SEVENTH FRAMEWORK PROGRAMME

THEME 6 ENVIRONMENT (INCLUDING CLIMATE CHANGE)

Grant agreement for: Large Scale Integrating Project

Annex I – "Description of Work"

ACQWA

Assessing Climatic change and impacts on the Quantity and quality of Water

- assessing the future of water resources in vulnerable mountain regions

Coordinator:
Professor Martin Beniston, University of Geneva, Switzerland

Grant agreement no.: 212250

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A.1 Overall budget breakdown for the project

Participant	RTD / Innovation (A)	Demonstration (B)	Management (C)	Other (D)	Total (A+B+C+D)	Total receipts	Requested EC contribution
UNIGE	737400.00	0.00	719000.00	0.00	1456400.00	0.00	1272050.00
AGROSCOPE	220000.00	0.00	0.00	0.00	220000.00	0.00	165000.00
ARPAPMNT	206667.00	0.00	0.00	0.00	206667.00	0.00	155000.00
ARPAVDA	133332.80	0.00	0.00	0.00	133332.80	0.00	99999.60
BOKU	186667.00	0.00	0.00	0.00	186667.00	0.00	140000.00
CEAZA	40000.00	0.00	0.00	0.00	40000.00	0.00	30000.00
CECS	40000.00	0.00	0.00	0.00	40000.00	0.00	30000.00
CEN	62340.00	0.00	0.00	0.00	62340.00	0.00	46755.00
ITDT	26400.00	0.00	0.00	0.00	26400.00	0.00	19800.00
CESI-R	210000.00	0.00	0.00	0.00	210000.00	0.00	105000.00
UNIAQ	266667.00	0.00	0.00	0.00	266667.00	0.00	200000.00
CNRS-LGP	425200.00	0.00	0.00	0.00	425200.00	0.00	318900.00
CSIC	220000.00	0.00	0.00	0.00	220000.00	0.00	165000.00
CVA	165000.00	0.00	0.00	0.00	165000.00	0.00	82500.00
ENEL	46000.00	0.00	0.00	0.00	46000.00	0.00	23000.00
ETH ZURICH	1544240.00	0.00	15600.00	0.00	1559840.00	0.00	1173780.00
FONDMS	40000.00	0.00	0.00	0.00	40000.00	0.00	30000.00
ICTP	266667.00	0.00	0.00	0.00	266667.00	0.00	200000.00
ISAC-CNR	120000.00	0.00	0.00	0.00	120000.00	0.00	90000.00
KNAS	33200.00	0.00	0.00	0.00	33200.00	0.00	24900.00
CEA	160000.00	0.00	0.00	0.00	160000.00	0.00	120000.00
MONTEROSASTAR	30000.00	0.00	0.00	0.00	30000.00	0.00	15000.00
MPG	666667.00	0.00	0.00	0.00	666667.00	0.00	500000.00
PNGP	80000.00	0.00	0.00	0.00	80000.00	0.00	60000.00
POLIMI	372000.00	0.00	0.00	0.00	378200.00	0.00	283650.00
UNIBE	240000.00	0.00	0.00	0.00	240000.00	0.00	180000.00
BHAM	213332.80	0.00	0.00	0.00	213332.80	0.00	159999.60
HEID	526720.00	0.00	0.00	0.00	526720.00	0.00	395040.00
UNIGRAZ	350932.80	0.00	0.00	0.00	350932.80	0.00	263199.60
UNIVDUN	193332.80	0.00	0.00	0.00	193332.80	0.00	144999.60
Total	7828966.20	0.00	734600.00	0.00	8563566.20	0.00	6493573.40

A.2 Project summary form

Project Number 1	212250	Project Acronym 2	ACQWA

ONE FORM PER PROJECT			
GENERAL INFORMATION			
Project title 3	Assessment of Climatic change and impacts on the Quantity and quality of Water		
Starting date 4	01/10/2008		
Duration in months 5	60		
Call (part) identifier 6	FP7-ENV-2007-1		
Activity code(s) most relevant to your topic 7	ENV.2007.1.1.5.2.: Climate change impacts on vulnerable mountain regions		
Free keywords 8		Climatic change, water resources, mountain regions, modelling, impacts, hazards, adaptation, policy	
Abstract 9 (max. 2000 char.)			

As the evidence for human induced climate change becomes clearer, so too does the realization that its effects will have impacts on natural environment and socio-economic systems. Some regions are more vulnerable than others, both to physical changes and to the consequences for ways of life. The proposal will assess the impacts of a changing climate on the quantity and quality of water in mountain regions. Modeling techniques will be used to project the influence of climatic change on the major determinants of river discharge at various time and space scales. Regional climate models will provide the essential information on shifting precipitation and temperature patterns, and snow, ice, and biosphere models will feed into hydrological models in order to assess the changes in seasonality, amount, and incidence of extreme events in various catchment areas. Environmental and socio-economic responses to changes in hydrological regimes will be analyzed in terms of hazards, aquatic ecosystems, hydropower, tourism, agriculture, and the health implications of changing water quality. Attention will also be devoted to the interactions between land use/land cover changes, and changing or conflicting water resource demands. Adaptation and policy options will be elaborated on the basis of the model results. Specific environmental conditions of mountain regions will be particularly affected by rapidly rising temperatures, prolonged droughts and extreme precipitation. The methodological developments gained from a European mountain focus will be used to address water issues in regions whose economic conditions and political structures may compromise capacities to respond and adapt, such as the Andes and Central Asia where complex problems resulting from asymmetric power relations and less robust institutions arise. Methodologies developed to study European mountains and their institutional frameworks will identify vulnerabilities and be used to evaluate a range of policy options.

A.3 List of beneficiaries

Beneficiary Number *	Beneficiary name	Beneficiary short name	Country	Date enter project**	Date exit project**
1(coordinator)	Université de Genève	UNIGE	Switzerland	1	60
2	Agroscope ART, Zurich, Switzerland	AGROSCOPE	Switzerland	1	60
3	ARPA, Ag. Reg. per la Protezione dell'Ambiente del Piemonte	ARPAPMNT	Italy	1	60
4	ARPA, Ag. Reg. per la Protezione dell'Ambiente della Valle d'Aosta	ARPAVDA	Italy	1	60
5	Universität für Bodenkultur (BOKU)	BOKU	Austria	1	60
6	Center for Advanced Research in Arid Zones	CEAZA	Chile	1	60
7	Laboratory of Glaciology and Climate Change (CECS)	CECS	Chile	1	60
8	Centre d'Etudes de la Neige (CEN), MétéoFrance	CEN	France	1	60
9	Inst. Torcuato d. Tella (ITTD)	ITTD	Argentina	1	60
10	Dipartimento Ambiente e Sviluppo Sostenibile, CESI Ricerca	CESIRICERCA	Italy	1	60
11	CETEMPS Center of Excellence, University of L'Aquila	UNIAQ	Italy	1	60
13	Centre National de la Recherche Scientifique	CNRS	France	1	60
14	Pyrenean Institute of Ecology, Spanish Research Council	CSIC	Spain	1	60
15	CVA Spa (Compagnie Valdotains des Eaux)	CVA	Italy	1	60
16	ENEL SpA	ENEL	Italy	1	60
17	Swiss Federal Institute of Technology Zurich (ETHZ)	ETH-ZURICH	Switzerland	1	60
18	Fondazione Montagna Sicura	FONDMS	Italy	1	60
19	International Center for Theoretical Physics (ICTP)	ICTP	Italy	1	60
20	Scienze dell'atmosfera e del Clima (ISAC)	ISAC-CNR	Italy	1	60
22	Kyrgyz National Academy of Science (KNAS)	KNAS	Kyrgyzstan	1	60
24	Laboratoire des Sciences du Climat et de l'Environnement (LSCE) – CEA	CEA	France	1	60
25	Monterosastar S.r.l.	MONTEROSASTAR	Italy	1	60

26	Max-Planck-Gesellschaft zur Förderung der Wissenschaften e.V.	MPG	Germany	1	60
27	Alpine Wildlife Research Centre	PNGP	Italy	1	60
28	DIIAR-Hydrology, Politecnico di Milano	POLIMI	Italy	1	60
29	University of Bern	UNIBE	Switzerland	1	60
30	University of Birmingham, Geography & Environmental Sciences	UNIBIRMINGHAM	UK	1	60
34	Graduate School for International Studies and Development (HEID)	HEID	Switzerland	1	60
36	Wegener Center for Climate and Global Change, University of Graz	UNIGRAZ	Austria	1	60
37	University of Dundee	UNIVDUN	UK	1	60

B1. Concept and Objectives, progress beyond state-of-the-art, S/T methodology and work plan

B1.1. Concepts and project objectives

As the evidence for human induced climate change becomes clearer, so too does the realization that its effects will have impacts on socio-economic systems and terrestrial ecosystems. Some regions are more vulnerable than others, both to expected physical changes and to the consequences they will have for ways of life. Mountains are recognized as particularly sensitive physical environments with populations whose histories and current social positions often strain their capacity to accommodate intense and rapid changes to their resource base. **This proposal aims to assess the impacts of a changing climate, focusing on the quantity and quality of water originating in mountain regions, particularly where snow- and ice melt represent a large, sometimes the largest, streamflow component**. There, they represent a local resource (freshwater supply, hydropower generation, irrigation), but in most cases also considerably influence the runoff regime of the downstream rivers and the related water availability. Such an influence is reflected mainly in the amount of surface water available for supplying irrigated agriculture and water supply systems, but also in the amount of groundwater recharge that can take place in river–fed aquifers. An increasing number of evidences of glacier retreats, permafrost reduction and snowfall decrease have been observed in many mountainous regions, thus suggesting that climate modifications may seriously affect streamflow regimes, in turn threatening the availability of water resources, increasing the downstream landslide and flood risk, impacting hydropower generation, agriculture, forestry, tourism and, last but not least the water dependent ecosystems. As a consequence, socio-economic structures of downstream living population will be also impacted, calling for better preparedness in developed countries and strategies to avoid the exacerbation of the already conflictual situation in many developing countries, like those in Central Asia and South America.

The goal of the project is to use advanced modelling techniques to quantify the influence of climatic change on the major determinants of river discharge at various time and space scales, and analyse their impact on society and economy, also accounting for feedback mechanisms. The focus will be on continuous transient scenarios from the 1960s up to 2050. In comparison to many existing studies, the limitation of the modelling horizon to mid of the 21st century allows to develop more realistic assessment of the progressive impact on the social, economical and political systems, which we expect to evolve typically in an adaptive mode on shorter time scales than the centennial ones, eventually shifting to new equilibria when forced abruptly.

The data required for the multiple model applications will be managed in the form of a "data warehouse" that will begin collecting and centralizing the data for the entire ACQWA community from the start of the project. The specification of data and the data formats will be defined in collaboration with the partners within the first 2-5 months of the project, and by the end of the first year, data will be available through the Internet for use in the different Work Packages. Additional data, such as remote-sensing information, will be ready by the end of the second year, while the socio-economic data required for many of the non-physical impacts studies will be brought online from the inception of ACQWA through to the end of the project. The data warehouse will be continuously updated and maintained for the entire duration of the project.

Regional climate models will provide the essential information on shifting precipitation and temperature patterns, and snow, ice, and biosphere models will feed into a hydrological model in order to assess the **changes in basin hydrology** and seasonality, amount, and incidence of **extreme events** in various catchment areas. The type of extremes that will be analyzed here include certain weather patterns that result in exceptional flooding (e.g., storms of Mediterranean origin: see Subtask 3.4.2, in particular), and geomorphologic hazards. These include various forms of erosion and slope instabilities that often end up in rivers, contributing to increased sediment loading and lead to potential problems for infrastructure close to the rivers or hydropower installations (see Subtask 3.4.3 later on in this document). One consortium partner (Subtask 3.4.1) will be developing appropriate analysis methodologies to address the impacts on watersheds of extremes of temperature, storm rainfall intensities, peak flows, and dry spells.

Essential regional climate model data will already be available within the first year of the project, while by Month 24, there will be fine-scale information based on downscaling techniques for use in regional/local impacts studies. While this data at fine spatial and temporal scales is being prepared, work on refining process-oriented models (hydrological, cryospheric, and biospheric models) will be undertaken so as to be in an optimal state of readiness by Month 24. As the project evolves, new data will be updated and will be made available through to the end of the funding period. Many of the models applied here require developments, updating and refinements that will depend not only on the availability of data but also on the intensity of the links between sub-components of the project (as shown later in Table B1.3f). Most of these process-oriented models will begin work from the very early stages of ACQWA or at the latest in the second year, and while many results are expected by the end of Month 48, some of the more resource-intensive modelling (climate and hydrological applications) will be conducted through to the end of the project.

Environmental and socio-economic responses to changes in hydrological regimes will be analyzed in terms of hazards, aquatic ecosystems, hydropower, tourism, agriculture, and the health implications of changing water quality. Attention will also be devoted to the interactions between land use/land cover changes, and changing or conflicting water resource demands. Integration of the information from all these sectors and the impacts on economies will feed into a quantitative model of water use incorporating supply and demand. Supply is conceived as having physical inputs (from the regional climate models) as well as societal inputs based on property, price, and regulatory factors. Demand reflects population evolution, price, and economic activity.

Components of the ACQWA project focusing on elements such as hydropower, tourism, or aquatic ecosystems will start little later in the project. This will enable the partners involved in these issues to be able to access the ACQWA databases (see ACQWA Data Warehouse under Work Package 2) that will be built up in the first year of the Project, and therefore to have the most up-to-date information for implementing their research. This delay in time should not exceed 12 months, however, in order for the work to be completed well ahead of the end of the project, in order for the research results to be appropriately disseminated and translated into policy terms. As shown in the table under B1.3.2, most of the tasks and subtasks beginning in Month 12 or later will be completed by Month 48, and any work done in the final year will be towards the final report, policy recommendations, and wherever appropriate, transposition of the methodologies to other regions.

The resulting integrated model will permit the construction of scenarios and allow us to evaluate various **policy options for adaptation and mitigation**. A significant novelty provided by the model constructs that will be implemented by the project is the ability not only to focus on the changes of the average values, but also to assess the variability at different time and space scales. It will be thus possible to identify changes of the hydrological response to climatic change and of its impact to the socio-economic compartments, which result from modifications of the temporal and spatial structure of the key variables describing water resources, thereby including inter-annual variability, distribution properties and scale issues. Variability estimates will represent an important input for the analysis of the costs and benefits of the changes and the associated new risks these represent for societies. Risk analysis and risk of catastrophic events in their socio-economic impacts have been analyzed by partners at Columbia University (Chichilnisky 1993,1998, 2000, 2006)

The research on policy for adaptation/mitigation will involve not only European but also non-European partners, and will provide one of the major social-science outputs of the ACQWA project. It thus seems essential that the research begin once essential data is made available by the data warehouse from Month 12 and be pursued through to Month 60.

The Rhone and Po river basins will be a common “test ground” for model investigations, where the different methodological approaches will converge to the basin scale through appropriate up- or down-scaling techniques. Both basins constitute ideal case-study areas, as they comprise all the elements of the natural environment that will be modelled (snow, ice, vegetation, hydrology), and at the same time are highly regulated watersheds, subject to hydropower, irrigated agriculture, and tourism activities in the context of a climate that is at the borderline between Mediterranean and continental, thus, as shown by previous studies (Beniston, 2000), particularly vulnerable to climatic change.

The focus on the two target areas will cover the first three years of the five year long project before extending the methodologies and results to other target regions, as discussed below.

The broad goal extends, however, beyond this geographical focus to the wider consequences of changing climate for water resources. Specific environmental conditions of mountainous regions will be particularly affected by rapidly rising temperatures, prolonged droughts and, on occasion, extreme precipitation. The consequences will not be limited to mountains, however, but will also have impacts on regions and sectors far beyond. Methodological developments gained from the Alpine studies will be used, in the last two of the five years of the project duration, to address these consequences, particularly for regions whose economic conditions and political structures may compromise capacities to respond and adapt. The focus will be on mountain areas in the Pyrenees, likely shifting from a nivo-pluvial regime to a purely pluvial one, in the Andes (Chile and Argentina) and in Central Asia (Kyrgyzstan). The latter are two exemplary case studies, which can serve as pilot areas to illustrate, on the one hand, changes occurring in a region with an almost complete dependence from melt-waters (Chile), and on the other hand, the impact of climatic change on regions where the complexity of the response results from asymmetric power relations and less robust institutions. Methodologies developed to study European mountains and their institutional frameworks will elucidate key criteria to identify vulnerabilities for those regions and will be used to evaluate a range of policy options, whereby the vulnerability of the different sectors of water issues is taken into account.

In some instances, it may be difficult to transpose directly the methodologies developed in the “data-rich” Alpine region to other regions where data is sparse. The partners of WP2 have a long-standing experience in these issues, and will make available key datasets from local to global scales that are necessary to develop the modeling approaches used and developed within ACQWA. Data such as digital elevation models, land cover classifications, soil characteristics, weather stations and hydrological data, climate change predictions and useful remote sensing datasets will be gathered and organized so as to be distributed to any interested partners.

The models and methods developed in the ACQWA project will benefit from the data-rich environment of the European test-beds. In general, this will allow to apply models designed for detailed process descriptions that are data demanding. However, this will not compromise the use of such models, or their modification, for those regions characterized by a limited availability of data. In fact the project will investigate specifically this problem, through the use of a number of different strategies.

For instance models developed with “full” data availability will be tested on the same area using an artificially degraded data set. Typical examples also found in the literature concern the degradation of the digital terrain models and/or thematic maps (e.g. Vazquez and Feyen, 2007). Such a procedure will provide an assessment of the sensitivity of the local scale process models to coarse description of the heterogeneities that characterize the morphological features of a particular hydrological basin.

In addition the modularity of the catchment models will allow the replacement of data-demanding modules with more parsimonious ones, which are tested for performance against the advanced and data-intensive techniques. Furthermore, the project will develop and test numerous disaggregation techniques, in addition to those available in literature, for disaggregation from higher to smaller temporal or spatial scales, as well as interpolation techniques suitable to compute spatial distributions from data that is spatially sparse. These techniques will also be tested in the data-rich case study areas by mimicking data-poor environments and comparing their results with those of their more sophisticated counterpart. Moreover, the increasing availability of remotely-sensed data, which is planned to be extensively used within the ACQWA project, progressively reduces the dependence on local data. Similarly re-analysis data of hydro-meteorological variables, increasingly available for many regions of the globe, will be used to test the performance of models in the data-rich cases study areas, thus enabling an assessment of the use of alternative data sets in data-poor environments.

There exists a wide expertise within the project to address these issues, as illustrated below for the exemplary case of basins with glaciers, one of the major foci of ACQWA. Glaciers that are well-monitored can be considered as data-rich compared to the majority of mountain glaciers, whose hostile environments generally preclude the use of permanent instrumented sites for long-term monitoring. For instance, Partner 17 has developed a parsimonious enhanced temperature index model, which combines the high accuracy of simulations of energy balance models throughout a continuum of scales with the data sparseness of traditional temperature index methods. The model indeed represents an intermediate step between the simple degree-day type of model and the physically-based energy-balance models. It requires only knowledge of temperature and precipitation fields as compared to the physically based energy-balance method. The model has been extensively tested on several glaciers in the Alps and for several ablation seasons and has proven to work well (Pellicciotti et al., 2005; Rimkus, 2006; Kretz, 2007; Carenzo et al., 2007).

Partner 17 has also investigated the model performance dependence on the degradation of the quality and amount of input data. Tests were done in this respect 1) with abundant data measured across one glacier at several Automatic Weather Stations (AWSs); 2) using only data measured at one AWS on the glacier; 3) using input data measured outside of the glacier boundary layer in the proglacial valley; 4) using observations from synoptic stations (Rimkus, 2006; Carenzo et al, 2007; Pellicciotti et al, in preparation). Moreover, the robustness and transferability of the model and its empirical parameters over several seasons and glaciers in the Alps (Carenzo et al., 2007) have been investigated. The model resulted to be robust both in time and in space, for different subsets of meteorological conditions. In addition, indication of parameters values for cases where data might not be available was provided.

Ablation models developed for the Alps were also tested in different climatic settings. The applicability and accuracy of two energy-balance models and one enhanced temperature index model (Pellicciotti et al, 2005) have been investigated in the dry Andes of central Chile (Pellicciotti et al, 2007), and both the physical processes and parameter set typical of this climatic setting were assessed. The study, conducted at the point scale, has provided the parameter values necessary for the application of the distributed version of the three models (Pellicciotti et al, 2007). Moreover, investigations of the applicability of energy-balance models (which might be more accurate for simulations under climate change scenarios) with input data measured outside of glaciers have been undertaken. The strategy is also here to test parameterisations, such as the so-called OG method (Oerlemans and Grisogono, 2002) for the turbulent fluxes, that can be used with meteorological data measured outside of the glacier boundary layer. This is being tested with both input data measured close to the glacier snout and from stations currently available from the standard meteorological networks. This is being done across several glaciers and seasons.

Specifically related to climate data, one technique that was pioneered by Giorgi and Mearns (1991) and has since become commonplace in the climate modelling arena is that of “nested modelling”. This technique was initially used to address the problems related to insufficient grid resolution in GCMs, in order to enhance climate information over particular regions and to provide climate data at an appropriate resolution for impacts studies, for example. In the original procedure, results from a GCM are used as initial and boundary conditions that are supplied to a regional climate model that operates at much higher resolution and with generally more detailed physical parameterizations. A regional model can thus be considered to be an “intelligent interpolator” that can help fill whatever data gaps require attention, since it is based on the physical mechanisms governing climatic processes and serves to enhance the regional detail lacking in global climate models. Further interpolation techniques may still be necessary, however, depending on the scale and nature of specific impacts studies. Many interpolation methods are based on correlation or covariance matrices and least-squares theory; these can be enhanced by a “self-nesting” procedure whereby a model supplies initial and boundary conditions to increasingly finer resolutions of the same model. Such a set of nested procedures, possibly enhanced by advanced spatial interpolation techniques, becomes particularly attractive for remote regions or those with topographic elements. These are typically regions of high complexity where the details of particular features are essentially unresolved by the coarse structure of a GCM grid, or where observational data is often sparse or nonexistent. This is likely to be the case for the non-European case-study regions envisaged within the ACQWA project (Andes and Central Asian mountains).

In socio-economic terms, already today a substantial data base exists for the issues evoked above in the World Bank Develoment indicators, an in depth compendium of socio-economic indicators for each country and region of the world. Contacts with relevant local institutions such as the Instituto Torcuato de Tella in Buenos Aires and the Kyrgyz Academy of Science Institute for Water and Hydropower will bring additional data bases for regional questions.

Application of the methodologies developed over the first 3 years for the Alpine region to other geographical case-study regions will begin in Month 36, under the assumption that much of the work required to reduce the problems of insufficient data discussed above are carried out by the relevant partners prior to this deadline. It is important that the technicalities related to observed or simulated data be completely resolved before moving on to investigations of non-European study areas, thereby enabling a full focus on the research aspects of Andean or Central Asian water resources.

The investigated climate change horizon, as better specified in the following sections, consists of **RCMs project specific generated transient scenarios from 1960 to 2050**. Additional GCMs and RCMs scenarios, both transient runs up to 2100 and large scale RCMs time slices 2040-2060 and 2080-2100, available from on going projects such as EU-FP6 “PRUDENCE” and “ENSEMBLES” will be considered.

In order for the results of the project to go beyond an academic exercise, efforts will be made to transfer the understanding of theses complex issues, and will involve:

- Sector-by-sector and interdisciplinary workshops at various critical phases of the project
- ACQWA-sponsored events at major international congresses (EGU, AGU, etc.) to highlight the results and their applicability to a wider scientific arena
- Local conferences/seminars organized by individual partner institutions in order to stimulate awareness-raising to some of the key issues addressed within ACQWA
- Web-based newsletters edited on average each 6 months. Contacts with other relevant EU projects, academic institutions and government agencies will be activated in order to advertise as widely as possible the link to the ACQWA information website.
- A summary for policymakers, similar to the philosophy developed by the IPCC. Such a summary will provide a short comprehensive overview of the most important conclusions of the ACQWA Project and the policy-relevant issues and solutions.
- An important step in the transfer of research results to adaptation/policy will be the development of an **ACQWA policy+stakeholder interface**. While the project will complete its work with targeted stakeholder workshops in order to disseminate its findings to relevant communities (hydropower authorities, agriculture and forestry, etc.), it would be appropriate to set up a working group in collaboration with the European Commission. This working group would typically comprise 10-15 persons working at the EU policy level and within governmental (e.g., environment ministries and/or water management authorities) and supra-national bodies (e.g., CIPRA, International Rhine Commission and similar organization). The policy working group will be updated on ACQWA results at regular intervals, both using Internet facilities and through targeted meetings. By creating this “interface”, it is expected that the policy-relevant information will reach the appropriate targets in the most rapid and efficient manner.

B1.2. Progress beyond the state-of-the-art

B1.2.1. Rationale

In the following, the key ideas that will be developed within the ACQWA project provide an outline of the range and scope of the issues being addressed. These issues have, by and large in the past, been addressed often in a cursory manner. By bringing together specialists from numerous fields of research, and by promoting the convergence of modelling approaches that up till now have been largely functioning in parallel but rarely in the context of a truly integrated modelling framework, ACQWA promises significant progress beyond current state of the art.

B1.2.2. Water as a measure of vulnerability

The **focus on water** is the key element of the ACQWA proposal, because it is an essential for human populations, animal and plant communities. Water is relevant in every aspect of mountain systems, in the physical, biological and socio-economic systems. It directly influences the energy supply (hydropower), tourism (snow, water usage, glaciers), forestry and agriculture (productivity changes with changes in water supply, need for irrigation) and services from natural and semi-natural ecosystems. On the other hand changes in any of these compartments will produce a feedback on water availability. Afforestation and deforestation processes triggered by climate change will likely affect the water balance, the generation of flood runoff and the sediment production due to enhanced or damped erosion. The project aims at going beyond the current state of modelling by accounting for such feedback mechanisms, particularly focussing on the impact of changing forests on the water regimes. Increased competition for water among these sectors may arise, requiring regulatory or market mechanisms to attenuate tension and assure efficient and equitable use. **Achieving sustainable water use poses particular challenges for policy making** because of its nature as **a public good** and because it often has both upstream/downstream *and* **transboundary/transnational characteristics**. Any changes in climate affecting precipitation and the behaviour of snow and, where relevant, glaciers, will have a major influence on the seasonality, amount, and quality of surface runoff. The main changes are thus expected in the surface water systems, which will be comprehensively analyzed, in order to quantify the changes affecting the streamflow regime, which may lead to uneven temporal distribution of the resource throughout the year. Thus, the project will mainly concentrate on surface waters, both because mountain regions are in general depending on them rather than on groundwater, and given that the configuration of topography and landscape that do not allow the presence of sizeable alluvial deposits necessary for groundwater systems to develop. However, an assessment of the impact on downstream river-fed groundwater systems will be carried out, though without detailed modelling of the aquifer systems, by considering the effects on the recharge of groundwater systems due to predicted altered streamflow regimes and to modified space-time precipitation patterns.

Whatever the nature of change in the hydrological characteristics of many rivers originating in mountain regions, shifts in climatic regimes in the mountains will have impacts that may reach far beyond the mountains themselves, into populated lowland regions that depend on mountain water resources for domestic, agricultural, energy, tourism, and industrial purposes (Beniston, 2004). Despite focussing on mountain water resources, the hydrological models used to assess the changes in the streamflow regimes will provide sufficient elements to assess the sensitivity of the groundwater systems directly dependent on the recharge from river flows. In addition, the project will allow to assess the effect of lack of direct recharge to local groundwater systems due to reduced precipitation on large scales by means of the downscaled regional climate models.

The ACQWA project will thus enable further progress in addressing these issues in the approaches that it will adopt in bringing together the modelling expertise from very different horizons.

B1.2.3. Natural hazards

A changing climatic regime could alter the frequency and the magnitude of a wide range of geomorphic processes related to extreme precipitation events that could in particular increase the severity of floods and debris flows (Stoffel and Beniston, 2006). Extreme precipitation events would in addition contribute to larger rates of erosion, discharge and sedimentation. A further factor responsible for decreased slope stability in a warmer climate is the reduced cohesion of the soil through permafrost degradation, particularly in the higher elevations in the Alps. Deglaciation can in some instances lead to problems of water accumulation behind unstable moraines that, if they fail, result in intense flooding and debris flows referred to as glacier-lake outburst floods (GLOFs) that put communities and infrastructure at risk. Similarly, hanging glaciers also pose a threat that is taken seriously in zones where glaciers are located above villages and major communication routes (Funk, 2006). In their retreat, these glaciers reveal a large quantity of unstable rubble and, sometimes ice that could result in severe down-slope flow of material. Given changes in the distribution of population with more extensive and intensive land use, particularly from tourism, any increase in the number and intensity of natural disasters could have proportionally higher human costs. By taking into account the impacts of extreme events within the hydrological cycle, ACQWA acknowledges that the resulting natural hazards could contribute to the disruption of access to, and use of, water for many economic uses. This is one further example of research that has been conducted in an independent manner in the past, but that needs to be integrated into the larger picture of water resources in vulnerable mountains as a means of fostering new approaches to water management and risk management.

B1.2.4. The economic and social impacts of shifts in water resources

Shifting precipitation patterns by season and sharply curtailed glacier mass in the mountains will lead to modifications in hydrological regimes and will also mean glaciers will no longer feed water into river catchments at a time of the year when precipitation amounts are low and the snow-pack has completely melted. These changes will have significant impacts on several critical socio-economic sectors in mountain regions, particularly since these are also subjected to various other forces that influence their viability. There will in addition be cascading effects on downstream areas. Climatic changes will affect overall land use patterns, which in turn feed back into effects on water and carbon fluxes. Different initial conditions (Pyrenees, Alps) are expected to lead to different levels of change but some general patterns will obtain. Mountain agriculture has been under pressure from lower-cost production in lowland areas. Potential increases in drought conditions will only serve to increase its vulnerability. Forests' crucial role in protecting against erosion and protecting biodiversity and water storage are potentially threatened. As a result of shifting seasonality of precipitation and glacier melt, the reduction in capacity to store water could also diminish the potential for hydroelectric production just as European-wide efforts are being initiated to reduce dependence on fossil-fuel based energy sources. Not only mountain regions, but the whole European electrical grid would thus be affected. Some rivers, such as those that flow from the northern part of the Alps, may dry up partially or completely towards the end of the summer; this is already the case in the Mediterranean mountains, where the drought situation may well worsen. Although the energy potential of the Alps has by now largely been exploited, this is not the case for other regions of the world where this usage has barely been tapped (Romerio, 2002). By investigating the challenges of managing crucial but often limited water resources in many of the mountain regions that will be studied, ACQWA will provide novel answers to social and economic issues such as changes in social arrangements among mountain populations and their downstream neighbours, energy production in regions where water is underused as a means of helping abate greenhouse-gas emissions, and environmental issues such as the future evolution of water supply for use in domestic, tourist, or agricultural sectors. The future challenges that ACQWA will address are significant, especially because of the growing interconnection among regions and among economic and social sectors. The relationships with downstream areas are especially critical, notably in cases where upstream and downstream entities concern separate sovereign countries. Analysis of upstream-downstream asymmetries and the particular vulnerabilities that arise from both is an important focus of the project, which will develop criteria for development of policies to reduce such asymmetries. The overall project goal is to provide general frameworks that include key factors and processes influencing the interactions among climate, hydrological regimes, and social systems. A central focus is on European mountain regions where data are most plentiful and permit rigorous testing of models. Comparative analysis will be undertaken by including cases from the Andes and the Pamir in Central Asia both to highlight key similarities and differences. End products will present data-based modelling analyses and general frameworks and scenarios that permit extrapolation to other regions, thus permitting evaluation of different policy options according to different initial natural and social conditions.

B1.2.5. Conflicting uses of water, social mutations and land-use changes

It is evident that climatic changes leading to modifications in hydrological regimes have the potential to increase competition over water that will be available at different times and in different quantities. Water is difficult to allocate because of its public good features, which are aggravated by upstream potential to capture the resource and by the fact that flowing water may cross internal and international borders. Adding further to the potential for conflict are socio-economic changes that modify existing distribution schemes. Changing land cover and land use (e.g., Begueria et al., 2006) will generate significant shifts in the amount and seasonality of water resources. For example, deforestation causes an increase in the average annual discharge, and an acceleration of runoff during rainstorm events, also enhancing erosion and downstream sediment supply. Changing social patterns and economic incentives have resulted in major land-use changes in many mountains of the world, and in some instances have exacerbated the risks associated with excessive runoff, erosion potential, etc. The AQCWA project will address such issues, particularly in regions with significant social change, for example resulting in land abandonment as farming loses attractiveness and spontaneous vegetation colonizes previously-managed terrain. Conflicting water use (e.g., between agriculture and hydropower, or between hydropower and tourism) as the resource diminishes through reduced precipitation in some areas and glacier retreat in others, is also a component of ACQWA that will be investigated to acknowledge the fact that new water resource management is not just a matter of adjusting to shifts in the physical environment but can also be strongly associated with social changes that are generated by changing types and levels of use and new market conditions affecting distribution.

B1.2.6. Project baseline and measure of progress against this baseline

The project has multiple baselines, in the sense that many of the activities involving data, observations and models have gained in maturity in recent years, but at an individual level, i.e., with little of the integration between methods and disciplines that this project will be implementing. For example, under the impetus of the Intergovernmental Panel on Climate Change (IPCC, 2007), climate modelling has become a major thrust of environmentally-relevant research and thus global and regional climate models are at an advanced stage of their development. Similarly, other process-oriented models (biosphere, cryosphere, etc.) have also moved rapidly forward in recent years, but the integration of the vastly different time and space scales, and the underlying methodological approaches, that these models imply, have not been attempted at the scale that the ACQWA project is proposing.

The project ***baseline*** thus comprises a suite of models and concepts that are sufficiently advanced in their respective domains to be used for sector-by-sector studies (e.g., hydropower, agriculture, extreme events, etc.). There is, however, currently a genuine need for ***integration*** of these models in order to provide a significant step forward in the understanding of the intricacies of water resources in vulnerable mountain regions. This in turn should provide a wealth of new information that can be used for detailed impact studies and the formulation of policy responses aimed at adaptation and mitigation options. ***Progress*** with respect to the existing baseline will be measured in terms of the added-value that integrated approaches to the problem will provide. The ACQWA project is designed in such a way as to **avoid simply placing different disciplines side-by-side** but by strongly **focusing on cross-disciplinary collaboration**. The added value will be measured through elements such as a common data-base that will comprise not only physical (climate, hydrology) and biological (terrestrial and aquatic ecosystems) data, but also social, economic and demographic characteristics that form part of the drivers of change in mountain water resources. A number of milestones and deliverables is foreseen to provide a direct measure of the ability of the consortium to generate integrated approaches that go beyond the sum of the single models. Furthermore, joint publications that require "cross-fertilization" of ideas and information through widely-different disciplines will of course help highlight the added-value that a high level of integration will bring when addressing these issues.

Additional **performance indicators** will include assessments of the ability of integrated model systems to reproduce past or current conditions. For instance, it will be of interest to determine whether a fully coupled atmosphere-vegetation model improves the manner in which the climate of the late 20^{th} is simulated compared to an a model that includes only the atmospheric component? Does a two-way coupled climate-glacier model reproduce observed changes in runoff characteristics better than the stand-alone models? Since a strong motivation of model integration resides in the inclusion of feedback mechanisms that might already have been important in the past (and might become even more important in the future), it is clear that if one can demonstrate in the ACQWA project that coupled models exhibit a superior performance with respect to single-sector models, then this will be a major achievement and will be a result of use to a wider research community. Furthermore, the identification of the most important feedback mechanisms and influencing parameters in the coupled systems would be a new outcome of research within ACQWA with respect to the current baseline.

B1.2.7. Links to other EU projects

Several EU projects currently underway deal with topics that are related to ACQWA. To the degree their goals and methodologies intersect with those of ACQWA, these projects could prove to be valuable assets, in terms of lessons learned, opportunities for collaboration and feedback from ACQWA to the scientists involved in these projects. In the context of the FP6 Framework, a few select projects relevant to ACQWA include:

AQUATERRA: "Understanding River-Sediment-Soil-Groundwater Interactions for Support of Management of Waterbodies (river basin & catchment areas)." One of the facets of this project is the use of an integrated modelling system to study these interactions, with the goal being to provide an improved knowledge base for river basin management and its impact on water quality and quantity in the context of a changing climate. Case studies for these modelling efforts are to focus major river basins in Europe. Since the ACQWA project will likewise use the Rhone and Po river basins as initial "test grounds" for its approach to modelling the water resource vulnerabilities of mountain regions to climate change, ACQWA could most certainly benefit from lessons learned in related case studies of the AQUATERRA project. In particular, one of the partners of AQUATERRA is the Eidgenössische Technische Hochschule Zürich (ETHZ) which is also participating in ACQWA, providing a natural avenue for consultation and collaboration.

NEWATER: "New Approaches to Adaptive Water Management under Uncertainty." Among the key elements of effective water management systems identified by this project, at least four are particularly relevant to the goals of AQWA: 1) Sectoral integration (integration with climate change adaptation strategies, cross-sectoral optimisation and cost-benefit analysis); 2) Scales of analysis (methods to resolve resource use conflicts; transboundary issues); 3) Finances and risk mitigation strategies in water management (role of public-private arrangements in risk-sharing); 4) Stakeholder participation (promoting new ways of bridging between science, policy, and implementation). ACQWA touches on each of these aspects throughout its five-year lifespan. For example, as already mentioned, an objective of ACQWA is to make academic knowledge available to the policy-making arena by means of summary documents. Another example is that ACQWA will address policy-making difficulties due to, among other issues, transnational/transboundary characteristics. In these regards, experience gained by NEWATER in connection with these key elements would be highly valuable. Once again, a convenient link between these two projects could be established via a common partner, the Max-Planck-Gesellschaft zur Förderung der Wissenshaften e.V.

AQUASTRESS: "Mitigation of Water Stress through new Approaches to Integrating Management, Technical, Economic, and Institutional Instruments." Similar to NEWATER, the AQUASTRESS project places emphasis on recommendations of new, integrated water management tools and decision-making practices, based on identification and analysis of representative reference sites dealing with water stress-related issues. This will be accomplished through the combination of academic and practitioner skills, generating knowledge in the technological, operational management, policy, socio-economic, and environmental domains. Further, one of the aims of AQUASTRESS is to develop a participatory process for the implementation of solutions that take into account the environmental, cultural, economic, and institutional context. ACQWA will likewise investigate the economic and social impacts of changing water resources, as well as water conflicts arising from social mutations and land-use changes. A linkage between these two projects could therefore result in a synergistic pooling of efforts and knowledge. However, there are no partners common to both projects, so the vehicle for collaboration would need to be identified.

WATCH: "Water and Global Change." This project has perhaps the most direct bearing on the objectives of ACQWA, since its goal is to clarify the vulnerability of global water resources with respect to the societal and economic sectors through analysis, quantification, and prediction of world-wide water resource components in the context of climate change. ACQWA, of course, has a narrower focus since it will examine water resource vulnerabilities of mountain regions with respect to climate change. Nevertheless, there are many features of WATCH that can be instructive for ACQWA, such as: evaluation of how the global water cycle and its extremes respond to future drivers of global change (including greenhouse gas release and land cover change); evaluation of the uncertainties in the predictions of coupled climate-hydrological-land-use models using a combination of model ensembles and observations; and development of an enhanced (modelling) framework to assess the future vulnerability of water as a resource in relation to climate-related vulnerabilities and risks of major water-related sectors, such as agriculture, nature, and utilities. Given the commonality of these points, the prospects for collaboration between the two projects are encouraging. A natural point of contact would be the Max-Planck-Gesellschaft zur Förderung der Wissenshaften e.V., a mutual partner.

TWINLATIN: "Twinning European and Latin-American River Basins for Research Enabling Sustainable Water Resources Management." This project proposes the concept of "twinning" water management practices in various Latin American river basins with policies established in well-known European basins. The river basins in this project are selected to represent a wide variety of conditions (including transboundary issues), and modifications of water management practices based on the local climatic-socio-economic context of the developing nations basins is to be analyzed and developed. This procedure has direct relevancy to ACQWA since one of ACQWA's latter objectives is the transfer of methodological developments gained from European alpine river basin studies to regions such as the Andes (Chile and Argentina), to help develop mitigation and adaptation policies under challenging political and economic conditions. A point of contact with this project would need to be identified.

BRAHMATWINN: "Twinning European and South Asian River Basins to Enhance Capacity and Implement Adaptive Integrated Water Resources Management Approaches." Similar to the TWINLATIN project, BRAHMATWINN aims to address integrated water resource management issues (including transboundary conflict resolution) by twinning Central

Europe’s Upper Danube River Basin with Asia’s Upper Brahmaputra River Basin. Again, lessons learned in this project with respect to the transfer of knowledge between Europe and Asia would be very useful for the latter phase of ACQWA which seeks to apply water resource management assessment and methodology to the selected river basin in Central Asia (Kyrgyzstan). In this instance, consultation and collaboration should be facilitated with two partners in common between both projects: the University of Dundee and the Eidgenössische Technische Hochschule Zürich (ETHZ).

ENSEMBLES: “Ensemble-based Predictions of Climate Changes and their Impacts”. This is currently the largest FP6 project involving climate simulations at the global and regional scales, using a suite of models and Ensembles-based approaches to reduce the uncertainties of future climate projections, whatever the spatial and temporal scale considered. ENSEMBLES will be a major source of climate-relevant data, that will enable not only current-climate simulations to be undertaken in an immediate first step, but also scenarios of climatic change and the impacts on mountain hydrology and associated systems to be implemented fairly rapidly in the early stages of the ACQWA Project.

B1.2.8. Wrap-up

The diverse and complex issues discussed succinctly above require an interdisciplinary and holistic approach to water management as climatic and socio-economic pressures change in the future. The project will promote a set of methodological approaches aimed at addressing these key issues and will prepare a decision-making framework for mountain water management. Short-term solutions to current and future problems of water resource management include, at least from a technological point of view, the construction of reservoirs to buffer the effects of increasing drought, although it is recognized that artificial lakes can also result in negative environmental impacts; there is also a reduction in the social acceptability related to the construction of new dams in many areas. Longer-term solutions require addressing the issues of greenhouse-gas emissions, beyond the 2012 targets imposed by the Kyoto Protocol. Changing land use in catchment areas may also be a means of adapting to the negative consequences of water availability and quality in many mountain regions in a changing climate. While the main focus is on the European case, its strengths and weaknesses are best assessed in a comparative framework. Response strategies are thus studied by contrasting the Europe Alps, with their relatively high level of economic development and robust institutional structure, with Central Asia (Luterbacher,et al. 2007, 2008)where poverty and latent conflict compromise effective water management. This approach permits an evaluation of a range of policy alternatives and may provide some positive recommendations to avoid conflict in a volatile region.

B1.3. S/T methodology and associated work plan

B1.3.1. Overall strategy and general description

Figure 1 provides a suggested outline of the different components of the project. This is made up of a number of work packages (WPs) that outline the overall concept by developing tasks (T) and subtasks (ST) as succinctly listed hereafter and discussed in more detail in section 3. The project WP structure is outlined as follows:

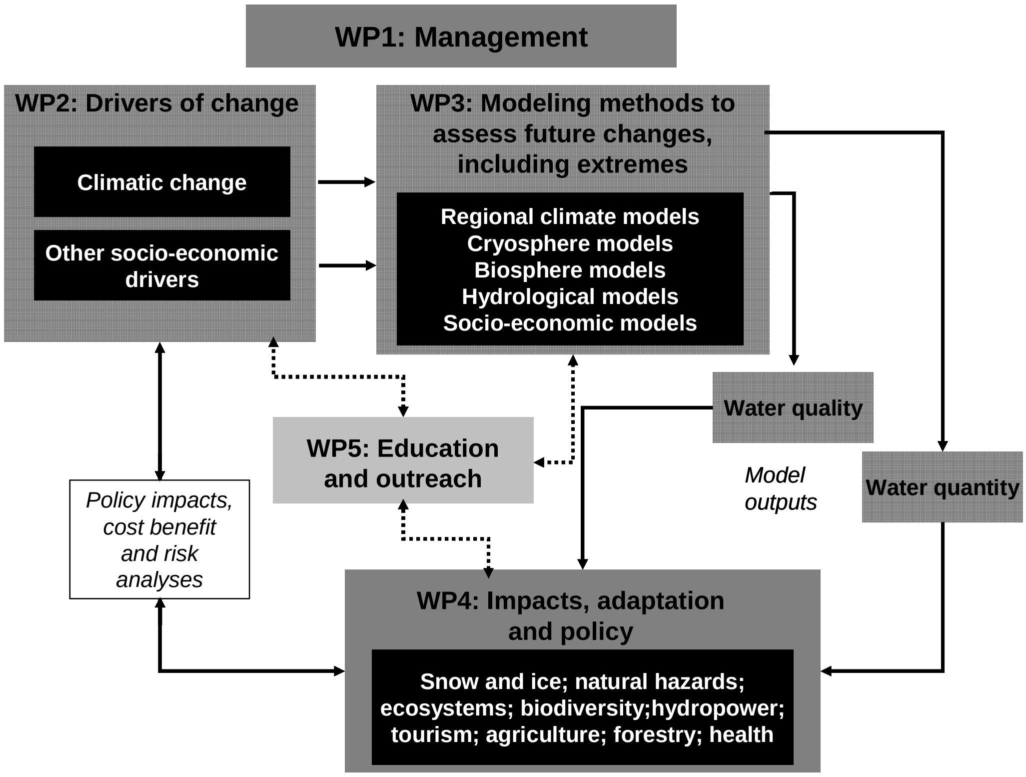

Figure 1: Flowchart illustrating the various work packages of the project. See also Figure 2.2 in Section 2.3 of this proposal for more detailed information on interactions between the work-packages and the team members.

- **WP1: Coordination and administration**

Coordinator: Martin Beniston, University of Geneva, Switzerland

The coordination of the project will be carried out by the University of Geneva and will conform to the rules and obligations imposed by the European Commission for all FP7 Large-Scale Integrated Projects. The coordination unit will also manage the financial aspects of WP5 (Dissemination and outreach activities).

- **WP2: Climatic and socio-economic drivers of change**

Coordinator: Anthony Lehmann, University of Geneva, Switzerland (Co-coordinator: Urs Luterbacher, Graduate Institute of International Studies and Development- HEID),

The WP will provide a quantitative description of the primary (or direct) driver, climate change, and of the indirect (or secondary) driver, the socio-economic factors. Specifically,

- the climate change driver will be described by means of recent climatic scenarios for validation of models and large and regional scale scenarios respectively from

General Circulation Models (GCMs) and Regional Climate Models (RCMs) simulations according to selected IPCC (Intergovernmental Panel on Climate Change) emission scenarios;

- the socio-economic factors will be quantified by means of scenarios of socio-economic developments, such as drivers of land use changes, drivers of energy demand, changes in agricultural policies, etc.

This WP will make available key datasets from local to global scales that are necessary to develop the modeling approaches used and developped within ACQWA. Data such as digital elevation models, land cover classifications, soil characteristics, weather stations and hydrological data, climate change predictions and useful remote sensing datasets will be gathered and organized so as to be distributed to any interested partners.

- **WP3: Modelling Climate Change Induced Regional and Local Effects on Water Resources, Including Extremes**.

Coordinators: Paolo Burlando, ETH-Zurich, Switzerland (Co-coordinator: Sven Kotlarski, MPG, Hamburg, Germany)

The focus of this WP is on developing the climate scenarios at the regional and local scale and on modelling of the effects of climatic change (CC) on water resources at the basin scale. The WP makes therefore use of (*i*) RCMs climate scenarios (regional scale), (*ii*) distributed models basin response to scenarios and (*iii*) models of local scale processes response.

The modelling strategy and the corresponding tasks, consist of developing and implementing a nested modelling framework that

- disaggregates the RCM scenarios to scales compatible with the catchment hydrological models by means of refined and/or newly developed downscaling techniques;
- describes the effects of CC at the scale of resources management by developing, refining and/or adapting a set of reference catchment scale models;
- describes the effects of CC on highly local processes – such as glacier retreat and morphological evolution, slope stability, debris flows – by means of local models that capture subgrid variabilities;
- develops methods to nest the subgrid variability models into the distributed basin scale models, to account for the propagation of local changes to the basin scale.
- The structure of the WP, as outlined in section 1.3.3, will deliver a number of outcomes, among which some of the key ones are:
- the extension of existing regional climate scenarios for the Alpine region (WP2) by high-resolution CC experiments in order to serve the specific needs of climate impact models within the project;
- the assessment of the uncertainty inherent to regional climate projections in the Alpine area;
- the development of new and refinement of existing downscaling methods for bridging the scale gap between RCMs and impact models in Alpine terrain, thereby including an explicit consideration of subgrid variability in the RCM projections, and a portfolio of techniques ranging from dynamic to stochastic downscaling;
- the analysis of CC effects on the hydrological cycle at the basin scale by using multiple hydrological models, thus matching the strategy used to produce climate scenarios from multiple models;
- an improved description, achieved by a nested scheme of hydrological processes modelling, of the basin response to CC through a continuum of space and time scales;

- a systematic and detailed analysis of glacier response to CC, which covers a variety of typical and representative glacier environments;
- an assessment of the stability of hanging glaciers resulting from recent climate fluctuations and a methodology to predict its evolution under CC forcing;
- an effort to model the double role of vegetation in the hydrologic-climatic system, first as reacting element to CC and controlling the hydrology and the nutrient cycle, second as feedback element to the climate system, specifically aiming at a bidirectional coupling with high resolution RCMs;
- an assessment of regional feedback effects that have a potential to modulate regional climate change signals (e.g., land cover changes).
- a prediction of the CC effect on extreme events, both of meterorological and hydrological nature, across several temporal and spatial scales, thereby including a focus on geomorphologic hazards.

- **WP4: Impacts of Climate Change on Water Quantity and Quality: Adaptation Strategies and Policy**

Coordinators: Ellen Wiegandt, HEID, Geneva, Switzerland (Co-coordinator: Ignacio Lopez, CSIC, Zaragoza, Spain)

The impacts, adaptation and policy work package will investigate the manner in which changing water resources and water use in the future will influence a range of socio-economic compartments in which water and water driven processes, and the climatic change effects on them, play a central role, namely:

- water quality and related human health
- hydropower production,
- winter and summer tourism
- forest management
- agriculture,
- ecosystems (aquatic and terrestrial) and biodiversity.

This WP will analyse not only the impacts but also a portfolio of adaptation and other response strategies together with their feedback mechanisms onto the natural system. These will be implemented back into the models of WP2 in order to assess the influence on the reduction of the severity of the effects and, in turn, on the speed and magnitude of climatic change driven socio-economic impacts.

- **WP5: Dissemination, outreach and training**

Coordination: Martin Beniston and Markus Stoffel, University of Geneva, Switzerland

As indicated by the EU project funding policy, this work package will be dedicated to project-specific workshop activities, publications, exchange of young scientists within the network, and public and stakeholder outreach activities. Steps will be taken to ensure that the results formulated within the project are disseminated to a wide audience, and that the conclusions reached within ACQWA can be implemented as widely as possible in national and supra-national frameworks. The following dissemination steps will include:

- Sector-by-sector and interdisciplinary workshops at various critical phases of the project
- ACQWA-sponsored events at major international congresses (EGU, AGU, etc.) to highlight the results and their applicability to a wider scientific arena
- Local conferences/seminars organized by individual partner institutions in order to stimulate awareness-raising to some of the key issues addressed within ACQWA
- Web-based newsletters edited on average each 6 months, to communicate the latest ACQWA results to the ACQWA community and beyond. Contacts with other relevant EU projects, academic institutions and government agencies will be activated in order to advertise as widely as possible the link to the ACQWA information website so that a wide audience can benefit from these information newsletters.

- A final report providing the essential details of the ACQWA Project results, a discussion of the methodologies and models used, and the possibilities and limits of applications of ACQWA developments to other mountain regions of the world. It is important that the momentum generated during the five years of the project be put to good use to other regions facing similar resource problems and vulnerabilities.
- A summary for policymakers: this document is similar in its concept to the philosophy developed by the IPCC to condense the information contained in the detailed reports. The ACQWA summary for policymakers will provide a short comprehensive overview of the most important conclusions of the ACQWA Project and the policy-relevant issues and solutions. The document will be circulated via the ACQWA policy+stakeholder interface (see the next point below).
- An important step in the transfer of research results to adaptation/policy will be the development of an **ACQWA policy+stakeholder interface**. While the project will complete its work with targeted stakeholder workshops in order to disseminate its findings to relevant communities (hydropower authorities, agriculture and forestry, etc.), it would be appropriate to set up a working group in collaboration with the European Commission. This working group would typically comprise 10-15 persons working at the EU policy level and within governmental (e.g., environment ministries and/or water management authorities) and supra-national bodies (e.g., CIPRA, International Rhine Commission and similar organization). The policy working group will be updated on ACQWA results at regular intervals, both using Internet facilities and through targeted meetings. By creating this “interface”, it is expected that the policy-relevant information will reach the appropriate targets in the most rapid and efficient manner.
- Additional spin-offs from the ACQWA Project could involve a trans-boundary Masters programme (see detailed WP5 description). A further by-product could brochure for school-children living in vulnerable mountain regions to raise awareness to the issues of water quantity and quality in a changing climate (including a teacher’s manual)**. These spin-offs would not be part of formal ACQWA deliverables but are destined to be follow-on products that will go beyond the duration of the project.**

Wrap-up of the Work-Package description

The project will focus in the **first three years out of five** on two test areas:

1 the Rhone river basin up to the Lake of Geneva and

2 the Po river basin up to Pavia, therefore including the Ticino catchment which partially shares the water divide with the Rhone basin.

The methodologies developed on the test cases will be transferred to other exemplary regions of the world, namely a more Mediterranean region, already with some overlap in time with the main research thrusts mentioned above; research on the following will begin between Months 12 and 24 and will be completed well before the end of the ACQWA Project in order to be correctly disseminate the research results:

1 the Pyrenees, which likely will shift from a nivo-pluvial regime to a pluvial one

2 the Aconcagua river basin in Chile, dominated by a number of large glaciers, which are the dominant source of water feeding the floodplains draining to one of the most productive regions of Chile that includes Valparaiso, the second largest urban agglomerate of the country, and finally

3 the mountain range of Kyrgyzstan, Central Asia, which is representative of a rather complex political, economical and social setup that may profit from climatic change impact on water resources, at least on the mid-term, and, at the same time, be at risk.