Spain, Water and Climate Change in COP 15 and Beyond: Aligning Mitigation and Adaptation through Innovation (WP)

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Contents

Summary and Key Policy Recommendations

(1) Introduction: Welcome to the Spanish 'Hot House' – Can Climate-Change Risk be Turned into a Water-Resources Opportunity?

(2) Water and Climate Change: an Intimate Relationship

(3) Climate Change Policy: the EU as a Confirmed Leader in Mitigation and a Potential First Mover in Adaptation?

(4) Spain: Difficult Political Choices between Adaptation and Mal-adaptation

(5) A measured Response?: High Pay-off, Low-risk Measures (No-regret Policy-Making)

(6) Conclusions: Framing the Climate/Energy/Food Nexus within Human Security

Appendix 1. Sample of Some No-regrets Core Policy Measures for Spain in the COP 15 and Beyond

Appendix 2. FAO: Aquastat Summary Fact Sheet for Spain

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Summary and Key Policy Recommendations

The water/energy nexus opens a range of opportunities to align mitigation and adaptation framed by human security, which prioritises human development. In this context, Spain has an opportunity to play a leading role in realising this potential by pursuing a coherent multilevel strategy specifically designed for water and climate variability and change:

(1) At the global level, at the COP-15 negotiations Spain should take the lead –together with other countries and organisations– in putting water on the agenda of climate change. Climate change is mainly mediated through water and, in turn, water is crucial for guaranteeing climate security.

(2) At the global level and in the context of the Spanish EU Presidency, Spain should build up support for the ratification of the transboundary rivers convention, and continue its work in strengthening the momentum for the human right to water led by Spain and Germany in the UN framework. This should be part of a wider benefit-sharing and rights-based approach to development that also includes the human right to food.

(3) At the EU level, Spain can strengthen the momentum to develop the EU's adaptation policy. It should build on first-mover advantages that the EU has already followed through the testing of the Integrated Water Resources management via the Water Framework Directive, the Floods Directive and the Communication on Water Scarcity and Drought. Spain in this context is particularly well placed to champion issues related to water scarcity and drought. It should build on policy innovation at the member-state level with national, regional and local adaptation initiatives. This linking of top-down and bottom-up emerging technologies and innovation should be fast-tracked wherever possible. This is particularly the case of, eg, high-tech innovation in renewable energy –like solar thermal and new water through desalination based on renewables, blue energy, poligeneration, etc– on the one hand, and micro-scale, affordable, low-tech technology –like low-cost, low-energy-intensive water treatment plants– on the other.

(4) In the context of global climate variability and change hotspots, Spain is well positioned in the Mediterranean to help facilitate a project of economic integration and political stabilisation based on the premise of green growth and with two key pillars: water and energy. A series of political decisions could be reached in time for the meeting of the Union for the Mediterranean in April 2010, as part of the legacy of the 2010 Spanish EU Presidency, to commemorate the 15th anniversary of the initiation by a previous Spanish EU Presidency of the Barcelona Process. Two areas in particular are key: in the case of water, the focus is on eco-efficient innovation in

agriculture framed by the essential first step of free trade in agricultural products planned for 2010. This integration, if successful would create a large regional market for both the supply and demand of high-quality Mediterranean products. In the context of energy, solar energy –and, in particular, solar thermal– need to be perceived as infant industries and supported as such with a view to developing a strong regional energy market. The success of wind energy, where Spain is now a global leader, offers a good precedent for policy transfer and learning. In the context of the links between Spain and Latin America, it has already taken the lead with the establishment, within the EUWI-LA and the CODIA process, by creating a Water Fund and a Climate Fund. These funds must, however, be deeply rooted within the Paris Agenda, whilst facilitating the transfer of knowledge and technology.

(5) Finally, Spain can only lead by example: it is likely to be at the forefront of potential climate change impacts. Science and knowledge in the context of climate change and variability will facilitate the eventual implementation of the new Law on a Sustainable Economy. In this context there are three issues:

(a) Science and knowledge have to be actionable, and be relevant to end-users and in the specific locations most impacted by climate change and variability.
(b) The existing inertia in Spanish water policy can be realigned through mitigation and adaptation. This offers opportunities for technological innovation, like desalination based on renewable energies, particularly solar.
(c) The existing inertias in current water allocation are unsustainable yet there are opportunities for innovation in water use, particularly in the context of CAP reform, since agriculture is Spain's main user of water.

Spain has a clear opportunity and, for practical policy reasons, a very clear self-interest in placing the water/energy nexus and the alignment of mitigation and adaptation high on the political agenda. The aim at COP-15 should be first for a global agreement and, as second best, a small multilateral group with Mediterranean and Latin American countries on the need to link water and climate change and variability. The second act will be the EU Presidency, where Spain can leave a legacy

(1) Introduction: Welcome to the Spanish 'Hot House' – Can Climate-Change Risk be Turned into a Water-Resources Opportunity?

Climate adaptation translates to a large extent into water adaptation: water is the common denominator (Dr M. Smith, IUCN-Water, and Dr G. Bergkamp, President, World Water Council).

Climate variability and climate change impacts are largely mediated through water: extreme events like floods and droughts, sea-level rises and the melting of glaciers. This paper will argue that Spain can play a leading role nationally, within the EU and in its areas of influence, due to its historical and geographical links with the Mediterranean and Latin America, to turn climate-change risk into an opportunity for innovation to decarbonise the economy. The greatest opportunity lies in focusing on the alignment of adaptation and mitigation through the water/energy/food nexus, where Spain can offer new ideas and practical examples.

In order to provide evidence and examples of the potential spin-offs from this alignment, the paper is divided into three separate sections. First, a global overview and summary is provided on the deep linkages between water and climate change, this is briefly outlined at the global level and in more detail at the European level. The second part focuses on Spain, which is located within one of the climate variability and change hotspots –the Mediterranean–, and where rational choice and self interest dictate preventative action, ie, the false arguments of adaptation vs. mitigation and the much more useful debate on the costs of mal-adaptation vs. synergy between mitigation and adaptation. The section analyses in depth how Spain can provide a useful testing ground for innovative climate proofing of an economy, through maximising the positive synergy between, eg, water and energy, by identifying *ex-ante* decisions that help shift existing inertias, using climate variability and change as an excuse to introduce deep –but politically difficult– change into the system. This final section will argue that ultimately, in the Spanish hothouse of water politics and climate change, it all boils down to political will and leadership in adopting policy measures, eg, both in water resources management (and planning) and in energy policies that are aligned. This will almost inevitably face resistance from those sectors where reform is needed, and in this case clever policy mixes can help ease the transition.

(2) Water and Climate: An Intimate Relationship

It is often overlooked –due to the focus on CO_2 reduction in mitigation policies– that water vapour is in fact the most abundant greenhouse gas and makes the greatest contribution to the natural greenhouse effect on Earth, and that its behaviour is fundamentally different from other greenhouse gases like CO_2. Water vapour is not a direct agent of radiative forcing but plays a role through climate feedback.[1] This is because the capacity of the atmosphere to 'hold' water vapour is largely dependent on

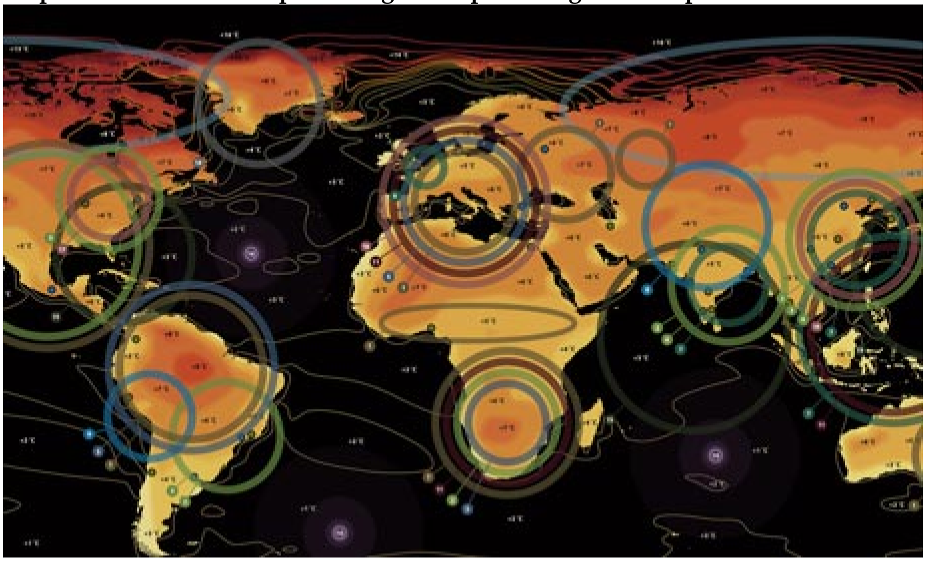
[1] Water vapour is the most potent of the greenhouse gases in Earth's atmosphere, but its behaviour is fundamentally different from that of the other greenhouse gases. The primary role of water vapour is not as a direct agent of radiative forcing but rather as a climate feedback—that is, as a response within the climate system that influences the system's continued activity. This distinction arises from the fact that the amount of water vapour in the atmosphere cannot, in general, be directly modified by human behaviour but is instead set by air temperatures. The warmer the surface, the greater the evaporation rate of water from the surface. As a result, increased evaporation leads to a greater concentration of water vapour in the lower atmosphere capable of absorbing infrared radiation and emitting it downward (from "Greenhouse Gas", *Encyclopædia Britannica Online*, http://www.britannica.com/EBchecked/topic/683450/greenhouse-gas, retrieved 5/XII/2009).

temperature, and warming provides a positive feedback since it is the Earth's temperature which regulates the amount of water vapour in the atmosphere (Carter *et al*., 2007). This intimate relationship between climate and water is reflected in the extent to which water is largely dependent on climate variability and change. The main focus in relation to water and climate change is the potential that climate change has in increasing the frequency and intensity of extreme global events, like flood and drought risk (climatic hazards), and also their occurrence (frequency). Table I (below) summarises the direct and indirect effects of climate on water, and some potential geographical examples of the climate security threats posed to society (for an interactive world map of impacts see Adam & Stratton, 2009).

Table 1. Climate change and water

Direct and Indirect effects of climate variability and change	• Unpredictable changes in water availability • Flood magnitude and flooding impacts • Sea-level rise • Probability of extreme storms • Changes in rainfall intensity, duration and frequency • Impact on yield of water resources • Probability and duration of droughts • Saline water intrusion into reservoirs/aquifers • Coastal land loss due to erosion and submergence • Impact on drainage network system • Snow melt, impact on glaciers
Examples of climate security potentially threatening human security	• Possible abrupt change of Asian monsoon to a substantially drier state • Potential loss of water storage capacity in Himalayan glaciers • Reduced water availability in the Indo-Gangetic plain • Increased numbers of forced migrants as a result of severe climate impacts • Disputes between states, already concerned over electric power and water-sharing • Hydroelectricity becoming less reliable, potential knock-on effect on the economy and loss of hydro-electric power schemes • Loss of summer meltwater from the Hindu Kush/Himalayan/Tibet glaciers that 22% of global population rely on; damage to Tibetan permafrost • Impacts on great rivers of Asia: Yangtze-Brahmaputra-Ganges-Huang Ho-Indus-Mekong-Salween • Flooding as glacial dams burst

Map 1. Details from a map showing the impact of a global temperature rise of 4ºC



For the full interactive maps of climate change impacts see *http://www.actoncopenhagen.decc.gov.uk/content/en/embeds/flash/4-degrees-large-map-final*.
Source: Met Office.

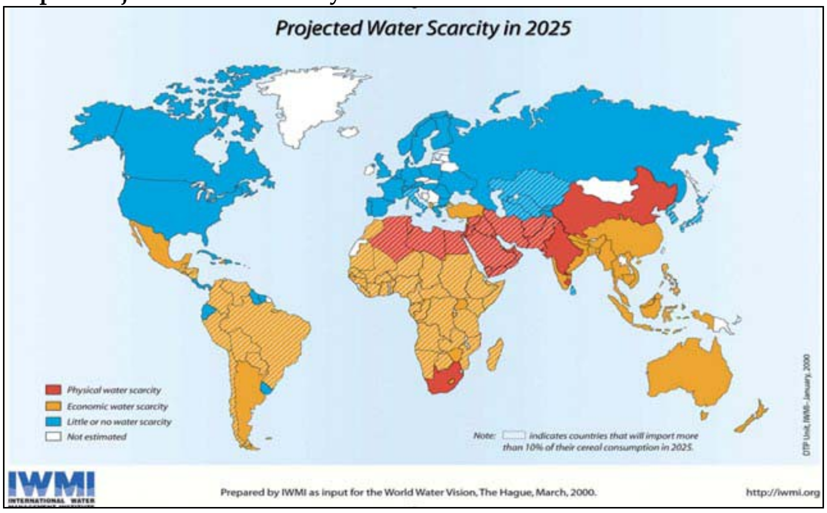
According to UN Water, it is estimated that by 2025, 1,800 million people will be living in countries or regions with absolute water scarcity[2] (UN-Water, 2006), while two-thirds of the world's population could be under water stress[3] conditions. In addition, there is the problem of water withdrawals:[4] water use is predicted to increase by 50% by 2025 in developing countries and by 18% in developed countries, meaning that water use has been growing at more than twice the rate of population increase in the last century. This was echoed by the CIA (2000), which predicted that by 2015 nearly half the world's population –more than 3 billion people– would be living in countries that are 'water-stressed' and have less than 1,700 cubic metres of water per capita per year –mostly in Africa, the Middle East, South Asia and northern China–.

[2] The definition refers to water scarcity as: the point at which the aggregate impact of all users impinges on the supply or quality of water under prevailing institutional arrangements to the extent that the demand by all sectors, including the environment, cannot be satisfied fully (UN-Water, 2006).

[3] The concept of Falkenmarl water stress indicator was defined by Malin Falkenmark (see Falkenmark, M. (1989) The Massive Water Scarcity Now Threatening Africa: Why Isn't It Being Addressed? *Ambio*, Vol. 18, No. 2 (1989), pp. 112-118 and it is defined when the annual availability of internal renewable water resources is less than 1700 and more than 1000 m3 per person per year.

[4] Understood as removal of water for any natural source or reservoir for human use not counting evaporative losses.

Map 2. Projected water scarcity in 2025



Thus, initial assessments are predicting that the geopolitical impacts of climate change (intimately connected to water) are unevenly distributed worldwide. The IPCC assessment (2007a and 2007b) predicts that global warming will hit the Arctic, sub-Saharan Africa, small islands and densely-populated river deltas in Asia (so-called mega deltas) the hardest. The estimate of environmental refugees due to the combined effects of climate change, desertification and deforestation could reach 50 million by 2010, as the poorest and most vulnerable populations will be hit first and hardest and will find it difficult to adapt due to problems of lack of capacity, resources and alternatives. In some countries food production could fall by half, eg, cereal productivity would drop with a rise of between 1°C and 2°C, which could happen by 2050. By 2080, between 1.1 billion and 3.2 billion people will face water shortages and between 200 million and 600 million people could face extreme hunger. In general the gloomiest scenarios portray a planet that will experience more storms, hurricanes, floods, droughts, heat waves and wildfires. Biodiversity and ecosystems could also be affected, with up to 30% of animal species facing extinction or displacement with an average warming of 2°C. If temperatures rise by 3°C, a third of coastal wetlands would be threatened, and the populations that depend on these natural ecosystems would also see their livelihoods (eg, fisheries) threatened. By region, Africa would be hit hardest with up to 250 million people by 2080 exposed to water shortages. Parts of Asia are threatened with flooding and avalanches from melting Himalaya glaciers, potentially hitting billions in low-lying deltas, in regions with high population growth.

One of the main climate change adaptation costs is related to water supply and flood management, ranking as one of the top three global climate adaptation costs in both the wetter and drier scenarios. The study estimates that the global net annual adaptation costs for municipal and industrial water supply will be between US$10.0 billion (€6.8 billion, wetter scenario) and US$11.1 billion (€7.5 billion, drier scenario) over the next 40 years. However, the costs are disproportionate in that, under both scenarios, Sub-Saharan Africa would pay nearly two-thirds of the costs. Global adaptation costs for water supply and sanitation infrastructure were estimated at US$700 million (€475 million) per year, of which Sub-Saharan Africa would bear the highest costs.

Therefore, it is thought that low latitudes –mainly low-income countries– will be hit hardest first. Some countries, those at high-latitude and mainly mid/high-income might even benefit to begin with. The contraction-convergence hypothesis[5] (GCI 2000), therefore has increasingly focused on issues of responsibility for human-induced climate change, since it is unevenly distributed worldwide.[6] Most historical emissions come from developed countries. However, emissions are now growing fastest in fast-growing, currently developing regions (eg, China and India). What is most important, however, is that the ability to pay for action and to adapt is also unevenly distributed worldwide. Therefore, the Kyoto Protocol, which involved about 200 sovereign nation states in its negotiation, is due for renewal, and in the process of re-negotiation equity concerns will be paramount, as well as the need for adaptation.

(3) Climate Change Policy: The EU as a Confirmed Leader in Mitigation and a Potential First-mover in Adaptation?

Over the last 15 years there have been a series of major alliances developing, namely the G77 and the so called Umbrella Group (the US, Canada, Russia, Ukraine, OECD countries outside the EU). Among this group the EU has positioned itself as a leader in climate change negotiations and policy initiatives (Schreurs & Tiberghien, 2007). The question in Copenhagen at COP-15 will be whether this leadership will be joined by the new rising power (China) and the incumbent global hegemon, the US.

This section will provide a review of predictions in relation to water and climate change for the EU. It will briefly review its past positioning and perception globally as a leader in climate change mitigation and the scope to increase its leadership in relation to adaptation. In this context, it can play a strong role because in the field of water it is also in a way a first mover in relation to integrated water resources management through the

[5] *Contraction and Convergence (C&C)* is a proposed global framework for reducing greenhouse gas emissions to combat climate change. Conceived by the Global Commons Institute in the early 1990s, the Contraction and Convergence strategy consists of reducing overall emissions of greenhouse gases to a safe level (contraction), where the global emissions are reduced because every country brings emissions per capita to a level which is equal for all countries. It is intended to form the basis of an international agreement which will reduce carbon dioxide emissions to avoid climate change, carbon dioxide being the gas that is primarily responsible for changes in the greenhouse effect on Earth. It is expressed as a simple mathematical formula. This formula can be used as a way for the world to stabilize carbon levels at any level. The supporters of Contraction and Convergence anticipate that future negotiations would focus solely on what that final level should be. (*http://en.wikipedia.org/wiki/Contraction_and_Convergence Accessed on 5.12.09*).

[6] The "convergence" would specify entitlements to emit carbon distributed between countries world. Initially these entitlements would reflect current emissions and eventually, these initial entitlements will converge towards equal per capita emissions across all countries.

implementation of the Water Framework Directive, the Floods Directive and a Water Scarcity and Droughts Strategy: these could be the three pillars necessary for water adaptation and readiness to climate variability and change. In addition, Europe is a good testing ground for the increased understanding between water and climate because of its diversity in climates and development paths across the 27 member states with one common regulatory framework. Finally, Europe can play a key role through its European Foreign and Security Policy, combining adaptation and human security.

According to the EEA (2004) over the last century temperature in Europe has shown an increasing trend of 0.8º–0.95°C. In relation to precipitation, trends in Europe were more heterogeneous, depending on regional circulation patterns and local topography. Mean annual precipitation in Northern Europe, based on observational data, increased by 10%-40% while it has decreased in some areas of Central Europe and the Mediterranean region by up to 20% over the last century (EEA, 2004). According to Krysanova & Hattermann (2009) 'in Europe extremely high precipitation events were recorded more frequently; prolonged drought periods in summer were reported for Central Europe, the UK and Southern Scandinavia; Southern Europe experienced extended winter droughts and reductions in river discharge in many catchments; an increase in the occurrence of heat waves was observed; 10 out of 12 European glacier regions were reduced in size; and sea levels in the North Sea and the Baltic Sea have been rising over the last century'. The EU PRUDENCE project (Prediction of Regional scenarios and Uncertainties for Defining European Climate change Risks and Effects) has generated a series of Regional Circulation Models (RCM), simulations for Europe. These projections anticipate that the mean European temperature will rise by 1.0º-5.5°C by the year 2100 (IPCC, 2007b).

The proportion of severe water stress could rise from 19% in 2005 to 35% in 2070, with the areas affected by drought increasing, potentially affecting 3.2 billion people mainly in Southern and Eastern Europe. Impacts of climate change on precipitation and river discharge show different trends across European regions. The key issues for policy are the changes in the availability of water resources and in the frequency and magnitude of extreme events (ie, droughts and floods). The general trend –although uncertainty remains high– is for an intensification of the hydrological cycle, ie, flood frequency and magnitude to increase in regions experiencing increased precipitation, while drought frequency will be higher in regions with reduced precipitation. In addition, the anticipated rise in sea levels, which could reach 10cm-70cm by 2050, could affect coastal aquifers with marine intrusion.

The goal for water managers should be to increase the adaptive capacity[7] to cope better with uncertain future developments, increasing the system's resiliency. This is a shift in policy-making, which has until now been based on finding traditional optimal solutions, based on predict and control, moving instead towards adaptive water management

[7] i.e. a measure of the internal vulnerability of the system.

(Mysiak *et al*., 2009), which accepts and builds probability and uncertainty into management (Cubillo, 2009).

Table 2. Main expected climate change impacts in different European regions

European Region	Main expected climate change impacts
Northern Europe	• Mean annual precipitation to increase • Winter precipitation up by 15%-30% by the end of the 21st century (Giorgi *et al*., 2004) • Runoff in Northern Europe will most likely increase in winter and decrease in spring (because less precipitation will fall as snow in winter and less snow will melt in spring) • Annual runoff is expected to rise in correlation with increased precipitation: up to 10% by the 2050s and by 50% by the 2080s • This would lead to higher water availability and hydropower production, higher flood risk • The magnitude of 100-year flood discharges might rise by more than 25% by the 2080s (EEA, 2005)
Western Europe	• Winter precipitation is projected to increase by between 15% and 30% by the end of the century • Summer precipitation is expected to decrease by 30% to 45% (Giorgi *et al*., 2004) • Recurring droughts in the future • Longest dry-spells could increase by up to 50% by the 2080s (Good *et al*., 2006) • Floods will become more frequent, and the magnitude of a 100-year flood discharge is expected to increase by 10% (EEA, 2005).
Central Europe	• Significant reductions in summer precipitation could occur by the end of the century, from 30% to 70%, depending on the scenario (Giorgi *et al*., 2004; Räisänen *et al*., 2004) • In winter, precipitation and the risk of snow-melt floods are anticipated to increase. Overall, a reduction in annual water flows is expected
Southern Europe	<Reductions in precipitation of up to 70% by the end of the century • Likely rise in occurrence of flash floods • Water availability is anticipated to decrease notably, eg, summer flows in south-eastern Europe could be reduced by up to 50% by the 2050s (EEA, 2005) • Rise in water stress particularly in southern France and Italy, Spain, Portugal and Greece

Source: Mysiak *et al*. (2009).

In terms of a specific policy related to water and climate change, the EU has taken a number of pro-active steps. First, it has established itself as a global leader in terms of mitigation on climate change. In terms of climate adaptation, the response however has been much more disjointed, or in many ways largely initiated from the bottom up, at the level of the member states, through spontaneous policy innovation. The new call by the European Water Partnership (EWP) (2009) at the 5th World Water Forum was for the EU to also become a leader in climate adaptation. Until now most of its legislation and activity has been in mitigation, overlooking the potential synergies between adaptation and mitigation and the potential risks and costs of mal-adaptation, ie, ensuring that adaptation measures have no adverse impacts on, for example, greenhouse emissions, as in the case of desalination.

In mitigation there have been clear EU-level initiatives. Flexibility mechanisms like the EU-ETS scheme, a full-blown European initiative, have been used to address pledges made for the Kyoto protocol.[8] The EU has also set the target of doubling its renewable energy from 6% in 1997 to 12% by 2010, through a number of initiatives[9] (Kerschner & Geraghty 2007). In relation to alternative fuels, the EU established its commitment to increase market share to up to 10% for EU transport fuel supply by 2010, from 1% in 2005[10]. This, however, has potentially unintended repercussions in relation to water and climate change adaptation, particularly in countries with naturally scarce water resources, indicating the need to establish ways to measure and link water and energy use though the development of a common metric.

In the case of adaptation in relation to climate change (and water), the EU has taken the initiative of drafting position papers and including climate change into the existing *acquis communataire* and sectoral policies like the CAP. The EC Green Paper 'Adapting to climate change in Europe' was adopted in June 2007, after stakeholder consultation to establish the vulnerability of social, economic and ecosystems to the impacts of climate change. This identified the need to develop adaptation strategies in the field of water, eg, filling knowledge gaps through EU-level research and exchange of information. It was then followed by the adoption of the White Paper in 2009, focusing on human capital (awareness raising, capacity building and research), green infrastructure (CAP, working with nature) and grey infrastructure (climate-proofing existing infrastructure) (EWP, 2009). At the EU level, the projected reform of the Common Agricultural Policy also includes the CAP 'Health Check', which includes water management and climate change as challenges that have to be considered as part of environmental protection in the required policy provisions (CEC, 2009).

In addition, EU Water Directives increasingly look at adaptation to climate change. For example, a Strategic Steering Group on Climate Change and Water has prepared a guidance document the EU Water Framework Directive and Climate Change. This requested that river basin management plans due out in 2009 perform a climate check, and that this is incorporated into a programme of measures by 2012 (EWP, 2009). Only 10 countries plan to carry these out as part of the River Basin Management plan process. For

[8] The first phase runs between 2005 and 2007, and the second 5 year phase coincides with the Kyoto compliance period (2008-2012). In the first phase the emissions restrictions were not very onerous

[9] Tax incentives to encourage consumption of renewable, grants for investment in renewable energy projects, feed in tariffs for renewable energy producers, and legislation mandating utilities provide a percentage of energy from renewable sources.

[10] In a similar line for example the US Energy Act of 2005 established an official commitment to use alternative fuels like bio-ethanol, requiring refineries that gasoline sold in the US contains a specific value of biofuels.

example, it is often not appreciated that meeting the water quality requirements inbuilt in the WFD are highly energy-intensive, as estimated by the UK (Larsen *et al*., 2009). In the EU the policy priorities for the alignment of mitigation and adaptation is clear: win-win no-regrets measures like water use efficiency, land use planning, flood management and reducing pollution itself, which is energy intensive, as in the case of nitrates, the main cause of diffuse pollution. These are inherently energy intensive to treat for public water supply, for instance, and in turn reduce the quantity of usable water for other uses like environmental flows (ie, this is lose-lose-lose strategy if not tackled). Meanwhile, the Floods Directive and the Water Scarcity and Drought Communication aims to ensure consistency with the WFD, by incorporating climate change (Balabanis, 2008). The floods directive, for example, aims to assess flood risk and reduce the danger to human beings and property, by preparing flood maps and management plans. This should include long-term developments including climate change, like the Dutch approach of integrating spatial planning with climate change.

The EU Water Directors created a Working Group within the Implementation Strategy of the WFD on Water Scarcity and Droughts, which was published on 17 July 2007, recommending developing a list of measures to cope with water scarcity and droughts (eg management measures), establishing drought management plans, a European Strategy on Water Scarcity and Droughts, European funds for prolonged droughts and the creation of a European Drought Observatory. Drought management plans at the local level (see below on the section on Spain) can complement the river basin plans currently being developed as part of the implementation of the WFD, to mitigate and prevent drought impacts, and developing indicators systems for drought status.

Table 3A. Summary of key EU-specific policies in mitigation, monitoring and adaptation

	EU level Policies	Directives/programmes/documents
Mitigation	Climate change programmes	First European Climate Change Programme Second European Climate Change Programme
	ETS Scheme	Directive for ETS Directive 2003/87/EC **Directive 2009/29/EC amending Directive 2003/87/EC** to **improve and extend** the greenhouse gas emission allowance trading scheme of the Community **Directive 2004/101/EC amending Directive 2003/87/EC establishing a scheme** for greenhouse gas emission allowance trading within the Community, in respect of the Kyoto Protocol's project mechanisms
	Renewables commitment by 2010	Directive 2009/28/EC of the European Parliament and of the Council on the promotion of the use of energy from renewable sources
Monitoring	MVR	Mechanism for monitoring GHG emissions and implementing the Kyoto Protocol in the EU (Decision 280/2004/EC)
Adaptation and Water Resources		White Paper on Adaptation (July 2009) Water Framework directive WFD (2000/60/EC) Floods Directive 2007/60/EC Water Scarcity and Drought Communication

Table 3B. EU and climate change related policy

Kyoto Protocol and international commitments	• Kyoto Protocol on climate change • Implementing the Kyoto Protocol • Global climate change alliance • Climate change in the context of development cooperation
Climate change Strategies	• Strategy on climate change: foundations of the strategy • Strategy on climate change: the way ahead for 2020 and beyond • Launching the European Climate Change Programme (ECCP)
Reduction in greenhouse gas emissions	• Mechanism for monitoring greenhouse gas emissions • Greenhouse gas emission allowance trading scheme • Reduction in fluorinated greenhouse gases • Reduction of greenhouse gas emissions not covered by the emission allowance trading scheme
Renewable Energy	• Promotion of the use of energy from renewable sources • Renewable Energy Road Map • Promotion of the use of renewable energy • Biomass Action Plan • EU strategy for biofuels
Transport and Emissions	• White paper: European transport policy for 2010 • Internalisation of external transport costs and encouragement of 'greener' transport use • Road transport: taxation of heavy goods vehicles; Eurovignette Directive;

	freight transport logistics in Europe; passenger car related taxes • Aviation: framework for creation of the Single European Sky (SES); Single European Sky II; Clean Sky JTI • Rail transport: White Paper (A strategy for revitalising the Community's railways) • Waterways: promotion of inland waterway transport 'NAIADES'; Maritime Policy Green Paper; Programme for the Promotion of Short Sea Shipping; Strategy to reduce atmospheric emissions from seagoing ships; The Marco Polo II Programme
Agriculture and land-use planning to benefit the environment	• Health-check of CAP • Carbon capture and geological storage • Thematic strategy for soil protection • Landfill waste • Production and labelling of organic products: new legal framework
Monitoring and adaptation	• Global Monitoring for Environment and Security (GMES) • Adapting to Climate Change • Civil Protection Mechanism • Flood management and evaluation • Combating deforestation
Less polluting, more efficient energy	• Green Paper: A European strategy for sustainable, competitive and secure energy • Energy efficiency for the 2020 goal • Green Paper on energy efficiency • Action Plan for Energy Efficiency (2007-12) • Towards a European Strategic Energy Technology Plan
Energy security and sustainability of supply	• An Energy Policy for Europe • Community framework for the taxation of energy products and electricity • Sustainable power generation from fossil fuels • Demonstration of the capture and storage of CO
Innovation, research and technological development, consumption and production	• Environmental Liability Directive • Competitiveness and Innovation Framework Programme (CIP) (2007-13) • Action plan in favour of environmental technologies • Strategic Energy Technology Plan (SET Plan) • Seventh Framework Programme (2007-13): Building the Europe of Knowledge

Source: modified from http://europa.eu/legislation_summaries/environment/tackling_climate_change/index_en.htm, accessed 9/XII/2009.

(4) Spain: Difficult Political Choices between Adaptation and Mal-adaptation

Spain is increasingly adopting policies to adapt to climate change in relation, for example, to the estimated reduction in rainfall which has been incorporated into new river-basin plans dues out in 2009, and extreme events like droughts through Drought Management Plans, already operational in the last drought (2005-07). What is less clear at this stage is whether mitigation –ie, the goal of not increasing emissions– is easily incorporated into normal water-resource management, never mind adaptation. For example, the two main National Water Plans presented in 2001 and 2005 both relied on highly energy-intensive supply management options, namely water transfers in the first case and desalination plans in the second (*Programa AGUA*) (Lopez-Gunn, 2009).[11] Spanish water policy is immersed in a process of flux and transition.[12] There is an inherent tension between a model focused on supply management (construction of dams and water transfers) and a model focused on demand (Martin *et al*., 2008). This is caused both internally in a re-defining of policy paradigms in a decentralised political system and externally (top down) due to a push from European policy in relation to, eg, implementation of the EU Water Framework Directive. As a system in transition internally, Spain has an ideal opportunity to integrate innovation both in terms of policy and technology, in order to allow for the emergence of a new system, and prevent a lock-in of the old system, which is becoming increasingly more expensive and difficult to finance.[13]

Spain, is the driest country in the EU, with high climate variability in a large part of its territory, and is located in one of the climate change hotspots (see Map 2 below) (Giorgi, 2006). Climate change predictions seem to point to variations in temperature, although they are less clear in relation to rainfall.[14] It appears that warming was higher than average in Europe (between 1.2ºC and 1.5ºC) in the 20th century (Castro *et al*., 2004; Abanades *et al*., 2007; MMA, 2005). In terms of future predictions, modelling predicts that for the last third of the 21st century there could be an increase of 3º-6ºC in the average temperatures (compared with 2º-6ºC on average in Europe). However, the use of different types of models gives different predictions.

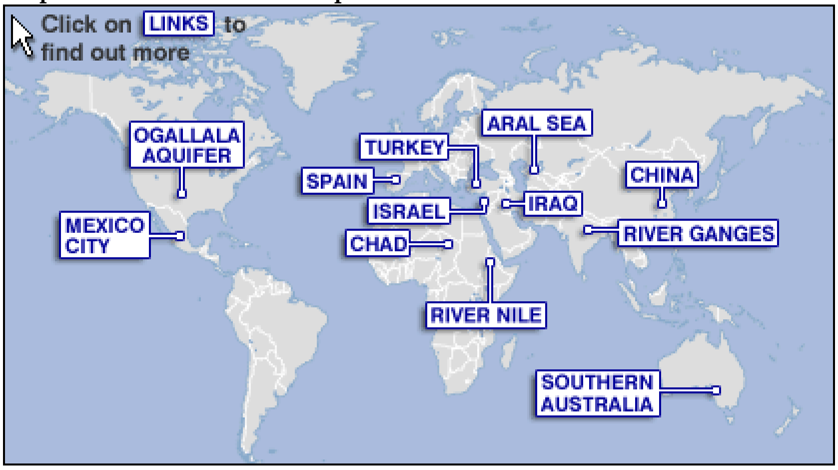
[11] 4.2 to 1.3. kwh/m3 of desalinated water and . The cost of producing –new water´ from e.g. 9 desalination plants equivalent to Carboneras generating 120,000 m3/day represents 1.5. million kWh/yr considering an energetic cost per m3 of 3.5 kWh/m3 (Olcina, 2001), and on average calculate at 4kWh7m3 (Uche, 2001). In the case of water transfers it is estimated at 1 kWh/m3 for each 290 m gross jump, which meant that the energetic costs from the Erbo to Almeria varied per segmente varying from 0,7 kWh/m3 in Castellón to 4,1 kWh/m3 in Almería (Albiac et al 2008).

[12] Rotmans (2005) four different stages can be identified in a transition: (1) predevelopment, (2) take-off, (3) acceleration, and (4) stabilisation (Fig. 3). In the predevelopment stage, the existing regimes and power status quo do not visibly change, while after the take-off a quick process of societal change starts until another situation is reached in which the speed of change and innovation decreases again. Transitions are stimulated either by endogenous or exogenous forces but are usually the result of coalition forces between agents, which create ''niches'' of regimes and organisation patterns that are alternative to those currently dominant and which are able finally to overthrow the dominant regime (…)The take-off phase starts when developments take place mostly at the micro- and macro-level. Changes at the macro-level, such as change in worldviews or macro policies reinforce certain innovations at the micro-level such as policy or technology. During the interactions between the micro- and the macro-level (the period
between pre-development and take-off), (…) polarization between the existing and the emerging paradigm. At this point, the regime tries to integrate innovations to avoid or end the polarization at the micro-level.(…) There is a need for feedbacks from the integration practices and experiences at the microlevel for the regime to maintain itself or to go into further innovations. The lack of such feedback can cause a drawback or a lock-in situation. (tabara and Ilhan, 2007,)

[13] For example, the AGUA programme which replaced a planned water transfer with an investment programme on desalination plants had a budget of €8 billion for a desalination capacity of 600 Mm3. for 34 new desalination plants over the period 2004-2008 (Lopez-Gunn, 2009).

[14] MCGA-AO (Estrela, 2008).

Map 2. The world's water hotspots



Source: BBC News, 20/X/2004, http://news.bbc.co.uk/2/hi/science/nature/3754520.stm.

A very useful first and necessary step, however, was a report published in 2005 on the *Impacts of Climate Change on Spain*, (OEEC and UCLM, 2005) which followed the procedures of the IPCC panel, commissioning a group of experts from different disciplines and geographical parts of Spain to review 15 climate-change impact areas.[15] In relation to water, the study reported on the increased likelihood that, in line with other projections for the EU, there would be an intensification and acceleration of the hydrological cycles. A year later, in 2006, Spain presented its *National Plan on Adaptation to Climate Change* (OECC, 2006). The Plan provided a framework stating the objectives, future climate scenarios and identified impacts and actions for 15 key sectors.[16]

Specifically, in relation to water resources, the Plan anticipated an increase in temperatures (and plant evapotranspiration) and a decrease in rainfall, by 5%-10% to up to 20%-22% by the end of the 21st century. Impacts would in theory be more pronounced in arid and semiarid areas, which occupy 30% of the territory where reductions in rainfall could be as high as 50%. This could be accompanied by increased variability on the Atlantic coast and greater floods inland and on the Mediterranean. The main action lines identified are listed in Table 4:

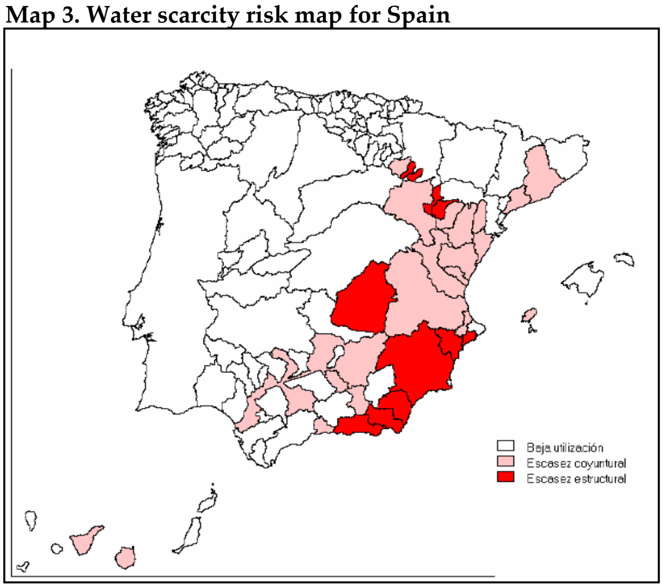
[15] Each area was assigned three experts to review climate change and their particular theme, based on published data and projections and calling on additional experts (including experts from other countries).
[16] Biodiversity, water resources, forests, agricultural sector, coastal zones, fisheries, mountain areas, solids, marine fisheries and ecosystems, transport, human health, energy and industry, tourism, finance and insurance and urban areas and construction.

Table 4. Spanish National Adaptation Plan to Climate Change and water resources (OECC, 2006)

- Development of coupled climate-hydrology models to obtain reliable scenarios of all aspects of the hydrological cycle, including extreme events
- Assessment of water management options in terms of the hydrological scenarios generated for the 21st century
- Application of the foreseen hydrological scenarios to other sectors highly dependent on water (energy, agriculture, tourism, etc)
- Identification of climate change indicators under the implementation scheme of the Water Framework Directive
- Development of guidelines and regulations to incorporate the foreseen impacts of climate change into the processes of Environmental Impact Assessment and Strategic Environmental Assessment of Plans and Programmes within the hydrological sector

Current river basin plans date back to 1998 and the planning cycle pre-WFD did not incorporate an evaluation of climate change impacts. These were considered for the first time in the preparation of the *Libro Blanco del Agua*, as part of the Technical Documents prepared for the 2001 National Water Plan. The *Libro Blanco del Agua* (MIMAM, 2000) undertook a study on how two scenarios (1 and 2)[17] would impact on river flows for 2030 (see Map 3). This, in turn, helped to generate water scarcity risk maps ranging from low-use, temporary-scarcity and structural-scarcity scenarios (see Map 4), and also percentages per river basin of the drop in rainfall for these scenarios for the water planning period to 2030[18] (see Map 3 and Table 5).

Map 3. Water scarcity risk map for Spain

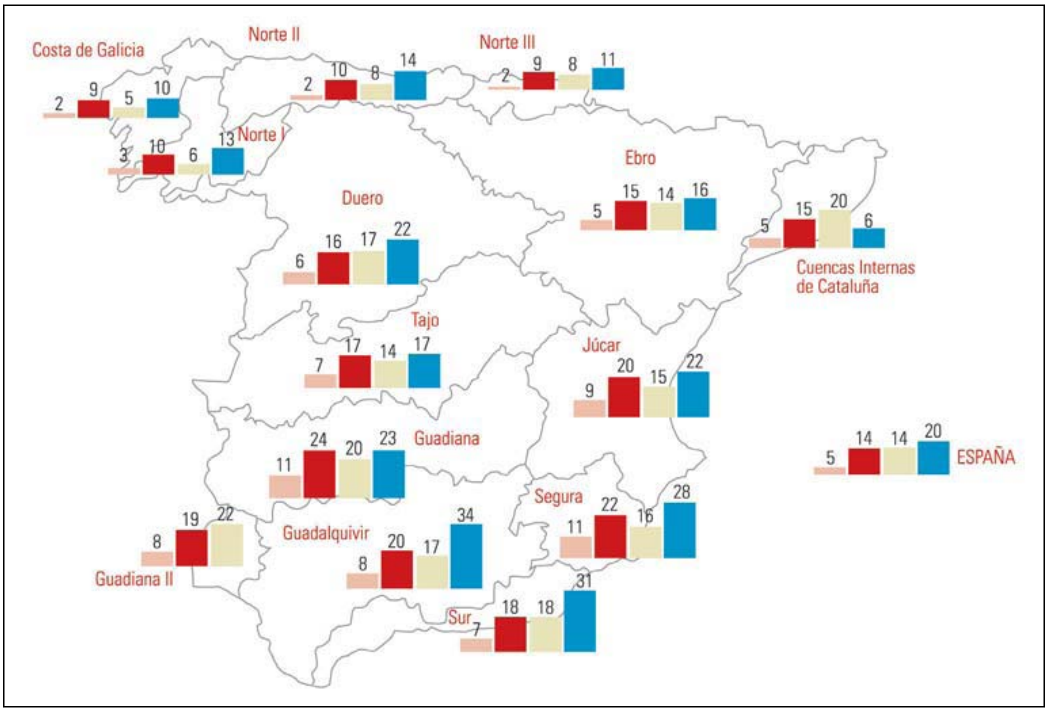


Source: Estrela (2008a and 2008b).

[17] Scenario 1 (1º C increase in temperature); scenario 2 (1º C temperature increase and a drop of 5% in rainfall).
[18] The deadline for the implementation of the Water Framework Directive is 2015, however, exceptions allow derogations up to the year 2027 for full compliance.

Map 4. Scenarios of potential reduction in water resources per River Basin

Scenario 1	Scenario 2	Scenario 3	Scenario 4
2030 +1ºC temperature rise No change in rainfall	2030 +1ºC temperature rise -5% decrease in rainfall	2030 PROMES Model No change in rainfall	2060 +2.5ºC in temperature 8% in rainfall
Reference: CEDEX (1988); MIMAM (1998) Libro Blanco del Agua en España; Fernández, C.P (2002). Ayala-Carcedo *et al.* (1996).			



PNACC: The Spanish National Plan for Adaptation to Climate Change (leaflet p.9)
Source: modified from OECC (2006).

The influence top-down came mainly from the EU Water Framework Directive (EC, 2000) which specifies that river basin plans are due to be finalised in 2009 and have to include measures on climate change and adaptation.[19] The current plans are including climate change in the planning process, as required by the WFD.[20] The way to implement the

[19] For example, Ayala e Iglesias (Ayala-Carcedo et.al 2001) use a monthly regional aggregate model for each large river basin. Meanwhile the MIMAM 2000 used an annual climatic scenario.

[20] The way to implement the Water Framework directive (CEC 2000) is based on identifying a series of basic and complementary measures to achieving environmental objectives in river basin plans. These River basin Plans have to include a Climate Check of the Programme of Measures. These in turn could include information on whether the planned measures are climate change proofed, i.e. the suitability of measures in the context of climate change. This in theory is to prevent mal-adaptation. In 2007 the Spanish government passed an Act, Royal Decree of Water Planning and a Ministerial Order[20], approving the Water Planning Technical Guidance (*Instrucción de Planificación).* These integrates into traditional River Basin Management newer requirements related to environmental requirements (i.e. WFD implementation) and due consideration in water planning to climate change. This Water Planning Regulation[20] includes under Art 11.4, the elaboration of an Inventory of Natural Water resources[20] , establishing the balance between *available resources and foreseeable demand for different uses and their* allocation. The concept of available resources would include a

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Table 5. Integration of climate change impacts into water planning

Level	Year	Initiative	Details
EU Level WFD and its implementation in Spain	2000	Water Framework Directive	• River basin plans to inform on whether the planned measures are climate-change proofed
	2007	Royal Decree of Water Planning Water Planning Regulation[23] and Ministerial Order[24] approving the Water Planning Technical Guidance (*Instrucción de Planificación)*	• Art 11.4: Inventory of Natural Water Resources,[21] establishing the balance between *available resources and foreseeable demand for different uses and their* allocation • Concept of available resources to include a reserve for environmental demand requested under the WFD in terms of water resources[22] • Due consideration in water planning to climate change
National	**Various (from 2005)**	National and Catchment Drought Plans (foreseen in Law 10/2001 of the National Water Plan under section 2)	See CHG (2007b)
Regional governments	**Various**	Regional strategies on the fight against climate change	Eg, Castilla La Mancha, Extremadura and Andalusia
Local, eg, water supply companies	**various**	Public water supply companies, eg, Canal de Isabel II (Madrid)	

reserve for environmental demand requested under the WFD in terms of water resources

[21] Inventario de recursos hídricos naturales (art 11.4)

El plan hidrológico evaluará el posible efecto del cambio climático sobre los recursos hídricos naturales de la demarcación. Para ello estimará los recursos que corresponderían a los escenarios climáticos previstos por el Ministerio de Medio Ambiente, que se tendrán en cuenta en el horizonte temporal indicado en el artículo 21.4.

[22] Balances, asignación y reserva de recursos (Art 21.4)

Con objeto de evaluar las tendencias a largo plazo, para el horizonte temporal del año 2027 el plan hidrológico estimará el balance o balances entre los recursos previsiblemente disponibles y las demandas previsibles correspondientes a los diferentes usos. Para la realización de este balance se tendrá en cuenta el posible efecto del cambio climático sobre los recursos hídricos naturales de la demarcación de acuerdo con lo establecido en el artículo 11. El citado horizonte temporal se incrementará en seis años en las sucesivas actualizaciones de los planes.

[23] Reglamento de la Planificación Hidrológica (RD 907/2007)

[24] Royal Decree (RD 907/ 2007) and Ministerial Order ARM/2656/2008.

Table 6. Drop in water resources for planning purposes per river basin due to climate change

River Basin	Spanish Water Planning Instruction (2007) Percentage reduction on natural availability to incorporate climate change
Cantábrico	2
Duero	6
Tajo	7
Guadiana	11
Guadalquivir	8
Segura	11
Júcar	9
Ebro	5
Miño-Sil	-3

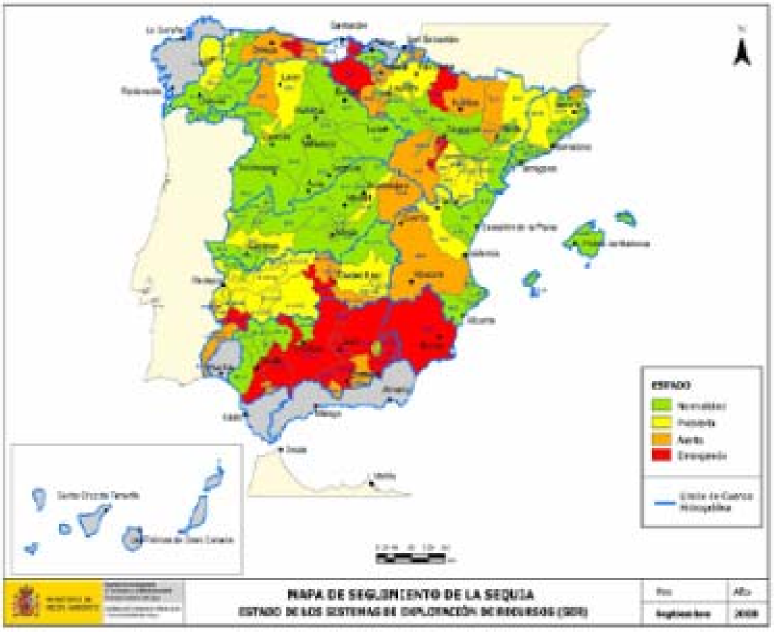
The Water Directorate, part of the Ministry of the Environment, Rural Affairs and Marine Areas (MARM), commissioned a study with the CEDEX on the effect of climate change for the analysis of climate-change impacts on water resources and water bodies in the context of the National Plan on Climate Change adaptation. There was a follow up Commission with members from the Water Directorate, the Climate Change Office and the CEDEX (*Centro de Estudios Hidrográficos*).[25] These initiatives of developing National and Catchment Drought Plans at the national level, in what could be considered autonomous or spontaneous adaptation (see CHG, 2007b), were foreseen in Law 10/2001 of the National Water Plan under section 2. This results in an indicator system based on drought risk, from very-low to very-high which is then translated into water planning of different status (normal, pre-alert, alert and emergency), designed for each individual river basin, producing monthly risk maps for each.[26]

[25] To evaluate climate change effect on water resources on rivers under natural regime (i.e. not regulated); effects on water use in irrigation, public water supply and industry, and adaptation strategies; the effect of climate change on water exploitation systems (e.g. reservoirs) and the environmental impact on water bodies. The analysis of regional climatic models were based on data supplied by the State Meteorology Agency[25] (AEMET, no date), and which generated monthly hydrological series for all river basins and impacts in terms of rainfall, river flow, evapo-transpirationDemands will in turn be affected by both climate scenarios and socio-economic scenarios. More detailed analysis has been undertaken for agricultural demand and irrigation, for example in terms of crop productivity and evapo-transpiration dependent on variation in CO2 levels and in relation to CO2 and temperature. It has also aimed to analyze impact on available water resources, the use of water-working simulation models to model incomes, demands, exploitation of water systems and ecological states. These simulations can help identify Guarantee criteria. For water systems like reservoirs or aquifers, for example reserving groundwater for drought periods or having more flexibility during droughts to meet full demand, using Drought Special plans.
[26] For the drought of 2005-2007, 710,896 million de € were spent.

Table 7. Typology of drought risk for water planning

Status Index Value Indicator Drought Risk	1.0-0.5	0.5-0.4	0.4-0.3	0.3-0.2	0.2-0.15	0.15-0
Status	**Normal**	**Pre-alert**		**Alert**		**Emergency**
Objective	Planning	Information control		Conservation		Restrictions
Type of Measure	Strategic			Tactical		Emergency

Source: Antolin (2008).



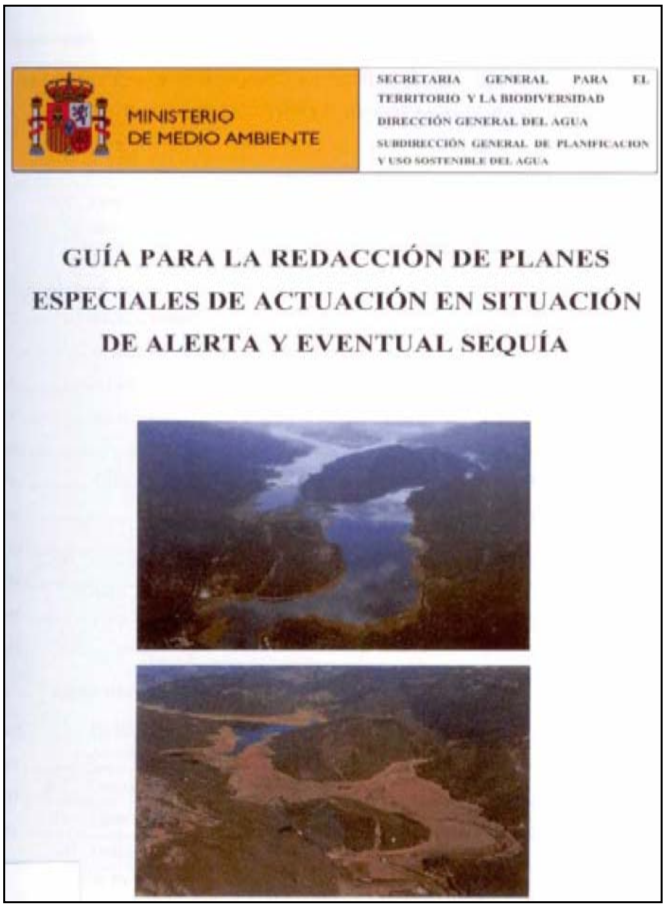
September 2008

However, until the approval of a Guidance Document for developing Drought Management Plans and Droughts Action Plans, droughts were considered a crisis.[27] The approval of these new Plans and Guidance means that droughts have now been fully integrated into the general planning framework, through risk analysis and strategies (Antolin, 2008). In the 1993-95 drought, more than 11 million people in eastern and southern Spain suffered water restrictions and associated water-quality problems in their public water supply. Estimates of agricultural losses ranged between US$4.7 billion to US$10 billion at 1995 value. Since the 1990s droughts have been the natural hazard that has affected more people in Spain (Iglesias *et al.*, 2009). These new droughts plans are a positive example of pro-active policy making in the face of climate variability. A recent law adopted on 7 December is taking some bold steps in terms of water rights (see Box 1).

[27] Droughts were considered an émergency´ which had to be tackled through extraordinary measures. Art 58 in Spanish Water Law (TRLA), included extraordinary drought situations which were addressed through the adoption of Decrees of Urgent and Extraordinary measures by the Government, heavily criticised by NGOs, to finance and develop the measures to address these situations as an exception to general water policy making. Often this referred to new water infrastructures or imposed reductions in water use.

Box 1. Law-Decree on urgent measures to alleviate the effect of droughts (7 December 2009)

Decreto Ley de medidas urgentes para paliar los efectos producidos por la sequía	
Applied to the following river basins: Duero, Tajo, Guadiana, Guadalquivir, Segura and Júcar	
Measures	To establish exceptional administrative measures for the management of water resources Establish urgent measures for the regulation of water-rights transactions Establish support measures to the title holders of water-use rights for irrigation and public water supply in areas affected by drought, when in the last season if they have a water allocation which is 50% or less than in a normal year Excuse, in relation to the Tablas de Daimiel National park, the payment of the corresponding tariff for the Tajo Segura aqueduct, in view of the scant amount of resources actually transferred The Government, Juntas and Presidents of water authorities are allowed to temporarily modify the conditions of use of the state water domain, no matter what type of legal title has given rise to the use of water and the following measures can be implemented: - Reduce water allocated to public water supply for a more rationalised use - Modify the priority criteria in the allocation of resources between different water users - Impose the substitution or replacement of part or all of the water concessions for others which could be of different origin but with sufficient quality, to make a rational use of the resource - Modify the conditions set for discharges into water, to protect public health, water resources and the environment - Temporarily modify allocations and reserves foreseen in the river basin plans - Demand from users the installation of measuring devices, regulation and control - Adapt the water-use regime for hydroelectricity with other needs, to make them compatible with other uses



Box 2. Spanish drought management plans

DIAGNOSIS:

- Identify and characterize territorial and environmental elements.
- Zonification
- Analysis of historical droughts and drought characterization
- Definition of indicators, thresholds and drought phases

PROGRAM OF MEASURES (POM):

- Definition of general measures and specific ones for each area in each drought phase
-

MANAGEMENT AND FOLLOW-UP SYSTEM:

- Organization and management systems
- Definition of indicators for the implementation follow-up and effects

Source: Antolin (2008).

Table 8. Series of recorded dry years and drought sequences in Spain

Dry years	Drought sequences
1836	1820-30
1853	1840-50
1882	1861-80
1907	1909-14
1950	1938-89
1952	1944-45
1955	1963-64
1961	1978-84
1966	1992-96
1970	2005-07
1973	
1998	

Source: Lopez *et al*. (2009) based on data from the Instituto Nacional de Metereologia.

In addition to the national level, regional governments have also started a process of developing action plans though regional strategies to fight against climate change (Varela-Ortega, *et al*., 2009; Poderoso Godoy, 2008). Equally, public water supply companies like the Canal de Isabel II at the local level have developed drought management plans, considered as a part of the hydrological cycle in Mediterranean countries (Cubillo, 2009). A new National Drought Observatory (ONS, from its Spanish initials) has been created by the MARM to include all Spanish Administrations with competence in water issues, to establish a centre of expertise and mitigation and to follow up the effects of drought events in Spain.[28]

[28] The Observatory is constituted by: eight inter-regional Basin Organizations that depend on the National Government; the seven intra-regional Hydraulic Administrations (Galician coast, Basque country, Catalonian

Drought Plans,[29] in turn, are complemented by an agricultural insurance system established by the MARM, to partly compensate for agricultural damages caused by drought events.[30] This experience is relevant at the EU level because one possible way to reform parts of the Common Agricultural Policy –to make it compatible with Doha– could be based on insurance schemes. The type of measure that is considered in drought plans, apart from its linkage with insurance schemes, refers to rules on water use, water savings and use restrictions, conjunctive use of surface and groundwater –eg, drought wells–, water re-use and water markets.

The synergies between existing policies (eg, drought plans) and climate change measures must be highlighted, although drought plans were not climate-change driven but rather driven by climate variability.

However, after a detailed analysis of the integration of climate change into Spanish water planning, some general comments have to be made:

- First, the overtly technical analysis of what will inherently be a political process. For example, according to Santafe (2005) some of the key areas will be the sectoral policies of different regions in Spain.
- Second, how to manage demand of all the interest groups affected and where potential difficult political decisions will have to be made, eg, in relation to land use planning and zoning, and the special case of groundwater use in Spain, which is often intensively (and illegally) abstracted but which generates high economic returns.
- Third, in the current process of public participation in water planning more attention is increasingly paid to two aspects: what is called 'actionable science' –ie, generating data on how climate impacts on users, rather than how users impact on climate–; and the creation of communities of practice in relation to climate change and variability. This can be integrated into the current participatory process that is a compulsory part of the WFD and which has the intention of legitimising

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Internal Basins, Mediterranean; Andalusian Watershed, the Balearic and Canary Islands); the autonomous cities of Ceuta and Melilla; seventeen Regional Governments and Local corporations (Lopez et al, 2009).

[29] Drought Plans are being developed by each Basin Organization to include drought thresholds and protocols of action. According to Articles 10 and 21 of the Law 9/2006 of April 28th, the preliminary versions of these Plans for the North, Duero, Tajo, Guadiana, Guadalquivir, Segura, Jucar and Ebro Basins Organizations are currently in the consultation period.

[30] Additional measures are also in place to alleviate some of the damages not covered by the insurance scheme. The insurable production types are: Agricultural Production (all vegetable production cultivated in Spain can be insured); Farming Production (cattle, sheep, goat and horses can be insured); Aquicultural Production (Trout, silt head bream, sea bass, turbot and mussels can be insured); Timber and Forest Production: although insurable by Law 87/1978, have not yet been included in the system. Drought risks are covered by integral insurance (winter cereals, vineyards…), production insurance (olive trees, almonds…), bee keeping and pasture insurances.

decisions currently being taken on water planning, which in the context of the time horizon contemplated (to 2015) will impinge on the different water users.

(5) A Measured Response?: High Pay-off, Low-risk Measures (No-regret Policy Making)

The twin challenges of climate-proofing the real-water economy (which will be mainly mediated through water –eg, floods, droughts, lack of rainfall, etc–) and decarbonising the economy mean that difficult decisions and choices have to be made. In 2002 the Spanish Parliament ratified the Kyoto Protocol, and its commitment to reductions in CO2 as part of the EU. In 2007 Spain presented its National Allocation Emissions Plan as well as its Spanish Strategy on Climate Change and Clean Energy (mitigation). A year earlier it had presented its National Plan on Climate Adaptation (adaptation) with the aim of mainstreaming adaptation to climate change into the planning strategy of different socio-economic sectors (EWP, 2009). On paper Spain is definitely ticking all the right boxes. The challenge, however, is to align much closer adaptation and mitigation. This section will analyse what would be the most practical and effective measures to be adopted as a priority.

The prioritisation of measures has to be based on a number of key areas: (1) prioritise sectors where the biggest gains can be made from their synergy; in this, two sectors stand out-agriculture and energy; (2) a realistic even if politically difficult assessment of structural measures to re-assess inertia in Spain to follow the hydraulic (expensive) paradigm based on correcting 'structural water deficits'; (3) give a greater weight to non-structural measures in urgent need of attention, like legislation, and market-based instruments; and (4) acquire deeper grounded knowledge on adaptive capacity and vulnerable hotspots at the local level, while putting pressure at the global level in climate change negotiations in two ways by showcasing that alignment is possible and by putting water firmly on the agenda of COP-15.

First, agriculture is a key sector for climate change and adaptation since it is the main global water consumptive user, accounting for 70% of the freshwater used is agriculture, and many of the impacts of climate change or increased variability are reduced rainfall or extreme events (floods or droughts). In many developing countries much of the population depends on agriculture in terms of employment, and agriculture itself is dependent on either green or blue water (rainfall, or water from rivers or aquifers). These make them much more vulnerable to climate change, in that developed countries have a smaller percentage of the workforce employed in agriculture, a more diversified economy and higher financial resources. In Spain employment in agriculture has dropped from almost 2 million in 1984 to half a million in 2010, with agriculture and fishing accounting for less than 5% of Gross Added Value[31] (Lopez *et al*., 2009). In contrast, almost two thirds

[31] With some marked regional differences, in some provinces this represents a much higher percentage both in

of global food is produced by evaporation and transpiration of green water,[32] and this green water constitutes about 90% of total agricultural water consumption (Liu *et al*., 2009). This highlights that the major sector where impacts and adaptation have to be aligned with the potential largest number of beneficiaries is agriculture. This is supported by research that seems to point to a differential impact of climate change between developed and developing countries, ie, with increased yields at high and medium latitudes and decreases at lower latitudes. More recent simulations, however, point to a possible increase in rainfall in Africa (Yang, 2009). They key point is the need to plan for this uncertainty where climate variability and the non-linearity of food systems is increasingly evident, with the potential threat multiplier of climate change. Developing countries are particularly vulnerable for two reasons: (1) because of their capacity to adapt is greatly related to wealth; and (2) because most countries have very substantial agricultural sectors that will be more vulnerable to potential changes in temperature (increased evapo-transpiration), change in rainfall patterns in the crop growth period, and to extreme events like droughts and floods. As Parry *et al*. (2004) suggest, agricultural managers need to prepare for a range of agricultural futures at the regional level since 'regional differences in crop production could grow stronger through time, which could lead to a significant polarization of effects' (p. 46), with an increased risk to food security.

As stated by Gerten & Rost (2009): 'Projected drier and/or more unstable climatic conditions are likely to imperil future food production in many regions, while at the same time a growing world population, changing lifestyles, and bio-energy production will put increasing pressure upon existing land and water resources. Therefore, any local efforts need to be taken to make best use of the water available on current cropland'.

In Spain, meanwhile, a country where some of its most productive agricultural sectors are dependent on irrigation –particularly groundwater–, there is a paradox in agriculture, since climate change is likely to increase productivity; yet it is also likely that demand for irrigation will increase, due to reduced water availability. This will put particular pressure in the south and south-east. Hence, win-win adaptation measures call for modernisation plans in irrigation (irrigation efficiency), the progressive transfer of full-cost recovery (operation, maintenance and capital costs of infrastructure and the more contested prices for resource use), changing crop patterns and the opportunity for an agricultural *reconversion (agricultural re-structuring)*, taking the opportunity of CAP reform (Santafe 2005). For example, there are key questions for water supply companies in terms of investments to reduce losses in the water supply systems. However, compared to water use in agriculture these savings are 'small water', compared with 'big water' savings (Allan, pers. comm.; Llamas, pers. comm.), to be made by the option of, for instance, buying up water rights from farmers. This is currently being considered by the Madrid public water supply company instead of additional expensive new infrastructure.

ters of employment and in terms of value added.

[32] rainwater stored in the soil as soil moisture, also called soil water (Hoekstra and Chapagain, 2008).

In this context, two issues are key: (1) irrigation and land use; and (2) energy itself. For example, irrigation plays the largest role in the management of water in many countries yet there is little consistent information on water use by irrigation. In the Mediterranean, irrigation accounts for 60% of total water use, while in Northern Europe this drops to 1%, due to growth irrigation requirements, with annual figures that range from 53 litres per m^2 of irrigated land in Denmark to 1,120 litres per m^2 of irrigated land in Spain. However, likely inefficiencies in transport and irrigation management mean that in reality the figures could be 1.3 to 2.5 times higher.[33] Meanwhile, recent research in terms of land use and consumptive needs of vegetation are starting to point to the dramatic impact that small changes in land use can have for water resources (eg, river flows) (Custodio, pers. comm.), and, in turn, the huge potential opening for managing land-use to effectively manage water. For example, in the Segura basin in southern Spain there has been a substantial reduction in water stored in reservoirs since the 1980s. There is a possible range of causes, ranging from climate variability, droughts and their impact on aquifer recharge and changes in land use (aforestation, rural exodus, agricultural land abandonment...). Evidence from hydrological modelling indicates a rise in temperature, inconclusive evidence in terms of a drop in rainfall (in some areas there is a decrease and in others no significant change or an increase) and a drop in evapotranspiration and aquifer recharge; in terms of land use there is an increase in forested areas from 26% in 1956 to 40% in 2000 and an increase in thickets (*matorral*) due to reduced grazing (Urrea, 2008). In other words, it is possible that changes in land use can have an impact on available water resources that could be as significant as changes in rainfall.

Meanwhile, in the case of energy, within the EU-30 the total energy consumption is expected to rise by 50% till 2025, the amount of water needed in energy production is expected to rise by 130% over the same period (Larsen *et al*., 2009). As Larsen states 'policies designed to grapple with the challenges of climate change have the potential to produce decisions that exacerbate water-energy challenges' (p. 32). The EU could undertake a study similar to that undertaken in the US to map the water consumption of major water-supply options (eg, comparing the water footprint of thermoelectric, biofuels and ethanol, oil and gas and hydroelectric) (Harte, 2007). Equally, California has also estimated the water/energy nexus for the state of California (CEC, 2005).

Mal-adaptation is defined as decisions that are supposedly justified or legitimised on the basis of, eg, adaptation by increasing water supply in the short term yet creating mal-adaptation in the long-term (GPPN, 2009), such as conventional desalination (not using renewables) to generate 'new water' that is at present highly energy intensive. Therefore, if desalination is considered an adaptation measure it should be on the basis of, eg, solar sea-water desalination or taking the opportunity of using 'blue energy' –ie, obtaining

[33] This is based on research conducted by the European Commission Joint Research Centre, used the crop growth model EPIC (Erosion Productivity Impact Calculator) to estimate European crop irrigation requirements. The results were then averaged nationally.

clean energy by mixing water streams from different salt concentrations in the process– or, for example, measures like water transfers operating on specific rainfall patterns and surplus of water in the ceding basin; water transfers are also highly energy intensive (see Albiac *et al*., 2006, 2007, for estimates for the 2001 Spanish National Water Plan). This highlights, first, the close link between water/energy decisions and, secondly, the need to also consider demand management measures like managing supply and demand by, eg, reallocating water between sectors and transferring water rights rather than water itself, or giving greater consideration to virtual water flows in low-value crops whilst saving scarce water resources for high added-value sectors and/or for amenity and environmental value activities (Llamas, pers. comm.). The suitability and cost effectiveness of different mitigation and adaptation measures can be evaluated by providing transparent information on sources of finance and costs, and also the equivalence values measured in m^3/kWh or kWh/m^3.

Table 9. Energy production and consumption indicators for different water uses

Water use			kWh/m³
Production	Electricity	Hydroelectricity (jump of 100m)	0.21
		Combined central cooling cycle (closed circuit)	345
		Central cooling-thermosolar (closed circuit)	245
		Thermal central cooling (open circuit)	17,5
Consumption		Pumping (100 m)	0,42
	Irrigation	Localised irrigation	0,18
		Spray irrigation	0,23
	Public water supply and treatment	Water treatment (primary)	0,18
		Water treatment (secondary)	0,3-0,5
		Tertiary water treatment	0,15-0,25
	Transport	Ebro Project Water transfer (average height 723m)	3,7
	Desalination	Desalination sea water	3.5-4,0
		Desalination brackish water	1,4-1,8

Source: Corominas (2009).

First-generation biofuels are an example of a mitigation policy that has had unintended consequences in terms of reducing food security, since they use too much water and imply 'burning food' and are partly responsible for the rise in food prices witnessed in 2008.[34] Meanwhile, other well-designed policies in relation to aforestation at the global level –like REDD+, or the reform of the CAP– offer opportunities for payments for environmental services, such as in climate change mitigation by linking it with the MAR movement to increase the recharge into aquifers[35] in the context of extreme events. This

[34] Terri Raney, Food and Agriculture Organization of the United Nations: "Biofuels demand is likely to keep basic food commodity prices 10 to 15 percent higher than they would have been otherwise.". Most estimates suggest that biofuels are responsible for between 25 and 40 percent of the increase in food prices. We are concerned that the rapid growth in biofuels, driven by government policies, is creating stresses on a world food system that has not had time toadjust. Half of the increase in global cereals demand between 2005 and 2007came from biofuels. This clearly poses risks for world food prices and a challenge for food security (*http://knowledge.allianz.com/nopi_downloads/downloads/Food%20Security%20Biofuels%20vs%20Food.pdf*)
[35] MAR -managed aquifer recharge to recover over-exploited and degraded aquifers (Vilholth, 2009).

could blend land-use designed to increase artificial recharge whilst taking the opportunity for slowing hydrological systems down and/or storing water in natural underground reservoirs resilient to climate variability and change. In adaptation policy what matters most is not developing adaptation policies, but rather adapting existing policies to climate-proof them to both change and variability from the climate system.

Secondly, in terms of structural measures, there has been a strong focus and emphasis on modelling water resources under different climate change scenarios. In the case of physical investments, anticipatory adaptation can be costly and is directly linked to the optimal investment timing of adaptation measures. Early adaptation is more necessary in long-lived investments with a long lead time because retrofitting would be expensive. In the case of water infrastructure (both soft and hard) the effect of extreme events influences investment and timing decisions, since most infrastructures have to be planned with respect to weather extremes. Most large investments are designed for a certain range of weather conditions, and if the climate deviates too much from normal, then performance declines. Yet with thresholds it is likely that changes in extremes are noticed earlier than changes to mean climate (Fankhauser *et al*., 1999). Issues related to the range of flexibility and robustness of investment decisions (so that they can cope with a wider range of climate), optimal replacement time, investment timing (or postponement) are issues to be considered in a proactive adaptation policy. Another issue to be affected is insurance premiums related to infrastructure, which is relevant considering Spain has the capacity to regulate 40% of the country's total renewable resources (Iglesias *et al*., 2009).

For example, most large water infrastructure investments have a useful life of 100-120 years, therefore an investment made in 2010 should be linked to an optimal design to cover the horizon to at least half its projected use term (50 years) (2060), which is the horizon normally used for amortisation of investments, which can look at the period of 25 years (2035). In theory, both considerations have to be taken into account, also including climate variability and change scenarios (Ayala-Carcedo, 2002). However, the supply approach to water planning is facing higher costs and limited opportunities for increasing supply. This, added to the social resistance to water infrastructure projects in many countries, is starting to limit the options to adapt to climate change through traditional infrastructure investments. As Frederick (1997) states: while new investments in storage (eg, reservoirs) and transport facilities (water transfers) may be appropriate responses to shifts in hydrological regimes, planning and justifying expensive new projects is difficult when the magnitude, timing and even the direction of climate-induced changes are uncertain. Building for changes that never materialise may be costly, and failing to build facilities to deal with changes that do occur is also potentially costly (p. 142). In this conundrum, expenditure on improved water management is the most cost-effective water supply investment. The real investment costs and investment risks of maintaining traditional supply-driven, infrastructure-based policies rise sharply if underlying supply and demand conditions change and also towards greater hydrological variability and extremes. One of the key questions would be the ideal timing for adaptation measures to be efficient, ie, the time at which the negative impacts of climate change are minimised and its positive effects maximised. A key issue is the investment decision to increase the flexibility of systems to cope with a greater range of climatic conditions.

Third, the huge potential offered by non-structural measures; namely legislation and regulation, market-based instruments, capacity building and technology measures. The section below briefly reviews some non-structural measures like legislation, insurance and the integration of climate change into strategic planning (SEA) and policies and programmes.

Non-structural win-win measure 1: introducing adaptable legislation

One of the key no-regrets policy measures to consider in the context of climate variability and change is reducing the rigidity of the legislative framework, for example in the case of water rights, to enable greater flexibility in water allocation. Flexibility in water-rights systems would allow the realisation of the potential of the motto proposed by Llamas (2009), 'more cash and nature per drop', based on the 'extended water footprint', by allowing to move water away from low-value cereals to high-value solar thermal energy, an example of mitigation aligned with adaptation, whilst also freeing up water for wetland recovery like the Tablas de Daimiel National Park. In this context one of the most important priorities is to evaluate the alignment between actual water use and allocation with formal water rights, to identify potential gaps or misalignments. The emphasis is on the development of flexible yet robust water allocation systems that protect social and environmental interests whilst ensuring an efficient use of a scarce resource. Rigid water rights are often also based on historical or, in many cases, even inaccurate water resource estimations. Effective climate change adaptation will inherently mean the prioritisation of uses. This, however, is a political hot potato that is usually translated into the preferred choice to opt to acquire more scientific knowledge, adopt technical measures first, delay difficult socio-political decisions on the priority of use and following through with this prioritization (eg, environmental health of the water system as a pre-condition, and then consumptive uses like public water supply, energy and agriculture).

This is also applicable at the global level, where new concepts like benefit-sharing open up ways to finally unblock the impasse to ratify the International Convention on the Non-Navigational Use of International Watercourses, whilst also reviewing it to include climate change (Task Force on Water and Climate, 2009). This is the framework for resolving water disputes and promoting cooperation on water management between states. The treaty has remained unratified for more than a decade, short of the 35 ratifications needed for it to come into effect. Spain has become the 18th nation to ratify the convention. Spain, one of Europe's largest water users, has an international water agreement, the Albufeira Convention on river management with Portugal signed in 1998. It is also a party to the European Water Framework Directive but, as stated by WWF, like other Mediterranean nations such as Italy and Greece it is experiencing difficulties in implementing the directive.

Non-structural win-win measure 2: adapting market based instruments
Water demand is tied to price and the ability and willingness to pay. Therefore market instruments in different guises (taxes, pricing, markets) would also help lead to a more efficient use of a limited resource (Frederick, 1997). Therefore, markets and prices –within the right policy mix, and dependent on context and on externalities being adequately internalised– are well suited for incentivising changes in supply and demand. In this context, the possibility of water banks enabled by the Water Law reform in Spain in 1999, offer potential opportunities for climate adaptation through the re-allocation of water rights with the administration acting as mediator or as a buyer of rights, eg, for public amenities or to guarantee environmental flows, or to provide a greater resiliency to the water system. These water transfers can be temporary (leases), such as the emergency measure adopted in the Jucar basin, or permanent, such as those foreseen in the Upper Guadiana Plan (CHG 2007a). In this case, the extended water footprint piloted in Spain offers a transparent and easily understandable metric on the productivity of water that can be compared within sectors (eg, different crops) and across sectors (eg, tourism and agriculture). Sometimes the regulatory framework itself impedes or inhibits water moving from low-value uses to higher-value uses, whilst also providing the wrong incentives to conserve water and be water efficient in use, often at the expense of environmental flows.

Non-structural win-win measure 3: building adaptation capacity and actionable science
The Water Framework Directive (WFD) and the periodic revision of the river district management plans can provide 'a powerful adaptive management tool' (EEA 2007, p. 27) in two ways: (1) identifying specific impacts per sector in specific locations; and (2) identifying the users that are most impacted. For example, it can facilitate public debate and discussion on the differential impact on different socio-economic sectors, including the spatial location of differential impacts, eg, the potential hotspots at the local level and/or on vulnerable areas or sectors.

A recent report produced by the US National Research Council asked that climate research should be refocused from the outset to address the needs of society, rather than being driven by unanswered questions in science, giving more attention to the social side of climate change, which has received 'a paltry 3% of the Climate Change Science Programme budget' (a US2 billion annual budget for research on climate change within US government agencies (Schrope, 2009). This would focus not only on how human beings affect the climate but how climate affects human behaviour. The impacts of increased climate variability and change will be felt mainly regionally and locally, and it is important to develop a 'climate-resilient nation' or communities that rely on 'science that is actionable' (Hefferman, 2009) and on science that is accessible to local and regional stakeholders such as farmers in their day-to-day decision making.

However to end this section the main measure to be adopted globally to increase adaptive capacity is to ensure human security. One important lesson is that 'development is the most powerful form of adaptation'. Vulnerability decreases as national income grows since, with growing income, health and education normally improve and the importance of a climate-sensitive sector like agriculture can decrease. The key is 'to steer income growth into a direction that reduces vulnerability to climate change rather than increasing it' (Fanhauser *et al*., 1999 p. 76).

(6) Conclusion

Climate change has more potency now as a mobilising idea than it does as a physical phenomenon. Ideas can be used but they cannot be solved (Hulme, 2009, p. 328). At the global level the issue of climate change runs the risk of becoming 'securitised', ie, moved away from the public arena. In 2007 the UN Security Council held its first discussion of the security risks of climate change and the UN Secretary General warned that climate change might pose as much of a danger as war. A 2007 report by a panel of retired military leaders saw climate change as a 'threat multiplier' in already fragile regions of the world, which could become breeding grounds for extremism and terrorism. In 2009 the CIA announced that it was opening a new centre on climate change to look at its security implications. This is also mirrored in the appointment of a serving officer for climate and security by the UK Ministry of Defence. However, one of the key challenges in the secutirisation of climate change will be to frame it firmly within the concept of human security. So, for example, when the potential risk of glacial melts in the Himalayas and the loss of clean water and the impact on economic uses of water is portrayed as a potential destabilising factor to exacerbate instability in, eg, Pakistan, initiatives are taken to strengthen multilateralism though the enhancement and creation of trans-boundary mechanisms such as intergovernmental water commissions, like the Chui-Talas water commission, operated jointly by Kazakhstan and Kyrgyzstan and supported by the OSCE (Tesoeriere, 2009).

In the context of a slowly receding global financial and economic recession, it will be difficult to reach an effective compromise at COP-15 between 192 nations. Research undertaken by Carraro (2009) demonstrate the difficulty in reaching agreements in global collective action problems like climate change, where the temptation to free ride is high and the incentives for cooperation low, despite the potential long-term costs of inaction. Regime analysis stresses the factors that favour successful compliance, namely low transaction costs associated with participating in the agreement, transparency regarding the extent to which state actors meet their commitments, clear common interests between states in co-operating to address the perceived problem, a high level of scientific understanding about the nature of the problem and appropriate responses. In this context, the path taken by the climate change regime is not surprising. Equally, according to Underdal (yr) compliance is more successful if it follows the 'law of the least ambitious programme'.

It is interesting that the one area were both supporters and detractors of the human causality of climate change coincide is on the priority of adaptation; this is even more persuasive in the case of water resources due to the still 'considerable uncertainties around projections of climate impacts on water resources at local and regional scales'. Water management remains fundamentally a local issue yet, to be effective, policy leadership has be both up-scaled to regimes being negotiated at the local level and down-scaled to the level of planners, decision makers, users and citizens. The emphasis therefore lies in managed risk, climate-proofing systems and water planning, building resilience into the system, as effective adaptation strategies.

Some of the key scientists (Carter et al., 2007) and sceptics on anthropogenic climate change, but not on climate variability and change itself (Jefferson *et al*., 2009; the IPCC group), agree that:

Figure 1.

Agreement on need for adaptation	**Shared agreement on evidence of climate change, agree on need for adaptation**	
Disagreement on need for mitigation	Sceptic on conclusive evidence climate change is mainly anthropogenically caused	Agree on conclusive evidence climate change is mainly anthropogenically caused
Example	'The main certainty is that natural climate change will continue, and that some of its likely manifestations –sea-level rise and coastal change in particular locations, for example– will be expensive to adapt to. But adapt we must and will. Moreover, reducing vulnerability to today's climate-sensitive problems will also help the world cope with future challenges from climate change whether that is due to natural variability, anthropogenic greenhouse gas emissions or other human causes. The most prudent way of ensuring that happens is to build wealth into the world economy and to be receptive to new technologies' (Carter *et al*. 2007)	'These include reducing inertia in social and economic systems; building on a growing public desire for governments to act on climate change; reducing activities that increase greenhouse gas emissions and reduce resilience (eg, subsidies); and enabling the shifts from ineffective governance and weak institutions to innovative leadership in government, the private sector and civil society. Linking climate change with broader sustainable consumption and production concerns, human rights issues and democratic values is crucial for shifting societies towards '(Richardson, *et al*., 2009)

Source: the author.

A recession in some ways is good for the environment, for instance, in terms of emissions; it has also meant that the geopolitical map is being redrawn. The world is gradually shifting back from unilateralism towards bilateralism or, at least, small multilateral agreements that can be more effective, purely because of the smaller number of actors involved. A recent editorial in *Nature* gives a good summary of the need for a climate deal at COP-15. However it also gives a good route map of the most pressing issues: 'ambitious emissions targets for the world's rich, the ability of emerging economies to slow their emissions growth and the transfer of capital from rich to poor nations for adaptation and green technology development' (Hefferman, 2009). Achievements on any or all of these issues would go a long way towards an equitable distribution of costs and benefits.

In this context, at the final meeting in Barcelona in preparation for COP-15 to discuss Non Paper 31 –the draft text for Copenhagen– all references to water according to the Global Public Policy network had been taken out. References to Water in UNFCC Decisions and Resolutions since 2007 have made no reference to water, despite the evidence that climate change and variability will have the common denominator of water. The inclusion in the text is critical to generate political will which can be reflected in the prioritisation of water in the UNFCC Adaptation Fund, and also the prioritisation in turn of the most vulnerable countries in a transparent manner avoiding the so-called donor-darling syndrome. It also implied a more consistent estimation of adaptation costs.

Spain will be taking the chair of the EU Presidency with an economy that is proving more difficult to pull out of recession than its immediate neighbours. As an article in Waddington from IUCN (2008) stated:[36] 'the route to growth was paved –almost literally– with higher greenhouse gas emissions as the construction industry took a leading role in generating the country's wealth and employment'. As is often repeated, crises are opportunities and the recent law on a sustainable economy offers the potential for policy innovation grounded on technological innovation and re-framing of the economic model, eg, with innovation in the water/energy nexus, where Spain is well positioned.

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The first step that Spain can take as a policy innovator in water and climate variability and change is to lead in the alignment of adaptation and mitigation, bolted clearly into a human security framework of human development.

[36] Waddington, R (2008) Climate Change will bring Spain more than just lack of rain 07 July 2008 IUCN

Appendix 1. Sample of Some No-regrets Core Policy Measures for Spain in the COP 15 and Beyond

This section highlights where policy innovation could have highly beneficial pay-offs and move the alignment between adaptation and mitigation closer. For a more detailed analysis of water and climate change please refer to the full paper.

Policy sectors: agriculture, water, climate variability and change
One of the most important issues in relation to water and climate change and variability is the international nature of food trade and food security, and the fact that weather and climate are still key determinant factors in agricultural productivity, more so in developing countries (Parry *et al*., 1999). At a recent meeting held at the FAO in Rome in November 2009 the President of the UN Ban Ki-moon stated that 'there can be no food security without climate security'. The efforts have now turned to the agreement at COP-15 as a foundational agreement, rather than a fully-fledged treaty as disagreements between rich and poor countries over emissions and over financing climate adaptation are still difficult to bridge in 2009. Yet linking energy, land use and agriculture can provide one of the clearest synergies directly linking mitigation and adaptation. In agriculture, mitigation and adaptation often involve the same management strategies and can thus be achieved at the same time, giving synergistic outcomes. This also applies to the potential of payment for environmental services in either productive agriculture or though a land use approach specifically designed for mitigation and adaptation.

Groundwater as a global strategic reserve to climate variability and change
Groundwater is a strategic key global water resource, since it is estimated that at least 40% of the world's food is produced by groundwater irrigation farming, both in low-income as well as high-income countries (Hetzel *et al*., 2009). In the context of climate variability and change, groundwater offers an inbuilt natural resiliency to climate fluctuations (Pernia-Liera & Fornes Azcoiti, 2008). Yet there is an urgent need to strengthen governance mechanisms for groundwater, eg, the key issue of groundwater rights, flexibility and prioritisation of allocation between users.

Technological innovation
Solar thermal energy is still largely un-competitive compared to traditional fossil fuels in many contexts. The example, however, set in the case of wind energy highlights the importance of high risk/high gain, which is particularly the case for technological innovation. Spain already has a first-mover advantage in solar energy both in terms of technology development and increasingly in technological transfer and adoption. The pending issue is now mainstreaming, as part of decarbonising the economy, and for this political will is needed. The recent announcement in the drop in R&D funding, however, is a worrying signal on the commitment to follow through precisely when R&D and associated industries are most vulnerable due to the economic crisis and the drying up of

finance, considering that Spain only invests 1.2% in R&D compared with a 2.3% average in the OECD.

Cross fertilisation as policy innovation

For a successful policy on climate adaptation in relation to water, the focus is not only on climate-specific groups like climate-change teams and environmental agencies but also in opening up debate and discussion at different levels to health service providers, disaster management, land planning agencies etc. There is increased awareness of the cross fertilisation that can take place between the field of DRR (Disaster Risk Reduction) and the (younger) growing field of CC adaptation, and the possibility of the joint development of DRR plans and adaptation (GPPN, 2009; Lázaro-Touza, pers. comm).

Regulatory innovation and commitment

WWF-Spain is hoping that the Spanish Government will use its 2010 EU Presidency to promote ratification of the UN Water Courses Convention. According to the GPPN 60% of international watercourses are not governed by agreements and 80% of agreements are bilateral despite the existence of other interested parties (UNEP, 2006). The new concept of benefit sharing has opened new political and policy venues to reach agreements on managing scarce resources (Phillips *et al.*, 2006) ratification might also facilitate the sharing of hydrological data in accordance with Resolution WMO 25.

Data and information transparency

Advances in technology can greatly contribute to data transparency and to the democratisation of scientific knowledge. Two examples worth mentioning are the SMOS project, to estimate soil moisture estimation from satellites, with a spatial resolution adapted to water management on a finer scale mapping that tracks water use. The recently launched Spanish satellite has been called the 'dowser' satellite, especially designed to measure soil water moisture. Water-use maps can help increase the accuracy and effectiveness of public decisions involving water –for instance, in monitoring compliance with legal water rights–. The maps are especially important in arid and semiarid land, where irrigated agriculture accounts for about 70% of all water consumption. The Landsat-based method can be as much as 80% more accurate than traditional measurement methods. Internationally, Spain, South Africa and Morocco have already begun to employ Landsat-based water-use maps. At a higher level there is an Open Skies Treaty, defined as a Cooperative Airborne Observation Regime (US Dept of State, 2009) whose primary purposes is 'Unarmed aerial observation flights over entire territory of signatory states in order to promote openness, enhances confidence and security, and increased transparency of national intent'. Technology can now help dramatically, eg, with monitoring coastal erosion, erosion of shorelines, threats to levies and canals and ice-shelf fracturing, to inform civil defence, disaster response and economic development, water flows and diversion.

Appendix 2. FAO: Aquastat Summary Fact Sheet for Spain

aquastat
global information system on water and agriculture

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
helping to build a world without hunger

Summary Fact Sheet
Spain

Land and Population	Year	Value	Unit
Area			
Country total area	2007	50 537	1 000 ha
Cultivated area	2007	17 560	1 000 ha
Population			
Total population	2008	44 486	1 000
Population density	2007	87.1	inhab/km²
Rural population	2008	10 187	1 000
Total economically active population in agriculture	2008	1 077	1 000

Renewable Water Resources	Year	Value	Unit
Long-term average annual precipitation			
In depth		636	mm/year
In volume		321.4	km³/year
Renewable water resources			
Total average annual internal (IRWR)		111.2	km³/year
Total average annual actual external (ERWR)		0.3	km³/year
Total average annual actual (ARWR)		111.5	km³/year
Dependency ratio		0.26	%
Total actual per capita	2008	2 506	m³/year
Total dam capacity		-	km³

Water Withdrawal	Year	Value	Unit
By sector			
Agricultural water withdrawal	2000	24.24	km³
Municipal water withdrawal	2000	4.79	km³
Industrial water withdrawal	2000	6.6	km³
Total water withdrawal	2000	35.63	km³
Total water withdrawal per capita	2002	863.6	m³
By source			
Surface water withdrawal		-	km³
Groundwater withdrawal		-	km³
Total freshwater withdrawal	2000	35.53	km³
Desalinated water produced	2000	0.1002	km³
Reused treated wastewater	2000	0	km³
Freshwater withdrawal			
Total freshwater withdrawal as percentage of ARWR	2002	31.86	%
Agricultural freshwater withdrawal as percentage of ARWR	2002	21.74	%

Irrigation and Drainage	Year	Value	Unit
Area equipped for irrigation			
Full control irrigation	2005	3 765	1 000 ha
surface irrigation			1 000 ha
sprinkler irrigation			1 000 ha
localized irrigation (1991)		160	1 000 ha
Equipped lowland areas	2005	0	1 000 ha
Spate irrigation	2005	0	1 000 ha
Total area equipped for irrigation	2005	3 765	1 000 ha
As percentage of cultivated area	2007	21.44	%
Actually irrigated	2005	3 365	1 000 ha
Other agricultural water managed area	2005	0	1 000 ha

Notes: 1 km³ = 10^9 m³ = 1 000 million m³; 1 ha = 1 hectare = 10 000 m²

Generated: 10 Nov 2009 at 16:28 CET

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