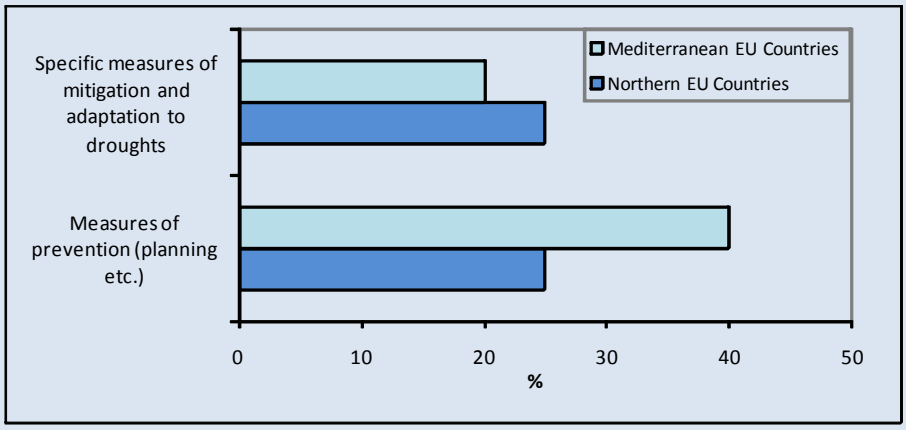
4.1 The EUWI survey on water scarcity and drought

The Water Scarcity and Drought related issues in the EU were addressed within the framework of the EU Water Initiative; in 2006 the EC has undertaken an extensive assessment of the levels of preparedness and adaptation to water scarcity and drought management plans within the EU Member States. Two more surveys, through WISE and EMWIS are presented in Box 14. This section focuses on presenting the results of the EUWI survey, which was addressed to stakeholders and interested parties, and was aimed at assessing and combining expert and local knowledge on how to better cope with water scarcity and drought.

The EUWI assessment was implemented using questionnaires in two rounds: pre- and post awareness. The pre-awareness survey (First Questionnaire) aimed at assessing the scale, causes and impacts of water scarcity and drought, as well as the use of policy instruments for the minimization of impacts. The post-awareness survey (Second Questionnaire) aimed at gathering and analyzing experiences on drought management at national level.

Box 14. Surveys on Water Scarcity and Drought through WISE and EMVIS

Within the framework of the WISE system (Water Information System for Europe) and within the framework of developing a Water Scarcity and Drought Indicator System (WSDIndiS), the EEA commenced a survey, which, among others, covered the issues of: a) research initiatives and projects undertaken by the Member States; b) the existence of drought management plans; and c) economic incentives for drought risk management (Kossida et al., 2008). Preliminary results were presented in the 2008 EEA Workshop on "Water Quantity and Use".



The WISE Survey results on Drought mitigation measures in EC Mediterranean and Northern Countries

Another survey addressed to Mediterranean Countries was undertaken by the Mediterranean Water Scarcity and Drought Working Group. The survey covered the issues of (i) scope and impacts of droughts, and (ii) proactive and reactive measures taken to cope with water scarcity and droughts (EMWIS website, 2007).

Overall, the main outcome of this process was the development of a set of policy priorities, as specified in the Communication Document COM (2007) 414 (EC, 2007b). The results formed also the basis for producing the 2nd interim report presented to the Water Directors in June 2007 (EC, 2007a).

The pre-awareness survey on water scarcity and drought covered the period 2000-2006 and aimed at gathering information at national (and when possible) at regional level). In total, 18 counties responded[4], providing information on:

- Water scarcity situations and drought episodes (area and affected population, causes, main social, economic and environmental impacts);
- The use of EU funds;
- Water pricing policies or other national instruments; and
- The contribution of the WFD for addressing future scarcity and drought issues.

The post-awareness survey was oriented towards an in-depth assessment of the scope and impact of droughts. The time scale of analysis was extended to the period 1976-2006, using a seasonal time step (spring, summer, autumn, winter). Member States were asked to provide information on deficiencies in precipitation, by comparing seasonal values to the average normal ones, calculated for the period 1961-1990, and the economic impacts of drought events.

The main problem encountered throughout the process was related to limited data availability, resulting from both the lack of integrated and consistent monitoring and reporting mechanisms, and from the lack of methods and tools for specifically evaluating the causes and impacts of drought events.

Table 6 summarises the adopted supply and demand-side options, whereas details on instruments employed by the individual Member States are provided in Annex II. Particularly with regard to water pricing policies, few examples directly aimed at addressing quantitative issues were identified. In addition, some MS mentioned having no water charges for agriculture (EC, 2006).

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[4] Respondent countries included: Austria (Federal Ministry of Agriculture, Forestry, Environment and Water Management), Belgium (Flanders Hydraulics Research, Water division of the Flemish Environment Agency-VMM), Cyprus (Water Development Department of the Ministry of Agriculture, Natural Resources and Environment), Germany (Federal Ministry for the Environment, Nature Protection and Nuclear Safety), Denmark (Danish EPA), Spain (General Directorate for Water, Spanish Ministry of Environment), Finland (South-West Finland Regional Environment Centre), France (Ministry of ecology and sustainable development, Water Agencies), Hungary (Hungarian Meteorological Service), Italy (APAT), Lithuania (Environmental Protection Agency), Malta (Malta Resources Authority), The Netherlands (Ministry of Transport, Public Works and Water Management–Institute for Inland Water Management and Wastewater Treatment RIZA), Norway (Norwegian Water Resources and Energy Directorate), Portugal (Instituto da Água - INAG), Slovak Republic (Slovak Hydro-meteorological Institute), Slovenia (Environmental Agency / Ministry of Environment), England (Department for Environment Food and Rural Affairs - DEFRA).

Table 6. Supply and demand side measures applied in the EU Member states (EC, 2007a)

Supply-side measures	Demand-side measures
▪ Aquifer replenishment ▪ Improvement in the efficiency of the water infrastructure ▪ Preservation of the functioning of natural catchment and aquifers	▪ Development of drought management plans ▪ Reduction of leakages ▪ Incentives for installing water saving appliances ▪ Use of new water efficient technologies in the industrial and agricultural sectors ▪ Natural storage improvement ▪ Promotion of wastewater reuse ▪ Water banks ▪ Awareness campaigns ▪ Water pricing

Recommendations derived from the survey can be summarized in the following:

- Member States should take advantage of the available EU instruments for promoting a water saving culture and investing in water infrastructure projects;
- Emphasis should be placed in demand management rather than water supply enhancement;
- Water pricing policies should reflect the conditions of limited water availability and promote water saving;
- The goal should be to develop a guidance on efficient measures for drought mitigation;
- Drought management efforts should be consistent with the provisions of the Water Framework Directive;
- Climate change impacts should be incorporated in any drought management plans; and
- The collection of information by the Member States should be properly organized on the basis of a core set of indicators.

4.2 Questionnaire survey undertaken within the Xerochore Project framework

A survey on drought management has been designed and undertaken among the Xerochore network and project partners, during the 1st Xerochore workshop on "Drought & Natural System (Climate & Hydrology)", held on 15-17 June 2009, Noordwijkerhout, the Netherlands. The corresponding questionnaire, was designed so as to: a) collect information on existing drought policies at the national level; b) identify drought mitigation options already applied in various countries or regions; and c) define key issues in the development of drought adaptation strategies. It was structured in 5 parts:

- Part A, “General information”, was aimed at identifying the involvement of respondents in drought planning processes, and at assessing the vulnerability of their countries and regions to drought events.
- Part B, “Drought policy issues”, dealt with the presentation and evaluation of national policies for drought management.
- Part C, “Adaptation and mitigation measures”, concerned the identification of drought risk and impact mitigation options.
- Part D, “Research efforts”, allowed respondents to share information on outcomes of drought-relevant research.
- Finally, Part E “Other issues” concerned additional comments or recommendations.

In total, 22 questionnaires were collected and processed. The respondents to the questionnaire mainly represented institutions from European Countries, namely Italy, Hungary, Slovenia, Norway, the UK, France, Greece, Germany, Bulgaria, Spain, Slovakia, France, The Netherlands, Belgium and Turkey, and from Morocco and China. 52% of the respondents came from universities and research institutes, while 33% were employed in public authorities. The remaining percentage corresponds to consultants. 71% indicated that they had extensive experience on drought issues, working in relevant fields for about 6 to 15 years, whereas 64% has already been involved in drought planning process.

Results are presented in the following paragraphs.

4.2.1 Vulnerability to Drought

With regard to vulnerability aspects two main issues emerged as important:

- The assessment of vulnerability in different contexts: Agricultural and lowland areas were identified as the more vulnerable (Figure 7).
- The assessment of the critical factors that increase vulnerability to drought, including climate change, inefficient water management practices and limited investment on water infrastructure (Figure 8).

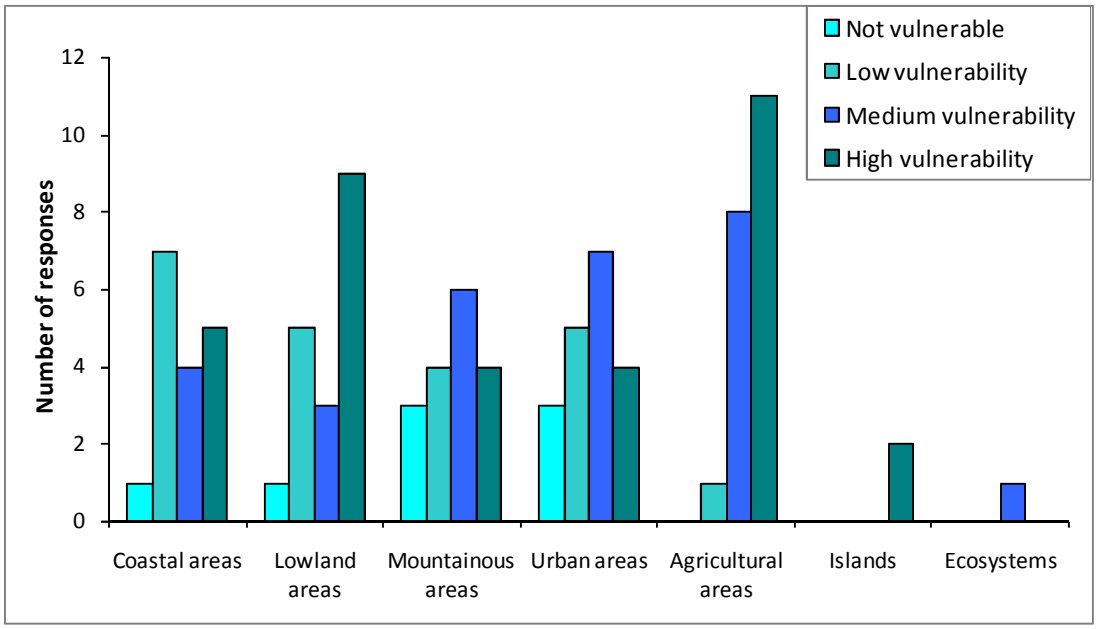


Figure 7: Drought vulnerability assessment for different areas

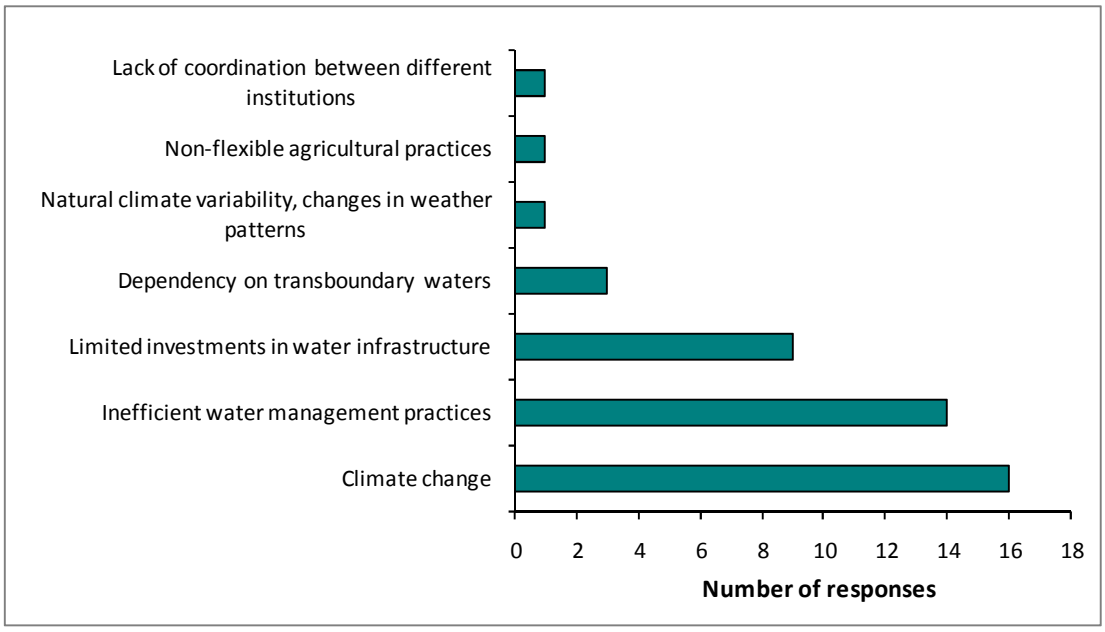


Figure 8: Assessment of factors that can enhance vulnerability to drought

Eleven (11) out of 21 respondents reported that vulnerability assessments have already been undertaken in their countries. These studies were undertaken either within the framework of a research project (e.g. through MEDROPLAN for Cyprus, Greece, Italy, Morocco, Spain and Tunisia), or as a dedicated assessment undertaken by water competent authorities. Examples for the latter include:

- The 1997 and 2003 assessments undertaken by the Hydro-Meteorological Institute of Slovakia on water supply and energy production at national level, and the yearly reports issued by the Ministry of Economy on the status of water resources.
- The report “Drought in Italy, 1988–90”, published by the National Department for Civil Protection, which analysed issues relating to water shortages experienced during the 1988-90 drought period, addressing agriculture, energy production and urban water supply.
- The 2006 Guidance Document issued by the Committee for Combating Desertification of Italy (APAT-CNLSD) for identifying the most drought-prone areas (Linee guida per l'individuazione delle aree soggette a fenomeni di siccità).
- The study undertaken by the Istituto per la Difesa del Suolo (Italy) for the areas at highest risk of desertification (Atlante Nationale delle Aree a Rischo Desertificazione).
- The 2007 Drought Assessment Study, developed by the National Drought Observatory of Morocco, which analysed relevant issues for the National Office for Potable Water Supply (ONEP) and the Hydraulic Basin Agencies.
- The 2003 assessment of drought impacts on hydroelectricity production, undertaken by the Water Resources and Energy Directorate of Norway.
- The studies undertaken in Hungary by the Ministry of Environment (2006) and by the Meteorological Office (2004), addressing environmental protection and agriculture respectively.

- The 2006 assessment undertaken by the Environment Agency of Flanders and the Flanders Hydraulics Research Centre for navigation, recreation, agriculture and ecosystems.
- Publications of the Rykswater-staat, the Netherlands, issued during the period 1999-2005, and addressing vulnerability of agriculture, energy production, environment, navigation.

4.2.2 National Drought Policies

Most survey respondents (11 out of 22) indicated that they are not aware of the existence of a drought policy in their country. Nevertheless, some provided information on active policy components for drought management. Only 8 persons indicated the existence of a national drought policy for Bulgaria, Italy, Spain UK, France and the Netherlands. A summary of responses is presented in Table 7.

Table 7: Assessment of national drought policies

Active policy components	Is there a national drought policy?			Countries with drought policy
	Yes	No	Not aware	
Establishment of committees for the analysis and evaluation of drought related data	5	2	1	IT, UK, ES, FR, NL
Definition of a drought declaration process	5	1	1	IT, ES, FR, NL
Definition of relief programs (process for implementing compensation measures)	6			BG, IT, ES, FR, NL, UK
Setting the drought planning framework (responsibilities for developing and implementing drought management plans)	5			UK, ES, FR, NL
Integration with other (national) policies	4			ES, FR, NL, UK
Research & Development on relevant issues	6	2	1	IT, UK, ES, FR

The identified weaknesses of drought policies primarily concerned the following aspects:

- The focus on a crisis rather than a risk management approach;
- The fragmentation of responsibilities among the different agencies;
- The lack of implementation mechanisms, e.g. in Hungary, where, although three drought management plans have been developed, none has been implemented;
- The emphasis placed on surface water resources, and the lack of integration of groundwater-relevant issues; and
- The insufficient targeting of drought recovery.

4.2.3 Drought Planning and Mitigation Approaches

Three aspects of drought planning were outlined in the questionnaire survey:

- Drought planning components (forecasting, early warning, development and review of management plans);
- Recommendations for improving the existing drought management efforts; and
- Drought mitigation options.

In most countries, drought is addressed through a crisis management approach. As a result, there are no structured processes for determining the onset of a drought event and for evaluating potential impacts. This is also indicated by the responses of participants concerning elements of drought planning and management:

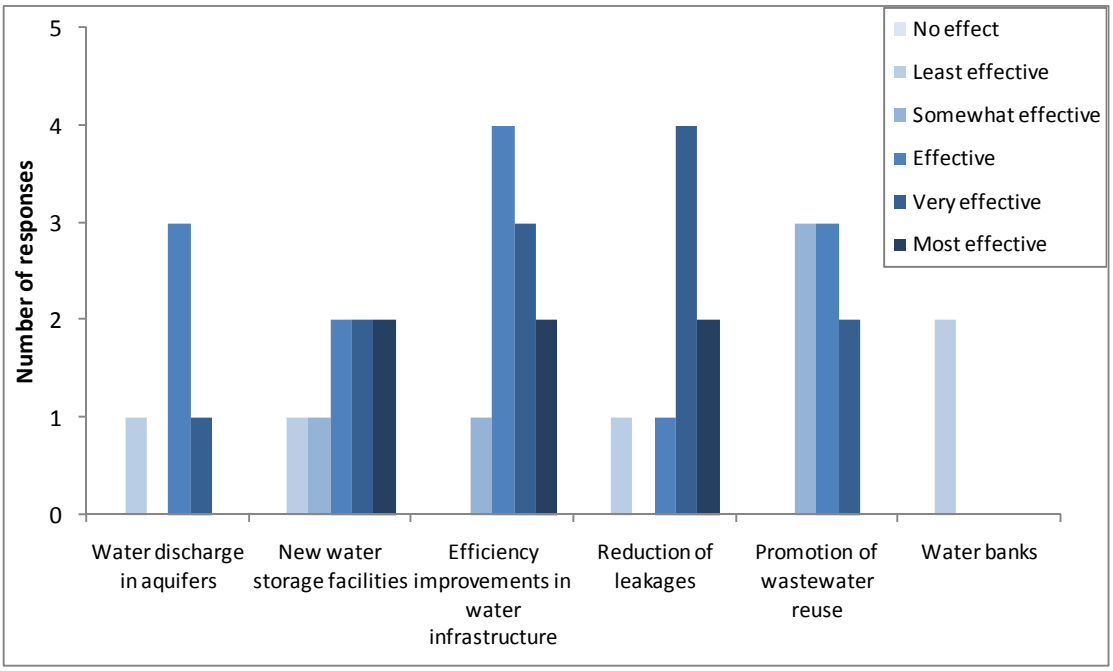
- Drought forecasting: 5 positive replies (Italy, Norway, Morocco, Spain, Netherlands);
- Early warning systems: 9 positive replies (Italy, Norway, China, Slovenia, Turkey, Spain, France, Netherlands, UK);
- Drought management plans: 7 positive replies (Italy, China, Morocco, Spain, France, Netherlands, UK);
- Processes for the evaluation and review of the plans: 4 positive replies (Spain, France, Netherlands, UK).

Particularly with regard to drought planning processes, the following issues were identified as critical:

- The establishment of monitoring and early warning systems;
- The development of drought management plans, supplementary to river basin management plans, based on drought assessment studies;
- The understanding of drought processes and drought impacts on different sectors;
- The use of drought indicators, particularly for drought characterization at different spatial scales;
- The adoption of risk management approaches;
- The application of top-down approaches in crisis management;
- The improvement of participatory processes and the strengthening of links between policy/decision makers and scientists; and
- The review of legislation in order to account for drought risk.

Respondents were also asked to assess the effectiveness of already applied or planned mitigation options in their countries. The most commonly implemented options concerned water pricing, restriction on water use and awareness campaigns. With regard to drought planning, most respondents indicated options aimed at supply enhancement (e.g. new storage facilities, aquifer replenishment, improvements in water infrastructure).

Figure 9 illustrates the ranking of drought mitigation options, using a scale from 1 and 5, with 1 corresponding to the least and 5 to the highest positive effect. Two respondents indicated that awareness campaigns have no effect as a drought impact mitigation option, whereas new water storage facilities, efficiency improvements in water infrastructure, leakage reduction and water pricing were identified as most effective.



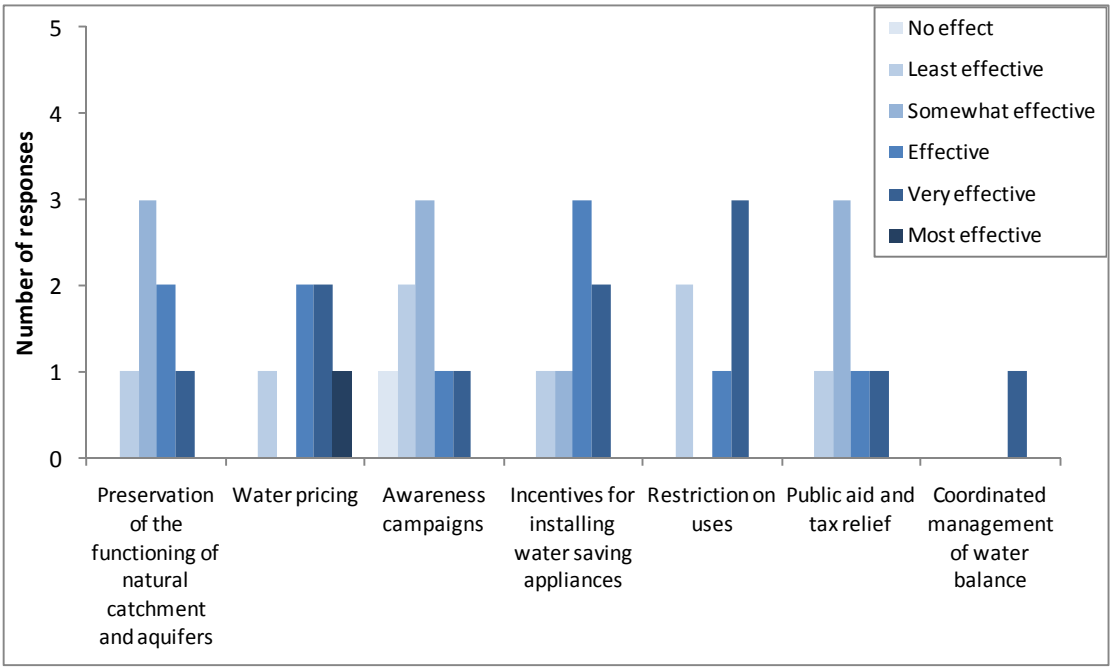


Figure 9: Assessment of the effectiveness of drought mitigation options

Factors that are identified as most critical for the successful implementation of mitigation options concern:

- Legislation enforcement and cooperation/coordination of agencies;
- Public participation in planning and management as well as provision of incentives for the implementation of options by stakeholders;
- Development of drought management plans that define activities and responsibilities in case of drought;
- Integrated implementation of several mitigation options;
- Holistic assessment of the impact of human activities on water bodies and definition of priorities in water use;

- Improvement of knowledge on drought, also through the establishment of monitoring and early warning systems; and
- General improvement in water management and capacity building.

4.2.4 Drought-related research

Table 8 presents the drought related research projects that were noted by the respondents. Most of these are EU-funded, whereas only two are ongoing (i.e. WATCH and MIRAGE).

Table 8: Drought related research projects

Acronym	Title	Financial instrument
ASTHyDA	Analysis, Synthesis and Transfer of Knowledge and Tools on Hydrological Drought Assessment through a European Network	FP 5, 2002-2004
WATCH	Water and Global Change	FP 6, 2007-2011
HYDROGRAM	-	National -Slovakia
FRIEND	Flow Regimes from International Experimental and Network Data	UNESCO
DSS-DROUGHT	A decision support system for mitigation of drought impacts in the Mediterranean regions	INCO MED, 1997-2001
WAM-ME	Water Resources Management Under Drought Conditions: Criteria and Tools for Conjunctive Use of Conventional and Marginal Waters in Mediterranean Regions	INCO MED (2), 2000-2003
MEDROPLAN	Mediterranean Drought Preparedness and Mitigation Planning	EU MEDAWATER, 2003-2007
PRODIM	Proactive Management of water systems to face drought and water scarcity in islands and coastal areas of the Mediterranean	INTERREG IIIB ARCHIMED, 2006-2007
MIRAGE	Mediterranean intermittent river management	FP7, 2009-2011
SEDEMED II	Sécheresse et Désertification dans le bassin Méditerranée II	INTERREG IIIB MEDOCC, 2004-2006
ARIDE	Assessment of the Regional Impact of Droughts in Europe	FP4, 1998-2000
-	Trends of aridity and human adaptation over northern China	National -Ministry of Science & Technology, 2006-2010
WETWIN	Enhancing the role of wetlands in integrated water resources management for twinned river basins in EU, Africa and South-America in support of EU water initiatives	FP7, 2008-2011
GRAPES	Groundwater and river resources action programme on a European Scale	FP4, 1996-1999

In addition to individual projects, respondents also noted the existence of dedicated centres for drought-related research:

- The Drought Management Centre for Southeastern Europe (DMCSEE), founded by the WMO and the UNCCD, coordinates and facilitates the development, assessment, and application of drought risk management tools and policies in South-Eastern Europe with the goal of improving drought preparedness and reducing drought impacts.
- The "International Centre for Traditional Knowledge against desertification and for a sustainable future in the Euro-Mediterranean", operating with the support of UNESCO-BRESCE, focuses also on Drought Planning and Management.

Predominant fields for further research, as identified by respondents concern drought prediction and forecasting, and integrated water management under drought conditions. Specific thematic areas concern:

- Drought impacts on water resources;
- Drought prediction and forecasting, taking also into account the effects of climate change;
- Evaluation of drought mitigation options in terms of applicability and efficiency;
- Impacts of human activities/policies that increase vulnerability to drought;
- Development of Drought Atlases at national/European level;
- Development of drought risk indicators of value for water management;
- Integrated decision making processes (from early warning to the implementation of developed management plans);
- Analysis of the relationship between river basin properties and climatic vulnerability to drought;
- Integrated management (water supply and demand oriented measures, land-surface water-groundwater, water management rules);
- Development of databases;
- Analysis of vulnerability to drought;
- Alternative water resources (desalination, waste water reuse);
- Analysis of the spatial extent and time variation of drought; and
- Economic analysis of drought impacts.

4.2.5 Water Management and Drought

The severe impact of drought on water availability requires integration of drought risk in water resource planning, in order to avoid as much as possible severe water shortage, and minimize adverse impacts. In this regard, issues of relevance concern the development of long-term adaptation strategies, and the development of water allocation schemes, addressing both short-term objectives (during a drought) and broader goals. Currently applied approaches for managing drought risk are presented in Figure 10, which indicates the prevalence of reactive over proactive approaches.

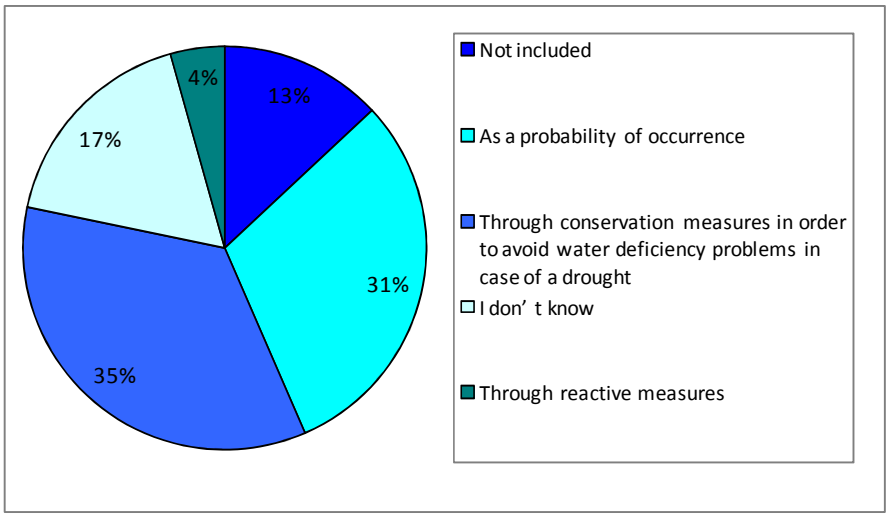


Figure 10: Currently applied approaches for addressing drought risk in water management

Furthermore, Figure 11 illustrates priorities for water allocation between different water use sectors (Domestic, Industry, Agriculture, Energy production, Environmental protection and recreation) in the different countries. Overall, emphasis is placed in securing drinking water supply.

Respondents further indicated several critical factors for the development of water management adaptation strategies:

- The existence of a legislative framework that promotes preparedness for drought and defines responsibilities among the institutions involved;
- The analysis of the current state of the water system (e.g. water resources assessment, water demand, infrastructure);
- The use of reliable data and appropriate tools for assessing alternative management practices;
- The evaluation of the already applied mitigation options;
- The continuous update of data and information concerning drought risk (drought forecasting, triggers);
- The involvement of stakeholders in planning and the realization of awareness campaigns;
- The analysis of interdependencies among water use sectors and between neighboring countries;
- The promotion of alternative sources (desalination, recycle, reuse);
- The integrated land and water management;
- The analysis of climate change impacts on water resources as well as the interrelationship between environmental protection and water management; and
- Adequate access to financial resources.

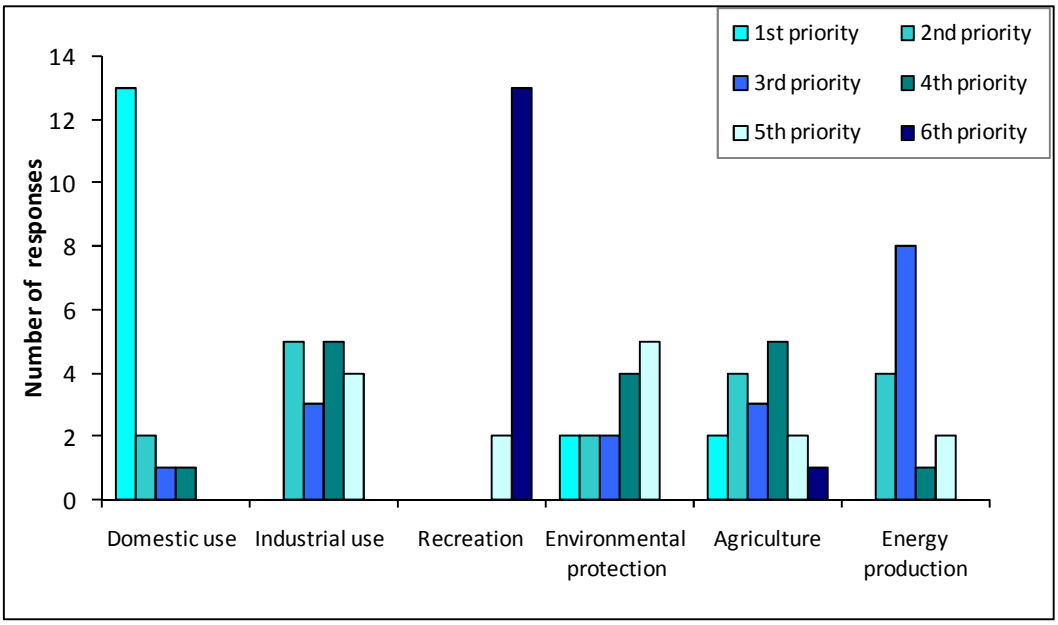


Figure 11: Priorities in water allocation under drought conditions

4.2.6 Summarising the main survey outcomes

The results of the Xerochore survey are indicative of current drought planning process. In most countries, drought is primarily addressed as a natural hazard rather than a risk. Even in drought-prone countries drought policy or management plans have not been developed. This shortcoming is mainly attributed to the limited knowledge on drought occurrence and impacts, and the lack of post-drought evaluation processes.

Elements of drought planning that should be improved include:

- The development of drought policies that promote risk-based management, define responsibilities among agencies, establish operational mechanisms and encourage participatory planning;
- The implementation of forecasting and early warning systems, based on well defined and accepted indicators;
- The development of a knowledge base on drought mitigation efforts. Post-drought evaluations are of critical importance for recognizing the successes and failures of applied plans and mitigation options;
- The compilation, review and update of drought management plans, which should also be integrated in the process of developing River Basin Management Plans.
- The promotion of research to address emerging decision-making needs.

PART B:

RESEARCH ON DROUGHT ASPECTS

5 Research in support of drought planning and management

5.1 Introduction: The science-policy interface

The development of a strong interface between policy-making and research is a critical factor for the successful application of drought management strategies and plans. Reliable and objective information is the key point of an "evidence-based policy making". This approach is gaining momentum for developing policies that are *"based on a clear understanding of what works"* (Robinson, 2000). Parsons (2002) further supports that evidence-based policy making should be seen "*as a project focused on enhancing the techniques of managing and controlling the policy-making process"*.

The research and policy-making interface should not be restricted to the simple exchange of data or information, but should be further developed to ensure the use as well as the evaluation of this information. This dynamic process will promote the quality of research, which will be based on validated data, will increase the trust of decision makers on scientific results and will encourage the implementation of research proposals.

Box 15: The need for cooperation between policy makers and researchers

Huberman (1994, p. 22): *"If it takes the research team two years to get hold of its study, conceptually speaking, why should we assume that the reading of a single report in a few days by a colleague or layperson will bring enlightenment?"*

Lomas (2000, p. 141): *"They (the decision makers) arrive at the research community's doorstep with complex questions and urgent deadlines…… It is unlikely that, in the absence of earlier communication of priorities and politically feasible options, any specifically relevant research products will be available…."*

5.2 Research on drought management

Despite the fact that drought and its impacts concern many scientific research fields, from soil erosion, desertification, water quality and quantity deterioration, biodiversity, hydrological modelling to economic and social aspects, it can be useful to cluster drought-related research themes along the drought management cycle of Figure 12.

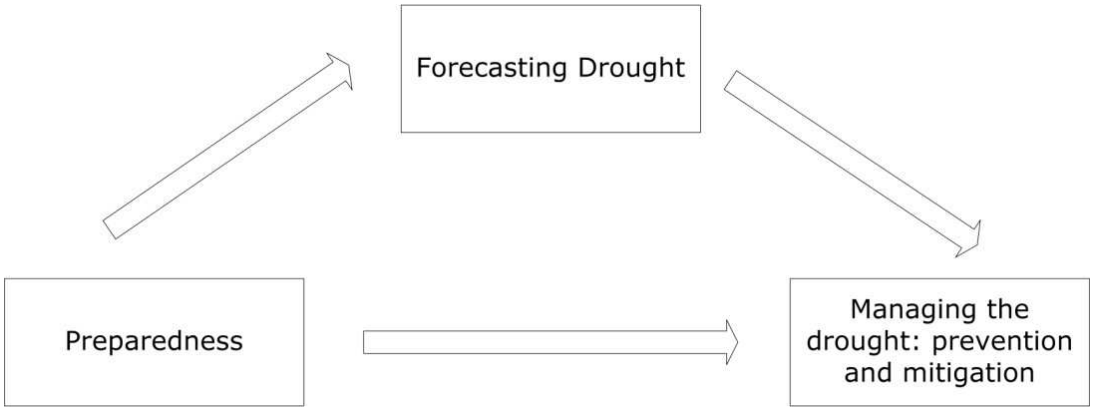


Figure 12: The drought management cycle

In this regard, the following research clusters can be defined:

Drought forecasting

- Early warning systems
- Networks on data collection and analysis
- Development of drought triggers
- Climate change impacts

Drought preparedness

- Planning methodologies that integrate drought risk- Best management practices
- Aspects of drought resilient societies and production systems (e.g. drought tolerant plants)
- Carrying capacity of natural systems (water, land and ecosystems)
- Education and participation of stakeholders in planning for drought
- Impact and vulnerability assessments (long-term and cumulative impacts)
- Policy options (e.g. research networks)

Drought management

- Sector-based decision support for vulnerability and impact assessment
- Evaluation of mitigation actions
- Management practices during drought episodes

In the above context, the following section presents research projects dealing with drought-related issues. The majority of projects has been funded by the European Community, through various Programmes and Frameworks, and mainly addresses processes and tools that can improve water management under drought conditions.

5.3 Research projects related to drought planning and management

5.3.1 Water management during drought episodes

The countries of the Mediterranean Basin are those that are considered as more vulnerable to drought events in comparison to the other European regions and have often been used as case studies for evaluating drought management efforts. Emphasis is given mainly to the development of methodologies that will enable Governments or organizations to prepare drought management plans. Examples of projects include the MEDROPLAN (2003-2007, MEDA Programme), the PRODIM (2006-2007, INTERREG IIIB ARCHIMED Programme), and the MEDMAN (2006-2008, INTERREG III Programme) projects which all addressed issues of drought preparedness and proactive planning in Mediterranean areas. In addition to the above, the WAM-ME Project (2000-2003, FP 5, INCO-Med Programme) focused on analyzing the potential for the use of non-conventional water supply sources as means to reduce vulnerability of the agricultural sector to drought events.

Further information on these projects is presented in Table 9.

Table 9: Information on research projects for water management during drought episodes

Acronym	MEDROPLAN	PRODIM	WAM-ME	MEDDMAN
Title	Mediterranean Drought Preparedness and Mitigation Planning	Proactive Management of water systems to face drought and water scarcity in islands and coastal areas of the Mediterranean	Water Resources Management Under Drought Conditions: Criteria and Tools for Conjunctive Use of Conventional and Marginal Waters in Mediterranean Regions	Integrated water resources management, development and comparison of common transnational methodologies to combat drought in the MEDOCC regions
Duration	15/6/2003 – 15/6/2007	1/6/2006-31/12/2007	01/04/2000 - 31/03/2003	01/04/2006 - 31/03/2008
Funding	EU MEDAWATER	INTERREG IIIB ARCHIMED	INCO MED (2) (FP5)	Interreg III
Objectives	To provide Guidelines for Drought Preparedness Plans To provide the framework for the setting up of a Drought Preparedness Network for the Mediterranean countries	To formulate a methodological framework to confront drought and water shortage based on proactive planning	To increase the scientific background and to develop technological tools for improving water resources management and environmental control in drought-prone Mediterranean regions To address the exigency of integrated water management and environmental protection, as already highlighted in the European Commission water policies and directives	To develop an integrated system, able to evaluate the state of surface water and resources of the ground water in MEDOCC areas
Output(s)	Drought Management Guidelines	A methodology for preparing a Strategic Water Shortage Preparedness Plan & Emergency Plan	Criteria for the efficient use of marginal water resources, including the reuse of treated waste water for irrigation and the withdrawal of deep groundwater Development of modelling tools and a Decision Support System (DSS) for the conjunctive use of conventional and marginal waters	Common, innovating methodologies on the analysis of the hydrological data and its cycle, the procedures and potentialities of the uses of water recycled, the management integrated of the water resources and the risk management to fight the drought
References	www.iamz.ciheam.org/medroplan/	www.project-prodim.eu/	www.dica.unict.it/users/fvaglias/	www.meddman.org/

5.3.2 Tools for supporting drought planning and management

The focus of several European funded projects has been placed on the development of monitoring networks and tools to facilitate decision-making by assessing vulnerability under different scenarios of water availability and use, and evaluating the impact of potential risk and impact mitigation options.

The processes followed and the instruments developed ultimately target to support the decision making process. The contribution of Decision Support Systems (DSS) in integrated natural resources management is highly acknowledged. Systems of this type could be of value to water managers as they provide objective means for analyzing alternative mitigation options.

Examples of projects include the SEDMED II Project (2004 – 2006), which focused on the development of an integrated monitoring network for drought management, and the DSS-DROUGHT (01/11/1997 – 31/07/2001), WADI (1/4/2001 – 31/7/2004), SyNaRMa (07/2006 – 12/2007) and AquaStress Projects focusing on the development of knowledge bases and Decision Support Systems to assist in the selection of mitigation options and to support the decision making processes before, during or after drought events. A summary of these is presented in Table 11 (p. 73).

5.3.3 Uncertainty

Drought episodes and the resulting increasing uncertainty for water management, have been addressed in several EC funded projects and national projects. For example, the NeWater IP (1/1/2005-28/2/2009) and the IMAGINE 2030 Project (07/2007- 06/2009) have addressed the issue of uncertainties in water availability due to drought at current and future conditions at EU and in France respectively.

Table 10. Information on research projects for reducing drought-related uncertainties

Acronym	NeWater	IMAGINE2030
Title	New Approaches to Adaptive Water Management under Uncertainty	Climate and water MAnaGement: uncertaINties on water resources for the Garonne rivEr basin in 2030
Duration	1/1/2005-28/2/2009	07/2007- 06/2009
Funding	FP6	National-France
Objectives	To understand and promote transitions to enhanced adaptive strategies for IWRM	To assess water availability and the risks of water shortage in 2030 when taking climate and water management into account
Output(s)	Innovative tools for adaptive management in river basins	The project highlights the difficulties in assessing hydrological extremes at regional scale, in order to derive generalized conclusions at the river basin scale for integrated water management
References	www.newater.info	Dupeyarat et al., 2008

Table 11: Information on research projects on the development of Decision Support Systems

Acronym	SEDMED II	DSS-DROUGHT	WADI	SyNaRMa	AQUASTRESS
Title	Sécheresse et Désertification dans le bassin Méditerranée II	A decision support system for mitigation of drought impacts in the Mediterranean regions	Water supply watershed planning and management: an integrated approach	Development of an Information System for Natural Risk Management in the Mediterranean - SyNaRMa	Mitigation of Water Stress through new Approaches to Integrating Management, Technical, Economic and Institutional Instruments
Duration	2004 - 2006	01/11/1997 – 31/07/2001	1/4/2001 – 31/7/2004	07/2006 – 12/2007	1/2/2005-31/1/2009
Funding	INTERREG IIIB MEDOCC	INCO MED (FP5)	FP5-INCO	INTERREG III	FP6
Objectives	To develop an integrated network for real time drought monitoring and methodologies for drought analysis and forecasting, To define mitigation strategies for Mediterranean countries	To develop a Decision Support System (DSS), to support the decision making processes in the water supply sector under drought conditions, and to determine the most effective policy delivery for irrigation	To assess the technical and scientific requirements for watershed planning and management, including social and legal aspects, as well as environmental constraints for sustainable development.	To develop tools for the effective management of natural disasters throughout the five stages of their lifecycle	To develop and evaluate stakeholder driven, European scale, comprehensive multisectoral, integrated approaches for the diagnosis and mitigation of water stress
Output(s)		Development of a DSS to assist irrigation scheduling, and simulation of water supply system under drought conditions in Mediterranean semi-arid countries; Definition of criteria and organizational structure of a Drought Watch System.	A user-friendly DSS under an integrated platform for data access, studying, analyzing, modeling and simulating	Development of a Web-based GIS tool for the management at local and regional level of natural hazards	Development of an Integrated Support Solution System; Guidance documents for water stress mitigation
References	Rossi et al., 2007	Rossi et al., 2002	www.medaqua.org/forum/WADI.html	Grigoriadis et al., 2008	www.aquastress.net

5.3.4 New technologies for water supply enhancement

Innovative technologies for water supply enhancement are also relevant to drought planning, as they can provide alternatives to increase water security and reduce vulnerability. In this regard, Table 12 and Table 13 present research projects relating to artificial groundwater discharge and desalination respectively.

Table 12. Information on research projects on artificial groundwater recharge

Acronym	RECLAIM WATER	GABARDINE
Title	Water reclamation technologies for safe artificial groundwater recharge	Groundwater Artificial recharge Based on Alternative sources of wateR: aDvanced INtegrated technologies and managEment
Duration	1/10/2005 – 30/09/2008	1/11/2005 - 31/10/2008
Funding	FP6	FP6
Objectives	To improve water reclamation and reuse technologies. To assess the performance of specific mitigation options, i.e. aquifer recharge, in selected case studies. To improve knowledge, concepts and models of natural processes in subsurface systems (soil, unsaturated zone, aquifer) when the reclaimed water is used for Artificial Recharge (AR). To disseminate the results into developing countries	To identify alternative sources of drinking water To investigate on artificial recharge (surface water runoff, treated effluent, imported water, brakcish water to be used after desalination) To investigate the feasibility, both environmental and economic of their utilization
Output(s)	Risk studies covering water intake, treatment, storage and distribution steps, analytical tools, monitoring and control systems, and operational procedures	Application of the suggested schemes to three test (Greece, Israel and Palestine, Spain)
References	http://www.reclaim-water.org/	http://www.gabardine-fp6.org/

Table 13. Information on research projects on improving water supply during or after drought

Acronym	MEDINA	MEDESOL
Title	Membrane – based Desalination – An Integrated Approach	Seawater desalination by innovative solar-powered membrane-distillation system
Duration	15/10/2006 – 14/10/2009	1/10/2006-31/3/2010
Funding	FP6	FP6
Objectives	To improve performance of membrane-based water desalination processes: To minimise environmental impacts from these plants; To optimise energy sources and consumption; To increase the fresh water production.	To develop an environmentally friendly improved-cost desalination technology based on solar MD, for fresh water supply in arid and semi-arid regions in the EU and Third Countries
Output(s)		Setup of prototype plant in Almeria
References	http://medina.unical.it/	http://www.psa.es/webeng/projects/medesol/index.html

5.4 Areas for further research

Despite the considerable research effort undertaken at the EU level for enhancing knowledge on water strategy and drought, several research areas of relevance to policy formulation and implementation remain inadequately explored. Deficiencies of past approaches of relevance concern:

- The lack of an integrated approach; research projects tends to focus on one specific aspect (e.g. water management or agriculture);
- The limited analysis and evaluation of economic instruments (e.g. tradable water use rights/quotas, water pricing, financial encouragement of eco-innovation, etc.);
- The prediction and assessment of hydrological extremes at regional level;
- The development of drought forecasting tools and the incorporation of uncertainty in water resource planning and management;
- The development of comprehensive drought mitigation strategies, targeting risk mitigation and impact minimization and encompassing all major water use sectors.

In the above context, the following sections present areas for further research, in relation to the different phases of drought planning and management.

5.4.1 Drought characterization and forecasting

Drought characterization processes and forecasting tools remain incomplete, as currently the developed indicators and triggers are insufficient in describing the severity of drought

situations. This, in turn, influences the development of DMPs, which can mostly rely on information from past drought events.

In this regard, the following research priority areas can be identified:

- Vulnerability assessment at River Basin level, addressing all main water use sectors, and the environment;
- Incorporation of uncertainty in drought characterization and declaration processes;
- Thorough investigation of linkages between hydrologic-based indicator thresholds and critical ecological demands, to ensure that selected values also secure the ecological stability of water bodies.

Horizontal aspects concern: 1) the definition of rigorous methodological approaches for drought characterization and forecasting, and 2) their adaptation to local conditions. Drought indicators should be selected according to local climatic parameters and the vulnerability of each region, whereas triggers should clearly describe the different stages of alarm.

Furthermore, new technologies, forecasting models, and early warning systems, e.g. with the use of earth observation systems, can be supported in order to facilitate the adoption of adequate and prompt responses to drought incidences. The development and inter-linkage of monitoring and early warning systems is also identified as a priority in the corresponding EC Technical Report on Drought Management Plans (EC, 2007c).

5.4.2 Scenario analysis, option evaluation and decision support systems in support of drought mitigation

A drought mitigation strategy is based on options that are technically feasible, economically viable, socially acceptable and environmentally sustainable at the spatial scale of application. In this regard the considerable effort for assessing water management options and strategies in terms of effectiveness and efficiency should be enhanced by explicitly considering the issues of uncertainty and risk, in order to facilitate more informed planning and decision-making processes. Furthermore, the evaluation of alternative for drought mitigation options requires a multi-disciplinary approach for adapting proposals to local conditions and specificities, explicitly addressing financial constraints, cultural and social aspects and regional development priorities. Multi-criteria tools can assist in the comprehensive evaluation of alternatives, as part of participatory planning processes.

In the above context, the enhancement of existing decision support systems to incorporate the multi-faceted drought impacts emerges as a research priority. Issues that can be considered relevant to future research on modelling include:

- The incorporation of aspects relating to environmental sustainability, particularly with regard to minimum environmental flows, and the integration of surface and groundwater modelling aspects.
- Particularly with regard to groundwater management, emphasis should be given in the modelling of conjunctive use systems and the investigation of artificial recharge options, as groundwater can also be considered as a strategic reserve to cope with emergency situations.

- The comprehensive assessment of drought impacts to strategic sectors (agriculture, energy production), so as to facilitate the development of appropriate adaptation strategies and actions for reducing vulnerability, where required.

Particularly with regard to agriculture, where water scarcity and drought is of great concern, scenario-based assessment can have an important role in planning and increasing preparedness for critical situations. However, is often impeded by the lack of reliable data and information on irrigated areas, water withdrawals and actual water demands. In addition to the development of integrated, comprehensive and easily accessible databases, there is need to expand future assessments by systematically considering the anticipated impacts of relevant policies (such as the CAP) on crop patterns and irrigation demands.

Finally, economic instruments, and particularly water pricing and ways of financing water efficiency, have been noted by the EC as a priority intervention for addressing water scarcity and drought. In this regard, further research is required on how these can be best applied in the EC Member States, on their potential contribution in developing drought-resilient societies and their impact both under normal conditions and at times of emergency.

5.4.3 Response and Recovery

Although risk management approaches can help to minimize drought impacts, they cannot completely eliminate the need for response measures. In this regard, during drought periods, when crisis management is crucial, the sharing of available water resources requires comprehensive assessment of water availability and demand (domestic, ecological, agricultural and industrial), so as to ensure fair water sharing and conservation of biodiversity. Thus, in addition to multi-scenario investigation (as part of drought planning), research is required to support holistic response and recovery frameworks, especially targeting drought-prone areas and vulnerable aquatic ecosystems, and taking into account the relevant provisions of the WFD. Similarly to risk mitigation, the analysis of alternative response plans should clearly consider the resilience of the different water use sectors, and the environment, so as to enable the selection of appropriate post-drought recovery options.

5.4.4 Strengthening the links between science and policy

All aspects of drought planning and management require strong collaboration between science and policy, so as to improve understanding, enhance knowledge and allow the exploitation of research findings and innovations.

Particularly with regard to the issues defined above, the following can be noted:

- Participatory planning is a main component in risk management. It further requires a solid strategy for disseminating research findings on alternative mitigation options, and vulnerability and impact assessment results among different stakeholder groups.
- Currently, the results of long-term and seasonal forecasting systems are not incorporated in DMPs or exploited during drought periods. This in turn hinders the best possible assessment of current and future conditions. Meteorologists and hydrologists need to work together with water managers to provide guidance on how to include forecasts in the decision-making process (European Drought Observatory web site).

- Beyond scientific and technical issues, DMPs concern water users and managers that usually sit together to negotiate in situations of “conflicting cooperation” (Barbier et al., 2007), either before or during a crisis. In this regard, it is critical to improve the understanding of the role and interests of different actors involved in the application of DMPs.

PART C:

To
wards the development of policies for adaptation to drought events

6 The Draft EC Guidance Document on River Basin Management and Climate Change

This section presents recommendations in relation to the development of Drought Management Plans, as identified in the Draft Guidance Document on "River basin management and Changing Climate". As outlined in Section 2.1, the Guidance document, which will be released by the end of 2009, is being developed within the context of the WFD Common Implementation Strategy, in order to provide guidance on how EC Member States should incorporate consideration of climate variability and change into the implementation of EU water policy (Ecologic, 2009).

6.1 Monitoring Issues

The guiding principles related to monitoring issues within DMP include the diagnosis of the causes that led to water scarcity in the past and/or may lead to similar situations in the future, and the collection of as much 'high quality information' as possible to enable changes to water supply reliability, and detect water scarcity at early stages. Overall:

- Monitoring of areas exposed to water scarcity requires special attention. As water scarcity is hidden behind the natural irregularities of the hydrologic regime, it develops slowly and is usually very difficult to detect. Water shortages appear after years of very low precipitation, while the boundary between normal drought impacts and structural water deficits is not clearly defined. Only in the mid and long term, when water shortages have proven to be unacceptably frequent or intense, can water scarcity be diagnosed. Early detection of water scarcity requires an advanced monitoring system based on high-resolution hydrometric networks and a system of objective indicators.
- In water scarce regions, the natural characteristics of water resources have achieved profound levels of adaptation to the existing conditions so as to better accommodate the water demand. Consequently, the hydrometric networks will have to further adapt to track the impact of climate change on water resources. Hydrometric networks were designed primarily to obtain average values, seasonal and interannual variability of precipitation and streamflow series on the assumption of stationarity. Given the deep human intervention on the hydrological cycle in water scarce regions it is currently difficult to obtain even those average values. The normalization of streamflow series is in many cases a complex modelling exercise similar to the rainfall-runoff transformation, and it is really difficult to close the water balance from the observations. With all these uncertainties, the possibility of detecting the gradual changes in average values should be ruled out, taking into account that the noise of the streamflow series due to natural variability may be much larger than the signal to be detected.
- As the current balance between water supply and demand is further affected by climate change, water scarcity will appear more frequently and with greater intensity. Therefore, the intensification of monitoring should be accompanied by the development of a comprehensive set of indicators, which can link different phenomena in order to predict drought and water scarcity impacts. The sooner a

negative effect is identified, the easier it is to plan for the appropriate response. The European Environment Agency Water Data Centre hosts ongoing data collection and distribution of information, data sets and indicators relating to specific thematic areas in support of European reporting initiatives. The Water Information System for Europe is a reliable source for gathering official data from Member States. Such information has many benefits including the possibility to elaborate appropriate indicators and to identify national and river basin scale problems related to water scarcity and droughts. Moreover, the establishment of a European Drought Observatory will be an important milestone to achieve systematic monitoring of climate-induced water stress.

6.2 Adaptation Measures Related to Water Scarcity & Droughts

The guiding principles behind the adaptation of measures related to water scarcity and droughts are related to the engagement of integrated water resource management to account for climate change and anthropogenic impacts on drought, and incorporate a combination of alternative water supply options and economic instruments. Emphasis is also placed on capacity building aiming at creating robust organizational systems:

- Most problems anticipated to intensify as a result of climate change, are really a result of the current structural problems created due to water scarcity. The determined implementation of adaptation strategies will produce beneficial results in a wide range of climate change and drought scenarios. From the viewpoint of the development of a DMP, taking climate change into account, particularly in water scarce regions, should lead to an intensification of policies for demand management as a way towards more efficient water management. It is important to always keep the long term in perspective. Some solutions which are perceived as adequate for a stationary scenario may not be so in the long run.
- The intensification of actions on demand management is expected to reduce pressure on the water supply sources, especially in times of scarcity. The greatest scope for action is in irrigation demands, which usually account for the largest fraction of total demand in water scarcity regions. In urban areas, the DMPs should also plan for the information and education of citizens to promote or impose the use of domestic water saving techniques and the intensification of programs for avoiding leakage in water distribution networks and reducing public demand.
- In a scenario of potential reduction of natural resources, supply enhancement measures should be used, promoting non-conventional water resources including wastewater recycling. Water scarcity is usually the result of the inadequacy of forces in the water market, which cannot attain balance between water supply and demand due to external intervention. Under the changing conditions expected due to climate change, it is essential to diagnose the causes that led to water scarcity in the past or may lead to it in the future and to set up appropriate regulations to restore a sustainable balance. Therefore, the use of market-based instruments should be assessed to address problems caused by water scarcity. It is essential to perform an economic assessment of water use and water value, promoting the efficient use of water by installing individual meters and establishing a pricing policy that penalizes excessive water consumption.

- The traditional concept of water resources planning should be revised. Water resources planning should rather strive to develop effective ways of managing the growing scarcity of the resource, mostly through demand management measures. Similarly, the role of the Water Administration will be substantially different from the past. Traditionally, its role in areas exposed to water scarcity has been to ensure and to increase the availability of water resources through the implementation of hydraulic infrastructure and the control of water uses. Under the imposed pressure from the expected increase of drought incidences, its main function will be to ensure economy and efficiency in water use and to manage the optimal allocation of water resources among different uses.
- It is also important to enhance the performance of water supply systems by increasing their robustness. Robustness can be built into water resources systems through the expansion and diversification of supply sources and their integration in combined systems. Resources of different nature (e.g. surface and groundwater) show highly significant differences in terms of variability and reliability. Even the same kind of resources (such as the regulation of surface water), but for different locations, will show the differences in terms of hydrological conditions on each site and the characteristics of their hydraulic systems. Systems that integrate a large number of supply sources can best respond to water scarcity situations, allocating each resource to the most appropriate use depending on its amount, regularity and reliability. The use of strategic reserves or the exchange of water rights allows for covering the most important demands in conjunctive systems, where different kinds of water demands are present. In the long term, investment in improving the performance of water supply systems delivers adaptation benefits.

6.3 Links to WFD Objectives and Processes

There are many links between water scarcity and drought adaptation measures and the WFD environmental objectives, such as good groundwater quantitative status, sufficient surface water quantity to sustain ecological status, and broader objectives such as sustainable water use. Countries facing water scarcity and droughts are challenged to comply with the WFD requirements.

- Although it mainly sets qualitative objectives, the WFD addresses to some extent quantitative issues, and it contains a specific obligation to ensure a balance between abstraction and recharge of groundwater. In particular, it promotes the application of appropriate measures (Programmes of Measures of the River Basin Management Plans) and includes the possibility of developing complementary Drought Management Plans.
- WFD also foresees the possibility of exemptions in case of disproportionate costs or prolonged droughts. Article 4.6 of the WFD defines that "*Temporary deterioration in the status of bodies of water shall not be in breach of the requirements of this Directive if this is the result of circumstances of natural cause or force majeure which are exceptional or could not reasonably have been foreseen, in particular extreme floods and prolonged droughts, ...,* provided that the conditions of Article 4.6 are met including among others taking all practicable steps to prevent further deterioration in status.

- In addition, the requirements of the WFD Article 4.7 should be applied to any adaptation measures that are modifying the physical characteristics of water bodies, especially measures related to the development of new water infrastructure to cope with scarcity in a changing climate.

7 Concluding Remarks: Xerochore Policy Relevant Outcomes and Considerations

Despite recent efforts and initiatives, the integration of drought planning in water and affected sectoral policies remains a challenging task. Drought events differ is terms of intensity, duration and spatial coverage and, thus, there can only be general provisions on the processes and the means to be used in the case of drought.

The ongoing discussion on Water Scarcity and Drought and its link to policy instruments is often complicated by the joint negative impact of overconsumption of water resources (scarcity) and temporary deficiencies in rainfall (drought). However both domains require substantially different management approaches and different policies to guide management.

In this regard, the urgency of addressing drought should be further elaborated, by identifying and analyzing:

- Impacts of drought on the Natural Systems and the Environment, and most importantly their type, the way to monitor them, as well as existing gaps and deficiencies, also considering commonly agreed indicators at the EU level;
- Socio-Economic Impacts, including the evaluation of social and economic costs and relevant instruments (pricing, quotas);
- Policy tools and frameworks at national and EU level, including among others existing frameworks (e.g. the WFD and the CAP), new policies (Soil Strategy, Climate Change Directive, etc.), and short and mid-term opportunities to enhance drought preparedness (through the WFD River Basin Management Plans for 2015 and the 2nd and 3rd RBMPs for 2021 and 2027 respectively).

In the above context, several policy concerns have been identified, which should be addressed in order to enable effective adaptation and mitigation of drought risk. Particularly, a drought policy should describe the contextual framework for developing Drought Management Plans by explicitly defining:

- How can the 3 phases in drought management (i.e. preparedness, mitigation, recovery) be better addressed within the current policy framework?
- Which procedures/processes should be communicated in order to improve governance in the implementation of drought management plans?
- Which type of indicators, information, data, and instruments would be required (indicators, monitoring, etc.) for Drought Management Planning?
- What are the limitations and the opportunities for linking the DMP to WFD?
- How to reach decision on the level of acceptability of the damages caused during a drought incident and how to assess the effectiveness of the measures adopted.

The above questions constitute the backbone of the Xerochore Conference (Brussels, February 2010). The Conference will provide an open forum for such discussions and for elaborating on the contribution expected by the scientific and research society towards the development of successful drought adaptation policies.

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ANNEXES

Annex I: Potential actions for drought risk mitigation

Assessment
▪ Develop criteria -- "triggers" -- for drought-related actions ▪ Develop early warning systems ▪ Inventory water bank contracts to find new water supplies for drought-stricken areas ▪ Evaluate water quantity and quality from new sources ▪ Evaluate use of ground water ▪ Establish new data collection networks ▪ Study public willingness to pay more for more reliable water supplies ▪ Study effectiveness of conservation measures ▪ Monitor vulnerable public water suppliers ▪ Improve the accuracy of seasonal runoff and water supply forecasts ▪ Establish alert procedures for water quality problems ▪ Investigate business and farm/ranch diversification strategies ▪ Evaluate capacities to withstand losses associated with drought such as incomes, assets, credit flexibility and decision-making processes, subsidy, loan, and welfare program applicability and the effect of government programs and policies ▪ Conduct public surveys on environmental, economic, and cultural beliefs for appropriate policy formulation ▪ Research drought impacts on various groups ▪ Inventory and monitor natural resources within the relevant areas ▪ Conduct further research into the relationship between drought and fires ▪ Evaluate the use of marginally productive farm and rangelands
Legislation and Public Policy
▪ Prepare position papers for legislature on public policy issues ▪ Examine statutes governing water rights for possible modification during water shortages ▪ Establish a state water bank ▪ Pass legislation to protect instream flows ▪ Pass legislation to protect and manage groundwater ▪ Pass legislation providing guaranteed low-interest loans to farmers ▪ Impose limits on urban development ▪ Develop a state water plan ▪ Pass legislation requiring water agencies to develop contingency plans ▪ Enact legislation to facilitate water recycling ▪ Establish standards for safe residential use of gray water ▪ Make decision-making authority relating to wildlife during drought conditions available in local offices of federal and state agencies

Water Conservation/Demand Reduction
▪ Establish stronger economic incentives for private investment in water conservation ▪ Encourage voluntary water conservation ▪ Require water users to decrease reliance on ground water and implement conservation ▪ measures ▪ Improve water use and conveyance efficiencies ▪ Implement water metering and leak detection programs ▪ Support local development of conservation programs ▪ Improve water scheduling ▪ Reduce consumptive use by changing the type of water application system or using water meters ▪ Institute conjunctive use of surface and ground water
Increasing Water Supply/Supply Augmentation
▪ Issue emergency permits for water use ▪ Provide pumps and pipes for distribution ▪ Propose and implement programs to rehabilitate reservoirs to operate at design capacity ▪ Undertake water supply vulnerability assessments ▪ Inventory self-supplied industrial water users for possible use of their supplies for emergency public water supplies ▪ Inventory and review reservoir operation plans ▪ Provide funds for water recycling projects ▪ Provide on-stream storage of excess water ▪ Implement water quality management and wastewater reuse ▪ Use carryover storage in a reservoir to "bank" a conserved water supply ▪ Use ground-water banking concepts to allocate and store surplus, inactive, or reclaimed water ▪ Establish water banks for voluntary sale, transfer, or exchange of water ▪ Establish water banks and transfers in conjunction with voluntary farmland idling programs ▪ Temporarily authorize deliveries of water outside service areas and/or for unauthorized project purposes when project water is available and with the consent of project water users ▪ Temporarily use project facilities for storage and distribution of non-project water ▪ Implement minor structural measures to obtain temporary water supplies from inactive or dead storage or from ground water sources
Economic Development
▪ Provide incentives for farm and business diversification ▪ Promote off-farm industry to diversify wage-earning strategies ▪ Enhance information flow between bankers, farmers/ranchers, businesses, and government agencies

Public Education and Participation

- Establish a public advisory committee
- Include public participation in drought planning
- Organize drought information meetings for the public and the media
- Implement water conservation awareness programs
- Publish and distribute pamphlets on water conservation techniques and drought management strategies
- Organize workshops on special drought-related topics
- Prepare sample ordinances on water conservation
- Establish a drought information centre
- Set up a demonstration of on-site treatment technology at visitor centre
- Include the media in drought planning
- Establish tuition assistance so farmers can enrol in farm management classes
- Develop training materials in several languages
- Provide education on different cultural perspectives of water resources
- Consult a marketing firm for strategies to draw public attention
- Employ public participation and public information specialists

Drought Contingency Plans

- Adopt an emergency water allocation strategy to be implemented during severe drought
- Recommend water suppliers develop drought plans
- Evaluate worst-case drought scenarios for possible further actions
- Establish a natural hazard mitigation council
- Establish a public advisory committee

Technical Assistance

- Advise people on potential sources of water
- Provide additional training to natural resource personnel
- Advise water suppliers on assessing vulnerability of existing supply systems
- Recommend adopting water conservation measures
- Help water agencies develop contingency plans
- Form a drought information centre and distribute real-time weather data
- Conduct workshops on various drought topics, including crop survival during drought
- Conduct workshops on design and implementation of water rationing programs
- Develop and market innovative technologies such as irrigation system improvements, waterless urinals, and monitoring technologies
- Develop and distribute software for irrigators and urban water suppliers
- Establish special plans to protect the values associated with wetlands, wildlife refuges, or exchange of water

Health and Nutrition
▪ Establish crisis counselling centres and hotlines (especially in rural areas) ▪ Establish food subsidy programs for drought-affected individuals ▪ Establish shelters for domestic violence cases ▪ Conduct workshops on stress management and basic nutrition strategies ▪ Conduct public information campaigns on the health dangers of drought
Media Participation
▪ Select official representatives for media contacts ▪ Establish a list of authorities regarding drought issues ▪ Organize education activities for the media ▪ Write reports for the media early in the event ▪ Include media personnel in drought planning ▪ Keep the media updated about new conditions and plans
Conflict Resolution
▪ Resolve emerging water use conflicts ▪ Investigate complaints of irrigation wells interfering with domestic wells ▪ Negotiate with irrigators to gain voluntary restrictions on irrigation in areas where domestic wells are likely to be affected ▪ Clarify state law regarding sale of water ▪ Clarify state law on changes in water rights ▪ Suspend water use permits in watersheds with low water levels ▪ Work with community-based organizations to promote public participation in conservation programs ▪ Maintain communication between the public, policy makers, scientists, and the media
Emergency Response
▪ Stockpile pumps, pipes, water filters, and other equipment ▪ Establish water hauling programs for livestock ▪ List livestock watering spots ▪ Establish hay hotline and provide emergency shipments ▪ Fund water system improvements, new systems, and new wells ▪ Fund drought recovery program ▪ Lower well intakes on reservoirs for rural water supplies ▪ Extend boat ramps and docks for recreation ▪ Issue emergency irrigation permits for using state waters for irrigation ▪ Create low-interest loan and aid programs for agriculture ▪ Create drought property tax credit program for farmers

Source: Knutson et al., 1998

Annex II: Mitigation instruments reported by the Member States in the EUWI Survey

Country	Legislative instruments	Financial instruments	Technical instruments	Water pricing policies
Austria	Disaster fund law (Katastrophenfondsgesetz) 1996 idF BGBl. I Nr. 112/2005 General framework guidelines for the grant of promotions from Federal Funds (Allgemeine Rahmenrichtlinien für die Gewährung von Förderungen aus Bundesmitteln)	Subsidies (cattle breeding) and capital asset loans		
Belgium		Social cost – benefit analysis to evaluate the effect of measures (both structural and operational)		Taxes on groundwater abstraction based on the quantity abstracted, the type of aquifer and the water table Fixed amount for agricultural use Taxes on surface water abstraction based on the quantity and the water use sector

Country	Legislative instruments	Financial instruments	Technical instruments	Water pricing policies
Cyprus	Law banning the use of hosepipes for the washing of cars or pavements, Drought Management Committee, efforts for establishing a new Directorate for Integrated Water Management, quota system for the allocation of government irrigation water in combination with penalty charges for over consumption etc.	Water charges, subsidies for saving good quality domestic water	Construction of dams, desalinization of sea water, re-use of treated waste water, aquifer recharge, drilling of boreholes, metering of water services, installation of improved farm irrigation systems, construction of modern efficient conveyance and distribution systems, application of leakage detection methods, water saving measures	Domestic water pricing policy is based on rising block tariffs Irrigation water in governmental schemes is charged volumetrically
Denmark		Levies	Reduction of water loss in distribution systems	Typical water price of 5Euro/m3 that corresponds to: 20% water tariff 44% wastewater tariff 14% water tax 2% wastewater tax 20% VAT

Country	Legislative instruments	Financial instruments	Technical instruments	Water pricing policies
Spain	Drought river basin plans	Market instruments and investments for improving the technical efficiency of the irrigation networks,		Two level pricing: 1) changes for the services provided by the River Basin Authorities (regulation and transportation mainly) 2) Charges set by the water suppliers to the water users
Finland				Full cost recovery, (capital, operation and maintenance costs) No common pricing policy for irrigation (system operated by individual farmers)
France	Compulsory reduction in the use of irrigation water in case of limited availability,	Water use rating system based on the status of the water resource	Construction of substitution reservoirs (cost allocation to the project beneficiaries)	85% cost recovery for domestic and industrial use 40-100% cost recovery in the agricultural sector In some cities tariffs are adjusted during summers to account for the tourist flux
Germany	License system			Water pricing based on cost effectiveness

Country	Legislative instruments	Financial instruments	Technical instruments	Water pricing policies
Hungary	Resolution 2142/2005. (VII. 14.) of the Hungarian Government about the Hungarian drought strategy			The water resource charge is estimated based on: the volume used, a base yearly charge, the use of metering equipment or not and the type of use and resource
Italy	An ordinance of water emergencies has been declared that includes both technical and financial measures. Organizations dealing with crisis management have been also established (e.g. for the Po river basin).			Water pricing policy is not yet complete and does not provide incentives for saving water
Lithuania				Volumetric water use rate The cost recovery varies from 74 % till 83 %
Malta				Pricing policies not yet developed
The Netherlands	National priority list of user functions in periods of water shortages	Taxes for water abstraction	Regional groundwater storage, construction of reservoirs	Groundwater abstractions are charged with: A levy on a national basis; and A charge defined by the provinces.

Country	Legislative instruments	Financial instruments	Technical instruments	Water pricing policies
Norway				The water pricing policy does not provide incentives for the efficient use of water
Portugal	New Water Law (Decree Law 58-2005) National plan for water efficiency		Development of a comprehensive database	Water tariffs do not cover the full cost of services An initiative is on going for establishing a reference model for tariff revision, considering principles of cost recovery and equity
Slovak Republic				Irrigation water use if free of charge Water rates are calculated based on the amount of water used
Slovenia	Development of a National environmental program that defined the “drought“ sensitive areas and listed preventive measures			A water pricing policy is not yet developed

Country	Legislative instruments	Financial instruments	Technical instruments	Water pricing policies
UK (England)	Act 1991 specifies that water companies should include drought planning in their management efforts. Complementary to this, the act encourages long term water resources planning.			Abstraction charges are levied on all licensed abstractors. Charges reflect environmental impacts: use, location, seasonal impacts