THE GUIDELINES OF THE PORTUGUESE ADAPTATION STRATEGY TO THE IMPACTS OF CLIMATE CHANGE ON WATER RESOURCES

LINHAS DE ORIENTAÇÃO DE UMA ESTRATÉGIA NACIONAL DE ADAPTAÇÃO AOS IMPACTOS DAS ALTERAÇÕES CLIMÁTICAS RELACIONADOS COM OS RECURSOS HÍDRICOS

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Abstract

The response to climate change requires action along two main approaches. Mitigation aims at reducing the greenhouse gases emissions which are causing global warming while adaptation attempts to decrease the economical, environmental and social impacts of climate change. Following an initial emphasis on mitigation, the importance of adaptation is being increasingly recognized as it becomes clear that some impacts are unavoidable. National responses to climate change must include actions on both these domains, and the climate change impact assessment studies and emission reduction strategies that have been developed in recent years need to be complemented with climate change adaptation strategies.
The water sector can and must contribute to both mitigation and adaptation, but assumes a pivotal role in the adaptation domain as it serves as the main transmission vehicle of climate change to other sectors, like water services, agriculture, forests, energy production, ecosystems and biodiversity and coastal zones
Portugal is developing its own national adaption strategy, which recognizes water as one of the key sectors deserving a specific *Adaptation Strategy to the Impacts of Climate Change on Water Resources*. This paper presents the guidelines of such strategy and discusses the challenges and the principles that need to be met when designing a coherent and effective approach.

Resumo

A resposta às alterações climáticas desenvolve-se ao longo de dois eixos fundamentais: a mitigação que visa a redução das emissões de gases com efeito de estufa e a adaptação que procura reduzir os impactos económicos, sociais e ambientais das alterações climáticas. As estratégias inicialmente propostas para controlar os impactos das alterações climáticas têm assentado sobretudo na mitigação dessas alterações, mas o papel das estratégias de adaptação às alterações climáticas tem vindo a ser crescentemente reconhecido.
O sector da água deve contribuir para o cumprimento dos objectivos de mitigação, mas é no domínio da adaptação que este sector assume um papel central dado ser o principal veículo de transmissão dos impactos das alterações climáticas na agricultura e florestas, na biodiversidade, na indústria, na energia, nas pescas, na saúde e no turismo.
Na sequência dos primeiros estudos sobre os impactos das alterações climáticas, vários países, incluindo Portugal, têm vindo a desenvolver trabalhos no sentido de definir as melhores estratégias de adaptação. O artigo apresenta as principais linhas de orientação da Estratégia Nacional de Adaptação aos Impactos das Alterações Climáticas relacionados com os Recursos Hídricos. Identificam-se os desafios que se colocam na definição e implementação de medidas e procedimentos de adaptação; apresentam-se os princípios orientadores de uma estratégia de adaptação multidisciplinar, consistente, coerente e que abranja os diversos sectores da sociedade; e descreve-se uma primeira geração de medidas que propõem para Portugal.

Introduction

The Stern report on the economics of climate change states that costs of extreme weather could reach 0.5 - 1% of world GDP per annum by the middle of the century, and will keep rising if the world continues to warm. If no serious attempt to control climate control is initiated, these costs could reach a loss of 5-20% loss in global GDP, with poor countries suffering costs in excess of 10% of GDP (Stern, 2007). These cost estimates are probably being optimistic as Stern later recognized (Stern, 2009).
To counteract these costs, global society should act to maintain the greenhouse gases concentration below a safe level that prevents major impacts associated with significant costs. Stern (2009) estimate that the cost to maintain the concentration of GHG below 500 ppm CO_2eq is 2% of global GDP, whereas a less ambitious

target of 550 ppm CO_2eq costs half of that value. Based on these figures, the rationale for acting is clear, but unfortunately nations have not been able to assume these targets and to agree on a global plan that ensures its achievement.
Given the inertia of the climate system, time is running out and it is clear that humankind will have to deal with some level of climate change impacts. The adaptation to new climate conditions is therefore a necessity in order to contain the risk of infrastructure failure, significant damages to the environment and the economy and even of human life loss. The performance of existing systems must be reviewed, probably leading to the conclusion that major renovation works and new infrastructures are required to overcome the shortcomings of the current ones. Operational procedures will to be adapted to a changing climate and the standard design and performance evaluation criteria will have to be revised.
The importance of adaptation has been recognized since the first report of the Intergovernmental Panel on Climate Change (IPCC, 1990) and is clearly assumed in the United Nations Framework Convention on Climate Change (UNFCCC, 1992). In 2006, the UNFCCC strengthened the focus on this component of the response to climate change and adopted the Nairobi Work Program, a five-year program on impacts, vulnerability and adaptation to climate change. The Conference of the Parties (COP) in Bali, in 2007, and subsequent COPs reaffirmed the importance of this program and strengthened their means.
The European Union has also been giving particular attention to aspects of adaptation, having organized several initiatives in the field of water management. In 2007, the European Commission launched a Green Paper on Adaptation (COM, 2007) and later a White Paper with formal and concrete proposals, particularly in the areas of legislation and funding (COM, 2009a). More recently, the Commission launched a discussion on the best ways to incorporate adaptation when implementing the Water Framework Directive (COM, 2009b). The United Nations Commission for Europe (UNECE) also issued a report with the conclusions of the discussions of a working group convened to discuss the issue of adaptation to climate change under the Protocol for the Protection and Use Rivers and International Lakes (UNECE, 2009).
Despite these initiatives, significant hurdles remains to incorporate climate change concerns and adaptations initiatives in water resources planning and management procedures. The significant costs of adaptation require a thorough weighting of several factors to decide on which precise measures are to be implemented at a specific time and place, but the uncertainty associated with climate scenarios and the non-stationary nature of the phenomenon deems this tasks particularly demanding. This paper addresses this issue and discusses how the Portuguese water sector is preparing to meet this challenge.

Climate change impacts on Water Resources

The water resources sector is one of the most important domains when addressing climate change. Climate change has direct impacts on the availability, timing and variability of water supply, and these impacts have profound implications on many sectors of our society. Water is used for human consumption, industrial purposes, irrigation, power production, navigation, recreation and waste disposal, as well as for the maintenance of healthy aquatic ecosystems. Its availability and the occurrence of extreme events like floods and droughts condition the location of cities, industrial and agriculture areas, power generation plants and trading centres. Adding to these direct impacts of climate change on water resources, there are the indirect impacts, those derived from changes in economic and social activities which may lead to new pressures of the water systems, namely a water demand increase, a pollutant load increment or a significant change in the way we use our land and distribute our activities. These indirect impacts may also affect our capacity to satisfy water needs and to protect humans and its activities, while protecting and promoting the quality of the water bodies and the health of the aquatic ecosystems.
The impact of climate change on water resources depends not only on changes in the volume, timing and quality of stream flow and recharge, but also on the system characteristics, the changing pressures on the system, how the management of the system evolves and what adaptation measures to climate change are implemented. In some cases, non-climatic changes may have a greater impact on water resources than climate change itself.
In Europe, the southern countries of the Mediterranean basin like Portugal, Spain, Italy and Greece, will be the region mostly affected by climate change. The SIAM and CLIMAAT projects studied several integrated scenarios of the impacts of climate change on water resources, agriculture, forests, biodiversity, energy, health and tourism for Portugal (Cunha et al., 2002, 2003, 2006, 2007; Oliveira et al., 2008; Santos et al., 1994, 1996). According to these studies, Portugal will likely experience a general decrease of overall water availability, an increase of seasonal and spatial asymmetries, an increase of flood risk and an increase of water quality problems. The impacts of climate change on sea level may also affect the groundwater levels and the groundwater quality, thus influencing the water resources availability, as well as increasing the risk of urban flooding. Furthermore, the decreased runoff in the Spanish part of the transboundary river basins is likely to accentuate even further the expected decrease of water availability in the Portuguese territory. Table 1 provides a brief survey of the impact of climate change on the Portuguese water resources, showing significant regional asymmetries within the country. In general terms this aggravation of the impacts is

expected from the Northern region of Portugal, with Atlantic influence, towards the South, with Mediterranean characteristics.

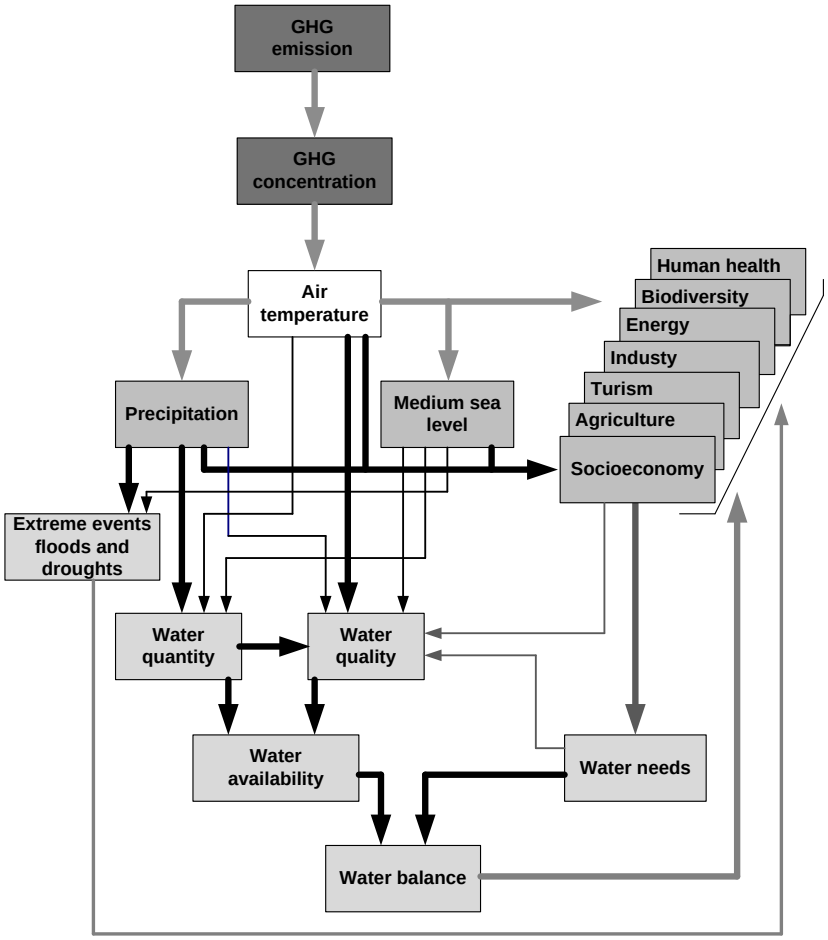

Figure 1 – Climatic change impacts on water resources

Table 1 – Summary of the climate change impacts on the Portuguese water resources

Issue	Impact scenario
Water availability	Decrease of annual runoff and aquifer recharge, mainly in the South. Increase of flow variability and of the regional asymmetry of water availability. Increase of drought risk.
Water demand	Possible increase of water demand for agriculture. Increase of water demand for energy production to reduce dependance on fossil fuels;
Flood Risk	Increase of flood risk, mainly in the North and in coastal areas
Water quality	Decrease of water quality due to flow reduction, temperature increase and possible soil erosion increase. Salinization of coastal aquifers, due to sea level rise and recharge decrease. Degradation of ecosystems health.

The challenge of climate change adaptation

Regardless of the success in reducing emissions, humankind will have to cope with some degree of climate change, but if the vulnerability to climate change is thoroughly assessed and a consistent and coherent set of actions is planned ahead, the potential costs and suffering associated with climate change can significantly minimized.

The design of an adequate adaptation strategy is alas a challenging task. The knowledge concerning future climate scenarios has significantly increased in the last decade, but considerable uncertainty is still

associated with the future trend and variability of various climate variables, particularly the critical ones for water resources management, such as annual and seasonal precipitation as well as extreme short duration precipitation.
The major challenge facing water managers willing to consider climate change in their planning efforts is how to evaluate and distinguish changes in water systems reliability resulting from climate changes from those resulting from natural variability**.** The American Water Works Association, for example, has stated that water agencies "should explore the vulnerability of both structural and non-structural water systems to plausible future climate changes and not just to climatic variability" and also that Governments "should reevaluate legal, technical and economic approaches for managing water resources in light of possible climate changes" (AWWA, 1997).
The uncertainty surrounding future climate scenarios significantly reduces the applicability of cost-benefits analysis which could be used to identify the actions that should be included in an adaptation strategy. Figure 2 illustrates the relationship between the cost and the benefits of adaptation as an adaptation program is implemented and the level of preparedness increases. The costs of adaptation increase with time as the less expensive actions are enforced leaving more expensive choices to be implemented at a later stage. Concurrently, adaptation benefits, arising from the avoided future costs of an improved preparedness to face climate change impacts, decrease as the most rewarding measures are implemented.

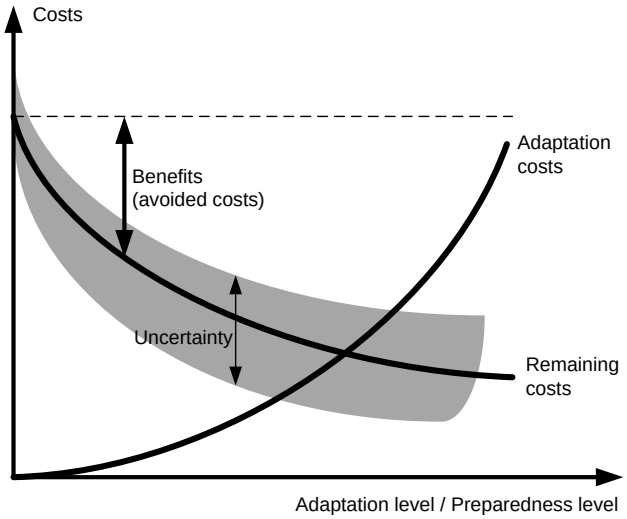

Figure 2 – Schematic cost-benefit analysis

While the cost of adaptation may be estimated with some degree of certainty, for they are usually associated with specific actions to improve or build infra-structure or to change operational procedures or design criteria, the benefits from adaptation are more difficult to estimate. Given the uncertainty surrounding future climate scenarios, the costs of the reference scenario assuming no adaptation and of an alternative one assuming a specific adaptation measure are hard to estimate. This uncertainty increases as prior adaptation actions are adopted, turning the decision on whether to execute or not to execute some actions at some point extremely difficult.
The need to consider the adaptation benefits in a long-term perspective adds another difficulty in applying a cost benefit analysis to design an adaptation strategy. The costs to execute a given action are assumed immediately but the benefits arising from that decision last for a very long time (may be 100 or 500 years). The present value of those benefits is therefore a function of a discount rate value which needs to be selected, a decision that directly determines if a given adaptation action is to be executed or not. There is a substantial discussion on whether present value estimates are adequate for analyzing projects with very long horizons (EEA, 2007).
The consideration of the risk of severe irreversible impacts is another challenge to this approach for irreversible impacts are extremely hard (if not impossible) to evaluated.
Nevertheless, the cost-benefit analysis illustrated in Figure 2 shows some important points. At an early stage of the adaptation process there are actions which definitely lead to greater benefits than costs, namely the ones that provide clear benefits, even in scenarios that assume a reduced or no climate change. Other actions deal with some impacts where the degree of uncertainty is smaller, like the sea level rise. These *win-win* or *no-regret* scenarios are justifiable in any circumstances and should be assumed as priorities. A second group of initiatives can be considered *low-regret* actions due their reduced cost and should be implemented on a second stage. Finally, the actions associated with smaller net benefits and greater uncertainty can be left for a later phase when, hopefully, new knowledge has reduced the uncertainty levels regarding climate scenarios.

The cost-benefit analysis is not the only factor shaping the adaptation program schedule. The implementation time of each action and their useful life are also important factors. Whenever possible a progressive approach should be adopted where a sequence of low impact actions are implemented in a time frame that maintains the risk level below a given acceptable threshold. This approach that defers larger investments to the future has clear financial advantages and takes advantage of the growing understanding of the climate change process as research continues. Unfortunately some of the actions that are required to meet the climate change challenge are only feasible by assuming sizeable investments in a short period of time to execute large construction works.

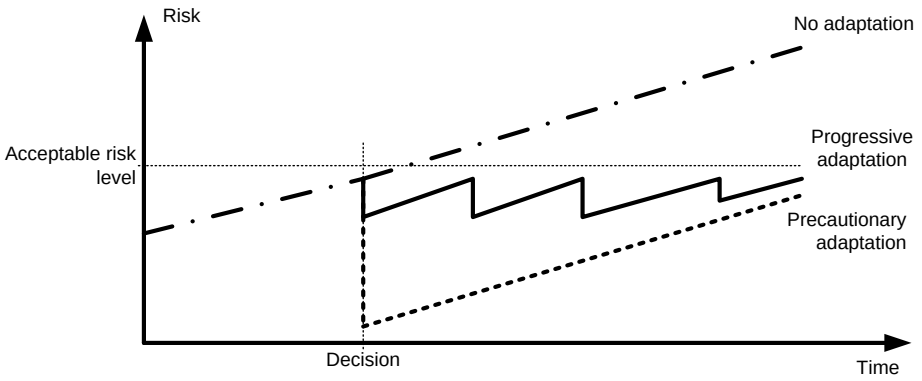

Figure 3 – Adaptation scheduling

Key adaptation principles

Climate change should be considered at all stages of the planning and management efforts and should be integrated as much as possible in national, regional and organizational water policies. If a broad and long-term perspective is assumed, the climate change impacts have to be considered as future water resources pressures or water related risks, therefore requiring adequate responses. Adaptation measures will then result naturally from the planning exercise, hopefully, coherently incorporated in the overall program of measures that aims to protect and improve the water resources status and to reduce water related risks.

To design the program of measures water planners need to accept a significant level of uncertainty and be able to decide on those conditions. To cope with the current uncertainty associated with current climate scenarios, a precautionary approach based on flexible actions that do not restrict future options is recommended. Water planning and management, and particularly climate change adaptation, is an on-going process where any proposed and implemented action should be periodically reviewed.

The goal of an adaptation effort is to reduce the vulnerability of a given system to climate change which is a function of i) its exposure to climate factors; ii) its robustness, i.e. its capacity to perform under new climate conditions; and iii) its resilience, i.e. its capacity to recover from adverse conditions. Any adaptation action must therefore address at least one of these issues.

Demand-side actions to limit the growth and, if possible reduce, the pressures on water resources are examples of some of actions that aim at reducing the exposure to climate. The reduction of the pressures on water resources, such water abstractions or pollutant discharges, creates a buffer that may be used to maintain operational goals in future climate stressed conditions. The removal of people and infra-structures from flood prone areas is another example of an action aiming at reducing the exposure to climate factors.

Actions to increase the robustness and the resilience of water resources systems include those that aim at improving the capacity to deal with new climate scenarios, such as the upgrading of monitoring and forecast systems, the improvement of water management processes to increase water efficiency use, the diversification of water supply sources, the increase of water storage capacity or the construction of floods defenses.

The guidelines of Portuguese national adaptation strategy

In parallel with the efforts to reduce GHG emissions, the Portuguese government is preparing a National Strategy for Climate Change Adaptation, whose guidelines were formally approved in 2009 by the government. A part of this national and transversal adaptation strategy is the Portuguese adaptation strategy to the impacts of climate change on water resources. A sign of the importance that Portugal assigns to adaptation in the water sector is the fact that the water resources adaptation initiative was launched simultaneously with the overall National Strategy for Climate Change Adaptation. The water resources adaptation strategy is currently being finalized before being submitted for approval by the Water Institute.

The Portuguese adaptation strategy to the impacts of climate change on water resources aims at reducing the country vulnerability to the impacts related to water in a way that is sustainable from the technical, economical, environmental and social perspectives.

The strategy assumes a broad and long-term perspective and proposes a flexible action program that does not restrict future options and is able to cope with the current uncertainty associated with current climate scenarios. It is organized around the following four strategic objectives:

- Reduction of pressures on water resources;
- Enhancement of water supply reliability;
- Risk management;
- Research and knowledge gathering.

These strategic objectives can be achieved though more specific goals, as shown in Table 2.

Table 2 – Objectives of the Portuguese adaptation strategy to the impacts of climate change on water resources

Strategic objective	Specific goal
Reduction of pressures on water resources	Water demand management to reduce dependency on water
	Protection of water bodies and their dependent ecosystems
Safeguard of water supply reliability;	Improvement of water resources planning and management procedures
	Upgrade or adaptation of water infrastructures
Risk management	Evaluation of climate change induced risk
	Upgrade of the monitoring, forecast and alert systems
	Raising public awareness on climate change induced risks
	Upgrade of infra-structures for flood protection
Research and knowledge	Strengthening of climate monitoring and analysis programs
	Review of methodologies and criteria for the design and performance evaluation of water systems and infrastructures
	Public awareness and technical training

For operational purposes, the strategy organizes the proposed actions around programs for each of the following seven sectors of water users:

- Water resources planning and management;
- Ecosystems and biodiversity;
- Water services;
- Agriculture;
- Energy production;
- Coastal zones;
- Tourism.

The water resources planning and management sector is considered a transversal sector that regulates all water uses to ensure the achievement and maintenance of good qualitative and quantitative status in all water bodies. The tourism sector is considered separately from the water services sector (i.e. water supply and waste water drainage and treatment services) due to its importance in Portugal.

Table 3 presents the programs of measures proposed for each of the sector while Table 4 presents a cross-over between strategic objective and specific goals with the programs of measures. The programs proposed for the risk management objective and research and knowledge gathering objective are cross all water users sectors.

Each program of measures includes several specific actions with demand-side actions to limit the growth or to reduce the pressures on water resources being favored in complement to supply-side actions to enhance water supply reliability. To foster the integration of climate change adaptation in the current water resources planning and management, the strategy also adopts many ongoing initiatives such as the River Districts Management Plans, the National Water Plan, National Plan for an Efficient Use of Water, the Strategic Plan for Water Supply and Wastewater Treatment, the National Strategy for the Effluents of the Agriculture and Cattle Breeding Industry and the National Program on Dams with High Hydroelectric Potential.

The River Districts Management Plans are the main planning instruments for water management in Portugal, defining for each water body of the river district the quality status to be achieved in the short and medium term, as well as the program of measures to achieve those objectives. These plans are now a requirement under the European Water Framework Directive and by a determination of the Portuguese water law must be integrated and complemented by the National Water Plan. In addition to specific action to reduce contamination the Water Law and its instruments determine water pricing schemes which contribute to a rational and sustainable use of water.

The National Plan for an Efficient Use of Water defines clear goals for water loss reductions for all sectors and specifies a set of measures to achieve these objectives by given deadlines. All water operators applying for public funding have to show how they will comply with those guidelines and goals.

The Strategic Plan for Urban Water Supply and Wastewater Treatment and the National Strategy for the Effluents of the Agriculture and Cattle Breeding Industry are special plans for the improvement of effluent

drainage and treatment systems. Some of the pressures on the quality of the Portuguese water resources will be reduced with the implementation of these plans.
The National Program on Dams with High Hydroelectric Potential aims to significantly increase the share of energy production from renewable sources. Those carefully selected reservoirs will bring up an important contribution (on a national level) to climate change mitigation. It will also alleviate the increasing water stress and allow better and more reliable service to the local communities.

Table 3 – Programs of measures

Sector	Program
Water resources planning and management	Water bodies protection
	Improvement of water resources planning and management processes
	Increase of water storage and flow regulation capacity
	Diversification and reinforcement of water supply sources
Ecosystems and biodiversity	Preservation of physical, chemical and biological conditions and of biodiversity
	Preservation and enhancement of hydrological and hydromorphological conditions
Water services	Promotion of water use efficiency
	Diversification and reinforcement of water supply sources
	Improvement of quality control and water treatment capacity for human consumption supply
	Review and upgrade of the operational procedures in wastewater drainage and treatment systems
Agriculture and forests	Increase of irrigation efficiency
	Promotion of agricultural soils water retention capacity
	Control and reduction of winter runoff
	Selection of forests species
	Water and organic matter content increase in forest soils
Electricity production	Enhancement of the robustness of the electricity production system
	Risk management and economic valuation
Coastal zones	Coordination of risk management and land management instruments
	Flood prevention and forecast
Tourism	Promotion of water use efficiency

Another aspect that must deserve particular attention is the coordination of adaptation efforts in Portugal and Spain, as climate induced pressures in the Spanish part of the transboundary river basins are likely to be transmitted to Portugal. In particularly, the decreased runoff in Spain is likely to accentuate even further the expected decrease of water availability in the Portuguese territory.
The development of a common strategy of adaptation to climate change in the River Basins shared by Portugal and Spain (Minho, Lima, Douro, Tejo and Guadiana) is therefore a major issue. As a first step, joint studies of climate change impacts on the water resources shared by Spain and Portugal is proposed as a main focus of scientific and technological co-operation of the two countries of the Iberian Peninsula. This international effort would be a valuable exercise for testing the UNECE Guidance on Water and Adaptation to Climate Change (UNECE, 2009).

Table 4 - Cross-over between the strategic objectives and specific goals with the programs of measures for each water user sector

Strategic objective	Reduction of pressures on water resources		Safeguard of water supply reliability		Risk management	Research and knowledge
Specific goal / Water user sector	Water demand management to reduce dependency on water	Protection of water bodies and their dependent ecosystems	Improvement of water resources planning and management procedures	Upgrade or adaptation of water infrastructures		
Water resources planning and management		Protection of water bodies	Improvement of water resources planning and management processes	Increase of water storage and flow regulation capacity Diversification and reinforcement of multi-purpose water supply sources	Evaluation of climate change induced risks Upgrade of the monitoring, forecast and alert systems Raising public awareness on climate change induced risks Upgrade of infra-structures for flood protection	Strengthening of climate monitoring and analysis programs Review of methodologies and criteria for the design and performance evaluation of water systems and infrastructures Public awareness and technical training
Ecosystems and biodiversity		Protection and enhancement of the physical, chemical and biological conditions and of biodiversity Protection and enhancement of the hydrological and hydro-morphological conditions				
Water services	Promotion of water use efficiency			Diversification and reinforcement of water supply sources Improvement of quality control and water treatment capacity for human consumption supply Review and upgrade of the operational procedures in wastewater drainage and treatment systems		
Agriculture and forests	Promotiom of irrigation efficiency Selection of forests species			Control and reduction of winter runoff Water and organic matter content increase in forest soils		
Energy production			Risk management and economic evaluation	Enhancement of the robustness of the electricity production system		
Coastal zones			Coordination of risk management and land management instruments			
Tourism.	Promotion of water use efficiency					

Final remarks

Climate change challenges existing water resources management practices, by adding additional uncertainties. An integrated water resources management is, therefore, needed to enhance the capacity for adaptation to change.

It is clear that the impacts of climate change must be considered with an increased attention on water resources management strategies and policies. The argument that the impacts of climate change are not yet fully known and that a number of uncertainties still exist should not be a reason to postpone action. The results of different studies have already identified some trends with a high probability of occurrence, which should be considered in future water management strategies and policies.

Furthermore, it must be realized that a sound water management policy has always required, in the past, a capacity for decision under uncertainty. Policy makers and water managers currently forecast the hydrology regime and the water resources system demands of future situations and act upon these forecasts. They try to plan in advance the response to future scenarios, usually selecting flexible and adaptable policies to be able to quickly react to specific situations.

In this perspective, taking climate change into consideration does not require any drastic change in the approach currently adopted by of water managers, as it only constitutes an additional source of uncertainty that will condition future values of both water supply and demand. The main conceptual change is the rejection of the traditional engineering assumption that considers the historical climate as a reliable indicator of future conditions. As a matter of fact water management agents must start considering climate change as a source of uncertainty.

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Disclaimer

The views presented in this paper are the responsibility of the authors. The Portuguese Adaptation Strategy to the Impacts of Climate Change on Water Resources has not yet been approved by the Water Institute.

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