Publishable summary

The Project ClimateWater (http://www.climatewater.org) is a 7th Framework Programme project of the Co-ordination and Support actions (supporting) type of 3 years duration (01 November 2008 – 31 October 2011). This summary report corresponds to the achievements of the first 18 month of the project.
The Project is co-ordinated by research institute VITUKI (P1, H) and the Co-ordinator is Prof. Dr. Géza Jolánkai. The 10 partners are: P2 UNIDEB (H); P3 CNR-IRSA (I); P4 (USF, D); P5 GeoEcoMar (Ro); P6 Geonardo (H); P7 UVIEN (A); P8 UNILEI (UK); P9 SHMU (SK); P10 SOGREAH (F) and P11 MRA (Malta).

The Project ClimateWater's **objectives are**; the analysis and synthesis of data and information on the likely (known, assumed, expected, modelled, forecasted, predicted, estimated) water-related impacts of the changes of the climate (**WP2**) with special regard to their risk and to the urgency of preparation to combat these changes and their impacts. The Project will identify all adaptation strategies (**WP3**) that are, and could be, developed in Europe (and also globally) for handling (preventing, eliminating, combating, mitigating) the impacts of global climate changes on water resources and aquatic ecosystems, including all other water-related issues of the society and nature. Research needs (**WP4**) in the field of 'climate impact on the water cycle and water users' will be identified. The most important output of the project will be the identification of gaps (**WP5**) that would hinder the implementation of the EU water policy in combating climate impacts on water.

By the mid-term of the project we have completed **WP 2 – Analysis and synthesis of water-related climate change impacts –** by reviewing several hundred project documents, books, papers & web sites. Consequently in this report it is not possible to refer to individual literature items and the reader is kindly requested to consult the website, where the full list of all reviewed documents is found by their Work Package and their sub-headings and topics. For the same reason only some of the most critical impacts revealed by this project can be mentioned in this summary report.

One of the **major water-related impacts is flooding.** It has close relationships to its cause – the unprecedented rainfalls and rainstorms and their impacts that include loss of human life, extreme health risk and the risk of epidemics; mud avalanches and land slides, loss of properties, devastation of natural treasures and serious water quality deterioration by the so-caused extreme pollutant loads. We found that the extremity and frequency of floods are very likely to be increasing, as a result of devastating flooding of the valleys of smaller streams and creeks, where floods had not been previously experienced. Here it should be stressed that at the **time of writing this report nearly the whole of Europe has been recently subjected to the most devastating floods ever experienced**, causing loss of life and serious health risk, induced by the highest recorded rainfall events, themselves of very high intensity at many sites.

Another **major impact area is drought and water scarcity**, the severity of which is also likely to be increasing over roughly the southern half of Europe, with special concern to the Mediterranean (also in some areas where floods and excess water are also causing severe problems). Drought and water shortage result in severe losses to agriculture and in the over-exploitation of groundwater resources. This latter might add to the severity of saltwater intrusion that stems from sea level rise.

Water supply will be seriously handicapped in many regions by the shortage of surface waters and the depletion of groundwaters, exacerbated by climate change-induced increased pollution of both. The forecasted limitations in the availability of clean and fresh water could result in difficulties in achieving the goal of improved safe access to drinking water, with conflicts between different users. All the expected modifications of the climate will also have a direct effect on both groundwater quality and quantity.

Water quality will deteriorate as a consequence of temperature rise, decreased flow (lower dilution rate) and higher runoff-induced nutrient loads. These factors will affect the rates of all chemical and ecological processes, resulting in accelerated eutrophication, decreased oxygen content and the increase of pollutant concentrations. Deterioration in terms of priority pollutants (e.g. heavy metals) and also pathogens are expected with flash floods and storm runoff events. This, in turn may result in serious health risks (e.g. among bathers of natural water bodies). A very **serious health risk** is associated with the overflow of combined sewers, as a result of intensive rainstorms of increasing intensity.

Indirect impacts on drought: Apart from the direct impact of climate change on water resources (and hydrology), we were dealing with the many indirect impacts, here only major impacts; a) Environmental impacts of damages to flora, fauna, biodiversity and to nature conservation areas; wind and water erosion of soils, reduced soil quality: b) Economic impacts of drought; losses to agricultural producers, losses to crop and livestock, fisheries and to timber production; loss to the recreation and tourism industry: c) Social impacts of drought, including health effects - increased conflicts of water users; reduced quality of life (increased poverty), loss of cultural sites; recognition of institutional restraints on water use.

Impacts on agriculture: The most evident negative impacts of climate change on agriculture coming out of the review are changes in water demand and availability along with a growing risk of drought, changes in length of the growing seasons, shift of zones, changes in crop yields, increase in the magnitude of several types of soil degradation, changes in agricultural diseases and loss of arable lands due to – among others – salinization caused by sea water intrusion and increased use of irrigation. The frequencies of drought may become regular; not only in semi-arid countries. As a causal chain drought leads to further negative effects on agriculture, such as loss of crops and animal stock, loss of arable land and desertification - which already affects several countries.

Major water-related/dependent industries, such as navigation, hydropower and nuclear power generation, will be strongly impacted. <u>Major impacts of navigation include</u> low water levels that will reduce loading capacity of freighters and affect transport prices. Low flows will increase the number and severity of fords and the severity of bottlenecks (narrows). This might lead to the need for replacing complete fleets by smaller vessels. Increasing level and frequency of high floods also impacts navigation over much of the inland waterways of Europe. Increased costs of routine infrastructure maintenance (e.g. dredging) and renewal are expected. In marine navigation, sea level rise can cause coastal erosion, degradation of port structures, incidents of over-topping and flooding of lowlands. <u>Impacts on hydropower generation</u> include a forecasted 6% decrease in utilisable capacity. Power transmission lines, offshore drilling rigs and pipelines, might be damaged by flooding and by more intense storm events (the Bay of Mexico catastrophe happened at the time of writing this report). Capacity increase of the EU hydropower industry might be possible in the part of Northern Europe "becoming wetter" . Nuclear power generation might be seriously impacted by rising water temperatures of cooling water for the stations. It has been estimated that about the half of the water intake in Europe is due to industrial water demand. Thus, in drying parts of Europe all strongly water-dependent industries might be at risk and subject to economic losses.

Impacts on landuse planning and on water management, as its major framework, will be facing serious impacts of both higher floods and drought and water shortage/scarcity (considering also land-slides and mud-avalanches). The major impact is in general terms that the methods and scope of the land-use planning need to be changed to suit a better and more efficient planning of adaptation measures (within RBMP).

Impacts on nature and within nature the aquatic ecosystems will be severe, as both too much (flooding) and too little water might cause severe degradation. Depletion of oxygen, increase of pollutant concentrations, excess pollutant and nutrient loads of high floods and runoff-washoff waters all cause problems, which span from fish-kill though various phases of planktonic and macrophyte eutrophication until poisoning by a large variety of organic and inorganic micropollutants that stem from increasing runoff from urban land and industrial "brown-field" sites. These are mostly existing anthropogenic impacts that might increase with climate change.

Terrestrial ecosystems will also become heavily impacted by both too much and too little water and by the shifting of temperature zones. At global scale the evapotranspiration from forests is responsible for the majority of the world's freshwater budget. Therefore climate change impact on forests and other terrestrial ecosystems could be the main driver of all water related problems. Changes in the form and amount of precipitation, along with associated water availability within a forest ecosystem, may directly affect bird, amphibian, and reptile communities by concentrating populations and increasing their vulnerability to parasites and pathogens, as well as intra- and inter-specific competition. With increasing temperatures and potential reductions in soil moisture, trees could become increasingly heat- and moisture-stressed, making them more susceptible to fire.

Terrestrial/aquatic ecotones are subject to severe impact of climate change, mostly because of induced shifting of the edge-community zones. Inland-water ecotones, edge community habitats of floodplain and lake-shore ecosystems, will be shifting with severe response of their flora and fauna and with unwanted exposure to invasive non-endemic species. For coastal ecotones sea level rise is seen as the major future impact. It will alter habitat conditions for present flora and fauna and open a "Pandora's box" of migrating, alien and invasive species.

In **WP3, Analysis and synthesis of methodologies of adaptation measures,** only some topics have been covered by several documents, as this work package is currently underway. Nevertheless, some very important strategies have already been identified. They concern firstly strategies to combat the **extreme hydrological consequences of climate change, floods and drought.** The recently-increasing number, and severity, of floods in Europe with their devastating consequences has forced both experts and authorities to take necessary measures. In this area they are concentrated mainly at structural measures (flood protection constructions, reservoirs, etc.); improving predictions and flood warnings; enlarging international cooperation on transnational rivers; improving information access and flood education for the public. A fairly new concern is the extreme flooding of small streams and even of creeks and rivulets in river basin headwaters. Adaptation techniques of this type must substantially reconsider hydrological and water management strategies of mountains and hills along with those of woodland and rangeland management strategies. Strategies to **fight storm-induced sea surges and rising sea water level** have also been reviewed, spanning from technical measures to detailed evacuation plans.

The second strategy is adaptation directed towards increasing frequency and extent **of droughts** in many areas in Europe, leading to shortness of sources of water – affecting practically all aspects of human activities – most directly **on agriculture**, but also on society (households**), industry, hydropower generation**, fisheries, recreation and tourism, nature conservation. The adaptation strategy in this area is divided in two basic categories: 1) efforts to **decrease water consumption** by both technical measures, pricing policy and by education to reduce water consumption by people and companies; 2) Measures within water supply include all kinds of storage, through "ecosystem services" with better soil management and other means such as as expansion of rainwater harvesting and increased storage capacity by building reservoirs (underground or covered reservoirs in areas of extremely high evaporation). Strategies reviewed for adapting **navigation** to the impacts of climate change also cover a wide range, from rebuilding infrastructures through changing fleets up to full river canalisation. Options reviewed for building of **adaptive capacities** offer considerable chances for the EU's societies to improve water management.

The revealed **strategies to combat climate change-induced water pollution** pointed to the rising importance of the control of non-point sources of pollution, which would be (are already) considerably increased by the extreme precipitation-runoff events expected.

The work on **WP 4, Identification of Research Needs,** has begun. Its main objective is to identify the research needed to fill the gap in the water-related policies of the EU to ensure the implementation of strategies to adapt to climate-change. In this context the results are (will be) included in WP5 discussed below. Some of the most relevant sub WPs are <u>WP 4.2: Ecohydrological water and ecosystem management strategies</u> and <u>WP 4.3: Research into climate change-induced causes of pollution</u>**.** Major findings so far are discussed under WP5 below. We have also recognized that there will be a need for **strengthening research** also beyond the need for identifying gaps in water-related policies. This **especially concerns floods and the related impacts of mud-avalanches, land-slides,** etc, especially in the light of the **European- (and world-) wide series of hydrological catastrophes of May-June 2010.** New research themes introduced are: WP 4.10 Research need in navigation and hydropower; WP 4.11 **<u>Research need in flood forecasting and defence</u>** and WP 4.12 Research need in water management.

The bulk of the work for **WP5**, **Identifying and Bridging gaps in Water-related European Policies**, is also just starting. Nevertheless some important gaps have already been identified during the processing of Project and literature documents simultaneously for all work packages. For indications only, the following most important ones are:

1) To cope with the ever-increasing impacts of drought, water pollution and flooding, an **<u>enforceable legal EU-wide regulation of the equitable use of the quantity and quality of water resources</u>** will be needed. Specifically, an "obligatory release flow" towards downstream countries of the river basins in concern, and the "Polluter Pays" principle for the quality assurance must be specified in scientific and legal-administrative, **enforceable**, terms! This means the complete reworking of all existing relevant EU-wide agreements, conventions and regulations on the use of water resources (which always contain an annex or footnote to ensure escaping from the assurance and implementation of these basic obligations).

2) As climate change-induced non-point source (diffuse) pollution loads seem to be a major impact on water resources, <u>serious gaps of WFD</u> and many relevant (agricultural, ecological) directives in dealing with NPS pollution must be eliminated.

3) A major weakness of Integrated Water Resources Management (IWRM), which is a major recommended tool of river basin management planning (RBMP), is the lack of integration of water quantity, with water quality and the state of the aquatic ecosystem. In coping with climate change impacts this integration must be ensured by reshaping the Water Framework Directive.

4) There is a series of strategies identified by many projects that are aimed at jointly applying quantity (flood) control, drought management (sustainable agriculture and water supply) and pollution control with special regard to climate-change induced diffuse pollution. The river basin wide planning of these strategies can be considered as one of the major objectives of this project and of adapting to climate change. These strategies together can be called (see references) **ecohydrological tools for planning strategies** that will have to be included in RBMP, itself the major tool of WFD. We strongly feel from our reviews to date that this tool is missing.

Partners (beneficiaries) of the ClimateWater Project Consortium

Beneficiary Number *	Beneficiary name	short name	Country
1	VITUKI Environmental and Water Research Institute	VITUKI	Hungary
2	University of Debrecen, Faculty of Engineering	UNIDEB	Hungary
3	Water Research Institute of the National Research Council	CNR-IRSA	Italy
4	Institute of Environmental Systems Research, University of Osnabrück	USF	Germany
5	National Institute of Marine Geology and Geo-ecology	GeoEcoMar	Romania
6	Geonardo Environmental Technologies	GEONARDO	Hungary
7	University of Vienna	UVIEN.FE	Austria
8	University of Leicester	UNILEI	United Kingdom
9	Slovak Hydrometeorological Institute	SHMU	Slovakia
10	SOGREAH Consultants	SOGREAH	France
11	Malta Resources Authority	MRA	Malta