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UNITED NATIONS
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MINISTERO DELL'AMBIENTE
E DELLA TUTELA DEL TERRITORIO E DEL MARE

THE ALPINE CONVENTION IS THE FIRST INTERNATIONAL TREATY FOR THE PROTECTION AND PROMOTION OF THE SUSTAINABLE DEVELOPMENT OF A CROSS-BORDER MOUNTAINOUS REGION
italian presidency 2013-2014
alpine convention

5th Alpine Water Conference

Water in the Alps - and beyond

Adapting alpine and mountain river basin to climate change

Trento, 25th -26th September 2014

Autorità di Bacino
DEI FIUMI ISONZO, TAGLIAMENTO, LIVENZA, PIAVE, BRENTA-BACCHIGLIONE

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DEL FIUME ADIGE

UNIVERSITY OF TRENTO - Italy

ORDINE DEGLI INGEGNERI DELLA PROVINCIA DI TRENTO

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PREMISE

Since 2006 Alpine Convention works on water management and water-related issues, themes to which the Second Report on the State of the Alps is devoted.

On the same topic, the Alpine water conferences are biennial meetings (held in Innsbruck 2006, Munich 2008, Venice 2010, Munich 2012, Trento 2014) born to raise the attention on water management in the Alps and to spread the results of the activities of the Platform of experts established by the Alpine Ministers on this field.

The fifth Water Conference signed the completion of the Italian Presidency of the Alpine Convention and, in particular, of the activities of the Water Platform whose main scope was to advance the awareness of the impacts of climate change on mountain areas, promote common strategies for their mitigation, and support the development of a common view on the application of the EU water and flood directives.

An important aspect of the Alpine Convention activities is the link that the Convention created between mountain villages and cities, with the purpose of giving equal opportunities to both of them. One of the main link-factors is water –including water uses and water-related risks – and,in this sense, the Alpine Convention started further international collaborations for achieving the objectivesof preservingand reestablishing healthy water systems, supporting multi-level and transboundary water quantity management, facing climate change impacts.Among these collaborations, the 5th Water Conference valorized the cooperation between the Alpine Convention and the UNECE Water Convention in terms of multi-sectoral and multi-lateral water management and adaptation to climate changes.

The 5th Alpine Water Conference has also been theoccasion to preliminarly illustrate and discuss the guidelines for local adaptation to climate change in the Alpine Region – whose aim is to connect the different levels of action in order to face climate change consequences –, later approved by the Alpine Ministries during the XIII Meeting of the Parties of the Alpine Convention in Turin (November 2014).

Therefore the Conference has been an important occasion that allowed a global comparison on climate change adaptation in the water sector in mountain regions, which deserve to be illustrated and reminded in this publication.

Paolo Angelini
Head of Delegation to the Alpine Convention
Italian Ministry for the Environment, Land and Sea

5TH INTERNATIONAL WATER CONFERENCE "WATER IN THE ALPS"
WATER IN THE ALPS – AND BEYOND

Adapting alpine and mountain river basins to climate change

Based on contributions delivered during the Conference in Trento, on September 25th-26th, 2014
Conference organization chaired by Paolo Angelini (IMELS - Italian Ministry of the Environment, Land and Sea) with the technical-scientific coordination of Andrea Bianchini (Eurac Research – Rome office) and the support of Matteo Dall'Amico (University of Trento Consultant), Ramona Paris (Eurac Research – Rome office), Riccardo Rigon (University of Trento), Antonio Ziantoni (Eastern Alps District Authority)

Publication developed by the Italian Ministry for the Environment, Land and Sea – Italian Delegation to the Alpine Convention

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A special thanks is devoted to all the speakers of the Conference, here mentioned in order of intervention: M. Marchesi, M. Gilmozzi, P. Angelini, S. Vrevc, M. Cozzone, S. Vito, J. Timmerman, A. Lipponen, R. Rigon, M. Patek, J. Mysiak, M. Beniston, R. Stephan, A.Bellin, W. Lexer, S. Gruber, A. Armanini, U. Morra di Cella, J.Papez, A. Bizjak, S.Grošelj, M. Howells, D. Iervolino,F. Baruffi, R. Rocco, R. Coali, R. Hornich, K. Gombas, L. Stravs, A. BallarinDenti, E. Buttanri, C. Schilling, R. Verdiyev, S. Szalai, N. Kruta, I. Domashov

Layout: Marco Di Palma (Eurac Research – Rome office)
Cover:
Photo Cover: Andrea Bianchini (Eurac Research – Rome office)
Printing:
Rome, May 2016
ISBN: 978-88-904995-7-9

TABLE OF CONTENTS

INTRODUCTION

The Alpine water conferences "Water in the Alps" highlight the importance of water management and water-related issues in the Alpine context. Water management, in fact, is included among the 12 pillars of the Alpine Convention (art. 2 of the Framework Treaty).

The V Alpine Water Conference "Water in the Alps - and beyond: adapting alpine and mountain river basins to climate change" aimed to spread the results in a wider context, involving other mountain regions like Carpathians, Caucasus, Central Asia and Lebanon. The event has been jointly promoted and developed by the Alpine Convention and the UNECE's Water Convention, in order to favor the creation of synergies and the exchange of experiences. The 5th Water Conference provided to a wide audience of experts, administrators, practitioners and stakeholders the state of the art, the best practices and the main findings about adaptation to climate change in the mountain trans-boundary river basins. Different panels of experts illustrated the main results of the last years of activities in the respective conventions. Furthermore, updated high-level information on climate change and adaptation strategies havebeen provided, together with the results of some relevant projects of European Territorial Cooperation on the issues. Finally, a special focus has been devoted to the implementation of the measures of flood management, in particular the EU Flood Directive.

The connection between climate change and water is the reason why the Alpine Water Conference is so important, being a way to disseminate knowledge and to create a link between local administration and scientists. The challenges addressed during the Conference are also about taking decisions that go beyond national borders and the need to find financial resources not only for emergency situations, but also for financing prevention.

Taking into account both the contributions of the speakers and the experts in the public during the Conference, as well the results of the activities of the Platform of experts established by the Alpine Convention, the publication aims to sum up the state of the art in adaptation to climate change in the water sector in different mountain regions, as well as promoting good practices in this sense.

The document is a dense synthesis that covers the three related topics of climate change and adaptation to climate change, application and harmonization of the EU water and flood directives, the management of transboundary basins, which were discussed at the Conference and are treated in distinct chapters.

CLIMATE CHANGE IN ALPINE AREAS AND ADAPTATION STRATEGIES

CLIMATE CHANGE IN THE MOUNTAIN REGIONS[1]

The Fifth Intergovernmental Panel on Climate Change (IPCC) Assessment Report contains a new family of projection based on scenarios called "Representative Concentration Pathways" and iscomplemented by a Special Report on Emissions Scenarios (SRES) (Misiak)[2]. Its main messages are the following:

1. The warming of the climate system is unequivocal and the assessment report provides a very convincing evidence that the last three decades where unique in the instrumental record period. It is extremely likely (more than 95%) that human influence has been the dominant cause of the observed warming since the mid-20th century.
2. The observed climate change is increasing magnitudes of warming, which increases the likelihood of severe, pervasive, and irreversible impacts.
3. Without additional climate mitigation efforts to reduce greenhouse-gas (GHG) emissions (beyond those in place today), projections suggest an increase in global mean temperature in 2100 of 3.7 to 4.8 °C.

As far as precipitation is concerned, there is less confidence in the trend of changes of the global precipitation patterns. Generally, in the future the rainfall is expected to increase, however, with great heterogeneity between wet and dry regions and wet and dry seasons.

If we downscale to Europe, the projections expect a marked increase in high extremetemperature, an intensification of meteorological droughts and an increase of heavy precipitation events. Downscaling to the alpine area, a more dramatic impact of climate change has been observed:

- in the last century, the Alps have seen an important rate of change regarding temperatures (1-1.5 °C), which is similar to other mountain regions, but more intense (three times higher than the global rate of change), as displayed by Illustration1where the blue curve represents the rate of change of global temperatures and the red line represents the rate of change of temperatures in the Alps (*Beniston*)[3]. Within the last 30 years the temperature increase recorded in the Italian Alps is threefold the average increase registered in the entire boreal hemisphere (OECD, 2008; Alcamo, 2007); in particular, an increase of at least 2°C in the 20th century in the Alpine region is forecasted (Massarutto, 2011);
- time series of snow height recorded in 41 meteorological stations in the Alps and spanning over the period 1920-2005 highlight a clear decreasing trend (Valt et al., 2005). This trend is even more evident in the last 30 years because the snowfalls have decreased by 18% with respect to the benchmark period 1959-2002; drop larger than 40% have been registered at stations at low elevations.

The variations in the climatic forcings forecasted for future years project an intensification of the warming and a rise of the snow-line. In particular for:

- temperature: a continuous rise in the average temperature is foreseen (IPCC, 2007, Beniston,

1 Text reviewed, based on the presentations exposed at the 5th Water Conference "Water in the Alps - and beyond: Adapting alpine and mountain river basins to climate change", Trento, Italy, 25th-26th September 2014,

2 Misiak, J. (2014): *Presentation of the 5th version of the assessment on climate change from the Intergovernmental Panel on Climate Change – main results and new findings,*Fifth Water Conference, Trento, Italy, 25th, 26th September 2014

3 Beniston, M. (2014): *Regional models and observed changes in the Alps,* Fifth Water Conference, Trento, Italy, 25th, 26th September 2014

2005);

- rainfall: forecasted changes in long-term rainfall amount vary between the different alpine regions but, due to changes in rainfall intensity and seasonal shifts, extreme events are likely to become more intense; i.e. a decrease in the rainfall amount, between -1 and -11% (Massarutto, 2011), and an increase in rainfall intensity is foreseen in the Italian part of the Alps (Brunetti et al). The long-term average rainfall amount will remain more or less constant, but with seasonal shifts from summer to winter season in all Austrian regions (BMLFUW 2012);
- snowfall: the minimum elevation with snow presence will increase; Foehn (1990) and Haeberli and Beniston (1998) claim that an increase in air temperature by 1°C will result in an increase of150 m in the minimum snow presence elevation;
- water and ice: consequent increase in water temperature as well as the melting of wide areas of permafrost (Massarutto, 2011); significant increase of flows in the winter (up to 20%) and decrease of flows in the summer (-20%) (CLIMCHALP WP 5, 2007); increased frequency in droughts and frequency and intensity of negative extreme events; melting of glaciers (Massarutto,2011);
- nature: migration of flora and shift of tree line (Massarutto, 2011); loss of biodiversity (IPCC, 2007).

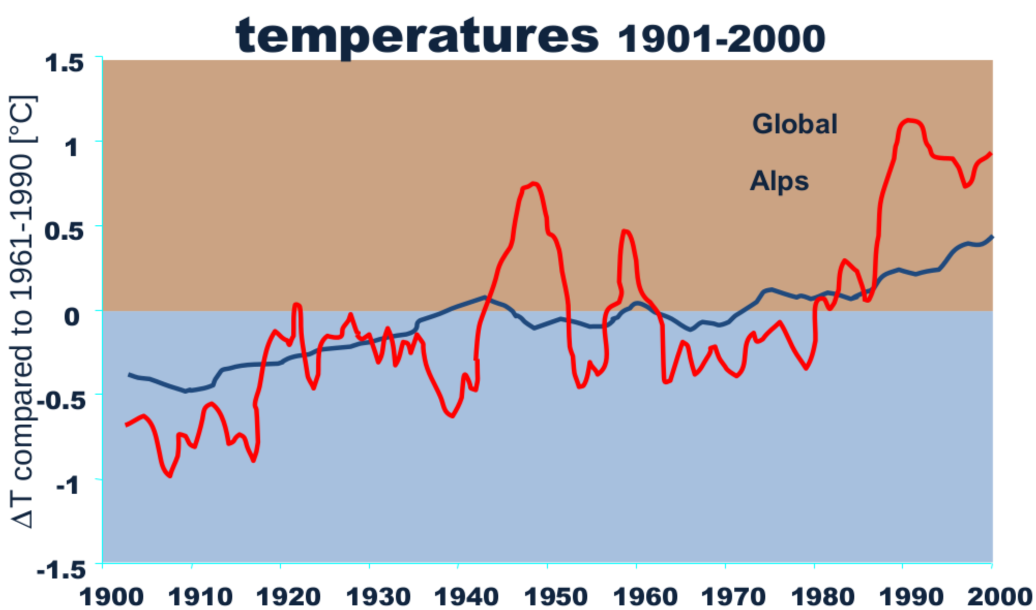

Illustration1 - *Evolution of global and alpine temperatures 1901-2000 (Beninston).*

Impacts on the cryosphere

The cryosphere may be defined as the portions of Earth's surface where water is in solid form. At mid latitudes, this normally indicates snow covered ground, glaciers and frozen ground (which includes permafrost). The cryosphere evolution is characterized by a complex interaction between moisture (precipitation) and energy fluxes and therefore is very sensible to climate change effects, in particular on air temperature and precipitation changes as they influence the formation of snow and consequently the evolution of glaciers. In the following, we present the major impacts on the cryosphere in the Alps according to the reports of Prof. Beniston, Gruber and Bellin[4] in this conference.

Snow presence and winter tourism: A 1˚C rise in average temperatures combined with winter drought may reduce the lastof the Alpine snow cover by 50% at 1500 meters, with enormous consequences for the skiing industry (Information Unit on Climate Change - IUCC, 2007). Light snowfalls are already a problem for many ski-site operators in the Alps and could, if they continue, eliminate winter sports from many regions within 20 or 30 years.

Glacier melting: Zemp et al. (2006) note that Alpine glaciers lost 35% of their total area from 1850 until the 1970s, and almost 50% by 2000 (Illustration2provides an example of glacier mass loss occurred during the last century). Based on model simulations, they show that a 3˚C warming of summer air temperature would reduce the currently existing Alpine glacier cover by some 80%, or up to 10% of the glacier extent of 1850. In the event of a 5˚C temperature increase, the Alps would become almost completely ice-free. For each one degree Celsius increase in summer temperature, precipitation would have to increase by 25 percent to offset the glacial loss, yet annual precipitation changes of ±20% would modify such estimated percentages of remaining ice by a factor of less than two.
Such extreme glacier wasting may have several impacts in densely populated high mountain areas such as the European Alps:

- National economic costs: glaciers play an important role as water reservoirs for hydro-power production (in Switzerland they supply water for generating 50% of all electricity, (Paul et al, in press) and also represent an important economic factor for tourism. Their retreat could eventually cause economic losses for the local community and even for the whole country;
- Glacial lake outburst floods (GLOFs): they are catastrophic discharges of water resulting primarily from melting glaciers. An accelerated retreat of the glaciers in recent times has led to an enlargement of several glacial lakes (Horstmann, 2004). As the glaciers retreat, they leave a large void behind and ponds occupy the depression earlier occupied by glacier ice. Eventually, a moraine dam may break by the action of some external trigger or self-destruction. External triggers can be earthquakes or a huge displacement wave generated by rockslide or a snow/ice avalanche from the glacier terminus into the lake that may cause the water to top the moraines and create a large breach that eventually causes dam failure. Self- destruction may be the result of the failure of the dam slope and seepage from the natural drainage network of the dam. Even-though more usual in Himalaya and Nepal, these hazards may occur also in the Alps. In the Swiss Alps, lake outbursts and subsequent debris flows have caused a large number of deaths and severe damage to alpine villages and other installations (Huggel et al., 2004). In the Italian Alps an emergency occurred in 2002 and 2003 at the base of the huge eastern face of Monte Rosa, where the "lagoeffimero" rapidly increased its extension, posting an extreme hazard to the downstream famous holiday village of Macugnaga (Fisher et al, 2006).

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[4] Beniston, Gruber, Bellin (2014): Fifth Water Conference, Trento, Italy, 25th, 26th September 2014

Illustration2 - *Photografic comparison of the Careser Glacier in 1933 and in 2012 (Bellin).*

- Debris flow triggering: especially critical is the availability of large quantities of unconsolidated, non-vegetated sediments as a consequence of general glacier retreat and permafrost degradation. Chiarle et al. (2007) show in how various and numerous ways, glacier and permafrost changes recently caused natural hazards and disasters in the Italian, French and Swiss Alps.

Permafrost degradation: the mountain cryosphere reacts sensitively to climate change but, whether the reduction in glacier area is well documented, a widespread and persistent melting of permafrost can only be inferred, without the opportunity of direct observation. This is in fact done using models whose outputs are maps of permafrost distribution like the one represented in Illustration3.

The permafrost thaw has consequences in many fields: the attenuation of debris flows is reduced, rock glaciers become faster, fine material is exposed to leaching and solute load changes.

Another important aspect that was registered is the connection between the degradation of permafrost and the release of rockfalls.

As *Morra di Cella*[5] outlines, the urgency to monitor the changes in permafrost conditions has originated the PermaNET project (http://www.permanet-alpinespace.eu/). Data collection allowed to create a map of permafrost distribution on an Alpine scale. Furthermore, strategies for dealing with permafrost-related natural hazards were developed. In fact, permafrost degradation can affect different sectors and mountain surface waters may experience a strong change in chemical composition. For example, it has been observed that water melting from rock glaciers is highly concentrated in heavy metals and ions.

[5] Morra di Cella, U. (2014): *Permafrost in the Alps: the experience of PermaNET project,;* Fifth Water Conference,Trento, Italy, 25th, 26th September 2015

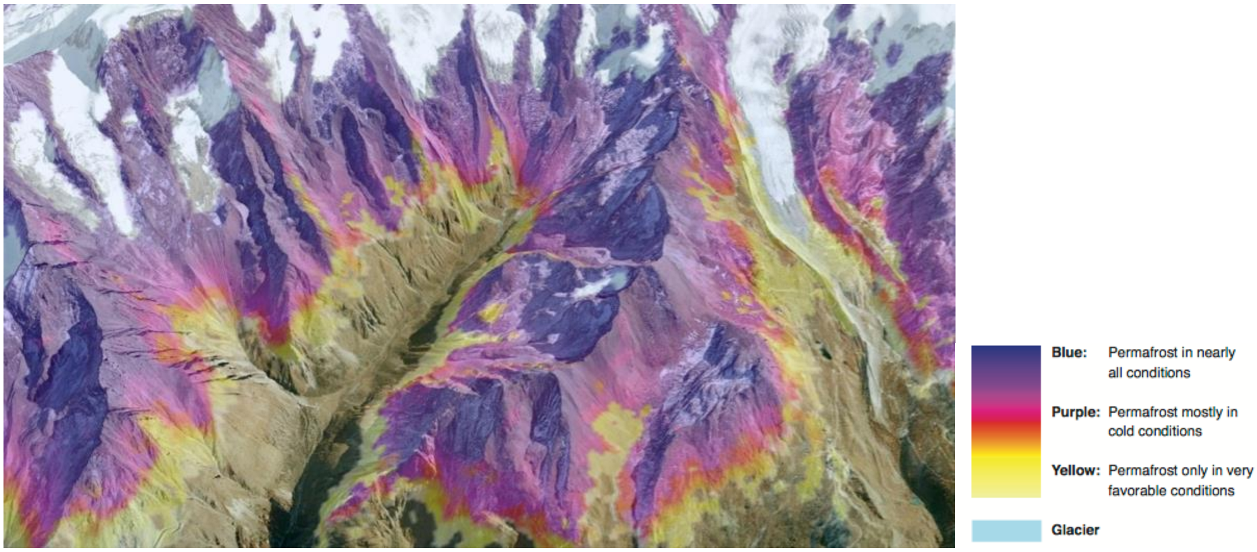

Illustration3 - *Permafrost distribution in the European Alps (Gruber).*

Impacts on water resources

Hydrological systems will respond in quantity and seasonality to the changing precipitation patterns and to the timing of snow-melt in the Alps, with a greater risk of flooding during the spring and a higher probability of droughts in summer and fall.

As *Beniston*[6] outlines, water resources are expected to affect downstream regions, both from an environmental andan economic point of view. In fact, key economic sectors such as tourism, hydropower, and agriculture will be affected, while shifts in extreme events will have an impact on the vulnerability of infrastructure and a range of economic services.

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6 Beniston, M. (2014): *Regional models and observed changes in the Alps*, Fifth Water Conference, Trento, Italy, 25th, 26th September 2015

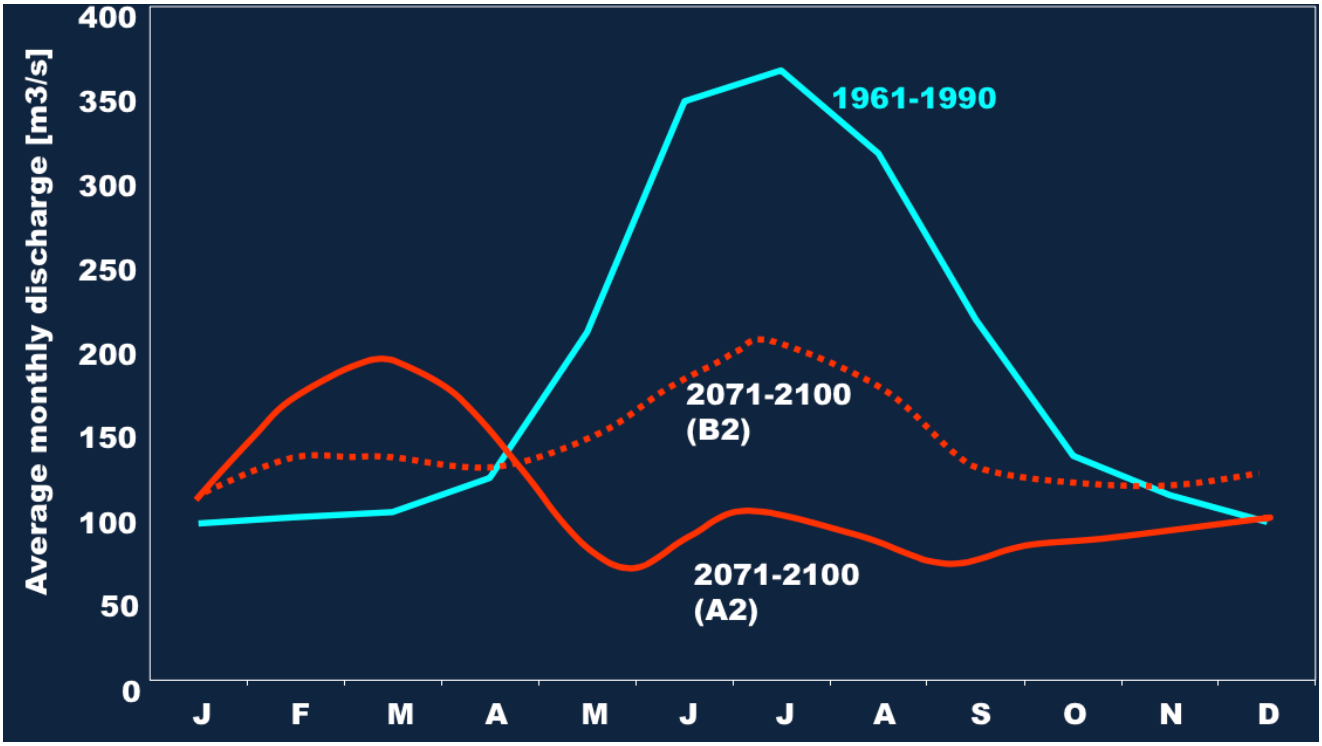

Illustration4 -*Possible future discharge by 2100 (Beniston et al).*

Impact on water resources due to climate changes can be classified as follows:

- changes in precipitation regimes: as reported in Illustration4, an increase in the snow elevation line and a progressive loss of ice mass,involve a variation of the flow regime in alpine torrents, consisting in a reduction in the summer discharge and an increase in the winter discharge (Beniston et al.)[7].With these conditions we might expect the increasing of flood hazards(Lautenschalger et al., 2008) and the decreasing of water availability during summer for agricultural activities and human consumption (Weingartner et al., 2007):
- in the last 130 years rainy days have decreased whereas dry days seems to have increased by 2 units per century (Lionello et al., 2009). Lehner et al. (2006) and Giannakopoulos et al. (2009) estimate that drought events will be two times more frequent than now in 2050 and three times more frequent in 2070. The increase in air temperature is accelerating glacier melting and permafrost degradation, as a consequence fresh water resources will be reduced and slope will become more unstable (Margottini et al., 2007). Zemp et al. (2006) estimates that an increase in the average air temperature in the summer by 3˚C can cause a decrease in glacier cover i.e. by 75% in the Italian Alps:
- Van Vliet et al. (2012) claim that bothmountain torrent environment (streams and rivers) and lakes and humid areas climate changes are causing an increment of water temperature; this, in addition to other secondary impacts, can degrade water quality and cause further problems on ecosystems. In the largest alpine lakes (such as Lago Maggiore, Lago d'Iseo, Lago di Garda e Lago di Como) the water temperature has increased roughly by 0,1-0,3°C every decade since the 1950s

[7] Beniston, M. (2014): *Regional models and observed changes in the Alps*, Fifth Water Conference, Trento, Italy, 25th, 26th September 2015

(Dokulil et al., 2006). In future decades larger additional increments are expected; presumably for Alpine lakes this increment will be larger in the superficial layers than in the deeper ones. This is likely to cause a thermal stability, which will result in a weaker vertical water circulation (Peeters et al., 2002), which, in turn, will reduce the oxygen available in the deep layers and, as a consequence, the chemical water quality:
the higher intensity in precipitation is likely to induce an increase in erosion processes and, as a consequence, an increase in the nutrient and sediment transport in streams and rivers (Garnier M., 2007):

- evaporation is also affected and in the future, it will be reasonableto lead to the change of vegetation species and the shift of the tree line (Massarutto, 2011).

It is important to remind that local downscaling of rainfall predictions provided by climate model is crucial for the assessment of climate change impacts on hydrological processes because the presence of bias in downscaled precipitation may produce large bias in the assessment of soil moisture dynamics, river flows and groundwater recharge (Portoghese et al., 2010). Some methodologies have been set up, in order to reduce the bias. The AQWA project (www.acqwa.ch), financed by the 7th Research Framework Programme, has developed models to investigate how climate changes can affect snow and ice, in order to help the formulation of guidelines and recommendations.

Impacts on sediment generation

The cryosphere is a potent modulator of sediment and solute transport in mountains and its changes are persistent, but due to complex interactions, difficult to predict. These changes can be expected to occur globally in all cold mountain ranges, however their relative importance, could bedifferent. As we begin to understand and quantify these effects, the Alps with their dense population, ready accessibility, and measurement infrastructure will provide a model region for other mountain areas.
The project SedAlp (SEDiment Management in ALPine basins, www.sedalp.eu) aims to develop and test strategic policies and tools for an integrated management of sediment transport in Alpine basins, directed to an effective reduction of sediment-related risk, while promoting the enhancement of riverine ecosystems and reducing the impacts of hydropower plants.
As *Papez*[8]outlines, under this project new technologies have been tested, such as in the case of using drones in sediment survey integration of historical data to better understand the Alpine catchment evolution. Moreover, SEDALP will allow to create a standardization of methods for data collection in sediment transport and to have a better understanding and estimation of wood discharge.
According to *Rosatti*[9], the increase in probability of events with high concentration of sediments requires models able to deal with these transport conditions. Exner-based models are not particularly suitable for Alpine rivers subjected to climate change, because they have a severe limit of validity that regards the solid concentration ($c<1\%$). Monophase models are unphysical and have no real forecasting capabilities, so two-phase isokinetic models are almost compulsory to account for climate change, however the type of numerical scheme used in the model has to be carefully chosen.

8 Papez, J. (2014): *Presentation of the results of the European Territorial Cooperation Project SedAlp* Fifth Water Conference, Trento, Italy, 25th, 26th September 2014

9 Rosatti. (2014): *Sediment transport in alpine river basins,* Fifth Water Conference, Trento, Italy, 25th, 26th September 2014

LOCAL ADAPTATION TO CLIMATE CHANGE[10]

The main goal of an adaptation strategy is minimizing the risks connected to climate changes, protecting public health, life quality, properties and preserving the nature, by improving the adaptation capability of natural ecosystems, social and economic systems; in addition, a robust adaptative strategy should be able to take advantages of new opportunities. As reported in the White Paper, the strategy tackling climate changes suggests two possible actions: 1) a reduction of the greenhouse emissions with the objective of slowing down global warming (mitigation actions) and 2) an increase in the ecosystem resilience and in human activities resilience to tackle unavoidable impacts in the short terms (adaptation actions).

The topic of adaptation to climate change is dealt not only by environmental agencies or Ministries, yet also by other organizations. For example OSCE (Organization for Security and Co-operation in Europe) has a whole sector dedicated to the environmental aspects. As *Buttanri*[11]points out, many activities are going on, e.g. transboundary water co-operation - in collaboration with UNECE, climate change and security, disaster risk reduction, hazardous waste management, and environmental good governance. The topic of this year's meeting was "Responding to Environmental Challenges with a View to Promoting Co-operation and Security in the OSCE Area" with particular focus on disaster risk reduction.

Within the Alpine area, at present, all the participating countries, besides Slovenia, have adopted their National Adaptation Strategies (NAS). On a local level, there are also good practices of local adaptation plans, especially on water resources (e.g Styria, Lombardy). However, due to the differences in expected impacts ofclimate changeonthe different Alpine countries, a "one size fit's all"- approach cannot be recommended. According to *Schilling*[12], the issue of dealing with natural hazards has been given different values in different countries. In fact, whether Austria is already provided with a national strategy for disaster risk prevention and management, Bavaria (Germany) and South Tyrol (Italy) are lacking of local adaptation plans. Therefore the Water Platform, in cooperation with the Planalp Platform, has provided a document[13] that includes a catalogue with a non-exhaustive list of potential measures/actions, which could be selected according to specific regional needs. The following section represents a synthesis of these measures.

Potential actions in the management of the water resources

Given the impacts, described above it is foreseeable that climate change will affect both the demand of water resources, which will increase and become more rigid and vulnerable with different characteristics across countries, and of water availability, which will become more aleatory and probably will decrease. Furthermore, it is foreseeable that the requests of defense for the environment and for the ecosystem will

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[10] Text reviewed, based on the presentations exposed at the 5th Water Conference "Water in the Alps - and beyond: Adapting alpine and mountain river basins to climate change", Trento, Italy, 25th-26th September 2014, and on the information taken from the document "Guidelines on local adaptation to climate change for water management and natural hazards in the Alps".

[11] Buttanri, E. (2014): *Responding to environmental challenges with a view to promoting co-operation and security in the OSCE area* Fifth Water Conference, Trento, Italy, 25th, 26th September 2014

[12] Schilling, C. (2014): *Adaptation to climate change in the water sector in the Alpine region – outcomes and main findings of the Workshop "Water and risk management facing climate change: towards the local adaptation",* Fifth Water Conference, Trento, Italy, 25th, 26th September 2014

[13] Guidelines on local adaptation to climate change for water management and natural hazard in the Alps

become more pressing and demanding, in order to guarantee human health, the equilibrium of the ecosystem and the prevention of natural hazards.
It is thus necessary to reduce the expected impacts and to increase the resilience of human activities. In order to do so, adaptation actions must be put in place. These potential actions may be divided into:

1. infrastructural and technological measures ("grey" measures): these potential measures generally include mitigation structures, efficiency improving interventions, monitoring actions or the implementation of decision support systems for responding in time to extreme events;
2. ecosystem oriented measures ("green" measures): these measures are about environmental and fluvial re-qualification interventions;
3. non-structural interventions ("soft" measures): these actions include the increase of knowledge through research, legislative and planning processes, communication tools aimed at increasing the consciousness and at influencing the lifestyles of people. In the following pages a list of strategic adaptation actions will be given, on the basis of what originally was proposed by the Italian Ministry for the Environment, Land and Sea[14], the Lombardy Region[15] and CIPRA Italy[16], subsequently discussed and shared with the delegations of the different Alpine Countries.

Potential "Grey" measures

1. Optimizing use of the available water resources (adjustment of the offer where appropriate, efficient irrigation, conservative agricultural system to increase the water storing capacity where needed, prevention of soil erosion, optimization of the distribution systems);
2. structural interventions aimed at updating the water pipelines and reducing water leakages;
3. strengthening of the current methods for monitoring the status of surface and ground water resources;
4. empowering of the current monitoring systems of water resource at high elevation (especially the snow water equivalent);
5. improving the current database and predictions of water consumptions and of runoff volumes;
6. strengthening the interregional exchange of data and monitoring systems;
7. technological upgrade of the measuring systems (e.g. remote sensing...) where appropriate.

Potential "Green" measures

1. Re-qualification of the rivers keeping into consideration the minimal vital flow (MVF) and of the ecological status;

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14 Elementi per una Strategia Nazionale di Adattamento ai Cambiamenti Climatici, documento per la consultazione pubblica, 12 settembre 2013 (ItalianMinistry of the Environment: public consultationprocesstowards a National Strategy of adaptation to climatechange - http://www.minambiente.it/sites/default/files/archivio/comunicati/Conferenza_29_10_2013/Elementi%20per%20una%20Strategia%20Nazionale%20di%20Adattamento%20ai%20Cambiamenti%20Climatici.pdf)

15 Linee Guida Piani di Adattamento ai Cambiamenti Climatici, Regione Lombardia (towards a regionaladaptationstrategy in Lombardia - http://www.reti.regione.lombardia.it/cs/Satellite?c=Redazionale_P&childpagename=DG_Reti%2FDetail&cid=1213581345956&pagename=DG_RSSWrapper)

16 Antonio Massarutto, Acqua e cambiamenti climatici, compact n. 03/2011, CIPRA InternationaleApenschutzkommission (http://www.cipra.org/it/pubblicazioni/4807)

2. creation of buffer zones between rivers and cultivated areas where appropriate;
3. protection and restoration of wetlands, not only in the riparian zones, but also more widely;
4. restoration of the ecological integrity of the riparian and lateral areal (transition zones) of the rivers where possible, in order to strengthen their role of regulation of bio-geo-chemical processes: a) insure the protection of the area devoted to the water; b) minimize the disturb associated with the uptake and release of water from hydropower plants; c) re-activation of the relict fluvial forms where possible;
5. Multipurpose management of existing reservoirs.

Potential "Soft" measures

Legislation and planning

1. Develop a multi-annual management attitude towards the water resources, where it is not yet considered;
2. recalculate the historical water requirement and water grant, where appropriate;
3. develop integrated programs for improving the efficiency of irrigation, drinking and industrial usage for optimizing the consumptions; ensure the minimum vital flow (MVF) taking into consideration climate change predictions.

Management

1. Create flood and, where appropriate, also drought management plans. Ensure the attainability of water resources management objectives in case of severe drought and design of *warning system* based on the expected most frequent water scarcity (LAWA, 2007):
2. ensure the progressive compliancy to the legislation on MVF and on the water quality standards based on the 2000/60 EC directive.
3. optimized management of the lake levels when appropriated. Efficient water management in the irrigation sector;
4. creation of plans for the management and utilization of urban run-off, where appropriate;
5. use of stored rainwater, joint use of resources with other big users, re-use of used water (e.g. for flushing the toilet or watering the garden).

Communication – Dissemination - / Participation

1. Collect and disseminate the available information on climate change;
2. disseminate information on the existence of good practices in agriculture, in domestic sector and in industry through stakeholder cooperation;
3. promote events for awareness raising in the area affected by the variation of the hydrological cycle (extreme events, drought, high runoff variability, etc.), e.g. Extend and strengthen the participation through negotiation tools and increase the protection measures of available water in the mountain territory.

Economy / incentives

1. Define incentives for production of products characterized by efficient water usage requirements and/or high water quality level (grey water), where appropriate.
2. Planning of economical tools for the management of climatic risk

(insurance, etc.), where feasible.

Potential actions for the management of natural hazard

As for the actions proposed in the context of water management, this chapter provide a catalogue with a non-exhaustive list of potential measures which could be selected according to specific regional needs.

In Alpine areas natural hazards represent one of the biggest threat tohuman life, the integrity of infrastructures and belongings. The actual hazard is sometimes exacerbated by the construction of infrastructures or urban expansion in hazardous zones and by the harshening of extreme events given by climate change. As some hazards (e.g. glacial and hydro-geological hazards) may interact in a synergic way, reacting to given meteorological events (heat waves or intense precipitation), the integrated and interdisciplinary management of natural hazards has become a crucial priority in the adaptation strategies of most alpine countries (AdaptAlp, 2011). The adaptation actions that may help in this context have been divided into three different classes: “grey”, “green” and “soft” measures as below described.

Potential “Grey” measures

1. Construction of additional mitigation structures to assure the security of hazardous zones;
2. strengthen the current monitoring network of the phenomena through the installation of meteorological stations (containing rain gauge, thermometer and snow height sensors) in (small) basins considered to be prone to extreme events.

Potential “Green” measures

1. Enlarge the room for rivers and restrict the soil pavement, in order to save the natural capacity of the river banks to smooth the discharge peak;
2. promote the recovery of mountain agricultural zones (e.g. terraces on the slopes) and insure a correct maintaining of the mitigation structures;
3. privilege the use of natural protection systems (e.g. water retention basins) when adding supplementary mitigation structures is necessary.

Potential “Soft” measures

Planning	1. Continuously update the cartography related to hazard maps, adding considerations on climate change; 2. identify the most critical areas subject to the combined action of natural hazard and climate change; 3. increase the use of territorial planning to reduce the demand of new infrastructures in hazardous zones and consequently decrease the vulnerability of the system.
Management	1. Empower the natural hazards management through the use of multi-risk analysis; 2. upgrade the current alert/alarm systems and the emergency procedures, given the increase of frequency of extreme meteorological events
Communication – Dissemination - / Participation	1. Assure the continuous education and training on natural hazards directed to the population living in the mountains; 2. increase the consciousness of the people on the main natural hazards and on

the residual risk;
3. promote the insurance systems on natural hazards;
4. promote events of communication directed to the house owners on the type of hydraulic risk and on the mitigation structures;
5. promote the exchange of experience and good practices (e.g. PLANALP database, PLANAT of Switzerland);
6. promote the cooperation with stakeholder;
7. assure the transparent sharing of the monitoring data, of the terminology and of the calculation methodologies of the integrated risk among the alpine regions.

Guidelines on Local Adaptation to Climate Change of the Alpine Convention

As reported in the *Guidelines for Climate Adaptationat the local level in the Alps*, climate change impacts haven't boundaries. Impacts are expected to vary across the countries and whithin each State. Climate change adaptation requires responses at all levels of governance: national, regional, local and collective.
Considering the point of view of the policy, the adaptation concept refers to take account of all types of policy-making and planning of the climate scenarios and all their possible socioeconomic impacts. To do this, it is important a forward thinking and a policy that involes all the political, social and economic actors.
The Alpine Convention's guidelines for adaptation strategies at a sub-national level were completed in September 2014 and its main points were presented.
The guidelines' structure is divided into three main topics: the first one describes the conceptual and institutional framework, the second one regards policy guidance for the development and the implementation of sub-national Adaptation Strategies in the Alps, finally the last one gives the description of the key factors to ensure success of sub-national adaptation strategies at local level in the Alps.

The aim of adaptation strategy is to minimize the risk connected to climate change, particularly safeguard public health, life quality, properties, and to preserve the natural environment by improving the adaptation capability of natural ecosystems and the social and economic systems. Adaptation implemented at local level can be carried out in short time scale and can be modified according the different local situations. However the management and the governance for the implementation of adaptation strategies at local scale can have some obstacles, due to knowledge gaps, political commitment by local policy-makers and technical support. With these difficulties it is important an effective economic aspect that has also a significant role concerning local adaptations. Costs and benefits assessment provides planners with essential information about priority, when and where to act and allocate financial and technological resources. The priorization of the adaptation measures has to be based on transparent and clearly defined criteria. However the shortage of funding and financial incentives can undermine the willingness of stakeholders to take part to these actionscooperations between local and regional actors.
Concerning the development and the implementation of sub-national Adaptation Strategies in the Alps, any adaptation process can be divided into four stages: 1) assessment of impacts, vulnerability and risks, 2) planning for adaptation, 3) implementation of adaptation measures, 4) monitoring and evaluation of adaptation interventions.It is essential that adaptation plans at local level must be consistent and coherent with the national ones and it is important that national authorities translate global indicator in

locally applicable ones, and develop specific projections of climate change and its impactat local scale.

Guidelines for Climate Adaptation at the local level in the Alps reported a survey to explain the three main challenges to be addressed, in order to deliver a defined and effective adaptation planning at the sub-national level: 1) perception and awareness, 2) knowledge and uncertainties, 3) policy integration.
Adaptation shows a number of possible synergies and integration among different sectors, that if properly managed can support other policies where money and engagement have less funding available. Integration among adaptation actions is desirable and it can be achieved by adopting a crosscutting approach, involving different sectors, stakeholders and interest groups in adaptation planning. As reported in the guideline, «*An effective participation brings about several benefits: it allows to spread out scientific information about climate change, identify the most significant impacts and vulnerabilities and consequences at local level, facilitate the integration of adaptation issues in sectoral policies and governance actions and it usually leads to a greater understanding and acceptance of the overall adaptation strategy*».

According to *BallarinDenti*[17], a regular procedure initially analyses every sector's point of view, while later two main operative structures take action:

- a technical board, which provide scientific and technical advising;
- an institutional board, which gives a horizontal coordination and participates in the consultative initiatives.

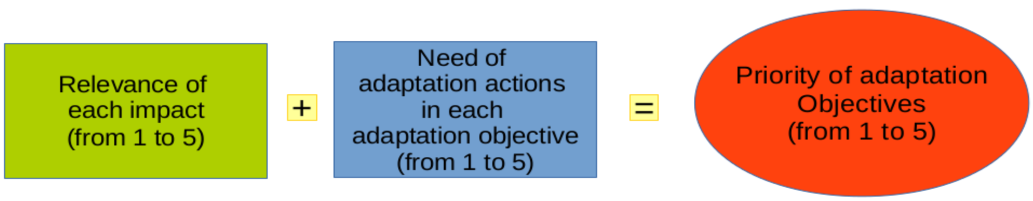

Illustration5- *Weighting algorithm (BallarinDenti)*

Third, the stakeholders' engagement starts, making sure that an inter-sectoral approach is used, by organizing workshops and doing questionnaries, so that awareness of stakeholders is increased and an adequate perception of the climate change issue is given.
Afterwards, the identification and adaptation of strategic objectives and consequent measures are done, but the necessity of weighting the importance of a sector's interests came out. The guidelines recommend thus a simple additive weighting algorithm, from which to derive a priority factor, as shown in Illustration5.

[17] BallarinDenti, A. (2014): Fifth Water Conference, Trento, Italy, 25th, 26th September 2014

EU territorial cooperation projects on climate change adaptation

AdaptAlp[18]

Detecting climate-related trends in hydrological series is important, in order to investigate the water resources in Alpine catchments. This trend detection should be based on a reliable dataset of homogenous hydrologic series representing undisturbed catchments. The project AdaptAlp aims at detecting trends in hydrologic regime of Alpine catchments based on a dataset of 177 runoff time series all over the Alpine space (see Illustration 6). These series cover forty years of daily record. Then, a set of hydrological indexes is defined to characterize the hydrologic regime in terms of low, medium and high flow. In particular, these indexes describe the drought severity and seasonality, and the intensity and timing of snowmelt flows. The work carried out by AdaptAlp partners led to the gathering of a hydrologic dataset well suited to the detection of climate-related trends in the hydrologic regime of Alpine catchment.
Statistical tests were applied to the stations of this dataset at the local and regional scales. The main significant trends can be summarized as follows:

- **Winter droughts**:
  - severity tends to decrease for glacier- and snowmelt-dominated regimes;
  - a slight shift (towards more precocity) is detected for snowmelt and composite regimes in the Northern Alps;
  - mixed snowmelt-rainfall regimes in the South-Eastern Alps (mostly Slovenian stations) show the opposite evolution: severity tends to increase and seasonality seems shifted towards more lateness.

- **Spring snowmelt-related high flows:**
  - an increase in the volume and peak of snowmelt flows is detected for glacier regimes;
  - an increase in the duration of the snowmelt season is detected for snowmelt regimes, along with an increased precocity of the beginning of the snowmelt season.

- **Medium flows:**
  - glacier regimes show increasing mean annual flow and increasing base flow index;
  - the consistency of detected trends at least suggests that the changes are unlikely to be linked with measurement issues, and are more likely climate-related.

18 www.adaptalp.org

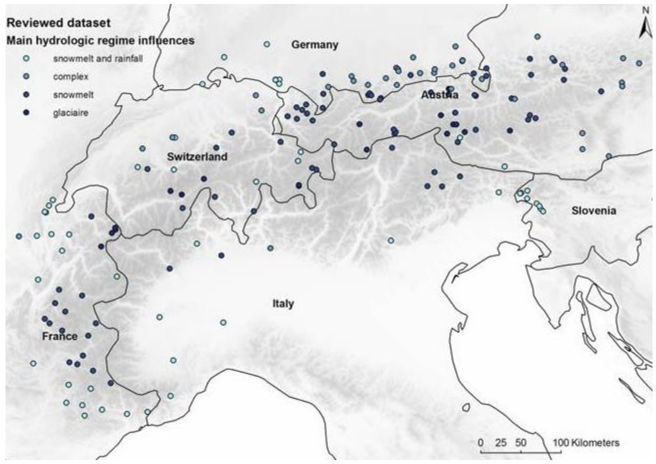

Illustration 6 - *The AdaptAlp Dataset (2011).*

C3Alps[19]

C3-Alps is a transnational capitalization project. Built on the results of previous projects and initiatives on adaptation to climate change in the Alps, C3-Alps seeks to synthesize, transfer, and implement in policy and practice the best available adaptation knowledge.

As *Lexer*[20] outlines, the aim of this organization is to establish an informal network of national CCA (climate change adaptation) policy-makers, in order to ensure information exchange, facilitate mutual learning, and allow benefits from synergies. The main target groups are municipalities and public administration. To do so, an Early Warning System based on the Water Scarcity Index (WSI) methodology was developed to predict critical situations.

Within the project a paper on the impact of climate change scenarios on water resources management in the Italian Alps has been published (Ranzi et al. 2009). The paper deals with the simulated runoff in the current and future climate scenarios in two Alpine relevant for irrigation basins in Northern Italy, water supply and hydropower. The results show that in spite of a slight increase of precipitation, a decrease of about 5% of runoff volume, for the 2050 scenario, and of 13% for the 2090 scenario was estimated at the outlet of the two basins because of the higher evapotranspiration losses. Same changes in energy generation are expected for the hydropower plants. For more information, please visit the web site: http://www.c3alps.eu.

19 http://www.c3alps.eu/index.php/it/

20 Lexer, W. (2014): *European Territorial Cooperation Alpine Space Project C3Alps – main results, achievements, foreseeable impacts, and conclusions for the way forward,* Fifth Water Conference, Trento, Italy, 25th, 26th September 2014

Clisp[21] CLISP (Climate Change Adaptation by Spatial Planning in the Alpine Space) is a transnational European project funded by the Alpine Space Programme under the European Territorial Cooperation 2007-2013. 14 Project Partners from six different Alpine countries tackled the challenges that spatial development and spatial planning are facing due to climate change.

The potential impact investigated is on flood prone areas, avalanche prone areas, rockfall prone areas and torrential process prone areas. The adaptive capacity consists in the application of the directives (e.g. through the Flood directive 2007/60/EC), in order to not increase the extension and number of hazardous areas.

As far as water management is concerned, the potential impact suggests that climate change is likely to reduce water availability due to more frequent aridity and drought, more concentrated precipitation events and higher temperature, which will, in turn, shift precipitation from snow to rain and reduce snow storage. The adaptive capacity entails the adoption of structural measures targeted to increase the water storage capacity in catchments, as well as non-structural measures, including more efficient water use, water conservation and appropriate land management. In this context the River Basin Management Plans, which will be composed according to the Water Framework Directive (2000/60/EC), represent a context in which a number of planning and management instruments are being developed and coordinated towards adaptation.

Alp-Water-Scarce[22] The work carried out within the "Alp-Water-Scarce" project (1.10.2008 – 31.10.2011), funded by the EU Alpine Space Programme, has resulted in a set of recommendations which are based on case studies performed in different Pilot Sites (Hohenwallner et al. 2011). Common to all of these recommendations is the need to preserve the water resources of the Alps for future generations, to deal with the increase of water demand and to cope with climate change-induced stress on those resources. The strong commitment of public bodies to cooperate on regional, national and transalpine levels and a common understanding of the terms "water scarcity" and "drought" are the preconditions for the implementation of long term measures to tackle water scarcity.

Within Europe, agreements for such trans-boundary water management exist for the main river basins of the Danube, the Elbe, the Meuse, the Mosel, the Oder and the Rhine. These agreementsalso have a clear impact on the Alps since they are the point of origin of some of these river systems. The technical solutions proposed are:

- increasing the efficiency of the supply network (minimize water losses);
- optimizing irrigation techniques;
- restoring floodplain ecosystems for improving water yield;
- increasing infiltration capacity by increasing the complexity of surface water networks;
- increasing the efficiency of water use for industrial production;
- infiltration instead of deviation of surface water or artificial groundwater recharge.

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21 www.clisp.eu

22 http://www.alpwaterscarce.eu/

Alpstar Project[23]

Temperatures in the Alps have risen almost twice as much as the global averageover the last century. And they are set to rise even more, especially if the Alps themselves continue to consume around 10% more energyper capita than the European average. However, clever and innovative adaptation or mitigation initiatives are emergingin local and regional Alpine areas facing to climate change consequences. The challenge is thus to makebest practice become the minimum standard if we want climate neutrality in the Alps to be achieved within the next 40 years. Here is the aim of the Alpine Space project *«Alpstar. Toward Carbon Neutral Alps – Make best Practice Minimum Standard»* through the collection, analysis, comparison, testing and implementation of climate protection measures in 12 pilot regions all over the Alps.

The main objective of Alpstar Project is to encourage the capitalization, diffusion and implementation of proven good practices and measures in reduction of climate change and preparation of cross-sectoral strategies and action plans toward carbon neutrality on regional and local level. The specific objectives are the following:

- to encourage and support exchanges of experiences, knowledge and know-how among pilot regions, in order to facilitate their implementation and to capitalize and spread local strategies and good practices for the reduction of GHG emissions;
- to search for good practices in the preparation and implementation of strategies, action plans and measures toward carbon neutrality and to make them become the minimum standard;
- to improve transboundary, cross-sectoral and inter-policy-level cooperation in coping with climate change;
- to promote an integrated and participatory approach in development of cross-sectoral strategies and action plans and implementation of measures toward carbon neutrality;
- to empower local and regional administrative actors and planners to become facilitators of change;
- to encourage pooling, transfer and implementation of innovative and efficient good practices from and to other Alpine regions and beyond.

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[23] http://alpstar-project.eu/

National initiatives on adaptation to climate change

StartClim2005.A4 [24](Austria)

The document deals with the emergencies caused by extreme events in drinking water supply in Austria. To assure water supply during extreme events, several different arrangements should be done. These arrangements are in sequence: disaster preparedness (organizational and technical arrangements), provisions at imminence, and a crises- and catastrophe management in case of emergency (drinking water emergency supply, information policy and cooperation with the media, collaboration with crises- and catastrophe management groups).

The comparison of different national concepts has shown that these concepts of watersuppliers strongly depend on the stimulation by the federal states (e.g. financial stimulations).

Mountland[25](Switzerland)

Mountain regions provide essential Ecosystem Goods and Services (EGS). Global change, however, endangers the capacity of mountain ecosystems to provide key services. The "Mountland" project, coordinated by the Swiss Federal Institute for Forest, Snow and Landscape Research WSL, focuses on three case study regions in the Swiss Alps and aims at proposing sustainable land-use practices and alternative policy solutions to ensure the provision of EGS under climate and land-use changes.

In "Mountland" an integrative approach is applied, combining methods from economics and the political and natural sciences to analyze ecosystem functioning from a holistic human-environment system perspective.

The first part of the project deals with sustainable land-use practices in mountain regions, through an integrative analysis of ecosystem dynamics under global change aimed at deriving socio-economic impacts and policy implications.

The second part of the project deals with the prioritization on adaptation to climate and socio-economic changes, backcasting tolerable future states to match supply and demand for ecosystem services in mountain areas.

HydroAlp[26] (Italy)

In Italy, the research center Eurac wrote a report on climate[27] dealing with the impacts of climate change on temperature, water resources (snow precipitation, glaciers), extreme events, natural vegetation and on human activities such as agriculture, water management, health and tourism. The adaptation consists firstly in preserving the climate and then in

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24 http://www.austroclim.at/index.php?id=45

25 http://www.wsl.ch/fe/walddynamik/projekte/mountland_home/index_EN

26 http://www.eurac.edu/en/research/projects/ProjectDetails.aspx?pid=9221

27 EuracResearch Rapporto sul Clima. Alto Adige

undertaking strategies to mitigate the inevitable consequences. The scientific approach allows to estimate the physics of the changes, in order to be better prepared to respond. The possible actions to contrast the climate change impacts on water are:

- save and reduce the consume of water;
- stock water in basins;
- implement a new and better monitoring system and forecast the availability of water with appropriate management plans.
- a project called Etsch-Dialog aims at recreating the complete equilibrium of the upper fluvial area of Adige (Etsch) river through the dialog between the different water users and the cooperation of the local population.

Irri4Web[28] (Italy)

A Decision Support System for irrigation scheduling is proposed as a tool to improve agriculture sustainability and adaptation to the ongoing climate change. In the Autonomous province of Trento (Italy), the newly implemented Public Waters General Exploitation Plan fixes new ceilings to the use of irrigation water and aims at its optimization by setting up limits to soil moisture. The protocol entails the assessment of water content in a soil parcel, given its location and the history of the latest irrigation actions. The water balance is carried out with rainfall and temperature values spatially interpolated from the neighboring meteorological stations (see Illustration7: the experimental area in Non Valley). Hargreaves' equation (Hargreaves and Samani, 1985, Battista et al., 1994), used for the calculation of evapotranspiration and pedologic information, is inferred by a "(pedo-) landscape map" compiled for this purpose. An estimation of soil water content is provided to end-users. Soil water content is calculated from 7 days before to 3 days after user's request. Weather forecasts are provided by the local weather service. The system is presently ready for its distribution to farmers and agricultural syndicates.

28 http://meteo.iasma.it/irri4web/

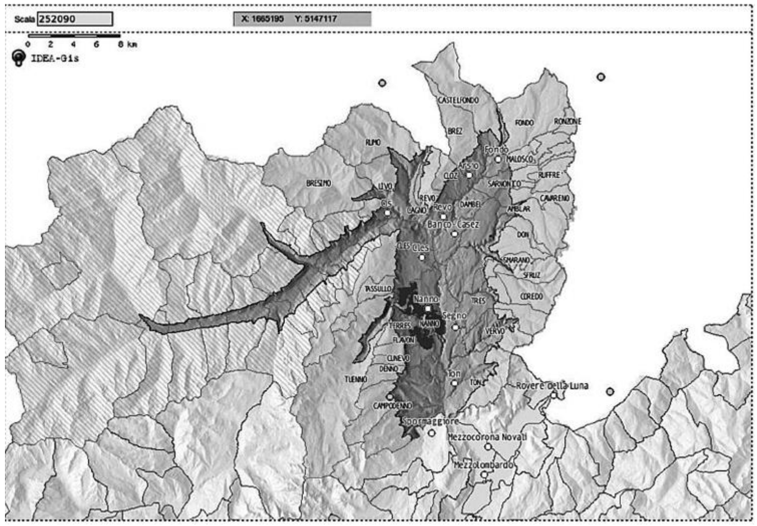

Illustration7 - *Experimental area of Irri4Web (Zottele et al).*

Bavarian climate adaptation strategy – BayKLAS (Germany)

In 2009 Bavaria launched the Bavaria climate adaptation strategy – BayKLAS project. It aimed at pursuing new policies about water management, agriculture, forestry, nature conservation, soil conservation and geological risk, health, civil protection, regional planning, urban, town and country planning, road building and traffic planning, energy sector, industry and trade, tourism and finance sector. Even if in Bavaria no holistic local adaptation plans for single municipalities are setup, theprogram and adaptation strategy mentioned aboveled to on-site measures in the municipalities.
Three examples are given below:

1. **Mountain Forest Initiative** [29]
   A special set of measures known as the "Mountain Forest Initiative" (Bergwaldoffensive, BWO), focuses on the adaptation of the alpine forests in Bavaria to climate change. The central aim of the BWO is to stabilize and to sustainably adapt the alpine mountain forests to climate change. For this purpose, 30 projects were identified in areas with special climatic risks. Integrated master plans were developed for these projects, which include different silvicultural measures, like thinning, planting and natural regeneration, construction of forest roads and hunting and pasture management for the reduction of browsing damage. A large number of owners are usually affected by the projects. Thus, the pilot measures are planned and initiated in agreement with the land owners and local

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[29] Alpine strategy for adaptation to climate change in the field of natural hazards – PLANALP 2013
www.forst.bayern.de
www.hswt.de

stakeholders. This strong focus on participation makesthe process transparent – a crucial factor for the success of the projects. Other important elements of the BWO include improving the supply of suitable tree seeds in the alpine region in Bavaria, strengthening applied research and generating new basic information for the management of alpine forests. For example, a digital map of forest soils in the northern Alps was generated as a basis for restoration and forecasts by the WINALP project (WaldinformationssystemNordalpen) in cooperation with partners from Austria (Tyrol, Salzburg).

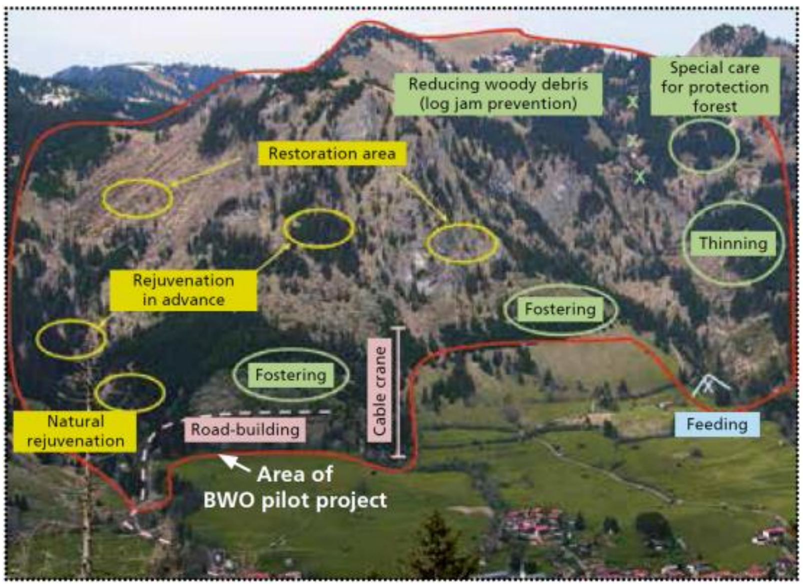

Illustration8 - *Example of measure combination within a Mountain Forest Initiative Area (Bavarian State Institute of Forestry).*

2. **Additional climate factor for hydraulic structures:**
   The "design-flood" for flood protection measures (like dikes) in Bavaria has a return period of 100 years.
   Even if no accurate prediction about a future change of the 100-year flood is possible, experts assume that there is an increasing of the discharge of 100-year flood events. Therefore,since 2009 Bavaria has used an additional climate factor of about 15% in case of the 100 year flood and 7,5% in case of the 200 year flood (see Illustration9). For new constructions of flood protection works the design discharge is increased by this factor.

Illustration9 - *An example of design flood, considering climate change.*

3. **Drinking water supply: taking precautions against drought**
   Investigations about the water supply structure in Bavaria showed that about one third of the 2.800 water supply facilities has no alternative supply possibilities.
   The seasonal and regional imbalancesin the distribution of precipitation in Bavaria have increased the secure supplies of drinking water at local and regional level by the water network or through the production of alternative water systems, especially in those parts of Upper Palatinate Forest and Bavarian Forest that have water shortages. This situation will have to take account of climate change. Some case studies showed that about 3% of the water supply facilities on the investigation area are not able to guarantee the peak consumption due to climate changes.

Program NRP 61: Sustainable Water Management (Switzerland)[30]

The research program NRP 61 "Sustainable Water Management" of the Swiss National Science Foundation had set the goal to provide a basis for sustainable water management in Switzerland. As part of this research program, the effects of climate and socio-economic changes in water availability, water use and water management were investigated in the Crans-Montana-Sierre region, situated in the dry inner-alpine Valais (project MontanAqua). The project followed an inter- and trans-disciplinary approach: stakeholders were involved from the very beginning.

30 Weingartner, R., Reynard, E., Graefe, O, Liniger, H., Rist, S., Schädler, B., Schneider, F., Effects of climate and socio-economic changes on water availability, use and management at the regional scale – a case study in the dry inner-alpine zone of Switzerland

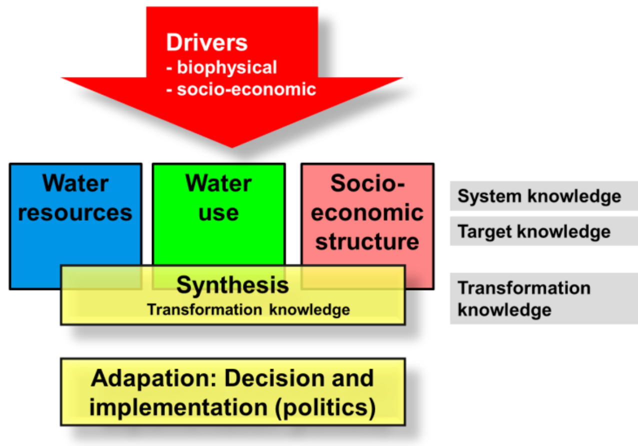

Illustration10 - *The inter-and trans-disciplinary approach of project.*

Thanks to the program, the current water situation have been assessed with quantitative and qualitative methods: A dense hydro-meteorological network was built-up, tracer experiments were conducted and communal water uses as well as the current water management system were analyzed. These investigations encouraged the development of models to simulate possible changes in the near and far future. For this purpose, existing regional climate change scenarios have been applied and socio-economic scenarios have been developed together with the stakeholders.

The output of MontanAqua can be summarized into five messages, here quoted, each with a short recommendation:

1 – The socio-economic changes have a greater impact on the water situation in 2050 than climate change: a territorial development that limits water needs is recommended. This requires important changes of current water- and land-management practices.

2 – The water quantities available now and in 2050 are generally sufficient. However, shortages are possible in some areas and seasonally: we recommend establishing a regional water management which goes beyond the development of technical infrastructure such as storage facilities or connections between water supply networks. This measure should be accompanied by a clarification and negotiation of water rights at the regional level.

3 – Water issues are primarily regional management problems: a better cooperation between the eleven municipalities of the region is recommended and the establishment of a demand management strategy which is aimed at coordinating uses and reducing water needs.

4 – Inter-communal measures on infrastructures can help to ensure sustainable water supply, but only if they are integrated into ambitious institutional reforms: a more equitable water management at the regional level requires a new negotiation of management principles and access rights to the water resources.

5 – To achieve a sustainable regional water management, improved data management and transparency is needed: we recommend that the Valais Canton develop a strategy for monitoring water at the regional level and for the collection of homogenized data. We also recommend that the Canton assess the current water management at the regional level in terms of sustainability. Finally, we advocate that a study to clarify the water rights is launched.

Adaptation to climate changes in other mountain regions

Caucasus (Kura/Aras river basin)

Significant reduction of water discharge of Kura river occurred during the last 20 years.

The country of Azerbaijan is very poor in water resource: water resources are unequally distributed and lowlands are the poorest regions (districts of Absheron and Kura-Araz). Additionally, in the last 20 years there was an increase in annual temperatures by 0.5°C.

According to many scenarios in the future there will be significant differences in the amount of precipitation in distinct regional areas. As a consequence, the water resources of Aras river and its tributaries will decrease by 30-40% in the upstream area of the basin, and by 20-30% in the downstream area. Additionally, a decrease (15-20%) of energy production, coming from hydropower, emerges.

According to *Verdiyev*[31], the water deficit will then increase in the future, due to climate change and anthropogenic use. This kind of situation will require limited water use, both in irrigation and in energy production.

To solve this problem, the use of fresh groundwater in addition to surface water may be sufficient for covering all economical sectors.

[31] Verdiyev, R. (2014): *Vulnerability assessment and measures of adaptation to climate changes of mountain river basins in the Caucasus,* Fifth Water Conference, Trento, Italy, 25th, 26th September 2014

Illustration11- *Kura/Aras river basin (Verdiyev).*

Carpathians

Within the Carpathian Convention a permanent group has been already created to work on Climate Change. Even though the annual precipitation level is slightly decreasing, which makes it difficult to have big evidences of significant changes on that specific parameter, an intensification of precipitation and a change in maximum daily precipitation were registered.

The main measures adopted so far in terms of adaptation to climate change include the attempt to enhance the connectivity of the Region, the diffusion of awareness and knowledge on the topic, the construction of climate-proofing infrastructures, and the development of forestry measures.

According to *Szalai*[32], three projects were directed under the Carpathian Convention:

- climate of the Carpathian region (CARPATCLIM);
- integrated assessment of vulnerability of environmental resources and ecosystem-based adaptation measures (Service contract CARPIVIA);
- in-depth assessment of vulnerability of environmental resources and ecosystem-based adaptation measures (Framework contract CarpathCC)

Dniester river is a source of drinking water for the majority of Moldova and for one of the biggest cities of Ukraine: Odessa. In 1994 an agreement on the joint management and protection of the cross-border waters was signed between Moldova and Ukraine. Later on, a more specific Bilateral Treaty on Cooperation on the Conservation and Sustainable Development of the Dniester River Basin was ratified. These examples of legal intervention facilitated the Dniester process, a trans-boundary cooperation some international bodies (OSCE, UNECE, UNEP) watch on.

As *Kruta*[33] outlines, in order to reduce vulnerability to extreme floods and climate change, two monitoring stations in the upper Dniester were installed. Moreover, a vulnerability assessment was done and workshops on flood communication were held.

The project, called "Climate change and security in the Dniester river basin", is dealing with climate change adaptation on a trans-boundary point of view, with the purpose of reducing damage from extreme floods, water deficiency and bad water quality, increase public awareness and conserve or restore water ecosystems. The measures adopted include the installation of new water level monitoring stations, the development of a new model, the promotion of events and contests that involve the Dniester river, and the implementation of new studies and research projects.

Central Asia

The modern trend of climate change in these regions is the increase of temperature in all countries considered, as displayed in Illustration 12where each color represents the curve of a country in Central Asia. On the other hand, two contrasting trends are shown if precipitation changes are considered, as one can see in13. Many signs of glaciers degradation have been noticed also, e.g. through the analysis of the Tien Shan glacier (Kyrgyzstan).

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32 Szalai, S. (2014): *International cooperation for the adaptation to climate change in the Carpathians,* Fifth Water Conference, Trento, Italy, 25th, 26th September 2014

33 Kruta, N. (2014): *The adaptation to climate change in a trans-boundary mountain basin of theCarpathians,* Trento, Italy, 25th, 26th September 2014

According to *Domashov*[34] a good example on how to adapt to climate change is provided by the promotion of an initiative in which endemic species were planted. Other projects regarded the communication of innovative knowledge, such as water-saving technologies and efficient energy solar greenhouses to the agriculture sector.
On the other hand, meetings were organized to teach local people how to recognize quality water, or workshops were held to promote the usage of renewable energy sources.For more information, please visit the website www.biom.kg.

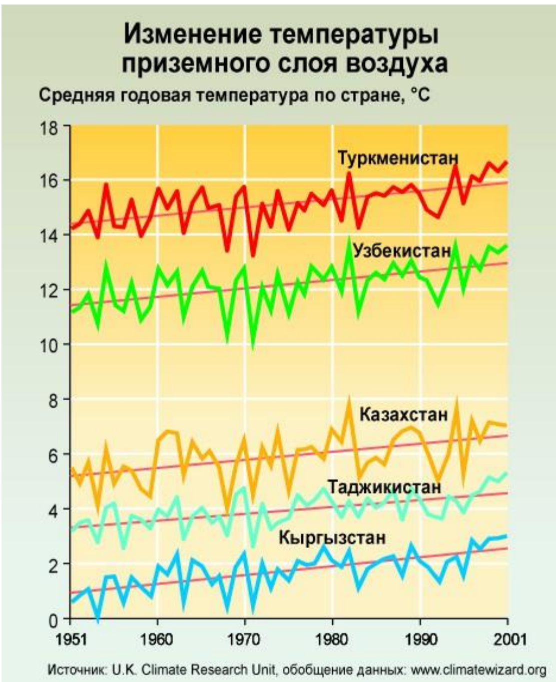


Illustration 12 - *Dynamic of average temperatures in Central Asia (Domashov).*

Illustration 13 - *Mosaic of precipitations in Central Asia (Domashov).*

[34] Domashov, I. (2014): *The adaptation to climate change in a mountain basin of the Central Asia,* Trento, Italy, 25th, 26th September 2014

INTERPRETATION AND APPLICATION OF WATER AND FLOOD DIRECTIVES IN ALPINE AREAS UNDER THE CLIMATE CHANGE PRESSURE

THE IMPACTS OF CLIMATE CHANGE ON FLOOD MANAGEMENT[35]

With the 2000/60/EC Water Framework Directive (WFD) the European Commission launched an innovative approach to the management of water resources, proposing a unique framework that includes the safeguarding, the defense and the management of water bodies. The 2007/60/EC Flood Directive (FD) in this framework may be seen as a complementary directive. This relationship is strengthened by the article 9 of Flood Directive that sets the "coordination with the WFD, public information and consultation".

The results of the workshop held in Aosta on March 19th 2013[36] underlined two main aspects: the need for a set of good practices and examples regarding the application of the two directives in their overlapping zones (e.g. flood mitigation and river restoration) and the need for a more targeted and coordinated research oriented at a better dissemination of the results. Furthermore, it highlighted that there is a high heterogeneity, both at international level (among alpine countries) and at national level (among the various regions) on the application of the hazard probability (e.g. return period), intensity level (e.g. water height, velocity ...) and on the scale of representation of the results.

This heterogeneity has created the need for an assessment on the current application methodologies of the Directives among the member States and also the creation of a collection of examples of coordinated application in the Alpine area. The Platforms "Water Management in the Alps" and "Natural Hazards" of the Alpine Convention, following the discussion emerged during the joint meeting held in Brescia on October 9th 2013, decided to produce the document "Flood Directive (2007/60/EC) and Water Framework Directive (2000/60/EC) in the alpine context"[37] that summarizes the experience of coordinated implementation of the FD and the WFD in the Alpine Countries.

[35] Text reviewed, based on the presentations exposed at the 5th Water Conference "Water in the Alps - and beyond: Adapting alpine and mountain river basins to climate change", Trento, Italy, 25th-26th September 2014, and on the information taken from the documents "Flood Directive (2007/60/CE) and Water Framework Directive (2000/60/CE) in the Alpine context" .

[36] http://www.alpconv.org/en/organization/groups/WGWater/flooddirective/default.html

[37] http://www.alpconv.org/en/organization/groups/WGWater/Documents/FD_WFD.pdf

Implementation of the 2007/60/EC Flood Directive

Austria

The competent authority for this issue is the Ministry of Agriculture and Forestry, Environment and Water, where a technical and a legal working group were established. The technical working group is composed of two sub-groups: one is concerned with the creation of the hazard and risk maps and the other is concerned with the preparation of flood risk management plans. The members of these groups are appointed bycompetent Ministries for civil protection, water management and spatial planning, by regional governments and by environmental agencies. In the working groups, there is very close contact with the Working Group on Floods of the European Union, with whom a bi-directional exchange of results and observations is established.

Procedure: the Ministry created an Austria-wide design where the Regions and the competent authorities customize the plans, according to local conditions and to the expert opinions. The time devoted to carry out this process is fixed in six months. The international aspects and transnational river basins are processed in the existing river commissions at international or bilateral level.

The results are then summarized again by the Ministry and then presented to the citizens through a public participation. In conclusion, the final version of the plan is forwarded as a report to the European Commission. The advantage of this method is that the flood risk management incorporates the results and knowledge of all involved parties and also from the Ministry of the Provinces, as well as the requirements of the international river basin commissions. All competent actors, e.g. the hydraulic agencies, civil defense organizations, regional planning authorities, including hydrological services, infrastructure services, municipalities and various stakeholders are invited to the preparation of flood risk management plans.

Size of river system and catchment areas: in Austria only river basins with an area of more than 10 km^2 have been considered for the entire flood policy. Underlying, catchment areas are treated with the Floods Directive only in special cases, selected on the basis of expert judgment.

Criteria for the preliminary risk assessment: the main criterion is the human health of the affected population, according to the number of inhabitants affected by the floods per river kilometer. Furthermore, significant historical flood events are taken into account in the risk assessment. In Austria around 3000 km are reported as significant risk areas, which counts for approximately 7% of the entire river system. Regarding the probability of flood events, there are considered the 30, 100 and 300 return periods.

Risk definition: strictly to the definition of the Floods Directive, Article 2.

Contrasts in the integration of the Floods and Water Directive: in Austria both policies are handled by the same Ministry and possible problems are soon outlined and processed. Currently, no conflicts are reported, probably because also the motto for flood protection "More room for our rivers" is taken into account and ecological aspects are considered in the implementation of countermeasures.

Involvement and participation of the public: in Austria it occurs through meetings with stakeholders and public information. For the implementation of the Floods Directive the

	website http://www.naturgefahren.atwas set up, and various brochures and flyers specifically explaining the guidelines of the Floods Directive have been produced and sent to the municipalities. Article 13 (transitional measures): Austria has not made use of Article 13. Hazard zones in urban areas: there is an absolute prohibition of construction and change of "destination use" in all the areas that are flooded with a 100 year return period. There is also an absolute denial of construction in the red zones and there is also a construction denial in the areas suitable for protection measures (e.g. flood retention basins). Finally, construction is forbidden within ten meters from both sides of the rivers.
Switzerland	Procedure: the Swiss approach to flood hazard, notwithstanding it is not an EU country, is very similar to what prescribed by the 2007/60 Directive. It comprises the integrated risk management through the prevention (mitigation structures and hazard mapping) and the emergency management (rescue and recovery). The integrated risk management requires a proper culture of "risk" that is extremely slow to be put in practice, as the "optimum" solution is the result of the interconnection of multiple administrations. The prevention activity produces important intermediate products: the intensity maps, used to design the mitigation and defense structures, the hazard maps, used for urban planning and the intervention maps (intersections between the intensity and hazard maps), used to calculate the possible escape paths and the intervention camps for the rescuing activity. The differences with the 2007/60 Directive are: • the comprehensive management plan is absent in Switzerland, as the federal government is responsible for defining the guidelines, the regional (cantonal) level for the implementation of the hazard maps and the municipalities for the implementation of the emergency measurements; • in Switzerland the Directive requires the frequency-intensity diagram and not just pure frequence. Furthermore, such diagram may be derived for all hazards and not just to the water-related hazards; • the hazard maps are provided also for events exceeding the design level of the mitigation structures ("overload events"), in order to verify the probability of collapse of the structures if the event exceed what pre-calculated; • the scenarios are defined not just following a pure hydrological computation, but considering also a combination of different events (e.g. debris-flow in a lateral creek impacting the main river, the reactivation of old river beds...). The geo-morphological approach is applied in all small streams, characterized by elevated hydrological uncertainties on solid transport that discourage a detailed hydraulic simulation. On the other hand, the hydraulic simulations are prescribed for the other streams characterized by a high solid transport or debris flow. Finally, for rivers in the main valley characterized by a considerable solid transport, the hydraulic simulations (1D or 2D) are required.

Germany	Criteria for the preliminary risk assessment: the preliminary flood risk assessment (PFRA) is calculated by intersecting the spatial information on the hazard and the vulnerability. The data base for this calculation includes the main rivers, the catchments exceeding the threshold of 10 km^2 area (in Bavaria, out of about 100.000 km of water network, only 23.000 comply with this criterion) and also other potential flood hazard areas, like river valleys or, especially in the Alps, the alluvial fan, derived through soil mapping techniques. The vulnerability assessment utilizes all available land-use data, i.e. protected areas (e.g. flora and fauna habitats, drinking water protection areas, nature-preserved areas), industrial sites characterized by the use of hazardous substances (166/2006/EC Directive) like large sewage treatment plants or chemical industries, and also historical area or UNESCO heritage sites. The essential principle is, starting from the mouth of a river upstream, to add all sections of the river where vulnerabilities are presentand, if this summing exceeds a certain percentage compared to the total river length, then integratethese sections of the river into the policy. The criteria used to choose the PFRA area are: all major rivers, all river sections that have more than 66% vulnerability (or more than 50% vulnerability if located in an urban area), all sections of the river characterized by the presence of industrial plants that operate with dangerous substances (this allows to account for the case that chemical substances may be flushed out during a flood event). Finally, historical or recent flooded areas were also added. The outputs were then validated through the analysis of local expects. The results show that, from our 23.000 km of analyzed river network, about 7.500 km are significant for the policy, i.e. out of 100.000 km total; this means 7% of rivers (exactly as much as Austria). For the Alps this approach would result in an underestimation of hazardous creeks, especially for the smaller ones. So, in addition to this preliminary risk assessment, Germany has done a kind of “hot-spot” analysis in 460 studies, in order to filter whereproblems in the Alps are still present and take advantage of these studies to produce in the Alps hazard maps, aligned with the risk management policy, where also debris flow should be taken into account in the scenarios. Article 13 (transitional measures) was applied for the whole Bavaria. In the southern area (Danube basin), the Article 1a has been applied. A sort of risk management plan was already available time ago for the main basins: Germany has then adapted this plan to comply with the Directive and the article 13.3. has also been used. In German law there is also a construction prohibition in the zones subject to flood for a 100yr return period, no matter if there are two inches of water, a meter or two. As far as the velocities are concerned, Germany has decided not to introduce the intensity maps. In fact, if a municipality started to play through this dispensation, flood-adapted construction modalities would have been adopted. As there are no flood-adapted constructions, Germany decided not to force this legislation and not to distinguish on the velocities. In these areas the municipalities cannot make any spatial planning and urban

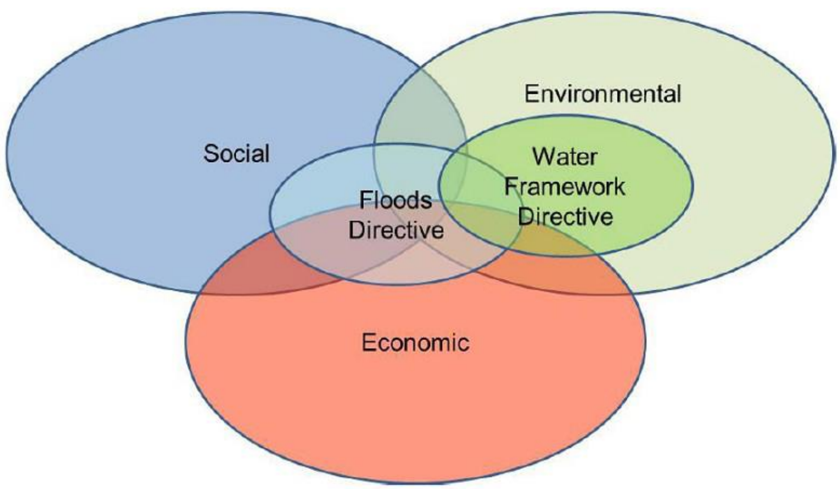
	development. There are exceptions and the municipality must meet nine criteria. The most difficult criterion is that a municipality must demonstrate that it has no other means of settlement development and then to demonstrate that the plan has no effect on the upstream- and downstream-areas, both on the water level and on the discharge. Furthermore, the planning must assure that no damage is expected and no loss in the retention area (in case settlements are built anywhere, the retention area must be elsewhere restored). But the critical point is certainly the first: no other means of settlement development. And therefore, due to the strict condition this 100yr event has, the modeling must be very accurate. Accurate 2-D modeling is in course of realization, and the designation of the 100yr event zones is already a measure of risk management. As far as the insurance industry is concerned, in Bavaria and Germany there is no insurance obligation. There are private <u>insurance companies</u> that offer insurance for flood, backwater from channels or heavy precipitation. The insurance industry has developed a zoning system (called Zürs: zones system for floods, backwater and heavy rainfall) and divided the maps into different zones with probabilities. These data could be updated with better data from the public hazard maps.the insurance price varies accordingly to the zone in which a house is located. There are also areas where no insurance policy will be ever given (this is true only for 1-2% of all houses in Bavaria). But until now, only 10% of firms and approximately 17% of households have secured. This insurance, however, is not so well accepted, although the cost for a house might be € 200 per year. There is also a State relief fund for damages caused by disaster, but it pays only not-insurable damages. So a measure of the additional risk management would certainly motivate the population to get the insurance.
Italy (Po river basin)	<u>Competent authority</u>: Italy finds itself in a transitional phase: at the beginning (late eighties) there were 41 river basin authorities, divided into national, interregional and regional, that had the objective of defining the flood and geological hazard with a basin view. After that, the 2000/60 Directive has imposed to organize the river basin authorities into 8 districts and this has created some difficulties of coordination between the various levels (national and regional). The national river basin authorities (Po, Eastern Adriatic, Tevere and Arno rivers) have a coordination role in this aspect, both at technical and at "political" level, where the contrasts have to be posed and solved. The main river network is managed by the national river basin authority, whereas the minor network (minor rivers in the mountain and artificial channels in the plain) is in charge to the regional level, which often deals with the risk aspect in different ways. <u>Preliminary flood assessment</u>: the preliminary flood assessment are available to the public and coincides with the flood and landslides hazard map (PAI: Piano di AssettoIdrogeologico), available since 2001. The starting point is the river network defined by the 2000/60 Directive (main river network), integrated by the minor network chosen according to a minimum extension criteria. <u>Updating of the plan</u>: the preliminary plan has been updated according the prescription of the 2007/60 Directive and then released by the end of 2013. The available hazard

	maps have been updated through mathematical simulations in case new topographical data are available (e.g. if a new lidar is available in the plain area where also the minor channels are visible). Then the vulnerability and risk maps have been produced. This activity has been performed through the involvement of the regional and local administrations, in order to get shared maps for the final PLAN, sent to the Commission in 2015. Construction prohibition: as far as the main river network is concerned, the flood maps are calculated according to a 100 yr return period. In the inner parts of the resulting inundation area, there is a rigid construction denial, whereas in the outer parts, where the velocities and water levels are reduced, just public structures are allowed (e.g. water purifier...). Risk management: it is advisable a cultural boost in the issue of flood risk. In Italy lots of casualties happened because people, curious in seeing the flood evolution, put themselves in dangerous locations. In this issue, it is important to adopt a multi-cultural approach, involving, not only geologist and engineers, but also psychologist, anthropologist etc., in order to find the best way to communicate with people. Furthermore, it is important to stress that a new approach is needed towards the increase of resilience and the use of non-structural interventions rather than adopting just structural mitigation structures.
Italy (Eastern Alps basin)	This district results from the merging of two national river authorities (Adige and Alto-Adriatico) and different other regional river authorities. Therefore, the new authority is facing an enormous work of homogenization of the various maps that were originally calculated according to peculiar thresholds and guidelines. Furthermore, some basins have produced both hazard and risk maps, whereas other basins include just the hazard maps. Size of river system and catchment areas: the 10 km^2 threshold is used to define the minimum basin extension for the preliminary assessment. Also, smaller basins are studied in case of known hazardous situations. Modeling approach: As far as the approach is concerned, mathematical simulations are used just in rivers that were previously mapped for homogenization purpose. One particular problem dealt with is whether to include the collapse of riverbanks into the modeling, both because the results may be very different and because some authorities have included and others haven't. Furthermore, according to the available dataset, the mathematical modeling is assigned with an uncertainty level. In fact, in some cases there are lots of data on discharge, precipitation, topography etc., whereas in other cases the dataset is very scarce, so also the results are affected by a higher degree of uncertainty. Public involvement: Also the involvement of the population has started, with the objective of communicating the basics of the flood planning. The website www.alpiorientali.it has been prepared in order to increase the audience and the means of communications. Construction prohibition: The regulations on urban planning and flood area are already

available in the PAI (the previous flood and landslides hazard maps) and then have been integratedin the new flood management plan.

Joint application of the Flood Directive and the Water Framework Directive

The purpose of WFD is to establish a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater. The result of it will bring to the creation of the River Basin Management Plan (RBMP). The purpose of FD is instead the assessment and management of flood risks, aiming at the reduction of the adverse consequences for human health, the environment, cultural heritage and economic activity. The product will be the drafting of the Flood Risk Management Plan (FRMP). As represented in Illustration14, three main aspects of the sustainable development – social, economic and environmental dimension – are a possible way to interpret the main fields addressed by both directives. In fact, whether WFD mostly discusses environmental aspects, FD involves all three dimensions.
As *Stravs*[38]points out, synergies between the two directives include the aspects of data usage and mapping. An important issue regards the coordination that should be followed during the preparation of FRMP and RBMP. In fact, in some cases, one measure mentioned in a directive can cause a conflict with one that belongs to the other directive, even though every part involved should fulfill obligations and demands of both directives.
In order to deal with conflicting directives, *Rocco*[39] proposes to work in an interdisciplinary and inter-sectoral environment. An important aspect that should be taken into consideration is the involvement of the local population in the implementation of directives, because the relationship between man and territory should not be forgotten. Policies must be stipulated according not only to the scientific and technical point of view, but also to the economic and the anthropological ones.



(Source: Adapted from Evers and Nyberg, 2013)

Illustration14 - *Main aspects of a sustainable development (Stravs)*

38 Stravs, L. (2014): *Links between the Floods Directive and Water Framework Directive*, Fifth Water Conference, Trento, Italy, 25th, 26th September 2014

39 Rocco, R. (2014): *The position paper of the Water Platform on the joint application of the EU Floods Directive and the EU Water Framework Directive*, Fifth Water Conference, Trento, Italy, 25th, 26th September 2014

Flood management in Alpine catchments

Due to the topographical circumstances and a particular climatic situation of the Alps, there are specific natural hazards with which the population of the alpine areas has learned to live over centuries. Almost every year in the last decade extreme precipitation events with high intensity took place in almost anycountry of the Alpine area. An example of Alpine country affected by specific problems regarding flood risk management is Austria, due to itstopographic and climatic situation. According to *Hornich*[40], the specific causes and related problems regarding flood risk management in alpine catchments are:

- the presence of sediments and bad load material;
- huge amounts of driftwood that aggravate the flood situation;
- the morphological spatial demand of rivers;
- the development of Alpine villages in areas endangered by natural hazards, with a consequent increase of damage potential;
- the possible solutions given by land use planning;
- the effects and needs of tourism;
- flood forecasting;
- climate change;
- protection of cultural heritages.

Protection against natural hazards has always had great significance in the Alpine areas. Apart from the technical safety measures, non-technical measures, which can be used for protection, exist. The presentation and mapping of hazard zones in the form of hazard zone maps has been applied in Austria and in other Alpine countries for more than 30 years. The big amount of investments in flood protection brought to a reduction of damages all over Europe. On the other hand, costs for proper maintenance raised. As a consequence, the EU Floods Directive is shifting the focus of the solution toflood risk management instead of only on structural measures. Hence, flood risk management plans, with regard to the specific circumstances in alpine regions, are a crucial basis for the security and future development of alpine living spaces.

The real benefits for local people depend on the management plans. In doing so, the most important part is to involve the public in the process of decision making.

This is why when creating flood risk management plans in alpine areas, great significance must be given to the measures of land use planning, to non-structural measures and to public relations.

Flood management in small basins: cases study from the Province of Trento

There are already evidences on the effects of climate change to increasing flood events and in the future climate change is predicted to lead to more frequent, heavier and more extended periods of rain in the Alps, increasing thus flood hazard. At the same time, socio-economic changes endorse the development of urban residential establishments in areas susceptible of flooding, therefore increasing flood risk. As a consequence, policymakers have to be able to identify flood risks to help design and implement mitigation strategies.

According to *Coali*[41], the current flood management strategy is to focus on guaranteeing a safe and secure

40 Hornich, R. (2014): *Specific problems regarding flood risk management in Alpine catchments,* Fifth Water Conference, Trento, Italy, 25th, 26th September 2014

41 Coali, R. (2014): *Flood management in small alpine basins: the current approach of the Autonomous Province of*

territory for the inhabitants and their activities, using especially non-structural methods. Consequentially, the Province of Trento is working on a territorial planning, realizing and maintaining protection structures and defining suitable plans of emergency management. A way to do so is using hydro-geological hazard maps and risk maps. Based on this work, a new land use planning can be developed and the identification of priority cases of intervention is made possible.
The current planning responds to the legislative requirements (Flood Directive) and thus uses as an indicator for the occurrence of debris flow events the quantity known as return period. Unfortunately, in small basins the effects of solid transportation depend on the sediment volume, but not on the return period. Therefore, it would be important to control debris flow events and to do in-depth analyses in different fields, in order to develop new parameters for determining the event's occurrence, to estimate sediment volumes and to measure the efficiency of protection structures.

Flood management in the Tisza river basin

The Flood Protection Expert Group (FP-EG) is responsible for dealing with the issue of monitoring the accomplishments made by the EU Flood Directive. The river is facing a heavy flooding phenomena. If one analyzes the climatic condition, through, for example, CLAVIER project (CLimateChAnge and Variability: Impact on Central and Eastern EuRope: http://www.clavier-eu.org), discharges are noticed to be increasing in winter and decreasing in spring and summer, due to a projection of warmer and wetter winters and hotter and drier summers. According to *Gombas*[42], the problem lies in the ability to recognize a common trend for floods. So far, the perception of the actual situation is that there is a lack of detailed investigation of the natural processes, a lack of research and that there is a non-proper use of floodplains, due also to the outdated legislation. The next activities planned by the International Commission for Protection of the Danube River (IPCDR) are a scientific investigation and a numerical modeling of the Tisza river basin, in order to reassess regulatory flood levels and create a sustainable floodplain management plan in that area.

Trento, Fifth Water Conference, Trento, Italy, 25th, 26th September 2014

42 Gombas, K. (2014): *Good practices and lessons learned on water and climate in the Tisza river basin, with a focus on flood management,* Fifth Water Conference, Trento, Italy, 25th, 26th September 2014

Flood protection and river restoration: case studies in the Alps

Brenta river (Trentino, Italy)

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Driving forces of river degradation	Urbanization, agriculture and industrial activities
Pressures on the environment	Use of areas adjacent to the river and emissions in the water course
Impacts	Floods, unhealthy water conditions and loss of biodiversity
Country	Italy
Water body at risk	Brenta
Location	Segment between the Caldonazzo lake and the BorgoValsugana town
Objective of the planning activity	Water quality restoration and flood protection

Current status of the Brenta river

The Brenta river originates from the lakes Levico and Caldonazzo (in Trentino, Italy) and flows into the Adriatic Sea, just south of the Venetian lagoon in the Veneto region. Its mountainous part runs across the Valsugana valley up to the town of BorgoValsugana (Illustration15). The watershed extension at the outlet of BorgoValsugana is about 212 km^2 and the river length is about 20 km.

Basically, it is a straight river where morphological features vary rarely: depth is constant, the channel shape is regular, and the riparian areas are sporadic, scattered and narrow (Illustration16). Surrounding areas essentially present semi-permanent agriculture activities. From an ecological point of view Brenta is a low valuable river: the water quality is low or very low, as well as the presence of biodiversity. It is subjected to flood events, given that the section of the river can contain on average about 100-120 $m^3 s^{-1}$ of water (that is lower than the discharge flowing for a return period of 100 years, i.e. 182 $m^3 s^{-1}$). Flood events usually occur in the agriculture areas, but also the town of BorgoValsugana may be interested: in fact, catastrophic events happened in 1966, when the town was totally inundated.

In order to guarantee the safeguard of the town, a project was carried on from 2001 to 2008. While different solutions come up (i.e. the creation of three detention basins together with the thalweg re-shaping in correspondence of BorgoValsugana, and the creation of one detention basin together with the construction of a hydraulic tunnel to bypass BorgoValsugana), local authorities underlined the need to look at restoring the whole segment between Caldonazzo and BorgoValsugana. Actually, the projected solutions appeared to be difficult to put into practice.

From a project to safeguard BorgoValsugana to a plan to restore Brenta

In 2008 a restoration plan has been started up by eight administrative offices of the Autonomous Province of Trento, with the aid of external professionals. The plan involves the watershed of Brenta, going from the Caldonazzo lake up to the town of Borgo Valsugana, it aims at satisfying ecological, social and economic needs of local people: the environmental restoration and protection of the watershed and the safe and secure conditions for dwellers with restrained costs. In particular, the plan aims at

maintaining the current upstream retention capacity of the river (hydraulic studies demonstrated that the flooding in the agricultural areas may strongly reduce the flooding in BorgoValsugana), at creating ecological connections with the existing protected areas, at recovering the lateral areas for flooding, and at improving the water quality and leisure opportunities.
The plan applies the project solutions previously found for the safeguard of BorgoValsugana in 2001-2008, and develops new hydraulic studies, in order to assess the natural retention capacity of the watershed and the effects of the restoration actions. It also takes into account the presence of a number of constraints of the territory: a gas pipeline (lying close to the Brenta river for a great length), a water treatment plant, bridges and land ownership.

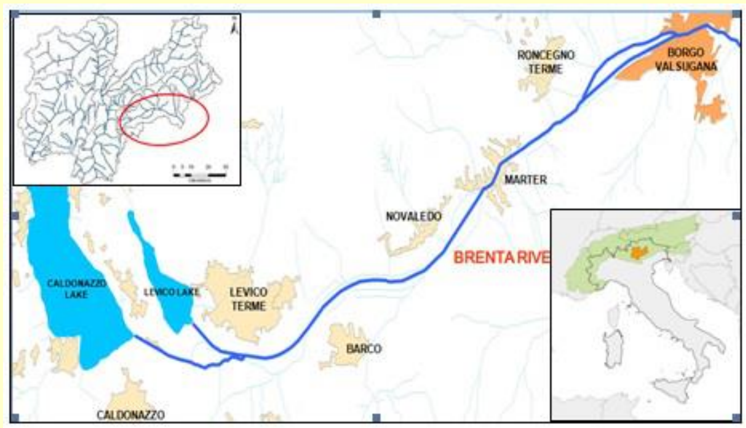

Illustration15 - *Course of the Brenta river from lake Caldonazzo to the town of BorgoValsugana.*

Illustration16 - *The Brenta river and a scheme of its section.*

The planned actions are intended to:

- improve the provisional retention capacity of the Caldonazzo lake (an increase in height of 1 m in the lake means 5 million m^3 of water retained) in terms of volume of water retained avoiding to damage local touristic activities;
- create retention basins upon agricultural areas and in the proximity of the gas pipeline and the water treatment plan. Retention basins will be in elevation, limited by banks of 3.5 m high and with variable width (up to 15 m);
- create a braided channel with cross sections that significantly change the morphological

conditions of the river (Illustration17and Illustration18);

- use of banks in the proximity of the industrial areas and of the water treatment plant;
- increase the capacity of the Brenta channel in BorgoValsugana (up to 150 m^3 s^{-1} of water) by punctual barriers and (whether necessary) re-building existing bridges;

At present the project is waiting for the Strategic Environmental Assessment process that will choose the best combinations of actions.

Matching 2000/60/EC and 2007/60/EC directives

The objectives of the 2000/60/EC are matched with the 2007/60/EC: the protection –as well as the recovering- of the water ecosystems and connected watersheds, the achievement of a good status of water quality and the mitigation of flood effects, while reducing risks from flooding.

A major message came up from the planning phase: people must learn to coexist with floods and must recognize and accept that certain areas may be periodically inundated. Water security does not mean total avoidance or the elimination of the risk, but it is rather the set of actions that can reduce risks at sustainable and suitable social and economic costs. For this reason a joint collaboration with the local civil protection has been established both to manage situations of emergency and to teach people how to coexist with the hydraulic risk.

Illustration17 - *Rendering of a braided channel (on the right).*

Illustration18 -*Scheme of a restored section of the river.*

Lindenbach (Bavaria, Germany)

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Driving forces of river degradation	Urbanization, agriculture
Pressures on the environment	Migration possibilities for fish and aquatic animals interrupted
Impacts	Floods, loss of biodiversity
Country	Germany
Water body at risk	Lindenbach
Location	Segment between Bad Kohlgrub and Murnauer Moos
Objective of the planning activity	flood protection, restoration

Situation and reasons for the project

The torrent Lindenbach has a watershed area of about 20 km² and flows from west to east onthe northern side of the Ammergauer Alps. Its tributary waters are situated at the northern hillsides of the mountain "Hörnle" with median slopes of 20%.

Because of former regulations, the river Lindenbach is straightened and narrowed and has several drop structures and smaller check dams of heights up to 3 m. Its channel slope is of about 2 % in this region, but becomes downstream much lower when it flows into the Murnauer Moos (flat moor region south of lake Staffelsee).

Illustration19 - *Wood log jam destroyed a bridge; also several check dams are damaged*

On 02.07.2009 a torrential rainfall of 92 mm in 3 hours causes a flood of about 57 m³/s, which is more than a one hundred year flood. Several check dams, bank protection works and road bridges were destroyed. Problems have occurred with debris and wood log jams. As consequence a prompt reconstruction of the damaged protection works was necessary.

Illustration20 - *Wood log jam destroyed a bridge; also several check dams are damaged*

A River restoration project starts

Responsible for the maintenance of river Lindenbach and this project is the Bavarian State represented by the water management agency Weilheim. Because this river was set as a priority to becomefaunistic river for fish and because of the occurred problems of the existing protection works during the flood, the water management agency Weilheim has decided for an alternative reconstruction. The drop structures and the check dams are redesigned and constructed as ramps. The goal was to guarantee, on the one hand, the flood protection and, on the other hand, to realize a rehabilitation of the river continuity and migration possibilities for fish and aquatic animals of about a length of 17 km.

In total about 16 check dams are replaced in some places with a single height of over 3 m. In total the ramp structures got a length of over 1 km. The project was financed by the state with total costs of about 850.000 €.

Illustration21 - *Before and after; a 3m high check dam is replaced by a 120 m long ramp.*

Illustration22 - *During and after the reconstruction (ramp with height1,6 m and length 70 m).*

Giffre river (France)

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Driving forces of river degradation	Mainly agriculture,some urbanization and hydro-electricity
Pressures on the environment	Channelization, with embankments built on river banks, gravel extraction
Impacts	River incision (loss if river habitat and biodiversity, weakening of multiple flow structures such as dikes and bridges), loss of braided pattern to a single channel pattern
Country	France
Water body at risk	Giffre
Location	Multiple reaches: upstream of Thézières bridge; at the Essertats; between Luche and the Perrière torrent; between Valentine and Verney weir; at the Toron of Tanninges confluence; in the Millière and Mégevette plains.
Objective of the planning activity	Flood protection, ecological river restoration

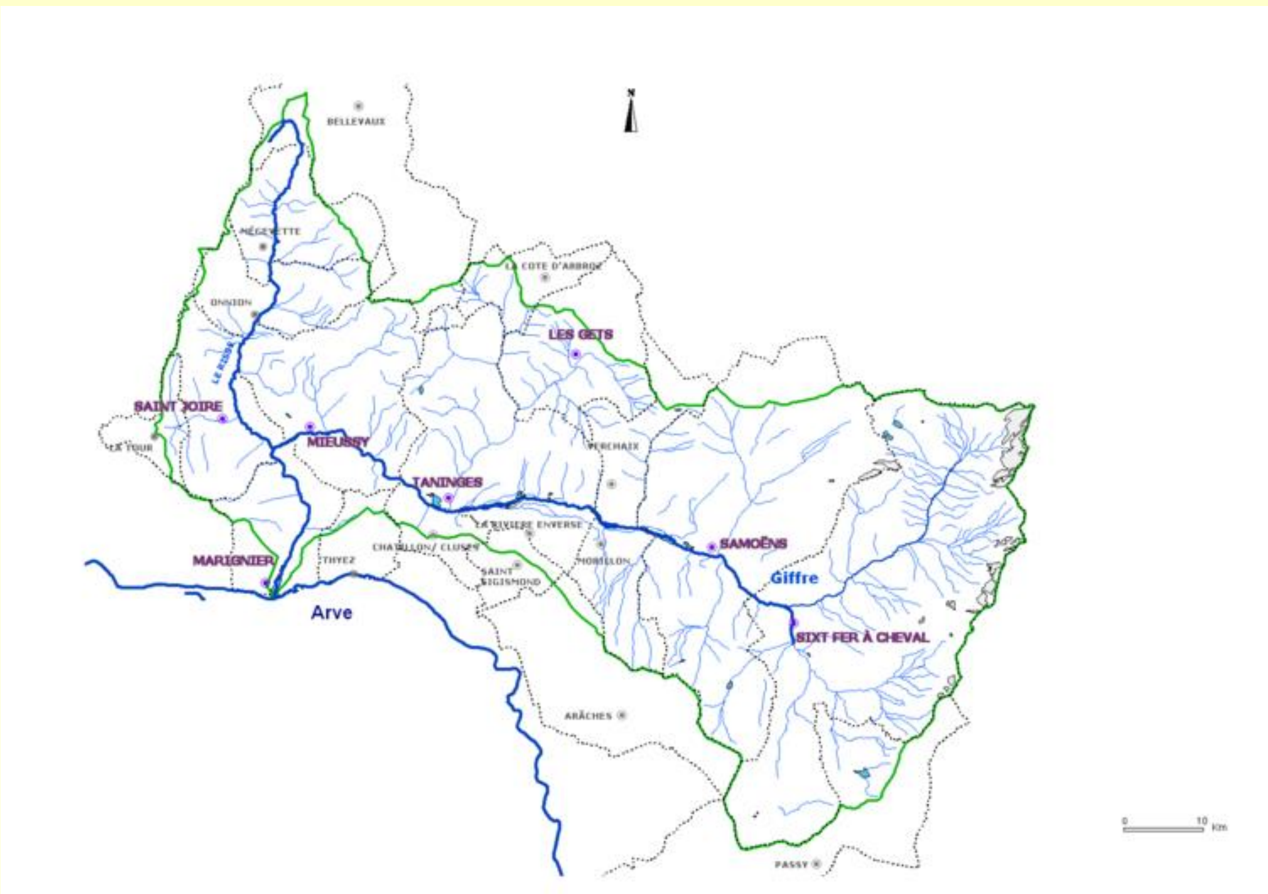

Illustration23 -*Location plan*

Situation and reasons of the project

The Giffre has a catchment area of about 475 km^2 and is located in a valley orientated following an east-west axis, in Haute-Savoie. It springs from the Ruan and Prazon glaciers and is 45km long. This river is the river Arve main right-bank tributary. Its annual rainfall is about 1650mm in Samoens.

The Giffre experiences torrential floods that are directly related to its geological and mountainous conditions and also to its climate. The Giffre has an average longitudinal slope of 0,6%, but this slope goes up to 3,5% in the Mieussy gorges and over 8% between the confluence of the Nantd'Ant and the Giffrenant dam. Sediment supply to the Giffre river is extremely high in some areas, particularly from very steep tributaries. About 450000m^3 of sediment lay in the Giffre main channel.

At the moment about 20% of the total river length is embanked, with sometimes very little space left to the river. Most of the embankments had already been built at the end of the 1980s.

Between 1912 and 2000, it is estimated that approximately 1,87 Mm^3 of gravels have been extracted from the river bed. This has had a very significant impact of the longitudinal profile as the river has incised by over 1,3m on average with some reaches incised by over 3,5m (along the Marignier reach). Without being the main cause, dams used to produce hydroelectricity have aggravated the incision of the river bed.

Giving space back to the river: an ambitious river restoration and flood protection project

The main aim of the project is to restore the erodible corridor on several reaches, thereby limiting the incision of the river, while restoring flooding areas. The restoration of two reaches has already been completed and a study is being launched to refine the work to be done on the other reaches.

In one of the restored reaches, the river bed active width contracted by over 50% between 1934 and 2004 and channel incised by over 2,5m. The project mainly consisted in removing vegetation from gravel bars, removing lateral riverbank protections, recreating side channels, taking back gravels from areas that had aggraded and re-injecting in areas where the channel had incised. Flood defenses, where existing, are setback. The scenarios taken into account in the hydraulic modelling are 10, 30, 50, 100, 300 and 1000.

The overall project is forecast to last for 7 years with a total cost estimated to be 42M€.

Illustration 24 -*Examples of river incision.*

Illustration 25 -*Example of works carried out on the oppositeriver bank to remobilize aggraded material.*

Illustration 26 - *Views of the Giffre looking downstream of the restored reach.*

Illustration 27 - *Views of the Giffre looking downstream of the restored reach.*

THE MANAGEMENT OF TRANSBOUDARY ISSUES UNDER CLIMATE CHANGE

WATER MANAGEMENT IN TRANSBOUNDARY BASINS

Meeting the growing water demand without compromising sustainability is a rising challenge in the context of an increase of population and under the pressure of climate change impacts. It is therefore crucial to better understand the interactions between water, food, energy and ecosystems in river basins, in order to strengthen synergies and policy coherence between the water, agriculture, energy and land management sectors. The assessment of these interdependencies is particularly relevant in transboundary basins, where identifying inter-sectoral synergies and mutually beneficial solutions can help reduce potential conflicts, not only across sectors, but also across borders, as well as supporting the decision-making process to enhance sustainability.

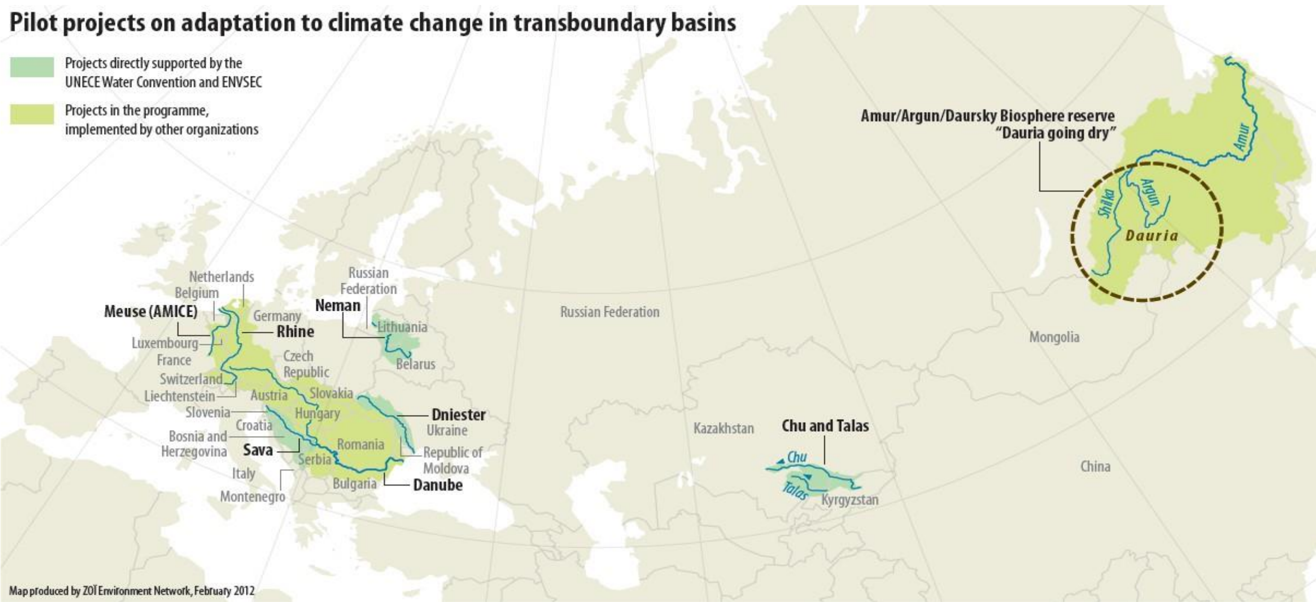

Illustration28 - *Pilot projects on adaptation to climate change in transboundary basins (Timmerman).*

The UNECE Water Convention and the nexus approach

The United Nations Commission for European Economy (UNECE) Convention on the protection and use of transboundary watercourses and international lakes (Water Convention) is signed by 40 Contracting Parties, but, thanks to a recent amendment of the Conference of the Parties, has been enlarged to the whole world.

The main obligations under the Convention are to protect transboundary waters, both surface and ground waters, to guarantee a reasonable use of these waters and to facilitate cooperation through agreements and institutions. Moreover, the Convention aims at concluding multilateral agreements, facilitating the exchange of information and elaborating objectives and action programs. A lot of guidelines have been developed in various fields, such as flood management or climate adaptation, in the last decades.

As *Timmerman*[43] points out, the task force Water and Climate of the UNECE has done some activities related to the adaptation to climate change, such as the drafting of the Guidance on Water and Adaptation to Climate Change, whose aim is to provide a general road-map for climate proofing of water management in a transboundary context, and the start of different pilot projects in many countries of Europe, Africa and Asia, see Illustration28.

Moreover, the Conference of the Parties of the UNECE Convention, as part of 2013-2015 activities, established the task force "Water-Food-Energy-Ecosystemnexus", in order to deepen the links between the management of water resources, the management of floods and ecosystem services in a context of increasing use of the resource and in the light of the impacts of climate change. The activities of the task force are focused on 8 transboundary basins around the world. As *Lipponen*[44], points out the Task Force on the Water-Food-Energy- Ecosystems Nexus is now working on the assessment 4 basins in different continents and it is expected to continue the work on other river basins in the next years. The pilot project is the Alazani/Ganikh case (river basin shared by Georgia and Azerbaijan) and the concept behind the task force's work is that of using a "nexus approach", in other words an inter-sectoral coordination. This was possible thanks to some partners, such as the Royal Institute of Technology (Stockholm), the Finnish Environment Institute SYKE, and FAO.

The aims of the nexus assessment at a basin level are to support transboundary cooperation and to help local communities move towards increased efficiency in resource use, by improving policy coherence and co-management. As reported in the nexus methodology document[45] for these aims, it is necessary to coordinate plans and management measures between the riparian countries. This could increase the understanding, dialog and participations between nations, effective institutions and legal frameworks, decision support tools (monitoring, impact assessment), economic tools, sharing, solidarity and political willingness.

In nexus approach, there is a set of features with the aim to ensure achievement of objectives. These features are:

- participatory process: discuss intersectorial issues without being limited to a specific sector or aspect (e.g. climate or water management) that is a condition for an interesting dialog on development priorities, existing constrains and shared advantages of coordinate actions;
- knowledge mobilization: very important are local knowledge and experience of the issues; experiences from previous projects, studies, databases and models about hydrology, energy system, land use and ecosystems, improve resource efficiency, as well as intersectoral and transboundary cooperation at local level;
- sound scientific analysis: scientific analysis improve the quality of the assessment outcome. The analysis is scaled according to the financial and human resources available. With limited financing, at least, data needs can be identified, as well as possible sources and methods.

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43 Timmerman, J. (2014): *Introduction to the UNECE Water Convention and to the activities of the task forces "Water and Climate" and "Water-Food-Energy-Ecosystem Nexus"*, Fifth Water Conference, Trento, Italy, 25th, 26th September 2014.

44 Lipponen, A. (2014): *The "nexus" approach to assessment of trans-boundary river basins and implications to water management*, Fifth Water Conference, Trento, Italy, 25th, 26th September 2014

45 Royal Institute of Technology (KTH) (2015): Methodology for Assessing the Water-Food-Energy-Ecosystems-Nexus Assessment in Transbounday Basins. Draft for a chapter of the final stock-taking report of the assessment of the water-food-energy-ecosystems nexus under the ECE Water Convention

- capacity building: sharing examples, promoting constructive discussion across Countries and sectors allow to better understand intersectorial linkages and gain experience in sustainable management of natural resources;
- collective effort: the outcome of the nexus approach will reflect the views of all expertise involved throughout the procedure, including both Parties to the Water Convention and non-Parties;
- benefits and opportunities: the dialogue and cooperation are a guiding principle of the methodological approach. They allow a more constructive approach, oriented to participation solutions and outcomes that may attract/mobilize wider support.

For what concerns Water Convenion, according to *Howells*[46], a key point is the importance of recognizing that energy management and water management have to evolve in harmony: combining water management with energy management, makes it possible to greatly increase the benefits for all.

Case study: the Sava river basin

The water, energy and food sectors are so strongly interlinked that actions in one area commonly have impacts in one or both of the others. Based on the interest in participating in the nexus assessment under the Water Convention expressed by the Sava countries, confirmed by the proposal of the International Sava River Basin Commission, the Sava River Basin has been selected as one of the basins to be assessed (www.savacommission.org).

The Sava river basin, represented in Illustration29, is divided among 6 countries and covers the area of nearly 100.000 km^2 and the population of approx. 8,5 million inhabitants. The nexus assessment's objectives on the Sava river are driven by the intent to give a contribution to dialogue with sectoral stakeholders, to promote an integration of policies, to coordinate an inter-sectoral and a sustainable river basin management planning.

According to *Grošelj*[47], the main issues that emerged during the introductory workshop concerned the hydropower development, as well as the need for flood protection measures, the expansion of agriculture, pollution and the climate change problem. Many issues have already emerged, e.g. hydropower and agriculture expansion, flood protection, energy production, pollution and different kinds of pressures to surface and groundwater and, last but not least, the difference between data existence and data availability.

The potential solution presented regarded a more efficient use of energy resources, the development of renewable solutions, an integration between energy and agriculture sectors and a better control of sediments.

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46 Howells, M. (2014): *First elements of discussion in a "nexus" perspective on the Soca/Isonzo river basin (a possible case study from the cooperation between Alpine Convention and UNECE Water Convention) – round table*, Fifth Water Conference, Trento, Italy, 25th, 26th September 2014

47 Groselj, S. (2014): *The "nexus" assessment on the Sava river basin*, Fifth Water Conference, Trento, Italy, 25th, 26th September 2014

Illustration29 -*Sava river basin (Groselj).*

Case study: the Soca/Isonzo river basin

The Isonzo/Soca river, whose cross-boundaries basin is represented in Illustration30, is located partially in Italy and partially in Slovenia. Its waters are permanently used for hydropower energy production on the Slovenian side, whereas they are mainly used for agriculture on the Italian side. Its management therefore requires a river basin planning shared amongthe nations involved, in order to consider the possible aspects of common interest.

The Isonzo river basin reflects all the typical problems of transboundary basins about qualitative and quantitative aspects in the water use, as well as possible hydraulic safety issues relative to border areas.

As far as the quantitative aspects are concerned, using a simplified hydrological balance, one can see that in a regular season the water use for irrigation in Italy is still sustainable, however problems of scarcity arise during a dry season. In fact, the presence in the Slovenian territory of some hydroelectric reservoirs can cause discontinuity in the discharges that reach the Italian territory. In particular, these issues become important in times of drought in relation of the Italian irrigation demand (for agriculture in the mid and low Friulian plain) and of the need to ensure a minimum flow for achieving and/or maintaining the ecological status of the watercourse.

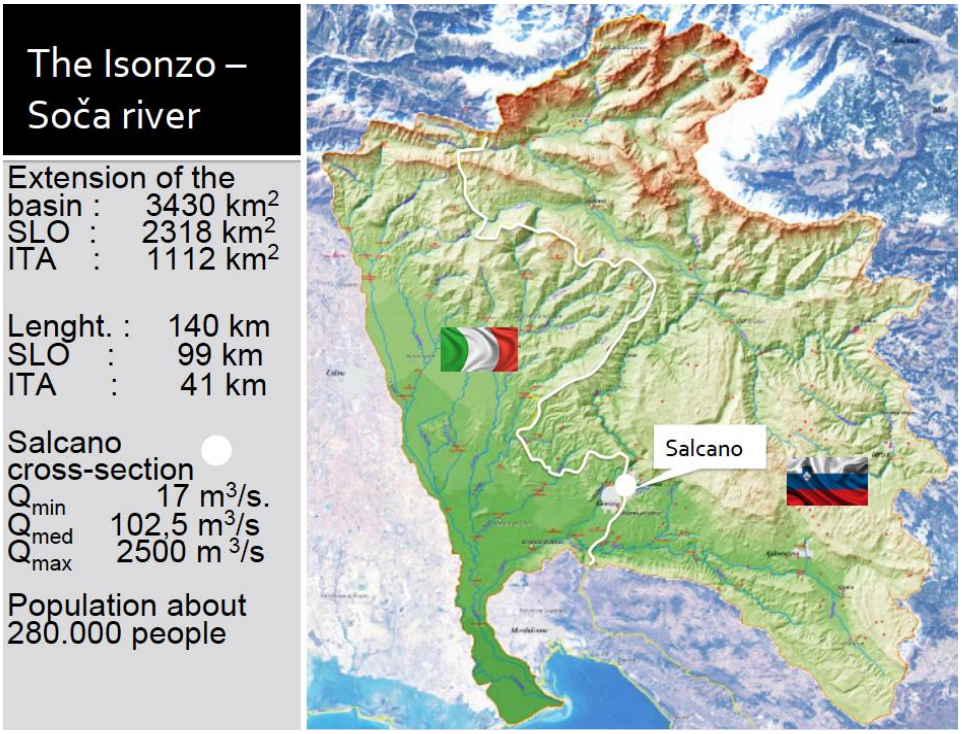

Illustration30 -*Isonzo-Soca river basin*

As far as surface water quality is concerned, pollution problems are present in the basin and derive from the typical fact that sees upstream territories transferring their contaminant loads downstream. Furthermore, water quality is worsened by the presence of some punctual source of mercury pollution coming from some former mines and transported by the tributary Idrija to the IsonzoRiver and then to Italy where the suspended mercury settles.
The adoption of common non-structural measures, such as forecasting systems, represents a fundamental starting point for avoiding that the water volume transported from upstream to downstream doesn't heavily modify the flow conditions and consequently the upstream profile (e.g. backwater effect).
According to *Baruffi*[48], three key ways of acting, in order to follow a nexus approach on the Soca/Isonzo river management are: (I) use of prevention, (ii) seek of a fair use of water resources and (iii) cooperation among the parties. As far as cooperation is concerned, *Iervolino*[49] points out that many common projects are currently involving the Soca/Isonzo river basin. Some of them have the aim of creating a common geographic system for the protection of drinking-, bathing-, ground-water resources, some aim to create common databases between Italy and Slovenia or to create guidelines for water management and vulnerability and risk maps. A short list of existing projects may be found in the Table below.

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48 Baruffi, F (2014): *First elements of discussion in a "nexus" perspective on the Soca/Isonzo river basin (a possible case study from the cooperation between Alpine Convention and UNECE Water Convention) – round table*: Fifth Water Conference, Trento, Italy, 25th, 26th September 2014

49 Iervolino, D (2014): *First elements of discussion in a "nexus" perspective on the Soca/Isonzo river basin (a possible case study from the cooperation between Alpine Convention and UNECE Water Convention) – round table*: Fifth Water Conference, Trento, Italy, 25th, 26th September 2014

Table 1 - ***List of existing projects which involve*** *the* ***Soca/Isonzo river basin.***

Project	Web	Description
GEP	http://www.gepgis.eu/http://www.gepgis.eu/	creation of a common geographic system for the protection of drinking water resources in case of emergency
CAMIS	http://www.camisproject.eu http://www.camisproject.eu/	coordinated activities for the management of the Soca/Isonzo river studies on river morphology, Hydrology and Hydraulics
HYDROKARST	http://www.hydrokarst-project.euhttp://www.hydrokarst-project.eu/	analyses of the Karstic aquifer, a strategic transboundary water resource
GOTRAWAMA	http://www.gotrawama.euhttp://www.gotrawama.eu/	transboundary water management between Gorizia and Nova Gorica
ASTIS	http://astis.ung.si/ithttp://astis.ung.si/it	protection of transboundary drinking groundwater in two local aquifers

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ISBN: 978-88-904995-7-9

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