Evaluation of Questionnaire Results

Impacts of Climate Change on Water Resources and Adaptation Strategies in Europe

Questionnaire addressed to the EEA National Focal Points,
Pilot River Basins and Water Directors

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Please note: This document was drafted on the basis of all questionnaire responses that were received by the end of October 2006. Evaluation and summary are the sole responsibility of the authors and may not be regarded as official positions or statements of the Member States.

Contents

1 Introduction and Background

Changes in climate and its impacts are already visible globally, and are expected to become more pronounced in the future. While uncertainties remain, there are clear indications that rising temperatures will exacerbate existing water shortages, impair water quality and enhance the frequency and intensity of floods and droughts. Climate protection and CO_2 reduction strategies are necessary to mitigate climate change; however there is a growing awareness that adaptation policies will have to be implemented as well in order to cope with impacts that cannot be prevented.

How will water resources in Europe be affected by global climate change, what will be the impacts on the water sector and on related economic sectors, and what options are available for adaptation? A discussion process has been initiated at the political level to identify not only the climate change impacts but also adaptation strategies that are practicable, cost-efficient and tailor-made to the needs of European regions, and that will be accepted by the public. Since their meeting in Rome (November 2003) the EU Water Directors have regularly addressed the issue resulting in the decision, taken in London in November 2005, to launch an activity on climate change and water. At the same time the Water Directors expressed their support for the German initiative for an international conference on climate and water issues and appropriate adaptation strategies at EU level to be held during the German EU Presidency in February 2007. This initiative is supported by relevant services of the European Commission not least against the background of the Green Paper on adaptation strategies which the Commission will present in early 2007. An ad hoc expert group was established under the lead of Germany in order to support the preparation of this conference.

The questionnaire was designed jointly by Ecologic and the EEA and distributed on behalf of the German Federal Ministry for the Environment and the EEA to the National Focal Points and the Pilot River Basins. By November 2006, 26 responses have been received from the following countries: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Estonia, Finland, France, Germany, Hungary (2), Iceland, Ireland, Lithuania, Luxembourg, Malta, The Netherlands, Norway, Romania, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, UK (England & Wales; Scotland). Their answers form the basis of the evaluation given in this document. The aim of the survey was to collect information on the degree of awareness concerning the issue of climate change impacts on water resources in Europe; to assess the vulnerability to climate change in Europe; and to compile potential adaptation measures and strategies as well as information on implementation experiences.

This document gives a qualitative evaluation of the results, and includes a list of current adaptation initiatives as provided by the recipients of the questionnaire (Annex A). A copy of the original questionnaire is included in (Annex B).

2 Evaluation of Responses

2.1 Part A: Assessment of Future Impacts resulting from Climate Change

2.1.1 Vulnerability

Most respondents classified water resources in their countries as sensitive to climate change impacts (Question 1). As expected, countries with extensive coastal and mountainous zones were more likely to describe them as Very Sensitive. Interestingly, urban areas were deemed less sensitive than others, with only the four island countries UK, Ireland, Cyprus, and Malta describing these as Very Sensitive, and one deeming them Not Sensitive (Switzerland). According to the predictions of most climate models, countries in southern Europe expect to be more vulnerable to the impacts of climate change

on water resources. This is reflected in the overwhelming number of areas judged as Very Sensitive by the southern respondents.

In terms of possible changes in different components of specific water resources (Question 3), the questionnaires returned a fairly consistent set of responses (see Figure 1).[1] All the possible changes stated in the question were deemed Negative by a majority of countries. However, some respondents see potential benefits from changes in precipitation patterns. There were clusters of Positive answers especially for 'increased precipitation' (as well as for 'increased run-off' and 'increased groundwater recharge'). As would be expected, this included many Nordic countries plus a few others whose Hydropower energy generation capacity (and possibly water supply systems) would benefit from these possible changes. The impacts from 'decreased precipitation' are expected to be Negative or Very negative by the large majority of respondents, while a small number of respondents see potential benefits. The impacts from increases in extreme events (flood and drought risk) were exclusively seen as Negative or Very negative. Many countries who described possible changes as Positive also recognised their negative impact.

The responses largely reflect national geographical and hydrological circumstances. For example: 'increased risk of floods' is a great concern in northern European countries that lie on major flood plains and/or experience heavy rainfall; 'increased risk of droughts' in densely populated countries and southern European states with high water stress; and 'sea level rise' in low lying coastal states and islands.

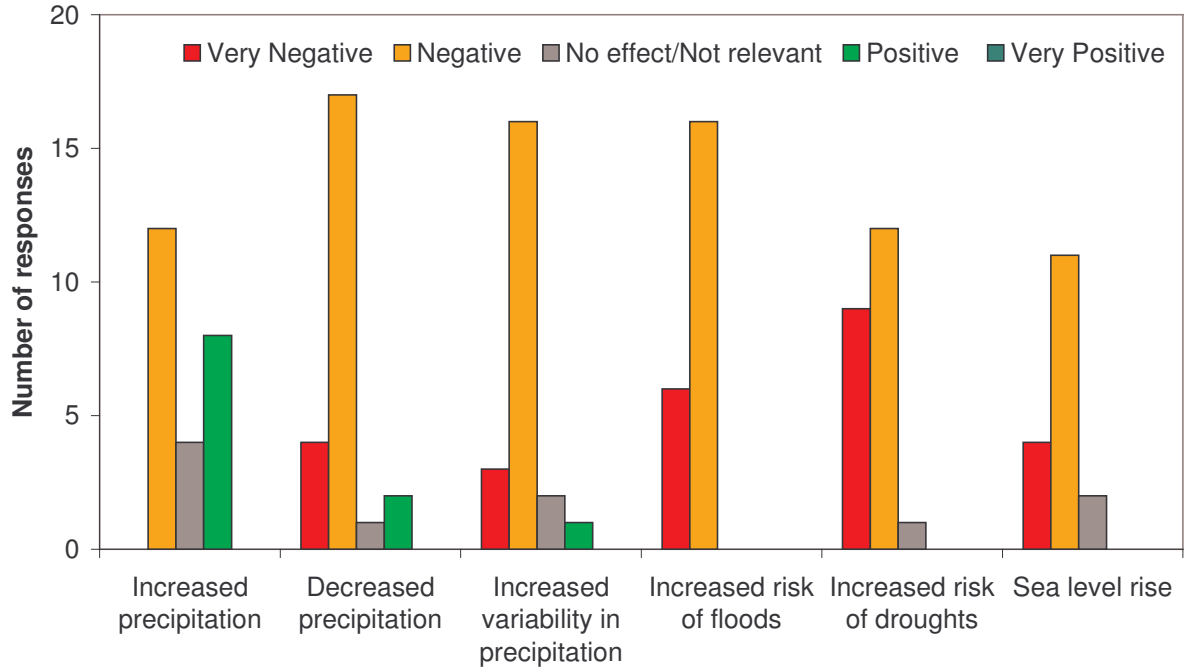


Figure 1 Vulnerability assessment (Question 3).

2.1.2 Specific Impacts

In Question 2, recipients were asked to provide information based on their predictions of changes to specific elements of the water system, namely precipitation, recharge, flooding, drought and sea level

[1] Most countries based their answers to Question 3 on a combination of Expert Knowledge and Research Studies.

rise. Many respondents gave very detailed responses, which differentiated between regions, individual river basins, time scale of impacts, and seasonal impacts. A summary of observations is presented in Table 1.

The information provided in response to Question 2 shows that respondents are highly familiar with scientific evidence (case studies, climate model scenarios, regional studies). Many countries make a distinction between summer and winter conditions, and between the predicted effects of climate change within sub-national regions. Based on the figures provided in the questionnaires, countries in Europe are expecting significant changes to occur in the water systems that influence their hydrology and water use.

Table 1 Quantification of impacts (Question 2)

Water variable	Expected changes
Increase in precipitation	The highest increases were predicted by north-western and Scandinavian countries (up to 30%), with more modest predictions from Alpine countries (generally 10-20%) and yet lower estimates from southern states (5-10%). The majority stated that these increases were based on winter precipitation, and a number specified that western or north-western regions would receive the most of this increased precipitation.
Decrease in precipitation	There was a greater variety of predictions as to the rate of decreased precipitation. Most often predictions fall within the range of 15-25%. Most results pertain to summer conditions, with an emphasis on southern and eastern regions. Northern as well as southern countries expect to experience significant decreases in precipitation.
Increase in runoff	The mode estimate was 10-25%; responses were usually based on winter conditions.
Decrease in runoff	Many countries gave very similar figures for decreased as for increased run-off, referring to winter and summer conditions respectively, and often highlighting a north-western/ south-eastern regional variability. Some countries expect large changes (up to 50% decrease).
Increase in groundwater recharge	Most predictions fall between 5 and 15%, again pertaining mostly to winter conditions. Southern states do not expect noteworthy increases, but most northern and western countries do.
Decrease of groundwater recharge	Recipients expect greater changes in reduced groundwater recharge in summer than from increased recharge in winter, according to the questionnaire. Although the accuracy of responses appears to vary, values ranging from 5 to 50% (and even 65%) were given.
Increase in flood frequency	All those who supplied information here expect significant increases in flood frequency, with most responses being between 5 and 20% (some higher), though a few countries noted the difficulty of giving a predicted rate of increase, simply noting that increases were expected.
Decrease in flood frequency	Very few countries attempted to provide values for decreased flood frequency, but a number of mountainous countries made the connection between decreased snowmelt and floods (spring and summer).
Increase in drought frequency	Most countries signalled their prediction that droughts will increase in frequency; the mode response was 20%, but some countries expect very strong increases (up to 100%). Some indicated a regional variation within their country, with southern and south-eastern regions expected to suffer the worst. Some countries preferred to express their predictions in terms of the increased frequency of 1 in 100 year floods (down to 1 in 60, or even 1 in 20 –The Netherlands), or in the number of heatwave days (up by 20 –

Water variable	Expected changes
	France).
Decrease in drought frequency	The only countries that predict a decrease in drought frequency are in Scandinavia, who specify the north-western peripheries as the likely areas to be affected.
Sea level rise	All countries with coastline expect sea-level rise, at least along some parts of their shoreline; predictions range from 0-100cm in the century, with a rate range of 2-30 mm a year (France).
Sea level decline	Two Scandinavian countries (Sweden and Finland) expect land upheaval to bring net decline in sea-level (0-60 cm) along portions of their coast.

2.1.3 Impacts by Sector

When specific changes in the water system are looked at in relation to certain sectors (Question 4) a more nuanced understanding of the responses is possible. For example, the same predicted change can bring about a range of negative *and* positive impacts: 'increased precipitation' may assist the water supply and waste-water management sectors (+2 Germany), whilst making flood management more difficult (-2 Slovakia), potentially helping agriculture (+1 Austria), significantly boosting the energy industry (+2 Norway), detracting from tourism (-2 Sweden), helping navigation (+1 Germany) but harming other transport and construction industries (-2 Norway) whilst positively affecting the Fishery (+2) and Forestry (+1 Lithuania) sectors. The following breakdown gives a basic impression of the respondents' predictions of specific climate change impacts on different economic sectors.

It has to be noted that for simplification, Question 4 subsumed several of the water indicators used in the previous questions under one category. For instance, the first category ("more water") comprises potential increases in precipitation, but also increased frequency and intensity of floods. Responses may thus vary depending on which of these effects are seen as more relevant in a certain Member State's context.

In summary, respondents seem to expect significant impacts from climate-driven changes in water resources on water management and water-related sectors, with the exception maybe of the tourism sector. There was also a broad appreciation, throughout northern, central and southern countries, of the sectoral impacts of drought conditions, namely decreased precipitation and impaired water quality.

Water Supply

On average, responses indicated that increased precipitation might bring a slightly positive effect on water supply. Otherwise, the list of possible changes was expected to bring negative impacts.

The strongly negative impact of decreased precipitation on water supply was noted by recipients. In fact, southern European countries expected strong negative effects for the vast majority of water management indicators as a result of decreased precipitation (except for flood management).

Waste Water Management

Several countries perceive waste water management to be highly sensitive to changes in the water regime, and expect each variable to bring about negative effects: increased precipitation, decreased precipitation, sea level rise, and increased variability and impaired water quality. Some respondents even expect these impacts to be strongly negative. These views reflect the delicate balance needed to maintain waste water facilities between sufficient and maximum flows.

Flood Management

Especially strong negative impacts on flood management were associated with increased precipitation, increased variability and sea level rise. Correspondingly, decreased precipitation was thought by many countries to have a positive or strong positive impact on flood management. One country noted that increased precipitation does not necessarily lead to negative flooding impacts in cold-temperate regions.

Agriculture

Overall, countries expect agriculture to be negatively impacted by predicted changes in water resources. The greatest area of concern seems to be decreases in precipitation, with many countries expecting a strong negative impact. Some respondents see potential benefits from increased precipitation. Increased variability and decreased quality are considered negative by most, but not to the same extent as the changes mentioned above.

Energy/industry

The potential positive impact of increased precipitation is recognised by many countries, in particular those that depend to a large extent on hydroelectricity. Decreased precipitation is expected to have a negative and often strong negative impact on the energy sector. This is perhaps also due to the effect of reduced precipitation on other energy sources (e.g. cooling water for thermal power stations). The countries that are potentially affected by rising sea levels expect negative to strong negative impacts on the energy sector.

Tourism

On average, responses signal a relatively low level of concern with respect to the potential of water-related climate change effects to affect the tourism sector. However, individual countries did indicate that they expect negative impacts, in particular from impaired water quality and sea level rise. Decreased precipitation is seen as beneficial by some respondents and damaging by other, mainly Southern, countries. One respondent explained that the attractiveness of changed weather conditions (e.g. less precipitation) to tourists may have a different effect to the ability of the host country to meet the water requirements of those tourists. Unsurprisingly, mostly island countries (Cyprus, Malta, Ireland) make the link between sea level rise and disrupted beach tourism.

Navigation

For inland waterway transport, a relatively small number of countries are concerned about the impacts of changes in water resources, which may be due to the fact that navigation on inland waterways plays an essential role only in some European countries. Those countries that do expect impacts describe them almost exclusively as negative. The greatest concern is a decrease in precipitation and lower river flows. To a lesser extent, the potential negative consequences from an increased variability in precipitation and river flow conditions, from increased precipitation, and from sea level rise are also recognised.

2.1.4 "Non-Economic Impacts"

Question 5 asked recipients to consider the impacts that changes in water resources would have in areas such as biodiversity and human health.

A range of responses was given, indicating a broad awareness of changes in water systems as a result of climate change, and of their wider implications for adaptation strategies. The links between changed water conditions and water dependent ecosystems are appreciated by a number of countries. Also, several respondents see links between climate-driven changes in water resources and human health (see Table 2).

Table 2 Impacts on biodiversity and human health

Area	Driver	Expected impacts
Biodiversity (Habitats)		
Water bodies (general)		**Romania**: Biodiversity loss, altered species composition, eutrophication and contamination, habitat loss, alterations in sediment and salinisation **Slovenia**: endangered water ecosystems and endemic species in Karst, decline of biodiversity

Area	Driver	Expected impacts
		Malta: loss of habitats and species and alteration of species composition in wetlands, riparian woodlands and watercourses
	Adaptation measures – construction of flood defences, drainage systems etc.	**Sweden**: society's attempts to adapt water systems to new conditions threatens to disrupt natural hydrological systems (such as natural flood plains, wetlands etc), which might impact a range of habitats.
Estuarine/ marine	**Freshwater discharge** –caused by increased precipitation and run-off	**The Netherlands**: lost shellfish stocks **Belgium**: decreased water residence time alters nutrient fluxes.
Wetlands	**Reduced groundwater** –caused by decreased precipitation	**The Netherlands**: loss of dune stacks, pools and small rivers **Lithuania**: loss of biodiversity **Belgium**: increased biomass productivity and summer drought
	Increased temperatures	**Finland**: loss of wetlands through changing conditions
Salt-dependent Ecosystems	**Sea level rise**	**UK**: rare saltmarsh habitats disappear **Malta**: adverse impacts on littoral species and communities
	Changes in hydrological cycle	**Austria**: low resilience ecosystems in Pannonian areas threatened.
Peatlands & Montane Heaths	**Increased temperatures** (summer drying)	**Ireland**: already vulnerable habitat further squeezed by drier conditions.
Streams & Lakes	**Increased temperatures** **Reduced run-off**	**Austria**: streams and lakes fed by glacial melt water disappear along with glaciers. **Spain**: rivers become seasonal (and seasonal rivers become irregular) affecting dependent biodiversity.
Forests	**Fire Damage** - caused by increased temperatures **Drought** –caused by higher temperatures and reduced precipitation	**Lithuania**: drier forests more susceptible to fire causing loss of biodiversity and habitat destruction. **Switzerland**: forests impacted by extreme events **UK**: beech woodlands not suited to summer drought conditions **Malta**: woodland, maquis and garigue more susceptible to fire and less productive under drought conditions **Luxembourg**: certain tree species would be subject to water and temperature stress and thus more prone to be affected by diseases.
Alien species	**Changing temperatures, seasonal shift**	**UK**: introduction of new diseases, pests and species that thrive in new climate threaten native species.
Human Health		
Water quality	**Increased temperatures, increased run-off, decreased recharge, increased evapo-**	**The Netherlands, Austria and Spain**: human health is dependent on clean water. **Luxembourg**: higher temperatures in summer more likely to affect public health, especially in urban areas.

Area	Driver	Expected impacts
	transpiration (concentrating pollutants)	
	Increased precipitation and storm run-off	**Belgium**: higher volumes of water pass through storm overflow without being treated by waste water works.
	Increased flood hazards	**UK**: overflow of sewage during extreme floods, potential for spread of water borne disease.
		Sweden: flood run-off leaches soil of nutrients and transports pollutants, potentially affecting water quality and therefore human health.
	Sea level rise	**Malta:** Change in amenity value due to changes in landscape and potential loss of recreational spaces (e.g. beaches, coastal areas)
Disease	**Northward migration of Ticks** –caused by increased (water) temperatures	**Slovakia and Finland**: diseases transmitted by ticks will be introduced into new areas with changing conditions.

2.1.5 Impacts of Climate Change on Society

Question 6 asked recipients to describe the impacts of climate change-driven changes in water resources on society. The responses provide an overview of the economic and social consequences European countries expect from physical changes in climate. The main responses are presented in Table 3, grouped by the climate impacts from which they result.

Table 3 Socio-economic impacts

Climate Impact	Social/ Economic Impact
Extreme Events: Floods	**Economic loss** (Austria, France, The Netherlands, Spain, Sweden, UK, Estonia, Hungary, Malta, Slovenia, Romania) **Infrastructure and property** (Austria, Belgium, Finland, Ireland, Lithuania, The Netherlands, Norway, Slovakia, Sweden, UK, Estonia, Malta) **Loss of life** (Belgium, Romania), **Adverse effects on human health** (Hungary)
Extreme Events: Drought / Heatwaves	**Economic loss** (Austria, UK, Ireland, Hungary, Slovenia) **Impacts on agriculture** (France, Switzerland, Norway, UK, Ireland, Malta)
Dry conditions	**Limited water supply, competition between users** (Belgium, Cyprus, Finland, Ireland, Norway, Spain, Sweden, UK, Malta, Slovenia) **Lost hydropower (and nuclear) output** (Spain, Switzerland) **Heightened water conflict, water use restrictions** (Slovakia, Spain, Switzerland, Ireland, Luxembourg, Hungary)
High flows	**Hydropower Benefit** (Finland, Norway, Sweden) **Dam Safety Risk** (Norway)
Increased Temperatures	**Disease** (Spain) **Lost Winter Tourism** (Switzerland)

As can be seen from Table 3, there is a high level of awareness among respondents with regard to the effects of extreme events, in particular the impacts of flooding. Many countries recognise the substantial economic losses and the damage to property and infrastructure that may be associated

with such events. This may reflect both observable trends over recent years and the amount of information collected by European states through research and as part of EU legislative commitments. However, the challenges resulting for societies from increased water scarcity and drought, and the potential need to deal with enhanced competition and conflict over water use, is also recognised by many respondents.

For some countries, the socio-economic impacts related to the production of electricity seem to be an issue. While Scandinavian countries expect benefits for hydropower potential in their region, negative impacts are predicted for electricity production in hydropower and nuclear power plants by Spain and Switzerland.

In summary, while a number of different impacts for society are mentioned by respondents, most countries' focus seems to be held by the relatively tangible social and economic impacts of flooding and extreme events, as opposed to longer term, progressive impacts brought about by climate change.

2.2 Part B: Adaptation

2.2.1 Adaptation Measures

The response of countries to the list of potential adaptation measures in Question 7 showed a wide variety of activity. Some countries that may be considered to lie outside the most critically affected regions within Europe showed only slight activity in adaptation measures and indicated that most suggestions were 'not relevant or necessary'. The majority of responses, however, suggest that a number of adaptation strategies are either underway and/or planned for the future.

For each adaptation measures that was suggested by Question 7, Figure 2 shows how many respondents indicated that these measures have already been *implemented* (dark blue), are *planned* (light blue), are considered *useful but have not yet been planned or implemented* (green), or are considered *not relevant or not necessary*. The first graph (Figure 2 a) summarises responses for measures related to flood protection, the second graph (Figure 2 b) refers to measures related to water scarcity and drought management, and the third graph (Figure 2 c) summarises all measures related to awareness and information, monitoring and insurance.

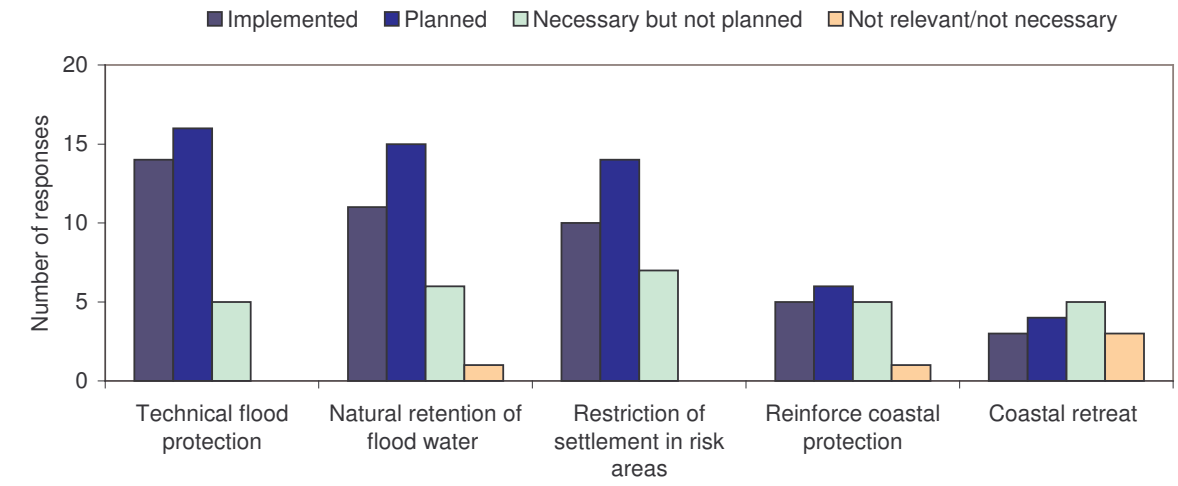
As can be seen from Figure 2, protection against floods generally receives a higher level of attention than protection against water scarcity and droughts. Among the measures that are considered useful, but where implementation is not yet far advanced, are "economic instruments (e.g. water pricing)", "landscape planning measures to improve water balance", and improvement of insurance schemes both against flood and against drought damage.

A significant number of respondents have either implemented or are planning measures to improve weather forecasting, monitoring and information, and it is also interesting to note that the vast majority of respondents have implemented and are planning 'awareness raising or information campaigns'.

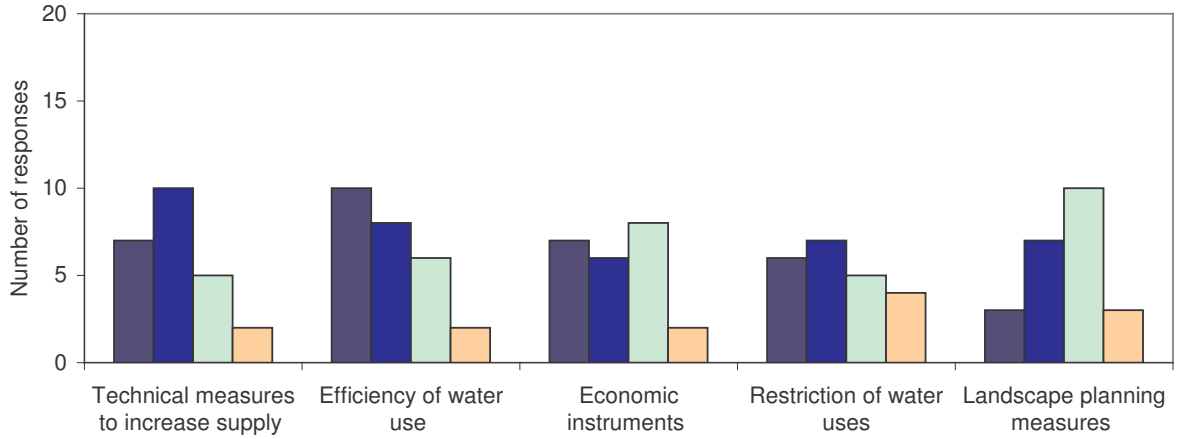
Not surprisingly, responses also reflect differences in geographical and hydrological conditions. A low level of activity is generally indicated by countries that do not expect to be strongly affected by certain water resource changes (e.g. no drought protection measures in Sweden).

A number of countries clearly indicated that many of the measures mentioned in the questionnaire were being implemented or under discussion, but that this was taking place outside the context of climate change.

a) Measures related to flood risk management



b) Measures related to management of water scarcity and drought



c) Measures related to information, monitoring, insurance

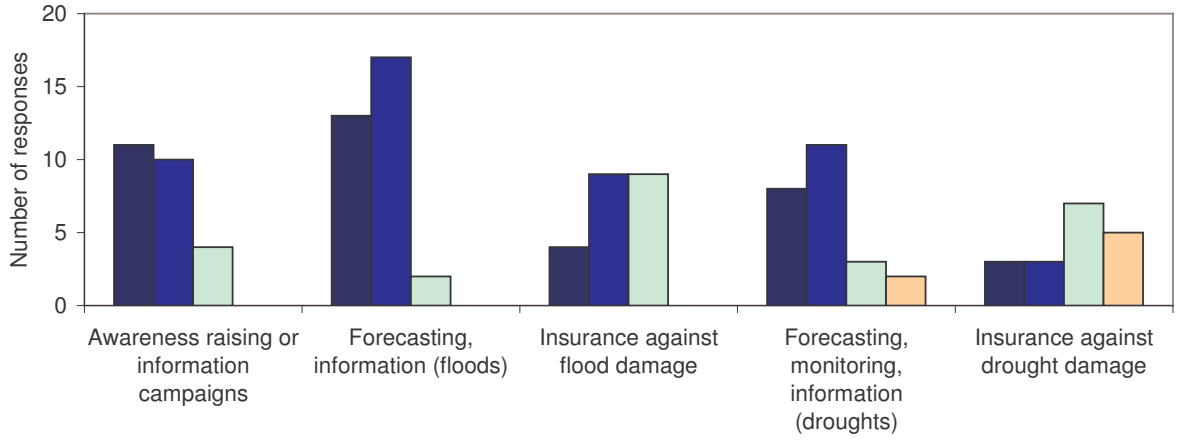


Figure 2 **Adaptation measures: status of implementation in the Member States**

2.2.2 The Water Framework Directive and Adaptation

The Questionnaire asked respondents to suggest ways in which elements of the Water Framework Directive (WFD) could be used to address climate change impacts (Question 8). The general impression given by the responses[2] is that the implementation of the WFD overlaps with many of the aims of adaptation measures, such as maintaining quality and quantity of water resources. The greater control and quality of information offered by the WFD policy system will aid water managers in their efforts to adapt to changing conditions.

However, whilst the suggestions made in response to Question 8 were all positive suggestions, elsewhere in the questionnaire (see Part C), it was indicated that some of the requirements of EU policy, such as meeting 'good status' in all waters, might also hinder adaptation efforts. This was especially the case when contemplating the upgrading of certain water courses as part of flood defences, and the impact this upgrading work might have on the ecological condition of water systems.

Additionally, one country (Norway) replied that the Floods Directive was a more relevant EU policy in terms of climate change adaptation than the WFD, again revealing the focus of many respondents on physical impacts and adaptation, especially flooding.

The responses received can be summarised under the following categories:

1. *Programmes of Measures: examples of and ways in which PoMs will help increase the adaptive capacity of water systems in respondents' countries.*

Suggestions include that each RBD should conduct a climate change impact assessment and then formulate PoMs to implement adaptation measures; using formal cost-benefit analysis. The potential role of PoMs in reducing the secondary impacts of climate change was highlighted. Some respondents called for PoMs to pay more attention to trends related to water availability, and to introduce measures for mitigating water scarcity, including control of groundwater abstraction. Another respondent argued that the WFD did not pay sufficient attention to extreme events, and called for additional management plans for flood and drought management.

2. *Water Management: ways in which water management principles and models associated with the WFD will enable countries to better adapt to changes in water systems.*

Some respondents pointed out how the implementation of the WFD might have the synergetic effect of improving adaptive capacity. Catchment-wide solutions as required by the WFD are considered more suitable to adaptation management than previously existing management systems. The cyclical review process of RBMPs provides means that procedures are amended regularly using the latest available evidence and information, which makes the management system more flexible and therefore adaptive. Furthermore, respondents emphasised that WFD assessment of flood risk is relevant to adaptation planning, as are cross-border management and early warning systems.

3. *Monitoring: the role of monitoring practices and information in helping the adaptation process.*

According to the responses, monitoring and risk assessment as foreseen under the WFD will provide valuable information for regional planning and development and thus create an adequate knowledge base which is a key prerequisite for adaptation. The collection of information under the WFD would provide information on water systems that are at, or near to, capacity, and it would help define which impacts are the result of climate change. One respondent pointed out that flood risk mapping would support policy makers in flood management.[3]

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[2] Not all respondents offered answers to this question.

[3] Note that the forthcoming EU Floods Directive was not mentioned by the questionnaire.

2.3 Part C: Adaptation Initiatives

In Part C of the Questionnaire, countries were invited to give examples of adaptation actions or initiatives currently underway (Question 9 to 12). The responses varied widely with respect to the types of initiatives mentioned and the level of detail provided. An overview of adaptation initiatives that were indicated by the respondents is presented in Annex A.

The responses may be summarised under the following categories:

- **Long Term Planning/ Policy/ Research**. Many countries' adaptation strategies currently exist in the shape of research programmes or policy investigations. These include policy guidelines, planning strategies and consultation processes. They are often responses to the large uncertainties in climate change adaptation, but reflect the country's intention to prepare for managing adaptation efforts (countries include Germany, The Netherlands, UK, Slovakia, Sweden, Spain). National or regional Action Plans or Strategies for adaptation were mentioned by the UK, Spain and Romania.
- **Flood Defence and Management**. Largely in response to observable trends, as well as projected climate scenarios, many countries have invested in projects to enhance their capacity to deal with flood events (countries include Austria, The Netherlands, Belgium, UK, Slovenia, Hungary). The scope of these initiatives differs largely and may include research, technical measures, or land use management.
- **Coastal Defence**: countries with vulnerable coastlines are adapting defence systems and management structures to better prepare and deal with storm surges and sea level rise (Germany, The Netherlands).
- **Water scarcity management**: Relatively few initiatives related to water scarcity management are mentioned. Most prominently, demand and supply management such as improving irrigation systems and water metering or leakage reduction and desalinisation are referred to by Malta and Cyprus.

Some of these initiatives are small and relatively low budget projects, while others are massive undertakings involving the co-ordination and support of several agencies, departments and stakeholders. Most initiatives are triggered by the results of climate models, although this does not appear to be sufficient grounds for undertaking large scale projects: observable trends and events, as well as coinciding objectives, are prerequisites for implementing such initiatives. Funding for such schemes comes from a variety of local, regional, national and EU sources, as well as from stakeholders. Before most large-scale initiatives receive funding, thorough cost-benefit analyses are conducted, which is a reason why many of the potential adaptation projects with uncertain or hard-to-calculate benefits may not have been undertaken on the basis of currently available information. Indeed, uncertainties are a major obstacle to these projects, according to the responses, as are a lack of resources and political disagreements in those large-scale initiatives that involve several stakeholders. One country (Norway) points out that whilst design parameters are constantly evaluated and adjusted in response to any (climatic) changes, the uncertainties remain too high for specific adaptation measures to progress from the discussion phase at this time.

2.4 Part D: EU level action

2.4.1 Adaptation at EU level

Question 13 asked which adaptation activities should be co-ordinated or decided at the EU level. The responses reflect very different concerns among Member States.

Recommendations included the following:

- **Framework for adaptation**. Several respondents suggested that a more consistent framework for adaptation should be created at EU level, and that adaptation should be mainstreamed under the

existing instruments dealing with water policy (e.g. WFD, Floods Directive, Groundwater Directive). It was suggested that such an adaptation framework could include an obligation for Member States to conduct national impact assessments, and a common reporting mechanism to communicate the results. One Member State also suggested that the EU could request Member States to draw up national adaptation strategies.

- **Monitoring and information exchange.** Several EU level activities were suggested that would improve information exchange and mutual learning, for instance the dissemination of 'success stories', the distribution of monitoring information, the development of a European observational climate network, and the creation of a database containing examples of adaptation activities carried out in EU.
- **Co-ordination between sectors and sectoral policies**. Some respondents saw a role for the EU in mainstreaming adaptation efforts in water-related sectors such as agriculture and the energy sector. It was suggested that the Common Agricultural Policy be adjusted to take account of climate change impacts and adaptation needs.
- **Strengthening international co-operation on climate change adaptation** was mentioned by one respondent as a possible area of activity for the EU.
- **Subsidiarity**. Several countries emphasised that the implementation of adaptation measures has to remain within the responsibility of the Member States in order to ensure that they can flexibly respond to the specific challenges in their countries.
- **Awareness raising and education**. Education and public awareness were often seen as overarching activities that might be co-ordinated at EU level.

2.4.2 Research needs

Respondents were also asked to make their suggestions for further research, especially at the European level (Question 14). The general role of European research in assisting national adaptation efforts was recognised. Respondents identified research needs in the following areas:

- **Climate modelling**: a very popular request was for enhanced regional climate change scenarios, or the scaling-down from global to regional and from regional to local climate scenario information. It was also suggested to address uncertainties in climate change scenarios and the seasonality of future changes in climate.
- **Modelling of changes in water resources**. Requests were also made for regional and local data to be merged with hydrological models, and to improve the accuracy of hydrological and hydraulic models. The need to improve the coupling of climate and hydrological models was also highlighted.
- **Observation**. With respect to the observation of climate change trends, respondents pointed to the necessity to maintain observation networks, and suggested to include remote sensing techniques in hydrological monitoring.
- **Impacts and vulnerability**. The need for research on the vulnerability of European societies to climate change impacts was felt by many of the Member States. Respondents were concerned about several specific issues, for instance water-related climate change impacts on individual sectors (for instance impacts of heavy rainfall and drought on the sewage system), the quantification of impacts, the socio-economic consequences of climate change impacts (for instance of sea level rise), the relationship between climate change impacts and land use (e.g. impacts on peatlands, sensitivity and responses of habitats and species), and research into the long term use of recycled water in agriculture, and desertification.
- **Adaptation**: Several respondents saw a need for research in order to develop adaptation measures and assess their effectiveness and efficiency. For instance, research should help to design tools that demonstrate the economic benefit and cost-effectiveness of adaptation at the river basin scale, and to develop indicators for successful adaptation measures.

3 Summary and key findings

Despite some inconsistencies in the detail and quality of the information provided, the set of replies allows to draw some clear conclusions about the level of awareness and adaptation initiatives underway in Europe.

Responses reveal that awareness of climate change impacts is generally high, that European countries expect significant changes in water resources and hydrology as a consequence of climate change, and that recipients are well informed about the results of up-to-date scientific research.

However, given the high degree of awareness, the implementation of adaptation activities seems to be lagging behind, at least in certain areas. A number of adaptation measures and initiatives are mentioned by respondents, but many of them are still at the planning stage. Furthermore, adaptation activities currently seem to be focused on flood management and defence, while adaptation measures related to the management of water scarcity and drought, although recognised in the vulnerability assessment as equally damaging, do not yet seem to be widespread.

It is interesting to look at the factors that according to questionnaire responses have triggered adaptation activities. Not all of the adaptation activity recorded by the questionnaire was claimed by the recipients to be motivated mainly, or even primarily, by climate change considerations. Often adaptation to climate change is incorporated into existing planning instruments by way of update or revision. Generally adaptation seems to be facilitated if it coincides with other objectives, and if win-win solutions can be implemented that also benefit other purposes. It also becomes clear from the questionnaires that countries are more likely to take concrete steps towards adaptation measures when they are sure of the costs and benefits involved.

Questionnaire responses suggest that European countries would welcome support of their adaptation efforts at European level. The Water Framework Directive is seen as a vehicle for adaptation strategies by many respondents, but a need is also expressed to create a consistent framework for adaptation involving all existing instruments in European water policy and related policies. While many respondents highlight the subsidiarity principle and the need of Member States to react flexibly to the specific challenges in their countries, many see a role for the EU in the co-ordination of sectoral policies, in supporting monitoring and information exchange, and in awareness raising and education. A need for research in several areas related to climate change impacts and adaptation is also identified by respondents.

Annex A: Examples of Adaptation Initiatives

Country	Adaptation Initiative	Notes	Triggers and Drivers
AT	FloodRisk –integrated flood management StartClim (flexible focus - heat waves and droughts, health, tourism)	Adaptation is main objective	Felt impacts, recent incidences
BE	Veilige Kunst (Flanders): coastal management	Adaptation is additional motivation	Weather events, risk assessment, CBA, land use pressure
	Sigma Flood Protection Plan: Regional initiative, focus flood protection and control	Adaptation is additional motivation	Weather events, risk assessment, CBA
BG	Initiatives are mentioned but not specified		
CH	Flood risk management measure	Long-running programme, initially adaptation as side-effect, growing importance	Weather events
CY	New and improved irrigation systems and desalinisation units	Adaptation is main objectivew	Felt impacts, e.g. decrease of agricultural production due to water scarcity
DE	Improvement in landscape water balance guideline (Brandenburg)	Adaptation is main objective	Policy and authorities, research results
	Adaptation to climate trends and extreme weather conditions and sustainable groundwater management strategy (Hesse)	Adaptation is main objective	Risk assessment
	Master Plan Integrated Coastal Defence Management (update)	Sea Level Rise scenario important, master plan has long existed	Observations and research
	KLIWA and ESPACE projects (Bavaria)	Mainly research/capacity building Adaptation is main objective	Weather events, research results
ES	National Adaptation Plan	Water resources is priority as key driver for many other systems and sectors; Adaptation is main objective	Evidence, social awareness, political support
FI	Improve Dam Safety and re-Design of Major Dam Discharges	Adaptation is main objective	Recent events
FR	Flood risk management measures Sustainable water management strategy	Mitigation and adaptation are main objectives Research/capacity building	Weather events, risk assessment, land use pressure
HU	VAHAVA project (co-ordination, publication/dissemination, expert debates on climate change issues)	Not specified	Not specified

Country	Adaptation Initiative	Notes	Triggers and Drivers
	The New Vásárhelyi Plan (emergency reservoirs along Upstream- and Middle Tisza sections to enhance flood safety. Focus on flood control, conservation and env. Protection, ecotourism, agro-ecological farming, rural development)		
IE	Inter-basin water transfer	Planning stage Main objectives: growing population, decreasing resources, but climate change impacts are taken into account	Risk assessment, CBA, research results
LT	National initiative, demand management and water quality		
MT	Water conservation and water saving measures (e.g. reducing leakage from distribution network; water metering in households and establishments	Adaptation is main objective	Weather events, heightened awareness resulting from research on climate change
NL	Space for the river –long term spatial reservation Agreement between authorities on incorporating climate change into planning for 2015 Increase capacity (pumping, discharge capacity of sluices) Strengthening coastal defence to incorporate seal level rise and extension of beach nourishment programme.	In some cases adaptation is main driver, it is always one of several objectives	Wave and climate research; reassessment of risks
RO	Adaptation under different water legislation; National Action Plan on Climate Change (2005) highlights the need for an Action Plan on Adaptation by 2007	Measures to be implemented to enhance resilience and reduce vulnerability; adaptation is main objective	Risk assessment
SE	Ongoing survey on vulnerability of society Permit system for water users	Research/survey Adaptation is side effect	
SK	Planning strategies	Adaptation is side effect	Weather events, research results, risk assessment, CBA
SL	Strategies for flood and drought mitigation under National Environmental Programme (determination of risk areas; regulation of land use)	Adaptation is not the main objective	Weather events, policy/legislation
UK	Incorporating climate change in long term planning Climate change allowances and flood risk management Changing Our Ways – impacts and adaptation strategy (Scotland)	Adaptation is main objective	Scenarios and felt impacts

Please note that the space given for responses is indicative only and can be adapted as necessary.

Annex B: Questionnaire

PART A: Assessment of future impacts

Q.1 How sensitive are water resources in your country to climate change? Please give a judgement for different areas as relevant in your country and indicate (x) as appropriate.

	Very sensitive	Sensitive	Slightly sensitive	Not sensitive
Coastal zones				
Mountainous areas				
Urban areas				
Lowland areas				
Other areas, please specify				

This answer is based on ☐ Expert knowledge ☐ A research study (please make reference) ☐ Others

Q.2 Which changes in water resources do you think will take place in your country as a consequence of climate change within the next century? Please give an ad-hoc estimate on the basis of your current knowledge. If necessary, please use the last column to indicate in which regions or river basins or during what seasons these changes will be most pronounced.

	Change	Specific regions/ river basins/ seasons
Increase in precipitation (rain and snow) of	__%	
Decrease in precipitation (rain and snow) of	__%	
Increase in runoff of	__%	
Decrease in runoff of	__%	
Increase in groundwater recharge of	__%	
Decrease of groundwater recharge of	__%	
Increase in flood frequency of	__%	
Decrease in flood frequency	__%	
Increase in drought frequency of	__%	
Decrease in drought frequency of	__%	
Sea level rise of	__cm	
Sea level decline of	__cm	

Thank you for your co-operation!

Please note that the space given for responses is indicative only and can be adapted as necessary.

Others, please specify:		

Q.3 In the following table, please give an assessment of the effects that possible changes in different components of water resources caused by climate change will have on your country. Please indicate (x) as appropriate. In case the anticipated impacts will vary regionally, please indicate specific regions or river basins in the space provided on the right-hand side.

	Very negative	Negative	No effect or not relevant	Positive	Very positive	Regions or river basins particularly affected
Increased precipitation						
Decreased precipitation						
Increased variability in precipitation						
Decreased runoff						
Increased runoff						
Increased variability in runoff						
Decreased groundwater recharge						
Increased groundwater recharge						
Declining surface water quality						
Declining groundwater quality						
Increased risk of floods						
Increased risk of droughts						
Sea level rise						
Others, please specify						

This answer is based on ☐ Expert knowledge ☐ A research study (please make reference) ☐ Others

Q.4 Please provide an estimate of the impact the changes in climate and water components would have on different **sectors** in your country. Please fill in numbers from –2 to +2 where appropriate (-2 = strong negative effect; -1 = negative effect, 0 = no effect or no relevance; +1 = positive effect, +2 = strong positive effect). Please leave spaces blank where information is not available.

Thank you for your co-operation!

Please note that the space given for responses is indicative only and can be adapted as necessary.

	Water supply[4]	Waste-water manage-ment[5]	Flood manage-ment	Agri-culture[6]	Energy/ industry[7]	Tourism[8]	Navi-gation	Other trans-port[9]	Cons-truction/ spatial plan-ning[10]	Fishery[11]	Forestry[12]
Increased precipitation, higher runoff, increased frequency and intensity of floods											
Decreased precipitation, lower river flows, decreased groundwater recharge, higher risk of droughts											
Increased variability in precipitation and river flow											
Impaired surface and groundwater **quality**											
Sea level rise											
Others, please specify											

Q.5 What impacts might changes in water resources have on other (non-economic) sectors (e.g. biodiversity/conservation, human health) in your country?

[4] E.g. reduced water availability/water shortages for consumers.
[5] E.g. pressure on drainage and sewerage systems, flooding of wastewater treatment sites.
[6] E.g. production losses, increased irrigation need.
[7] E.g. decrease of hydropower potential, shortage of water for cooling, flood damage to infrastructure.
[8] E.g. decline in tourist numbers due to increased precipitation, heat waves or water shortages.
[9] E.g. infrastructure damage.
[10] E.g. damage to real estate and infrastructure, loss of land.
[11] E.g. decline in fish population or reduction in species diversity.
[12] E.g. damage or loss due to drought, increased fire risk or water logging.

Thank you for your co-operation!

Please note that the space given for responses is indicative only and can be adapted as necessary.

Q.6 Please briefly describe the potential impacts of climate change-driven changes in water resources on society (e.g. economic loss, decreasing economic viability of an activity, conflicts between water users, damage to property/infrastructure, health damage and loss of lives etc.)

Part B: Adaptation measures

Q.7 The following table lists a number of potential adaptation measures. Please indicate (x) which of these are planned or have been implemented in your member state as a response to climate change concerns, and which of these you deem necessary and/or effective in addressing climate change-related problems. Please add additional measures if necessary.

Adaptation measure	**Implemented**	**Planned**	**Effective/-necessary (but not planned yet)**	**Not relevant/ necessary**
Flood protection				
Technical flood protection (e.g. raise dykes, enlarge reservoirs, upgrade drainage systems etc.)				
Natural retention of flood water (e.g. floodplain restoration, change of land use)				
Restriction of settlement/building development in risk areas				
Standards for building development (e.g. permeable surfaces, greening roofs etc.)				
Improving forecasting and information				
Improving insurance schemes against flood damage				
Others, please specify:				
Drought/low flow protection				
Technical measures to increase supply (e.g. reservoir volumes, water transfers, desalinisation etc.)				
Increasing efficiency of water use (e.g. leakage reduction, use of grey water, more efficient irrigation etc.)				
Economic instruments (e.g. water pricing)				
Restriction of water uses				
Landscape planning measures to improve water balance (e.g. change of land use, reforestation, reduced sealing of areas)				
Improving forecasting, monitoring, information				

Thank you for your co-operation!

Please note that the space given for responses is indicative only and can be adapted as necessary.

Adaptation measure	Implemented	Planned	Effective/-necessary (but not planned yet)	Not relevant/ necessary
Improving insurance schemes against drought damage				
Others, please specify:				
Coastal zones				
Reinforce or heighten existing coastal protection infrastructure				
Retreat strategies, e.g. managed realignment of dams				
Others, please specify:				
General adaptation measures				
Awareness raising or information campaigns				
Others, please specify:				

Q.8 To what extent could programmes of measures under the Water Framework Directive address climate change impacts?

Part C: Title of adaptation initiative/action

Q.9 Does any action or measure exist in your country with regard to adaptation of water management to climate change impacts? If yes, please add the following more detailed information, for each of these actions or measures.
Summary description (what is the adaptation action/initiative?)

Objective of the measure	Brief description of adaptation initiative

Relevant water sub-sector		
		Demand management (e.g., regulation, metering, education)
		Supply management (e.g., irrigation, leakage, new capacity)
		River flood risk management (e.g. planning, infrastructure, early warning)
		Water quality (e.g. regulation, abstraction quotas)

Thank you for your co-operation!

Please note that the space given for responses is indicative only and can be adapted as necessary.

		Hydrological cycle management (e.g., hydropower, dams, inland shipping etc)
		Other (e.g., fisheries, recreation, conservation)
Administrative and management Scale	EU, national, or sub-national	
Geographical location	Where is the adaptation initiative taking place?	

Q.10 Adapting institution(s) (who is involved?)

Institution	Name of organisation/government department, etc
Ownership	Public, private or NGO
Key stakeholders	Public/private sector organisations, communities, individuals

Q.11 Adaptation process (how does adaptation take place?)

Type of adaptation		(i) Building adaptive capacity (e.g. research, mapping and modelling impacts and vulnerability, risk assessments, planning/strategy development, developing and participating in networks, awareness raising, training)
		(ii) Policy - including new/revised legislation, Bills, Acts of parliament etc

Thank you for your co-operation!

Please note that the space given for responses is indicative only and can be adapted as necessary.

		(iii) Operational - physical or managerial implementation of adaptation measure(s)
Purpose	Is climate change adaptation the main objective (i.e. intentional) or an unplanned side-effect of a different initiative?	
Triggers and drivers	What stimulated the adaptation initiative? (E.g., weather event, policy/legislation, research results, risk assessment, cost-benefit analysis etc)	
Decision making process	Who makes the decision to adapt? Who decides how to adapt? What, if any, criteria are used to evaluate and prioritise adaptation options? What roles do stakeholders play?	
Key information sources	What are the key information sources for informing decision making?	
Funding sources	What financing mechanism is used? Who is paying for the initiative - are those who benefit from measures involved in the financing (e.g. charges)?	
Obstacles	Which obstacles were met during the planning or implementation process?	

Q.12 Evaluation of Adaptation

Cost and costing method	Estimated cost of planning and implementing the initiative. If appropriate, which costing method is used to estimate the cost?

Thank you for your co-operation!

Please note that the space given for responses is indicative only and can be adapted as necessary.

Major outputs	Technical reports, web-site, new network, policy briefing/guidance, new infrastructure etc.
Criteria for evaluation	What, if any, are the criteria for measuring the success of adaptation?
Outcome of the evaluation	Has the adaptation been a success, partial success, failure, or is it too early to say?
References/background information for each of the adaptation measures in part C	

PART D: Further information

Q.13 Which adaptation activities would you prefer to be co-ordinated or decided at EU level?

Q.14 With respect to which impacts or adaptation measures do you think further research is needed? What kind of research efforts do you think should be undertaken at European level?

Q.15 Please provide further information you consider relevant in the context of this survey, or indicate additional persons that you think should be contacted in your country.

Thank you for your co-operation!