WATER SCARCITY AND DROUGHT
A Priority of the Portuguese Presidency
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Index

5  Foreword

7  Environment Council Conclusions on Water Scarcity and Drought
   30 October 2007

15  Addressing the Challenge of Water Scarcity and Drought
    Background text for the Informal Council

23  Speech of the Minister for the Environment, Spatial Planning and Regional Development

31  Climate Change and its Links to the Water Scarcity and Drought Problems in Europe
    Ghislain de Marsily

61  Economic Impact of Droughts: Challenges for Water & Environmental Policies
    R. Andreas Kraemer

91  Water Scarcity and Droughts: Main issues at European level and the Portuguese Experience
    José Rocha Afonso

105  Presidency Conclusions on Water Scarcity and Drought
    1 September 2007

113  Communication from the Commission to the European Parliament and the Council:
    “Addressing the challenge of Water Scarcity and Drought in the European Union”
Foreword

It is with a sincere feeling of accomplishment that I invite you to read this publication on Water Scarcity and Drought.

The Portuguese Presidency of the European Union Council has placed “Water Scarcity and Drought” as one of its main priorities and now that the semester is approaching its end I am pleased to confirm that we have succeeded in our goal: to make Water Scarcity and Drought become an environmental policy area per se, with specific instruments and strategies.

Water Scarcity and Drought is no longer a problem exclusive of Southern European countries. It has spread out across Europe in the current and complex context of climate change. It has now a European dimension. Hence the absolute need of establishing a common approach at European Union level.

The Informal Meeting of Environment Ministers, held in Lisbon in September 1, was dedicated to the theme of Water Scarcity and Drought. Elaborating on the Communication from the Commission “Addressing the challenge of water scarcity and droughts in the European Union”, issued in July, the Portuguese Presidency presented a Background Paper for discussion at the Informal Ministerial Meeting. Moreover, the Presidency invited three experts to present their views on sharing experiences on water scarcity and drought management, climate change as a spreading cause and aggravating factor of water scarcity and droughts in the European and Mediterranean regions, and the economic effects of droughts. Morocco, Algeria and Tunisia were also invited to attend this Ministerial Meeting to share with the European neighbours their concerns and knowledge. The fruitful discussions were reflected on the Conclusions of the Presidency then adopted.

The debate went on at technical level to fine-tune the path to be chosen at EU level and agreement was possible at the Environment Council of October 30, where Council Conclusions were approved on the issue of Water Scarcity and Drought. According to the Council Conclusions, and beyond the full implementation of the Water Framework Directive envisaged, the Commission is invited to present a follow-up report in 2008, including deadlines for the implementation of the measures identified in the Communication and pursue the work on an EU strategy until 2012, thus guaranteeing Water Scarcity and Drought a place on the European environmental agenda.

This book intends to provide an overview of the abovementioned major steps of this second semester of 2007. It compiles documents that are key to understand the dynamics of the discussions among the EU Environment Ministers around the theme of Water Scarcity and Drought, as well as the scientific and economic data related to the occurrence of these problems. I sincerely hope it can be a useful work tool.

The exercise of the Presidency of the Environment Council, as I conceive it, is a service to fostering the EU environmental agenda. I hope that the Portuguese Presidency was instrumental in raising awareness to the specificities of Water Scarcity and Drought and in opening the path towards concerted and effective action.

Francisco Nunes Correia
Minister for Environment, Spatial Planning and Regional Development
Environment Council Conclusions
on Water Scarcity and Drought

30 October 2007
The Council of the European Union,

1. RECALLS that water scarcity and droughts (WS&D) are problems with relevant socio-economic and environmental impacts in the European Union; NOTES that their occurrence has been increasing in both intensity and frequency in recent years, affecting Member States and neighbouring countries at different levels; RECALLS the request for European action on WS&D from the Environment Council in June 2006 and the results of the informal meeting of Environment Ministers on this subject, which took place in Lisbon in September 2007;

2. RECOGNISES that Climate Change (CC) is expected to influence the baseline of present WS&D issues, with potential impacts on water quantity and quality, contributing in particular to an increase in extreme hydrological events, such as floods and droughts; NOTES that a link between WS&D and CC and their associated adaptation strategies, including the aspects already dealt with in the EC Green Paper on adaptation to climate change in Europe, should be integrated into the implementation of the Water Framework Directive (WFD) as far as possible;
3. WELCOMES the Commission communication entitled “Addressing the Challenge of Water Scarcity and Droughts in the European Union”, adopted on 18 July 2007, as a fundamental and well-developed first set of policy options for future action, within the framework of EU water management principles, policies and objectives; NOTES that the communication requires a clear commitment from the EU as a whole, to establish the adequate conditions for implementing the actions envisaged therein and to develop further knowledge;

4. ACKNOWLEDGES that the problem of water scarcity and droughts cannot only be confined to its European aspect since it has international repercussions, such as a direct relation with poverty and migration; RECOGNISES that it is important for the European Union to consider the international dimension when dealing with this matter and to pursue the achievement of the international commitments of the European Community and its Member States, in particular the United Nations Convention to Combat Desertification, the United Nations Framework Convention on Climate Change and the Convention on Biological Diversity;

5. RECOGNISES that integrated water management will contribute to mitigating water scarcity and drought impacts and therefore CALLS UPON the Commission and all the Member States to enhance their efforts to implement the EU Water Initiative as a privileged tool to progress towards the achievement of the objectives of the World Summit on Sustainable Development and the Millennium Development Goals;

6. ACKNOWLEDGES that the full implementation of the WFD, the EU’s flagship Directive on water policy, is a major priority; STRESSES that the WFD establishes a framework of great value, innovation and scope for integrated water management in Europe, while providing tools for achieving good status in all European waters, promoting sustainable water use, contributing to mitigating the effects of floods and droughts and encompassing a flexible approach in addressing environmental objectives;

7. RECALLS that some concerns regarding quantitative aspects, which influence the achievement of the environmental objectives, have been identified during the ongoing implementation of the WFD, particularly dealing with floods, water scarcity and droughts; RECALLS that the recently adopted Directive on the assessment and management of floods will contribute to the achievement of these objectives and RECOGNISES that WS&D have become increasingly important at the technical and political level;

8. ACKNOWLEDGES that water scarcity and droughts have a direct impact on citizens and economic sectors, such as agriculture, forestry, tourism, industry, energy and transport, significantly affects natural resources, places stress on ecosystems and habitats thus endangering biodiversity and otherwise affects the environment as a whole; NOTES that there is a close connection between droughts, soil degradation and desertification, particularly in semi-arid regions, in terms of the direct impact on the performance of soil functions and
STRESSES the broader impacts of droughts in terms of increased risks of forest fires and the consequent significant effects on atmospheric pollution and emissions of greenhouse gases;

9. UNDERSTANDS that water scarcity on the one hand, and drought on the other, should be considered different matters, in as much as water scarcity should refer to water imbalances between supply and long-term demand, while drought should refer to significant decreases in average levels of natural water availability; RECOGNISES that it is not possible to control the occurrence of droughts, although the resulting impacts may be mitigated to a certain degree through appropriate surveillance and management strategies in the context of the WFD among others;

10. RECALLS that, as shown by the Commission’s assessment, with respect to water scarcity several Member States, representing at least 12% of EU territory and 19% of the EU population, have also been affected, with at least 33 river basins concerned; NOTES that the worst-affected river basins are located in southern Europe, but that nonetheless northern and eastern countries have also identified river basins subject to water scarcity;

11. RECALLS that the Commission’s in-depth assessment, presented in 2007, shows that droughts have concerned all EU countries to varying degrees and that, recent events (2003) have affected more than 100 million inhabitants (20%) and a third of the EU territory; NOTES that the total economic impact of drought at EU level over the last 30 years is estimated at EUR 100 billion;

12. HIGHLIGHTS that the ineffective management of water resources is a fundamental problem which influences water scarcity and can induce additional impacts when a drought occurs, even though it cannot generate a drought in itself, the latter being a natural phenomenon; CONSIDERS that the implementation of the demand-side approach, the enhancement of water efficiency (e.g. reduction of leakages) and further educational measures must be a clear priority, even though in some circumstances it might be necessary to consider further approaches on the supply side to address the impacts of WS&D;

13. UNDERLINES that River Basin Management Plans, as established under the WFD, should take due account of the balance between demand and supply, including seasonal and inter-annual analysis, to achieve the environmental objectives and consider the need for new water supply measures once the projected impacts of water saving measures prove insufficient; NOTES that these supply measures may consist of traditional or alternative options, including, for example, waste water re-use and desalination, carried out under sustainable conditions;
14. STRESSES that a comprehensive approach to addressing the issues of water scarcity and droughts is a fundamental requirement for achieving water policy objectives and moving towards sustainable development. This approach should include, inter alia, the effective implementation of integrated water resources management, the strengthening of water demand management and water saving policies, the implementation of the “user-pays” principle in accordance with the WFD, the incorporation of sustainable water use concerns into other sectoral policies (e.g. agriculture, forestry, regional development, tourism, energy production), land-use and inland water-ways planning, and an assessment of aquatic ecosystems and their functions;

15. NOTES that the water pricing provisions of the WFD will provide an incentive to promote more efficient use of water resources while guaranteeing equitable public access to them and taking social aspects into account. In this context, awareness-raising campaigns can be an important tool for promoting water saving practices;

16. NOTES the Commission’s intention to explore how sectoral policies could better and further contribute to effective water management, using associated funds to foster the delivery of environmental services by water users in an efficient way, to examine the access conditions of the Solidarity Fund and to consider all opportunities to incorporate drought issues in future annual work programmes of the Civil Protection Mechanism;

17. UNDERLINES the need to pay special attention to the further development and, if necessary, adaptation of current agriculture policies to contribute to sustainable water management; NOTES the Commission’s intention to include management of water scarcity in the forthcoming CAP Health Check and to further assess the inter-linkages between bio-fuel development and water availability;

18. RECOMMENDS that water scarcity issues be dealt with, as far as possible, through the implementation of an appropriate set of measures within the River Basin Management Plans, including identifying the necessary adaptation strategies for climate change and coordinated water resources management in international river basins; RECOGNISES that transboundary agreements between riparian states are necessary to tackle the problem of water scarcity;

19. UNDERLINES the need to move from a crisis-management approach to prevention and preparedness actions to tackle the impacts of droughts; CALLS for a common approach to drought risk assessment and drought management planning, consistent with the WFD, to be jointly developed by the Commission and the Member States in the near future, given that droughts, with their specific regional characteristics, are a serious natural hazard for a range of Member States and have potential transboundary impacts in various regions of the European Union; NOTES that drought management planning should include inter-alia cross-border coordination, public participation and warning systems, and should be developed in the potentially affected areas at the appropriate level;
20. SUPPORTS the work currently under way to contribute to a more transparent application of the relevant exemptions set under the WFD, in particular the definition of “prolonged droughts”, and its implications for achieving environmental objectives during and after drought periods;

21. CONSIDERS that arrangements for establishing a platform for data-collection and research activities, which is based on and closely interlinked with the existing structures and activities of the EEA, ESA and the Commission, are an important measure setting the conditions for increasing knowledge, contributing to a wide exchange of experiences on this issue and improving the preparedness to tackle drought events; NOTES that this process may lead to the setting up of a European Drought Observatory;

22. INVITES the Commission to present a follow-up report in 2008, including deadlines for the implementation of the measures identified in the communication; NOTES that this implementation process should bring together Member States and the Commission to exchange information and best practice and that any legislative initiatives should be based on an in-depth impact assessment; CONSIDERS that the need for further measures, namely on drought risk management, should be assessed taking into account these conclusions, the experience gained with the implementation of the WFD, and the results from research and technical activities on WS&D which are currently in progress; INVITES the Commission, on this basis, and taking into account the international dimension, to review and further develop the evolving EU strategy for WS&D by 2012.
Addressing the Challenge of Water Scarcity and Drought
Background text for the Informal Council
This document supplements the EC Communication of July 18th as the basis for the Informal Council of Environment Ministers, which will take place in Lisbon from 31 August to 1 September 2007.

Water scarcity and drought (WS&D) are events that presently affect a significant number of EU residents and which cannot be addressed only through actions undertaken by each Member State on its own. Rather, they imply the discussion about a European strategy, including consideration of adequate institutional, technical and financial instruments at European level. Climate change scenarios further raise concerns and demonstrate the need to take measures to adapt to current and future climate change, as underscored by the recently adopted Green Paper.

The discussions at the Informal Council will aim, namely, to:

- recognize the relevance of WS&D and its impacts at European level;
- discuss the set of proposed options in the EC Communication;
- analyse the current situation, which is aggravated due to climate change;
- envisage the creation of adequate EU indicators in order to reflect scarcity and drought situations;
- envisage a European Strategy and adequate institutional, technical and financial instruments to deal with WS&D;
- analyse the need for future legislative action on droughts.
1. Over recent decades, a significant number of European Countries have been subject to water scarcity and drought events. These phenomena are not new but they have been increasing in intensity and extent at European level, with worsening socio-economic and environmental impacts. Therefore, at the Environment Council on 27th June 2006, some Member States requested European action on water scarcity and drought;

2. The full implementation of the Water Framework Directive (hereinafter WFD), the EU’s flagship directive on water policy, is a major priority. The WFD establishes a framework of great value, innovation and scope for water management in Europe, establishing the tools for achieving the good status of all European waters, while encompassing a flexible approach to addressing environmental objectives;

3. Some concerns and gaps relating to quantitative issues, which influence the achievement of the environmental objectives, were identified during the ongoing implementation of the WFD, particularly in regard to floods, water scarcity and droughts. Within the Common Implementation Strategy (CIS) of the WFD, the Commission has conducted an in-depth analysis and diagnosis (Second Interim Report, June 2007) of Water Scarcity and Droughts in the EU (hereinafter WS&D);

4. This assessment shows that drought affected all EU countries in different ways. According to the replies received so far from several Member States, severe events were identified that on an annual basis have affected more than 800,000 km² of the EU’s territory (37%) and at least 100 million inhabitants (20%) in recent years with different degrees of intensity. Austria, Belgium, Cyprus, Finland, France, Germany, Hungary, Italy, Lithuania, Malta, the Netherlands, Norway, Portugal, Spain and the United Kingdom all provided specific data, but other European countries have also been severely affected by drought (e.g. Slovenia, Greece, Romania). As for the economic impacts of drought at the EU level, estimates suggest losses over the last 30 years of 100 billion euros (€);

5. With respect to water scarcity, impacts have also been felt in several Member States, affecting a total population of 130 million inhabitants (27% of the EU’s population); thirty three river water basins have been affected by water scarcity, representing 12% of the EU’s territory and 19% of the EU’s population. The most affected river basins are located in southern Europe; however, northern and eastern countries (Belgium, Denmark, Germany, Hungary and the United Kingdom) also identified river basins subject to water scarcity;

6. The European Commission is presenting a Communication addressing the challenge of WS&D. This Communication is a fundamental and well-developed first set of proposed measures, based inter-alia on the technical work conducted within the CIS of the WFD and on the input coming from the Member States, from results of research activities undertaken at EU level and from the Stakeholder Forum meetings. The Communication provides a valuable overview of policy orientations for future action within the framework of EU water management principles, policies and objectives. It also defines a clear commitment to a European effort regarding the implementation of the foreseen actions and the development of further knowledge;

7. Water scarcity, on one side, and drought, on the other, should be considered as related but different issues that need to be dealt with using somewhat different strategies. Water scarcity should refer to long-term water imbalances between supply and demand, while drought should refer to important deviations from the average
natural water availability conditions, the occurrence of which cannot be controlled and the impacts of which can be mitigated to a certain degree, namely through appropriate surveillance and management;

8. Water mismanagement is a problem that influences water scarcity and which can induce additional impacts when a drought occurs, even though it cannot generate a drought, because this is a natural phenomenon. In relation to water mismanagement a clear priority should be assigned to the enforcement of demand side measures. However, WS&D impacts might not be solved through these measures alone. River Basin Management Plans, as established under the WFD, will need to take into due account both demand and supply side measures, including within-year and over-year behaviour analyses, and to consider new water supply infrastructures when necessary, subject to the scrutiny of EU legislation enforcement;

9. Water scarcity issues in the affected river basins should be dealt with as much as possible through the identification of the appropriate set of measures within the River Basin Management Plans; nevertheless climate change can aggravate the existing balances;

10. A common approach to drought risk assessment and drought management plans should be adopted, bearing in mind that droughts, with their specific regional characteristics, are a common concern of all Member States, similar to an extent to concerns about flooding. The drought management plans should include transboundary coordination, public participation and early warning systems, and should be developed at different levels: European, state, river basin and local;

11. The Commission is currently developing a European Drought Observatory which will enhance the knowledge of the drought issue, aiming at developing prototypes and set up implementing procedures for operational European Drought Observatory and early warning system by 2012. It is an important step and a further discussion on its fundamental objectives, budget, organisation and EC involvement should be welcome;

12. Climate Change (CC) is expected to influence the baseline of present WS&D difficulties, with a direct bearing on water availability and quality, affecting in particular the temporal and spatial variability of water availability and extreme hydrological events. In this way a link should be established between the two issues of WS&D and CC and their specific strategies, also bearing in mind that concerns regarding adaptation to CC should be integrated as a matter of priority in the implementation of the WFD. The adopted EC Green Paper on adaptation already focuses on these aspects;

13. The adoption of more sustainable water-related and sectoral measures - inter-alia, integrated water resource management, effective enforcement of pricing policies, investment in water-saving potential and the improvement of water use efficiency, the adoption of more water-friendly land-use planning and of further integration of water-related concerns into water intensive sectoral policies, and the further acquisition of high-quality information and knowledge - is a fundamental requisite to fulfilling the water policy objectives and to attaining sustainable development;
14. Coping with WS&D impacts in the EU should imply the possibility of the allocation of financial support to the Member-State regions and activities affected, in terms to be further established. It should also give access to the foreseen flexibility when implementing the WFD, by providing the opportunity to allow exemptions when it is necessary and justified (technically, economically and environmentally);

15. The WS&D process should be kept open for follow-up in the near future, not excluding legislative action if need be, bearing in mind that research and work on WS&D is still progressing and further results should be available by 2008.

Some questions to be Addressed at the Debate:

- The EU Communication presents a fundamental and well developed first set of policy options to deal with WS&D issues at European level. Does it address all WS&D concerns?
- Of these policy options, which should receive particular attention with a view to their implementation?
- The Water Framework Directive is the EU’s flagship directive on water policy, establishing the tools for achieving the good status of all European waters, and its full implementation is a priority, namely in order to address mismanagement of water resources. Does the WFD provide a solution to all water-related issues, in particular those of a quantitative nature, and does water scarcity and drought create distortions when implementing the WFD, influencing the achievement of the environmental objectives?
- Should a specific European Policy on Droughts be developed? By what legal instruments?
- Are the available European financial tools adequate to deal with WS&D events?
- Should the Commission present a follow-up program in the near future to implement the measures defined in the Communication, including legislative action if need be, bearing in mind that work and research on WS&D are still progressing?
Speech of the Minister for the Environment, Spatial Planning and Regional Development
Dear Ministers,
Dear Director-General for the Environment of the European Commission, in representation of the Commissioner for the Environment,
Guests, Ladies and Gentlemen,

It is a pleasure and a great honour for me to receive you here, in Lisbon, so that we may together analyse the problems of water scarcity and drought, in their present and future contexts, as well as the responses we need to prepare today in order to prevent situations tomorrow. These tend to be ever more complex, especially in the context of climate change.

Existing EU instruments, as well as new instruments we must create in order to deal with these problems, must be conceived so as to be both pro-active, with a view to preventing situations of risk, and reactive, in a logic of adaptation strategies, with a view to minimising the consequences of those risks.

Water scarcity and drought are realities which presently affect a significant number of countries and constitute problems which dimensions surpass national scales. Many of us have already had to confront the direct and indirect consequences of these phenomena and can confidently speak of personal experience. But many Member States, which have not known this reality in the past, can no longer consider themselves immune to this type of occurrence. The truth is that, in recent years, these phenomena have increased in intensity and become more widespread throughout Europe, with ever greater social, economic and environmental impacts. This is made clear by numerous studies, which reflect the growing interest that the European scientific community is dedicating to the theme.
As demonstrated by the assessment carried by the European Commission in 2006, in the context of the Common Implementation Strategy for the EU Water Framework Directive (WFD), drought affected all European countries, though to varying levels of intensity. With regard to economic impacts, losses in the past 30 years are estimated in the order of at least 100 thousand million (or 100 billion) Euros.

Water scarcity has also been experienced by many Member States, directly affecting at least 130 million inhabitants – almost one third of the total population of the EU.

According to climate change forecasts, we will feel the impact of extreme events (floods and drought) at an increasing rate, and some specialists believe that this climate trend can already be observed in many phenomena over the past five years, in many EU river basins.

But these phenomena are not limited to the European Union territory, and naturally do not recognise political or administrative frontiers. They are relevant at a global scale and, in particular, seriously affect some of our neighbours, in particular to the South and to the East.

This is also why the Portuguese Presidency extended a very special invitation to our close neighbours from the south of the Mediterranean to join us in our exchange of opinions on the problems we face. I wish to thank, in particular, the Minister for Environment and Sustainable Development of Tunisia, Nadir Hamada, and the High-Level Heads of Delegation from Algeria and Morocco, for being here with us today and participating in this discussion about matters pertaining to all of us, and regarding which they have much relevant experience.

I wish to thank also the Ministers from the Candidate Countries, namely Croatia, the Former Yugoslav Republic of Macedonia, and Turkey, as well as the Ministers from Norway and Switzerland, for their presence at this Informal Meeting and for the contribution they can make to enrich our dialogue.

A word of welcome to the representative of the Environment, Public Safety and Food Safety Commission of the European Parliament, to the Director of the European Environment Agency, and to the Vice President of the European Investment Bank, who are also here with us on this “day of reflection”.

Because we wish this discussion to be transparent and open to society, we have invited a representative from European non-Governmental Organisations and a representative from Portuguese non-Governmental Organisations to accompany us in this session. We are grateful for their positive response and for their presence.

Dear colleagues, ladies and gentlemen

Though related, water scarcity and drought should be differentiated, and, as such, require distinct approaches and strategies.

Water scarcity relates to the disparity between supply and demand of water, relative to normal values, or, more precisely, to medium values and those close to medium. Drought should be viewed as a significant deviation from natural availability conditions of water. Scarcity deals with the double difficulty of adjusting use to availability, and to mobilise resources to meet needs. Drought is a natural disaster, an extreme event - like floods - which occurrence cannot be controlled and which impacts can only partially be mitigated.

Portugal chose this theme for this Informal Meeting of Environment Ministers because it is committed to highlight the European dimension of this problematic and to contribute to the furthering of a specific strategy to approach these
unavoidable realities. Climate change will only exacerbate the problems if we do not deepen our understanding of these phenomena, and if pro-active policies are not adopted and resources mobilised with which to confront them.

This Meeting will enable us to ponder, together, whether it is necessary to develop a legal instrument for water scarcity and drought, similar to that developed for floods. Both situations deserve the same level of treatment in the context of the Water Framework Directive.

Naturally, we can not speak of water resources management and discuss which route to follow without discussing the WFD, its objectives and requirements.

It is clear that the WFD establishes a very well systematised and encompassing framework, with many innovative and far-reaching elements for the management of water resources in Europe. Notwithstanding, during the implementation process, some insufficiencies were noted relative to quantitative issues, which can be decisive in achieving environmental objectives. In the present phase of the Directive’s application, it is important to identify these weaknesses and seek solutions to overcome them.

As such, it becomes evident that there is a need to improve the definition of “prolonged drought”, with a view to establishing objective criteria for matters as sensitive as the compliance with environmental requirements under the Framework Directive in the periods which can be considered within that definition. But let us be clear that it is not this specific issue which drives us. Rather, it is the much farther-reaching and complex issues of the structural nature of scarcity, the lack of structured policies to tackle the natural disaster which is drought, and the lack of understanding that is still felt, at times, in relation to countries and regions which are not privileged in having naturally regular hydrological regimes.

This is a key issue and, as such, allow me to call attention to the problem of hydrological regimes which are more or less naturally regular. A difference between North and South is sometimes established as if the geographic coordinates were, of themselves, relevant. In fact, what we have are natural hydrological regimes which are more or less regular, or with greater or lesser seasonal and inter-annual variations.

We must all recognise that the management of a basin’s water resources, in which the regime of natural flows does not vary more than 10 or 20 percent during the year, has obviously to be different than the management of a basin which has the same resource annually, but in which the natural flows vary throughout the year in ratios of 1 to 20, 1 to 50, 1 to 100 or even greater. Quite often, annual availability is concentrated in only two or three months and this torrentiality effect must be taken into consideration in Europe as in anywhere else in the world. Climate change will tend to exacerbate conditions of torrentiality in wider regions of Europe, and a problem which is already significant will become even more serious.

The Commission has been focussing more attention to these issues and we recognise and appreciate the work that has been done. The Communication recently presented on the challenge of water scarcity and drought in the European Union is a most important contribution to our reflection. As such, we have decided that this document shall also provide a basis for our discussions in this Meeting.

In 2005, Portugal endured one of the worst droughts on record. More than 80% of the territory was in a state of severe or extreme drought. Consequences were felt in relation to urban water supply, availability of water
for agricultural irrigation, lower productivity of some species, and loss of biodiversity. Also, the drought led to an increase in the number of forest fires and a decrease in hydroelectric production, with dramatic social and economic effects, as well as a significant rise in atmospheric CO$_2$ emissions. Losses were estimated, at the time, at more than 1.5% of GDP.

The 2005 drought also affected vast regions of Spain, which saw the drought prolonged into an even more serious disaster in 2006. This fact demonstrates clearly the macro-regional nature of this type of phenomenon. The agreement between Portugal and Spain for the management of shared basins, entitled “Convention on the Cooperation for the Protection and the Sustainable Use of Water of the Luso-Spanish River Basins”, normally referred to as the Albufeira Convention, was essential as a bilateral basis for the coordination between the two countries and as a support to the expression of solidarity which characterised the way in which problems were approached. I recall that about 50% of Portugal’s surface water resources originate in Spain.

The drought experience of 2005 and 2006 was rewarding for Portugal and, we are certain, also for Spain. It obliged the adoption of innovative institutional, technical and financial solutions and created conditions favourable to the very active participation of water users and society in general, building consensus and defining new priorities for the use of the scarce resources available. The experience of this drought also demonstrated the need for a close coordination between countries which share river basins, as was the case of Portugal and Spain.

Dear colleagues and guests,

According to the Stern report, vast regions of Europe and, in particular, the Mediterranean region will be negatively affected by climate change. In addition to the more frequent occurrence of floods and drought, precipitation in the South of Europe may be reduced at a rate of 1% per decade. This will contribute to a severe exacerbation of the already existing water scarcity problems. Situations of scarcity and drought which are occurring with growing frequency and intensity in regions in Europe which were not previously affected are also alerting us to these and other effects of Climate Change.

We agree with the Communication by the Commission as it points to the need for a disciplined management of water resources as a primary form of dealing with water scarcity. We agree that, in order to achieve that objective, a vast array of instruments should be considered, and that demand-side management is an instrument of utmost relevance and priority. We agree that environmental concerns continue to be of primary importance, even in situations of scarcity and drought. We agree that all these issues should be considered in the preparation of Basin Management Plans, and we feel a great discomfort when some argue that our objective, in raising the theme of water scarcity and drought, is of obtaining derogations in relation to compliance with the Framework Directive, and paving the way to construction of infra-structures. That supposition corresponds with a simplistic and caricatural vision of the problems and we doubt that, if those who affirm it had the personal experience of managing water in scenarios of extreme irregularity and natural unpredictability, their attitude of distrust would persist.

We wish to make clear that we do not aim to set aside the demanding levels of environmental quality and we do not aim to consider the construction of infrastructure as the only solution, or even as a priority solution, to resolve the disparity between needs and availability. We only want to contribute to a balanced vision, in which problems of
water management are not looked at in a general and abstract way, but rather focus on the specific context of each natural regime and the trend which that regime is undergoing as a result of climate change.

Actually, the Framework Directive will provide a response to problems of scarcity in the context of River Basin Management Plans if those plans include climate change adaptation strategies. The question remains as to whether, in order to deal with the natural disaster of drought, a normative framework is not necessary, similar to that adopted for floods, establishing methodologies for the assessment of common risks and promoting preventive approaches in regions of greater vulnerability, while leaving to Member States ample space to determine concrete solutions to adopt.

The Green Paper on Adaptation to Climate Change, recently presented by the Commission, also provides a highly relevant contribution which we should consider in our discussion of these matters. That document calls our attention to other natural phenomena which, directly or indirectly, are related with drought and are strongly exacerbated with the predictable climate trend.

I refer to the processes of soil erosion and desertification and, especially, to the phenomenon of forest fires, which assume as-yet-unseen proportions in many regions of Europe.

I cannot speak of forest fires without expressing, on behalf of Portugal and the Portuguese Presidency, and, I am certain, in interpreting the sentiment of all the delegations present, our most profound solidarity with Greece due to the devastating situation the country is going through at this moment. We extend a special word to our Greek colleague, with hope that the difficult situation his country is in will be quickly overcome, and that all concrete forms of European solidarity which can be mobilised can contribute to this resolution.

Although it is not the theme of today’s discussions, it is clear that forest fires also deserve our attention, and, here too, the adoption of common strategies may be very positive. That approach shall surely be made in the near future.

Ministers, Guests, Colleagues, Ladies and Gentlemen,

I reiterate my initial words of gratitude for your presence, and I am certain that your experience and your vision will enable us to clarify the objectives and trace a path which is fair and balanced, and which will guide us to concerted and effective action in the area of water scarcity and drought.

Our European Union enjoys international prestige, and this comes with responsibility. We are known for our ambition and for our solidarity in environmental matters. I am convinced that, in placing this theme on the agenda, we are contributing to the opening of a path which, while we do not know where it will take us, time will reveal to be ever more pertinent.

Thank you very much.

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Minister for the Environment, Spatial Planning and Regional Development
Climate Change and its Links to the Water Scarcity and Drought Problems in Europe
Ghislain de Marsily
Abstract
The French Academy of Sciences published in October 2006 a “Science and Technology Report” entitled “Continental Waters”, which was prepared by the Academy for the French Government, to examine some of the major water problems that may face the World in the second half of the present century. The aim of this report, written by a panel of contributors, was to determine the possibility of major crises occurring in the World due to water-related problems, and to suggest possible actions to anticipate such crises. The perceived risks were linked to climate change consequences for water resources availability, to the increase of the World’s population, to the impact of society on water ecosystems, to potentially deteriorating drinking water quality and to the increasing number of mega-cities (with more than ten million inhabitants) mostly in the developing world.
This paper focuses on one of the major findings of this report, the likely consequences of climate change at the World scale, for both average and extreme events. The European situation is then examined, in terms of water scarcity and droughts, as well as the effects of climate change on energy production (cooling capacity). A brief outlook on food production at the World level is given, including the potential competition between food production and bio-energy production. The potential for major food shortages in case of severe global droughts (e.g. during very strong El Niño events) is discussed. The consequences of climate change and food requirements affecting ecosystems and biodiversity are briefly discussed. Potential solutions are listed, and the issue of water saving is discussed.

Key words
Climate change; extreme events; El Niño; floods and droughts; food supply; bio-energy; biodiversity; ecosystems; water saving
Climate change

Since the beginning of the industrial revolution, man has significantly modified the concentration of greenhouse gases (GG) in the atmosphere, mostly CO₂, CH₄, N₂O, thus favouring the retention in the atmosphere of the terrestrial infrared emissions, with, so far, an estimated increase of the terrestrial heat flux of 2.3 W/m² since 1750. For the 21st century, emission scenarios have been derived by the International Panel on Climate Change (IPCC, 2001, 2007) and their impact calculated on the CO₂ concentration in the atmosphere, presented in Figure 1. It is important to notice that the variability of the CO₂ concentration between scenarios is quite small until 2050, but becomes very significant in 2100, as a function of the effectiveness of the emission reduction scenarios.

As a consequence of these GG concentrations, the global temperature increase at the surface of the earth is estimated to have been 0.74°C in the last 100 years. Figure 2 shows, for instance, the evolution of the mean temperature in the summer in France, measured from 1860 to 2003, and predicted up to 2100, using the IPCC A2 scenario without aerosols, which is an average scenario. It can be seen, for instance, that the heat wave of 2003 would be in the range of normal summers in the second half of the 21st century.

The review conducted by the Académie des Sciences, (2006) concludes that the effects of climate changes for the next century are fairly well predicted as far as the temperature is concerned, depending, of course, on the GG emission scenario, but that their hydrologic effects are really much more uncertain. Nevertheless, the current

Figure 1:
Past and future CO₂ atmospheric concentration for 8 different scenarios of CO₂ emission, from IPCC (2001).
prediction is that the temperature increase would generate a significant acceleration of the water cycle, with more evaporation and an increase of the amount of water vapour present in the troposphere, while the relative humidity would remain more or less constant. The global rainfall would thus increase, but its spatial distribution is much more uncertain, as it depends very much on the assumptions made in the models and also on the presence of aerosols, which are a function of the human activity, of the atmospheric circulation, and of volcanic emissions.

Figure 2:
Evolution of the mean summer temperature in France from 1860 to 2100. Measurements until 2003, predictions with the IPSL model, IPCC SRES A2 scenario, without aerosols (from Dufresne et al., 2002).

Figure 3 is a description of the zonal distribution of average rainfall (from pole to pole) for the current climate, as measured (thick black line) and as calculated for the present with 15 different climate models. A large variability between models can be observed, which partly explains why the model predictions of rainfall for future climates are so uncertain.

Figure 3:
Mean zonal precipitation (mm/d) for December, January, February, for the current climate, observed (thick line) and calculated with 15 models. The tick red line is a schematic representation of the precipitation changes for the future climate at the end of the century (Adapted from Lambert and Boer, 2001).
The expected general consequences of climate change would be a shift towards the poles of the climate zones, as shown by the thick schematic red line in Figure 3. The dry areas of the World, as shown in Figure 4, would move towards the north in the northern hemisphere, and towards the south in the southern one. At the same time, it would rain more in the upper latitudes.

These changes are depicted in Figures 5 and 6, which show the precipitation changes (in mm/y and in %) from the second half of the 20th century to the second half of the 21st century, for the months of December to March (Fig.5) and June to September (Fig. 6), calculated by the Météo-France model CNRM for IPCC scenario B2. The same results supplied by the latest IPCC report (2007) from an average of different models are also shown for scenario A1B in Figure 7, thus illustrating the uncertainty in these predictions. The following Table 1 gives an estimate of the precipitation changes taken from Fig. 5 and 6, for several regions in Europe and Africa.

<table>
<thead>
<tr>
<th>Geographic Zone</th>
<th>December to March</th>
<th>June to September</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equatorial Africa</td>
<td>+25%</td>
<td>+10%</td>
</tr>
<tr>
<td>African Sahel</td>
<td>Uncertain, +/- 10%</td>
<td>+30%</td>
</tr>
<tr>
<td>North Africa</td>
<td>-15%</td>
<td>-10%</td>
</tr>
<tr>
<td>Southern Europe</td>
<td>Uncertain, +/-10%</td>
<td>-20%</td>
</tr>
<tr>
<td>France on average</td>
<td>+15%</td>
<td>Uncertain, +/- 10%</td>
</tr>
<tr>
<td>Northern Europe</td>
<td>+25%</td>
<td>+15%</td>
</tr>
</tbody>
</table>

Table 1:
Precipitation changes in %, for different climate zones, second half of 21st century.
Figure 5:
Precipitation anomalies (top: mm/d, bottom: %) calculated for December to March for the IPCC B2 scenario with the CNRM French model, comparing the averages for years 1950-1999 and 2050-2099 (From Académie des Sciences, 2006).
Figure 6:
Precipitation anomalies (top: mm/d, bottom: %) calculated for June to September for the IPCC B2 scenario with the CNRM French model, comparing the averages for years 1950-1999 and 2050-2099 (From Académie des Sciences, 2006).
Apart from the average precipitation changes described above, the issue of climate variability was also considered by the Académie des Sciences (2006) and IPCC (2007). Will extreme events have a different probability of occurrence than today?

Figure 8 is a schematic representation of the likely changes of the probability of occurrence of any hydrologic magnitude, such as the annual rainfall, or the discharge of a river, etc. The blue distribution represents the current climate, with its mean “m”. On average, the annual rainfall is m, but a rainfall of m/2 is an event which occurs, according to this graph, with a frequency of 10%, etc; the curves describe the probability of droughts on the left side, and that of floods on the right side with respect to the mean.

Climatologists agree that if the average annual rainfall increases, and becomes m’ instead of m, then it is most likely that the whole curve will be shifted to the right, as shown by the green curve in Figure 8. In that case, the probability of floods will increase, and that of droughts decrease. On the other hand, if the green curve with mean m’ was the
current one, and was shifted to the left to become the blue curve with a decrease of the mean \( m \), then the probability of droughts would increase and that of floods decrease. But what is not known is whether the shift in the mean, \( m \) to \( m' \), will also affect the form of the distribution, for instance modify its shape to form the red curve in Figure 8. In that case, the probability of both floods and droughts could increase. The latest IPCC report (WG1, Chap. 3, 2007) indicates that, based on observations, an increase in the variability of the climate seems indeed likely to occur, i.e. both a shift in the distribution and a change towards the red curve with more variability. Unfortunately, today climate models are not able to answer this question, only observations can be used to infer these changes, but they obviously require long time-series.

These changes are, as explained before, quite uncertain, and might perhaps occur earlier than 2050. Their major expected consequences for the water resources in European countries, in this century, appear to be:

For Southern Europe and Mediterranean-latitude zones:
- Large decrease, on average, of soil water content (higher evapotranspiration due to temperature increase and lower rainfall, particularly in summer), which means that more irrigation water will be needed, if agricultural production is to be maintained at its current level.
- Increased risk of agricultural droughts, which occur during the spring and summer months, and mostly affect the vegetation.
- Increased risk of hydrologic droughts, which occur in the fall and winter, and affect the recharge of aquifers and therefore the flow of rivers the rest of the time; but this risk is probably lower than that of agricultural droughts, since rainfall reduction occurs mostly in the summer months.
- Increased risk of floods, very intense rains are likely to occur more frequently in the South.
- Increased risk of forest fires in Mediterranean-latitude zones.

For Northern Europe:
- Increased water resources, both in summer and winter.
- Increased risk of floods, particularly in winter.
- Possible increase of droughts.

In general:
- Ice melting in the Alps (and also the Himalayas, the Andes…) and on the polar cap edges (but perhaps increase of ice at the poles, due to increased rainfall).
- Increased sea surface temperatures, likely to increase (in strength and/or frequency) hurricanes in the tropical zones.
- Increased frequency of El Niño - La Niña events. This is still debated, but would affect mostly the monsoon zone.
- Rise of sea level (about 0.50 m in 2050, currently 3 mm/\( \gamma \)) from general warming of the seas (thermal expansion) and ice melting.
- A possible effect on the Gulf Stream is sometimes mentioned; this would reduce the temperature in Europe, but is very uncertain, and its timing is unknown; it would nevertheless not compensate for the general temperature increase.
As an example, Figure 9 provides an estimate of the likely changes in the annual river discharge in Europe, comparing 2070 to 2000.

Figure 9:
Change in average annual river discharge in % in Europe 2070 versus 2000, for two different climate models. (From Lehner et al., 2001).

Water Stress

These changes in the water cycle must now be compared with the current water needs in European countries. Table 2 is an estimate of water withdrawal, based on the Report “EU Water saving potential” by Ecologic, 19 July 2007, made available by the EC as a support document to the Impact Assessment study “Addressing the challenge of water scarcity and droughts in the European Union” of July 2007. This report gives current withdrawal (for 2000) in 30 European countries (EU27+Bulgaria, Romania and Turkey), and estimated values for 2030 for the same countries, assuming continuation of global trends, improved technologies and savings, but no major public policy changes. The water uses are domestic, irrigation, industry and energy production (cooling and hydropower). To these original data, I have added a rough estimate of the amount of water that is used by rain-fed agriculture, which evaporates only rainfall, and does not require “withdrawals”. I have also roughly estimated the amount of water which is

1. This number is based on the cultivated area of EU27: 182 million ha, according to Ecologic, 2007, plus an estimate for Bulgaria, Romania and Turkey of 35 million ha, assuming the same ratio of cultivated surface area per inhabitant as the rest of Europe. The assumed evapotranspiration rate is 400 mm/y, between the estimated World average for rain-fed agriculture (330 mm/y) and the total evapotranspired amount for all continental surfaces, 550 mm/y. This number is also consistent with the amount of water required to produce wheat (1000 m³/t) and an average productivity of 40 quintals/ha. For 2030, these rain-fed areas are assumed to increase by 10%, and the Southern states (67 million ha) are assumed to receive only 320 mm/y, due to rainfall decrease.
actually consumed by various uses as a function of withdrawal (lines with yellow background in Table 2). It is indeed very important to distinguish between the water that is withdrawn and that which is actually consumed. For instance, domestic water is mostly used for cleaning; after use, it is rejected into the sewer system, and goes back to the rivers or aquifers, after treatment, if any (except in coastal zones where it goes to the sea). This water can be re-used downstream, or benefit the ecosystems. Similarly, water used for energy in hydropower or cooling is not consumed, it continues to flow in the rivers, only a small fraction is consumed. Only agriculture consumes most of the water withdrawn, as it is evaporated by the plants into the atmosphere or incorporated into food. Although precise numbers of the ratio consumption/withdrawal are not easily available (they vary between regions and uses), I have assumed a ratio of 10% for domestic, 75% for irrigation (as in the EU Impact Assessment), 100% for rain-fed agriculture, 15% for industry, and 10% for energy. It can be seen from this table that rain-fed agriculture is by far the major consumptive user, then irrigation, then industry and energy, then domestic; industry and domestic are very small in terms of consumption.

<table>
<thead>
<tr>
<th></th>
<th>Total withdrawal, km³/y</th>
<th>Domestic water, km³/y</th>
<th>Irrigation water, km³/y (blue water)</th>
<th>Rain-fed agricultural water, km³/y (green water)</th>
<th>Industrial water, km³/y</th>
<th>Water for energy, km³/y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe, EU30, Withdrawal, 2000</td>
<td>251</td>
<td>63</td>
<td>65</td>
<td>~870</td>
<td>34</td>
<td>89</td>
</tr>
<tr>
<td>Europe, EU30, Consumption, 2000</td>
<td>~939</td>
<td>~5</td>
<td>~49</td>
<td>~870</td>
<td>~5</td>
<td>~10</td>
</tr>
<tr>
<td>Europe, EU30, Withdrawal, 2030</td>
<td>208</td>
<td>61</td>
<td>74</td>
<td>~900</td>
<td>46</td>
<td>27</td>
</tr>
<tr>
<td>Europe, EU30, Consumption, 2030</td>
<td>~971</td>
<td>~5</td>
<td>~56</td>
<td>~900</td>
<td>~7</td>
<td>~3</td>
</tr>
</tbody>
</table>

Table 2: Water withdrawal and consumption in Europe, for 2000 and 2030. Adapted from “EU savings potential”, Ecologic, July 2007.
It is difficult to estimate, with the documents I have, what is the “available” water resource in EU30. I have estimated it at around 2,000 km³/y, representing water available in rivers and aquifers, not that used by rain-fed agriculture, estimated at 870 km³/y, nor the rainfall used by natural land ecosystems (forests, meadows, wet zones, etc.) which is on the order of 800 km³/y.

Overall, EU30 is withdrawing about 12% of the “available” resource, and consuming 3.5% of it, whereas it uses about 55% of its evapotranspired flux for rain-fed agriculture, and 45% for its natural ecosystems. In 2030, according to the EU documents, total withdrawal (including irrigation) should decrease, and consumption should increase to 4%, while rain-fed agriculture would expand by 10%. Of course, the global rate of 12% covers a large variation within the EU (from 53% for Cyprus, 32% for Spain, to less than 2% for Scandinavia, Baltic Countries, Hungary, etc.). In normal conditions, EU30 is therefore not overall on the verge of a large water deficit! Remember that at the global level, the threshold for water-stressed countries is taken at 75% withdrawal of the resource and 60% is an alarming situation, while a ratio of 25% is said to be “abundant” (e.g. IWMI, 2007, see Figure 10).

Figure 10: Physical and Economic Water Scarcity (from IWMI, 2007).

Red: Physical Water Scarcity. More than 75% of the river flows are withdrawn for agriculture, industries or domestic purposes (accounting for recycling of return flows). This definition of scarcity relating water availability to water demand—implies that dry areas are not necessarily water scarce. For example, Mauritania is dry but not physically water-scarce because demand is low.
Light Red: More than 60% of river flows are withdrawn. These basins will experience physical water scarcity in the near future.
Orange: Economic Water Scarcity. Water resources are abundant relative to water use, with less than 25% of water from rivers withdrawn for human purposes, but malnutrition exists. These areas could benefit by development of additional blue and green water, but human and financial capacity are limiting.
Blue: Abundant water resources relative to use: less than 25% of water from rivers is withdrawn for human purposes.

2. I have used for that purpose the “Water Exploitation Index” (including energy), as given by the EU “Impact Assessment” (2007). This is the ratio provided by the EEA and based on EUROSTAT data, defined as “the mean annual total demand for freshwater divided by long-term average freshwater resources”. I assume that the total demand is the withdrawal. Then the withdrawal per country is given in the “Water Savings” report (Ecologic, 2007), country by country. By dividing the two, the freshwater resource can be estimated country by country, giving the above 2,000 km³/y. I have checked that number for France, where I have the exact figures. Exact withdrawal and resource: 34 and 175 km³/y, ratio 19%. From these EU data: 31 and 163 km³/y, ratio 19%. This method seems thus acceptable. For Turkey, as no data for resources were available, I have used the surface area of the country, multiplied by a net resource estimate of 150 mm/y, as shown in the water availability map of the EU Impact Assessment (2007).
However, Figure 11 and 12, from Ecologic (2007), provide an estimate of “water stress” in Europe for the years 2000 and 2030, taken from the work of the University of Kassel, using their WaterGAP 2.1 model (Lehner et al., 2001). This “water stress” is defined as water withdrawal - water availability in rivers ratio, and is calculated at the river basin scale. Three classes of water stress are considered: 0-20%; 20-40%, and >40%. With this definition, the “stress ratio” does not consider consumption and therefore neglects the recycling of water in the hydrographic network, nor does it take into account rain-fed agriculture. Three conclusions can be drawn from these comparisons:

(i) In Northern Europe, climate change (increased rainfall) and predicted withdrawals (general decrease due to technology) will reduce the water stress to less than 20% in most basins and consumption to less than 4%, at least in normal conditions.

(ii) The water stress ratio is a very poor indicator and should not be used for decision making, as it does not consider net consumption nor include rain-fed agriculture.

(iii) The most severe water problems in normal conditions in Europe will occur in the Southern States, where rain-fed agriculture will be significantly impacted, due to rainfall decrease, and irrigated agriculture will expand and require more water. Figure 12 shows the corresponding zones in 2030: Southern Spain, Southern Italy, Greece, and Turkey. But the stress ratio is not significant in evaluating the real stress situation.

In comparison with agriculture, it is clear that in normal conditions, domestic water supply will never be a major issue, as it concerns small volumes, and “expensive water” can be made available (long-distance transport, desalinised water, recycled water). Water for industry and energy may be a problem in Southern states, but the major issue will be water for agriculture. This will be further discussed in a following section.
Effect of climate change on power-plant cooling capacity

Figure 13 provides an example of the likely effect of climate change on the cooling capacity of rivers. The case study is the Loire River at Gien in France, from Manhoa et al. (2007). On the one hand, the flow rate of rivers will decrease in summer, in Southern states, as shown here for the Loire, and the water temperature will increase, thus decreasing the cooling capacity of the rivers. This may impact on the electric production in the summer, or require technical alternatives to maintain the cooling capacity without increasing the temperature in the rivers at the expense of aquatic life. The phenomenon has already been observed, e.g. in France in 2003.
Water for agriculture

Apart from water availability, the increased temperature and CO₂ concentration in the atmosphere will also affect agriculture. It is estimated (IPCC, 2007) that for a temperature increase of 1-3°C, there will be an increase of productivity in Northern Europe and a decrease in the South and in the Tropics. For a temperature increase above 3°C, a general decrease of productivity is expected.

At present, Europe as a whole is importing food (virtual water), and is not self-sufficient, but exporting rain-fed agriculture (wheat) and importing irrigated agriculture. EU27 is the 5th World food exporter (virtual water export of 23 km³/y from 1995 to 1999, the 1st being the US with 152 km³/y of virtual water).

At the World scale, food will be a major problem due to demographic growth. In 2050, it is expected that around 9 billion inhabitants will live on Earth. Given that, at present, already 850 million inhabitants do not receive enough food for their basic needs, the increase in food production required by 2050 is shown in Table 3, taking into account expected diet changes (in particular increase in meat consumption, see Table 7) and age of the population.

<table>
<thead>
<tr>
<th>Regions</th>
<th>Asia</th>
<th>Latin America</th>
<th>West Asia North Africa</th>
<th>Sub-Saharan Africa</th>
<th>OECD and Russia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food need 2000</td>
<td>1 800</td>
<td>272</td>
<td>154</td>
<td>262</td>
<td>_</td>
</tr>
<tr>
<td>Food need 2050</td>
<td>4 150</td>
<td>520</td>
<td>390</td>
<td>1 350</td>
<td>Same as 2000</td>
</tr>
<tr>
<td>Food need multiplying factor</td>
<td>2.34</td>
<td>1.92</td>
<td>2.5</td>
<td>5.14</td>
<td>~1</td>
</tr>
</tbody>
</table>

Table 3:
Food needs in 2000 and prospects for 2050 per continent, in Mt y⁻¹ (Griffon 2006).
To produce this additional food, arable land is needed. Table 4 presents the surface area available for agriculture, per continent.

<table>
<thead>
<tr>
<th>Area</th>
<th>World</th>
<th>Asia</th>
<th>Latin America</th>
<th>West Asia North Africa</th>
<th>Sub-Saharan Africa</th>
<th>Russia</th>
<th>OECD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultivated area (2000) (a)</td>
<td>1 600</td>
<td>439</td>
<td>203</td>
<td>86</td>
<td>228</td>
<td>387</td>
<td>265</td>
</tr>
<tr>
<td>Area suitable for agriculture (b)</td>
<td>4 152</td>
<td>585</td>
<td>1 066</td>
<td>99</td>
<td>1 031</td>
<td>874</td>
<td>497</td>
</tr>
<tr>
<td>a/b</td>
<td>39%</td>
<td>75%</td>
<td>19%</td>
<td>87%</td>
<td>22%</td>
<td>44%</td>
<td>53%</td>
</tr>
</tbody>
</table>

Table 4: Cultivated area in 2000 (Mha) and area suitable for agriculture, according to the FAO, (Griffon 2006).

The current rate of increase of irrigated surfaces is 1.34 Mha y⁻¹. With 234 Mha of irrigated area in 2000, this will bring the irrigated surfaces to 331 Mha in 2050. This is insufficient to produce the necessary food. Unless the present expansion rate of irrigated surface areas is multiplied by ten, irrigation will not be able to provide the food needed by 2050; the food will depend on rain-fed agriculture. But it is also clear from Table 3 and 4 that some regions, in particular Asia and West Asia–North Africa, where the food multiplying factor is very large (around 2.5) do not have the soils for growing their food: they already use respectively 75 and 87% of the area suitable for agriculture. The major conclusion of this survey is thus that food production will most likely come from the increase of rain-fed agriculture, in those areas where land is still available: mainly South America and Africa, while other regions such as Asia and West Asia – North Africa will not be self-sufficient in food production. Table 5 presents one possible scenario of food production that would meet the demand in 2050, after Griffon (2006). This scenario assumes significant technological changes to improve efficiency (+50% and +33% in rain-fed and irrigated agriculture, respectively), in Asia, Latin America and sub-Saharan Africa, nominal investment in irrigation, major areal increase in rain-fed agriculture in Africa (to satisfy the demand on this continent) and in South America to compensate for the deficits of Asia and West Asia – North Africa that cannot be self-sufficient.
In Table 6, the same scenario assumes that in addition, some land is used for energy production, which gives the following distribution of cultivated land in 2050.

<table>
<thead>
<tr>
<th>Region/ Food production</th>
<th>Asia</th>
<th>South America</th>
<th>West Asia and North Africa</th>
<th>Sub-Saharan Africa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food production needed</td>
<td>4 150</td>
<td>520</td>
<td>390</td>
<td>1 350</td>
</tr>
<tr>
<td>Food production grown</td>
<td>3 190±100</td>
<td>1 704±100</td>
<td>166±10</td>
<td>1 350</td>
</tr>
<tr>
<td>Shortage/Surplus</td>
<td>-960±100</td>
<td>+1 184±100</td>
<td>-224±10</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 6:
One scenario of cultivated surface areas per continent in 2050, for food production and energy production and remaining protected areas, in million ha (from Griffon, 2006).
According to this scenario, the cultivated area is projected to increase from 1.574 billion ha in 2000 (1.34 rain-fed + 0.234 irrigated) to 3.152 billion ha in 2050, with 2.587 billion ha for food production (2.174 rain-fed + 0.413 irrigated) and 0.565 billion ha for bio-energy production. Even if energy production is not included, feeding the planet will require increasing the cultivated area by 1 billion ha. The natural ecosystems will have decreased from 2.578 billion ha in 2000 to 1 billion in 2050, or 1.565 billion if there is no bio-energy production. In conclusion, water is not likely to be the limiting factor in controlling the current demographic growth of the planet; there will be enough land and water for producing the required food in normal years, but with:

- enormous “virtual water” trade between continents, as Asia and North Africa will not be self-sufficient and will have to import food essentially from South America;
- dramatic reduction of the biodiversity and of natural ecosystems all over the world.

Given the World food scarcity, it appears very important that Europe maintains its high agricultural production, and even participates more in the international effort to feed the planet.

Risk of droughts at the World scale

Disregarding climate changes, the World has always experienced large climate variability, for instance the seven years of fat cows and lean cows in the Bible... Some archaeological studies conducted simultaneously in Greece and China seem to show that a severe drought occurred in these two countries around the year 400 AD. It is likely that such events will occur again, the question is: will they severely affect food production, and occur simultaneously across different continents? In 1998, following a strong El Niño event, there were large deficits in grain production in China and Indonesia, at the same time. These two countries were able to import from the World stocks the required amount of grain, and no major adverse consequences were felt; the current global food stocks of cereals, of the order of 400 million tons, which is about 2 months of the current global consumption, fell to a very low point, but were sufficient. These stocks have been decreasing regularly for the last few years, and, as a result, the cereal prices have greatly increased in 2006 (+31% for wheat and +67% for maize exported from the US).

The current theory is that drought situations will occur in the future, as they did before, but not at the same time on all continents, and that a situation of drought here will be compensated by normal or good production elsewhere, and therefore that no major global food shortage should occur. This may be true most of the time. But a brief look at history may be of interest here. It is well known for instance that the Krakatoa major volcanic eruption in 1883 had a worldwide effect on temperature and rainfall (a global 5% reduction of rainfall is often mentioned). In 2001, M. Davis published a historical analysis of the 19th century famines and described two major drought episodes in 1876-1878 and 1896-1900 that affected simultaneously at least Brazil, China, India and Ethiopia. Contrary to the general belief, in this case severe droughts occurred at the same time on different locations and continents, Davis (2001) relates these droughts to very strong El Niño events affecting the monsoon zones, see e.g. Fig. 14, taken from Davis (2001).
The consequences of the famines in the 19th century were very severe; Davis (2001) mentions in each case around 30 million deaths in China and India only, i.e. a total of 4% of the World’s population at the time (around 1.5 billion in 1875). The winner of the Nobel Prize for economy Amartya Sen (Sen, Drèze 1999) also analysed the same events, and determined that in most cases of drought, which he called “Food Availability Decline”, the major cause of death and famines is not really the lack of food, but rather the lack of economic resources for the poor farmers whose crops (their unique source of revenue) have been lost, and who therefore are no longer able to buy food, whose price becomes un-affordably high. He showed, for instance, that the same happened in Ethiopia in 1975, when a drought and agricultural disaster in one part of the country created a large famine and many deaths, while in other parts of the same country, food was available, and even the means of transporting it to the famine zone, which was situated along a major highway...

In this context, it is of interest to look at the observed historical frequencies of very strong El Niño events. Ortlieb (2000) tried to reconstruct, from historical archives in South America, the years of strong and very strong (in bold) El Niño events from 1525 to 1950 (plus 1998) as follows:

1539, 1546, 1552, 1559, 1567, 1574, 1578, 1589, 1600, 1604, 1607, 1614, 1618, 1621, 1630, 1640, 1650, 1652, 1661, 1671, 1681, 1687, 1694, 1703, 1715, 1723, 1728, 1737, 1747, 1761, 1776, 1782, 1790, 1802, 1814, 1824, 1827, 1832, 1837, 1844, 1850, 1854, 1864, 1867, 1876, 1877, 1887, 1891, 1899, 1904, 1913, 1918, 1925, 1940, 1998
It can be seen from this list that 1876, 1877 and 1899 were indeed very strong El Niño years, as stated by Davis (2001), but also that on average, such strong El Niño events occur about twice every century: they are indeed relatively rare.

In conclusion, what can be seen from this brief survey is that once or twice per century, or perhaps more often if climate changes affect the El Niño variability, a major drought period lasting several years may affect several continents simultaneously, impacting food production at the global scale. Probably, stocks will not be sufficient to satisfy the demand, as the current level of stocks, which is about two months of global consumption, will soon be used up, and its transportation to remote places will still be a problem. The international market prices of food will suddenly become very high, and “Food Availability Decline” will occur, generating famines of unknown magnitude. The poor countries or the poor rural communities affected by the droughts will be the first to suffer, but may not be the only ones. This already happened at a smaller scale in Niger in 2005.

There is no reason to assume that this cannot occur. What is, however, unknown is when; next year? Ten years from now? The only feasible measure to prevent such a catastrophe would be to very significantly increase the world food stocks. But where to put them, and who will pay?

**Droughts plans**

To prevent severe water shortages in case of droughts, several countries have already prepared “drought plans” to anticipate the lack of water. In general, the plans require advanced warning of the water deficit. This is possible for “hydrologic droughts”, where the lack of rain occurs in the winter, and the aquifers are not sufficiently recharged, and the flow in the rivers is low during the following summer. Predictions can be made by first defining a correlation between aquifer levels and river flow, as shown for instance for the Essonne River in France (Fig. 15).

![Figure 15: Correlation between 3-day averaged piezometric level and flow in the river Essonne, France (from Verjus, 2007).](image)
It is also possible to use hydrologic models to predict water levels in aquifers based on the current situation at any given time, the recorded rainfall over the past few months and scenarios for the rains to come, as there is always a lag between rainfall and aquifer piezometric variations. Figure 16 is an example of the use of a hydrologic model to predict the piezometric level in the Beauce aquifer two years beforehand, on the basis of a hydrologic model and three rainfall scenarios (low, average, high). Based on correlations between piezometric level and river discharge (or water availability in the aquifer), several warning thresholds are defined: vigilance, alarm, crisis, reinforced crisis. Each time it is predicted that a threshold will be crossed, the public authority may decide how to optimally allocate the water among the various users: domestic, industry, agriculture, ecosystems, recreational needs, tourism, etc.

Figure 16: Observed piezometric level in the Beauce aquifer, France (from Verjus, 2007). From 2005, the water levels are predicted for 3 rainfall scenarios (dry, average, wet). Four horizontal lines are “drought thresholds”, vigilance, alarm, crisis, reinforced crisis.

Ecosystems and biodiversity

Both climate change and demographic growth will affect water resources and land occupation on the Planet. But man is not the only “user” of that water, ecosystems and millions of species need water and land, as illustrated by Figure 17.

Figure 17: The Okawango delta, Namibia, from Kinzelbach (2006).
It is necessary here to realise that natural ecosystems are self-regulated to use all the resources they have access to. On land, rainfall is used by natural vegetation and in streams and lakes, the biota adapts to the available resource. Even in coastal zones, the freshwater flux is used by amphi-haline ecosystems. When humans arrived on earth and started to use land and water for their own needs, it was always at the expense of some ecosystem, which had to reduce its share in the resource. In Europe, for instance, a major deforestation occurred in the Middle-Ages, reducing biodiversity and the share of natural ecosystems. Today, a similar deforestation is taking place, e.g. in South America, Africa, and the Northern Countries, causing major threats to biodiversity, particularly in “hot spot” areas in the tropical forests. According to Table 6, for one scenario of food and bio-energy production, the World will suffer a reduction of 1.5 billion ha of natural ecosystems for the next half century, and only retain 1 billion ha for conservation. Will this be enough to keep a viable planet?

At the European scale, it appears that an increase in food and bio-energy production will be necessary, to contribute to our own food and energy security and for other continents’ needs. But preserving ecosystems and biodiversity should also be a high priority: the minimum share of water necessary to maintain healthy ecosystems in Europe should be determined and considered as an equally important “user” of our water resources. This should be particularly pertinent in drought situations, where ecosystems should place high in the ranking of water allocations by the authorities, most likely before agriculture. Loosing one year of crops is certainly painful, but it can be compensated financially with few consequences for the next year, whereas letting an ecosystem degenerate may be irreversible or require many years before it recovers.

This important aspect of water policy is not sufficiently addressed, in my view, in the current EU “Impact Assessment” study, although it is mentioned on several occasions. Although it may be difficult to carry out, an assessment of the amount of water used by ecosystems should be made, and their sensitivity (health, productivity, number…) to the amount of water left to them in drought situations should be assessed. An optimal water management policy should take into full consideration the preservation of ecosystems in Europe.

Water savings

Saving water, or saving any natural resource, is always a positive action, since the share of the resource which is not used by man is then left to nature. I will discuss here water savings for agriculture and domestic water supply.

In agriculture, reducing the water consumption by plant transpiration is not likely to be effective. As shown by e.g. Tardieu (2005), reducing evaporation losses by leaves is feasible, but would also reduce CO₂ input into leaves through the same stomata and thus reduce biomass production. There is no known method to reduce one without affecting the other, even for MGOs. Saving water can only be achieved by reducing losses between the water actually used by the plant and that brought to the field: evaporation into the atmosphere (water sprinklers and irrigated bare soils) and infiltration into the ground. But infiltration into the ground is not really a loss; the underlying aquifer is recharged and the water can be used again or will flow into rivers. The major water savings in agriculture will result from changes in crops and in dietary habits, as shown in Table 7, from the Académie des Sciences (2006).
It is clear from this table that a meat diet uses much more water than a vegetarian one, and vice versa; all food products do not have the same efficiency when water requirements are considered. For instance, feeding poultry on corn is about twice as effective as feeding it on rice or one-and-a-half of feeding it on wheat. Water savings in agriculture require addressing the diet issue. This aspect has been overlooked in the Impact Assessment.

### Table 7:

<table>
<thead>
<tr>
<th>Plant product</th>
<th>Water needed (m³ t⁻¹)</th>
<th>Animal product</th>
<th>Water needed (m³ t⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetable oil</td>
<td>5 000</td>
<td>Beef</td>
<td>13 000</td>
</tr>
<tr>
<td>Rice</td>
<td>1 500 – 2 000</td>
<td>Poultry</td>
<td>4 100</td>
</tr>
<tr>
<td>Wheat</td>
<td>1 000</td>
<td>Eggs</td>
<td>2 700</td>
</tr>
<tr>
<td>Corn</td>
<td>700</td>
<td>Milk</td>
<td>800</td>
</tr>
<tr>
<td>Citrus fruits</td>
<td>400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetables</td>
<td>200 – 400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potatoes</td>
<td>100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Domestic water supply is a different issue, as most of the domestic water is not consumed, and returns to the hydrographic network, except for coastal cities. For instance, reducing by half the domestic water withdrawal in Europe would result in only a 30 km³/y savings, i.e. 1.5% of the available resource, but in real terms of water consumption, it would be less than 1 per 1000 of the available resource in normal conditions. Saving water means, in fact, mostly saving the energy required to produce that water, which is estimated in France at 0.75 kWh/m³. For instance, saving 100 l/d of water is equivalent to not letting a 75 W lamp burn unnecessarily for 1h/d, or reducing by 56 m/d the transport distance of an average car! Saving 100 l/d of hot water represents a far greater energy saving: 40h/d of a 75 W lamp. And throwing away 100 g of spoiled beef is equivalent to wasting 1 300 l of water, as shown in Table 7! Whereas domestic water saving may be compulsory in drought situations, or in very dry parts of Europe, it should not be presented, in my view, as a general EU policy for the whole of Europe, as its benefits to the citizens and the ecosystems will, in most cases, be very small compared to other savings (food, energy, etc.). Trying to convince the public to save water when, eventually, the public will realize that it has very little positive effect (compared to other savings) may be counterproductive and undermine the credibility of policy makers. A final remark is that if
domestic water consumption is reduced, it will inevitably lead to an increase in the water price, for those countries where domestic water is metered, as the cost of maintaining water distribution systems is not a linear function of the distributed volume. The fixed costs of network maintenance is dominant, together with that of waste water treatment, which is also more a function of the (constant) waste load than of the total volume. It may then be difficult to explain to the citizens that the efforts they make to save domestic water is the reason why the price of water has to increase! Reducing loss through leaks is, however, always beneficial.

The situation may be different in a developing country, where a new water distribution system is to be built: if the water consumption is reduced, the investments for production and distribution of domestic water will be directly impacted and domestic water saving makes sense; it also makes sense when an old system is to be rejuvenated in a developed country.

Conclusions

With our present understanding of the effect of climate change on the water cycle, its most likely consequences in Europe (EU) will be as follows:

In normal conditions:

- Increase of the water resource in Northern Europe, at the same time as water withdrawal is decreasing.
- Strong decrease of water resources in Southern Europe, affecting mostly agricultural production.

Given the growing global demand for food and bio-energy, maintaining or increasing agricultural production in Europe should be a priority for security reasons. Although some water savings in agriculture can be expected, it is most likely that additional water resources will be required in Southern Europe, demanding long-distance water transfers from country to country, or additional water storage (e.g. in dams or in aquifers by artificial recharge, waste water reuse). Domestic and industrial water supply is, in comparison, a minor problem and can be resolved by water savings or technology. Water cooling capacity from river water for energy production in Southern countries may also become an issue in the summer.

In extreme conditions:

- Flood and drought frequencies are very uncertain. They are both expected to occur, with or without climate change. The current understanding of the effect of climate change on the frequency of droughts and floods is really too limited to support any meaningful quantitative analysis, the most likely indication is that the frequency of drought should increase, particularly in Southern Europe, and that of floods increase, particularly in Northern Europe.

- Drought plans should therefore be developed and contingency measures taken from the beginning of a drought period, to organize savings and allocate water to priority users, among which ecosystems should rank very high.
To prevent flood damage, reducing the vulnerability in advance should be the priority. This means removing sensitive equipment from the flood plain (electric transformers, fragile industry, museum archives, etc.) and building systems to protect underground services, e.g., blocking the entrances to the metro system in Paris, in the flood plain...). Managing the flood e.g. by inundating upstream reaches with low population density to protect populated downstream regions should also be considered.

Research efforts:
Societies are much more vulnerable to hydrological changes than to changes that only affect the temperature. Therefore strong research efforts are still needed in climate modelling, in extreme events analysis, in palaeoclimatology, to better constrain the predicted effects of climate change on the water cycle. Large international efforts are needed on data collection and availability for climate research (hydrologic data are no longer available, neither in developed nor developing countries, for lack of recording in some situations, but mostly because hydrologic and meteorological data are now considered proprietary and are sold expensively).

There is a lack of operational scenarios balancing demand and resources over the next 10 to 50 years, region by region, taking into account water withdrawal, water consumption, recycling and water quality. They should include:

- predictions of agricultural activity as a function of the markets, diet, technical progress…
- demands for water other than for farming, e.g., cooling water for power plants…,
- climate condition changes,
- protection against floods and inundations caused by a potential increase in climate variability,
- necessity to reserve a share of the water – (quantity, quality at the appropriate time) to allow the ecosystems to function.

The water requirements of natural ecosystems should be estimated and taken as a primary component of the water needs.
References


Economic Impact of Droughts: Challenges for Water & Environmental Policies

R. Andreas Kraemer
Rationale and Summary

Water scarcity and drought is one of the main environmental policy priorities for the EU Presidency of Portugal in 2007. The Informal Council of Environment Ministers on “Water Scarcity and Droughts” on 31 August and 1 September 2007 in Lisbon is designed to further the debate already underway in the European Union.


The key messages and conclusions from this paper, which focuses on the economic impact of droughts, can be summarised as follows:

- Droughts have noticeable economic effects on a range of important economic sectors, and they affect significant shares of the population and territory of the European Union. The same is true for other (developed) countries.
- The key economic sectors affected by drought are usually agriculture including animal husbandry, forestry, public (on municipal) water supply and power generation, tourism and recreation, inland navigation, and certain segments of industry such as pulp and paper production.
- In each of these sectors, economic impact can be significant, at least within the regions directly affected by the drought. Some of the effects linger and affect sectors for some time (years) after the drought has passed.
- The overall (macroeconomic) impact of most droughts on the national or European-wide economy are relatively small. The example of Australia shows, however, that the effects of widespread severe drought on Gross Domestic Product or total employment can be significant. A wide-spread drought in the EU could have a similar impact.
• In addition, droughts can have significant impact on the natural environment, where effects can be aggravated by human intervention or activities.

• The economic impact of droughts can be as high or even higher than those of other weather-related disasters, such as floods or storms. US data show that average economic losses from droughts are two to three times higher than those from floods other than those connected with hurricanes. This conclusion would become even stronger if full account were taken of the economic impact of droughts.

• At present, only a part of the economic impact of droughts is captured. This is shown in relation to the United States and the European Union. Additional efforts should be made to ‘mobilise’ knowledge and data from Member States and sectors, and to produce more complete estimates and aggregations as a basis for EU policy decisions. The European Drought Observatory, currently being developed by the European Commission should have a focus on the economic impact of droughts.

• Saving water and improving the efficiency of water use are obvious measures to reduce water scarcity and mitigate the risk of water shortage during drought as well as the consequences of drought. In a study for the European Commission, Dworak et alii (2007) found significant water saving potentials:

<table>
<thead>
<tr>
<th>Sector</th>
<th>Range</th>
<th>Overall Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>10–25%</td>
<td>43%</td>
</tr>
<tr>
<td>Public Water Supply</td>
<td>18–70%</td>
<td>47%</td>
</tr>
<tr>
<td>Household Use</td>
<td>15–90%</td>
<td>57%</td>
</tr>
<tr>
<td>Industry</td>
<td>10–80%</td>
<td>38%</td>
</tr>
<tr>
<td>Energy (switch to dry cooling where possible)</td>
<td>99%</td>
<td></td>
</tr>
<tr>
<td>Tourism</td>
<td>10–80%</td>
<td>38%</td>
</tr>
</tbody>
</table>

• More attention should be paid to the nexus between various fields of environmental policy, the reform of the Common Agricultural Policy and rural development. Three issues come to the fore:

• The linkage and synergies between policies on drought, water management and soil protection (from erosion, loss of organic matter, and degradation of soil structure).

• The linking of the debate about droughts to that on adaptation to, as well as mitigation, of climate change.

• The lively debate about expanding the production of bioenergies or biofuels, which should also address the linkages between bioenergy and droughts.

• Finally, as the frequency and intensity of extreme weather events, including droughts, increases with climate change, helping with adaptation to regular drought conditions should become more important than compensation for losses resulting in part from inadequate structures, land use patterns, and management practices, especially in relation to EU financial instruments.
1. Introduction

In summer, a drought never comes alone: with it usually come heat and fire, and after it comes rain, sometimes heavy. The impact of droughts is then the result of all forces combined. The impact of drought is slow and does not attract much media attention outside the directly affected area. That changes once fires start. The economic impact of droughts cannot easily be disentangled from those of heat and fire, and the impact can be compounded by wind accelerating erosion of the dried-out soil.

When droughts end and rains fall, the barren earth, now often without or with an insufficient protective vegetation cover, can be vulnerable to water erosion. The combined effects of drought and the rains afterwards can be more severe than either drought or floods would be on their own.

Droughts cause misery and economic hardship in some sectors, but by themselves they do not cost human lives in countries with the level of development found in the EU. In developing countries, droughts do cause starvation and death.

Fires lead to loss of life in small and easily accountable numbers. Heat waves, however, have the power to cause large numbers of premature deaths, even if the lives lost usually cannot be attributed to the drought with certainty but must be estimated with statistical methods.

In the following, the impact of droughts on key sectors or ‘water uses’ is briefly described. The focus is on the effects and economic impact in Europe, which are presented on a sector-by-sector basis. For additional insights, information relating to the impact of droughts in the United States of America and the Commonwealth of Australia is also presented.

One of the most important measures in mitigating or combating the effects of drought is the reduction of water consumption or the increase of water-use efficiency. Key findings from a recent study carried out by Ecologic are included in this paper. They reveal overall water saving potentials across all sectors of 25 to 47 per cent (except the energy sector).

On this basis, a number of conclusions are drawn which should stimulate further reflection and debate.

1. Droughts also occur in winter. They tend to be much less spectacular but can, for instance, directly reduce plant growth in winter crops. Or they might affect the recharge of groundwater or the development of snow-pack on the mountains, which can cause water shortages in spring and summer.
2. There appear to be no all-encompassing assessments of the economic and other impacts of droughts and related effects on all sectors. The “Water Scarcity and Droughts In-Depth Assessment – Second Interim Report” by DG Environment, European Commission of June 2007 gives a good overview. For the United States, see the “Story 51” on the web site of the National Oceanic and Atmospheric Administration (NOAA, 2002).
2. Impact of Droughts on Natural Ecosystems and Biodiversity

In general, reduced precipitation (or inflow of water above or below ground) reduces soil moisture, and thus causes a decline in microbiological activity in the soil and the root zone of plants. With less water available for the plants, they experience (severe) drought stress, grow more slowly, and become susceptible to pests and disease, and ultimately fire. In the natural environment, drought resistant plants would have a comparative advantage and might even benefit as their less resistant competitors die back.

The effects on animals vary greatly among the species, their habitat and capacity for migration. Sometimes – such as when water holes dry out – fish or other animals depending on it will be affected directly, sometimes the effect is more indirect, for instance where the plants on which the animals feed die back.

Droughts and most fires are natural phenomena, and their effects on the natural environment can be regarded as natural, not requiring mitigation, compensation or adaptation.

According to research in the field of fire ecology over the past 70 years, ‘fire is an integral component to the function and biodiversity of many communities, and that the organisms within those communities have adapted to withstand and even exploit it. Fire suppression, in combination with other human-caused environmental changes, has resulted in unforeseen changes to ecosystem dynamics and species composition and has backfired to create some of the largest, most intense wildfires yet.’

In effect, human activities, including widespread pollution, have altered many ‘natural’ ecosystems and increased their vulnerability to droughts and fires as well as to other extreme weather events.

Wetlands dependent on surface water flow or groundwater may serve as an example. Where water extraction has reduced water availability and resulted in lower river flows or groundwater levels, the dependent ecosystems will be hit earlier and harder when water is further reduced at times of drought. Where water abstraction is increased at times of drought, which is often the case, the impact on natural ecosystems can be aggravated.

Most of the loss of natural ecosystems and biodiversity that results from droughts and fire has no “economic value” in the sense that an owner or user would suffer direct economic costs as a result of the loss.

http://en.wikipedia.org/wiki/Fire_ecology; see also the web site of the Association for Fire Ecology at http://www.fireecology.net/ or http://www.cnr.uidaho.edu/range456/hot-topics/fire-ecol.htm for an introductory article by Elizabeth Fisher, from which the illustration is taken.
3. Effects and Economic Impact on Agriculture etc.

3.1. Effects of Droughts on Agriculture and Animal Husbandry

As with natural ecosystems, the impact of droughts on agriculture and breeding of animals is mainly from higher costs and from reduced productivity, both immediately and over the longer term. Where the lack of rainfall can be compensated by irrigation, which is not possible in all cases, drought induces additional costs for water abstraction and pumping, including on occasion the drilling of new wells. In spite of such measures, which can negatively impact natural ecosystems, agricultural plant productivity is generally reduced, as is the size, the total weight and general health of animal herds.

The effects linger on after a drought has ended, especially where the drought, wind or subsequent precipitation falling onto barren soil have caused erosion, loss of organic soil matter, or degradation in soil structure. Drought-induced stress physiologically affects the health also of perennial plants and makes them more vulnerable to pests and disease in subsequent years.

Animal herds may need additional feeding during and after droughts, when fodder may have to be bought in at higher prices than usual. Where herd sizes need to be reduced during drought periods, revenue from animal or meat sales are usually significantly lower than normal, and it can take some time to rebuild herds to original levels.

3.2. Economic Impact of Droughts on Agriculture and Animal Husbandry

The economic impact of droughts on the agricultural sector is acutely felt in the regions affected, but their macro-economic consequences are usually small. This is in part because agriculture is usually only a small part of total national economic activity. Consumers may pay higher prices, but that provides economic opportunities for producers in regions not affected by drought. However, a wide-spread drought and heat wave can have a significant impact on the wider economy, as the example of the 2002-2003 drought in Australia shows later in this paper.

Evidence from the EU indicates that crop yields fall significantly (Spain, 2005: cereals by 42%, wine by 20%, payments to the livestock sector added up to 1 billion Euros; France, 2005: autumn crops by 10%, maize by 20%). The reduction in farm income following the 1990–1995 droughts in Spain was estimated at 1.8 billion Euros. The cost of the 2003 drought in France has been estimated at 590 million Euros.3

The costs or losses in farm income reported for some EU Member States cannot simply be extrapolated to give an estimate for the European Union as a whole. However, the figures from Europe match those reported from the United States when taking into account the agricultural land surfaces involved.

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4. Effects and Economic Impact on Forestry and Wilderness

4.1. Effects of Droughts on Forestry and Wilderness Areas

Slower growth, more pests, and loss by fire are the most important effects of droughts on managed forests and wilderness areas. Estimates from Bavaria suggest that tree growth can be reduced by 50% during dry years, such as 2003, resulting in longer-term financial losses of about 360 million Euros (minus harvesting costs delayed or saved) for the German Free State of Bavaria alone (Borchert, 2004). Such losses may be compensated, however, by above-average growth in years with good climatic conditions. Borchert estimates the loss from bark beetle infestation, which can be a consequence of drought stress in spruce trees, at 42 million Euros in reduced revenue from timber sales alone for the 2002 drought in Bavaria. Forest management measures, such as cleaning out immature but damaged trees, replanting and rejuvenating the plantation bring the total cost to about 130 million Euros.

Drought-related forest fires (or wildfires) have economic impact through the cost of fire-fighting and often the loss of human lives. Landscapes and unique cultural or archaeological sites may be lost, including (valuable) timber, and fire-induced soil erosion and run-off from burnt areas can degrade aquatic ecosystems. Animals escaping the fire can add to pressure in surrounding areas. These effects may in part be natural and should then be tolerated, but may be aggravated by human activity. Loss of wilderness areas often results in (temporary) loss or displacement of tourism and recreation, with knock-on effects on the regional economy.

Where forest plantations are destroyed by drought or fire, it should be borne in mind, as DG Environment (2007: 48) points out, that some such forests, e.g. of eucalyptus, are detrimental to the preservation of biodiversity and may make sustainable water management impossible. Where this is the case, a forest fire may help by accelerating the redevelopment of the plantation with more suitable species.

4.2. Economic Impact of Droughts on Forestry and Wilderness Areas

Four Member States of the European Union reported costs, according to DG Environment (2007: 48):

- In Portugal, the droughts of 2004-2006 resulted in costs of 8.8 million Euros linked to forest fires. Other EU Member States also reported costs.
- In Spain, fires on 28,822 hectares during the 1994-1995 droughts have caused expenditure of 36 million Euros.
- In France, a significant increase in burnt areas has been noticed from 1976 to 2003 (an increase of 17,000 hectares). The average cost for a burnt hectare is estimated to 8,550 Euros. The average cost due to fires in years with outstanding drought can be estimated to 145 million Euros. The exceptional features of the 2003 drought led to a total cost of 370 million Euros.
- In 2002-2003, drought increased the amount of dead wood in Southern Finland, more than doubling the number of forest fires compared to average years.
5. Effects and Economic Impact on the Energy Sector

5.1. Effects of Droughts on the Energy Sector

The impact of droughts on the energy sector can be summarised as:

- Increased power demand for air-conditioning and other cooling processes (and water pumping);
- Reduced water availability for hydropower, which may then need to be compensated by increased use of fossil fuels;
- Reduced water flow or warmer water flow in rivers, reducing the capacity for cooling thermal power plants (nuclear and coal).

The economic impact of droughts on the energy sector differs greatly depending on the electricity generation mix, the capacity of water bodies and so on. Where power generation has to be lowered in areas highly dependent on hydropower or where large power plants are located on inland rivers with exceptionally low flow, the economic consequences for electricity using sectors can be significant (see below).

5.2. Economic Impact of Droughts on the Energy Sector

According to DG Environment (2007: 43-45), several Member States have reported reduction in hydroelectricity production due to drought events (Finland, France, Portugal, Spain). As hydroelectricity production is related to the amount of water stored in the upper reservoirs, the production level can be lower during a drought. Peak demands then need to be satisfied by other means available in the short term (gas turbine, etc). The amount of losses depends on hydroelectricity infrastructures and drought severity: 50 million Euros in Finland in 2002-2003, 210 million Euros in Spain in 1990-1995, 182 million Euros in Portugal in 2004-2006.

In Spain, the 2005 drought led to a reduction of 36% in national hydroelectric power production (equivalent to 12,876 GWh), with respect to the past five year average. Nuclear power generation was also affected by a shortage of cooling water. The decrease in hydraulic and nuclear production has been compensated by an increase in fuel-gas plant production and combined cycles that increased their production by respectively 28% and 66%, compared to 2004. This extra production led to an additional cost of 713 million Euros.

Belgium reports that if a 1976 drought event occurred under current water demand, two energy suppliers would fail for 8 to 13 days, resulting in direct costs of 5.4 million Euros.

The 2003 summer drought and heat wave in France resulted in an electricity sector crisis. Low levels of water in the reservoirs reduced hydropower by about 1000 MW for current flow and 600 MW for lake production. A decrease in the cooling power of rivers (high water temperature, low flows) resulted in a concurrent loss of thermal electricity capacity of up to 16,000 MW. At the same time, energy demand was 5–10 % higher than usually for the time of year. The EDF power company reported a cost of about 300 million Euros for additional material and human resource costs, and electricity purchase on the market.

6.1. Effects of Droughts on Public Water Supply

EUREAU, the federation of national associations of drinking water suppliers and sewerage services, identifies the effects and consequences of droughts on public water supply as:

- Interruptions to supply;
- Restrictions on water use (bans on the use of hosepipes, lawn watering, other);
- Demand reduction (which tends to result in rising volumetric prices for water);
- Competition for water rights (which become scarce and expensive during droughts);
- Additional investment to secure future water supplies.

6.2. Economic Impact on Public Water Supply

Public water supply systems in Europe provide a service at relatively low cost, which is of very high value to consumers; in other words: the benefits to consumers and water users are normally much higher than the water prices they pay or the total cost of providing the service. In such circumstances, the economic impact of droughts on public water supply are best estimated by looking at restriction on water use, and deteriorations or interruptions in supply, even if that does not result in a monetary estimate of the economic impact.

According to DG Environment (2007: 42-43), based on data from the water supply industry, about 50 million inhabitants were affected during 2004–2006, significantly more than in the 1970s. Restrictions have led to a reduction in water consumption by an average of 10%.

Where normal water supply operations cannot be maintained, unusual measures have to be adopted. France reports the case of Belle-Ile, where water quality deteriorated to the point that 5000 inhabitants had to be supplied with bottled water while water was transported from the mainland by tankers. Problems such as these can occur not only on island but also in coastal and even inland areas where water supply interconnections are insufficient.

In Sweden, problems have emerged from the summer of 2000 in coastal areas and islands. Most of the islands now have to cope with salt-water intrusion, due to abstraction (or pumping) in groundwater. In Gotland, it has been decided to use surface water, but the municipality still needs to issue restrictions on water use in summer.

During the 2004-2006 drought, Portugal spent 23.2 million Euros in urban water supply. In 66 municipalities with 100,500 inhabitants, urban water supply was supplemented by 22,850 water supply operations using tankers. The costs and the economic value of the inconvenience to the inhabitants affected, the loss of “consumer rent”, would be significantly higher than the direct costs reported.

Belgium assessed that if a 1976 drought event occurred under current circumstances of water demand, the country would face a shortage of infiltration capacity for drinking water production for 44 days with an associated cost of 1.87 million Euros.

7. Effects and Economic Impact on Tourism and Recreation

7.1. Effects of Droughts on Tourism and Recreation

The effects of droughts on the tourism sector vary widely and depend very much on the type and timing of the drought and the region affected:

- A winter drought in the mountains can have a direct impact on the skiing industry as well as an indirect or delayed impact on summer tourism activities, such as canoeing or rafting in rivers carrying melt-water in spring or summer.
- A summer drought in a coastal region or over islands can reduce the water available for holiday homes, hotels, swimming pools, or the irrigation of golf courses, for instance.
- Constant water shortage is what makes a desert location attractive for a segment of the tourism and recreation industry.

Where a drought leads to subsequent wildfires and the destruction of attractive landscape features, forests or wildlife, the economic impact on the tourism sector in the region can be significant and prolonged. Other tourist destinations might benefit by attracting more tourists.

7.2. Economic Impact on Tourism and Recreation

According to DG Environment (2007), there are currently few data on the economic impact of droughts on tourism and recreation. The tourism industry does not seem to want to talk about droughts as it would be bad publicity for the sector. Instead, the focus is on sunshine.

France reports losses of 144 million Euros during the winter 2006–2007 in the Alps (Savoie), a skiing area. Portugal took action during the drought of 2004-2005 in order to mitigate the impact on tourism, but economic data seem to be unavailable.

Hayes et alii (2004) report estimates for economic losses caused in the US State of Colorado by the drought during 2002. The losses for the agricultural sector were 1.1 billion US$, of which 640 million were for crop losses and 460 million related to livestock. The losses for the Tourism sector were 1.7 billion US$ and thus significantly higher than for agriculture.

8. Effects and Economic Impact on Industry and Navigation

8.1. Effects of Droughts on Industry and Inland Navigation

Apart from those already mentioned, a number of industrial sectors are susceptible to drought and related events. The pulp and paper industry depends on forestry for its input, and is thus affected indirectly by droughts and fires. It may also be directly affected in its operations when, for instance, river flow is so low that plant operations suffer. Other industries depend on power supply, which can, as was seen above, be affected by drought conditions. Another vector of indirect economic impact is inland navigation. Where low water flows in rivers and canals reduce shipping capacity, because ships cannot carry a full load, or halt shipping altogether, supply of bulk materials and the shipping of some products can be interrupted. Most businesses would prepare for periods of low flow and reduced shipping by keeping stock of materials, inventories, and products. In the United Kingdom, in the South East and Thames river basin districts, for instance, low flow rivers gave rise to navigation problems. Locks could not operate normally due to low water.

8.2. Economic Impact on Industry and Inland Navigation

Belgium estimated that if a 1976 drought event occurred under current circumstances of water demand, two important companies would stop their production for 80 to 100 days. The associated cost is estimated at 350 million Euros.

Finland reports that during the drought of 2002-2003, pulp and paper industries suffered from deficiencies due to drought conditions. Financial losses were estimated at 1 million Euros.

Portugal reports that in 2004-2006 the fertilizer industry as well as the pulp and paper industry faced an additional cost of 32.25 million Euros.

Belgium reports that if a 1976 drought event occurred under current circumstances of water demand, navigation would be made impossible on the canal system for 115 days, resulting in a cost of 123 million Euros. The estimated damage is only based on the direct damage experienced by the sector itself and thus does not reflect the important economic damage borne by all the industries depending on this mode of transport. In 2003, navigation was hindered for 22 days on the canal system, with an associated cost of 0.05 million Euros. (All information according to DG Environment (2007: 43, 46).)
9. Overall Economic Impact of Droughts – Non-EU Examples

The economic impact reported for the European Union is similar to that in other developed countries, where asset values, farming and industrial structures with their vulnerabilities, as well as policy approaches and capacities for coping with drought are also similar. The United States is interesting because it allows the economic impact of droughts to be compared to those of other extreme weather events. Among developed countries, the economy of the Commonwealth of Australia is perhaps most affected by prolonged droughts, and the overall economic impact has been estimated.


In the United States of America, the National Climatic Data Center (NCDC) maintains an ongoing record of “Billion Dollar Weather Disasters” since 1980, with the latest data available for 2006. The map below gives an impression of the distribution of the main types of weather events [hurricanes, tropical storms, and nor’easter (storms); severe weather, tornadoes, and floods; blizzards, freezes and ice storms; as well as droughts, heat waves, and wildfires].

Source: http://www.ncdc.noaa.gov/img/reports/billion/billion2006t.jpg
Hurricanes and tropical storms are generally the most costly weather disasters, with damages or losses ranging from 1 billion to a preliminary estimate of approximately 125 billion dollars for hurricane Katrina that devastated New Orleans and much of the Gulf Coast in 2005.

The level of “normal” losses to (almost annual) droughts in the US appears to be between 1 and 3 billion dollars per event. Higher losses in the 5 to 10 billion dollar range per event are rarer and would appear, if that can be said from the short time series available, once in a decade. Lives tend to be lost in small, but easily attributable and accurately recorded numbers when wildfires occur. Deaths during heat waves are not clearly attributable and estimates range (low ends of ranges are given in the table below). Losses from drought often coincide with losses from heat waves and wildfires. The highest loss was recorded during 1988, with 61.6 billion dollars in economic loss and between 5,000 and 10,000 premature deaths.

### Chronological List of US Billion Dollar Droughts, Heat Waves, & Wildfires

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
<th>Losses [bn $]</th>
<th>Losses [lives]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>Widespread Drought, and Wildfires</td>
<td>7,0</td>
<td>28</td>
</tr>
<tr>
<td>2005</td>
<td>Midwest Drought</td>
<td>1,0</td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>Southern California Wildfires</td>
<td>2,5</td>
<td>22</td>
</tr>
<tr>
<td>2002</td>
<td>Widespread Drought, and Wildfires</td>
<td>12,0</td>
<td>21</td>
</tr>
<tr>
<td>2000</td>
<td>Western Fire Season</td>
<td>2,1</td>
<td></td>
</tr>
<tr>
<td>1999</td>
<td>Eastern Drought / Heat Wave</td>
<td>1,1</td>
<td>502</td>
</tr>
<tr>
<td>1998</td>
<td>Southern Drought / Heat Wave</td>
<td>9,9</td>
<td>200</td>
</tr>
<tr>
<td>1996</td>
<td>Southern Plains Severe Drought</td>
<td>6,0</td>
<td></td>
</tr>
<tr>
<td>1994</td>
<td>Western Fire Season</td>
<td>1,2</td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>California Wildfires / South-Eastern Drought &amp; Heat Wave</td>
<td>2,6</td>
<td>20</td>
</tr>
<tr>
<td>1989</td>
<td>Northern Plains Drought</td>
<td>1,5</td>
<td></td>
</tr>
<tr>
<td>1988</td>
<td>Drought/Heat Wave</td>
<td>61,6</td>
<td>5000</td>
</tr>
<tr>
<td>1986</td>
<td>Southeast Drought/Heat Wave</td>
<td>2,6</td>
<td>100</td>
</tr>
</tbody>
</table>

Source:
Based on Lott and Ross (2007, ongoing); where ranges were reported, economic losses in the table are at the upper end of the range, and lives lost at the lower end. All losses in 2000 or earlier are reported in 2002 dollars (adjusted for price inflation).
The real costs or losses associated with droughts are almost certainly significantly higher than the estimates in the table. This can be deduced from a study on the 2002 drought. Hayes et alii (2004) comment on the data base as follows:

“[The estimate of 12 billion dollars] is the best and only estimate for the comprehensive drought loss for the United States in 2002. [...] However, very few sectors are represented from only a handful of states. There are certainly other states that were significantly affected by drought in 2002 that do not appear in the table. Agriculture is the main sector included, although the 2002 drought had a major impact on other sectors as well. For example, energy production in the South-Eastern United States had a huge economic impact that nobody has estimated. And, using Colorado as an example, an argument could be made that the losses to the tourism and recreation sector were similar to, if not greater than, losses in the agricultural sector. Other states, not just in the West, rely heavily on tourism- and recreation-based companies that were badly affected by drought.”

Following those arguments, one could assume that the actual losses would be 2 to 3 times higher than those reported by the NCDC. By comparison, the economic losses as a consequence of droughts are generally in the same order of magnitude as those from floods, although floods occur less often than droughts. Of the 27 years from 1980 to 2006, for which information is available, drought and heat waves are reported for 14, and flooding events for 8 of those years. The average annual economic loss from drought and heat waves (as reported) was 5.9 billion dollars (in 2002 dollars), the equivalent average loss from floods was 2.5 billion dollars.

In terms of human lives, not so much droughts but the accompanying heat waves account for the highest losses. For 1988, the estimates range between 5000 and 10,000 lives lost, and in 1980, approximately 10,000 premature deaths occurred due to the heat. By comparison, the death tolls for flooding events are typically well below 100. The exception is the year 1996, when the Pacific North-West severe flooding and the blizzard followed by flooding of 1996 caused 196 deaths in total, many of which due to cold rather than the flood (see Lott and Ross, 2007, ongoing).

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It is too early for a full assessment of the economic impact of the 2005 or 2006 droughts, but some of the effect of the 2002-2003 drought on the wider Australian economy has been analysed by Lu and Hedley (2004). Australia experienced a prolonged series of droughts over the past six years, notably in 2002–2003, in 2005, and again in 2006.

The main sector affected was (and is) agriculture and livestock, which account for only 3.5 per cent of the Australian economy. Nevertheless, the prolonged time of drought does have a noticeable impact on the national employment and growth. Throughout most of 2002 and 2003, drought affected large areas of rural Australia.

About 90% of the state of New South Wales (NSW), 65% of Queensland and 48 of 59 municipalities in the state of Victoria were affected by drought in August 2003. Below average rainfalls were also affecting significant parts of South Australia, Tasmania, and Western Australia, as well as the Northern Territory.

As the map below shows, rainfall deficiencies were widespread. According to Lu and Henley, 56.1 per cent of Australia were seriously or severely rainfall deficient for the 11 months from March 2002 to January 2003. Most of the (white) areas in Western Australia, South Australia, Queensland and the Northern Territory that were not affected are extremely arid or otherwise not suitable for cultivation in any case. In essence, the drought affected almost all the agricultural land in Australia.
Rainfall Deficiencies in Australia 1 March 2002 to 31 January 2003

Source:
As the authors conclude, the 2002–2003 drought led to a significant contraction of the national economy, greater than the relative size of the farm sector would suggest. Farm gross domestic product fell by 24.3 per cent through the year 2002 to the June quarter 2003, rural exports fell by 26.6 per cent, and agricultural income fell by 46.2 per cent. Drought related reductions in production also contributed to increased food prices as of mid 2002.

The farm sector subtracted around 1 percentage point from GDP growth and around 0.75 of a percentage point from employment growth during the period. These macro-economic effects are large in comparison with the size of the farm sector — typically around 3.5 per cent of GDP but about 20 per cent of exports.

The drought led to the largest declines in employment on record in the Australian agricultural sector; it cost the sector around 100,000 jobs, with almost three-quarters of job losses in the grain, sheep and beef cattle farming industries. The size of the decline in employment, in comparison to other droughts, reflects the widespread nature of the drought.

In aggregate, real farm income growth was relatively strong leading up to the drought. Nevertheless, the scale of the drought would have affected all farmers to some degree, particularly those who had experienced below average rainfall in the period leading up to the beginning of the drought.

A predicted record winter grain harvest in 2003–2004 was then expected to improve farm incomes. The recovery in livestock was predicted to take a number of years, and has been hampered by the high cost of restocking. Furthermore, depleted water storages in many areas has led to a reduction in planting of irrigated summer crops and irrigated pasture for dairy (milk) production was also severely affected. The horticultural industry also suffered from the drought.

9.3. Conclusions from the Droughts in Australia and the United States

The example of this severe drought in Australia shows not only that droughts have the capacity to cause significant impact on the wider economy, but also that even a country as experienced in drought as Australia has not been able to develop strategies for avoiding the impact of prolonged (series of) droughts. The effects can last for some time after the drought has ended, especially in the case of such a widespread drought where restocking by importing animals from other, not affected, regions is not an option.

Droughts as widespread as the case in Australia are unlikely in Europe. If one should occur, however, the knock-on effects and total economic impact could be similar.

The data from the United States shows that the economic impact of droughts can be as important or even stronger than those of other weather-related disasters. The average annual economic losses from droughts are two to three times higher than those from floods other than those connected with hurricanes. This difference would probably become larger and the conclusion even stronger if full account could be taken of the economic impact of droughts on all sectors in all states, including the wider, indirect effects.
10. Realising Water Saving Potential – Improving Water Efficiency

In the context of the economic impact of droughts, saving water and improving the efficiency of water use are obvious measures to reduce the pressure on water sources, reduce water scarcity where it exists, and mitigate the risk of water shortage during drought as well as the consequences of drought. In a study for the European Commission, Dworak et alii (2007) investigated the water saving potential in the European Union for the main sectors of water use. The study findings are summarised as follows.

10.1. Water Saving Potential in Public Water Supply (Domestic Use)

As regards public water supply (including households, public sector and small businesses), the reduction of leakage in water supply networks, water saving devices and more efficient household appliances have an overall potential for up to 50% water savings. These water saving technologies are easy to introduce and implement and they also have short payback periods, further enhancing their possibilities for adoption or implementation.

Applying the above-mentioned measures would allow for a reduction in water consumption from 150 litres/person/day (average in the EU) to a low 80 litres/person/day. A similar reduction could be applied to public water supply, leading to an estimate in potential savings of up to 33% of today's abstraction.

10.2. Water Saving Potential in Agriculture

In agriculture, water savings can be carried out with improvements in irrigation infrastructure and technologies. Potential water savings resulting from improvements in the conveyance efficiency of irrigation systems ranges between 10 to 25% of their water withdrawals. Water savings resulting from improved application efficiency are estimated at 15% to 60% of water use. Additional water savings can be expected from changes in irrigation practices (30%), use of more drought-resistant crops (up to 50%) or reuse of treated sewage effluent (around 10%). The potential water savings in the irrigation sector would amount to 43% of the current agricultural volume abstracted.

10.3. Water Saving Potential in Industry and the Energy Sector

Industries that use much water include the paper and pulp, textile, leather (tanning), oil and gas, chemical, pharmaceutical, food, energy, metal and mining sectors. Based on examples found, the application of technical measures (e.g. changes in processes leading to less water demand, higher recycling rates or the use of rainwater) can lead to savings of between 15 and 90% with a global estimate of 43% of today's water abstraction.

A particular sub-sector of industry is electricity production. Electricity production uses large quantities of water for abstracting fuel and for cooling purposes in thermoelectric power plants. However, as usually a large
A proportion of the water used in the energy sector flows back to the local environment; the benefits of water saving in this sector are marginal.

10.4. Water Saving Potential in Tourism

The tourism sector is a key water user in some areas of Europe. Technical water saving measures for the tourism sector are similar to those for households. The sector has the potential to increase water use efficiency significantly by installing newer appliances in guest rooms, cafe areas, kitchens, etc.

Since some of the measures identified in the report show a potential for a maximum of 80-90% savings, tourist accommodations could considerably reduce costs by buying more efficient appliances that only have payback periods of 3 years or less. In the case of irrigation of golf courses and sporting areas, more efficient irrigation techniques or rainwater harvesting could provide additional savings of up to 70%.

10.5. Benefits of Water Saving and Improving the Efficiency of Water Use

Clearly, the potential water saving volumes estimated are large and stress the potential for policy action at EU level. Water savings will help addressing water scarcity and droughts. They will also deliver financial and economic benefits. Such benefits include delayed or avoided procurement of additional water supply infrastructures, reduction in sewage and wastewater treatment capacity or reduced water bills. Further water saving can also bring environmental benefits beside reduced stress in river basins such as lower fertiliser use, reduce soil erosion and leaching.

It should be noted however that “net” water savings leading to environmental improvements in the status of aquatic ecosystems will only be achieved if all water saved in one sector is not used elsewhere by the same or another sector! Last but not least, water savings will also bring additional ancillary benefits, for example by reducing energy consumption, electricity bills and thus CO₂ emissions – thus contributing to climate change strategies and policy actions.

10.6. Measures for Promoting Water Saving and Efficiency in Water Use

In many cases, technical water saving measures are readily available but not yet applied. In order to foster their application, additional instruments need to be applied in order to provide the right institutional environment, incentives and awareness. Dworak et alii (2007) review three main approaches:

- Water pricing,
- Drought management plans and,
- Information campaigns.
10.6.1. Efficient Water Pricing

Drowak et alii (2007, section 6.1) assess the different situations, challenges and opportunities for water pricing to promote water savings in different sectors. The exercise leads to a very heterogeneous picture in what can or cannot be achieved with water pricing. The main function of currently existing water pricing schemes is to recover infrastructure and operational costs. This results from perceived political risks and concerns that higher prices would hurt farmers, producers and consumers. This might change in the future since water pricing policies setting economic incentives for efficient water use are required by the European Water Framework Directive by 2010.

10.6.2. Drought Management Plans

Drought management plans aim at minimising environmental, economic and social impact of eventual drought situations. They provide strategic mechanisms for managing water supplies during drought periods, for implementing water rationing measures to cope with gaps between water demand and supply and by proposing measures aimed at enhancing reliability of supplies and reducing risk. Measures set up by such plans can be voluntary in cases of low risk, but are mainly mandatory in cases of higher risk. The type of measures included in such plans can range from technical measures up to limitations in water use. Currently, drought management plans are not widely applied in Europe, but they might become more recognised in the future when droughts become more frequent.

10.6.3. Information Campaigns

Water use is mainly influenced by present consumer lifestyles. Information campaigns are considered to be an important part of initiatives, such as promoting water-saving devices, raising prices to pay for leakage and encouraging more rational water use. Not only are household customers targeted for these programs, but also industrial and commercial consumers as well. Such campaigns should inform the target audience about the water consumption level in order to enable them to make an informed decision.

10.7. Summarising the Water Saving Potential

The following table is a summary of the water saving potential identified by Dworak et alii (2007). For each sector, an overall or ‘core’ estimate is given in the last column, which is based on the technical potential identified through case studies including those found in the literature, as well as an assessment of the share of the technical potential that would be economic to realise. Water saving potentials vary widely, and it must be taken into account that technical and economic potentials do not exist everywhere in the same way. Where possible and appropriate, the ranges are illustrated through low and high values (refer to the study for details). It should be borne in mind that water should be saved in regions – or river basins – where scarcity exists and the risk of droughts is high. In other regions, where water availability is sufficient, water saving may not be necessary.
## Water Saving Potential in Various Sectors

<table>
<thead>
<tr>
<th>Sector</th>
<th>Subsector or Activity</th>
<th>Range</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>low</td>
<td>high</td>
</tr>
<tr>
<td>Agriculture (mainly irrigation)</td>
<td>Improving conveyance in irrigation</td>
<td>10%</td>
<td>25%</td>
</tr>
<tr>
<td></td>
<td>Irrigation efficiency (application to plants)</td>
<td>15%</td>
<td>60%</td>
</tr>
<tr>
<td></td>
<td>Changes in irrigation practices</td>
<td>30%</td>
<td>30%</td>
</tr>
<tr>
<td></td>
<td>Use of more drought-resistant crops</td>
<td>20%</td>
<td>50%</td>
</tr>
<tr>
<td></td>
<td>Reuse of treated sewage</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>Public Water Supply</td>
<td></td>
<td>18%</td>
<td>70%</td>
</tr>
<tr>
<td></td>
<td>Rainwater harvesting</td>
<td>30%</td>
<td>80%</td>
</tr>
<tr>
<td></td>
<td>Waste water reuse (&quot;grey water&quot;)</td>
<td>25%</td>
<td>35%</td>
</tr>
<tr>
<td></td>
<td>Leakage reduction</td>
<td>20%</td>
<td>52%</td>
</tr>
<tr>
<td>Household use</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Toilet</td>
<td>32%</td>
<td>55%</td>
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<tr>
<td></td>
<td>Shower</td>
<td>33%</td>
<td>44%</td>
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<tr>
<td></td>
<td>Bath</td>
<td>26%</td>
<td>26%</td>
</tr>
<tr>
<td></td>
<td>Taps</td>
<td>15%</td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td>Washing Machine</td>
<td>25%</td>
<td>33%</td>
</tr>
<tr>
<td></td>
<td>Dish Washer</td>
<td>30%</td>
<td>40%</td>
</tr>
<tr>
<td>Industry</td>
<td></td>
<td>15%</td>
<td>90%</td>
</tr>
<tr>
<td></td>
<td>Transport</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Leather Industry</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pulp &amp; Paper</td>
<td>15%</td>
<td>62%</td>
</tr>
<tr>
<td></td>
<td>Manufacturing</td>
<td>12%</td>
<td>90%</td>
</tr>
<tr>
<td></td>
<td>Chemicals</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Textile</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Food</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All Sectors (water saving approaches)</td>
<td>Closed loop recycling</td>
<td></td>
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<tr>
<td></td>
<td>Closed loop recycling with treatment</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Automatic shut-off systems</td>
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<td></td>
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<tr>
<td></td>
<td>Counter-current rinsing</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spray jet upgrades</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reuse of wash water</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Scrapers</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cleaning in place</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
11. Discussion of Emerging Issues and Some Conclusions

A number of issues emerge from the above that merit attention in the further debate about a European Policy on Droughts as well as environmental and water policies in general:

- One is the possible linkage and synergies between policies on drought, water management and soil protection.
- Another would be the linking of the debate about droughts to that on adaptation to, as well as mitigation of climate change.
- A third is the lively debate about expanding the production of bioenergies or biofuels, which should also address the linkages between bioenergy and droughts.

On the whole, the data and information on the economic impact of droughts in Europe is currently not satisfactory. What is needed is a short-term process for mobilising more of the information that is unpublished or difficult to locate in the “grey literature” in the Member States, in order to inform the policy debate at the European level. In addition, Europe may well need to strengthen its capacity to monitor and understand the economic impact of droughts. Practicable proposals to this effect conclude this chapter.

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<table>
<thead>
<tr>
<th>Sector</th>
<th>Subsector or Activity</th>
<th>Range low</th>
<th>Range high</th>
<th>Overall Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Energy</strong> (switching to dry cooling)</td>
<td>68%</td>
<td>88%</td>
<td><strong>99%</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Tourism</strong></td>
<td>10%</td>
<td>80%</td>
<td><strong>38%</strong></td>
<td></td>
</tr>
<tr>
<td>Camping sites</td>
<td>10%</td>
<td>45%</td>
<td>52%</td>
<td></td>
</tr>
<tr>
<td>Bed &amp; Breakfast</td>
<td>15%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Holiday houses</td>
<td>10%</td>
<td>43%</td>
<td>43%</td>
<td></td>
</tr>
<tr>
<td>Hotels</td>
<td>30%</td>
<td>70%</td>
<td>70%</td>
<td></td>
</tr>
<tr>
<td>Restaurants &amp; Cafés</td>
<td>28%</td>
<td>80%</td>
<td>80%</td>
<td></td>
</tr>
<tr>
<td>Infrastructure (stadiums, pools, etc.)</td>
<td>28%</td>
<td>80%</td>
<td>80%</td>
<td></td>
</tr>
<tr>
<td>Outdoor use</td>
<td>30%</td>
<td>76%</td>
<td>76%</td>
<td></td>
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Source: Based on Dworak et alii (2007).

In European environmental policy, we currently see largely parallel rather than inter-connected discussions about three important policy areas, each at a different stage of development:

- The ongoing learning process around the Water Framework Directive (WFD) and the Common Implementation Strategy (CIS) process (as well as related legislation on groundwater, chemicals, and floods), which is in the implementation phase;
- The debate about the future orientation of soil protection policy (Soil Strategy) and legislation, which is in the legislation phase;
- The current debate about a European Policy on Droughts, which is in the policy formulation stage.

It is to be expected that debates about policies and legislation at different stages of development and with different groups involved are not strongly connected. In the case of these three, however, more effort should be made to understand the linkages, identify possible synergies and avoid inconsistencies and conflicts.

The rationale for this would appear to be strong: droughts have a negative impact on soils moisture, organic matter and soil structure, making them more vulnerable to water erosion. Eroded soil has a negative impact on water bodies. Protecting soils and their productivity through increased irrigation results in higher pressure on water resources, in turn aggravating water scarcity and droughts.

In a virtuous cycle, soil conservation practices, such as no-tillage farming, can help build up organic matter in soils, enhance soil structure and moisture retention, making soil not only less vulnerable to erosion but also more resilient at times of drought.

11.2. Focusing on Adaptation in Agriculture

For some time, the main focus of climate policies was on climate protection and the reduction of greenhouse gas emissions. More recently, attention has also been paid to adaptation to climate change as far as it is unavoidable. The European debate focuses on the European Commission (2007a) Communication (COM(2007) 354 final), the Green Paper Adapting to climate change in Europe – Options for EU action of 26 June 2007.

The Green Paper makes references to drought, soil, and water, and mentions ‘no or minimum tillage’ in its section on agriculture and rural development. This is an important step towards strengthening coherence between the various objectives and instruments of environmental policy on the one hand, and the discussion about reforming the Common Agricultural Policy and strengthening rural development on the other.

It seems likely that crops and land management practices will need to change in response to global warming and the expected increase in the frequency and severity of extreme weather events. No-tillage or low-tillage farming is obviously an option, but so are agro-forestry and other production systems using perennial plants.

A future European Drought Policy can facilitate the process of adaptation in agriculture, land management and other sectors, for instance through the targeted use of emergency relief. In view of the 2007 drought, heat wave, and fires in Europe, a coherent approach combining the various policies would appear to be necessary.
11.3. Droughts in Relation to Climate Change & Bioenergy Production

As a consequence of rising energy prices and the desire to increase farm income by producing more bioenergies and biofuels, the amount of land under cultivation is increasing, and the methods of cultivation are becoming more intensive. There is increasing pressure to bring land of marginal productivity into cultivation, land that is often more vulnerable than average to wind and water erosion. As a consequence of increased bioenergy production, agricultural land may well become more susceptible to the effects of drought.

At the same time, bioenergy production implies a significant increase in agricultural water use, which adds to pressure on water resources and might also make agriculture more vulnerable to water scarcity and drought.

In view of ensuring that bioenergies are produced by sustainable methods, the effects of drought conditions on bioenergy production systems, and the impact of bioenergy production on the resilience of agriculture and hydrological systems to drought should be clarified.

11.4. Improving Estimates of Economic Impact of Droughts

The estimates of the economic impact of droughts – in the United States through the services of the National Oceanic and Atmospheric Administration (NOAA) and notably in the “Water Scarcity and Drought: Second Interim Report” by DG Environment (2007) of the European Commission – have been rather eclectically arrived at. More systematic and structured approaches are needed for economic impact assessments, filling gaps and overcoming the limitations of national and regional data gathering to provide meaningful aggregates for sectors and river basins. Two remedial measures come to mind:

- As part of the 7th Framework Programme of Directorate-General Research, a Coordination and/or (Policy) Support Action could be launched in the short term in order to stimulate the establishment of a network of national agencies and research facilities working on the economic impact of droughts. This should facilitate the exchange of data, the clarification of issues around the transfer of cost estimates from one region, river basin, Member State or sector to another, and eventually the calculation of European aggregates of the economic impact of droughts;\(^9\)

- The planned European Drought Observatory might play a useful role in the medium term, provided it can count economists among its staff, draw on data held by other European and Member State bodies, and has the resources to conduct or commission the research necessary to fill data gaps and develop and refine estimation and aggregation techniques.

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\(^9\) The aim of this proposal is not to establish a new institution, but to make use of existing capacities and synergies available in the short run, so that the results are available for the economic analyses, the selection of cost-effective measures, and the design of efficient and effective water pricing policies under the Water Framework Directive.
Literature and Information Resources

Literature (Selection)


• Lott, Neal, Tom Ross (2007, ongoing): Billion Dollar U.S. Weather Disasters. Website (with links to .pdf reports and papers, National Climatic Data Centre (NCDC). URLs:
  http://lwf.ncdc.noaa.gov/oa/reports/billionz.html
  http://www1.ncdc.noaa.gov/pub/data/papers/200686ams1.2nfree.pdf


• NOAA, National Oceanic and Atmospheric Administration (2002): “Economic Impacts of Drought and the Benefits of NOAA’s Drought Forecasting Service”, in NOAA Magazine Online, Story 51. URL:
  http://www.magazine.noaa.gov/stories/mag51.htm


• Reserve Bank of Australia (2002): “Statement on Monetary Policy” (November 2002), Box A: Economic Effects of the Drought. URL:

Web Sites and other Information Resources (Selection)

The European Commission, Directorate-General Environment, has a web site dedicated to “Water Scarcity and Droughts”, focusing on the Commission Communication COM(2007) 414 final with the same title; the site has links to a number of documents resulting from the preparation of the Commission Communication and stakeholder involvement. URL:
http://ec.europa.eu/environment/water/quantity/scarcity_en.htm

The European Drought Centre (EDC) is a virtual centre of European drought research and drought management organisations to promote collaboration and capacity building between scientists and the user community. URL:
http://www.geo.uio.no/edc/

In the USA, the National Oceanic & Atmospheric Administration (NOAA) of the US Department of Commerce maintains a website as a “Drought Information Center”. URL:
http://www.drought.noaa.gov/

All URLs given above were checked and found to be correct on 27 to 29 August 2007.
Water Scarcity and Droughts: Main issues at European level and the Portuguese Experience
José Rocha Afonso
1. Introduction

The Portuguese Presidency of the Council chose the Water Scarcity and Droughts theme (hereafter WS&D) as one of its priorities within the environmental agenda.

In doing so, it acknowledged the relevance and impacts of WS&D on Member States, as well as supported the recent initiatives and developments taking place at EU level, particularly concerning the water policy and the on-going implementation of the Water Framework Directive (WFD).

The Communication from the Commission to the European Parliament and the Council addressing the challenge of water scarcity and droughts at the European Union, issued on 18th of July 2007, provided a fundamental basis for the discussions to be held at this Informal Council in the 1st of September.

It must be stressed that the focus on WS&D at EU level cannot be separated from the global concerns on the same issues, which are severely affecting many areas of the globe.

“Coping with Water Scarcity” was chosen as the theme for the World Water Day of 2007, celebrated in the 22nd of March, as a clear sign of the increasing significance of water scarcity worldwide and of the need for increased integration and cooperation to ensure sustainable, efficient and equitable management of scarce water resources, both at international and local levels.

The current facts and concerns on climate change add up to the overall need for action on WS&D.
2. Background of Water Scarcity and Droughts in the European Union

The full implementation of the Water Framework Directive, the EU’s flagship directive on water policy, is a major priority. The WFD establishes a framework of great value, innovation and scope for water management in Europe, incorporating the tools for achieving the good status of all European waters, while encompassing a flexible approach for addressing environmental objectives.

Some concerns and gaps relating to quantitative issues, which influence the achievement of the environmental objectives, were identified during the on-going implementation of the WFD, particularly in regard to floods, water scarcity and droughts.

Also the occurrence of some major floods and droughts during this period further fuelled the concerns about these natural disasters. Main events were the catastrophic floods that occurred along the rivers Danube and Elbe in 2002, and one of the most widespread recent droughts, in 2003, when over 100 million people and a third of the EU territory were affected.

The above referred concerns were reflected within the Common Implementation Strategy (CIS) of the WFD, from the first stages to the present developments.

On a first approach, the informal meeting of the EU Water Directors held in Rome in November 2003 agreed to develop an initiative on water scarcity issues. A core group led by France and Italy within the CIS of the WFD – and also in the framework of the MED-EU Water Initiative/WFD joint process, launched in 2004 - prepared a technical document on drought management and long-term imbalances that was presented to the Water Directors Meeting in June 2006.

The need for further developments, however, was envisaged by the Member States, both at a political level, aiming at acknowledging the relevance of WS&D and of its environmental, social and economic impacts, and at technical level, namely to foster the analysis of measures to deal with WS&D within the implementation of the WFD.

So the Environmental Council held in June 2006 requested for action on WS&D.

The Commission proposed to come back with an in-depth assessment identifying the magnitude of the problems linked to WS&D and the gaps in the implementation of EU existing policies, on the basis of complementary data to be provided by Member States and stakeholders.

It should be highlighted that water scarcity, on one side, and drought, on the other, whilst related, are considered as different issues that need to be dealt with using somewhat different strategies. Water scarcity should refer to long-term water imbalances between supply and long-term demand, while drought should refer to important deviations from the average natural water availability conditions, the occurrence of which cannot be controlled and the impacts of which can be mitigated to a certain degree, through appropriate surveillance and management.

Within the CIS, an Expert Network on WS&D was established, chaired by France, Italy and Spain, and a Stakeholder Forum was also created, chaired by the Commission.

The Expert Network undertook to develop specific work, on the themes of “Drought Management Plans”, “Prolonged Droughts” (Article 4.6 of WFD) and “WF&D and Agriculture”, whilst it also supported the Commission’s activities on further data collection and analysis.
The Commission thus produced an Interim Report which included the above mentioned in-depth assessment.

This assessment shows that drought affected all EU countries in different ways. According to the replies received from several Member States, severe events were identified that on an annual basis have affected more than 800,000 km² of the EU’s territory (37%) and at least 100 million inhabitants (20%) in recent years with different degrees of intensity. Austria, Belgium, Cyprus, Finland, France, Germany, Hungary, Italy, Lithuania, Malta, the Netherlands, Norway, Portugal, Spain and the United Kingdom all provided specific data, but other European countries have also been severely affected by drought (e.g. Slovenia, Greece, Romania). As for the economic impacts of drought at the EU level, estimates suggest losses of 100 billion Euros over the last 30 years.

With respect to water scarcity, impacts have also been felt in several Member States, affecting at least a total population of 130 million inhabitants (27% of the EU’s population); thirty three river water basins were reported as being affected by water scarcity, representing 12% of the EU’s territory and 19% of the EU’s population. The most affected river basins are located in southern Europe; however, northern and eastern countries (Belgium, Denmark, Germany, Hungary and the United Kingdom) also identified river basins subject to water scarcity.

Further on the Commission presented the Communication to the European Parliament and the Council, addressing the challenge of WS&D in the European Union.

On the basis of the Communication the Portuguese Presidency, as said, prepared the present Informal Council, aiming at discussing the theme and at opening the way for the adoption of formal Council Conclusions.

3.1. Droughts in Portugal

Being positioned in a water divide between Atlantic and Mediterranean climates, mainland Portugal’s geography is favourable to the occurrence of droughts, and so this phenomenon is not viewed as an extreme event but rather as an endemic part of climate itself, since it has occurred in the past and it will occur in the future.

Precipitation in Portugal has an annual average similar to northern European countries (900 mm), but it presents a pronounced seasonal variability - in the wet semester it rains 75% of the annual precipitation (Fig. 1).

Precipitation varies also spatially from a more Atlantic climate type region in the Northwest to a more Mediterranean climate type in the South.

Runoff’s variability is very pronounced. The average runoff in the dry semester is in some basins less than 10% of the average annual runoff, and in general it is less than 25%.

Figure 1:
Annual average precipitation, evapotranspiration and runoff in Portugal.

Figure 2:
Precipitation in the Tagus and Danube basins.
The variability between dry years and wet years is also high in comparison with other countries in Europe, some of which have in fact a naturally regulated runoff (e.g. Fig. 2) and thus have lesser or no need to create reservoirs for regulating purposes.

Within this climate regime, the more severe droughts in Portugal are mostly multi-year droughts.

Water storage in reservoirs and in aquifers is an important component in the identification of a drought event, because those are the main water supply sources. In some years a meteorological drought might be declared, but without having major impacts in some of the water uses that depend on reliable water storage (e.g. multipurpose over year storage reservoirs, large aquifers). For less frequent situations, however, a hydrologic drought also takes place.

The main drought events experienced in the last 70 years were the following:

- 1944-1945: 2 years duration, affecting the whole country
- 1953-1954: 2 years duration, affecting 50% of the country
- 1975-1976: 1.5 years duration, affecting 40% of the country
- 1981-1983: 2.5 years duration, affecting 90% of the country
- 1992-1993: 2 years duration, affecting the whole country (during 1994 and 1995 there was a moderate drought)
- 2004-2005: 1.5 years duration, affecting the whole country

### 3.2. Droughts identification

The current drought monitoring and warning program is based in meteorological and hydrological data and indicators.

In normal conditions the Water Institute and Meteorological Institute monthly monitor the precipitation and assess its effect on a monthly basis as an input to the water cycle, namely flows in the rivers, water storage in the reservoirs, groundwater levels and water quality.

The meteorological evaluation of possible drought conditions is done namely by applying the Standardized Precipitation Index (SPI), the Palmer Severity Drought Index (PSDI) and the Regional Drought Distribution Model, with monthly precipitation data.

The hydrological indicators are obtained from the data collected by the Water Institute on the groundwater piezometric levels, river flows, reservoir water levels and water quality, using the existent network stations. These indicators are defined by a percentile of long term monthly average data.

When the meteorological indicators start to show that a drought might take place, in a specific zone or even at country level, and when the water storage in the reservoirs becomes low and there are foreseen economic and social impacts because of water unavailability, the Water Institute proposes to the Government that a state of drought might be declared.

When this event occurs, a Declaration of Drought is issued and specific multistakeholder and multisectoral
bodies are put into action. The periodicity of monitoring and prediction is increased and results are publicly
displayed.

The drought warning and alert program used by the Water Institute is schematically presented in Fig.3.

3.3. The 2004-2005 Drought

In 2004-2005 a drought occurred in Portugal, whose characteristics and impacts are thoroughly described in

During this drought new organizational efforts were put in place to cope with its impacts at national level,
that eventhough consisting much of a crisis management effort, also led to the development of new methodologies
for preparedness, action efforts and public participation. These in turn gave lessons as to the present strengths and
shortcomings and to the future needs in drought management.

Amongst other features, the meteorological drought accessed at the end of the 2004-2005 hydrologic year
presented the following features (Fig. 4):

- Two different nucleus of impact (one in the northern part of the Portuguese territory and another, more
  extensive although less intense, in southern Portugal);
- An exceptionality (measured in terms of average recurrence time interval) lying between 175 and 250
  years (whether considering its focus on southern or on northern country territory);
- A multi-year severity persistence (measured in terms of recurrence interval) of the order of magnitude of
  40 to 120 years (again more intense in the Northern Portuguese territory).
Existing storage in reservoirs and aquifers was an essential prerequisite to avoid dramatic shortages for the main activities affected. This is particularly so for urban water supply, which in fact has priority over other uses during the drought period, notwithstanding its own imposed restrictions.

From the organizational point of view, and from a political and strategic sphere, a “Drought Commission” was established, with decision-making capacity, chaired by the Ministry for Environment and composed by representatives from central and regional Government agencies, municipalities, public companies and sectoral and environmental associations.

The Drought Commission was mainly mandated to:

(i) Manage the evolution of the drought via regular analyses and the establishment of measures to be implemented;

(ii) Identify the entities responsible for implementing measures;

(iii) Identify and put forward legislative and budget-related initiatives deemed essential to the implementation of actions;

(iv) Identify a set of specific measures to support the continuation of agriculture in affected areas, with special focus on those concerning the integrated use of surface and underground water reserves and the more prudent and efficient use of water;

(v) Identify measures recommended by the Programme for Efficient Water Use that could be immediately implemented and prepare medium and long-term measures;

(vi) Identify measures that assist in preventing forest fires, within the framework for this area coordinated by the Ministry for Home Affairs;

Figure 4: Areal spread of drought severity in 2005.
(vii) Establish possible exceptional mechanisms related to tendering of public works, supply of goods and provision of services, in order to urgently solve extraordinary situations. The entities and types of intervention that should benefit from this system were to be defined.

An internet page was set-up and managed with the purpose of making permanently available the relevant information to all authorities, economic agents and the general public. At a more restricted level it served to carry out contacts and information exchange between all the members of the Secretariat and the Commission.

Another existing body, the “Commission for Reservoirs Management”, was also fully active throughout the drought period. Its action scope was even broadened, beyond the decision role on large reservoirs, also to the main aquifers, in the framework of an integrated management of these two water sources. As a result, a future revision of its legal mandate is envisaged.

Some of the main impacts of this drought were the following:

- Lowering of reservoirs (use restrictions – mainly irrigation, also water supply - imposed in several cases; quality problems; algal blooms; measures for fish protection; in the southern province of Algarve, two major reservoirs -Funcho, Arade- ended totally emptied)
- Diminished flows in rivers: problems with migrating species (e.g. lamprey in Minho river) and abstractions (e.g. paper industry in Lima and Mondego; irrigation in Mondego)
- Lowering of water tables (e.g. restrictions of abstractions in major aquifers: Querença –Silves in the South, Aveiro Cretacic in the West)
- Degradation of rivers water quality
- Some upstream migration of saline concentration in transitional waters (e.g. Tagus Estuary, Lima river: restrictions in abstractions)
- Reduction on 30% of renewable production energy (hydropower) and increase in CO$_2$ emission
- Agriculture sector was much affected with restrictions on reservoir water abstraction in order to guarantee urban water supply
- In 66 municipalities (100.500 inhabitants) urban water supply affected was supplemented by 22.850 water tank operations
- To prevent water sources quality deterioration caused by fish mortality 140 actions were undertaken and 220 ton. of fish removed

Some of the main direct costs accounted for were the following (about 300 M€):

- Urban Water supply – 23 M€
- Fertilizer industry and pulp and paper industry – 32 M€
- Hydropower losses of production – 182 €
- Agriculture – 39 M€
- Sensibilization / awareness campaigns – 1 M€
- Forest fire – 9 M€
- Biodiversity and ecosystem protection – 0.3 M€
However, these numbers do not include long-term costs (e.g. forestry, livestock, orchard, fishing), and some of the estimates are partial (e.g. biodiversity and ecosystem costs are difficult to ascertain, the figure mainly refers to fish removal).

During this drought a number of measures were taken that proved to be innovative and successful in dealing with the many and serious difficulties posed by multi-year droughts. On the other side, a series of problems and shortcomings were identified at different levels. The above referred “Balance Report” describes all these aspects in a detailed and comprehensive manner.

The 2004/2005 drought must be seen as a challenge relative to adapting activities to the country’s water resources and to enhance efficient water use, as a mean to ensure that less negative impacts might happen in future droughts.

The improvement of actions to minimise the consequences of drought events implies looking at the problem in a new manner, focused on prevention and mitigation, through the implementation of risk management principles and timely interventions to reduce vulnerability to the impacts of droughts.


The Communication from the Commission to the European Parliament and the Council addressing the challenge of water scarcity and droughts at the European Union, issued in the 18th of July 2007, proposes an important first set of measures and policy options, based, inter-alia, on the technical work conducted within the CIS of the WFD, and also on the input coming from the Member States, the results of research activities undertaken at EU level and the Stakeholder Forum meetings.

The Communication provides an overview of policy orientations for future action within the framework of EU water management principles, policies and objectives. It also defines a clear commitment to a European effort regarding the implementation of the foreseen actions and the development of further knowledge.

The major lines adopted by the Commission focus the need for full implementing the WFD and the need to move towards a water efficient and water-saving economy, namely by improving the water demand management.

Under such general lines, the main options proposed in the Communication, developed throughout the text, are structured in the following topics:

- Water pricing and metering
- Allocating water and water related funding
- Drought risk management
- Additional water supply infrastructures
- Water efficient technologies and practices
- Water saving culture
- Knowledge and data collection
Some target dates are referred to, either related to the overall framework of the water policy, or more specifically to certain options, reflecting the fact that work and research on WS&D are still progressing. Amongst them:

- **By 2008:**
  - Improve in-depth assessment
  - EC assessment of water supply alternative options
  - Risk Management Plans:
    - Foster exchanges of information
    - Identify methodologies for drought thresholds and mapping
    - Develop recommendations by the end of 2008
  - EC report reviewing progress

- **By 2009:**
  - Drought Management Plans in place
  - River Basin Plans
  - Results of research projects

- **By 2010:**
  - Water tariffs in place

- **By 2012:**
  - Drought Observatory operational
  - Warning system in place

Complementing the Communication views, some further aspects should be stressed.

Water mismanagement is a problem that influences water scarcity and which can induce additional impacts when a drought occurs. Unsustainable practices should be tackled with and a clear priority should be assigned to the enforcement of demand side measures. Member States have already put in place different initiatives in this respect, and further ones should follow. However, WS&D impacts might not be solved through these measures alone. River Basin Management Plans, as established under the WFD, will need to take into due account both demand and supply side measures, including annual and inter-annual analyses, and to consider new water supply infrastructures when necessary, subject to the scrutiny of EU legislation enforcement.

It is essential to shift from a crisis management practice to a risk management and drought preparedness stage. Work being conducted by the Expert Network is preparing ground for this. Practices in other parts of the world, namely in the USA, should provide a comparison input. So, a common approach to drought risk assessment and drought management plans should be discussed, bearing in mind that droughts, with their specific regional characteristics, are a common concern of all Member States, similar to a certain extent, to concerns about flooding. The drought management plans should include transboundary coordination, public participation and early warning systems, and could be developed at different levels: European, state, river basin and local.

It must be analysed how the WFD provides a solution to all water-related issues, in particular those of a quantitative nature, knowing that water scarcity and droughts create difficulties for the WFD implementation, by
influencing the achievement of the environmental objectives. The concept of “prolonged drought” as introduced in the WFD must be interpreted, and in fact work on that subject is also being conducted by the Expert Network.

Coping with serious droughts impacts might imply some support allocation from the EU to the Member States regions affected, and this has proved in the past to be difficult, within the existing mechanisms. The Communication deals with some aspects of this matter.

Developing methodologies and targets and having them reassessed throughout the implementation of the WFD are important aspects in dealing with the fundamental reality of WS&D, in the scope of an integrated water management within the European Union.

The Informal Council aims at raising awareness of the fundamental relevance of WS&D, which is a serious problem that affects, even if at different degrees, the whole of the EU Member States, at environmental, social and economic levels. So a common reflection on the basis of the Communication and the setup of a strategic way forward are foreseen.

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References

Presidency Conclusions on Water Scarcity and Drought

1 September 2007
1. Water scarcity and droughts are problems with relevant socio-economic and environmental impacts. These phenomena are not new but their occurrence have been increasing both in intensity and frequency at European level and neighbouring regions in recent years, and consequently countries have been affected at different levels. Therefore, at the Environmental Council of June 2006, some Member States requested European action on Water Scarcity and Droughts.

2. These problems are recognised as a global concern hence the United Nations have highlighted “Coping with Water Scarcity” as the theme of the World Water Day 2007 and consider these as strategic issues and priorities requiring joint action. Droughts and water scarcity are most acute in the driest areas of the world and in developing countries, but developed countries also face this threat at a different level.

3. On July 18th 2007, the European Commission adopted a Communication addressing the challenge of water scarcity and droughts in the European Union. The Communication provides a fundamental and well-developed first set of policy options for future action, within the framework of EU water management principles, policies and objectives. It also states a clear commitment from the EU, as a whole, to jointly establish the adequate conditions to implement the foreseen actions and to develop further knowledge.
4. The full implementation of the Water Framework Directive (hereafter WFD), the EU’s flagship Directive on Water Policy, is a major priority. The WFD establishes a framework of great value, innovation and scope for water management in Europe, establishing the tools for achieving the “good” status in all European waters, while encompassing a flexible approach in addressing environmental objectives.

5. In the context of integrated water resources management and sustainable development, some concerns were identified in relation to quantitative aspects with possible implications for the achievement of the environmental objectives set under the WFD. Issues such as floods, water scarcity and droughts have become increasingly important on the technical and political agenda. In recognition of this, the formal adoption of the proposed directive on the assessment and management of floods will occur later this year, and the issues related to water scarcity and droughts are currently under discussion at a political level.

6. Water Scarcity and Droughts have a direct impact on people and economic sectors, such as agriculture, tourism, industry, energy and transport. WS&D have a significant effect on the natural resources available and on the environment as a whole. There is also a close connection between droughts and desertification, particularly in semi-arid regions, with direct impacts upon the performance of soil functions, as well as the influence upon the level of forest fires risk.

7. Water scarcity, on one hand, and drought, on the other, should be considered different matters. Water scarcity should refer to average water imbalances between supply and demand, while droughts, as a natural phenomenon, should refer to important deviations from the average levels of natural water availability. Although it is a natural hazard, drought can be aggravated by Climate Change. It is not possible to control the occurrence of droughts although the resulting impacts may be mitigated to a certain degree, namely through appropriate surveillance and management strategies.

8. Water mismanagement is a fundamental problem, which influences water scarcity and may induce additional impacts when a drought occurs, even if it cannot generate a drought in itself, which is a natural phenomenon. The implementation of the demand side approach must be a clear priority, even though in many circumstances the WS&D impacts might not be solved through that approach alone. The River Basin Management Plans, as established under the WFD, will need to take into account both demand and supply side measures, including seasonal and interannual analysis, and to consider the need for new water supply sources, only when other measures do not suffice. These sources may consist on traditional or alternative options, namely waste water re-use and desalination.

9. A comprehensive approach to address water issues, including, inter alia, the effective implementation of integrated water resources management, the strengthening of water demand management and water saving
policies, the integration of sustainable water use concerns by other sectoral policies (e.g. energy production),
the valorisation of the aquatic ecosystems and its services, is a fundamental requirement to allow the
achievement of the water policy objectives and to move towards sustainable development.

10. The need to pay special attention on adapting agriculture policies to contribute to sustainable water
management was emphasized by the Ministers. They welcomed the intention of the Commission to include
management of water scarcity in the forthcoming CAP Health Check.

11. Water scarcity issues should be dealt with, as much as possible, through the identification of the appropriate
set of measures within the River Basin Management Plans, including the necessary adaptation strategies for
climate change. Due to the linkages to the WFD, water resources management in the international river basin
districts should be done in a coordinated way.

12. A common approach for drought risk assessment and drought management plans should be adopted by the
Commission and the Member States, considering that droughts, with their specific regional characteristics,
are a common concern for the Member States and are natural hazards in the same way floods are. Drought
management plans should include cross-border coordination, public participation and warning systems, and
should be developed at European Union, Member States, River Basin District and local level.

13. Additional work is needed and is currently underway in order to contribute to a more transparent application
of the relevant exemptions set under the WFD, in particular the definition of “prolonged droughts” and its
impact upon the achievement of the environmental objectives during and after drought periods.

14. The arrangements to set up a European Drought Observatory is considered an important measure, setting the
conditions to increase knowledge and improve the preparedness to tackle drought events. This observatory
should provide a platform for data collection and research activities, and contribute to a wide exchange of
experiences on this issue.

15. Climate Change (CC) is expected to influence the baseline of present WS&D issues, with potential impacts on
water quantity and quality. A link between WS&D and CC and their associated adaptation strategies should
be integrated into the implementation of the WFD as much as possible, including the aspects already dealt
with in the EC Green Paper on adaptation to climate change in Europe.

16. The development of a concerted follow-up program to implement the measures identified in the Communication
is of crucial importance. The process should bring together Member States and the Commission to exchange
information and best practice. Highlighting the political dimension of Drought management, political
measures should be considered, taking into account the present Presidency Conclusions, including legislative action, if needed, considering that research and work on WS&D is still progressing and that further results should be available by 2008.

17. Beyond the direct impacts of drought, there are many indirect effects and correlated phenomena that deserve serious attention. Forest fires are among those issues, as the recent events in Southern Europe clearly prove. Solidarity with those Member States who have been affected by the recent forest fires and with the relatives and families of those who have lost their lives was expressed by the Ministers.

The assistance provided by Member States and the important role played by the Community's Civil Protection Mechanism in co-ordinating this assistance was recognised by Ministers, who called on the Commission to urgently review the scope for supporting Greece in the context of all relevant Community instruments and to strengthen the Community's capacity in the future to prevent and to increase preparedness and the ability to respond and support recovery after such disasters. The Commission was requested to present the results of this review to the Council and to propose, if needed, additional measures.
Access to good quality water in sufficient quantity is fundamental to the daily lives of every human being and to most economic activities. But water scarcity and droughts have now emerged as a major challenge – and climate change is expected to make matters worse. This is a worldwide problem, and the European Union is not spared.

Over the past thirty years, droughts have dramatically increased in number and intensity in the EU. The number of areas and people affected by droughts went up by almost 20% between 1976 and 2006. One of the most widespread droughts occurred in 2003 when over 100 million people and a third of the EU territory were affected. The cost of the damage to the European economy was at least € 8.7 billion. The total cost of droughts over the past thirty years amounts to € 100 billion. The yearly average cost quadrupled over the same period\(^1\).

While “drought” means a temporary decrease in water availability due for instance to rainfall deficiency, “water scarcity” means that water demand exceeds the water resources exploitable under sustainable conditions. At least 11% of the European population and 17% of its territory have been affected by water scarcity to date. Recent trends show a significant extension of water scarcity across Europe.

Water scarcity and droughts are therefore not just a matter for water managers. They have a direct impact on citizens and economic sectors which use and depend on water, such as agriculture, tourism, industry, energy and transport. In particular, hydropower which is a carbon neutral source of energy, heavily depends on water availability.

Water scarcity and droughts also have broader impacts on natural resources at large through negative side-effects on biodiversity, water quality, increased risks of forest fires and soil impoverishment.

In a context where changes in climate are foreseen in spite of significant EU mitigation efforts, this trend is expected to continue and even worsen, as underscored in the recently adopted Commission Green Paper on adaptation to climate change. According to the Intergovernmental Panel on Climate Change\(^2\), climate change would bring water scarcity to between 1.1 and 3.2 billion people if temperatures rose by 2 to 3° C. Drought affected areas are likely to increase in extent. In these circumstances, it has become an EU priority to devise effective drought risk management strategies.

On 10 January 2007 the Commission adopted an Energy and Climate package to guide the EU towards a sustainable, competitive and secure energy policy. One of its central themes is to tackle the energy challenge by first making an effort to use energy more efficiently before looking at alternatives. This approach is also valid for water scarcity and droughts. In order to come to grips with water scarcity and droughts, the first priority is to move towards a water-efficient and water-saving economy. Saving water also means saving energy, as extracting, transporting and treating water comes at a high energy cost. In this context, it is essential to improve water demand management. Just like energy, water is necessary for all human, economic and social activities. A wide range of policy options will therefore need to be considered.

Against the above background, this Communication presents an initial set of policy options at European, national and regional levels to address and mitigate the challenge posed by water scarcity and drought within the Union. The Commission remains fully committed to continuing to address the issue at international level, in particular through the United Nations Convention to Combat Desertification and the United Nations Framework Convention on Climate Change.

This Communication also responds to the request for action on water scarcity and droughts from the Environment Council in June 2006.

1. Setting the Scene

The following challenges need to be addressed:

- Progressing towards full implementation of the Water Framework Directive\(^3\) (hereinafter “WFD”), the EU’s flagship Directive on water policy, is a priority in order to address mismanagement of water resources.
- This issue is often a result of ineffective water pricing policies which generally do not reflect the level of sensitivity of water resources at local level. The ‘user pays’ principle is hardly implemented beyond the sectors of drinking water supply and waste water treatment. Introducing this principle at EU level would put an end to needless losses or waste, ensuring that water remains available for essential uses across Europe, including all parts of transboundary river basins. In other words, it would encourage efficient water use.

\(^2\) IPCC WGII Fourth Assessment Report, 6 April 2007.
\(^3\) Directive 2000/60/EC establishing a framework for Community action in the field of water policy.
Land-use planning is also one of the main drivers of water use. Inadequate water allocation between economic sectors results in imbalances between water needs and existing water resources. A pragmatic shift is required in order to change policy-making patterns and to move forward effective land-use planning at the appropriate levels.

There is huge potential for water saving across Europe. Europe continues to waste at least 20% of its water due to inefficiency. Water saving must become the priority and all possibilities to improve water efficiency must therefore be explored. Policy making should be based on a clear water hierarchy. Additional water supply infrastructures should be considered as an option when other options have been exhausted, including effective water pricing policy and cost-effective alternatives. Water uses should also be prioritised: it is clear that public water supply should always be the overriding priority to ensure access to adequate water provision.

Further integration of water-related concerns into water-related sectoral policies is paramount in order to move towards a water-saving culture. Integration achievements at EU, national and regional levels vary widely from one sector to another. In general terms, there is a lack of consistency and, in some cases, even counter-productive effects on water resource protection.

Finally, in order to be fully effective, policy action on water scarcity and droughts needs to be based on high-quality knowledge and information on the extent of the challenge and projected trends. Existing European and national assessment and monitoring programmes are neither integrated nor complete. Filling knowledge gaps and ensuring data comparability across the EU is therefore a precondition. In this context, research has a significant role to play providing knowledge and support to policy making.

2. Addressing the Challenge: Policy Orientations for Future Action

It emerges from stakeholder consultations and the proportionate impact assessment carried out for this Communication that an integrated approach based on a combination of options would be the most appropriate approach for addressing water scarcity and droughts, compared to alternatives based on water supply or economic instruments only.

Further economic and legal analyses will be required in the coming months to specify in detail the potential, feasibility and possible timeframe for each of the options considered. Impact assessments should be carried out prior to the introduction of any of the proposed measures.

2.1. Putting the right price tag on water

The issue:

The Commission actively promotes the use of market-based instruments in an environmental context, as underscored by the recently adopted Green Paper on Market-Based Instruments\(^5\). The existing legal framework in the WFD offers ample room for tackling both water scarcity and droughts through such instruments. In spite of the WFD’s specific requirements (Article 9), economic instruments have not been widely used by Member States thus far. Pricing policies that may appear to be very well designed can prove totally ineffective if most water abstraction is not even metered or registered by the authorities. The WFD (Article 11) requires the implementation of systematic control over water abstraction.

Way forward:

At national level, by 2010:

- Put in place water tariffs based on a consistent economic assessment of water uses and water value, with adequate incentives to use water resources efficiently and an adequate contribution of the different water uses to the recovery of the costs of water services, in compliance with WFD requirements. The ‘user pays’ principle needs to become the rule, regardless of where the water comes from. Nevertheless, private households should, irrespective of their available financial resources, have access to adequate water provision.
- Enhance efforts to introduce compulsory metering programmes in all water using sectors.
- More broadly ensure full implementation of the WFD in order to guarantee or recover sustainable water resources.

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Good practice:
In France, irrigators have to be equipped with water meters whenever they go beyond abstraction thresholds. In period 2000-2003, the level of equipment rose from 54% up to 71%, representing 85% of the overall irrigated area.

2.2. Allocating water and water-related funding more efficiently

2.2.1. Improving land-use planning

The issue:
The economic development of some river basins can lead to adverse effects on water resource availability. Particular attention needs to be paid to river basins facing quasi-permanent water stress or scarcity. Existing EU policies have tended to exacerbate the sensitivity of these basins. The widespread development of tourist resorts in sensitive river basins, for instance, has led to significant impacts on local water resources. Farming also has significant impacts notably related to irrigation. Over-abstraction remains an issue also due to incomplete decoupling by some Member States. Successive reforms of the CAP and in particular rural development support have already contributed to improving the situation. Future adjustments of the CAP and the ‘Health check’ of 2008 could provide opportunities to examine how to further integrate water quantity issues in the relevant CAP instruments. In this context, it should be for instance considered to what extent the CAP and the “Health check” of 2008 could promote more complete use of full decoupling and increased support for water management within rural development programmes. It will be also important to analyse the impact of the increase in biofuels on water availability. All production including irrigated and biomass production and all economic activities should be adapted to the amount of water available locally. This is a key condition for sustainable land-use planning across Europe.

Way forward:
At European level:
• The increased emphasis on sustainable agriculture over the past decade provides a useful platform for policy debate on further progress in order to increase water management sustainability. This will be of particular importance in the period up to the implementation of the river basin management plans in 2010.
• Further assess the inter-linkages between biofuel development and water availability.

At national level:
• Ensure stringent implementation of the Directive6 on Strategic Environment Assessment in all economic sectors. Member States still need to strengthen their national procedures and ensure that the conditions attached to the final decisions adequately prevent any environmental impact.
• Encourage Member States to identify river basins which face quasi-permanent or permanent water stress or scarcity.

• For those river basins, set up appropriate regulations to restore a sustainable balance. Voluntary schemes could make a positive contribution and need to be promoted. If results prove insufficient in very sensitive areas, compulsory measures on water saving and water efficiency should be introduced. All measures will ultimately be part of the WFD programmes.

Good practice:
In the framework of the UN Convention to Combat Desertification, Greece has issued a National Action Programme which considers specific measures to address imbalances between demand and supply.

2.2.2. Financing water efficiency

The issue:
The potential for water efficiency is not exploited to the fullest extent in the EU. Even though they are cost-effective, a number of measures are not taken owing to unaffordability.

Addressing the consequences of climate change in particular water scarcity and droughts is one of the priorities of EU regional policy in the period 2007-2013. The new legislative framework provides for investments in infrastructure related to water management (storage, distribution, treatment), clean and water-efficient technologies as well as risk prevention measures.

European funds and State aids offer significant opportunities to meet this challenge, but budgets are undoubtedly insufficient to duly cover all the issues.

National priorities can also be counterproductive in promoting additional water supply infrastructure as the primary option, going against the logic of the water hierarchy and the need to support water-saving and efficiency measures in the first place. It continues to be essential to ensure that the allocation of funding is sufficiently conditional on independent and ex-ante evidence of full utilisation of water savings and efficiency, effective water pricing policy and metering, minimum performance of public water supply networks or recovery of the costs of projects by the water users concerned. National support measures must also fully respect State aid rules where applicable.

Way forward:
At EU level:
• Refine existing Community strategic guidelines for water infrastructures and in the context of the regional and rural development policies, determine whether further progress needs to be made as regards environmental preconditions related to effective water management before support can be given to any additional water supply infrastructure or equipments.
• Explore how sectoral policies could better and further contribute to effective water management, utilising associated funds to foster the delivery of environmental services by water users in an efficient way.
At national level:
- Ensure efficient use of EU and national funds to improve water demand management, in particular through measures of adaptation, sustainable practices, more water savings, monitoring systems and adapted risk management tools.
- Develop fiscal incentives for the promotion of water-efficient devices and practices, in particular in water scarce areas, taking into account the social context and the potential regional differences.

Good practice:
Cyprus has taken conservation measures at household level by encouraging the re-use of “grey water” (i.e. from washing and washing machines) for watering gardens and flushing toilets, reducing per capita water consumption by up to 40%. In 2007, government subsidies cover 75% of the cost of the system.
In Germany, one fifth of the biggest cities have been supporting rainwater harvesting for more than 10 years with the objective of equipping 15% of buildings by 2010.

2.3. Improving drought risk management

2.3.1. Developing drought risk management plans

The issue:
Following the increasing droughts in the past few years, some Member States have moved from crisis management to drought risk management. The associated measures often result in comprehensive drought risk management plans with water stress area mapping, alert levels, warning systems, etc. The WFD has all the necessary flexibility to develop specific drought management plans in relevant river basins.

Way forward:
At European level:
Foster exchanges of information and best practices on drought risk management. Identify methodologies for drought thresholds and drought mapping. By the end of 2008, develop recommendations.
At national level:
- By 2009, set up specific drought management plans to supplement WFD river basin management plans, where needed, in accordance with WFD provisions (Article 13(5)).
2.3.2. Developing an observatory and an early warning system on droughts

The issue:

The Commission is currently developing a European Drought Observatory which will enhance the knowledge of the issue. Efficient alert systems are also an essential dimension of risk management. An early warning system will therefore follow suit to improve the drought preparedness of the relevant authorities. This system will integrate relevant data and research results, drought monitoring, detection and forecasting on different spatial scales, from local and regional activities to continental overview at EU level, and will make it possible to evaluate future events.

Way forward:

At European and national levels:

- By 2012, develop prototypes and set up implementing procedures for operational European Drought Observatory and early warning system.

Good practice:

Within the context of the United Nations Convention to Combat Desertification, Slovenia is hosting a Drought Management Centre for South-Eastern Europe which works on drought preparedness, monitoring, forecasting and management.

Within the context of FP5, a European Drought Centre has been proposed. This is a virtual knowledge centre, which promotes collaboration and capacity building between scientists and the user community, and thereby increases preparedness and resilience of society to drought.

2.3.3. Further optimising the use of the EU Solidarity Fund and European Mechanism for Civil Protection

The issue:

Up to now, Member States affected by severe droughts have never applied for assistance under the European Union Solidarity Fund (EUSF). Nor have they asked for civil protection assistance to obtain urgent water supplies.
Way forward:
At EU level:

- Reiterate the Commission’s readiness to fully examine any request for EUSF support communicated by a Member State seriously affected by a drought while ensuring that the request is not the indirect result of inefficient water management and that appropriate drought management plans are in place.
- In the context of the EUSF regulation, examine whether further progress needs to be made as regards the definition of the criteria and eligible operations in order to allow the Solidarity Fund to better respond to drought events.
- The Mechanism for Civil Protection will consider all opportunities to incorporate drought issues in future annual work programmes. One objective will be to identify all possibilities of assistance in cases of severe droughts, having consequences such as forest fires, and to aim at using and complementing the scarce resources available in the best way.
- The Civil Protection Expert Group on Early Warning Systems will be requested to develop an approach to optimise the use of the drought early warning system at European and national levels and to anticipate any civil protection preparatory action.

2.4. Considering additional water supply infrastructures

The issue:

In regions where all prevention measures have been implemented according to the water hierarchy (from water saving to water pricing policy and alternative solutions) and taking due account of the cost-benefit dimension, and where demand still exceeds water availability, additional water supply infrastructure can in some circumstances be identified as a possible other way of mitigating the impacts of severe drought.

There are several possible ways of developing additional water infrastructures, such as storage of surface or ground waters, water transfers, or use of alternative sources.

The constructions of new water supply dams and water transfers are subject to EU legislation. Interruption or transfers of stream flow inevitably change the status of water bodies and as such are subject to specific and strict criteria. In addition, large projects often provoke social and political conflict between donors and receiving basins, which calls their sustainability into question.

Alternative options like desalination or waste water re-use are increasingly considered as potential solutions across Europe. Any definitive Commission position on these options will have to be based on further work on risk and impact assessment, taking into account the specific bio-geographical circumstances of Member States and regions.
Way forward:
At EU level:
• By the end of 2008, prepare a Commission assessment of all alternative options
At national level:
• Ensure that all adverse effects linked to any additional water supply infrastructure like dams or desalination plants - are fully taken into account in the environmental assessment. The changes expected as a possible consequence of climate change and the objectives to be achieved within the Energy Policy for Europe must be fully considered in order to avoid any incompatibility.

Good practice:
Research projects such as MEDINA\(^7\) and MEDESOL\(^8\) (6th Framework Research Programme) are currently underway with a view to minimising the volume of brine or reducing energy consumption in case of desalination.

2.5. Fostering water efficient technologies and practices

The issue:
All economic sectors need to continue to develop water-efficient technologies and practices. Water performance could still be considerably improved across the EU. In some regions, up to 30% of the volume of water consumed in buildings could be saved\(^9\). In some cities, leakages in public water supply networks can exceed 50%. Similar wastage of water has been recorded in irrigation networks. In addition to improving technologies, the upgrading of water management practices is a necessary instrument in all sectors where huge quantities of water are used (e.g. agriculture, manufacturing or tourism).

Way forward:
At EU level:
• Consider developing standards for water-using devices such as irrigation systems and other farm energy-using equipments.
• Consider developing legislation to cover non-energy-using products including water-using devices (taps, shower heads, toilets).
• Include water efficiency criteria in performance standards for buildings when harmonising Life Cycle Assessments and Environmental Product Declarations.

7. MEDINA: Membrane based desalination: an integrated approach.
8. MEDESOL: Seawater desalination by innovative solar-powered membrane distillation system.
• Consider developing a new directive similar to the Energy Performance of Building Directive\(^\text{10}\) for water performance of buildings. This could cover taps, showers and toilets, rainwater harvesting and reuse of “grey water”.
• Consider adopting of a performance indicator on the use of water in the revision of the EMAS Regulation to be presented by the Commission. Working towards the possible certification of all buildings of the European Institutions gradually over the next years.
• Encourage enhanced research on adaptation of economic activities to water scarcity and droughts, water efficiency and decision-making tools.

At national level:
• Encourage the adoption of binding performances for new buildings and for public and private networks, with systems of fines for excessive leakages.

At EU and national levels:
• Develop voluntary agreements with all economic sectors that need water (builders, building managers, manufacturers, tourism professionals, farmers, local authorities) to develop more water-friendly products, buildings, networks and practices.

Good practices:
In Spain, proactive water-saving programmes have been launched in several towns and have produced significant results. In 1997, Zaragoza launched a comprehensive programme based on updated water devices and equipment, introduction of metering and raising public awareness. Its implementation resulted in the saving of 1.2 billion litres of water per year and the lowest water consumption per inhabitant and per day in Spain (96 l/person/day).

2.6. Fostering the emergence of a water-saving culture in Europe

The issue:
Developing a responsible water-saving and efficiency culture requires an active awareness-raising policy in which all actors in the water sector need to be involved. Information, education and training are priority areas for action.

Consumers increasingly demand more information on the way water is used at all stages of the industrial or agri-food process. Labelling is an effective way to provide targeted information to the public on water performance and on sustainable water management practices. The marketing of ever more efficient devices or “water-friendly” products should be encouraged.

In line with Corporate Social Responsibility (CSR), economic operators involved in quality or certification schemes should be encouraged to promote their products on the basis of the demonstrated efficient use of water.

Way forward:
At EU level:
• Explore, together with the European Business Alliance on CSR, the possibility of launching an Alliance initiative on the efficient use of water.
• Encourage the inclusion of rules on water management in existing and future quality and certification schemes.
• Explore the possibility of expanding existing EU labelling schemes whenever appropriate in order to promote water efficient devices and water-friendly products.
At national level:
• Further encourage the development of educational programmes, advisory services, exchanges of best practices and large targeted campaigns of communication focused on water quantity issues.

Good practice:
In summer 2006, France launched a national campaign entitled “Will everyone get enough water?” This campaign based on television and radio spots encouraged individual efforts at water saving. The public considered the messages were convincing. 88% said that they make efforts to save water.

2.7. Improve knowledge and data collection

2.7.1. A water scarcity and drought information system throughout Europe

The issue:
Reliable information on the extent and impacts of water scarcity and droughts is indispensable for decision-making at all levels. Shared definitions are necessary to ensure data consistency at EU level. The recently published Water Information System for Europe (WISE) provides the ideal platform to integrate and disseminate such information.

Way forward:
• Present an annual European assessment, based on agreed indicators and data provided by Member States and stakeholders to the Commission or the European Environment Agency on a yearly basis.
• Fully exploit the Global Monitoring for Environment and Security (GMES) services for the delivery of space-based data and monitoring tools in support to water policies, land use planning and improved irrigation practices.

2.7.2. Research and technological development opportunities

The issue:
Support coordination and dissemination of research efforts between the EU and national levels will ensure the best match between research needs and what is on offer to society including practitioners and policy makers. LIFE+ and transboundary programmes under the European Neighbourhood and Partnership Instrument (ENPI) on water scarcity and drought management should be coordinated. Synergies have to be sought between policy and research in this respect.

Way forward:
- Disseminate and facilitate the use and exploitation of the results of research on water scarcity and drought issues.
- Explore, enhance and encourage research and technological activities in this area, including networking, under the opportunities that the Seventh Community Research Framework Programme may bring. These research results may start to be operational and integrated to policy by 2009.

3. Conclusions

The challenge of water scarcity and droughts needs to be addressed both as an essential environmental issue and also as a precondition for sustainable economic growth in Europe. As the EU seeks to revitalise and reinvigorate its economy and to continue to lead on tackling climate change, the devising of an effective strategy towards water efficiency can make a substantial contribution.

This Communication identifies a first set of policy options with a view to opening up a wide-ranging debate on how to adapt to water scarcity and droughts, two phenomena that could potentially increase in a context of climate change. The options proposed in the Communication could already start to bear fruit in the short term. The Commission therefore believes that more has to be done to introduce these measures swiftly at EU level. In this sense, it is important to consider the role of the state of the art research results can play for policy making. The Commission will review progress towards the set orientations and will report on them to the Council and the European Parliament. The report will be presented in the context of a Stakeholder Forum to be held in 2008.

In the light of the discussions on this Communication in the Council of Ministers - starting with the Informal Environment Council on 1 September 2007 - and the European Parliament and of the results of the above-mentioned report, the Commission will consider follow-up initiatives and action within the coming few years.